Vol. 1

Agricultural Entomology
Sericulture

BOOK of EXTENDED ABSTRACTS

Golden Jubilee International Conference

Global Perspectives in Crop Protection for Food Security (GPCP 2021)

December 8-10, 2021

Organized by :

Department of Agricultural Entomology
Department of Sericulture
Department of Plant Pathology
Department of Nematology

Centre for Plant Protection Studies, Tamil Nadu Agricultural University
Coimbatore - 641 003.

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International Conference on Global Perspectives in Crop Protection for Food Security

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FOREWORD

Agriculture is the backbone of many developed and developing countries in the world and the mankind is dependent on this noble profession for livelihood. In ensuring crop production and productivity, the agricultural communities of the world have walked through dynamic phases in combating pest and diseases of cultivated crops. The traditional economic development and poverty reduction goals of governments focus on transformation phases in agriculture and allied disciplines. Over the years Academic, Government and Non Governmental Bodies have strongly advocated Integrated Pest Management (IPM) programmes. We have seen remarkable successes in the implementation of the measures in IPM in all the continents. In India, as a policy, IPM has been adopted to ensure food safety and security. The Tamil Nadu Agricultural University (TNAU), Coimbatore, the motherland of agricultural innovation and agrotechnology provider has been in the forefront in development of smart technologies in tune with the requirement of agricultural settings. The University has contributed in the area of IPM for decades. In its transformational plans in this segment, the University has introduced the concepts and philosophies for next generation crop protection. Significant attention is being given to climate smart technologies in crop protection, need based use of agrochemicals, extensive use and integration of biorational inputs, monitoring and management of invasive alien species (IAS), adoption of artificial intelligence and novel delivery systems are few worth mentioning. In the coming decades these technologies will assume significance in crop protection and contribute to the overall crop production and biodiversity conservation.

Keeping in view all the dimension of agricultural and allied disciplines, the Centre for Plant Protection Studies (CPPS), TNAU, Coimbatore is organizing the International Conference "Global Perspectives in Crop Protection for Food Security" (GPCP 2021) in commemoration of the Golden Jubilee year celebrations of TNAU. The conference is planned in hybrid mode. We have international experts, researchers, and student scholars participating in the conference hosted by the constituent Departments of CPPS viz., the Department of Agricultural Entomology, Department of Plant Pathology, Department of Nematology and Department of Sericulture.

I am extremely pleased to be part of this International Conference and utilize this opportunity to compliment the sincere and dedicated efforts of the Organizing Committee of the Conference in bringing out the Compendium of Invited Papers and the Book of Abstracts in separate volumes. These research outputs would serve as a pool of scientific understanding and review the current status and assess our future requirements. I also appreciate all the contributors for this conference and these compilations will be testimonies to the current efforts with future outlook.

I must congratulate the team CPPS and other participants for the marvellous efforts in organizing this conference and I am sure that the recommendations emanating in the deliberations will be of great importance to the scientific community, policy makers, administrators and user groups.

6/12/21

(A.S. Krishnamoorthy)

Dr. K. Prabakar, Ph.D
Director, Centre for Plant Protection Studies

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Coimbatore - 641 003

PREFACE

Scientific community on agriculture worldwide has been advocating improvement in agricultural productivity in recent times very aggressively for long term outputs and growing population. This is possible if only new innovations reach the corridors of implementing agencies. In crop production sector, crop protection scientists face the innumerable challenges caused by pests and diseases; have to safeguard production; crop losses; and facilitate quality assured produces from farmgates. Therefore, the needs of expanding populations have to be met with key objectives viz., ensuring crop health, judicious use of frontline inputs in crop protection, assurance on food safety and security.

It must be understood that agriculture is the backbone of developing nations and has the potential to bring all-round socio economic development. The commitment of crop protection scientists in this context is of great significance. In order to prevent the adverse effects of irrational practices in crop management and production, the Government of India adopted Integrated Pest Management and Crop Production Policy since 1985 and embarked on it throughout the country. Likewise, many nations adopted the IPM practices. Over the decades, IPM has undergone transformation, giving key benefits in sustained production and economic returns. Now time has come for us to redefine our targets in crop protection with more and more innovative concepts, tools, methodologies and implemental programme in the farmscapes. In order to meet these future goals, we have to set the stage today and this International Conference “Global Perspectives in Crop Protection for Food Security” could be the gateway for future recommendations.

I am duty bound to thank TNAU, for providing the opportunity to conduct the International Conference in commemoration of Golden Jubilee year of TNAU which is expected to play a crucial role in highlighting the relevance and context of crop protection. In this connection, the invaluable contribution of national and international Plant Protection Scientists, faculties and postgraduate students belonging to plant protection disciplines of TNAU is note worthy. They all left no stone unturned in the consummation of this lifetime opportunity of successfully hosting the conference and compiling this masterpiece of the conference.

TNAU has a strong Industry - Institute collaboration and the industry has come forward to contribute to this conference in a generous manner. Without adequate finance, an international conference could not be successful. My gratitude and thanks to the sponsors whose logos adorn the pages of this compilation.

(K. Prabakar)

ACKNOWLEDGEMENT

The Centre for Plant Protection Studies (CPPS), Tamil Nadu Agricultural University, Coimbatore has been delegated with the responsibility of hosting the International Conference "Global Perspectives in Crop Protection for Food Security" (GPCP-2021) at Coimbatore during December 8-10, 2021 as part of the year long Golden Jubilee celebrations.

The CPPS involved its four constituent Departments viz., the Department of Agricultural Entomology, Department of Plant Pathology, Department of Nematology and Department of Sericulture and all the Plant Protection Scientists of the University, in the conduct of the conference GPCP 2021. Various committees were formed for carrying out the tasks and completion in time. The list of committees is appended in each volume of the conference proceedings. With the active involvement of the Crop Protection Scientists in the main campus and meticulous planning of the Organizing Secretaries, we could achieve the milestones in record time.

This enabled quick and reliable communications. The GPCP 2021 conference is planned in hybrid mode, involving international and national experts in the field of crop protection, system engineering, automation, besides crop protection researchers and scholars. Participants from the country include those from ICAR, SAUs, Conventional Universities, stakeholders from industry, etc. We have more than 575 registrants for the conference and 63 invited speakers of international standing. As a maiden venture, we created a website, https://sites.google.com/tnau.ac.in/gpcp2021 and all the transactions were performed using the platform in tune with requirement of the scientists. Coinciding with conference, an exhibition with participation of industry involved in crop protection and other disciplines is also conducted.

As part of this conference, we have brought out print and e-publications

1. Compendium of Invited Papers
2. Book of Extended Abstracts – Entomology & Sericulture (Vol. I & II)
3. Book of Extended Abstracts – Pathology & Nematology (Vol. III)

All these activities were planned ahead of the conference and realization was possible due to the support and constant encouragement of the University given to the Organizing Committee. At this juncture, in letter and spirit, the core team extends sincere acknowledgement to all those concerned.

We are greatly indebted to our beloved former Vice Chancellor of TNAU, Dr. N. Kumar, Ph.D, F.H.S.I., F.S.P.H., who was instrumental in conceptualization of this international conference. His constant guidance and encouragement formed the basis for the success we have achieved. The Organizing Committee wishes to place on record the deep sense of gratitude for his commitment and invaluable guidance.

The Organizing Committee is greatly supported by the Registrar and Acting Vice Chancellor of TNAU in planning the activities and we wholeheartedly thank our senior plant protection faculty, Dr.A.S.Krishnamoorthy, the Registrar and Acting Vice Chancellor of TNAU in this regard. We are duty bound to record our sincere appreciation to other University Officers of TNAU also, for their sustained support.

The assistance of Comptroller and other administrative sections of University in ensuring timely financial and administrative sanctions in fulfillment of the requirements of the Organizing Committee is gratefully acknowledged.

From across the globe and the country, goodwill messages have poured in from our alumni for the successful conduct of the international conference. We feel proud of our distinguished alumni and thank them for showering praises and extending technical support.

There have been overwhelming responses from invited speakers in the country and abroad, besides showing

immense enthusiasm and encouragement. All the invited papers have been compiled and we were able to bring out a compendium with their timely support. We extend our boundless gratitude to the 63 invited speakers from India and foreign nations.

Agricultural research is always dynamic and the new findings have to be systematically brought to the knowledge of scientific community. With overwhelming and unprecedented scale of response, we received 705 extended abstracts from scientists, research scholars and postgraduate students. These research inputs have really added value to the core objectives of the conference. The organizing committee is pleased to acknowledge the support of the researchers showing high scholarly abilities and attitudes.

Various committees were engaged in hectic activities allocated to them and the performance is exemplary. Their commitment, meticulous planning and execution of assigned tasks is priceless. The scientists of the constituent departments, showed the highest degree of professionalism, passion and elegance in fulfillment of the technical, financial and regulatory activities. All the conference related activities were managed by the conference secretariat at the Department of Agricultural Entomology, ably supported by the scientists of other disciplines and administrative staff. The secretariat served as the backbone and nodal centre of the conference and it is worthy to mention the untiring work and support of the secretariat managers, Dr. N. Ganapathy, Professor (Entomology) and Dr. M. R. Srinivasan, Professor (Entomology).

Finally, the contribution of Postgraduate students belonging to Plant Protection in TNAU for registration, editing abstracts and online communication related activities of the conference is gratefully acknowledged.

There is no substitute for hard work and efforts seldom fail.

Organizing Chairman (GPCP 2021)

K. Prabakar

Organizing Secretaries (GPCP 2021)

N. Sathiah

G. Karthikeyan

A. Shanthi

K. Chozhan

Place: TNAU, Coimbatore

Date: 08.12.2021

CONTENT

GOLDEN JUBILEE INTERNATIONAL CONFERENCE

GPCP 2021

CPPS - TNAU

Theme

ES 01: Biosystematics, Taxonomy and Molecular Diversity of Insects

ES 01 OPD 01

First Report of Two Biotypes in Cassava Whitefly (*Bemisia Tabaci*), their Endosymbiont Variability and its Significance

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Keywords: *Cassava, Bemisia tabaci, biotypes, endosymbiomts variability*

Introduction

Cassava is the third largest source of carbohydrates for human food in the world after rice and maize. Cassava is vulnerable to a broad range of diseases caused by viruses. Among them, cassava mosaic disease (CMD) is the most severe and widespread, limiting production of the crop. Whiteflies are regarded as the most invasive pest of crops all around the world. It acts as the vector for the transmission of Cassava mosaic virus. Among various whitefly populations attacking cassava, some may be more important than others, as for as disease transmission ability is concerned and also this polyphagous agricultural pest harbours diverse bacterial communities in its gut, which perform multiple functions in whiteflies, including nutrient provisioning, amino acid biosynthesis and virus transmission. The present exploratory study compares biotype dependant variability of bacterial communities associated with cassava whitefly, collected from different zones from Kerala, India, using next-generation sequencing of 16S rDNA and its probable significance.

Materials and Methods

Bemisia tabaci samples were collected from cassava fields of 13 different agro-ecological zones of Kerala (Latitudes 8.1730° N to 12. 4740° N and Longitudes 74.2747° E to 77.3712° E), India. Genetic variability study using mitochondrial *Cytochrome oxidase* 1 gene (primers C1-J2195 and L2-N-3014) had conducted. Metagenomic DNA extraction and sequencing using Illumina next-generation sequencing of 16S rDNA were also done and bioinformatic analysis using QIIME and MG-RAST were conducted to identify the bacteraial endosymbionts present in *Bemisia.*

Results and Discussion

Genetic variability study had shown the presence of two biotypes/ genetic groups of Bemisia, Asia I (H) and Asia II5 (P) in cassava plants of Kerala. Next generation sequencing data set consisted of 3,513 operational taxonomic units (OTUs). Sequence analysis shown a marked difference in the abundance of bacteria in the populations. A total of 16 bacterial phyla, 27 classes, 56 orders, 91 families, 236 genera and 409 species were identified from P populations, while in H populations, the abundance were 16, 31, 60, 88, 225 and 355 respectively.

The presence and abundance of bacterial endosymbionts shows significant variation between the populations of whitefly based on biotype variation. *Arsenophonus* sp. (Enterobacteriaceae) is reported to be important in virus transmission of whitefly and is abundant in P, whereas *Bacillus* sp. found to be the most dominant group in H. *Arsenophonus* sp. reported to be important in virus transmission of whitefly is abundant in the CMV transmitter whitefly vector biotype Asia II5. The association found between different whitefly biotypes and secondary endosymbionts suggests a possible contribution of these bacteria to host characteristics, such as virus transmission. A detailed study in these aspects could be useful in planning management strategies against the pest.

ES 01 OPD 02

Pupal Cremaster based Identification of Some Economically Important Lepidoptera

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Keywords: *Lepidoptera, identification, pupual cremaster*

Introduction

Taxonomy of immature stages remains widely overlooked as it is time consuming. Moreover, immature stages are not generally not available in the entomological collections (Freitas and Brown, 2004). Morphological characters of immature Lepidoptera provide important information for taxonomy and phylogeny studies. Further, unprecedented rate of biological invasions poses greater threats to diversity of life and disrupt native ecosystems as that of *Spodoptera frugiperda* (JE Smith) in the recent past. So, it is essential and inevitable to identify the insect even in the immature stages. Use of pupal characters has a long history in Lepidoptera systematics. An attempt was made to identify economically important Lepidoptera based on the pupal cremaster.

Materials and Methods

Economically important insect pests of different Lepidopteran families: Crambidae, Erebidae, Noctuidae and Nolidae were reared on their respective host plants. On pupation, the pupal cremasters were examined for the different insects under stereo zoom microscope (Leica M 205 A) and photographed with image analyser.

Results and Discussion

The results revealed that the structure of the cremaster varied between the Lepidopteran families but almost similar within the sub families: Crambidae: Glaphyriinae: blunt at the terminal end with curved tendril-like weakly sclerotised structures, Erebidae: Erebinae: there were no scelrotised structured but partially sclerotised curved tendril-like structures arranges in an almost circular fashion at the cone-like terminal corrugated portion of the pupa, Lymantriinae: similar to Erebinae with more numbers of tendril-like structures on an elongate rod-like to corrugated bluntly pointed terminal end of the pupa, Noctuidae: Heliothinae pupal cremaster (2 numbers) was sharp pointed at the tip and basally closer at the base, Glotullinae: similar to Heliothinae slightly separated at the base, Hadeninae: similar to Heliothinae, but widely separated at the base, Noctuinae: cremaster (4 nos) very short and appears as two sclerotised projections in a stepped manner, Eublemminae: cremaster appears as four sclerotised minute projections in four corners, Plusinae: single sturdy cremaster surrounded by eight terminally curved structures, and Nolidae: Nolinae: pupal terminus almost squarish with no prominent cremaster. Study on the other Lepidopteran pupa will pave for instant identification with other characters of the pupa as well.

Reference

Meier, R. and Lim, G.S. 2009. Conflict, convergent evolution, and the relative importance of immature and adult characters in endopterygote phylogenetics. *Annual Review of Entomology,* 54, pp.85– 104.

ES 01 OPD 03

Diversity and Distribution of Aleyrodids in Different Agro Climatic Zones of Tamil Nadu

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Keywords: *Aleyrodid, agro climatic zones, simpson diversity, distribution and PAST*

Introduction

Aleyrodids are one among the most important pests that has colonized many agricultural, horticultural and ornamental plants. Worldwide, there are 1556 species and 440 species of whiteflies in India. Some of the Aleyrodids have been recently got introduced into India viz., *Aleurodicus dispersus* Russell, *A. trachoides*, *A. rugioperculatus* Martin, *Aleurotrachelus atratus* Hempel, *Paraleyrodes bondari* Peracchi, *Paraleyrodes minei* Iaccarino and *Aleurothrixus floccosus* (Maskell) (Sundararaj *et al.*, 2020). This study undertaken to understand the diversity and distribution of the invasive whiteflies in agricultural ecosystems so as to design pest management strategies.

Materials and methods

The whitefly diversity in major vegetable growing districts belongs to five agro climatic zones were surveyed *viz*., North Eastern Zone, North Western Zone, Western Zone, High Rainfall Zone and Southern zone of Tamil Nadu was explored. The samples were collected randomly in a zigzag manner from ten plants on 3 leaves representing of top, middle and bottom of canopy. The number of nymphs, pupae and adults per square centimeter leaf area was observed using a cm^2 paper window and averages were worked. The annual vegetable crops observed were of the age 40-60 days from planting/transplanting. Based on the population intensity, the Simpson diversity and distribution range were analyzed in Paleontological statistics software package (PAST) (Oyelade and Ayansola, 2015).

Results and Discussion

In the survey, seven species were identified *viz*., *Bemisia tabacci* (Gennadius), *Aleurothrixus(=Aleurotrachelus) trachoides* (Back), *Aleurodicus rugioperculatus* Martin, *Aleurodicus dispersus* Russell, *Paraleyrodes bondari* Peracchi, *Paraleyrodes minei* Iaccarino and *Aleurothrixus floccosus* (Maskell). T*he percentile distribution of Aleyrodidae in Tamil Nadu* is g*iven in Fig.1.All t*he seven species reported in the study *were distributed with 26 percentiles in Western Zone. Five species viz., B. tabaci, A. dispersus, A. trachoides, P. bondari and A. rugioperculatus in North Western Zone and two species viz., A. trachoides* and *A. rugioperculatus* were distributed within 16 percentiles in North Eastern Zone. Three species *viz*., *A. trachoides*, *B. tabaci* and *A. rugioperculatus* in High Rainfall Zone and *B. tabaci* in Southern Zone were distributed within 17 and 15 percentiles respectively. The Simpson Index of diversity of whitefly species in Tamil Nadu is given in Fig.2. The Western Zone had the highest diversity index of 0.8 with a distribution range of 3.5, followed by North Western Zone had the diversity index of 0.7 with a distribution range of 4.4. The diversity was less in following zones *viz*., High Rainfall Zone, North Eastern Zone and Southern Zone as 0.4, 0.3 and 0 with a distribution range of 4.5, 4.0 and 4.6 respectively.

Compared to all other factors, rainfall and temperature played a major role in the diversity and distribution of Aleyrodids (Oyelade and Ayansola, 2015). Irrespective of all other factors, when temperature is high, as is normally noticed in that zone, it influences the distribution of Aleyrodids in that zone, at the same time if rainfall is low in that particular zone it directly affect the diversity of species. Western Zone has the highest diversity index of 0.8 with a distribution range of 3.5 and is the result of combination of moderate rainfall with lowest temperature prevailing in that Western zone. The highest temperature prevailing in the Southern zone might have resulted in the highest distribution range (4.6) with the lowest diversity index (0) of Aleyrodids in that zone (Fig. 2).

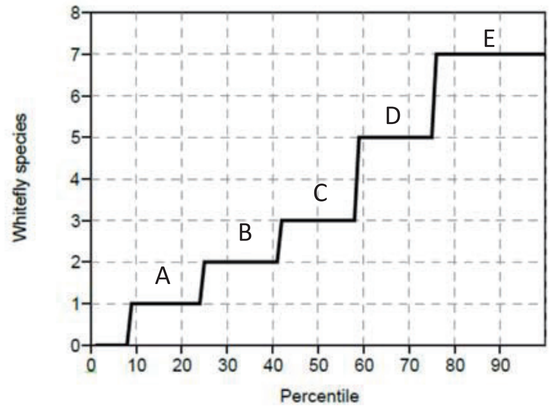

Fig 1: Percentile Distribution of Aleyrodidae species in Tamil Nadu

A –North East Zone; B –North West Zone;

C –South Zone; D –High Rainfall Zone;

E –West Zone

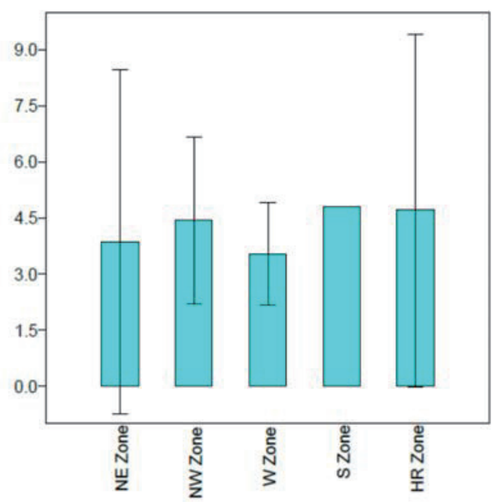

Fig 2: Diversity of whiteflies in Tamil Nadu

NE Zone –North East Zone; NW Zone –North West Zone; W Zone –West Zone; S Zone –South Zone; HR Zone –High Rainfall Zone

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Oyelade, O. J., and Ayansola, A. A. 2015. Diversity and distribution of whiteflies in south-western Nigeria. *African Crop Science Journal,* 23 (2), pp.135-149.

ES 01 OPS 01

Assessment of Land Use in Tamil Nadu, India through MaxEnt Modelling of Tussock Moths (Lymantriinae: Erebidae: Lepidoptera)

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Keywords: *Ecosystem, conservation, bio-indicator species, tussock moths, MaxEnt, Species D*istribution Modelling

Introduction

Degradation and restoration of land are complex processes that resonate climate change, its regulation, ecosystem service provision, for a harmonious and sustainable ecosystem functioning. This necessitates the urgent assessment of the well-being of the ecosystems. The assessment of presence or the absence of ubiquitous insects would be the most appropriate method to evaluate the land use and to extrapolate the required interventions for land restoration in places of degradation. Tussock moths (Lymantriinae: Erebidae: Lepidoptera), often a neglected group of moths in scientific research, prefer diverse and undisturbed ecosystems to thrive. With Maximum entropy (MaxEnt) a tool for Species Distribution *Model*ling (SDM) (Fand et al., 2014) the probable niche of 18 species of tussock moths was evaluated within the geographical limits of Tamil Nadu with special focus on the Western Ghats and Eastern Ghats regions of Tamil Nadu.

Materials and methods

The presence-only data of tussock moths were prepared based on the light trap collections from 54 locations of Tamil Nadu undertaken during 2017-2021. MaxEnt (version 3.4.4), an open-source software estimates species probability in a location with range between 0 (lowest) and 1 (highest) was utilized. The occurrence data was split into two for model training (75%) and validation (25%).

Results and Discussion

A total of 18 species from 12 genera under 5 tribes were collected in light trap collections, which constituted the occurrence data. The model fit as measured by AUC was 0.763 and 0.710 for training and test data respectively. Geographic regions having a probability threshold value of more than 0.77 indicate high suitability of tussock moth distribution, while range between 0.38 and 0.69 indicate moderately suitable (Phillips *et al*., 2006). The distribution model (Figure 1) indicated the presence of tussock moths was confined to the districts in Western Ghats regions of Tamil Nadu *viz.*, Coimbatore, Dindigul, Theni and Kanyakumari (areas at the foothills of Western Ghats) and those of Eastern Ghats regions *viz.*, Salem, Vellore and Tiruvannamalai (areas at the foothills of Eastern Ghats). Cauvery Delta zone (Central Tamil Nadu) is the least preferred region with most area under rice cultivation. Areas of northern Tamil Nadu comprising Krishnagiri, Dharmapuri, Salem, Vellore, Tiruvannamalai and Villupuram were moderately preferred. In the Nilgiris, there was a patch of poor probability corresponding to absence of vegetation which needs to be restored through afforestation.

References

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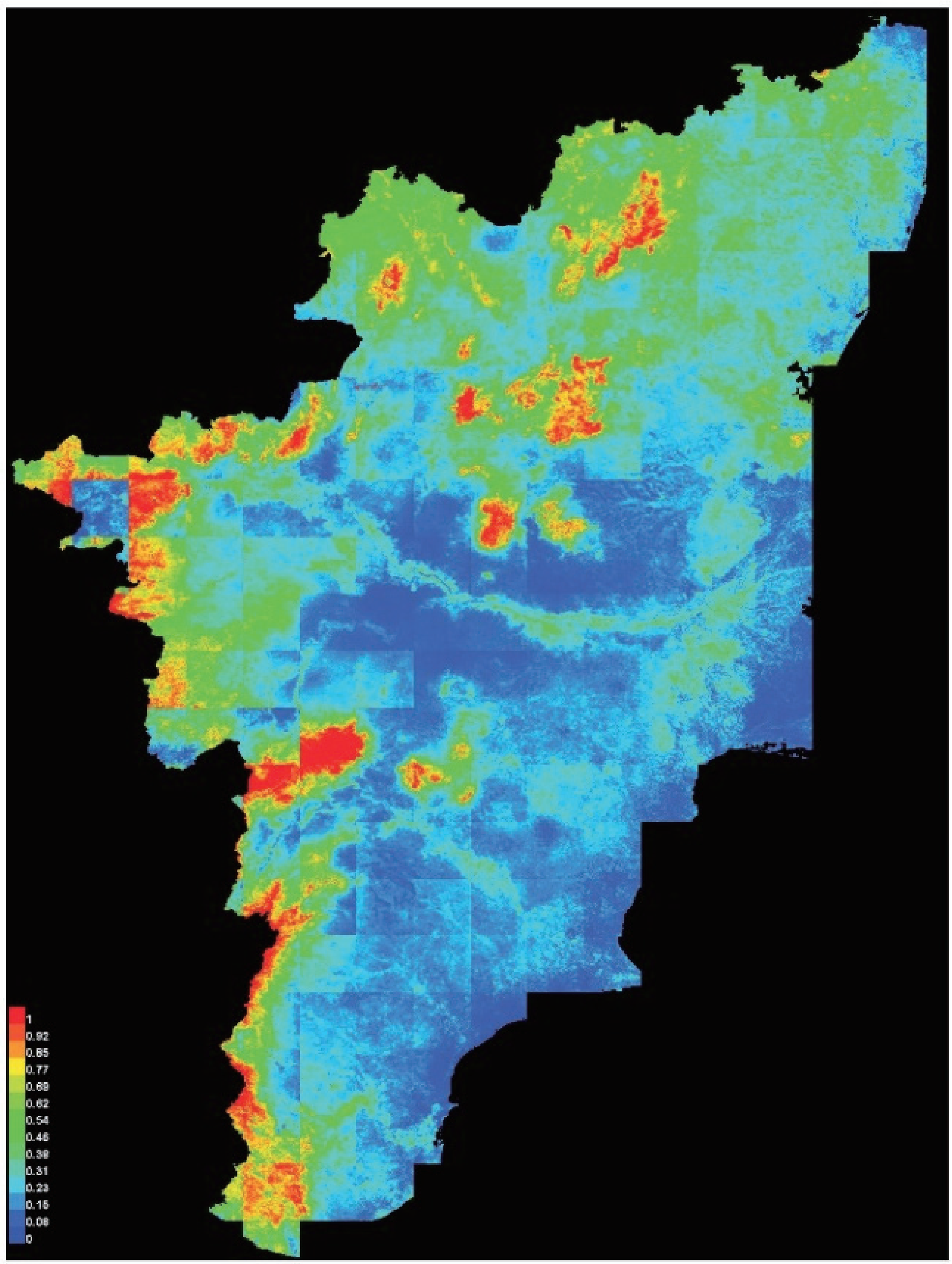
Phillips, S.J., Anderson, R.P. and Schapire, R.E. 2006. Maximum entropy modelling of species geographic distributions. *Ecological Modelling,* 190(3-4), pp.231-259.

Figure 1. Potential Geographic Habitat of Tussock Moths in Tamil Nadu



ES 01 OPS 02

Antennal Morphology and Sexual Dimorphism of the Ash weevil, *Myllocerus subfasciatus* Guerin-Meneville (Coleptera: Curculionidae)

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Key words: *Ash weevil, Myllocerus subfasciatus, sexual dimorphism, thoracic glands*

Introduction

Brinjal or aubergine is an important vegetable crop cultivated and consumed throughout India. Ash weevil, *Myllocerus subfasciatus* (Coleopera: Curculionidae) is an emerging major pest on brinjal and other horticultural crops. Under favourable conditions it has the potential to cause 100 per cent yield loss (Nair, 1975; Srinivasan *et al*., 2021). To explore semiochemicals as one of the strategies for management of ash weevils, *M. subfasciatus* and conducting subsequent chemical ecology experiments to identify semiochemicals, we studied scanning electron microscopic studies of antennal morphology and sexual dimorphism of both the sexes of *M. subfasciatus*.

Materials and methods

The insect was mounted onto the copper pin having a double-sided carbon adhesive tape and were examined with a scanning electron microscope (Hitachi Tabletop TM3030) at different magnifications. For measuring the different morphological characters of male and female adults, Images were captured with a stereomicroscope (Leica M2050). A total of 10 insects each (male and female) were measured for different parameters *viz*., length, width of body, head, thorax, abdomen, antenna etc., by using image analysis (Leica M2050). A total of 10 adult females and males are weighed and mean weight was calculated separately.

Results and Discussion

In M. subfasciatus, *antennal funicl*e articulates at an angle to the scape originating from the rostrum. The flagellum comprises of flagellomeres. There was no morphological difference in the antennal sensilla, setae, scales of male and female adults observed. The length of the antenna in females (1.75 ± 0.00) is slightly longer than males (1.04 ± 0.00) (Table. 1).

The size, length of body, width of body, thorax, antenna abdomen of females was significantly larger than males (P<0.0001). The weight of females (20-70mg) is double the weight of males (10-14mg). SEM images of thoracic glands of males have openings on the top whereas the females are lacking such openings. We observed clear difference in the cuticular hydrocarbons/secretions structures on the male and female abdominal sternites. No difference observed in the cuticular scales, abdominal openings in the last sternites.

Table 1. Morphological parameters of male and female ash weevil, *Myllocerus subfasciatus* (Mean and range n=10)

	Male				Female			
	Length (mm)	Range (mm)	Width (mm)	Range (mm)	Length (mm)	Range (mm)	width (mm)	Range (mm)
Body	3.161 ± 0.011	3.098 - 3.204	1.056 ± 0.00	1.02 - 1.08	4.586 ± 0.013	4.529 - 4.664	1.75 ± 0.00	1.67 - 1.78
Head	0.603 ± 0.00	0.54 - 0.661			0.73 ± 0.00	0.698 - 0.756		
Thorax	0.603 ± 0.00	0.601 - 0.611	0.887 ± 0.00	0.877 ± 0.898	0.654 ± 0.00	1.00 -1.089	1.054 ± 0.012	0.623 -0.666
Abdomen	2.35 ± 0.019	2.23 - 2.401	1.056 ± 0.00	1.02 - 1.08	3.05 ± 0.016	3.016 - 3.123	1.75 ± 0.00	1.67 - 1.78
Antennae	1.04 ± 0.00	1.03 - 1.04	-	-	1.75 ± 0.00	1.73 - 1.79	-	
Weight (mg)	12.1 ± 0.50 mg	10-14 mg	-	-	49 ± 4.81 mg	20-70 mg	-	-

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ES 01 OPS 03

Diversity of Mymarid Fauna in Forest and Horticultural Ecosystem

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Key words: *Mymarid fauna, diversity, forest and horticultural ecosystem*

Introduction

Fairyflies are small parasitic wasps. Mymaridae: Hymenoptera utilized for the classical biological control against insect pests such as Curculionidae, Chrysomeiidae, Cicadellidae and Delphacidae. Fairyflies diversity is yet to be ascertained and its fauna known. Classification of this fauna is in the elementary stage; their abundance and economic importance is yet to be understood. The present study has been undertaken to study the diversity of mymarids in forest ecosystems Thadiyankudisai, Dindigul and horticultural ecosystems of Periyakulam, Theni, India.

Materials and Methods

Mymarids were collected with yellow pan traps (Noyes, 1982). Yellow pan traps were emptied for every 48 hrs. The collected specimens were stored in 20 ml borosil glass vials containing 70% ethyl alcohol. Mymarids were examined under stereo zoom microscope for taxonomic details, identified up to generic level based on the keys provided of Subba Rao and Hayat (1983) and Lin *et al.* (2007), Rameshkumar (2011) and Rameshkumar *et al.* (2013). Mymarids collected were also subjected to Biodiversity calculator and the diversity indices (Shannon Weiner index) and Pielous evenness of mymarid fauna were calculated.

Results and Discussion

Mymarid fauna collected from forest ecosystem, consisted of 626 parasitoids represented by 16 genera. Among the various genera collected *Camptoptera* (53♀+25♂=78) was the most predominant genus followed by *Mymar* (22♀ + 52♂ =74), *Gonatocerus* (22♀ +40 ♂ =62), *Polynema* (24♀ + 35♂ =59), *Anaphes* (49), *Anagrus* (47), *Eofoerstria* (42), *Dicopus* (38), *Lymaenon* (32), *Cosmocomoidea* (32), *Erythmelus* (28), *Alaptus* (22), *Arescon* (18), *Stethynium* (17), *Palaeoneura* (16) and *Narayanella* (12).

The Mymarid parasitoids collected from horticultural ecosystems of Theni revealed the occurrence of total of 304 parasitoids, represented by 12 genera *viz*., *Erythmelus* (45) followed by *Anagrus* (43), *Arescon* (38), *Dicopomorpha* (30), *Camptoptera* (27), *Palaeoneura* (25), *Polynema* (24), *Mymar* (23), *Lymaenon* (17), *Alaptus* (17) and *Stethynium* (15). Nevertheless the genus *Erythmelus* was the most dominant taxa (24♀ +21♂= 45). The diversity indices (Shannon Weiner index) and Pielous evenness of mymarid fauna of Dindigul district were 2.63882:

2.32942 and 0.95175 and for Theni district were 2.42014: 1.90491 and 0.97393. Higher index value refers to higher diversity, forest ecosystem than horticultural ecosystem. Cultivation methods of horticultural ecosystem may have altered the mymarid diversity. Future research is required to documente the mymarid fauna in other agro ecosystems for their conservation.

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ES 01 BOPD 01

Coleoptera Diversity in Coffee Ecosystem in Thadiyankudisai, Tamil Nadu, India

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Key words: *Coleoptera, diversity, coffee ecosystem, relative abundance*

Introduction

Coleoptera, with about 400,000 species, is the largest insect order comprising 40 per cent of described insects and 25 per cent of all known animal life-forms. Beetle diversity in the coffee plantations of Thadiyankudisai in the Lower Palni Hills (a part of the Western Ghats in Tamil Nadu, India) was studied so as to assess the status of the insects as pests and as well as those to be conserved.

Materials and Methods

The coleopteran diversity in coffee ecosystem at Horticultural Research Station, Thadiyankudisai, Tamil Nadu, India was studied. Coffee was intercropped with star fruit, citrus, Indian cherry, water apple, guava, banana, avocado, silver oak, pepper, mandarin orange, macadamia nut, silk cotton and jack. Collection of beetles was undertaken during the morning hours from 8.00 to 10.00 am and evening hours from 4.30 to 07.00 pm at weekly intervals from 2017-2019 by manual collection, light trap collection, pit fall traps and sweep netting. Collected insects were transferred into polythene bags containing cotton dipped in chloroform (99.4%). Specimens were pinned and photographed**.** The coleopterans diversity was quantified for relative abundance and the indices of species richness (α) (Margalef, 1958), species diversity: Shannon-Wiener Index (H') (Shannon and Wiener, 1949) Simpson's Index Diversity (SID) (Simpson, 1949) and species evenness (EI) (Pielou, 1966) was calculated with biodiversity calculator (2021).

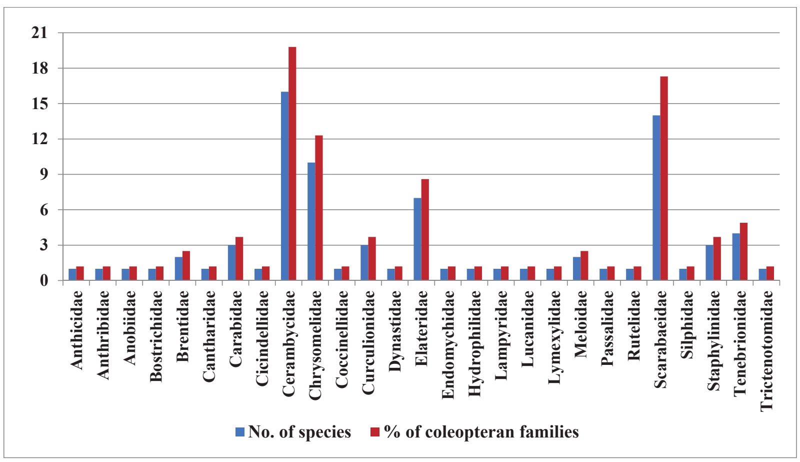
Results and Discussion

A total of 1,659 individuals of Coleoptera of 27 families, 79 genera and 81 species were collected in the coffee ecosystem at Horticultural Research Station, Thadiyankudisai, Dindigul, Tamil Nadu. Cerambycidae was the most specious family (16 species) followed by Scarabaeidae (14 species) and Chrysomelidae (10 species) (Fig.1). Margalef Index of Species Richness (12.38) and Shannon-Wiener Index of Dominance (3.78) was the highest during winter. Simpson Index of Diversity was the highest (0.96) during all the three season *viz.*, winter, summer and NEM. The species were evenly distributed during NEM with Pielou's Index of Evenness value of 0.91 (Table 1). Aland *et al.* (2012) reported a total of 152 species distributed over 101 genera belonging to 25 families of beetles were recorded and the Shannon-Weiner (2.29) and Simpson Diversity Indices (0.79) revealed rich diversity and abundance in the region of Amba Reserve Forest of the Western Ghats, Kolhapur. Detailed studies on the species –wise functional role and their population dynamics is further required for conservation purpose.

Table 1. Diversity indices of Coleoptera in coffee ecosystem at Thadiyankudisai

Season	Margalef Index (α) of species richness	Simpson's Index of Diversity (SID)	Shannon-Wiener Index (H')	Pielou's Index of Evenness (EI)
Winter	12.38	0.96	3.78	0.88
Summer	10.90	0.96	3.74	0.88
South West Monsoon	9.88	0.94	3.34	0.83
North East Monsoon	11.36	0.96	3.71	0.91

Figure. 1. Distribution of Coleopteran families in coffee ecosystem at Thadiyankudisai



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ES 01 BOPD 02

Molecular Diversity of *Nilaparvata lugens* (Stål) (Hemiptera: Delphacidae) from India

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Keywords: *Haplotype, mitochondrial, CO1, ITS1, nucleotide, population*

Introduction

Nilaparvata lugens (Stål) (Hemiptera: Delphacidae) is a major pest of rice causing significant yield losses (Pandi *et al.,* 2018). *N. lugens* cause damage by sucking the plant sap and producing a characteristic symptom called "hopper burn". Since rice is the main food source for humans and livestock, importance should be given on designing efficient management strategies against *N. lugens* (Pandi *et al.,* 2021). Hence, the present study was undertaken to assess the genetic variability parameters of *N. lugens* populations from different places in India to comprehend the correct management strategies.

Materials and Methods

The diversity in *N. lugens* populations was evaluated using mitochondrial cytochrome oxidase subunit I (COI) gene sequences from India, Bangladesh, China, and Japan. Genetic diversity indices like nucleotide diversity *(π)*, haplotype number *(H),* haplotype diversity *(Hd),* and the average number of nucleotide difference *(k)* of *N. lugens* populations were operated out with Dnasp ver. 6. Geographical relationship was described among haplotypes using NETWORK ver. 10.2. ARLEQUIN ver. 3.5 software was used for Analysis of Molecular Variance (AMOVA). The spatial analysis of molecular variance (SAMOVA) was performed using SAMOVA version 1.0. Tajimas' D and Fu's Fs were determined for neutrality and Dnasp was used to calculate the demographic history.

Results and Discussion

Genetic diversity analysis of the sequences revealed 47 haplotypes identified from all the studied populations of *N. lugens* from India. Range of genetic variability ranged from low to high level of genetic diversity amongst the Indian population. A significant negative correlation of demographic history of *N. lugens* population along with no significant sum of squared deviations indicated possible recent expansion of *N. lugens* with population expansion time of 1.9 million years. Additionally, the network reconstructed exhibited a star-like shape among haplotypes from India and other Asian countries denote population expansion (Fig. 1). The sharing of major haplotypes among China, Bangladesh and Indian populations analysis indicates recent gene mixing of *N. lugens* of the various populations. This is also in line with an interpretation that the *N. lugens* are highly migratory and gene flow is happening in the relatively recent past through migration (Hereward *et al.,* 2020). However, occurrence of unique haplotypes in Indian *N. lugens* population in the present study will be useful in monitoring the future inter-population movement across India. This is the maiden attempt to assess the molecular diversity of Indian populations in comparison to populations from other Asian countries.

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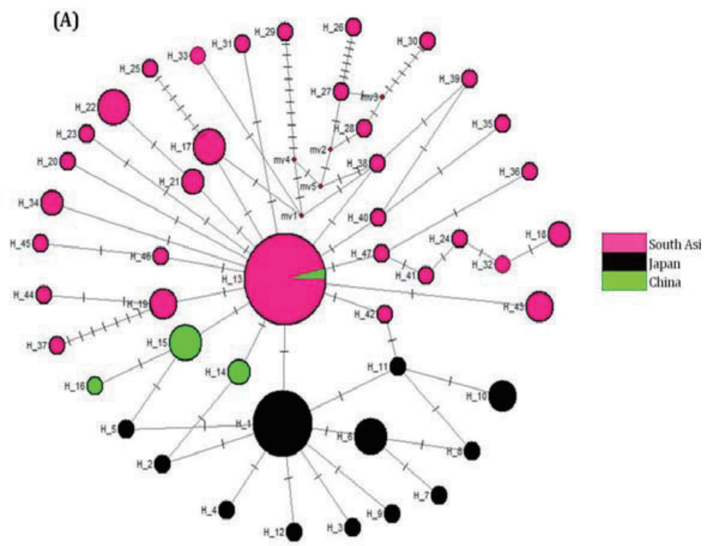
Figure 1. Median joining network of mtD NA haplotypes of *N. lugens.* **Haplotype network with the median- joining of grouped population (A)**



ES 01 BOPD 03

Diversity and Seasonal Abundance of Odonata in Coffee Ecosystem at Thadiyankudisai, Tamil Nadu

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Keywords: *Odonata, diversity, coffee ecosystem, seasonal abundance*

Introduction

Insects belonging to the order Odonata (Dragan flies and Damsel flies) have been studied from the perspective of ecological indicators, and many studies show that certain species exhibit high association with particular habitats (Smith *et al.,* 2007)**.** Indiscriminate usage of pesticides causes the loss of biodiversity of beneficial organisms. Recently, biodiversity in agricultural land has received growing attention (Dudley *et al.,* 2005).

Material and Methods

The present study was carried out to study at Horticultural Research Station, Thadiyankudisai. The area falls under Lower Pulney hills where coffee is intercropped with silver oak, pepper, avocado, mandarin orange, jack and banana. The research plot was allotted near northern region of Kodavan river and southern region of Thathampara canals, which the name usually has been called by the native people of Thadiyankudisai. Net sweeping (30 cm diameter of the hoop and collection bag length 60 cm) was carried out at weekly intervals randomly from five plots of size 10 m x 10 m between 10.00 h and 12.00 h. Collected insects were transferred into polythene bags containing cotton dipped in chloroform (99.4 %). while the other insects were placed on filter paper and sorted out. Photographed image was taken with a Canon camera. Identification was done based on the taxonomic keys of Fauna of British India (Fraser, 1936). Further expertise of Dr.K.A.Subramanian, Scientist of ZSI, Chennai for identification of Odonata. Identified collections were deposited at Tamil Nadu Agricultural University (TNAU), Insect Museum, Entomology, Coimbatore. The Odonata diversity was quantified with biodiversity calculator. https://www.alyoung.com/labs/biodiversity_calculator.html.

Result and Discussion

A total of 419 individuals under 4 families, 9 genera and 10 species of Odonata were recorded in the present study. Among the Odonata families, Libellulidae was speciose (6 species) followed by Chlorocyphidae (2 species), and Coenagrionidae, Euphaeidae (1 species). The dominance order of Odonata: *Pantala flavescens* (44.40%) > *Diplacodes trivialis* (22.70%) > *Orthetrum* sp. (7.40%) and rest of the fauna ranged from 6 to 29 numbers. *Pantala flavescens* was the maximum during NEM (50.00%) while *Diplacodes trivialis* (26.90%) in SWM and *Orthetrum* sp. (9.60%) in SWM (Table 1). The dominance of Libellulidae has been previously reported from other parts of the Western Ghats (Koparde *et al.,* 2015). Libellulidae occur commonly in the plains, semi evergreen forests, moist deciduous forests, coastal swamps (Subramanian *et al.,* 2008).

Table 1: Seasonal abundance of Odonata in coffee ecosystem at Thadiyankudisai

S.No	Family/ Scientific name	Seasonal abundance				Numerical abundance (Nos.)
		Winter	Summer	*SWM	NEM	
I	Aeshnidae					
1	*Anax indicus*	2	1	3	2	8
II	Chlorocyphidae					
2	*Heliocypha bisignata*	2	6	2	6	16
III	Coenagrionidae					
3	*Esme mudiensis*	3	2	1	5	11
IV	Euphaeidae					
4	*Euphaea dispar*	1	2	3	0	6
5	*Euphaea cardinalis*	3	3	4	3	13
V	Libellulidae					
6	*Brachythemis contaminata*	7	4	7	6	24
7	*Diplacodes trivialis*	19	21	28	27	95
8	*Hylaeothemis indica*	5	8	6	10	29
9	*Orthetrum chrysis*	8	7	10	6	31
10	*Pantala flavescens*	39	42	40	65	186
	Total	**89**	**96**	**104**	**130**	**419**

*SWM – South West Monsoon (Jun-Jul), NEM – North East Monsoon (Oct-Nov)

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ES 01 BOPD 04

Arthropod Diversity in Aonla under Arid Zone Farming Ecosystem from Tamil Nadu, India

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Keywords: *Shoot gall maker, stone borer,fruit midge,Chrysoperla, Lynx spider, potter wasp*

Introduction

Aonla or Indian Gooseberry, *Emblica officinalis* Gaertn. (Euphorbiaceae) the king of arid fruits is indigenous to India. Known for its great medicinal and nutritional value it is popular among farmers and consumers having immense potential of cultivation in arid and wastelands. Aonla fruit production is ravaged insects, diseases and some physiological problems. Approximately around 30 insect and mite species have been recorded on aonla (Thanlas *et al*., 2018). In light of the above said, the present study was aimed to document the arthropod diversity in major aonla growing areas in Tamil Nadu, India.

Materials and Methods

Documentation of arthropod diversity in aonla was carried out during 2016 and 2017 in the major aonla growing blocks (Reddiyapatti and Aruppukottai) of Virudunagar district, Tamil Nadu, India. Ten randomly selected plants were observed for the arthropods occurring on aonla. Herbivorous insect pests were categorized into major (persistent occurrence considerable numbers), minor (occasional occurrence in small numbers) and stray pests (scarce occurrence) while the carnivorous insects were categorized as predators and parasitoids.

Results and Discussion

Arthropods documented on aonla comprised 20 species under 20 genera belonging to 15 families of 10 orders. The most diverse was order Lepidoptera (7 species) followed by Hemiptera (3 species). Among the different functional group's herbivores were predominant with 15 species followed by carnivores with five species. Among the herbivores, four species *viz.*, *Schoutedonia emblica, Nipaecoccus vastatar, Caloptilia acidula, Betousa stylophora* were the major insect pests documented. Among the carnivores, *Cheilomenes sexmaculatus* and *Peucetia viridans* were observed to be occur almost persistently on aonla. Occurrence of these major insect species on aonla has been reported earlier (Sandeep and Gaur, 2015; Muthiah and Indiragandhi, 2021). More detailed studies on the natural enemies of these major pests need to be studied in the future.

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Table 01. Arthropod diversity of Aonla in arid zone ecosystem

SI.No.	Order/Family/Scientific Name	Functional Group	Status
A	Coleoptera		
I	Coccinellidae		
1	*Cheilomenes sexmaculatus*	Carnivore (Predator)	Major
II	Curculionidae		
2	*Curculio* sp.	Herbivore (Stone borer)	Stray
3	*Myllocerus discolor*	Herbivore (Defoliator)	Minor
B	Dictyoptera		
III	Termitidae		
4	*Odontotermes obesus*	Herbivore (Wood feeder)	Minor
C	Diptera		
IV	Cecidomyiidae		
5	*Clinodiplosis* sp.	Herbivore (Fruit feeder)	Stray
D	Hemiptera		
V	Aphididae		
6	*Schoutedonia emblica*	Herbivore (Sap feeder)	Major
VI	Membracidae		
7	*Tricentrus congestus*	Herbivore (Sap feeder)	Minor
VII	Pseudococcidae		
8	*Nipaecoccus vastatar*	Herbivore (Sap feeder)	Major
E	Hymenoptera		
VIII	Vespidae		
10	*Eumenes sp.*	Carnivore (Predator)	Minor
F	Lepidoptera		
IX	Cossidae		
11	*Indarbela quadrinotata*	Herbivore (Bark feeder)	Minor
X	Erebidae		
12	*Euproctis fratrena*	Herbivore (Defoliator)	Minor
XI	Gracillaridae		
13	*Caloptilia acidula*	Herbivore (leaf roller)	Major
14	*Phyllocnistis citrella*	Herbivore (leaf miner)	Stray
XII	Lycaenidae		
15	*Deudorix isocrates*	Herbivore	Major
XIII	Psychidae		
	Undetermined	Herbivore (twig bagworm)	Stray
	Thyrididae		
17	*Betousa stylophora*	Herbivore (twig gall maker)	Major
G	Neuroptera		
IV	Chrysopidae		
18	*Chrysoperla zastrowi sillemi*	Carnivore (Predator)	Minor
H	Araneae		
XV	Oxyopidae		
19	*Peucetia viridans*	Carnivore (Predator)	Major
20	*Oxyopus* sp.	Carnivore (Predator)	Minor

ES 01 BOPD 05

Blossom Midge *Contarinia maculipennis* Felt (Cecidomyiidae: Diptera) on *Dendrobium* spp. in Tamil Nadu, India

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Keywords: *Contarinia maculipennis, Orchids, Taxonomy*

Introduction

Orchid's production is mainly hampered by many insect pests. Among the insect pests collected, blossom midges severely infested orchids (Dendrobium spp.) in Thakkalai, Kanyakumari, India. Adults and larvae of the midge were collected and identified based on external morphology and DNA barcoding.

Materials and Methods

Taxonomical identification of blossom midge on orchids

Taxonomical identification and molecular confirmation of orchid blossom midge were carried out in the Department of Agricultural Entomology, Agricultural College and Research Institute, Killikulam, Thoothukudi. Flower buds showing the infestation or damage symptoms were brought to the laboratory and different life stages were mounted on slides using Canada balsam as medium and observed for taxonomical characters following keys of Felt (1933) under stereo zoom microscope (Model: Magnus MLX® microscope,ZENITH, India). Further, DNA barcode was done by Gem-CTAB method (Rouhibakhsh et al., 2008). The mitochondrial DNA homology was performed using the BLAST program searched in the database of National Center for Biotechnology Information (NCBI), USA. Further, the identity based on morphological characters was also confirmed by Dr. Kumar Ghorpade, University of Agricultural Sciences, Dharwad.

Results and Discussion

Adults had moniliform antennae with whorl hairs nearly twice the length of the body was observed. Antennal length in male midges measured three fourth of the body. Reddish brown mesonotum with black head present. Wings distinctly sub hyaline and abdomen yellowish brown in colour. In DNA homology analysis, the sequence of COI region of mitochondrial DNA of the specimen showed 100 per cent identity with COI region of mitochondrial DNA of C. maculipennis. The identification methods are in line with Uechi et al. (2007).Blossom midge, Contarinia maculipennis is a polyphagous pest that causes severe damage by infesting the blossoms of orchids. This is the first report of Contarinia maculipennis causing significant damage in a commercial orchids production industry in Tamil Nadu. Research on the population dynamics and appropriate management measures for the management of Contarinia maculipennis is necessarily required.

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ES 01 BOPD 06

Ladybird Beetle Species Complex on Major Tropical Fruits in Tirunelveli, India

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Keywords: *Coccinellids, species complex, tropical fruits*

Introduction

Coccinellid beetles are well known predators of injurious insects like aphids, scales, mealybugs and also on phytophagous mites. In the recent past, emergence of new insect species on indigenous crops necessitates the need to study the indigenous natural enemies. The exploitation of indigenous coccinellids as a biocontrol agent on tropical food crops appears prospective. This study aimed to assess species complex of coccinellids on major tropical fruits in Tirunelveli, Tamil Nadu, India.

Materials and Methods

An extensive documentation was made on the diversity of coccinellids on different fruit crops viz., guava, mango, citrus and pomegranate in Tirunelveli district of Tamil Nadu, India during 2005 - 2007. Coccinellid beetles were collected by manually. In addition direct counts of predators were made for population assessment (nos/tree), with prey density (nos/cm of a shoot). The dominant species of aphidophagous and coccidophagous coccinellids were identified. Mealybugs and aphid species were identified by following the keys given by Williams and Watson (1988) and Bei-Bienko (1967) respectively.

Results and Discussion

The coccinellid species complex comprised six species viz., *Cheilomenes sexmaculatus, Chilocorus melas, Cryptolaemus montrouzieri, Scymnus coccivora, S. latemaculatus* and *S. nubilus* (Table. 1). Among the coccinellid species the abundance of *C. montrouzieri* was observed to be the maximum (16 nos/tree) while that of *S. nubilus* was the least (2 nos/tree) documented species. *C. montrouzieri* exhibited a wider prey range viz., *Toxoptera citricidus, Aphis gossypii* and *Rastrococcus iceryoides. S. nubilus* was documented only on *Ferrisia virgata* feeding on pomegranate. However, *C. sexmaculatus* had a wider host range than *C. montrouzieri* with an additional host of *Ferrisia virgata* with the other hosts of *C. montrouzieri*. Among the prey insects of the coccinellids, *A.gossypii* was predominant (35 nos/cm/shoot) followed by *Planococcus lilacinus* (31 nos/cm/shoot) on guava. Among the three study sites, Kadayanallur block had the maximum number of species. Subramanian (1924) listed coccinellids of South India which included *C. montrouzieri, S. coccivora* and *C. sexmaculatus* along with the description of hosts. *C. montrouzieri, S. coccivora* and *C. sexmaculatus* were the dominant coccinellids and the use of these predators may be further exploited in the biocontrol for the management of mealybugs in fruit crops.

Table 1. Status of coccinellids and its prey in various fruit crops in different blocks of Tirunelveli district

Place	Tree	Prey	Prey density* (Nos/cm/shoot)	Species	Predator density (Nos/tree)
1. Kadayanallur block					
i. Idaikal	Mango	*Rastrococcus iceryoides*	18.0	*Cheilomenes sexmaculatus*	4.0

	Guava	*Aphis gossypii*	30.0	*C. sexmaculatus*	2.0
	Mango	*R. iceryoides*	23.0	*Scymnus coccivora*	3.0
				C. sexmaculatus	5.0
ii. Velayuthapuram	Citrus	*Toxoptera citricidus*	18.0	*Cryptolaemus montrouzieri*	13.0
	Pomegranate	*Ferrisia virgata*	22.0	*S. nubilus*	2.0
iii. Mangalapuram	Citrus	*Planococcus citri*	3.0	*C. sexmaculatus*	1.0
2. Sivagiri block					
i. Puliangudi	Citrus	*T. aurantii*	28.0	*C. sexmaculatus*	2.0
		P. citri	16.0	*S. coccivora*	7.0
ii. Vasudevanallur	Mango	*R. iceryoides*	12.0	*C. montrouzieri*	7.0
iii. Cinthamani	Guava	*P. lilacinus*	31.0	*S. latemaculatus*	8.0
	Pomegranate	*F. virgata*	15.0	*C. sexmaculatus*	5.0
3. Tenkasi block					
i. Ayikudi	Guava	*A. gossypii*	25.0	*C. montrouzieri*	16.0
				S. coccivora	2.0
ii. Vallam	Mango	*T. odinae*	12.0	*Chilocorus melas*	3.0
iii. Illanji	Guava	*A. gossypii*	35.0	*S. coccivora*	1.0

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ES 01 BOPD 07

Thrips Species Complex in Cotton from India

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Keywords: *Cotton, Scirtothrips dorsalis, Thrips palmi and Thrips tabaci*

Introduction

Cotton plant is ravaged by multitude of sucking pests and there is a constant change in the pest scenario in cotton. Among the sucking pests, the increased incidence and prolonged appearance of thrips cause of concern recently (Monga, 2021). Thrips being with high reproductive capacity, short generation time, high survival of cryptic instars, parthenogenetic reproduction and development of resistance to insecticides, at emerged as a major pest of cotton in many cotton growing regions of India (Diaz Montano et al., 2011). The present investigation was undertaken to study the diversity of the thrips fauna on cotton at Coimbatore, Tamil Nadu, India.

Materials and Methods

Ten cotton plants were randomly selected for sampling. Thrips samples were collected by beating the foliage and tapping flowers collected thrips were transferred in vials containing thrips preservative media (9 parts 10% alcohol + 1part glacial acetic acid + 1 ml Triton X-100 in 1000 ml of the mixture). The vials were labeled with host name, location and collection date for identification. Specimens were send to ICAR-National Bureau of Agricultural Insect Resources (ICAR-NBAIR), Bengaluru, Karnataka, India for identification with voucher specimens deposition.

Results and Discussion

Seven thrips species were recorded on cotton. Three thrips species, viz. *Scirtothrips dorsalis Hood, Thrips palmi* Karny and *Thrips tabaci* Lindeman were identified on leaves and four species, viz. *Thrips florum* Schmutz, *Thrips hawaiiensis* (Morgan), *Frankliniella schultzei* (Trybom) and *Thrips parvispinus* (Karny) were recorded on flowers. Among the thrips recorded *Thrips parvispinus* has been designated as one of the notorious pests on numerous agricultural and horticultural crops of South East Asia, and is of quarantine importance. This is the first record of *T. parvispinus* on cotton in India. *F. schultzei, S. dorsalis, T. palmi* and *T. tabaci* are notorious pests as well as vectors of plant viruses. Since these species may attain major pest status, this study necessitates regular monitoring on cotton. This study provides the status of diverse thrips species present on cotton. Based on the dominance of thrips species, pest management practices need to be formulated.

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ES 01 BOPD 08

Arthropod Diversity in Tobacco from a Pest Management Perspective

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Keywords: *Arthropods, diversity, tobacco, IPM, shannon index*

Introduction

Arthropods are important indicators of environmental change and their multitudinal services are termed Arthropod-Mediated Ecosystem Services (AMES) (Suheriyanto et al., 2016). Soil organisms, predominantly, arthropods contribute to soil productivity and fertility in natural and agricultural ecosystems. They transform organic matter in terrestrial ecosystems and hence aid in production of healthy plants. Most soil fauna occur in the surface layer because this layer contains carbon and other nutrients in the form of organic matter (Ruiz and Lavelle, 2008). Flue Cured Virginia (FCV) tobacco is a high valued commercial crop cultivated very scientifically for producing the so-called golden leaf. Protection of vegetative parts requires regular surveillance and need based pesticide applications. However, farmers resort to indiscriminate pesticide applications in order to fetch blemish-free leaf and good returns. In such a scenario, studying the soil arthropod fauna is very essential to understand the natural pest management offered by them and to measure the loss of biodiversity.

Materials and Methods

The experiment was conducted during 2019-20 in rabi at Indian Council Agricultural Reasearch- Central Tobacco Research Institute, Black soil farm, Katheru, Rajahmundry, India. Pitfall traps were employed 20 m apart to collect nocturnal and surface-dwelling arthropods. Soil arthropods were sampled every ten days during the crop season in various pest management modules. Some of the most common arthropods were recorded up to morphospecies and some were sent for identification to taxonomists. Arthropod species composition and biodiversity indices were calculated. Biodiversity indices were computed to compare the diversity and distribution of arthropods using the software PAST version 4.03.

Results and Discussion

During the cropping season, about 1,072 soil arthropods were collected through pitfall traps. Fig 1 shows the arthropods collected under different management modules starting from the outer whorl inwards– sole tobacco, IPM, jowar barrier, chemical, bio-intensive, chickpea and cowpea intercropping. The highest number of arthropods was collected in cowpea, chickpea intercropping and IPM modules. Cowpea and chickpea intercropping modules have the highest number of arthropods followed by IPM that has significantly higher diversity (> 180) than other treatments. It is followed by botanical (98), control (98) and chemical modules (97). Jowar border treatment had least number of soil arthropods (74), albeit carrying numerous foliar insects and natural enemies. Biodiversity indices are presented in the Table 1. IPM had the highest number of species (13), Shannon Weiner index (2.04), Simpson (0.82) and evenness indices (0.59). Shannon index is also better for cowpea (1.76) and chickpea (1.75). Simpson index is better in chickpea (0.77) and cowpea (0.76) after IPM. Evenness was higher in the case of IPM and Jowar barrier modules (0.59 each), cowpea (0.53) and chickpea intercropping modules (0.52). Hence adoption of Integrated Pest Management can maintain a stable agro-ecosystem.

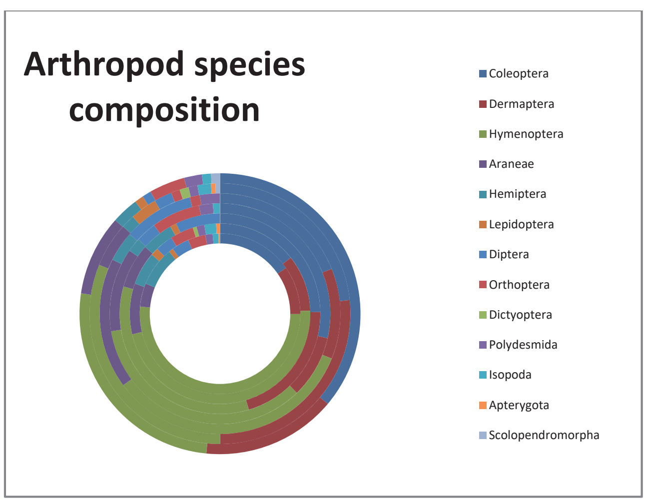

Fig 1. Arthropod species composition of tobacco under various pest management modules

Table 1. Arthropod diversity indices of tobacco

Module	IPM	Cowpea	Chickpea	Bio-intensive	Sole Tobacco (Control)	Jowar barrier	Chemical
No. of Species (S)	13	11	11	10	10	8	7
ShannonWeiner (H') Index	2.04	1.76	1.75	1.56	1.56	1.56	1.18
Simpson's Index	0.82	0.76	0.77	0.68	0.68	0.74	0.55
Evenness Index	0.59	0.53	0.52	0.47	0.47	0.59	0.46

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ES 01 BOPD 09

Pest Succession and Documentation of Insect Pests and Natural Enemy Fauna in Maize Ecosystem, Post Fall Armyworm (*Spodoptera frugiperda* (JE Smith) Noctuidea: Lepidoptera) Invasion

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Keywords: *Insect pests, natural enemies, succession, post- fall armyworm infestation, maize*

Introduction

Maize Fall Armyworm (FAW) a native pest of America invaded South Africa in 2016 (Goergen et al., 2016) and India in June 2018. Since then, the pest has spread to all the maize growing districts of Tamil Nadu with an estimated loss of 60-70 per cent. The pest has been spotted on crops other than maize like rice, barnyard millet, cabbage, pearl millet, etc. since spotting the first infestation in maize (GoTN FAW Annual Report, 2021). Maize did not pose serious impediments in terms of insect pests pre-FAW infestation, barring mostly the stem borer and shootfly. There seems to be a wide shift in the pest and natural enemy fauna since infestation by FAW which needs thorough documentation.

Materials and Methods

Field trials were laid out between 2019-21 at Department of Millets, and Eastern block, Tamil Nadu Agricultural University, Coimbatore. Approximately 1000 m2 field was maintained with maize hybrid (Co8) without any insecticidal sprays. Faunistic diversity including insect pests and natural enemy fauna were continuously recorded at weekly intervals from first week after emergence until harvest of the crop by manual collection and net sweeps (20 nos) during early morning hours throughout the study period. Sampling was taken at five different points (four different corners and one in centre) representing the whole field (Pineda et al., 2012).

Results and Discussion

Weekly observations on the insect pests and natural enemy fauna revealed that FAW has become the dominant pest in the maize ecosystem since its invasion. Regular pests on maize viz., stem borer (*Chilo partellus*) and shoot fly (*Atherigona orientalis*) has declined after FAW invasion (Fig 1). FAW, *Spodoptera frugiperda* damage started between 9-12 days after germination (DAE) with less than 5 per cent whorl damage and a leaf injury rating in the range of 2.0 – 3.0. Damage by FAW was severe up to 45-50 days and then, the damage reduced when the plants have attained tasseling stage. The tassel damage was in the range of 7.14 – 20.0 per cent. At the time of harvest, the ear and kernel damage varied between 1.0 to 5.0 with relatively lesser infestation (less than 24 %). During early vegetative stage (up to 35 DAE), an array of parasitoids were also noticed viz., *Chelonus* sp., *Goniozus* sp., *Trathala* sp. etc. besides predators like *Geocoris* sp. and earwigs (undetermined) which had contributed for increased larval parasitism and predation of FAW. *Paederus* sp. a generalist predator was also found to move actively inside the whorls at 7-8 per whorl in some plants during early vegetative stage.

Chilo partellus incidence was noticed to an extent of only 5 per cent during 60-70 day old crop in the tassels and later in the silks of the developing cobs. Minor infestation by *C. partellus* was also recorded in the tassels. During cob formation stage, the carabid predators actively fed FAW larva. The cob was also infested by *C. partellus* to a feeble extent and hairy caterpillar, *Somena scintillans* (3-5 / cob) in one of the farmers' fields. Nonetheless, since invasion of FAW, the regular maize pests (pre-FAW situtaion) have been observed in reduced proportions. Similar replacement of *C. partellus* and *Sesamia inferens* was reported by Divya et al. (2021).

Fig 1. Depiction of pest/ natural enemy succession and intensity

Pests / Natural enemies	Week after emergence													
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
Hoppers 1			*					*							
Fruitfly 2	*					*									
Pyrilla 2	*					*									
Flea beetle 1	*	*													
FAW 1		**	***	***	***	***	***	**							
Psyllid 1		*													
Menochilus 3			*	*				*	*	*	*				
Trathala 3			*	*	*	*									
Chelonus 3			***	***	***										
Ropalidia 3				*	*	*	*								
Goniozus 3				**	***										
Geocoris 3				*	*										
Marasmia 1					*										
Paederus 3					***	***	***								
Carabids 3					*									*	*
Cockroach 3					*	*									
Cyrtorhinus 2						*									
Aleurodicus 1						*		*					*	*	*
Chilo 1							*	*			*	*			
Aphids 1								**	**	**	**	**			
Cryptolaemus 3								*	*	*	*	*			
Encarsia 3								*					*	*	*

Functional roles assigned as 1, 2, 3 where 1 = Insect pests 2 = Predators/ parasitoids; 3 = scavengers
Shaded cells represent the presence of concerned species
Number of stars inside shade represents the intensity of the pest/ natural enemy

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ES 01 BOPD 10

Endophallus of Male Genitalia as a Taxonomic Tool in Differentiating the Species of *Batocera* Dejean (Cerambycidae: Lamiinae) from South India

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Keywords: *Insect taxonomy, coleoptera, species delimitation, borer pests*

Introduction

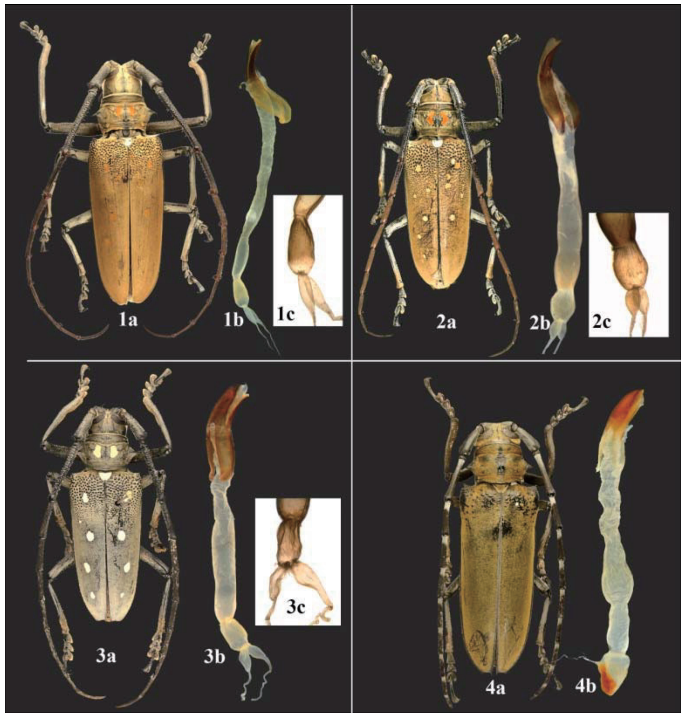
Genus *Batocera* Dejean, is an economically important group in the subfamily Lamiinae (Coleoptera: Cerambycidae). The species of *Batocera* are widely considered as pests of forest and horticultural ecosystem. Among them, *Batocera rufomaculata* (Degeer) is a serious pest of mango in the South Asian countries. In India, the genus Batocera is represented by 12 species, of which, four species viz., *B. numitor* Newman, *B. parryi* (Hope), *B. rubus* (Linné) and *B. rufomaculata* (Degeer) occurs in south India. Historically, members of Cerambycidae are differentiated mostly based on the morphological characters; however, of late, usefulness of endophallus of male genitalia has been elucidated to define tribal, generic and species boundaries in several groups of longhorned beetles (Danilevsky et al., 2005; Yamasako and Ohbayashi, 2011; Bi and Lin, 2014; Hiremath, 2018). In the present study, three species of Batocera occurring in South India viz., *B. numitor, B. parryi* and *B. rufomaculata* are differentiated based on the characters of endophallus of male genitalia. Besides, endophallus of the genus Batocera is also compared with its closely allied genus, *Apriona chevrolat*. Endophallus of all the included species are copiously illustrated with notes on the differences between them.

Materials and Methods

The present study is based on three species of Batocera viz., *B. numitor, B. parryi* and *B. rufomaculata* (De Geer) collected from various locations of South India. The dissection of male genitalia and inflation of endophallus without eversion follows methodology adopted in Hiremath (2018). The study was undertaken at Department of Agricultural Entomology, Kerala Agricultural University, Vellayani, Kerala, India. The following abbreviations are used for endophallic structures: BPH—basal phallomere; MPH—median phallomere; APH—apical phallomere; CS—crescent shaped sclerites; MT—medial tube; CT—central trunk; PB— preapical bulb; ED—Ejaculatory duct.

Results and Discussion

The present study reveals that, the genus *Batocera* can be defined based on the following characters of endophallus: Endophallus with APH 0.09-0.11 times as long as endophallus, with its apex bearing paired, elongated appendices; ED paired, distinctly elongate, narrow tubes, originating independently from apex of each appendices of APH. The genus *Batocera* is closely allied to *Apriona,* however, both of them can be differentiated based on the following characters of endophallus: APH with its apex bearing paired elongated appendices in Batocera (APH without apical appendices in Apriona); ED paired, originate independently from the apex of each appendices of APH in Batocera (ED paired, originate as a short tube adpressed to the dorsal wall of APH, and then continued as two distinct narrow tubes in Apriona). Among the three species studied here, *B. numitor* is closely allied to *B. rufomaculata* and it can be differentiated based on the following characters of endophallus: APH is pear-shaped, bearing a pair of spindle-shaped appendices in *B. numitor* (APH is oval-shaped, bearing a pair of stout, oval-shaped appendices in *B. rufomaculata*). While, *B. parryi* has cylindrical APH, bearing a pair of elongate, pear-shaped appendices. Present study elucidates the importance of endophallus in defining generic and species boundaries. Detailed illustrations provided here will be a handy tool for economic entomologists and other stake holders in correctly identifying the above discussed south Indian species of Batocera. This is the first report on detailed study of endophallus of the members of Batocera genus. A thorough study of endophallus across the Batocerini tribe will be useful to update its current status in the subfamily Lamiinae.



Figs. 1-3. Species of *Batocera*, 1a-c. *Batocera numitor*, 1a. Habitus, 1b. Endophallus, 1c. Close up of APH. 2a-c. *Batocera rufomaculata*, 2a. Habitus, 2b. Endophallus, 2c. Close up of APH. 3a-c. *Batocera parryi*, 3a. Habitus, 3b. Endophallus, 3c. Close up of APH. Fig. 4a-b. *Apriona trilineata*, 4a. Habitus, 4b. Endophallus

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ES 01 BOPD 11

A New Canestriniid Mite, *Bircericola oryctae* sp. nov. (Acari: Canestriniidae), Phoretic on *Oryctes rhinoceros* (L.) (Scarabaeidae: Coleoptera) from Tamil Nadu, India

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Keywords: *Phoresy, Oryctes rhinoceros, Idiosoma, Solenidia, elytra*

Introduction

Astigmatid mites are interspecific relationships with vertebrates and invertebrates for its survival and its transportation. Solarz *et al*. (2004) observed astigmatid mites caused damages to the food grains and disseminate dermatitis and allergic rhinitis diseases. The family Pygmephoridae, species of genus *Uropodina* and *Macrocheles* possess specialized structure for phoresy *i.e*., anal pedicel, modified first leg and specialized tooth in chelicera, respectively. The present study has been carried out to describe mites phoretic on the elytra of rhinoceros beetle.

Materials and Methods

Phoretic mites on rhinoceros beetles, *Oryctes rhinoceros* L (Scarabaeidae: Coleoptera) were collected from various places of Tamil Nadu. In addition, some of the preserved insect specimens in the Department of Agricultural Entomology at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Madurai, Trichy; Horticultural College and Research Institute, Periyakulam and Forest College and Research Institute, Mettupalayam were also examined for the presence of these mites. Both live and dead insect specimens were used for examining the presence of mites. The terminology of the structures and setal notation is based on Haitlinger (1994).

Results and Discussion

Male dorsum: Body flattened, idiosoma 485 length and 290 widths. Dorsum with uniform fine reticulate pattern all over the body; 13 pairs of setae are present, out of which 6 setae are long. SCe=230; SCi=20; d_1=d_4 =45 and vs=e_1=e_2=40; e_3=300; d_2=280; d_3=80; d_5=90; d_6=70; d_7=65. Venter: Gnathosoma 85 long and 58 wide. Venter with faint reticulations, genito anal region wrinkled. The genital shield 95 long with two pairs of apodemes and five pairs of simple stout setae (20). Four pairs of ventral setae are present measuring 20-25 long. One pair of long setae (285) arises posterior end of idiosoma. Legs: Leg I to IV with a broad pretarsal claw and condylophore. Legs I to IV measures 184, 154, 214 and 230, respectively. Leg I to IV, with one tarsal setae each considerably very long and whip like, measuring 43, 61, 105 and 106, respectively. Leg chaetotaxy: Trochanter, 1-1-2-0; femora, 1-1-0-0; genua, 3-3-1-0; tibiae, 1-1-1-1 and tarsi, 8-6-3-4. Types: A holotype male marked on slide and two paratype slides, INDIA: Tamil Nadu, Coimbatore, 14.VII.2006. Eg: *Oryctes rhinoceros* (L.) (Scarabaeidae: Coleoptera), Coll. V. Radhakrishnan, (No: 245/6).

Orange coloured mites described as Bercericola oryctae sp. nov. were found beneath the elytra and tegmen of the adult rhinoceros beetles. This new species resembles *Bircericola bertrami* Haitlinger (2000) in its general appearance, but differs by the absence of leg solenedion character. Solenidion is present in *B. bertrami*, where as this new species is devoid of solenedion. Dorsum of idiosoma with 13 pairs of setae is similar to the *Bircericola bertrami* (Haitlinger, 2000). Haitlinger (1990) reported that, Canestriniid species associated with various host in many other countries *viz*., Cyprus, Congo, China, Brazil, Australia, Uganda, Morocco, Italy, Ghana, Cameroon, Venezuela and Madagascar. In India, *Bircericola* genera is reported first time in rhinoceros beetle in our study. Moreover, the general information about the *Bircericola* is also scanty.

The new species differs the following features as against *Bircericola bertrami* (Haitlinger, 2000) and *Bircericola oryctae*.

Bircericola bertrami **n. g., n. sp.**	***Bircericola oryctae*** **sp. nov.**
Setae d2 short	Setae d2 long
Tarsus I with 8 setae and two solenidia	Tarsi I 8 setae without solenidia
Tarsus II with only 6 setae	Tarsi II only 5 setae
Tarsi III and IV both with only 4 setae	Tarsi III & IV with 3 & 4 setae, respectively

Etymology: The mite species is named after the type host genus.

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ES 01 BOPD 12

Incidence of Wood Boring Bostrychid Beetles in Different Wood Yards at Mettupalayam

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Keywords: *Bostrychids, wood boring, beetles, abundance*

Introduction

Bostrychid beetles have a world-wide distribution but are mainly found in tropical and arid areas. New geographical records continue to be added from all over the world (Liu 2010). One of the most characteristic signs of infestation are the exit holes created by the adults at emergence which are perfectly circular with varying diameters depending on the wood-boring species (Herald et al 2009). Damage is typically caused by the boring activity of larvae and adult beetles in the stems, branches and twigs of dead, and damaged or stressed hosts (Halperin and Geis 1999; Liu *et al.,* 2008). Tunneling through the host tissues leads to extensive frass-filled galleries (El Obied, 1998; Beaver *et al*., 2011). It is because of the ability of the larvae and some adults to reduce wood into a powdery frass that the beetles are of considerable economic importance to forestry and the wood-using industries, especially in countries within the tropics (Liu *et al.,* 2008; Beaver *et al.,* 2011).

Materials and Methods

The study was conducted at Forest College and Research Institute, Mettupalayam, India to assess the seasonal incidence of wood boring bostrychid beetles on different wood. Five wood depots located at Mettupalayam were selected and infested wood samples of economically important woods *viz.,* silver oak, teak, neem, eucalyptus and rose wood were collected. The wood samples were cut into pieces each measuring 20 cm and placed in clear plastic containers. They were kept in the laboratory at temperatures of 26 ± 1°C, 60 ± 10 % relative humidity (RH) for 6 months for emergence of positively phototropic beetles as described by Sittichaya and Beaver (2009). Emerging adult beetles were handpicked with forceps, placed in killing jar with ethyl acetate. The specimens were curated and identified.

Results

Wood boring beetles were identified as *Dinoderus* sp; *Lyctus* sp., *Scolytus* sp. and *Sinoxylon* sp. (Coleoptera: Bostrychidae). Wood boring beetles recovered from wood depots were dominated by the family bostrichidae ranging from 65.00 to 74.66 per cent of the total abundance. *Sinoxylon sp.* (Coleoptera: Bostrychidae) was the dominant species with 349 beetles accounting for 76.70 per cent of the total abundance, followed by *Lyctus* sp. (19.78%), *Dinoderus sp.* (2.19%) and *Scolytus sp.* (1.31%) (Table 2). Wood-damaging *Sinoxylon* spp. are commonly found in tropical areas, especially in the arid regions, where they damage a wide range of soft and hardwoods (Bushara 1981). More intensive studies required to determine the identity of the undetermined wood boring beetles to take up appropriate control measures.

Table 1. Percent contribution of the family bostrychidae recovered from wood depots at Mettupalayam

Study site	Beetles collected	Bostrychidae	Percent Contribution
M/s. Sajeena Timber, Kothakiri road, Mettupalayam	120	78	65.00
M/s. Sudharsan Timber, Annur road, Mettupalayam	90	65	72.20
M/s. Gayathiri Timber, Odonthurai, Mettupalayam	110	78	70.90
M/S. Alim Timber, Ooty Road, Mettupalayam	60	42	70.00
M/s. Vijay sawmill, Kothagiri Road, Mettupalayam	75	56	74.66

Table 2. Wood boring beetles recovered from wood depot between September, 2019 to February, 2020

Insect species	No. of beetles	Percent (%)
Sinoxylon sp.	349	76.70
Lyctus sp.	90	19.78
Dinoderus sp.	10	2.19
Scolytus sp.	06	1.31

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ES 01 BOPS 01

Madursia undulatovittata (Galerucinae:Chrysomelidae:Coleoptera) a Potential Herbivore in Pulse Ecosystem

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Keywords: *Madurasia, pulses, adult taxonomy, economic pest.*

Introduction

Madurasia (Galeruciane) is a monotypic genus described by Jacoby in 1886 with *M. obscurella* as type species and South India as type locality. Prathapan (2016) had designated a new combination as *M. undulatovittata* for *M. obscurella*. *M. undulatovittata* is one of the important insect pests in pulse ecosystem infesting potential damage from seedling to flowering stage. To assess the occurrence of species complex of *Madurasia*, if any, this study was taken to characterize the *Madurasia* spp. in pulse ecosystem of Tamil Nadu.

Materials and Methods

Insect collection was done from pulse crops in different pulse growing regions of Tamil Nadu, India. Specimens were collected with aspirator and sweep netting. The specimens were curated and studied for morphological and genetalia characters at Insect Biosystematics Lab, Tamil Nadu Agricultural University (TNAU), Coimbatore. Identification was done based on Maulik (1936) and Prathapan (2016). The identified insects were deposited in the TNAU Insect Museum. Host plants and degree of damage was recorded. Species Occurrence Index (SOI) was also calculated for the different study locations.

Results and discussion

Adult body colour is dirty brown. Head black in colour. Prothorax and ventral side of body is darker brown; Blackish, obscure stripe is found in both elytra; antenna piceous, and the basal two or three segments somewhat lighter. Head with vertex impunctate; area between the scape of two antennae and the labrum are roughly punctate and bear long hairs. Eyes are strongly convex. First segment of antenna three times as long as the second; third and second are subequal; fourth slightly longer than third; fifth slightly shorter than fourth; sixth nearly equal to fifth; seventh to eleventh equal; last bluntly pointed. Prothorax with the upper surface uniformly convex and closely punctate. Scutellum is smooth surfaced with the apex rounded. Elytra closely and confusedly punctate. Underside more shining than the upper side and possess hairs; abdominal sternites finely punctate. In male, apical ventrite is medially lobed. Laterally, aedeagus is curved at basal half and narrowed at proximally. In ventral view, widest in proximal and narrowing sharply towards apex in apical. In female, receptacle of spermatheca is wider than long. Tignum is narrower towards proximal end; distal region is wider medially.

Host plants of *M. undulatovittata* documented included *Vigna mungo, V. radiata, V. unguiculata, Sesbania bispinosa* and *Lablab purpureus.* Adult beetles made holes in the leaves. It caused severe damage during early stages of the crop. The damage level ranged from 5 – 35 per cent (Table 1). Higher level of damage was recorded during seedling stage (22 -35 %). In flowering stage damage was low (4-10%). SOI was the maximum in Pudukkotai and Thanjavur districts (90%) and minimum in Erode and Madurai districts (60%) (Figure 1).

Table 1. Distribution, host plant, damage level and Species occurrence index (SOI) of *Madursia undulatovittata*

Collection site	Host plant	Stage of the crop	Damage (%)
Coimbatore	*Vigna mungo* *V. radiata* *V. unguiculata* *Sesbania bispinosa*	Vegetative stage Flowering stage Vegetative stage Flowering stage	10 5 13 4
Erode	*V. mungo* *V. radiata*	Seedling stage Vegetative stage	30 16
Salem	*V. radiata* *V. unguiculata*	Vegetative stage Vegetative stage	20 10
Pudukkotai	*V. mungo* *V. radiata* *V. unguiculata* *Lablab purpureus*	Vegetative stage Seedling stage Flowering stage Vegetative stage	15 35 10 5
Thanjavur	*V. mungo* *V. radiata* *V. unguiculata*	Vegetative stage Vegetative stage Vegetative stage	18 10 11
Madurai	*V. mungo* *V. radiata*	Seedling stage Seedling stage	22 28

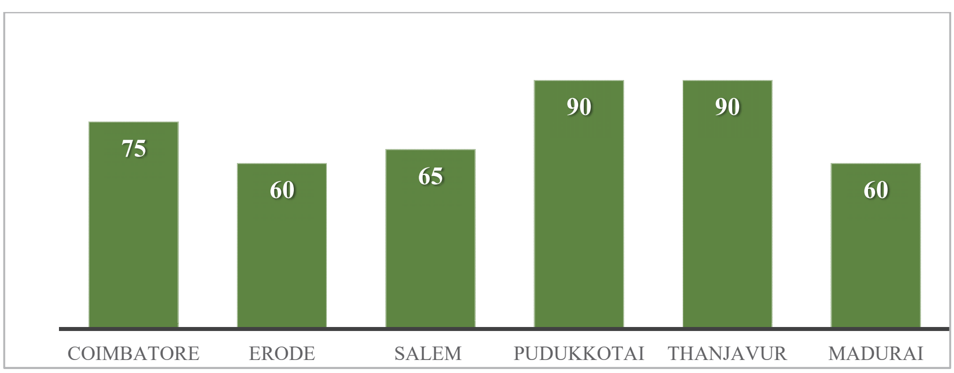

Figure 1. Species Occurrence Index of *Madursia undulatovittata* in Pulses from Tamil Nadu

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ES 01 BOPS 02

Insect Pests and Natural Enemies on Selected Rice Varieties

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Keywords: *Rice, net sweeping, insect pests, yellow pan trap, parasitoids*

Introduction

Rice is one of the important cereal crops to provide food and livelihoods for millions. Rice is mainly grown by direct-seeded rice and transplanted rice. A major shift from Transplanted Rice (TR) production to Direct-seeded Rice (DSR) in irrigated and assured or high rainfall areas has been observed (Edirisinghe and Bambaradeniya, 2006). The major insect pests attacking rice include yellow stem borer, leaf folder, green leafhopper, grasshopper, earhead bug, white leafhopper. Naturally occurring biological control has a potential role to play in the management of rice fields and there is a need to conserve the indigenous natural enemies. Abundance and diversity of natural enemies, such as parasitoids and predators, contributes to biological arthropod pest control in different stages of paddy crop. A change from transplanting to direct seeding may affect the status of various pests. Hence, this study was taken up.

Materials and Methods

The field experiment was conducted during 2018-19 at Annamalai University, Experimental farm, Chidambaram, India under DSR and TR rice varieties CR Dhan 200, CR Dhan 201, CR Dhan 202, CR Dhan 203, CR Dhan 204, CR Dhan 205, CR Dhan 206, CR Dhan 207 and CR Dhan 209. Major insect pests were collected with sweep nets. Yellow Pan Trap was used for collecting parasitoids, notably small insects as well as other groups of insects. The contents are then filtered the same day and the parasitic hymenopterans are preserved in 70% ethyl alcohol.

Results and Discussion

The results showed that the maximum number of yellow stem borers were observed in the DSR variety of CR Dhan 209 (7.66). In the case of stem borers, DSR was preferred than the TR. The reason may be that the DSR was in the main field for more duration than TR. More chances for infestation DSR might have coincided with the life cycle of rice stem borer (Ashrith *et al*., 2016) and the leaf folder population was maximum in the DSR variety of CR Dhan 204 (6.66) (Fig 1.). The peak population of grasshopper and green leafhopper was recorded in the TR variety of CR Dhan 200 (12.00), CR Dhan 209 (9.33). The maximum number of Braconidae was observed in DSR variety of CR Dhan 205 (3.66) while Ichneumonidae was recorded the highest in DSR variety of CR Dhan 202 (3.66). Among parasitids, maximum population of family Chalcididae was collected in TR variety of CR Dhan 207 (3.33). The peak population of Trichogrammatidae was recorded in DSR of CR Dhan 207 (5.66) (Fig 2.). Presence of Platygastridae was high in the TR variety of CR Dhan 201 (7.33). Eulophidae was high in the DSR variety of CR Dhan 201 (9.66) and the parasitoid family Pteromalidae was collected maximum numbers in the DSR variety of CR Dhan 203 (5.66), respectively. More insect pests and crop damage were recorded in DSR more than TR.

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ES 01 BOPS 03

Comparative Taxonomic Account of *Metioche bicolor* (Stål, 1861) and *Metioche vittaticollis* (Stål, 1861) (Orthoptera: Gryllidae: Trigonidiinae)

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Keywords: *Metioche bicolor, M. vittaticollis, morphological characterization, molecular Phylogeny*

Introduction

Genus *Metioche* (Stal, 1877) comprises 41 species distributed in Asia, Africa, South America, the Pacific and Australia. In India, five species have been documented, amongst which, *M. bicolor* and *M. vittaticollis* have been observed to be predatory on eggs of lepidopterous insect pests of rice (Chitra *et al.,* 2000). Old world Trigonidiinae is delimited because of focused study on the morphology of wings, stridulatory file and tympanum. This has become a major shortcoming as acoustic communications may adrift during the evolution of gryllids. This is evident in case of *Metioche* sp. and systematic status of this genus needs detailed study. Hence, *M. bicolor* and *M. vittaticollis* collected from rice fields are described based on morphological characters and genitalia further supported by molecular phylogenetic analysis.

Materials and Methods

Metioche sp. adults were collected from rice fields of Tamil Nadu Agricultural University (TNAU), Coimbatore, India from 6.00 to 8.00 hours with sweep nets. Collected specimens were killed with chloroform (99.8%), pinned, labeled and deposited in TNAU Insect Museum. Morphological and genitalia characters were examined under stereo zoom microscope (Leica M205A, Software LAS v4.12). Morphological description follows Otte and Alexander (1983) and male genitalia follows Kai and Robillard (2012). Adults were subjected to DNA barcoding and phylogenetic analysis using CTAB method of extraction and sequences were aligned using CLUSTALW.

Results and Discussion

Key to *Metioche bicolor* and *M. vittaticollis*

Hind wings present in both sexes and extend beyond abdominal apex into a caudate-like process. Epiphallic lophi asymmetrical; ramus bears no spinules *Metioche bicolor*

Hind wings absent in both sexes. Epiphallic lophi weakly symmetrical; spinules present on epiphallic ramus *Metioche vittaticollis*

Metioche bicolor can be easily confused with dark forms of *Metioche vittaticollis.* Since hind wings were present in *M. bicolor*, this was sometimes presumed as macropterous forms of *M. vittaticollis.* Evident morphological characterization was defined after careful examination of male genitalia: Ep lo was found to be weakly asymmetrical in *M. bicolor* (4 spines on left side and 3 spines on right side) whereas it was symmetrical in *M. vittaticollis* (3 spines on both sides). Sp present along posterior margin of Ep r in *M. vittaticollis* while it was absent in *M. bicolor*. Further, the study was confirmed by molecular phylogenetic analysis.

Molecular phylogeny analysis (Fig. A) revealed that the Indian population sequence matched 100 per cent with that of *M. vittaticollis* population from French Polynesia and 89 per cent with that of Australia. Comparatively, the molecular evolution was observed to be more in the population from Queensland, Australia (VAQT1058-10). All the DNA sequences submitted for *M. vittaticollis* from India and other countries formed a single clade. *M. bicolor* DNA sequence was submitted for the first time and it was observed that it formed a separate branch distinctly from that of *M. vittaticollis.*

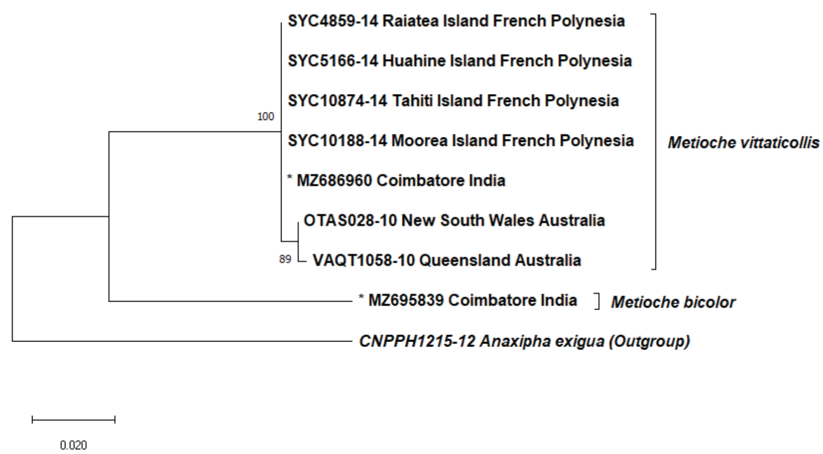

Figure A. The NJ tree obtained using nucleotide data following Bayesian inference in MEGA X. The accession numbers with '*' are sequences obtained in this study.

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ES 01 BOPS 04

Morphological and Molecular Characterization of Genus *Ischnura* (Odonata: Coenagrionidae) from Rice Ecosystem of Tamil Nadu, India

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Keywords: *Ischnura, rice, Tamil Nadu, mt COI, adult morphology*

Introduction

Damselflies are slender predatory insects of order Odonata and sub order Zygoptera. In Indian sub-continent, Zygoptera accounts for 213 species (9 families, 59 genera). *Ischnur*a (Coenagrionidae) as a cosmopolitan genus and is widespread with 72 species worldwide and nine species in India. Irrigated rice crop acts as a temporary wetland providing appropriate niche for aquatic insects. Larvae and adult *Ischnur*a are generalist predators which feeds major rice pests such as *Scirpophaga incertulus*, *Nilaparvatha lugens* and *Nephotettix virescens*. Considering the importance of *Ischnur*a in rice ecosystem, the present study was taken up on the species of *Ischnura* present.

Materials and Methods

Ischnura sp were collected in major rice growing regions of Tamil Nadu, India *viz.,* Coimbatore, Aduthurai, Pudukottai, Bhavanisagar, Ramanathapuram and Gudalur regions from 2019 to 2020 in all rice growing seasons. Adult damselflies were collected with sweep net and the specimens were killed, pinned and labelled for identification purpose. Morphological description was carried out based on Fraser (1934) and Heckman (2008). Molecular confirmation of adult odonata was conducted by PCR amplification using the universal primers, Forward Primer - LCO 1490 (GGTCAACAAATCATAAAGATATTGG) and Reverse Primer – HCO 2198 (TAAACTTCAGGGTGACCAAAAAATCA). Sequences (mt COI) obtained during the study were aligned using Cluster W sequence alignment editor and molecular phylogenetic analysis was done using MEGA x software. Maximum likelihood method with Tamura 3 parameter model was used to generate the tree.

Results and Discussion

Ischnura species *viz., Ischnura rubilio (239 individuals) and Ischnura senegalensis (65 individuals)* were collected from different rice growing regions of Tamil Nadu. The main difference in these two species were as in *Ischnura rubilio (Fig. 1)* abdomen S1- S8 citron yellow, S6 with a dorsal black diamond shaped spot on the distal end and with black bordering at the end. S7 black on the dorsum. S8 to S10 azure blue except S10 with dorsal black coating and raised tubercle pointing away from the body and incase of *Ischnura senegalensis (Fig. 2)* abdomen S1 black on dorsal side, blue at apical border and lateral sides. S2 dorsal black, ventral pale blue. S3 to S7 with black dorsum pointed basally and widens at apical end, yellow lateral side. S8 azure blue with small black line traverse basally on dorsal side. S9 black dorsum, azure blue on ventral side. S10 black dorsum, ventral side pale yellow, two tubercles present on apical end. The molecular identity confirmation of Mitochondrial Cytochrome Oxidase subunit 1 gene of *Ischnura rubilio* (Accession no. MW143324) and *Ischnura senegalensis* (Accession no.MW135330). The phylogenetic tree analysis *(Fig. 3)* of *Ischnura rubilio* (MW143324) collected from Coimbatore matched 100 per cent with the specimen collected from Kerala (MH449981) where as for *Ischnura senegalensis* (MW143324) matched 100 per cent with to the specimen collected from Punjab MG517561. *Ischnura* are widespresd predators in rice ecosystem and they need to be conserved in sustainable production systems.

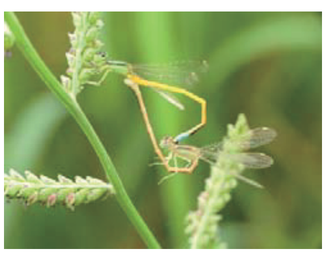

Fig. 1. *Ischnura rubilio* Selys, 1876

Fig. 2. *Ischnura senegalensis* (Rambur, 1842)

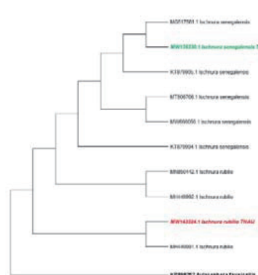

Fig. 3. Phylogenetic Tree

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ES 01 BOPS 05

Insect Herbivore Diversity in Different Jasmine Species (*Jasminum* spp.)

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Keywords: *Jasminum spp., herbivores, comparative mean population.*

Introduction

Jasmine is an important ornamental flower crop widely cultivated and venerated for its attractive fragrant flowers. Research on herbivore diversity of jasmine ecosystems are scanty. Present study was conducted to explore the diversity of herbivores in different jasmine species in Trichy, India.

Materials and Methods

Population of herbivores were assessed in three different Jasmine species viz., *Jasminum sambac*, *J. auriculatum* and *J.grandiflorum* in Horticultural College and Research Institute, Tamil Nadu Agricultural University, Tiruchirappalli from September 2019 to - March 2020 in an area of approximately 25 cents each maintained under unprotected conditions. Observations were recorded at fortnightly interval. Mean population of insect were worked out and expressed in numbers per bush.

Results and Discussion

A total of 16 herbivore species under Lepidoptera (2 species), Hemiptera (5 sp.), Orthoptera (3 sp.), Diptera (1 sp.), Thysanoptera (1 sp.), Hymenoptera (1 sp.), Phasmida (1 sp.) and Coleoptera (1 undetermined sp.) was recorded from the plants of three jasmine species (Table 1). It is clearly evident from the diversity study that highest mean herbivore population of *F. schultzei* (62.4nos./bush) was recorded on *J. grandiflorum*. *F. schultzei* was highest in *J. auriculatum* with 57.9nos./bush. The population of *C. maculipennis* was not noticed in *J. auriculatum* and *J. grandiflorum*. Kamala (2020) reported the preference of red spider mite was higher towards *J. sambac* when compared with *J. auriculatum* and *J. grandiflorum* in controlled lab conditions. In a similar research, variation in population of herbivore was observed in *J. sambac* at different location (Pirithiraj *et al.,* 2021).

Comparative population studies on three different jasmine species revealed their suitability for feeding by various insect pests. Some of the major pests like blossom midge and whitefly were not infesting on *J. auriculatum*and *J. grandiflorum*. Similarly, bud worm damage was not observed in *J. grandiflorum*. Bio-physical or volatile compounds might be responsible for the difference in their susceptibility which can be probed further.

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Table 1. Mean population of herbivores in different jasmine species

S. No.	Order/ Family/ Scientific Name *J. sambac*			Stage of insect observed* *J. auriculatum*	Species#		
					J. grandiflorum		
Insect herbivores							
1	Lepidoptera	Crambidae	*Hendicasis duplifascialis* (Hampson)	I	3.53±2.64	0.58±0.53	0.00
2			*Nausinoe geometrialis* (Guenee)	I	4.84±1.86	5.83±2.18	14.38±6.8
3	Hemipteran	Aleyrodidae	*Dialerodes kirkalydi* (Kotinsky)	I & A	0.84±0.32	0.00	0.00
4		Pentatomidae	*Nezara viridula* (Linnaeus)	A	0.76±0.36	0.00	0.00
5		Pentatomidae	*Antestiposis cruciate* (Fabricius)	I & A	1.00±0.75	5.08±2.59	0.00
6		Tingidae	*Corythanma ayyari* (Drake)	I & A	1.30±0.69	0.00	0.00
7		Coreidae	*Riptortus pedestris* (Fabricius)	I & A	0.30±0.16	0.00	0.00
8	Orthoptera	Acrididae	*Anacridium flavascens* (Fabricius)	I & A	1.30±0.44	0.41±0.38	0.00
9		Pyrgomorphidae	*Neorthocris* sp.	I & A	1.07±0.46	0.83±0.43	0.00
10		Acrididae	*Oxya nitidula* (Walker)	I & A	0.07±0.07	0.33±0.30	0.00
11	Diptera	Cecidomyiidae	*Contarinia maculipennis* (Felt)	I	5.76±4.48	0.00	0.00
12	Thysanoptera	Thripidae	*Frankliniella schultzei* (Trybom)	I & A	11.7±9.74	57.9±35.5	62.4±14.4
13	Hymenoptera	Megachilidae	*Megachile* sp.	A	0.07±0.07	0.00	0.07±0.07
14	Phasmida	Lonchodidae	*Carausius morosus* (Br)	I	0.15±0.10	0.00	0.00
15	Coleoptera	undetermined	Flower beetle	A	0.00	0.00	0.15±0.14
Non insect herbivores							
16	Trombidiformes	Tetranychidae	*Tetranychus urticae* (Koch)	I & A	25.4±11.1	0.00	0.00

* I - Immature stage, A - Adult, # Mean of 13 observations ± SE.

ES 01 BOPS 06

Community Turnover of Aquatic Insect Assemblage in Irrigated Rice Fields of Coimbatore, India

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Keywords: *Aquatic insects, community turnover, chemical inputs and rice fields*

Introduction

Rice is the staple food of more than half million population in Asia. Irrigated rice fields are rich in insect faunal diversity with more than 800 species. Chemical inputs such as herbicides, fertilizers and pesticides are the major inputs used in modern rice cultivation methods. These inputs alter the species richness and diversity of insects in rice ecosystems (Stenert *et al*., 2012). Aquatic insect fauna in rice ecosystem is enormous, which indeed, is also affected the chemical inputs applied. Hence, the community turnover of aquatic insect in organic and inorganic rice field under irrigated condition was studied.

Materials and Methods

Aquatic insect diversity in irrigated rice fields of Coimbatore was studied during 2018 -2019 under organic and inorganic methods of cultivation. Aquatic insect samples were taken at three days interval at different growth stages of rice with dip net and D-frame kick net. Community turnover of the aquatic insect fauna was analyzed following Diamond (1969).

Result and Discussion

Organic rice fields comprised 2,254 individual aquatic insects while inorganic rice field aquatic insect assemblage consisted of 1,735 individual insects. However, the aquatic insect assemblage included 22 species under 22 genera of 19 families belonging to six insect orders. The species richness and abundance of aquatic insects increased with stage of the crop reaching the zenith on 39DAT (Days after Transplanting) in both organic and inorganic rice fields. Correspondingly the rice crop was in the early vegetative stage with more exposure of aquatic zone and invasion of aquatic insects into the rice field. During the vegetative stage due to canopy closure the decline in the aquatic faunal abundance was observed. The next community turnover was observed during the reproductive phase (organic rice: 66 DAT, inorganic rice: 63 DAT). In inorganic rice field, Chlorpyriphos (0.3 %) was applied on 60 DAT. Consequently, there was a sharp decline of predators (44%), omnivores (30%), herbivores (11%) and scavengers (15). Species richness and diversity comparatively was less towards harvest stage when compared to the vegetative stage. This may be attributed to the canopy closures as well as volume of the standing water body. Among the different functional groups, predators were the dominant over omnivores, herbivores and scavengers. *Micronecta* sp. (Corixidae) and *Anisops* sp. (Notonectidae) of Hemiptera were predominant in all the growth stages of the rice crop. Predominance of *Micronecta* sp. and *Anisops* sp. may be due to the reason that it being an omnivore is able to tide off the situations of being either predatory or detrivorous in the absence of its predators. Whenever fishes were absent in aquatic ecosystems, Corixidae were plenteous (Soldan *et al*., 2012) as in this study also. More scholarship is required on the interaction of the terrestrial and aquatic insect fauna in rice to strike a balance sustaining the ecosystem.

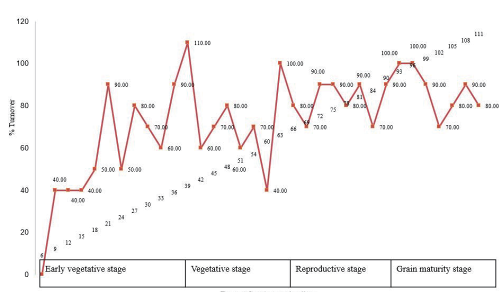

Figure 1. Community turnover of aquatic insects in inorganic rice field

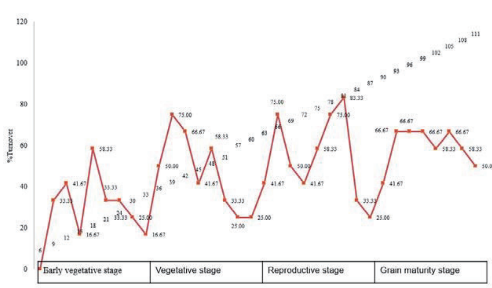

Figure 2. Community turnover of aquatic insects in organic rice field

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ES 01 BOPS 07

Morphological Characterization of Colour Morphs of Common Blossom Thrips *Frankliniella schultzei* Trybom (Thysanoptera: Thripidae)

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Keywords: *Common blossom thrips, Frankliniella schultzei, Distribution, Chaetotaxy*

Introduction

With a widening vegetarian population, India is shifting its focus from food security to nutritional security. Fruits and vegetables, which are rich in minerals and vitamins, are an essential component of a balanced diet. Pests are regarded as major hurdles to successful crop production. The first and foremost step in the pest management is to rightly identify pests is. Thrips, the smallest insect, found to infest many horticultural crops. In addition to the direct feeding damages caused by thrips, they are the sole vector of tospoviruses *viz.*, tomato spotted wilt virus (TSWV), tomato chlorotic spot virus (TCSV), groundnut ring spot virus (GRSV) and chrysanthemum stem necrosis virus causing severe economic losses in crop plants. Among the thrips species reported, *Frankliniella schultzei* Trybom (Thysanoptera: Thripidae), recorded over 83 plant species of 35 families, is found to be omnipresent on maximum horticultural crops (Kakkar *et al.,* 2010). It has colour morphs too. This study deals with the taxonomic identification of *F. schultzei* colour morphs.

Materials and Methods

Thrips specimens were collected from various horticultural crops grown in different agro-climatic zones of Tamil Nadu from December 2020 to May 2021 on the crops *viz.,* cowpea (*Vigna ungiculata*), French bean (*Dolichos lablab*), groundnut (*Arachis hypogea*), lablab (*Lablab purpureus*), tomato (*Solanum lycopersicum*) and temple flower (*Plumeria alba*). Thrips were collected by tapping the plant parts on a white sheet and brought to laboratory by transferring them with a fine camel hair brush (Size' 000) in Eppendorf tubes® (1.5ml) containing 95–100% ethanol. They were transferred to AGA fluid (6:1:1 ratio of 60% Alcohol (ethanol): Glycerol: Acetic acid). The thrips specimens were processed as per Mirab-Balou and Chen (2010). The slide mounted thrips were identified based on chaetotaxy and using taxonomic keys of Moritz and Mound (1999) and Lucid keys of 'Pest thrips of East Africa' (Moritz *et al.,* 2013).

Result and Discussion

Both pale and dark forms of *F. schultzei* were collected in the survey from different agro climatic zones and on different crops too. Initial segregation of the species was done by identifying presence or absence of tubular ovipositor. Here, conical ovipositor was observed and characterized as Terebrantian thrips. Further, adult body was uniformly dark brown in colour. The size of adult varied from 1.08mm to 1.32mm. There were three number of ocelli and eight antennal segments with forked sensory cone on III&IV segments. These were used to confirm the family Thripidae. The head width was around 0.12 – 0.14mm. In head, there were 3 pairs of ocellar setae observed. In which the pair III was arising close together between anterior margins of hind ocelli and longer than the post ocular setae.

Pronotum width varied from 0.14-0.18mm in size. posteroangular setae, 5 pairs, were observed in pronotum. One pair of shorter antero-angular setae compared with the slightly longer antero marginal setae were seen. Another pair of longer postero angular setae and postero-marginal setae were present. In between the two, a pair of median setae was also observed. The width of mesonotum was 0.21-0.23mm. In fore wing, two complete rows of veinal setae were observed. In abdominal segments, paired lateral ctenidia on tergites VI–VIII were present which further confirmed the species as *F. schultzei.* In eight abdominal segment postero marginal comb was weakly developed or absent. Finally, the width of abdomen varies from 0.23-0.28mm respectively. These observations were in accordance with Kakkar *et al.* (2010).

From the observed data on field, the host range for *F. schultzei* included Fabaceae and Solanaceae. Both the pale and dark forms of *F. schultzei* were observed in lablab (Amin *et al.,* 1981). In all other observed crops only the dark form was present. Though two morphs of *F. schultzei* were observed, the effective vector of tospoviruses and its interaction with host plant have to be studied further. These two morphs have similar taxonomic characters except the colour form. Hence, the variances between two morphs in their genetic traits have yet to be explored.

Table 1. Prevalence of colour morphs of common blossom thrips *F. schultzei* in different regions of Tamil Nadu

S.No	Location	Geo position	Crops collected	*F. schultzei colour* morph
1.	Theni (Anaipatti, Cumbum)	N 9°44" E 77° 19" N 9°38" E 77°14"	Cowpea (*V. ungiculata)*, Lablab (*L. purpureus*), Tomato (*S. lycopersicum*) Temple tree (*P.obtusa*)	Dark and pale
2.	Dharapuram (Pannapalayam)	N 11°0" E 77°19"	Lablab (*L. purpureus*), Tomato (*S. lycopersicum*)	Dark and pale
3.	Salem (Vellapillakovil, Palanthinnipatti)	N 11°26" E 78°7"	Lablab (*L. purpureus*), Tomato (*S. lycopersicum*)	Dark and pale
4.	Kothagiri (Kukkal)	N 11°29" E 76°49"	Cowpea (*V. ungiculata)*, Lablab (*L. purpureus*) French bean (*D. lablab*),	Dark
5.	Coimbatore (Kuppanur, Thondamuthur, Devarayapuram)	N 11°0" E 76°55" N 10°59" E 76°48"	Temple flower (*P.obtusa*) Cowpea (*V. ungiculata)*, Lablab (*L. purpureus*), Tomato (*S. lycopersicum*)	Dark and pale
6.	Dindigul (Vedapatti)	N 10°35" E 77°22"	Tomato (*S. lycopersicum*)	Dark
7.	Thanjavur (Marudhankonviduthy)	N 10°52" E 79°13"	Cowpea(*V. ungiculata)*, Groundnut (*A.hypogea*)	Dark

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ES 01 BOPS 08

Odonata Diversity in Tenkasi, Tamil Nadu, India

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Keywords: *Odonata, dragonfly, damselfly, species diversity, vasudevanallur*

Introduction

Odonata (Dragonflies and Damselflies) are wonderful aquatic insects distributed throughout the world. Globally, 5952 species of Odonates under 652 genera have been reported (Subramanian, 2014). India harbours 474 species and 50 subspecies belonging to 142 genera in 18 families and the Odonata fauna of the Western Ghats diverse with 176 species, out of these, 68 species are endemic in nature (Subramanian, 2009). They are highly niche-specific, rely significantly on water bodies for eating, reproduction and sensitive to their environmental changes. Hence, dragonflies and damselflies are considered an bioindicators for healthy wetland ecosystem and are also important elements of the food chain in sustaining the environment. So, the objective of the study was to assess the diversity of odonates at Vasudevanallur, Tenkasi district, Tamil Nadu.

Materials and Methods

The study was conducted in different locations at Vasudevallur, Tenkasi District, Tamil Nadu. Adult Odonata were collected with the help of a sweep net at weekly intervals from January 2020 – March 2020. The specimens were photographed for various identification features. The specimens collected are deposited in the Department of Agricultural Entomology, S.Thangapzhagm Agricultural College, Vasudevanallur. Collection and estimation of population density was done once in a week and the data was compiled on a monthly basis. Odonata were identified based on the taxonomic keys of Subramanian, (2009). Odonates observed were categorized into five groups based on their abundance. Accordingly, those species observed 80 - 100% of the survey days were categorized as very common (VC), 60-80% as common (C), 40-60% as occasional (O), 20-40% as rare (R) and below 20% as very rare (VR) (Adarsh, 2015).

Results and Discussion

A total of 18 species of odonates with 12 species of Anisoptera (dragonflies) and 6 species of Zygoptera (damselflies) were documented from the study area. Libellulidae dominated with 11 species among Anisoptera followed by Aeshnidae (1). Among Zygoptera, Coenagrionidae (2) Lestidae (2), Synlestidae (1). Among the 18 species recorded**,** *Diplocodes trivialis* (Libellulidae) was the most dominant Anisoptera and *Ischnura aurora* (Coenagrionidae) was the most abundant Zygoptera.

Table 1. Relative abundance of Odonates at Vasudevanallur, Tenkasi district

Family	Number of Genus	Number of Species
Anispotera (Dragonfly)		
Libellulidae	11 (91.66%)	11 (91.66%)
Aeshnidae	1 (8.33%)	1 (8.33%)
Total (Anisoptera)	12	12
Zygoptera (Damselfly)		
Coenagrionidae	2 (50%)	3 (50%)
Lestidae	1 (25%)	2 (33.33%)
Synlestidae	1 (25%)	1 (16.66%)
Total (Zygoptera)	4	6
Grand Total	**16**	**18**

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ES 01 BOPS 09

Influence of Weather Parameters on Spider Population at Karaikal, Puducherry

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Keywords: *Spiders, kharif, rabi, correlation, regression*

Introduction

Order Araneae are the most abundant predators of insect pests of terrestrial ecosystems and the first among predators to colonize crop fields after post management practices. Patil *et al*. (2018) reported that spiders as potential bio control agents of crop pests. Considering the importance of spiders, the study focused on seasonal distribution of spiders in horticultural ecosystem.

Materials and Methods

The study was conducted at Western farm of Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry, India containing mango, sapota, guava, amla and tamarind trees from June 2019 to February 2020. Based on the relative abundance of spiders the weather parameters *viz*., maximum and minimum temperature, morning and evening relative humidity, bright sunshine hours and rainfall were correlated with the spider populations to study their seasonal distribution.

Results and Discussion

Correlation in *Kharif* 2019 resulted that *Neoscona theisi* showed positive correlation maximum and minimum temperature whereas *Cheiracanthium melanostomum, Oxyopes javanus and Thomisus* sp. showed negative correlation with maximum temperature. And negative correlation was noted with minimum temperature in *C. melanostomum*, *O. javanus, Thomisus* sp. and *U. krishnae.* With respect to relative humidity, positive morning relative humidity favored the population growth of *C. melanostomum*, *O. javanus* and *U. krishnae.* Negative correlation on morning relative humidity was observed in *N. theisi* and *Thomisus* sp. Evening relative humidity was favourable for *C. melanostomum*, *O. javanus* and *U. krishnae* whereas *N. theisi* and *O. javanus* showed negative correlation with negative evening relative humidity. With bright sunshine hours, positive correlation was noted with *C. melanostomum* and *Thomisus* sp. and negative correlation was noted with *N. theisi, O. javanus* and *U. krishnae.* With total rainfall, positive correlation was noted with *C. melanostomum, O. javanus* and *U. krishnae* whereas negative correlation was noted with *N. theisi* and *Thomisus* sp. Multiple regression showed that *O. javanus* and *Thomisus* sp. showed significant values where *C. melanostomum*, *N. theisi* and *U. krishnae* showed non-significant values (Table. 1).

In *Rabi* 2019 - 2020 correlation with weather parameters concluded that, *C. melanostomum*, *O. javanus* and *U. krishnae* showed positive correlation with maximum and minimum temperature. And *N. theisi* and *Thomisus* sp. showed the negative correlation with maximum and minimum temperature. Regarding morning relative humidity, negative correlation was found with *C. melanostomum*, *O. javanus*, *U. krishnae, N. theisi* and *Thomisus* sp. And the population of *N. theisi* was favoured with evening relative humidity whereas it unflavoured the population of *C. melanostomum*, *O. javanus*, *U. krishnae and Thomisus* sp. With bright sunshine, *C. melanostomum*, *N. theisi*, *Thomisus* sp. and *U. krishnae* showed negative correlation and where *O. javanus* showed positive correlation. With total Rainfall, negative correlation was observed with *C. melanostomum*, *O. javanus*, *Thomisus* sp. and *U. krishnae* where, *N. theisi* showed positive correlation. Multiple regression showed *N. theisi* population as significant and *C. melanostomum*, *O. javanus*, *Thomisus* sp. and *U. krishnae* with non-significant values (Table. 2). Similar study by Jadhav *et al*., 2017 on correlation between maximum temperature (r = 0.625*), minimum temperature (r = 0.827**), evaporation (r = 0.815**), wind velocity (r = 0.809**) with spider population were positive and significant.

Table. 1 Correlation and multiple regression of major spider species during *Kharif* 2019

Spiders	Temperature (°C)		Relative humidity (%)		Bright sunshine	Total Rainfall (mm)
	Maximum	Minimum	Morning	Evening		
Cheiracanthium melanostomum	-0.16	-0.24	0.13	0.07*	0.24	0.11
	$Y= 74.23-0.21X_1-2.65X_2+0.07X_3-0.16X_4+1.46X_5-0.31X_6$					0.409
Neoscona theisi	0.26	0.13	-0.10*	-0.18	-0.07*	-0.14
	$Y= -29.73+1.68X_1-1.26X_2-0.05X_3+0.20X_4-0.24X_5-0.11X_6$					0.184
Oxyopes javanus	-0.53	-0.50	0.40	0.36	-0.59	0.27
	$Y= 52.92-2.33X_1+1.60X_2+0.20X_3-0.29X_4-0.98X_5+0.01X_6$					0.510*
Thomisus sp.	-0.14	-0.06*	-0.08*	-0.06*	0.28	-0.26
	$Y= 54.75-1.76X_1+0.09X_2+ 0.15X_3-0.16X_4+1.03X_5-0.49X_6$					0.540*
Ulorobus krishnae	-0.48	-0.40	0.24	0.32	-0.23	0.25
	$Y= 119.21-0.75X_1-1.88X_2-0.62X_3+0.20X_4-0.19X_5+0.03X_6$					0.411

*= Significant at p=0.05; ** at p=0.01; # - Not significant; X_1 = Maximum temperature; X_2 = Minimum temperature; X_3 = Morning relative humidity; X_4 = Evening relative humidity; X_5 = Bright sunshine hours; X_6 = Rainfall

Table. 2 Correlation and multiple regression of major spider species during *Rabi* 2019 - 20

Spiders	Temperature (°C)		Relative humidity (%)		Bright sunshine	Total Rainfall (mm)
	Maximum	Minimum	Morning	Evening		
Cheiracanthium melanostomum	0.24	0.12	-0.10	-0.21	-0.19	-0.10
	$Y= -44.48+0.27X_1+0.34X_2+ 0.14X_3+0.11X_4+1.06X_5+0.17X_6$					0.362
Neoscona theisi	-0.38	-0.16	-0.02**	0.35	-0.26	0.31
	$Y= 68.82-1.72X_1+0.30X_2+0.08X_3-0.53X_4+0.93X_5+0.48X_6$					0.736*
Oxyopes javanus	0.28	0.18	-0.08*	-0.26	0.01**	-0.18
	$Y= -77.89+0.62X_1+0.83X_2-0.03X_3+0.46X_4+1.86X_5+0.08X_6$					0.267
Thomisus sp.	-0.17	-0.18	-0.36	-0.32	-0.03	-0.24
	$Y= -48.88-0.22X_1+0.81X_2+0.40X_3+0.01X_4+0.20X_5+0.05X_6$					0.236
Ulorobus krishnae	0.12	0.39	-0.13	-0.07*	-0.15	-0.15
	$Y= 104.23-1.40X_1+1.41X_2-0.61X_3-0.44X_4-0.59X_5+0.01X_6$					0.415

* = Significant at p=0.05; ** at p=0.01; # - Not significant; X_1 = Maximum temperature; X_2 = Minimum temperature; X_3 = Morning relative humidity; X_4 = Evening relative humidity; X_5 = Bright sunshine hours; X_6 = Rainfall

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ES 01 BOPS 10

Diversity and Taxonomy of Mealybug Complex Infesting Cassava (*Manihot Esculenta* Crantz)

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Keywords: *Cassava mealybug complex, COI region 2, Diversity, Taxonomy*

Introduction

Cassava is a staple food cum industrial crop which is mainly grown in tropical countries. In India, Tamil Nadu is the leading producer of cassava. Mealybugs (Pseudococcidae: Hemiptera) have become a major pest of cassava in Tamil Nadu nowadays. Their infestation results in distortion of terminal shoots, bunchy top, reduction in vigour and death of the plant and may cause up to 80% yield loss in cassava (Nwanze, 1982). The present study was conducted to document the mealybug species complex associated with cassava in major cassava growing tracts of Tamil Nadu. For the successful bio-control, correct identity of species is important. Hence, morphological and molecular characterization of the mealybugs of cassava was undertaken.

Materials and methods

Collection of mealybugs were carried out from major cassava growing tracts of Tamil Nadu *viz*., Namakkal, Salem, Erode, Tiruppur and Coimbatore districts from February to October, 2021. The percentage infestation and mealybug density were calculated. Adult females were slide mounted according to the standard protocol with slight modifications and morphological identification was done following the keys of Williams (2004). DNA was extracted using CTAB method and amplification was done at mt-COI region 2 and sequences were obatined. The sequences were submitted in NCBI-GenBank and phylogenetic tree was constructed using the obtained sequences and homologous sequence retrieved from NCBI.

Results and Discussion

Morphological characterization revealed the presence of five species of mealybugs belong to the two sub families Phenacoccinae (*Phenacoccus manihoti* and *Phenococcus solenopsis*) and Pseudococcinae (*Ferrisia virgata*, *Paracoccus marginatus* and *Pseudococcus jackbeardsleyi*) infesting cassava. The diagnostic characters of each species were studied in detail. Subfamily Phenacoccinae was distinguished from Pseudococcinae with the characters such as claw with denticle, nine segmented antennae and setose tarsal digitules (Williams, 2004). *Ph. manihoti* was differentiated from *Ph. solenopsis* by the presence of quinquelocular pores located in ventral body surface which is numbering 32 in the anterior side of clypeolabral region and ox-yoke shaped circulus. *F. virgata* was identifed based on the presence of only anal cerarius and absence of oral rim tubular ducts absent on both dorsal and ventral body surface. *Ps. jackbeardsleyi* was identified and differentiated from *P. margnatus* by the presence of more than four discoidal pores arround the sclerotized rim of the eye and absence of translucent pores absent on hind coxa.

Molecular characterization confirmed the five species infesting cassava and shown more than 98 percent identity with homologous sequence in NCBI. The phylogenetic tree revealed the relationship between the species existing in cassava ecosystem which was in accordance with Hardy *et al*. (2008)

The mealybug species were recorded as a complex in 11 locations across the five districts. In the species complex, *Ph. manihoti* was predominant with more than 90 per cent of the locations surveyed. The mealybug density and percent infestation was maximum during summer months and declined after rainy season. This rapid build up can be attributed to the increase in temperature along with parthenogentic reproduction. Among the different varieties, higher incidence was observed in Mulluvadi. In Tamil Nadu, Sampathkumar *et al*. (2021) first reported the occurrence of *P. manihoti* in Namakkal and Salem districts. This study revealed the high incidence of this pest in neighbouring districts (Coimbatore, Tiruppur and Erode) also. Hence, intensive research on appropriate management measures for the mealybug complex may be taken up at the earliest.

Table I. Details on the mealybug complex infesting cassava

S. No.	District (Block)	Cassava variety	Mealybug species complex
1.	Namakkal (Rasipuram,Sendamangalam, Mallasamudram,Vennandur, Elachipalayam, Paramathi)	MUL, YTP2, WHT, H226, UVL	*Ph. manihoti*, *P. marginatus* *F. virgata*, *Ps. jackbeardsleyi* *Ph. solenopsis*
2.	Salem (Veerapandi, Omalur, Edapadi, Sankari)	MUL,YTP2, WHT	*Ph. manihoti*, *F. virgata Ps. jackbeardsleyi*
3.	Erode (Nasiyanur, Ammapettai)	MUL, YTP2	Ph. manihoti
4.	Coimbatore (Papanaickenpalayam, Annur)	MUL, YTP2	*Ph. manihoti*, *P. marginatus* *F. virgata*, *Ps. jackbeardsleyi*
5.	Tiruppur (Madathakulam)	MUL	*Ph. manihoti*, *F. virgata* Ps. jackbeardsleyi

MUL- Mulluvadi; WHT- White Thailand; UVL-Usivellai

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ES 01 BOPS 11

First Morphological Description of the Immature Stages of *Psorosticha zizyphi* (Stainton 1857) (Depressariidae: Lepidoptera)

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Key words: *Psorosticha zizyphi, Murraya koenigii, immature and adult taxonomy*

Introduction

Psorosticha zizyphi was described as *Deprassaria zizyphi* (Stainton, 1857) and after many taxonomic revisions at present, it is designated as *Psorosticha zizyphi.* Nye and Fletcher (1991) included *Psorosticha* in the subfamily Depressariinae under Oecophoridae. Hodges (1999) classified it as a subfamily of Elachistidae. Based on the adult taxonomy of many moths' subfamily status of Depressariinae has been elevated to family Depressariidae. In this study, along with the adult taxonomy, the morphological characters of immature *Psorosticha zizyphis* is described for the first time.

Materials and methods

Different life stages of *Psorosticha zizyphi* was collected from different parts of Tamil Nadu and reared on curry leaf in the Insect Biosystematic Laboratory, Department of Agricultural Entomology, Tamil Nadu Agricultural University (TNAU), Coimbatore, Tamil Nadu, India. Morphological characterization of different growth stages of *P. zizyphi* was undertaken: egg, larva, pupa and adult through stereo zoom microscopy and scanning electron microscopy. The specimens were deposited in the TNAU Insect Museum, TNAU, Coimbatore.

Result and Discussion

Eggs were oval or oblong, flattened, creamy white in colour and microscopic. Eggs were laid overlapping each other with mean diameter 0.30-0.67 **µm. Chorion s**urface with zigzag markings. Larva**-** Head: Cranium sclerotized, light brown; frontoclypeus longer. Each half of the head represents 17 tactile setae, 4 proprioreceptors and 10 pores. Thorax: T1 lateral and subventral group bisetose; T1 and T2 lateral group trisetose and SV unisetose. Abdomen: A1-A7 dorsal group bisetose; subdorsal group unisetose; lateral group trisetose; subventral group bisetose. Triordinal circular crochets present in A3-A6 and A10. Pupa: Head dark brown, thorax olive green ventrally, light brown in the abdominal region. Dorsoventrally compressed. Pupa initially olive green with brown gradually darkens and turned dirty brown before adult emergence. Pupa obtect, stout and seen attached to leaves or hidden inside the folds with length of 3.65mm to 6.26mm. Cremaster spines eight, slightly curved in the terminus. Adult: Head brownish grey; face pale yellow. Palpi ochreous; tip of terminal joint dark fuscous. Labial palpi long and recurved; three segmented with admixture of fuscous scale. Antenna long and filiform; pale brown, strongly ciliated. Wing span 11-12mm. Forewing ground pale yellow. Two fuscous points on costal margin. Forewing with R4 and R5 stalked. Hindwing light grey; R and M1 separate; M3 and Cu1 origin same point. Male genitalia symmetrical; socii small, membranous. Female genitalia ductus bursae long; less sclerotized; corpus bursae spherical. *Psorosticha zizyphi* adult taxonomy was studied by Lvovsky (2010) earlier. Morphological features of egg, larvae and pupae are described for the first time.

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GOLDEN JUBILEE INTERNATIONAL CONFERENCE

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Theme

ES 02: Emerging Pests of Crops and Stored Grains

ES 02 OPD 01

Emerging Invasive Whiteflies (Hemiptera: Aleyrodidae) in India and their Management Strategies

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Keywords: *Co-existence, colonization, establishment, host plants, invasion, natural enemies*

Introduction

The enormous increase in the volume, diversity and swiftness of movement of plant products throughout the world resulted in easy dispersal of insect pests also particularly the ones closely associated with plants, such as scales and whiteflies. In India, 469 whiteflies species belonging to 71 genera are known to feed on many agricultural, horticultural and forestry crop plants which include 8 invasive species (Sundararaj *et al.,* 2021). These invasives cause direct damage to their host by feeding and indirect damage by producing wax and excreting sticky honeydew which provides a substrate for the growth of black sooty mould on infested plant which reduces the photosynthetic capacity of the plant. The present studies were aimed to document invasive whitefly species, the range invasion, expansion of host plants, patterns of co-occurrence, and their natural enemies to develop a biocontrol strategy in India.

Materials and Methods

Systematic and continuous surveys were conducted from February 2015 to September, 2020 in different states of India v*iz.,* Karnataka, Tamil Nadu, Kerala, Andhra Pradesh, Maharashtra, West Bengal, Goa, Telangana, Meghalaya, Gujarat and Lakshadweep islands and observations on the spatial range, host range, patterns of co-occurrence, intensity of infestation of invasive whiteflies whiteflies and their natural enemies were recorded. Surveys were focused on plantation crop plants, ornamental plants, landscape plants and field crops in both rural and urban areas in various locations. The frequency of the surveys at each site varied from one to twenty six trips across the study areas. The identity of the whitefly species was confirmed based on the morphological characteristics of the puparia and the sequencing of partial mitochondrial cytochrome c oxidase I gene (658 bp size) using adult.

Results and Discussion

The identities of the whitefly species were confirmed as spiralling whitefly, *Aleurodicus dispersus*; solanum whitefly, *Aleurothrixus trachoides*; rugose spiralling whitefly, *Aleurodicus rugioperculatus*; legume feeding whitefly, *Tetraleurodes acaciae*; Bondar's nesting whitefly, *Paraleyrodes bondari* ; nesting whitefly, *P. minei*; palm infesting whitefly, *Aleurotrachelus atratus* and woolly whitefly, *Aleurothrixus floccosus*. Most of these invasive whitefly species were mostly predominantly spread in entire South India and few species reported from Gujarat, Chhattisgarh, Odisha, West Bengal, Maharashtra, and Meghalaya including Andaman and Nicobar and Lakshadweep islands. The current rapid geographical expansion of these invasive species is likely mediated by humans through the movement of infested seedlings and plant materials and prevalence of favourable weather factors and availability of host plants. The most of these invasive are polyphagous and expanded their host range in India considerably; this could be a mechanism to overcome the abiotic constraints and buffer the depletion of optimal resources. Host range expansion leads to increases in population growth and potentially to greater geographic range expansion. Species of exotic whiteflies with similar habits co-exist in more or less the same niche and have a similar pattern of growth and development (Fig.1). Similar observations were made by Mohan *et al*. (2019).

The study also revealed the occurrence of two parasitoids, *Encarsia guadeloupae* and *E. dispersa* that were found to colonize *A. dispersus* and *A. rugioperculatus.* Among these, *Encarsia guadeloupae* was the dominant parasitoid which parasitized 62-95% and 56-82% of *A. dispersus* and *A. rugioperculatus*, respectively whereas *E.*

dispersa parasitized 28-92% and 5-10% of *A. dispersus* and *A. rugioperculatus,* respectively (Selvaraj *et al.,* 2017. Predator's *viz., Pseudomallada astur*, *Jauravia pallidula, Cheilomenes sexmaculata* and *Cybocephalus indicus* were also observed to be feeding on *A. rugioperculatus* and *A. dispersus*. In addition, the entomopathogenic fungus, *Isaria fumosorosea* was found to be effective against *A. rugioperculatus, P. bondari,* and *P. minei* and *A. atratus* (Sumalatha *et al.,* 2020). Native predators such as *P. astur*, *C. indicus, Axinoscymnus puttarudriahi, Cryptolaemus montrouzieri* and *Acletoxenus indicus* were recorded for the other invasive whitefly species and no parasitoid was recorded so far (Sundararaj *et al.,* 2021).

Post incursion management mostly through timely implementation of classical biocontrol programme using potential natural enemies by importation. Fortunately, most of such invasive hemipteran species are amenable for classical biological control. Effective biological control programme has been implemented for *A. rugioperculatus* and *A. dispersus* resulting in saving millions of rupees by mitigating their adverse impacts on agriculture. There is urgent need to survey and document the potential natural enemies of *P. bondari, P. minei, A. floccosus* and *A. atratus*, and explore the potential natural enemies for their introduction from their native countries to India for the development of efficient classical biocontrol management strategies.

Fig. 1. Co-occurrence of invasive whiteflies on coconut

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ES 02 OPD 02

Outbreak and Management of Serpentine Leaf Miner, *Liriomyza huidobrensis* (Blanchard) on Potato Crop in Southern Hills of India

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Keywords: *Leaf miner; identification; alternate hosts; potato; Liriomyza huidobrensis*

Introduction

Potato (*Solanum tuberosum* L.) is the third most important food crop in the world after rice and wheat (Divya et al., 2020). Nilgiri Hills located in southern India has the oldest potato growing history in our country. Due to congenial climatic conditions, potato production in Nilgiris is being threatened regularly by several existing and newer biotic stresses. Recently, an outbreak of a new insect pest that mines potato leaf was detected in the Nilgiri hills. This newly arrived leaf-mining pest causes severe damage to the potato leaf, and in many places, severe crop losses were also noted during the summer and autumn seasons of 2020. As this pest was new to this area, the present study was formulated to know the status of this pest in the Nilgiris. Furthermore, the effective management strategies have been developed to manage this pest in potato crop.

Materials and methods

A survey was conducted during the autumn season of 2020, throughout the potato growing regions of Nilgiri hills of Southern India following the outbreak of leaf-mining pest. Morphological identification of the pest was confirmed based on key diagnostic characters given by LucidKey (2021); Malipatil (2007); Maharjan et al., (2014). Adult specimens identified using morphological criteria were further subjected to molecular characterization using the mitochondrial cytochrome c oxidase I (*mtCOI*) gene. Further the field experiments were conducted with locally available insecticide molecules during the autumn season on an emergency basis for the management of this new pest problem. The differences in larvae per leaflet^{-1} and percentage of damage incidence in survey samples and percentage infection by *L. huidobrensis* and yield of the potato crop in field experiments were subjected to analysis of variance (ANOVA) (SPSS version 21.0).

Results and Discussion

Based on the morphological (Malipatil, 2007; Maharjan et al., 2014) and molecular characterization of the adult fly, the pest was identified as *Liriomyza huidobrensis* (Blanchard) belonging to Agromyzidae family of order Diptera. During the survey the potato crop was found severely infested with the *L. huidobrensis* (Fig. 1), the incidence of this pest was 92-100%, with a damage severity ranging from 20-100% on the potato crop in Nilgiri hills. The incidence of *L. huidobrensis* was also recorded on seven cultivated crops and seven weeds commonly observed in Nilgiris. This suggests the need of cleaner cultivation and community approach in managing this new pest. The field experiments for the management of this pest recommend the application of abamectin for the management of *L. huidobrensis* in Nilgiri Hills of India. In addition to this installation of yellow sticky trap at initial crop stage is also recommended, which helps in monitoring and catching of the leaf miner adult flies. In future, the studies should focus on the exploration and conservation of biological control and evaluation of safer chemical molecules to minimize the crop losses and to avert its further spread in new localities.

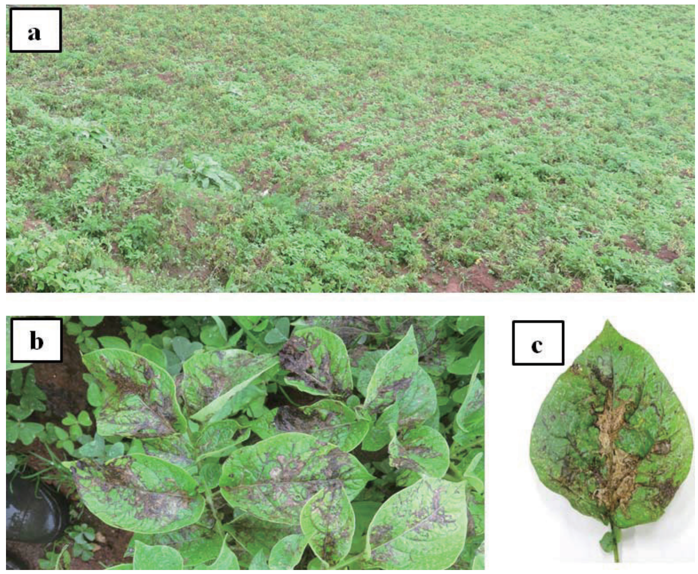

Figure 1. Leaf miner attack in potato crop at Nilgiris: a) field infestation in potato cultivar Kufri Jyoti, b) Infected plant, c) typical pattern of leaf mining by *Liriomyza huidobrensis*

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ES 02 OPD 03

Bacterial Microbiome Associated with Rugose Spiralling Whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae)

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Keywords: *Rugose spiraling whitefly, gut bacteria, metagenomics*

Introduction

Rugose spiralling whitefly was originally described and recorded as a pest of coconut in Belize and Mexico (Martin, 2004). In India, so far, six species *viz*., *Aleurocanthus arecae* David and Manjunatha, *Aleurodicus dispersus* Russell, *Aleurodicus rugioperculatus* Martin, *Aleurotrachelus atratus* Hempel, *Paraleyrodes bondari* Peracchi, and *P*. *minei* Iaccarino are known to infest coconut (Selvaraj *et al.*, 2019). Insects harbour abundant microorganisms in their intestinal tract, and interaction with their host varies from symbiosis to pathogenesis (Mrázek *et al.*, 2008). Phloem sap is rich in carbohydrates but deficient in nitrogen and essential amino acids (Pandey *et al.*, 2013). Gut bacteria associated with whiteflies provide balanced nutrition with essential amino acids (Douglas, 1998), nitrogen source (Gil *et al.*, 2004), resistance to temperature, insecticide and natural enemies (Montllor *et al.*, 2002; Oliver *et al.*, 2003; Werren, 2012) and immune responses (Weiss *et al.*, 2011) to their host. The present study investigated the cultivable and non-cultivable gut bacterial diversity of rugose spiralling whitefly

Materials and Methods

Surface disinfected RSW second nymphal stages were taken for culturable gut bacteria isolation (Indiragandhi *et al.*, 2007) and homogenized with 0.1 M phosphate buffer (pH =7.0) and serially diluted in sterile distilled water and placed on seven different bacterial growth media *viz*., Nutrient agar, Luria Bertani, MacConkey agar, Tryptic soy agar, Endo Agar, Reasoner's 2A agar and De Man, Rogosa and Sharpe agar (de Vries *et al.*, 2001). Petri plates containing gut homogenates were incubated for 48h at 28 ± 2°C and monitored for at 24h every interval and colonies were selected based on their colony morphology and subjected to molecular characterization. These gut bacteria were grown in nutrient broth for genomic DNA isolation using HipurA® Bacterial Genomic DNA Purification Kit and then amplified with 16S rRNA gene target universal primers 27F and 1492R in a thermocycler. Complete sequences obtained from the isolates were then aligned and identified using the e-server, EzTaxon (http://eztaxon-e.ezbiocloud.net/) (Yoon *et al.*, 2017) to determine their relative isolates. Identified sequence were submitted in NCBI. Non-cultivable bacteria were identified through the next generation sequencing. The metagenomic sequencing for V1-V9 region of 16S rRNA gene was performed using nanopore platform.

Results and Discussion

Results on 16S rRNA gene sequencing revealed that the cultivable bacterial isolates belong to 16 different species namely, *Bacillus licheniformis*, *Exiguobacterium mexicanum*, *Acinetobacter refrigeratoris*, *Bacillus manliponensis, Bacillus velezensis, Bacillus zanthoxyli, Bacillus albus, Bacillus altitudinis, Bacillus aryabhattai*, *Bacillus xiamenensis*, *Bacillus subtilis* sub sp. *stercoris*, *Bacillus siamensis*, *Lysinibacillus xylanticus, Arthrobacter nitrophenolicus*, *Pseudomonas stutzeri* and *Bacillus tequilensis.* Gene bank accession numbers were MN782273 to MN782284, MN784432 to MN784435, MN907648 to MN907660, MT027239 and MN907663 to MN907689.

Non-cultivable gut bacterial isolates identified by 16S rRNA metagenomic sequencing revealed the presence of *Candidatus Portiera*, *Lactobacillus*, *Wolbachia, Pseudomonas*, *Dialister*, *Faecalibacterium*, *Bacillus, Candidatus Tremblaya, Oscillospira*, *Lysinibacillus, Burkholderia*, *Gluconobacter*, *Clostridium*, *Vibrio*, *Ruminococcus*, *Streptomyces*, *Serratia*, *Acinetobacter*, *Streptococcus* and *Paenibacillus* in RSW. Sequences accession numbers are SAMN15150881, SAMN15150882, SAMN15150883, SAMN15150884, SAMN15150885, SAMN15150886, SAMN15150887 SAMN15150888, SAMN15150889, SAMN15150890, SAMN15150891, SAMN15150892.

Similarly, eleven bacterial genera were isolated from *B. tabaci* namely *Pseudomonas*, *Deinococcus*, *Sphingomonas*, *Acinetobacter*, *Staphylococcus*, *Modestobacter*, *Micrococcus*, *Bacillus*, *Kocuria*, *Microbacterium*, *Erwinia*, *Brevibacterium*, *Exiguobacterium* and *Moraxella* (Visôtto *et al.*, 2009; Ateyyat *et al.*, 2010; Indiragandhi *et al.*, 2010). And also, *Acinetobacter*, *Enterobacter*, *Exiguobacterium, Staphylococcus*, *Pantoea*, *Lysinibacillus*, *Delftia*, *Enterobacter*, and *Bacillus* were recorded in the rice sucking insect, *Nilaparvata lugens* (Malathi *et al.*, 2017).

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ES 02 OPS 01

Behavioural Response of Stored Product Insects to Various Food Bait Attractants

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Keywords: *Behavioural response, Rhyzopertha dominica, Tribolium spp., Sitophilus oryzae, attractants*

Introduction

Food baits are one of the strategies for monitoring and mass trapping of the stored product insects. Food attractants are exploited to detect several stored product insects (Bark, 1989). The food bait material used for detecting stored product insects may be a liquid or solid. The ability of food baits to attract insects is dependent on the presence of attractants (Subramanyam *et al.,* 1992).

Materials and Methods

The food bait materials *viz.* wheat flour, sorghum flour, pearl millet flour (20 g each) and control (without food) were filled in the four-arm olfactometer. Test insects viz., Lesser grain borer, *Rhyzopertha dominica,* red flour beetle, *Tribolium* spp., rice weevil, *Sitophilus oryzae* were starved for 24 h in Petri plates before the commencement of olfactory bioassay. Fifty unsexed adults were released in the centre of the olfactometer (7 mm hole) and it was covered with cloth to minimise the phototactic response of insects. Each treatment was replicated 5 times. The response of *R. dominica, Tribolium* spp. and *S. oryzae* was assessed on wheat flour, sorghum flour and pearl millet flour. On each arm, the numbers of settled and unsettled insects were assessed 30 Minutes After Release (MAR).

Results and Discussion

The highest orientation of *Tribolium* spp., *R. dominica* and *S. oryzae* was recorded in the olfactometer arm which contained wheat flour attracting 36.67% of *Tribolium* spp, 36% of *R. dominica* and 39.33% of *S. oryzae* respectively by 30 Minutes After Release (MAR) (Table 1). The results conform with the findings of Ukeh and Umoetok, (2007) who reported that both male and female *R. dominica* were attracted to maize and wheat grain. Vijay *et al.* (2020) reported that the highest orientation of *S. oryzae* was recorded towards sorghum (51%) in 20 MAR. These observations could be exploited for the development of kairomone compounds to manage stored product insects in cereal and millet storage.

Table 1. Orientation of stored product insects to cereal baits

Food bait	**Insect settled (%)**		
	***Tribolium* spp.**	***R. dominica***	S. oryzae
Wheat flour	36.67 (37.27) [a]	36.00 (36.87) [a]	39.33 (38.84) [a]
Sorghum flour	20.00 (26.57) [bc]	24.00 (29.33) [b]	20.00 (26.57) [c]
Pearl millet flour	22.00 (27.97) [b]	16.00 (23.58) [c]	12.00 (20.27) [d]
Control (without food)	4.00 (11.54) [d]	5.33 (13.35) [d]	2.67 (9.40) [e]
Unsettled	17.33 (24.60) [c]	18.67 (25.60) [bc]	26.00 (30.66) [b]
SEd	1.763	2.666	2.260
CD	?	?	?

Values in parentheses are the arcsine transformed data
Means followed by the same letter (s) in a column are not significantly different by DMRT (P=0.05)

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ES 02 OPS 02

Biology of *Spodoptera frugiperda* (J. E. Smith) on Sunflower, *Helianthus annuus* (Linn.)

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Keywords: *Spodoptera frugiperda, Helianthus annuus, biology, morphometrics, life fecundity*

Introduction

The fall armyworm *Spodoptera frugiperda* (J. E. Smith) (Noctuidae; Lepidoptera) is a dreaded insect-pest native to tropical and subtropical America (Luginbill, 1928 and Sparks, 1979) spread all over the globe and assumed the position of level A1 threat. where it has remained confined despite occasional interceptions by European quarantine services in recent years. The pest has currently become a new invasive species in West and Central Africa where outbreaks were recorded for the first time in early 2016. In India the invasion of *S. frugiperda* was reported first in May 2018 on maize from Shivamogga, Karnataka (Sharanabasappa and Kalleshwaraswamy, 2018). The growth, development and reproduction of insects are directly influenced by the quality of host plant. The responses of insect herbivores to changes in host plant quality vary within and between feeding guilds (Awmack and Leather, 2002). Hence, the basic biological studies of insect pest on different food sources are important for addressing the effect of the nutritional composition on biological and life fecundity parameters of *S. frugiperda.*

Material and Methods

The study was conducted at the Department of Agricultural Entomology, College of Agriculture, Latur, VNMKV, Parbhani. The biology, of *S. frugiperda* on sunflower host was studied in laboratory condition. Duration of all the stages of *S. frugiperda* on Sunflower host was recorded and data were presented as mean ± SD and range (days). One hundred numbers of larvae were reared on leaves as well as head of sunflower.

Result and Discussion

While studying the biology of *S. frugiperda* on sunflower host the following observations was obtained. Females gives 400-1000 eggs with mean of 691.60 eggs per female. Average incubation period of eggs of *S. frugiperda* was 2.70 days with range of 2-3 days and per cent egg hatchability was 96.40 per cent. The larval period observed is 13-15 days with mean of 13.74 days. Mean developmental period of I to VI larval instar was 2.74, 2, 2, 2, 2 and 3 days, respectively. Range of pupal period was 7-9 days with mean of 7.55 days. The pre-oviposition period, oviposition period and post-oviposition periods were 3.16, 1.84 and 3.53 days, respectively. Adult longevity of male and female was ranges from 6-7 and 8-9 days, respectively, with mean of 6,92 and 8.53 days, respectively. The total life cycle of male and female of *S. frugiperda* on sunflower host was ranged from 30-31 and 31-33 days, respectively, with mean of 30.31 days and 32.42 days, respectively.

Table 1. Growth and development of *S. frugiperda* reared on sunflower leaves (n-100)

Stages	Mean±SD	Range (days)
Incubation period	2.60±0.41	2.00-3.00
Larval period	13.74±0.43	13.00-15.00
I instar	2.74±0.51	2.00-3.00
II instar	2.00±0.00	2.00
III instar	2.00±0.00	2.00
IV instar	2.00±0.00	2.00

Stages	Mean±SD	Range (days)
V instar	2.00±0.00	2.00
VI instar	3.00±0.00	3.00
Pupal period	7.55±0.11	7.00-9.00
Pre-oviposition period	3.16±0.20	3.00-4.00
Oviposition period	1.84±0.33	1.00-2.00
Post- oviposition period	3.53±0.23	3.00-4.00
Fecundity/female (Numbers)	691.60±28.11	400-1000
Egg hatchability (%)	96.40±1.81	94-98
Adult longevity Male Female	6.92±0.13 8.52±0.31	6.00-7.00 8.00-9.00
Total life cycle (egg to adult) Male Female	 30.81±0.46 32.42±0.41	 30.00-31.00 31.00-33.00
Sex ratio	1:1.02	-

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ES 02 OPS 03

Herbivore-Host Interaction Under Elevated Temperature and Elevated Carbon dioxide: A Study on the Demography of Maize Fall Armyworm *Spodoptera frugiperda* (J. E. Smith) (Noctuidae: Lepidoptera)

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Keywords: *Elevated temperature; elevated CO_2; biochemical components; maize; FAW*

Introduction

In recent years, overall agriculture has been influenced by climate change *viz.,* increased temperature and CO_2 concentration, which in turn have effects on insect-plant interactions. The effect of elevated temperature and CO_2 may greatly influence the growth, development, quality, nutrition status and yield of the host plants. The life cycle of insect could be directly influenced by stable and variable temperature and indirectly affected by elevated CO_2 through the difference in host plant biochemistry and metabolism, which leads to the variations in chemical composition. In light of these, the present research was programmed to study the host plant and insect herbivore interaction under elevated temperature and elevated CO_2 concentration.

Materials and Methods

Experiments were undertaken to study the life history of fall armyworm *Spodoptera frugiperda* in maize at elevated temperature and elevated CO_2 concentrations under Open Top Chamber (OTC) and Soil Plant Atmosphere Research (SPAR) system, respectively. Six levels of temperature (31°C, 32°C, 33°C, 34°C, 35°C and 36°C) and carbon dioxide (415 ppm, 430 ppm, 460 ppm, 490 ppm, 520 ppm and 550 ppm) were maintained. For each set of experiment, samples were collected from the second and third leaf from top of the maize plants separately for the analysis of ten different biochemical components. The life history of *S. frugiperda* was performed using the computer program, TWO-SEX MS Chart. The population survival curve over different lengths of time period was estimated using Kaplan-Meier analysis (Kaplan and Meier, 1958). GLM–ANOVA (Generalized linear model repeated measures ANOVA) was carried out for fertility rate (m_x) and survivorship (l_x). Experimental groups were tested against single control using Dunnett's test.

Results and Discussion

Biochemical analysis of maize leaves revealed that with increase in temperature and CO_2 concentrations, there was increase in carbohydrate, protein, proline, phenol, tannin and carbon content but reduction in C: N ratio, vitamin C and chlorophyll content (Figure 1). The age specific survivorship of fall armyworm decreased with the progress of age at elevated temperature and CO_2 concentrations (Figure 2). The increased fertility and population outburst were recorded up to 34°C and 490 ppm. The rise in temperature and CO_2 concentrations above the ambient environmental condition directs to variation in demography of *S. frugiperda* through biochemical changes in the host plant maize (Sreenivas *et al*., 2019).

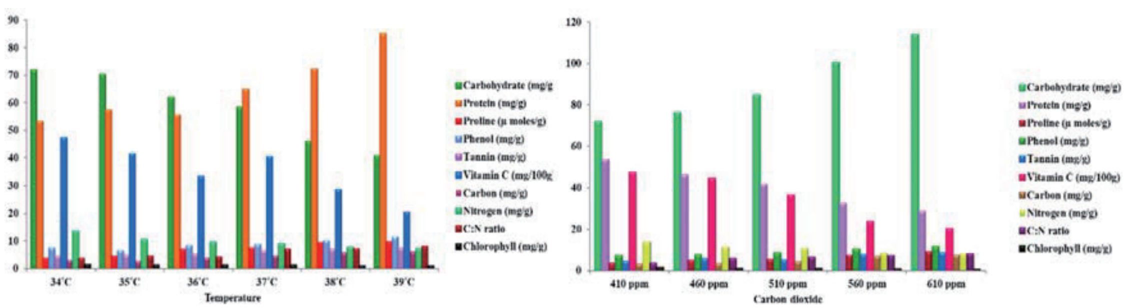

Figure 1. Biochemical estimation from maize leaves under elevated temperature and CO_2

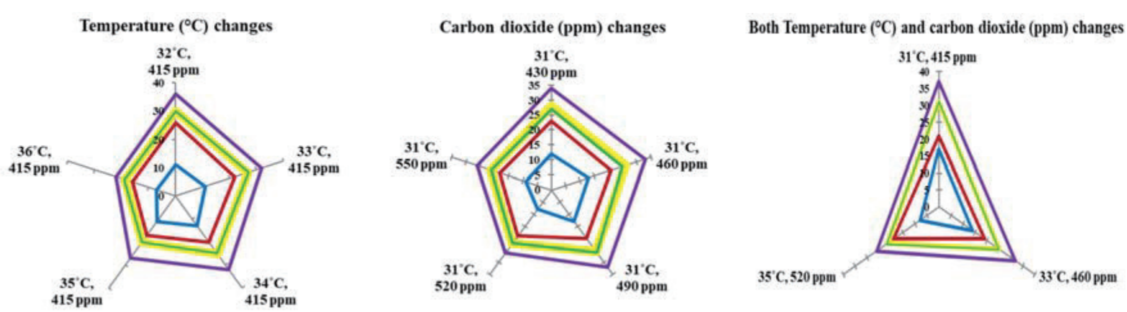

Figure 2. Survivorship of *S. frugiperda* under elevated temperature and CO_2

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ES 02 BOPD 01

Seasonal Incidence of Pink stem borer, *Sesamia inferens* in Barnyard Millet

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Keywords: *Barnyard Millet, Pink stem borer, Sesamia inferens, seasonal*

Introduction

Barnyard millet is a multi-purpose crop which is cultivated for food and fodder. It occupies a special place in the marginal and rainfed areas mainly due to its short life cycle and low requirement of water for its growth. It is a very good source of nutrients like proteins and dietary fibres and also contains high amount of soluble and insoluble fractions. In the account of the grains with high nutrient content, the demand for this crop has been recently increased. So, the present study has been under taken to study the seasonal incidence of pink stem borer to identify the suitable management practice for Sesamia inferens**.**

Methodology

The seasonal incidence experiment was conducted in the fields of AC & RI, Madurai. The barnyard millet variety, MDU 1 was sown in field in an area of 25 cents in two seasons respectively. All the agronomic practices were followed properly and no plant protection chemicals were applied. Observations on the stem borer incidence were recorded at weekly interval with three replications throughout the cropping period, by removing the dead hearts every time.

The damage levels were assessed by recording the total number of tillers and damaged tillers and comprising the percent incidence of the borer as

$$\text{Percentage of incidence} = \frac{\text{Damaged tillers with dead heart or white ear}}{\text{Total no. of tillers}} \times 100$$

Also, weather parameters like maximum temperature, minimum temperature, rainfall, relative humidity, *etc.,* at AC & RI, Madurai were recorded during the cropping season. The seasonal incidence of *S. inferens* was assessed through correlation and regression studies of weather parameters and per cent incidence in both seasons (Katke and Patel, 2014).

Result and Discussion

The pink stem borer damage was very low during the months of November and December. While the incidence was more during March and April months. Mahesh *et al.* (2013) reported the natural incidence of pink stem borer in sugarcane. The incidence was started from second week of March and reached its peak during first week of May. The slight variation in incidence may be due to planting date and agro-ecosystem of that habitat. The incidence got reduced after the onset of monsoon (Table.1)

The maximum temperature, minimum temperature had positive correlation and morning relative humidity, evening relative humidity and rainfall had negative correlation with white ear damage by pink stem borer. The weather parameters contribute more towards pink stem borer damage. This is in congruence with Hussian *et al.* (2018), who reported the population dynamics of stem borer. The incidence was started from September and lasted up to May. The incidence was more when the temperature was high (Table.2)

Table 1. Correlation matrix: Influence of weather parameters on the incidence of pink stem borer in barnyard millet

Population	Correlation	Temperature(°C)		Relative Humidity (%)		Rainfall (mm)
		Maximum	Minimum	Morning	Evening	
S. inferens	r	**0.578	0.144	- 0.345	- 0.439*	- 0.241
	Y = a + bx	Y = - 115.57 + 3.63x	Y = -15.22 + 1.78x	Y = 95.35 – 0.99x	Y = 47.37 - 0.79x	Y = 14.07 – 0.70x
	Significance (P value)	0.002	0.135	0.650	0.276	0.050
	Non significance (P value)	-	NS	NS	-	NS

NS - Non significant

*significant at 5% Level of significant

**significant at 5% and 1% Level of significant

Table 2. Multiple linear regression models for weather parameters on the incidence of pink stem borer

Population	No. of observations	Constant	Temperature(°C)		Relative Humidity (%)		Rainfall (mm)
			Maximum	Minimum	Morning	Evening	
			(X_1)	**(X_2)**	**(X_3)**	**(X_4)**	**(X_5)**
S. inferens	30	- 204.537	6.522	- 3.854	0.305	0.526	- 1.056

Multiple linear regression equation: $Y= -204.537+6.522X_1–3.854X_2 +0.305X_3 +0.526X_4-1.056X_5$ Coefficient of determination (R^2) = 0.478

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ES 02 BOPD 02

Biology of Fall Armyworm, *Spodoptera frugiperda* (J.E. Smith) in Banyard Millet

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Keywords: *Spodoptera frugiperda, barnyard millet, biology, life cycle.*

Introduction

In India fall armyworm (FAW), *Spodoptera frugiperda* (J.E.Smith) was first reported in July, 2018 from Karnataka (Sharanabasappa *et al*., 2018a). In Tamilnadu it was reported in sugarcane from Karur during August, 2018 (Srikanth *et al*., 2018). In recent this is a major pest of maize, which feeds on more than 100 hosts. And it was first reported in barnyard millet from Madurai, Tamilnadu during 2020 (Roopika *et al*., 2020). Hence the biology of FAW in barnyard millet was studied along with duration of different life stages.

Materials and Methods

Larvae from barnyard millet field was collected, fed with barnyard millet leaves and reared individually in rearing trays to avoid cannibalism. The later instar larvae were maintained in trays with sand for easy pupation. Pupae were transferred to adult rearing cages. Adults emerged were maintained at adult rearing cage, fed with honey solution mixed with vitamin E tablets and allowed for egg laying. And in successive cycle's biology of FAW in barnyard millet was studied by maintaining five replications and observations on duration of egg, larvae, pupa, adult and fecundity rate of female were made.

Results

The eggs were laid in mass and covered with tuft of hairs. The egg duration was 2.8 ± 0.83 days. The larva has four characteristic spots on the last second abdominal segment forming a square. The inverted 'Y' shaped mark was seed on the head. The larva has six instars. The instar duration was 3.2 ± 0.83 days. The second, third, fourth and fifth instar duration were 3.0 ± 0.70, 2.4 ± 0.54, 2.6 ± 0.54 and 3.4 ± 0.89 days. The sixth instar larval duration was 6.0 ± 0.70 days. The total larval duration was ranged from 17 to 23 days with a mean of 20.6 ± 2.07 days. The pupal duration was 8.8 ± 1.30 days. The adult duration was 10.2 ± 2.04 days. The female adults were laid around 5 to 9 egg mass in the leaves. The fecundity was 7.6 ± 2.07 egg mass per female adult. The male moths shown triangular shaped spots near to tip and near the center of the wing and female moths has uniform grayish color forewings.

Table 1. Biology of fall army worm, *Spodoptera frugiperda* (J.E. Smith) in barnyard millet

Life stages		Mean ± SE *
Egg duration		2.8 ± 0.83 Days
Larval duration	I instar	3.2 ± 0.83 Days
	II instar	3.0 ± 0.70 Days
	III instar	2.4 ± 0.54 Days
	IV instar	2.6 ± 0.54 Days
	V instar	3.4 ± 0.89 Days
	VI instar	6.0 ± 0.70 Days
	Total larval period	20.6 ± 2.07 Days
Pupal duration		8.8 ± 1.30 Days
Adult duration		10.2 ± 2.04 Days
Total life cycle		42.2 ± 4.26 Days
No. of Egg mass laid by gravid female		7.6 ± 2.07 Egg mass

*Each value is the mean of five replications;Mean followed by standard deviation

Reference

Roopika, M., Srinivasan, G., Shanthi, M., Moorthy, A.V and Prabhu, R. 2020. First record of barnyard millet as new host for fall armyworm, *Spodoptera frugiperda* (J.E. Smith) in Madurai, Tamil Nadu. International Seminar on Transboundary Pest management, TNAU, Coimbatore.

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ES 02 BOPD 03

Preferential oviposition of tea mosquito bug, *Helopeltis antonii* Signoret in guava, neem and moringa with their feeding symptoms

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Keywords: *Helopeltis antonii, symptoms of damage, ovipositional preference.*

Introduction

Now-a-days, tea mosquito bug (TMB) has been emerging as a major problematic pest of guava, moringa and neem. Biology of TMB mainly depends on suitable climatic conditions and also on hosts and varieties in which it feeds. They determine the growth, development, fecundity, longevity and life cycle of TMB. Since, the host range and damage of TMB have been increasing in recent past, the need of managing this pest became the important task, hence the current study is focused on the damage symptoms and ovipositional preference of TMB in guva, moringa and neem which pave a good way in managing the pest in these hosts during further research and studies. And so, an investigation has been made during the year 2019-2020 to study the preferential oviposition of TMB in guava, neem and moringa.

Materials and Methods

A comprehensive survey was conducted in Dindigul and Theni districts of Tamil Nadu for the TMB incidence on guava, neem and moringa. In all the locations, the symptoms of damage in each host were observed and documented. The rearing cage having size of 74 X 74 X 74 cm made with aluminium is used for mass culturing TMB. The seedlings were replaced three days once based on feeding punctures and drying of leaves. To evaluate the ovipositional preference of tea mosquito bug among the hosts, choice tests were conducted with five replications. The cashew, neem and guava seedlings were placed together and five pairs of adults were released inside the cage. Symptoms on feeding and oviposition injuries by nymphs and adults were observed in young leaves and twigs of moringa and neem seedlings as well as mid rib of young leaves in guava. Also observations on total number of eggs laid till 7th day after release were made individually on each host, using hand lens of 10X magnification (Sundararaju and John, 1992).

Results and Discussion

In guava the growing meristem get dried due to feeding of TMB. Irregular necrotic spots are formed on young leaves. Egg laying of TMB is found on mid rib of young leaves. After hatching the first instar nymphs congregate over the young leaves and in later stages the nymphs spread away to other flushes and fruits for feeding. In fruits, there will be formation of corky out growths developed along the feeding puncture of TMB. As the fruit size increases, the size of scab also increased and later formation of cracks over the fruits occur. The infestation of TMB was observed more during flowering and fruiting stage of guava crop. In moringa, due to TMB infestation, the leaves and flowers dry and resembles wilted appearance. The nymphs and adults feed on young twigs and flowers and at severe stage the tree wilts. In some occasions the bugs will even feed on pods. In neem the nymphs and adults feed on young flush. There is exclusion of honey like resins from the dried young twigs. In both moringa and neem, the trees bloom again at next favorable season after infestation. According to Srikumar *et al.* (2016) TMB causes complete destruction of crops. In other hosts, the young and succulent parts of cashew such as the shoots, young leaves, inflorescence and fruits were fed by nymph and adult of TMB.

Among three hosts, neem has recorded a numerically higher number of eggs per female (5.76 ± 1.52 eggs/ female) followed by guava (4.52 ± 1.05 mean number of eggs per female) and moringa (3.64 ± 0.89 mean numder of eggs/ female). The descending order of preference of tea mosquito bug for egg laying is neem, guava and moringa (**Table 1**). This was in accordance with Selvamuthukumaran (2001).

Table 1. Ovipositional preference of tea mosquito bug, *H. antonii* in different hosts in laboratory condition

Host	No. of eggs laid/ female*
Guava	4.52 ± 1.05
Neem	5.76 ± 1.52
Moringa	3.64 ± 0.89

*Each value is the mean of five replications; Mean followed by standard deviation

Reference

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Plates

Adult TMB in guava fruit

Dried flushes on moringa tree due to TMB infestation

Moulted skin of TMB nymph in dried neem twig

ES 02 BOPD 04

Biology of Fall Armyworm, *Spodoptera frugiperda*(J.E. Smith) in maize

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Keywords: *Spodoptera frugiperda, maize, biology, life stages.*

Introduction

In recent the fall armyworm (FAW), *Spodoptera frugiperda* (J.E.Smith) is a major pest of maize, which feeds on more than 100 hosts. In India it was first reported in July, 2018 from Karnataka (Sharanabasappa *et al*., 2018a) and in Tamilnadu it was from Karur during August, 2018 (Srikanth *et al*., 2018). It causes major destruction of maize crops with incidence level raging from 1.85 – 30.86% in field level. In Tamilnadu it was also reported in sugarcane (Srikanth *et al*., 2018) and banyard millet (Roopika *et al*., 2020). Hence the biology study was carried out and duration of different life stages was noted down.

Materials and Methods

A short study on biology of FAW was done by collecting egg mass from maize field with 15 days old crops and maintained at room temperature for hatching. The hatched larvae were fed with maize leaves and reared individually in rearing trays to avoid cannibalism. The later instar larvae were maintained in trays with sand for easy pupation. Pupae were transferred to adult rearing cages for adult emergence. The adults were fed with honey solution dipped cotton. For egg laying by gravid female, maize whorl were kept inside the cages. For biology study, five replications were maintained and observations on duration of egg, larvae, pupa, adult and fecundity rate of female were made.

Results

Form the study it is evident that the fall armyworm has an egg stage, six larval instars, pupal stage and adult stages with complete metamorphosis. The egg duration of FAW is 2.8±0.83 days, larval duration 16.4 ± 2.30 days, pupal duration 7.6 ± 1.14 days and adult duration 6.8 ± 1.30 days. Hence the total life period of FAW was 33.6±3.78 days. Number of egg mass laid by a gravid female was 9.6 ± 1.51 egg mass/female. This is in accordance with Sharanabasappa *et al*., 2018b, who reported the life cycle of FAW in maize.

Table 1. Biology of Fall army worm, Spodoptera frugiperda (J.E. Smith) in maize

Life stages	Mean ± SE *	Range
Egg duration	2.8±0.83 Days	2 – 3 Days
Larvae duration	16.4 ± 2.30 Days	14 – 18 Days
Pupal duration	7.6 ± 1.14 Days	6 – 8 Days
Adult duration	6.8 ± 1.30 Days	5 – 7 Days
Total life cycle	33.6±3.78 Days	30– 37 Days
Fecundity	9.6 ± 1.51 Egg mass	7 – 11 Egg mass

*Each value is the mean of five replications; Mean followed by standard deviation

Reference

Roopika, M., Srinivasan, G., Shanthi, M., Moorthy, A.V and Prabhu, R. 2020. First record of barnyard millet as new host for fall armyworm, *Spodoptera frugiperda* (J.E. Smith) in Madurai, Tamil Nadu. International Seminar on Transboundary Pest management, TNAU, Coimbatore.

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Sharanabasappa, C.M., Kalleshwaraswamy, R., Maruthi, M.S and Pavithra. H.B. 2018b. Biology of invasive fall army worm *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on maize. Indian Journal of Entomology 80(3): 540-543.

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ES 02 BOPD 05

Population Dynamics of Pests and its Natural Enemies' Occurrence in Citrus Garden

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Keywords: *Citrus, Population dynamics, economically important pests, natural enemies*

Introduction

Citrus is the largest cultivated group of fruits in the world, which includes mandarin, sweet orange, lemons, tangerines and grape fruit. The various factor of lower yield in India pest problem is one of the major constraints in the production of citrus. Citrus crop is being infested by large number of economically important pests. However, 120 insect species were reported in citrus from India. The major pests of citrus are citrus butterfly larva, *P. demoleus* followed by Cowbug, Grasshopper, Ashweevil complex and Leaf miner. In this study, we assessed the variety of insect pests occur in citrus orchard.

Materials and Methods

In order to study the population dynamics and impact of weather parameters on incidence of various pests and its natural enemies in citrus orchard, a field experiment was carried out at Sethu Bhaskara Agricultural College and Research Foundation, Karaikudi from December 2018 to April 2019 on existing trees of acid lime. The observations on various pest populations and its natural enemy's incidence were recorded at weekly interval on the basis of number of larvae, grub, adult and leaf infestation for citrus leaf miner. Plots were kept completely free from the spray. For this purpose, 10 trees were randomly selected and tagged. Observation on pest population was recorded from randomly selected trees. Data regarding weather parameters were obtained from Agricultural Meteorology, SBAC & RF, Karaikudi. The relationship between weather factors and pest occurrence was established.

Results and Discussion

We have taken count at weekly basis for 20 weeks. All the data are pooled together to month wise. So, totally 5 months observation has been recorded from December - April. The population density was at the peak during December and January based on our data. The maximum citrus butterfly *P. demoleus* larval population and leaf infestation were recorded with an average of 3.15 in the month of December and minimum was observed in the month of March (0.75) because of severe heat. Ash weevil incidence was found to be high in December (2.55) and found to be low in April (0.57). Population dynamics of cowbug incidence was found to be high in December (2.3) and found to be low in April (0.6). Citrus leaf miner incidence was observed very high in the month of December (2.2) because of moderate temperature and found to be low in April (0.8). Grasshopper incidence was found to be high in December (2.17) and found to be low in April (0.7) because of high temperature.

Citrus Butterfly

Ash weevil

Leaf Miner

Parasitized citrus larva
By Tachinid

Figure 1. Insect Pests of Citrus and natural enemy of Citrus butterfly

Table 1. Population of different insect pests in Citrus

S. No.	Month	Average of pest incidence for different insect pests in Citrus				
		Citrus Butterfly	Ash weevil	Cow bug	Leaf miner	Grasshopper
1.	December	2.65	2.55	2.3	2.2	2.17
2.	January	2.4	2.05	1.5	1.9	1.43
3.	February	2.5	0.65	0.6	0.8	0.6
4.	March	0.75	0.75	0.8	0.9	0.7
5.	April	1.1	0.57	0.6	0.8	0.7

Each values are the mean 4 weeks. The above data revealed that population dynamics of pest was found to be high in winter season (December and January as temperature was low as well as moderate and pest population found to be low in succeeding summer months (February - April) as the temperature was high. We also recorded naturally occurring biocontrol agents like tachinid parasitoid and nuclear polyhedrosis virus affected larva with tree top disease symptom.

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ES 02 BOPD 06

Evaluation of Organic Inputs Against Citrus Butterfly, *Papilio Demoleus* Linnaeus on Citrus Trees

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Keywords: *Citrus Butterfly, botanical extracts, ecofriendly, organic pest management*

Introduction

Citrus industry is the third largest, in the world after mango and banana. The lemon butterfly, *Papilio demoleus* Linnaeus (PDL) is one of the economically important pests whose larval forms cause serious damage to citrus family by devouring large quantity of foliage during the later stages of their development. Under present globalized situation of the world scenario, the side effect of chemical pesticides on non target organisms including Natural enemies, Animals and human beings has been increased. Hence pest management with botanicals and bio-rational pesticides are the only method to solve these environmental pollution problems.

Materials and Methods

Experiment was conducted in the Citrus orchard of SBAC & RF, Karaikudi in 100 numbers of Citrus trees. The experimental materials used are Botanical Herbal Extract (100 ml/L) prepared by the combination of *Calotropis*, *Azadirachta*, *Ipomea fistulosa* and *Ocimum* foliages, Panchakavya (30ml/L), Agni Asthra (50ml/L), Neem Asthra (10ml/L), Coleus whole plant aqueous extract (10ml/L), Lemon grass aqueous extract (10ml/L) and Neem oil (3%). Botanical extracts were sprayed to run off point using a high volume hand operated knapsack sprayer with hydraulic cone nozzle. Larval population of Citrus butterfly, *P. demoleus* per tree was assessed from all treated citrus trees on pre-treatment (one day before treatment) 3, 7 and 10 days after sprays / treatments (DAT). The data from various field experiments were scrutinized by RBD analysis of variance (ANOVA) after getting transformed into $\sqrt{x+0.5}$, logarithmic and arcsine percentage values where appropriate (Gomez and Gomez, 1984)

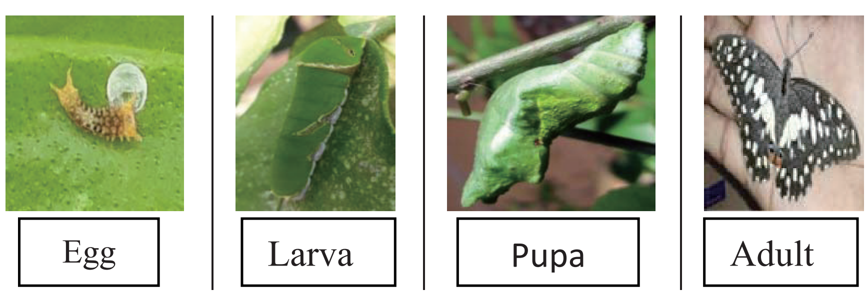

Figure 1. Life stages of ***Papilio demoleus*** **L.**

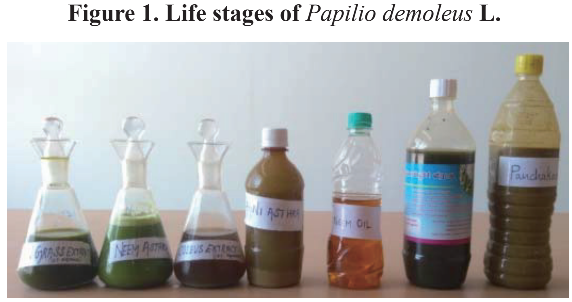

Figure 2. Organic inputs used

Results and Discussion

From the following Table 1, the data revealed that Agni Asthra shows significant larval reduction with lowest population of mean value 0.60 with 62.2 per cent reduction over control. Botanical herbal extract was the next best treatment shows 0.89 larvae per tree (62% reduction over control) and Panchakavya shows 0.70 larvae per tree (45% reduction over control), Neem Asthira revealed that 0.71 larvae per tree (45% reduction over control), Coleus extract resulted 0.72 larvae per tree (45% reduction over control) and this was on par with the Neem Asthira, Lemon grass extract shows that 1.16 larvae per tree (47% reduction over control) and this was on par with the Neem oil with 1.16 larvae per tree after the spray.

Table 1. Effect of organic inputs against citrus butterfly, *P. demoleus* on citrus trees

Treatments and doses (per litre of water)	Number of larvae per tree on days after treatment				Mean	Per cent reduction over control
	Pre count	3rd DAT	7th DAT	10th DAT		
T1-Botanical herbal extract (100 ml)	1.5	0.8^{b}	0.8^{b}	1.0^{b}	0.89^{c}	62.0
T2-Panchakavya (30 ml)	0.8	0.6^{a}	0.7^{a}	0.8^{a}	0.70^{b}	45.0
T3-Agni asthra (50 ml)	1.5	0.5^{a}	0.6^{a}	0.7^{a}	0.60^{a}	62.2
T4-Neem asthra (10 ml)	0.8	0.6^{a}	0.7^{a}	0.8^{a}	0.71^{b}	45.0
T5-Coleus extract (10 ml)	0.8	0.6^{a}	0.7^{a}	0.8^{a}	0.72^{b}	45.0
T6-Lemon grass extract (10 ml)	1.4	1.3^{c}	1.2^{c}	1.0^{b}	1.16^{d}	47.5
T7-Neem oil (3 %)	1.5	1.3^{c}	1.2^{c}	1.0^{b}	1.16^{d}	51.3
T8-Untreated check	1	1.2^{c}	1.4^{d}	1.8^{c}	1.35^{e}	-
CD (0.05%)	-	0.09	0.18	0.20	0.28	-
SEd	-	0.04	0.08	0.10	0.13	-

Data are mean values of three replications.

Figures were transformed by square root transformation and the original values are given

Means within columns lacking common lower case superscript are significantly different ($P<0.05$)

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ES 02 BOPD 07

Predicted risk of Brown planthopper, *Nilaparvata lugens* (Stål) (Hemiptera: Delphacidae) in India under chancing climate scenario

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Keywords: *Brown planthopper, Nilaparvata lugens, MaxEnt*

Introduction

Climate change is the key factor to regulate habitat distribution, species migration, seasonal population dynamics etc. of insect pests and diseases. The brown planthopper (BPH), *Nilaparvata lugens* (Stal) is one of the major insect pest of rice in Indian subcontinent. Being the world's second largest producer of rice, India suffers a severe loss due repetitive outbreaks of *N. lugens* in many part of the country. *N. lugens* has the capability of damaging rice cultivation from vegetative stage to reproductive stage and its infestation leads to "hopper burn" symptom (Pandi *et al.,* 2018). The present study attempted to understand the potential suitable geographical areas for population dynamics and spread of BPH in India.

Methodology

A species distribution model, MaxEnt (maximum entropy modelling program) was used to map a suitable habitat for BPH under current climate and future climatic scenarios for 2050 and 2070 (Elith *et al.,* 2006). The annual mean temperature, precipitation of coldest quarter and precipitation seasonality are predicted the most important environmental variables determining the potential distribution of BPH. Model predictions of each location were imported to geographic information system (GIS) and maps were generated using ArcMap. Four approximate categories, low (<0.265), mild (0.265-0.4), moderate (0.4- 0.6) and high (0.6- 1) of BPH occurrence at current and future scenarios were defined based on the predicted habitat suitability. Spatial analyst tool in ArcGIS was used for computing the area (km^2) under each polygon. Absolute and percentage areas under each category of an index for current and future scenarios were calculated.

Results

Our model suggested that approximately 30% area of India is currently suitable for *N. lugens*. Highly suitable habitats of BPH are predicted in the states of Tamil Nadu, Andhra Pradesh, Telangana, Odisha and Punjab. States like Chhattisgarh, West Bengal, Bihar, Jharkhand, Haryana, southern parts of Karnataka and coastal regions of Kerala have moderate suitability, while states like Maharashtra, Gujarat, Rajasthan, Madhya Pradesh, Himachal Pradesh, north eastern states, Jammu and Kashmir are unsuitable for BPH distribution. The Southern and Eastern rice-growing areas of Indian mainland are particularly predicted with high risk of *N. lugens* spread and dispersion due to better adaptability of the pest species to these regions climate as against very low to nil risk in the western India.

Our results revealed that total area under high risk was 7.5% (i.e. ~238192.6 KM^2) at present climatic scenario, which expected to increase into the tune of 15 to 27 % (i.e. ~519046.905.1 to 887744.5 KM^2) at 2050 and 15 to 58% (i.e. ~ 481090.5 to 1899556 KM^2) at 2070 (Fig. 1). The predicted percentage of high habitat suitable area for *N. lugens* at present is less than 10% in India, whereas in the projected climate scenario high habitat suitable area of *N. lugens* was doubled up at 2050 and tripled up at 2070. Likewise moderate habitat suitable area also increased from 20% at present to 30-40 % in near future at 2050 and 2070 (Fig. 1). Percentage changes of area suitable for *N. lugens* over current scenario exhibited a unique trend as low and mild habitat suitable area was found in negative trend, whereas moderate and high habitat suitable area was increased for both the projected scenario of 2050 and 2070 in all four RCP (RCP 2.6, RCP 4.5, RCP 6.0, RCP 8.5) (Fig. 1).

Conclusion

Present study is the first attempt to understand the *N. lugens* distribution and habitat suitability under the changing climate scenarios in India based on MaxEnt model with 10 climatic variables. The current study have produced clear and more accurate potential distribution map of *N. lugens* under current and future climate with more environmental factors, hence could more clearly reveal the survivability of the pest. Results from present study will be used by researchers, agriculture departments and policy makers for designing national-level *N. lugens* management strategies.

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ES 02 BOPD 08

Stored Product Insects Identified in Cashew and Peanut Kernels

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Keywords: *Stored product insects, cashewnut, peanut*

Introduction

Cashew (*Anacardium occidentale* L.) is one of the most valued processed nuts traded in global market and India is among the top producers of cashew. During processing, various grades of kernels are obtained, mostly the higher grades (wholes and splits) are preferred for export. Brokens and bits are retailed in local markets. As they are cheaper compared to other grades, they are preferred by restaurants, confectioners and bakers for utilizing in various culinary. Generally, the high graded produce is paid much attention during processing, handling and storage. Peanut (*Arachis hypogaea* L.) is another important crop of India which has export potential for oil as well as table purpose and it is being processed in several cottage industries located in east coast of Andhra Pradesh. Stored product insects are considered as the major contributing factors of post harvest losses both qualitative and quantitative. They can pose huge threat to the entire supply chain in the processing facility. In view of the importance of nuts as export commodities, it is necessary to have scientific storage and preservation activities.

Materials and Methods

Samples (250 g) were collected in plastic containers (500 mL) from each processing centre and preserved in the laboratory at Post Harvest Technology Centre, Bapatla. A total of 30 cashewnut samples and 33 peanut samples were collected. They were observed for the presence of stored grain insect pests one day after collection and again observed for the emergence of insects twice at 30 days interval so that the immature insect pests if any, can also be identified after developing into adults. Upon sieving each grain sample, all adult insects collected were identified and counted.

Results and Discussion

Physical observations revealed the incidence of various species of stored product insects in both the nut samples collected from processing units. In most cases, though not visible immediately at the time of collection, emergence of insects was observed upon storage. Cashew and peanut kernels recorded eight and nine insect species, respectively, mainly representing two major insect orders *i.e.,* Coleoptera with six families, Lepidoptera with two sub-families and Acarina with one family (Table 1). The bruchid (*Caryedon serratus* Oliv.) was specific to peanuts and the remaining insect species were common to both the nuts. Both pods and kernels of peanut were susceptible to *C. serratus* (Rekha and Swamy, 2017). Dried fruit beetle (*Carpophilus hemipterus* L.) prefers moist produce particularly the ones contaminated with fungus or yeast (Nair *et al*., 1985). Hence, presence of these beetles is an indicator of damp and mouldy conditions. Storage mites (*Acarus siro* L.) consume stored grain and oilseeds, transfer toxicogenic microorganisms and produce allergens. Infestation by meal moth larvae causes heavy webbing in the produce, increases moisture and encourages mold growth. Once damaged by insect pests, they become susceptible to microbial and oxidative spoilage and a series of biochemical changes occur inside the kernels leading to the loss of nutritive value and quality of food staff.

The study further strengthens the need for close monitoring of stored product pests and moulds in the produce as they are the sources for contamination and secondary infestations. In designing of any pest management strategies, knowledge of existing insect fauna is useful to derive best benefit out of it. The information on the insect pest populations will help in taking necessary preventive measures in time.

Table 1. Insect species identified in cashew & peanut samples collected from processing centres

Common name	Scientific name	Order: Family
Groundnut bruchid*	*Caryedon serratus* Olivier	Coleoptera: Chrysomelidae
Red flour beetle	*Tribolium castaneum* Herbst	Coleoptera: Tenebrionidae
Saw-toothed beetle	*Oryzaephilus surinamensis* (L.)	Coleoptera: Silvanidae
Dried fruit beetles	*Carpophilus hemipterus* (L.)	Coleoptera: Nitiduliidae
Red-legged ham beetle	*Necrobia rufipes* De Geer.	Coleoptera: Cleridae
Rusty grain beetle	*Cryptolestes ferrugineus* (Steph.)	Coleoptera: Cucujidae
Rice meal moth	*Corcyra cephalonica* Staint	Lepidoptera: Pyralidae Sub: Gallerinae
Almond moth	*Ephestia cautella* Walker	Lepidoptera: Pyralidae Sub: Phycitinae
Grain mite	*Acarus siro* (L.)	Acarina: Acaridae

*Exclusive to peanuts

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ES 02 BOPD 09

Outbreak of *Naxa textilis parvipuncta* (Lepidoptera:Geometridae) in Lower Pulney Hills, Tamil Nadu, India

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Keywords: *Diospyros, N.t. parvipuncta, geometridae, outbreak*

Introduction

Indiscriminate use of pesticides in forest ecosystem for vegetables, spices and fruits leads to killing of natural enemies along with the pest and the absence of natural enemies, pest increase their population. Changes in climatic condition also favour reduction or increase in pest population. Under forest eco-system, such an increase in population of Lepidopteran pest was noticed on *Diospyros* trees. Here, we have reported for the first time the outbreak of *Naxa textilis parvipuncta* Prout 1916 from the Lower Pulney Hills, Dindigul District, Tamil Nadu, India.

Materials and Methods

Roving survey was made in and around Lower Pulney hills in Dindigul District during 2021. It was observed that the forest trees in the road side of Kuppammalpatti village, were severely affected with semi-looper. The pest was found to attack *Diospyros* species of forest tree. The larva constructed a silken web covering the entire tree resembling like a ball. Each affected tree harbors around 2000 – 3000 larvae. The grown-up larva moves down to earth through a silken thread and reaches ground level. The larva was identified with a red colour head, and the body was thick black with two white longitudinal stripes running from head to tail. Large number of white hairs were found throughout the body. Larvae were collected from the affected trees and brought to biocontrol laboratory for rearing and collection of adults for further identification. The emerged adult moths were sent to Department of Agricultural Entomology, TNAU, Coimbatore for identification.

Results and Discussion

The identified pure white medium sized moth was identified as *Naxa textilis parvipuncta* Prout 1916. The adult moth has black spots (4 nos) on each forewing. Two rows of black spots were also present in the coastal margin of both the wings. Earlier *N. t. purvipuncta* was reported from South Indian states of Kerala and Karnataka (Anonymus 2021). *N. t. textilis* was reported from North Eastern states like Arunachal Pradesh, West Bengal and Assam. This is the first report about the occurent of the *N.t.parvipuncta* in one more state, Tamil Nadu in South India. The identified *N. textilis purvipuncta* larva feeds on *Diospyros* tree species. Robinson *et al*., (2010) documented the presence of *Naxa textilis* Walker in *Olea dioica*.

Table 1. Distribution of *Naxa* species in different states of India

States	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Species	District/ year
Tamil Nadu					***	***							*N. t. parvi puncta*	Dindigul, 2021
Arunachal Pradesh					***						***		*N. t. textilis*	East Kameng, 2011
Assam											***		*N. t. textilis*	Jorhat, 2017
Karnataka								***		***			N.t.parvipuncta	Coorg, 2014
Kerala									***	***			*N.t.parvipuncta*	Idukki, 2010
West Bengal				***									*N. t. textilis*	Alipurduar, 2018

*Month of occurrence

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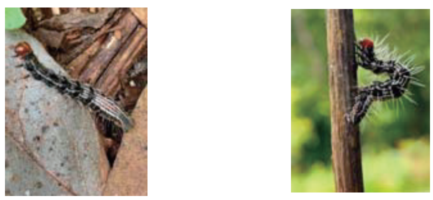
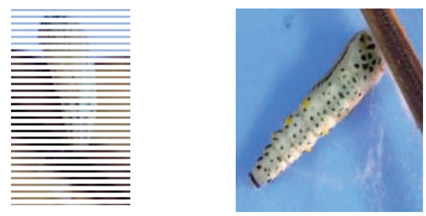
Acknowledgement: Authors thank Director, Centre for Plant Protection Studies, TNAU, Coimbatore for encouraging the scientist to keep on monitoring on any insect pest and diseases invasion and outbreak in their respective Districts.

Entire tree covered with silken web of *Naxa* larva

Drifting of larvae to the ground



Individual larva and its movement



Pupa dorsal and ventral view

***N. t. parvipuncta* moth**

Bipectinate antenna

Figure 01. Naxa textilis parvipuncta damage symptom and its bio stages

ES 02 BOPD 10

Qualitative and Quantitative Losses by three Bruchid Species in Pigeonpea

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Keywords: *Bruchids, Callosobruchus maculatus, C. chinensis, C. analis, pigeonpea, post-harvest losses, qualitative, quantitative, biochemical deterioration*

Introduction

Pigeonpea is an important legume food crop in semi-arid tropics of the world and chief source of protein for more than one billion people of developing countries. Bruchids of the genus *Callosobruchus* cause substantial post-harvest deterioration of pigeonpea seeds during storage. Direct feeding damage reduce seed weight, germination and nutritional value; and presence of dead insects and their remnants, mould growth lowers the market value. Previous studies reported 10-30, 19-56 and 24-55 per cent seed damage in pigeonpea by *Callosobruchus maculatus* (F.), *C. chinensis* (L.) and *C. analis* (F.), respectively (Jaiswal *et al.,* 2019). Seed weight losses were 8.9, 7.8 and 1.8 per cent due to infestation by *C. chinensis, C. maculatus* and *C. analis,* respectively (Ghosal and Senapati, 2006). The study was conducted to assess the qualitative and quantitative losses caused by three cosmopolitan bruchid species *viz*., *C. maculatus*, *C. chinensis* and *C. analis* in pigeonpea.

Materials and Methods

Three bruchid species used in the study were obtained from the pure cultures maintained in the Storage Entomology Laboratory, ICAR-IIPR (Kanpur). The pre-sterilized pigeonpea seeds (300 gm, variety: IPA-203) were infested with three pairs of each *Callosobruchus* spp. and infested seeds were incubated in the laboratory for three successive generations at 27±1°C temperature and 65±5 % RH. The experiment was conducted in CRD and replicated 5 times. The quantitative losses by three bruchid species like seed damage, weight loss, and qualitative deteriorations like decrease in seed viability, changes in seed moisture, carbohydrate and protein content were estimated.

Results and Discussion

Seed damage and associated weight loss differed significantly for three bruchid species. Highest seed damage was inflicted by *C. analis* (46.47 %) followed by *C. chinensis* (39.81 %) and *C. maculatus* (37.21 %) after F3 generation. However, highest weight loss was manifested in *C. maculatus* infested seeds (11.16 %), followed by *C. analis* (9.00 %) and *C. chinensis* (7.36 %). The gradual surge in seed damage and weight loss was apparent with increased in storage duration due to the higher population build-up of beetles in successive generations. The preferred feeding on the germ portion of the seeds steadily reduced the germination and seed vigour at every generation and being significant for three bruchids species. After F3, the germination was reduced to 3.50 % in both *C. analis* and *C. chinensis* infested seeds and 5.33 % in case of *C. maculatus* as compared to 96.80 % germination in healthy seeds. The biochemical deterioration following bruchid infestation was manifested by reduced protein and carbohydrate content of the seed flours and increased moisture content of the seeds, which differed significantly with uninfested samples by *t*-test ($p<0.05$). Protein content reduced by 6.25 % in *C. maculatus*, 5.12 % in *C. analis* and 2.03 % in *C. chinensis* infested seed flour while carbohydrate content reduced by 17.77, 13.11 and 11.76 % in *C. analis, C chinensis* and *C. maculatus* infested samples, respectively. Moisture content increased by 14.06 % in *C. analis,* 12.21 % in *C. maculatus* and 3.31 % in *C. chinensis* infested seeds. The increased moisture content was probably due to higher moisture absorption by infested seeds and moisture content from insect excreta and body fluids. The higher percentage of damaged seeds and increased moisture content by *C. analis* infestation was attributed to the higher population buildup than other species. The pronounced reduction in seed weight and protein content in *C. maculatus* infestation could be due to the intensive larval feeding by large sized species. The decreased carbohydrate content could be due to the larval feeding on the endospermic portion of the seeds (Nadhine and Rawat, 1985).

Conclusion

Present study gave the detailed account of qualitative, quantitative and biochemical deterioration of stored pigeonpea seeds and revealed that post-harvest infestation by three dominant bruchid species differed significantly in respect of quality and viability of seeds, beside physical deterioration.

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ES 02 BOPD 11

Field-carry-over Infestation of Bruchids and its Impact on Stored Pigeonpea

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Keywords: *Bruchids, pigeonpea, field-infestation-window, field-carry-over, WAFI and MAS.*

Introduction

Nearly 200 insect species are reported to infest pigeonpea crop at field and storage.The bruchids (*Callosobruchus* spp.) cause substantial losses to stored legumes including pigeonpea. Bruchids take several routes to enter store houses and field infestation is one among them. Although, the field infestation is found to be very low, the qualitative and quantitative deterioration of legumes is often realized under storage conditions as the field carried population multiplies by damaging grains at rapid rate, if the grains left unattended (Taylor, 1981; Nahdy *et al.* 1999). Reports on Bruchid field infestation in pigeonpea are limited to field infestation, confirmation of field carry-over through random pod collection, polymorphism in field infesting bruchids, phenotypic characteristics influencing field infestation (Nahdy *et al.*, 1999; Gandhi *et al.*, 2017), etc. Hence, the present study was emphasized on a systematic approach to identify level of infestation *vis-a-vis* crop stage and their field-carry-over impact on stored pigeonpea.

Materials and Methods

Investigations to identify the bruchid field infestation window and the impact of field-carry-over infestation on stored pigeonpea was carried out for two years; *kharif* 2018-19 and2019-20as per the methods (Revanasidda *et al.*, 2020). To identify field infestation window *vis-à-vis* crop stage, the infestation parameters on plants (per interval: n=10 plants/set, r=3) were recorded at eight definite intervals starting from two Weeks After Flower Initiation (WAFI) till crop harvest: seven at biweekly intervals from 2–14 WAFI and one during harvest. To confirm the field infestation and subsequent carry-over, a sets of plants were covered with bruchid proof nylon cages (Fig. 1) at similar eight intervals (per interval: n=20 plants per cage, r=3).The pods often plants from each cage were harvested and stored in separate cloth bags and observed for bruchid emergence at one Month After Storage (MAS).Similarly, the grains from remaining ten plants from each cages were harvested and stored in cloth bags, and observed at bimonthly intervals up to six months (n=50 gram grains per replication set) to quantify the impact of field-carry-over infestation on storage losses.

Results and Discussion

The bruchid species (*Callosobruchus maculatus* L.) was found to infest pigeonpea at field level during both years. Adults activity and pod infestation was commenced from 8th WAFI, whereas, the pod damage was recorded from 10th WAFI. Infestation parameters found incremental towards crop maturity. During *Kharif* 2018–19, the infestation (%),damage (%), and adult bruchid density (mean ± SE) per plant was ranged between 0.57–8.1, 0.24–4.85, and 0.83 ± 0.03–8.1 ± 0.25, respectively. Whereas, during *Khari* 2019–20, it was 0.86–7.26, 0.32–4.37, and 1.1 ±0 .06–6.3 ± 0.49, respectively (Fig.1). The pod density and infestation parameters were varied significantly between different biweekly intervals(Kruskal Wallis ANOVA at P<0.05).Although bruchids preferred completely developed green pods over matured dry pods, the correlation studies demonstrated a significant positive correlation (at P=0.01) with dry pod density than green pods. The pods harvested from the plants which were caged between 2–6th WAFI recorded nil infestation, whereas, the pods from the plants caged after 6th WAFI recorded higher infestation parameters at one MAS (Fig. 2).Besides, the grains which were harvested from the plants caged between 2–6th WAFI remained undamaged during storage, whereas, the grains harvested from the plants caged after 6th WAFI recorded significant grain damage with increase in storage duration due to the continuous perpetuation of infestation in successive generations of bruchids and damage reaching to > 90 per cent within six months of storage.

Present study reports the bruchid field-infestation *vis-à-vis* crop stage and the impact of field-carry-over infestation on stored pigeonpea which could open further scope to intervene with a suitable insecticidal measures (within existing IPM package for other field pests) to tackle bruchid infestation during identified field-infestation window and their subsequent impact on stored grains through field-carry-over.

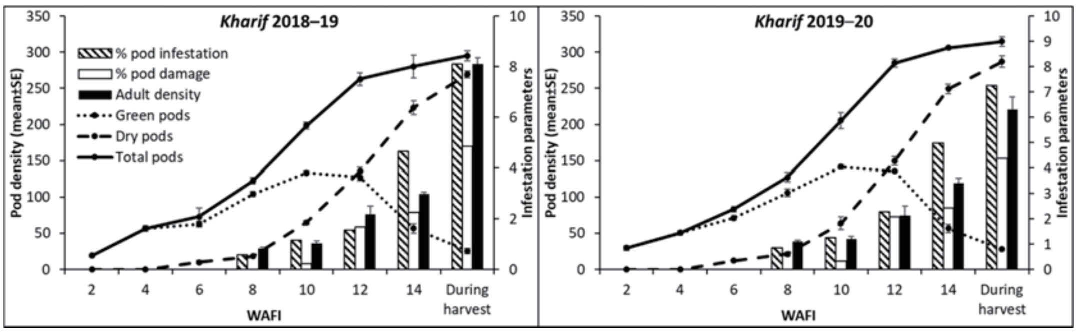

Fig. 1: Bruchid field infestation window*vis-à-vis* crop stage

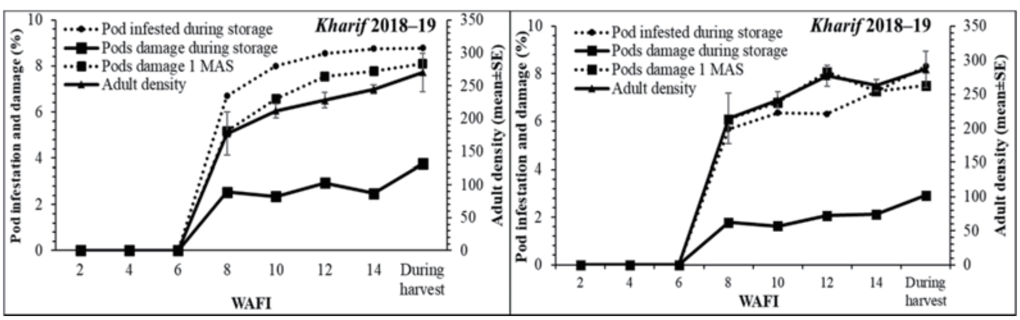

Fig. 2: Bruchid field-carry-over infestation *vis-à-vis* storage duration.

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ES 02 BOPD 12

Coincidence of Rugose Spiralling Whitefly and Bondar's Nesting Whitefly in Coconut Grooves of Cauvery Delta Zone

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Keywords: *Coincidence, rugose and bondari nesting whitefly, coconut grooves*

Introduction

India is the largest producer of coconut with a share of 19 per cent of world coconut production. Apart from major coconut pests *viz.,* rhinoceros beetle, red palm weevil and eriyophid mite, invasion of four neotropical whiteflies *viz.*, rugose spiralling whitefly, *Aleurodicus rugioperculatus* (Shanas *et al.,* 2016); bondar's nesting whitefly, *Paraleyrodes bondari* (Josephrajkumar *et al.,* 2019); nesting whitefly, *Paraleyrodes minei* (Chandrika Mohan *et al.,* 2019) and arecanut palm whitefly, *Aleurotrachatus atratus* (Selvaraj *et al.,* 2019) were also reported in coconut in India. The introduction of rugose spiralling whitefly from Pollachi areas to Cauvery Delta Zone was in 2016 and subsequently the bondari nesting whitefly in 2021 through the trade of planting materials was observed.

Materials and Methods

A field study was conducted to observe the coexistence of rugose spiralling whitefly and bondari nesting whitefly and their natural enemies, an encyrtid nymphal parasitoid, *Encarsia guadaloupae* and chrysopid predator, *Dichochrysa astur* in Madukkur, Pattukottai and Thiruvonam blocks of Thanjavur district and Kottur, Mannargudi and Muthupet blocks of Thiruvarur district. The population number of pests and natural enemies were counted in each 10 leaflets of 10 trees and per cent parasitisation was worked out.

Results and Discussion

The results of three observations revealed that the population of RSW ranged from 22 to 32, 17 to 39 and 21 nos / 20 leaflets in Pattukottai, Madukkur and Thiruvonam blocks of Thanjavur district whereas the population was 31, 15and 32 to 37 nos/ leaflet in Mannargudi, Muthupet and Kottur blocks of Thiruvarur district. The natural parasitisation of RSW by *Encarsia* ranged from 36.89 to 38.59, 27.35 to 41.91 and 34.80 per cent in the respective blocks of Thanjavur district and it was 35.44, 29.98 and 33.36 to 48.88 per cent in respective blocks of Thiruvarur district. The population of bondar's nesting whitefly ranged from 4 to 7,7 to 28 and 3.0/ leaflet in Thanjavur district and 4.0, 4.0 and 5.0 to 12.0 nos./ leaflet in Thiruvarur block. The population of the chrysopid predator, *Mallada* ranged from 0.4 to 0.5 nos/leaflet in all the blocks. The occurrence ratio of RSW: BNW were 1:4, 5.5 : 1 and 7:1 in Thanjavur and 6.4: 1, 7.7:1 and 3.7:1 in Thiruvarur districts.

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ES 02 BOPD 13

Outbreak of Mango Shoot Looper, *Perixera illepidaria* (Lepidoptera: Geometridae) in Theni District, Tamil Nadu, India

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Keywords: *Geometridae, shoot looper, inflorescence caterpillar, outbreak, cashew*

Introduction

Mango (*Mangifera indica* L.) is king of all fruits. India is the major mango producing and exporting country in the world. There are number of insect pests damaging mango tree but the most abundant and destructive are mango hoppers, mealy bug, stem borer, fruit fly, mango nut weevil and play a major role in bringing down the fruit quality and yield. In addition to these regular and major pests, some of the minor pests became major one to the level of outbreaks due to changes in climatic and other biotic factors. Mango looper/mango shoot looper *Perixera illepidaria* (Lepidoptera: Geometridae) (Vinodkumar *et al*., 2014; Soumya *et al*., 2021) is such a kind of pest observed in mango orchards during 2021.

Materials and Methods

Random survey has been made in Mango orchards in Sothuparai (10.1307°N, 77.4638°E) and Kumbakarai villages (10.1824°N,77.5293°E), Farm Orchard of Horticultural College and Research Institute, Periyakulam during March, 2021 where the mango crop is under maximum area in Periyaklam block, Theni district, Tamil Nadu. Severe incidence of looper was noticed in inflorescence of mango trees in both the villages irrespective to mango varieties. Ten mango trees were randomly selected and from each tree five branches were randomly chosen and from each branch five inflorescence were observed for number of larvae/inflorescence, no.of pupae/leaf, no.of adults/leaf (male) and no of adults/tree (gravid female).

Results and Discussion

In the surveyed mango orchards, on an average, from 28 to 32.85 looper/inflorescence, pupa 2.5 no/leaf, adult moths 4.5 nos/leaf, gravid female moth 6.5 nos/tree were recorded. Based on the following morphological characters of different biostages and the damage symptom, the looper was identified as *Perixera illepidaria* (Lepidoptera: Geometridae).

Larva: Larvae vary in colour from yellow to black, with a mottled or 'tiger' patterned appearance with brown bands. Larvae have a 'looping' appearance when moving, and may make silken threads that hang vertically between flower panicles and leaf material. These threads allow them to move on the plant to reach new feeding areas. Loopers feed voraciously on flowers and peanut size to immature fruits. Though the pest is mainly feeds on new flush, during reproductive stage/ peak season the incidence and looper population was more in mango inflorescence. Similar feeding symptoms in mango were reported from queensland mango orchard and litchi (*Litchi chinensis*) orchard in Bihar as a first case (Vinodkumar *et al*., 2014).

Pupa: The newly formed pupae were green in colour and distinctively triangular in shape. Before adult emergence green pupa turns to brown. More than 4-5 pupae were seen scattered on the upper surfaces of leaves.

Adult: The adult male was pinkish fawn, while females were rather uniformly pinkish. The wings of the adult had 2 rows of dark brown spots on the dorsal surface, the first row being just near the distal edge of each wing.

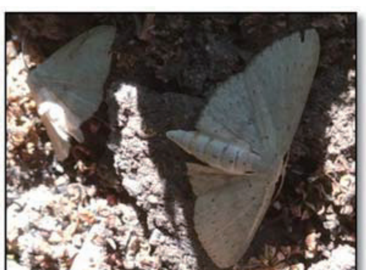
It is evident from our survey that the incidence of *P. illepidaria* in mango was high and caused severe damage to the foliage in vegetative stage and flowers and pea nut sized fruit during reproductive stage. During 2014, severe outbreak of *P.illipedarai* was noticed in litchi orchard in Bihar (Vinodkumar *et al*., 2014). Soumya *et al*., (2021) reported that the shoot looper causing damage to mango fruits at IIHR, Bengaluru. Researchers suggest that despite Mango and Litchi/lychee are known hosts, related plants such as rambutan, cashew and pistachio may also be considered as potential hosts. Hence, it is necessary to take up management trials for this looper in mango.

Damaged Inflorescence

Damaged peanut size mango

Looper on leaves

Pupae on upper side of leaf



***P.illepidaria* gravid female**

Roving survey in mango orchard

Fig. 01. Damage symptom and bio stages of mango shoot looper – *P.illipedaria*

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ES 02 BOPD 14

Vegetable Based Border Cropping Systems to Enhance Natural Suppression of Fall Armyworm, *Spodoptera frugiperda* (J.E. Smith) in Maize

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Keywords: *Cropping Systems, Spodoptera frugiperda*

Introduction

FAW has become a major threat to maize production in Tamil Nadu, since the region provides favourable climatic conditions for constant reproduction and continuous maize crop in a year in many areas. Farmers have experienced 30-45% yield loss in Kharif, Rabi and summer seasons in Tamil Nadu. Subsequently, the occurrence of the pest was also reported in sugarcane (Srikanth *et al*., 2018) and in Barnyard millet (Roopika *et al*., 2020) in Tamil Nadu. Indiscriminate use of synthetic chemical insecticides including insecticide cocktails for the immediate control of FAW resulted in the destruction of natural enemies which are already available in maize cropping systems. This condition warranted research on conservation of entomophages in maize ecosystem through ecological engineering based diversified cropping system approach to pull the entomophages into the maize. This research aims at determining the impact of vegetable based border cropping system in maize to reduce FAW damage through enhancement of natural biocontrol.

Materials and methods

The experiments were conducted under unprotected condition at Agricultural College and Research Institute, Vazhavachanur in two seasons during 2020 – 2021 in RBD with six vegetable border crops as per Table 1. Border crops were sown or planted in 3 to 4 rows around the maize crop by adjusting the timing of sowing or planting of border crops to coincide with the duration of maize. Larval population and damage of FAW; and number of grubs and adults of predators and parasitoids by *in situ* observation, sweep net and yellow water trap methods were counted once in a week from 7 DAS till the harvest. Maize grain yield, cost benefit ratio and pest defender ratio (PD ratio) were estimated.

Results and discussion

Maize pure crop registered significantly maximum FAW score of 2.50 per plant; maximum whorl and cob damage of 54.25 and 50.39 percent respectively; minimum population of coccinellids (1.02/plant) and spiders (0.82/ plant) and minimum PD ratio (1.05), yield (3220 kg/ha) and BC ratio (1.16). Lab lab border cropping system recorded lower FAW score (1.80/plant) whorl damage (36.87%), cob damage (21.73%) higher coccinellids (2.33/plant), spiders (1.17/plant), higher PD ratio (2.20), yield (4505 kg/ha) and BC ratio (1.72). Similarly, cluster bean border cropping system resulted in minimum FAW score (1.61/plant), whorl damage (26.04%), cob damage (24.22%), higher coccinellids (1.85/plant), spiders (1.23/plant), higher PD ratio (2.34), yield (4675kg/ha) and BC ratio (1.85).

Vegetables based border cropping systems such as bhendi, brinjal, tomato and chilli contributed significantly lower FAW score (1.60 to 1.85/plant); whorl damage (24.10 to 33.15%) and cob damage (23.16 to 25.31%); higher coccinellids (1.56 to 1.70/plant) and spiders (0.97 to 1.42/plant), higher PD ratios (2.25 to 2.82), yield (4340 to 4635 kg/ha) and BC ratios (1.62 to 1.84). Abundant availability of nectar, pollen and suitable sheltering places through diversified border crops might be the reasons for the enhancement of entomophages and natural FAW suppression, which was evidenced in ecological engineering based cropping methods in rice (Chandrasekar *et. al.,* 2017) and in black gram (Lokesh *et. al.,* 2017).

Table 1. Effect of vegetable based border cropping systems on FAW damage in maize CoH (M) 8

Treatment details	FAW Score / Plant	% Whorls damage	% of cobs damage	Coccinellids / Plant	Spider/ Plant	PD Ratio	Cob yield (kg/ha)	BC ratio
Maize + Lab lab	1.80	36.87	21.73	2.33	1.17	2.20	4505	1.72
Maize + Cluster bean	1.61	26.04	24.22	1.85	1.23	2.34	4675	1.85
Maize + Bhendi	1.65	24.10	23.33	1.65	1.17	2.82	4440	1.71
Maize + Brinjal	1.85	24.40	24.44	1.56	1.42	2.43	4340	1.62
Maize + Tomato	1.60	28.35	25.31	1.70	0.97	2.25	4400	1.67
Maize + Chilli	1.75	33.15	23.16	1.58	1.31	2.77	4635	1.84
Maize pure crop	2.50	54.25	50.39	1.02	0.82	1.05	3220	1.16
Sem	0.0650	2.2209	2.1070	0.0812	0.0420	-	104.46	-
CD ($P \leq 0.05$)	0.0253	0.1102	0.1409	0.0348	0.0268	-	1.2458	-

Pooled data of two season: Mean of twelve weeks observations (7, 14, 21, 28, 35, 42, 49, 56, 63, 70, 77 & 84 DAE) and mean of ten randomly selected plants per each treatment

Figures were transformed by square root or logarithmic or arcsine transformation as applicable and the original values are given

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ES 02 BOPD 15

Damaging potential of Tea mosquito bug *Helopeltis theivora* Waterhouse in Cotton

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Keywords: *Tea mosquito bug, Helopeltis theivora, cotton*

Introduction

Infestation of Tea mosquito bug, *Helopeltis theivora* Waterhouse in cotton was recorded for the first time at ICAR-CICR, Coimbatore during 2018. Tea Mosquito Bug (TMB) is a sucking pest belonging to genus, *Helopeltis* (Hemiptera: Miridae). Three species of TMB, *Helopeltis antonii* Signoret, *Helopeltis bradyi* Waterhouse and *Helopeltis theivora* Waterhouse were recorded in India. Tea mosquito bug is the important sucking pests of tea, cashew, coffee and cocoa. It is a polyphagous pest and widely distributed in India, Sri Lanka, Vietnam, Indonesis, Malaysia and Africa (Dharajothi *et al*., 2018).

Both nymphs and adults feed on leaves, buds and tender stems, injecting toxic saliva into the plant causing necrotic patches. The badly affected leaves become deformed and even curl-up. Severely damaged shoots die back due to the effect of bug saliva, the subsequent development of numerous auxiliary buds causes a bunched terminal growth known as 'Witches broom'. The boll infested by this pest develops characteristic black wart eruptions. Unchecked infestation leads to 100% of the crop loss under favorable conditions if the appropriate management practices are not followed (Muraleedharan, 1992). Considerating the importance of this pest, studies were conducted to assess the damage potential.

Materials and Methods

Newly hatched nymphs were used for the experiment. Single cotton leaf was inserted into glass vial containing water by wrapping with absorbent cotton and kept in insect rearing box. A single 1st instar, 2nd instar, 3rd instar, 4th instar, 5th instar nymph and female and male adult of *H. theivora* were released on cotton leaf. There were three replications for each treatment. The insects were allowed to feed for 24 hours and the number of feeding spots was recorded. The feeding rate of nymphs and adults on cotton leaves was calculated from the feeding spots produced by an individual per day under laboratory condition.

Results and Discussion

A single 1st instar, 2nd instar, 3rd instar, 4th instar, 5th instar nymph and female and male adult of *H. theivora* could make as many as 63, 80, 71, 59, 51, 96 and 56 feeding punctures in 24 hours respectively. Cotton leaf area damaged by individual per day for 1st instar, 2nd instar, 3rd instar, 4th instar, 5th instar nymph and female and male adult of *H. theivora* were 25, 62, 119, 173, 186, 229, 526 mm^2 respectively. Cumulative number of feeding spots was recorded as 1659.13 and 2847.53 for male and female respectively. Data on total area damaged by individual/day showed that, among the nymphal stage 5th instar nymph and among the adults female found to be voracious feeders.

Table 1. Damage potential of different stages of *H. theivora* on cotton

Stage of the insect	Feeding spot/individual /day (Nos.)	Area of feeding spot (mm^2)	Total leaf area damaged / individual/day (mm^2)	Total feeding spots/stage	Cumulative feeding spot /stage
1st instar	63.4±1.21	0.39±0.04	24.62±1.92	145.22±7.57	145.22
2nd instar	80.8±2.78	0.77±0.03	61.58±2.36	230.72±2.79	375.93
3rd instar	71.8±2.28	1.68±0.05	118.72±2.85	220.40±11.84	596.33
4th instar	59.6±1.56	2.94±0.12	173.39±8.51	123.61±3.78	719.94

5th instar	51.2±1.24	3.64±0.21	185.7±12.39	55.98±2.61	775.93
Male adult	56.4±1.69	4.10±0.19	228.52±7.31	883.20±41.24	1659.13
Female adult	96.2±1.68	5.48±0.21	526.36±24.01	2071.60±96.43	2847.53
S.Ed	0.165	0.039	0.392	0.721	
CD	0.342	0.082	0.814	1.497	

Conclusion

This emerging pest may become a major threat to cotton cultivation because of its severity of damage. Therefore, a detailed study on integration of multiple pest suppression technique is the need of the hour.

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ES 02 BOPD 16

Occurrence of Fall Armyworm, *Spodoptera frugiperda* (J.E. Smith) on Sugarcane in Kallakurichi District of Tamil Nadu

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Keywords: *Fall armyworm, Sugarcane, Occurrence of insect pest*

Introduction

Native to the Americas, the fall armyworm (FAW; *Spodoptera frugiperda* (JE Smith); Lepidoptera, Noctuidae) was first reported on the African continent in January 2016. Subsequent investigations revealed the pest in nearly all of sub-Saharan Africa (SSA), where it is causing extensive damage, especially to maize fields and to a lesser degree sorghum and other crops. Currently, over 30 countries have identified the pest within their borders including the island countries of Cape Verde, Madagascar, São Tomé and Príncipe, and the Seychelles. In India the pest was reported for the first time during the month of July 2018 from Karnataka (NBAIR, 2018) and subsequently in Tamil Nadu, Telangana, Odisha, Gujarat and Chhattisgarh. The FAW is capable of feeding on over 80 different crop species, making it one of the most damaging crop pests. This study was undertaken to find out the occurrence of fall armyworm in different crop species and weeds in Kallakurichi districts of Tamil Nadu.

Materials and Methods

Fortnightly roving surveys were conducted from June 2019 to May 2020 in different maize growing blocks of Kallakurichi districts. Two plots were selected at each village and the incidence of fall army worm in the crops cultivated in the village and weeds present nearby were assessed. The larvae samples were collected and were identified with the taxonomic expertise available at TNAU, Coimbatore and on the basis of the distinguishing features of the species (Shylesha *et al*., 2018) *viz.,* dome shaped brownish yellow coloured eggs loosely covered with pale yellowish coloured frass, greenish first instar larva with black head and dark grey head final instars larva with dull grey body having white subdorsal and lateral white lines and matured larva with a white inverted on the head and distinct black spots on the body. The arrangement pattern of black spots is square on 8th and trapezoidal on 9th segment.

Results and Discussion

Occurrence of fall armyworm on sugarcane was noticed during December, 2020 in the sugarcane growing areas *viz.,* Thenkeeranur and Malaikottalam village in Kallakuruchi district of Tamil Nadu. Larvae were present inside the leaf whorls and central shoot and caused pin hole, windowing and elongated damage hole symptoms on sugarcane leaves (Fig. 1). Incidence was observed only in one field each at the two villages in 45 days old sugarcane crop (Variety Co 86032) planted under SSI (Sustainable Sugarcane Initiative) system. The incidence to a tune of 31.00 and 35.21 per cent tiller damage with a mean larval population of 0.7 and 0.2 per tiller was observed in Thenkeeranur and Malaikottalam village. The per cent leaf damage was 23.12 and 27.01 respectively with a mean damage score of 1.93 and 1.32 respectively in Thenkeeranur and Malaikottalam village of Kallakuruchi district respectively. No incidence of fall armyworm was observed in the nearby crops *viz*., cotton and turmeric and other sugarcane fields also. No maize crop was cultivated in the surrounding areas up to 2 kms radius. This indicated the migratory capacity of the fall army worm and the potential of fall armyworm to infest the sugarcane crop, especially under SSI system of cultivation which is being promoted by the sugar mills. A constant surveillance is the need of the hour to prevent the fall armyworm becoming a pest of sugarcane.

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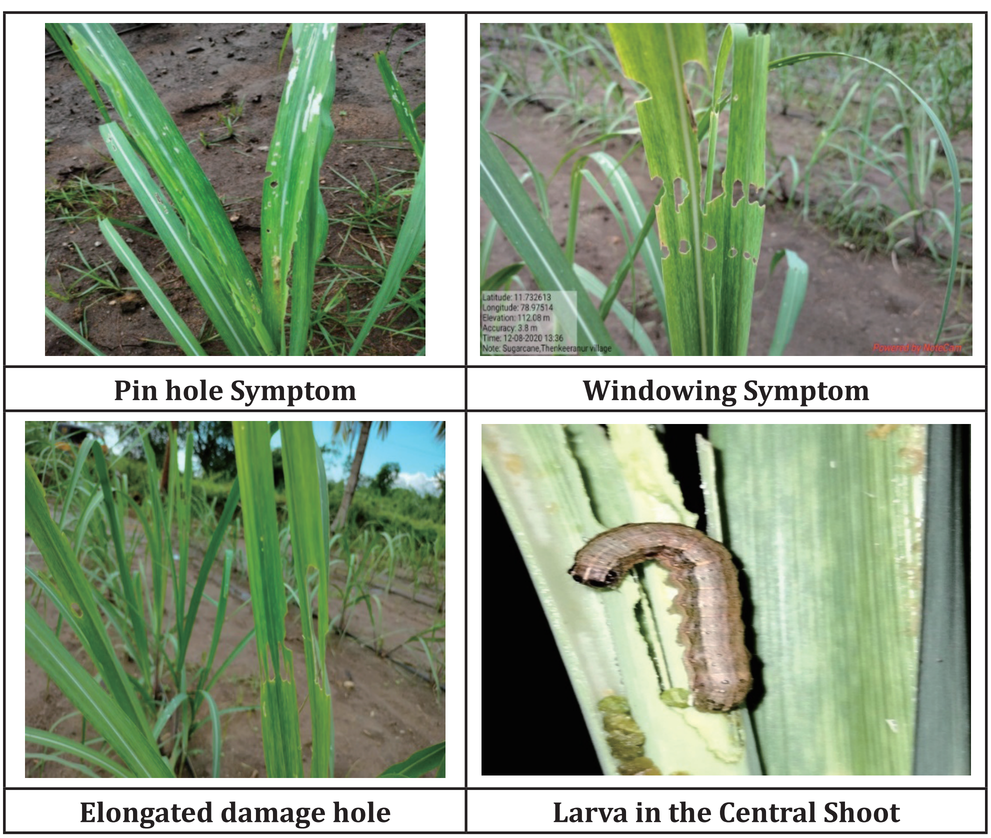

Fig.1. Incidence of Fall armyworm in Sugarcane at Thenkeeranur village, Kallakurichi Dt.

ES 02 BOPD 17

Survey for Infestation by Fall Armyworm, *Spodoptera frugiperda* (J.E. Smith) in Maize in Coimbatore district, Tamil Nadu, India

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Keywords: *Fall armyworm, Spodoptera frugiperda, roving survey, coimbatore district*

Introduction

Maize is facing a serious threat in recent times with the invasion of maize fall armyworm (FAW), *Spodoptera frugiperda* J.E Smith (Lepidoptera: Noctuidae). The pest has been reported as polyphagous, capable of causing economic losses in major agricultural and horticultural crops, lead to qualitative and quantitative losses in maize, extremely adaptable, has a huge migratory potential and hence a threat to agricultural systems (Goergen *et al*., 2016). The spread and intensity of the pest needs to be thoroughly documented to provide a broader perspective on its capability to inflict extensive damage.

Materials and methods

Extensive surveys were conducted in different maize growing blocks of Coimbatore district, Tamil Nadu, India, during September to December 2020 (*Kharif* season). Observations on FAW incidence (per cent infestation and TNAU 1-5 score) have been recorded at vegetative, tasseling and cob formation stages. In each field, a total of 50 plants were observed at random (at five different spots in the field), and FAW infestation was recorded on the whorl, tassel and cob infestation was recorded based on the crop stage available during survey.

Results and Discussion

The roving survey in different maize growing blocks of Coimbatore district revealed that the whorl infestation ranged between 16.0 to 77.7 per cent (Table 1) with a score ranging from 1.3 to 4.3 (on a scale of 1-5). At Kanjapalli, Annur block, about 14 second and third instar larvae per plant were observed, where the farmer did not spray any chemicals. Further, at five locations in Annur, Sulur and Pongalur blocks, mycosed larvae were recorded to the tune of up to 66 larvae from 100 plants. The pathogen was later identified as *Metarhizium rileyi*. During the tassel formation stage, 5.0 to 30.0 per cent damage was noticed in the tassels. Upon reaching the tassel stage, generally the FAW infestation tend to decline and necessitated no further sprays. Mycosed larvae were also collected from the maize tassels. Firake and Behere (2020) observed natural mortality to an extent of 50 per cent due to *M. rileyi* in North East India. Cob infestation could be noticed only at the tips and destructive sampling of 10-20 cobs from plots revealed a maximum of 14.0 per cent infestation (score=3). Mostly farmers take up 2-3 sprays of the TNAU recommended insecticides *viz*., chlorantraniliprole, emamectin benzoate and spinetoram during the period up to tasseling stage which could have been the reason for lesser cob infestation. Thus the key to tackle FAW is to have early intervention with insecticidal sprays. As TNAU recommends a refined IPM capsule with two rounds of insecticidal sprays up to the period of tasseling stage, the overall FAW situation is kept under check in the state.

Table 1. Incidence of Fall armyworm in Coimbatore district of Tamil Nadu

Village	Block	Crop age (DAE)	FAW Infestation		Larval population /10 plants
			Per cent	FAW score	
Whorl infestation					
Kannampalayam	Sulur	30	77.7	3.7	3
Ravathur	Sulur	50	70.0	4.3	5

Ranganathapuram	Sulur	40	35.0	1.6	5
Dasappalayam	Annur	20	20.5	2.3	2
Kanjapalli	Annur	20	41.0	3.1	14
Rudriyampalayam	Annur	40	45.0	3.2	3
Kumaragoundenpudur	Annur	20	16.0	1.7	1
Ichipatti	Annur	30	35.0	3.0	2
Allapalayam	Pongalur	30	16.0	1.3	0
Tassel infestation					
Poorandampalayam	Sultanpet	50	10.0	-	0
Kannampalayam	Sulur	55	10.0	-	0
Peedampally	Sultanpet	50	30.0	-	0
Poothottam	Sulur	45	5.0	-	4
Kalangal	Sulur	40	5.0	-	4
Sulur	Sulur	50	10.0	-	0
Lakshminaickenpalayam	Sulur	55	0.0	-	0
Kethanur	Pongalur	50	22.0	-	0
Cob infestation					
Gomangalampudur	Pollachi	80	8.8	3	3
Poorandampalayam	Sulur	65	10.0	3	3
Vadavalli	Sulur	70	0.0	0	0
Selakkarichal	Sultanpet	95	0.0	0	0
Chittanaickenpalayam	Sultanpet	70	14.0	3	3
Vavipalayam	Pongalur	80	5.0	2	2
DAE – days after emergence					

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ES 02 BOPD 18

Population Dynamics of Invasive Rugose Spiraling Whitefly, *Aleurodicus rugioperculatus* Martin and their Parasitoid, *Encarsia guadeloupae* Viggiani in Coconut

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Keywords: *Rugose spiraling whitefly, Encarsia guadeloupae, population dynamics, parasitisation.*

Introduction

Rugose Spiralling Whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae), is a, small, sap sucking polyphagous, invasive pest. De-sapping by RSWF especially from the older fronds would induce stress on the palms. Voracious feeding habit led to the excretion of abundant honey dew which subsequently gets deposited on the upper leaf surface of lower fronds, and develops dense sooty mould on leaves. This exotic whitefly was reported in India, from different locations of Coimbatore district of Tamil Nadu and Palakkad district of Kerala during July-August 2016 on coconut (Sundararaj and Selvaraj, 2017; Srinivasan *et al.,* 2016). The present investigation on population dynamics of invasive rugose spiraling whitefly, *Aleurodicus rugioperculatus* and their parasitoid, *Encarsia guadeloupae* in coconut was carried out to study the seasonal abundance of RSW in coconut.

Materials and Methods

The present investigation on population dynamics of invasive rugose spiraling whitefly, *A. rugioperculatus* and their parasitoid, *E guadeloupae* in coconut was carried out from 2017 to 2021 at Coconut Research Station, Aliyarnagar, Tamil Nadu, India. The observations were recorded from three RSW infested gardens at monthly intervals. The varieties grown in the three gardens were 15 years old Chowghat Orange Dwarf (COD) and Kenthali Dwarf (KTD). Five palms were randomly selected in each garden to record the percentage of incidence and parasitisation by *Encarsia guadeloupae* Viggiani.

Results and Discussion

The results (Figure 1) revealed that the incidence of RSW was at the peak during June 2017 (52.5%), May 2018 (43.2%) and June 2019 (60.2%) and at minimum during January 2018 (28.5%) and December 2018 (20.5%). The results showed that the incidence of RSW was found to be increasing from January to June and after June the incidence declined due to the onset of South West Mansoon. Again upward trend on incidence was noticed from August to November and reaching low level from December to January. The parasitisation by *E. guadeloupae* was initially 25.5% during June 2017 and reached highest parasitisation during December 2019 (84.6%). Lowest parasitisation was recorded during June 2018 (22.5%). The low parasitisation was recorded during rainy season from June to August and during summer from March to June. The same trend was observed thought out the study period (Alagar *et al.,* 2020).

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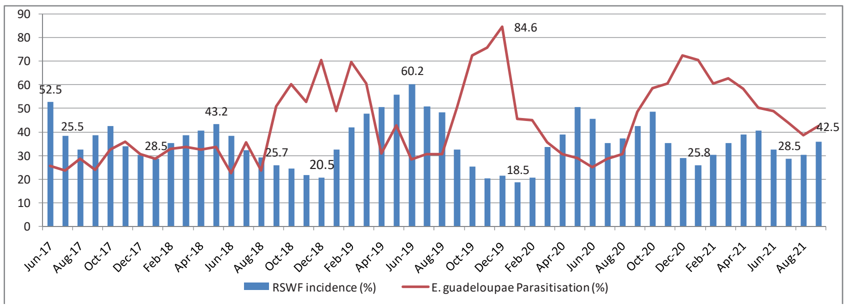

Figure 1. Population dynamics of coconut rugose spriralling whitefly, *A. rugioperculatus* and its parasitoid *E. gaudeloupae*

ES 02 BOPD 19

A New Uropodid mite, *Fuscuropoda irridipennae* sp. nov. (Acari: Uropodidae) on *Trigona irridipennis* Smith (Apidae: Hymenoptera) from Tamil Nadu

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Keywords: *Trigona irridipennis, camera lucida, peritreme, chela and chaetotaxy.*

Introduction

Stingless bee combs were affected by uropodid mites found on outer surface of the bee comb. Moreover, the bees are also spreading the mites from entire colony as well as the foraging site. The dispersion behaviour of infested colonies were reported by Makkar and Chhuneja (2011). In our apiary mites were observed from outer surface of the dammer beehive. Hence, the present study has been carried out to describe the mite to genera and species level.

Materials and Methods

The present study was conducted to know the mites associated with bees in Tamil Nadu including plains and hilly regions. Various dammer bee colonies were observed for the presence of mites and observed mites were mounted (Krantz, 1968) and camera lucida drawings were carried out for the description of the genera as well as species.

Results and Discussion

Female dorsum

Dorsum oval with 21 pairs of simple setae. Setal length ranges from 13 µm to 24 µm. Idiosomal length 508 µm and width 419 µm with 4 pairs of dorsal pores; j_1 13 smaller than others. Setae J_1 31 µm long. Setae $J_2 = J_3 = J_4 =$ 24 µm long. Setae $Z_1 = Z_2 = 21$ µm long. Setae S_1 = 17 µm long. The dorsal shield is entire with faint striations and punctations.

Venter

Ventrum with 28 pairs of setae. Most of the setae found on the sternal shield and anal shield. The sternal shield 330µm long and 315µm wide with 5 pairs of sternal setae. St_1 to St_5 length, 50, 60, 65, 83 and 88 µm long, respectively. The anal shield 28 µm long and 22 µm wide with two paranal and an adanal setae. The ventral striations are prominent, as shown in Fig. 30. The peritreme base lies in between coxae III and IV. The adanal seta is (45 µm) longer than the paranal setae.

Legs

Leg I to IV measures 316, 285,325 and 442 µm long, respectively.

Leg chaetotaxy

Coxa: 1-1-2-2; Trochanter: 4-2-5-7; Femora: 11-7-5-5; Genua; 14-11-6-6; Tibia: 13-10-6-7 and Tarsus: 27-14-15-17.

Gnathosoma

Gnathosoma 120 µm long and 72 µm wide. The chelicerae are long and when retracted, their shafts extend almost to the posterior margin of the body, bearing dentate chela. One pair of simple, hypostomal setae (15 µm) are present.

Types: A holotype female marked on the slide, INDIA: Tamil Nadu, Coimbatore. 23.XI.2006. Eg: *Trigona irridipennis* Smith (Apidae: Hymenoptera), Coll: V. Radhakrishnan, (No: 290/1). Twelve paratype slides with collection data same as type.

Diagnosis

This new species resembles *Fuscuropoda marginata* (Koch) and *Fuscuropoda catharciphorae* Chinniah (Ramaraju, 1994) in dorsal shield arrangements and chaetotaxy but it differs in dorsal ornamentation. Ventrum of the new species differs from *F. catharciphorae* by having striations all over the body. Adanal setae in the new species are small (45) length in contrast to (60) in *F. catharciphorae*. The new species possess long sternal setae 5 against small sternal setae in *F. catharciphorae*.

Relationship to the host

The orange coloured mites were found on the outer surface of the dammer beehive. The exact relationship is not known. It is presumed that the mites may feed on the debris found in the colony. Further studies are needed to know the exact association between host insect and the mite.

Etymology

The mite species is named after the type host species.

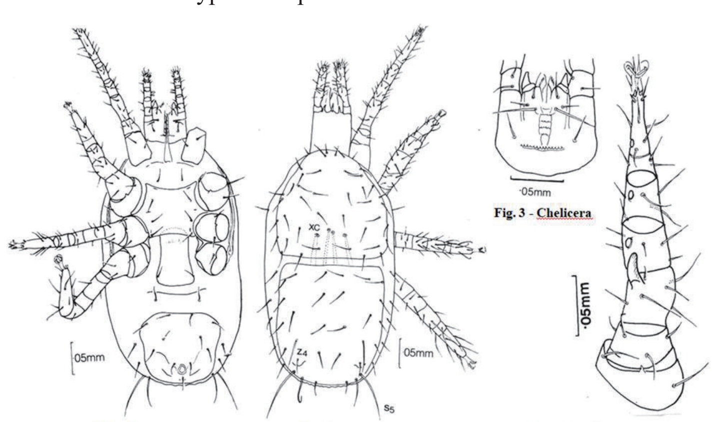

Fig. 3 - Chelicera

Fig. 1 - Dorsum Fig. 2 - Ventrum Fig. 4 - Leg

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ES 02 BOPD 20

Characterisation of Malathion Resistance in Red Flour Beetle, *Tribolium castaneum* Herbst (Tenebrionidae, Coleoptera) and Rice Weevil, *Sitophilus oryzae* Linn (Curculionidae, Coleoptera) in Warehouses of Tamil Nadu

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Keywords: *Survey, warehouses, rice storage pests, malathion resistance*

Introduction

Malathion, dichlorvos, deltamethrin and aluminium phosphide are the commonly used insecticides consistently over many years to manage stored product pests in different parts of the world in a closed condition within warehouses. Therefore, the treated insects developed resistance to these insecticides. As a result, it warrants frequent application of insecticides. Hence, effort was taken to characterize malathion resistance among the test insects *viz.,* red flour beetle and rice weevil at 23 warehouses of Tamil Nadu.

Materials and Methods

FAO fixed Discriminative Dose (DD) (IRAC method No. 6) (www.irac-online.org) for malathion was 0.5 ppm and 1.5 ppm against *T. castaneum* and *S. oryzae* respectively. By utilizing this available DD, the resistance level prevailing in various warehouses of Tamil Nadu was characterized for both the insects at warehouse and farmers holdings level. The adults were collected from 23 government warehouses of Tamil Nadu including seven farmer's holdings. From each warehouses, live test insects were collected in aerated poly bags. The collected test insects were reared in their host medium under *in-vitro* condition. The emerging uniform aged adults from first generation were exposed to discriminative dose (DD) and per cent resistance was calculated as per the methodology of Regupathy and Dhamu (2001).

Results and Discussion

Among 23 warehouses, the red four beetle, *T. castaneum* population collected from 20 warehouses exhibited maximum resistance with 100 per cent except three warehouses *viz.,* TNCSC of Nagerkoil, Dindigul and Thirunelveli with 98.33 per cent. Out of seven farmer's holdings, all the seven *T. castaneum* were found to be resistant to malathion ranging from 6.67 to 23.33 per cent. Considering, rice weevil, *S.oryzae* population the resistance ranged from 75.00 to 93.33 per cent. Highest resistance level (93.33%) was recorded in Thiruchirappalli, TNCSC while lowest level of resistance was seen at Nagerkoil, TNCSC (75 %). Rice weevil, *S.oryzae* from farmers holdings showed malathion resistance level from 1.66 to 8.33 per cent. Farmers holding from Thiruthuraipoondi, Thanjavur District recorded a maximum level of resistance for *S.oryzae* (8.33 per cent) and Cumbum, Theni District recorded the lowest frequency of resistance (1.66 per cent). It suggests that there is an existence of low level of resistance among the tested insects at farm level. Hence, it is concluded from the data that resistance is more common in public warehouses than farmer's holdings. The first case of malathion-specific resistance in *T. castaneum* to malathion was reported in 1961 in Nigeria (West Africa) (Parkin *et al.,* 1962). Malathion resistance in *S.oryzae* has been reported from Egypt (Toppozada *et al.,* 1969). In India, so far eight insects species have been reported to have developed resistance to malathion (www.pesticideresistance.org.).

Table 1. Malathion resistance in storage pests of rice from warehouses of Tamil Nadu

Sl.No.	Location	Collection Date	Per cent Resistance at Discriminative Dose (DD)	
			T. castaneum (0.5ppm)	*S. oryzae* (1.5ppm)
Food Corporation of India				
1	Coimbatore	January, 2014	100.00±0.00 (89.40)	81.67±5.04 (64.65)
Central warehouse corporation				
2	Thiruchirappalli	January, 2014	100.00±0.00 (89.40)	81.67±5.04 (64.65)
3	Thanjavur	January, 2014	100.00±0.00 (89.40)	78.33±5.36 (62.26)
4	Thiruvarur	February, 2014	100.00±0.00 (89.40)	78.33±5.36 (62.26)
5	Chennai	February, 2014	100.00±0.00 (89.40)	81.67±5.04 (64.65)
6	Virudhunagar	March, 2014	100.00±0.00 (89.40)	78.33±5.36 (62.26)
7	Madurai	March, 2014	100.00±0.00 (89.40)	85.00±4.65 (64.65)
8	Erode	March, 2014	100.00±0.00 (89.40)	76.60±5.51 (67.22)
State warehouse corporation				
9	Thiruchirappalli	April, 2015	100.00±0.00 (89.40)	90.00±3.91(61.10)
10	Pudukkottai	April, 2015	100.00±0.00 (89.40)	81.67±5.04 (64.65)
11	Thiruchirappalli	April, 2015	100.00±0.00 (89.40)	93.33±3.25 (75.03)
12	Madurai	April, 2015	100.00±0.00 (89.40)	91.67±3.60 (73.23)
13	Thoothukudi	May, 2014	100.00±0.00 (89.40)	85.00±4.65 (75.04)
14	Thirunelveli	May, 2014	98.33±1.67(82.58)	81.67±5.04 (64.65)
15	Sivagangai	May, 2014	100.00±0.00 (89.40)	78.33±5.36 (62.26)
16	Ramanathapuram	June, 2014	100.00±0.00 (89.40)	86.67±4.43 (73.23)
17	Perambalur	June, 2014	100.00±0.00 (89.40)	81.67±5.04 (64.65)
18	Namakkal	June, 2014	100.00±0.00 (89.40)	85.00±4.65 (64.65)
19	Karur	July, 2014	100.00±0.00 (89.40)	81.67±5.04 (64.65)
20	Ariyalur	July, 2014	100.00±0.00 (89.40)	85.00±4.65 (64.65)
21	Dindigul	August, 2014	98.33±1.67(82.58)	86.67±4.43 (73.23)
22	Theni	August, 2014	100.00±0.00 (89.40)	86.67±4.43 (73.23)
23	Nagerkoil	August , 2014	98.33±1.67(82.58)	75.00±5.64 (73.23)

Per cent Resistance ± SE, n = 23 warehouses; Figures in parentheses are arc-sine transformed values;

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Acetylene as Novel Fumigant for the Management of Storage Pests in Rice and Pulses

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Keywords: *Paddy, pulses, storage pests, fumigation, acetylene gas, mortality, progeny reduction*

Introduction

Storage pest management using controlled / modified atmospheres remains unpopular among farmers, due to leakage of storage structures, requirement and transportation of gases to the site and monitoring of gas composition through gas monitors or gas chromatography. Acetylene (C_2H_2), an industrial gas with oxygen for producing flame in welding is considered to replace the oxygen to the insects during storage when used to fill the void volume. Production of acetylene gas from calcium carbide, on site is easier which does not involve filling and transportation when compared to production of other gases. Thus, the present study was undertaken to study the feasibility of using acetylene as an alternate gas for N_2 and CO_2 in controlled atmosphere for the management of storage pests in paddy or pulse.

Materials and Methods

Experiments were conducted to study the effect of acetylene against storage pests of paddy and pulses using fabricated airtight 500 ml conical flasks and 25 kg bins. Test insects, *Sitophilus oryzae, Rhizopertha dominica, Tribolium castaneum* and *Callusobruchus maculatus* obtained from susceptible population maintained at the Department of Plant Protection, Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli. Paddy (TRY 3) and Pulse (VBN 6) seeds were utilized for the study. The flasks/bins were filled with paddy or pulse seeds up to the bottom of the rubber cork and ensured that no space is left unfilled. Before closing with the cork fitted with inlet and outlet for gas, thirty number of the test insects were released and closed airtight, with labels. Acetylene gas from the cylinder was delivered into each conical flask through the inlet and allowed the gas to exit through the outlet to ensure that the pore volume is completely filled with acetylene gas and both inlet and outlet were well closed using the pinch cork. Control was maintained with grains and insects without acetylene gas. The storage pests were assessed for mortality at an interval of 24 h up to 120 h.

The containers opened after bioassays were left for progeny production up to 4 months. Gases with insects and seeds are also tested in larger bins, with three replications and control maintained at 30-35°C and 65-70% relative humidity. The mortality was assessed after a long-term storage of four months. All these experiments were performed at Modified Atmosphere Packing (MAP) Laboratory, AEC&RI, Kumulur. The data were subjected to statistical analysis by implementing one way analysis of variance (ANOVA) in completely randomized block design (CRD) and the mean values of treatments were separated by Least Significant Difference (LSD) (Gomez and Gomez, 1984) using AGRES ver. (7.01), Pascal International Solutions. To correct the mortality in control, Abbott (1925) formula was utilized.

Results and Discussion

After 24 h of exposure, mortality among the storage pests ranged from 3 per cent (*R. dominica*) to 25 per cent (*T. castaneum*). More than 50 per cent mortality was recorded after four days of exposure in all the exposed insects except *T. castaneum.* Mean mortality of 96 to 98 per cent was recorded among various storage pests over exposed duration of 120 h (Table 1). The progeny of these storage pests were found to be insignificant with respect to the storage period, during long term storage up to four months. Production and use of acetylene gas at storage site will ease the adoption of controlled atmosphere storage of food grains using acetylene as alternate gas. Acetylene gas will be a suitable alternate for CO_2/N_2 in controlled atmosphere storage of food grains and control the storage pests, by reducing the availability of oxygen.Modified atmosphere is generated by decreasing the oxygen or increasing the carbon dioxide /nitrogen concentration in the atmosphere thereby interfering with normal respiration of insects (Jayas *et al.,* 1991). The germination of the exposed seeds were found to be more than 95 per cent.

Table 1. Mean mortality of the storage pests at different exposure period for paddy/pulse filled with acetylene gas

Exposure duration (h)	*T. castaneum*	*S. oryzae*	*R. dominica*	*C. maculatus*
	Percent mortality			
0	0 (0.52)[a]	0 (0.52)[a]	0 (0.52)[a]	0 (0.52)[a]
24	25 (30.00)[b]	11 (19.37)[b]	3 (9.97)[b]	6 (14.18)[b]
48	41 (39.82)[c]	18 (25.10)[c]	13 (21.13)[c]	28 (31.95)[c]
72	68 (55.56)[d]	46 (42.71)[d]	26 (30.66)[d]	38 (38.06)[d]
96	86 (68.03)[e]	69 (56.17)[e]	67 (54.94)[e]	70 (56.80)[e]
120	98 (81.87)[f]	98 (81.87)[f]	96 (78.47)[f]	98 (81.87)[f]
SEd	0.52**	0.86**	0.79**	1.53**
CD	1.20	1.87	1.82	3.32

Figures within parentheses are arcsine transformed values

Means followed by common alphabets are not significantly different at 5% level by LSD;

**Significant at 0.05% level

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Management of Fall Armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) by seed treatment with Chlorantraniliprole 625 g/L FS in Maize

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Keywords: *Maize, FAW, chlorantraniliprole, mortality, natural enemies, phytotoxicity*

Introduction

The recently introduced polyphagous pest, Fall Armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) that originated in the Americas (Luginbill, 1928) is a major threat to several crops globally. Montezano *et al.* (2019) reported about 353 host plants from 76 plant families with the Poaceae family having the largest host taxa (106 taxa), followed by Asteraceae and Fabaceae (31 taxa each). It is essential to manage this pest effectively. Therefore, an effort was made to utilize a new seed treatment molecule Chlorantraniliprole 625 g/L FS for the management of FAW in Maize.

Materials and Methods

The maize seeds (Pioneer 3396 with 4000 seeds per kg) were treated with different doses of Chlorantraniliprole 625 g/L FS and thoroughly shaken to have uniform coating over the seeds. The treated seeds were sown in the field layout following randomized block design. Carbofuran 3% G was applied as per the recommended dose (33.5 kg/ha) in furrows at the time of sowing as a standard check. Untreated Mahyco hybrid seeds were sown as border crop. The field trial was conducted twice at Cotton Research Station, Perambalur with Black cotton soil (Peelamedu series/vertisol with typic chromosterts) during *Rabi*, 2019-20 and *Rabi*, 2020-21. Totally seven treatments and three replications were maintained.

Results and Discussion

Observations on the 14 days after sowing, the larval population ranged from 0.22 to 1.54 per plant and was found statistically significant among the treatments (Table 1). There was 0.22 larva per plant seen in the plot sown with the highest dose of Chlorantraniliprole 625 g/L FS @ 6.4ml/kg of treated seed. Treatments such as chlorantraniliprole 625 g/L FS @ 5.60 ml/kg and 4.8 ml/kg of seed were found on par with each other and recorded 0.32 and 0.81 larvae per plant, respectively. The carbofuran 3 G @ 33.3 kg/ha recorded 1.36 larvae / plant. Untreated control recorded 1.54 larvae / plant, both of these have been significantly different from Chlorantraniliprole seed treatment. The same trend of larval count was noticed at 21 and 28 days after sowing. Leaf damage observations on the 14 days after sowing, ranged from 0.98 to 1.89 score and was found statistically significant among the treatments. Treatment such as chlorantraniliprole 625 g/L FS @ 5.6ml/kg and 6.4ml/kg of seeds recorded significantly lowest leaf damage of 1.03 and 0.98 respectively and were found on par with each other. Chlorantraniliprole 625 g/L FS @ 4.8 ml/kg of seed recorded 1.32 leaf damage score followed by 4.0ml/kg of seed with 1.41 leaf damage. The standard, carbofuran 3 SG @ 33.3 kg/ha recorded 1.46 leaf damage score. Untreated control recorded 1.89 leaf damage score. Similar trend was noticed at 21 days after sowing. Whorl damage observations on the 14 days after sowing, the whorl damage ranged from 0 to 4.00 and was found statistically significant among the treatments (Table 1). Treatment with chlorantraniliprole 625 g/L FS @ 5.6ml/kg of seeds recorded significantly lowest whorl damage of 0.33 while there was no whorl damage in the plot sown with chlorantraniliprole 625 g/L FS @ 6.4ml/kg of seeds. Chlorantraniliprole 625 g/L FS @ 4.8 ml/kg of seed recorded 0.67 whorl damage score followed by 4.0ml/kg of seed with whorl damage score of 1.00. The standard check, carbofuran 3 SG @ 33.3 kg/ha recorded whorl damage score of 2.33. Untreated control recorded whorl damage score of 4.00. Chlorantraniliprole 625 g/L FS @ 5.60 ml/kg of seed was found to be an optimal dose in significantly reducing the *S. frugiperda* population with minimum leaf and whorl damage up to 28 days after sowing. This dose was found to be on par with its higher dose at @ 6.40 ml/kg of seed. Natural enemy population in Chlorantraniliprole 625 g/L FS treatments were on par with standard and untreated check. There was no phytotoxicity symptoms on corn plants treated with various dosages of Chlorantraniliprole 625 g/L FS.

Table 1. Efficacy of Chlorantraniliprole 625 g/L FS against Maize FAW (*Rabi*, 2019-20)

S. No.	Treatments	Larvae / plant * (No.)			Leaf damage (score)			Whorl damage (score)			Yield(q/ha)
		14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS	
1	T_1 Chlorantraniliprole 625 g/L FS - 4.0 ml	1.02 (1.23)	1.15 (1.28)	1.32 (1.35)	1.41 (1.38)	1.90 (1.55)	2.53 (1.74)	1.00 (1.22)	1.00 (1.22)	2.00 (1.58)	40.25 (6.38)
2	T_2 Chlorantraniliprole 625 g/L FS - 4.8 ml	0.81 (1.14)	0.91 (1.19)	1.02 (1.23)	1.26 (1.35)	1.82 (1.52)	2.35 (1.69)	0.67 (1.08)	1.67 (1.47)	3.33 (1.96)	42.75 (6.58)
3	T_3 Chlorantraniliprole 625 g/L FS -5.6 ml	0.32 (0.91)	0.36 (0.93)	0.56 (1.03)	1.03 (1.24)	1.23 (1.32)	2.15 (1.63)	0.33 (0.91)	0.67 (1.08)	1.33 (1.35)	48.50 (6.71)
4	T_4 Chlorantraniliprole 625 g/L FS - 6.4 ml	0.22 (0.85)	0.30 (0.89)	0.54 (1.02)	0.98 (1.22)	1.11 (1.27)	2.07 (1.60)	0.00 (0.71)	0.67 (1.08)	1.00 (1.22)	52.25 (6.84)
5	T_5 Carbofuran 3% G (per ha) -33.3 kg	1.36 (1.36)	1.52 (1.42)	1.58 (1.44)	1.56 (1.44)	1.68 (1.48)	3.03 (1.88)	2.33 (1.68)	3.33 (1.96)	4.00 (2.12)	34.75 (5.94)
6	T_6 Untreated Check	1.54 (1.52)	2.16 (1.63)	2.35 (1.69)	1.89 (1.55)	2.45 (1.72)	5.20 (2.13)	4.00 (2.12)	4.67 (2.27)	5.00 (2.35)	25.25 (5.07)
S Em ±		0.005	0.02	0.02	0.02	1.88	0.02	0.16	0.21	0.10	0.02
CD (P=0.05)		0.32	0.28	0.40	0.08	4.19	0.20	0.37	0.36	0.21	0.14
CV		0.56	1.79	1.43	1.60	15.09	1.43	15.74	13.37	7.16	0.32

Pooled Mean of 2 field trials DAS: Days after Sowing * Figures in parentheses are square root transformed values

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ES 02 BOPD 23

Seasonal Occurrence of Fall Armyworm *Spodoptera frugiperda* J.E. Smith (Noctuidae: Lepidoptera) in Tiruppur District

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Keywords: *Fall armyworm, roving survey, seasonal occurrence*

Introduction

Maize is cultivated to meet the demand for human consumption, animal feed and food processing industries. About 141 insect pest species are known to cause damage to maize from sowing to till the harvest (Reddy and Trivedi, 2008). The American origin fall armyworm *Spodoptera frugiperda* incidence was first reported in Karnataka during July 2018 and subsequently in other South Indian states. The farmers resort to applying insecticide combinations and direct whorl application of insecticides to combat the FAW menace. Under these circumstances, continuous monitoring of FAW in the major maize growing district is a prerequisite for developing management strategies against FAW.

Material and Methods

Roving survey was conducted in major maize growing areas of Tiruppur district during Kharif and Rabi 2020 – 21. The roving survey was conducted along with State Department of Agriculture Extension officials in Palladam, Pongalur, Madathukulam, Udumalpet and Pethappampatti blocks of Tiruppur District. During survey, the details *viz*., hybrid/variety grown, seed treatment details, border crops grown, number of insecticides sprayed, use of pheromone traps and indigenous methods of pest management practiced against FAW were collected from the farmers. The FAW whorl damage (TNAU 1 – 5 score), cob damage (TNAU 1 – 5 score), presence of natural enemies and diseases infected FAW larvae were recorded along with Geo-coordinate details during the survey.

Results and Discussion

The fall armyworm infestation ranged between 9.0 – 90.0 per cent in whorl and 5.0 – 30.0 per cent in the tassel stage in Tiruppur district (Table 1). Severe incidence was observed wherever the control measures were not initiated. In Kannankovil village, 90% whorl damage was observed in 3 week maize crop. Least whorl damage of 9.3 per cent was recorded in Ragalbavi village of Udumalpet block in 30 days maize. Negligible presence of natural enemies was recorded in maize which may be due to the periodical application of insecticides. During Rabi, natural epizootics of *Metrahizium rileyi* was observed in Gudimanagalam and Madathukulam block areas. Vijayaakshaya Kumar *et al*. (2020) recorded maximum fall armyworm incidence during November 2019 in Perambalur district. In Tiruppur district also, the incidence was more in most of the blocks during November, 2020.

The response of farmers to different management practices is presented in Table 2. The preference to grow border crop was very low among the farmers (10 %). The labour required and applications of herbicides are the major impeding factors in growing border crops. Though the farmers are willing to do seed treatment and pheromone trap installation the knowledge on choosing correct insecticide is lacking. The empowerment of farmers on the basic aspects of seed treatment, border crop and pheromone trap will reduce the number of insecticide application.

Majority of the farmers do take up the TNAU recommended insecticides at the advised doses which is one of the important breakthrough in the fall armyworm management programme. However, the targeted application of insecticides into the whorls where the larvae reside, is yet to reach a larger group.

Table 1. Details of roving survey in Tiruppur District

Village	Block	Crop age (DAE)	Mention as Whorl/ cob / tassel	FAW Infestation			Natural enemies/10 plants				
				% infestn	FAW score	Larval popln./10 plants	Cocc.	Hym.	Ear wigs	spi.	Others.
Karanampettai	Palladam	30	Whorl	85	3.7	3	1	3	0	0	2
Karanampettai	Palladam	40	Whorl	50	2.5	0	0	0	0	0	0
Kannan Kovil	Kundadam	25	Whorl	90	3.2	14	1	2	0	0	0
Kannan Kovil	Kundadam	10	Whorl	46.7	2.1	3	0	0	0	0	0
Ragalbavi	Udumalpet	38	Whorl	32.5	3.8	5	2	0	0	0	0
Poolanginar	Udumalpet	30	whorl	44	2.52	5	0	0	0	0	0
Pottinaickanur	Gudimangalam	55	tassel	5	-	0	0	0	0	0	0
Pongaliappa-goundenpudur	Pethappampatti	35	whorl	50	4.7	3	0	0	0	0	0
Senjerimalai	Pethappampatti	20	whorl	32	2.8	3	2	0	0	0	0
Thanthoni	Madathukulam	90	cob	0	-	0	0	0	0	0	0
Thungavi	Madathukulam	60	tassel	15	-	0	0	0	0	0	0

DAE – Days after emergence

Table 2. Farmers response to adoption of Fall Armyworm Management practices

Particulars	Response (%)
Practice of seed treatment	15%
Willingness to grow border crops	10%
Number of insecticides sprayed (3-4 sprays)	90%
Use of pheromone traps	20%
Novel method (Change in nozzle, direct whorl application etc.)	30%
Adoption of TNAU Ad-hoc management practices	60%

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Assessment of Yield Loss in Maize due to Fall Armyworm *Spodoptera frugiperda* (J. E. Smith), in Tamil Nadu, India

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Keywords: *Fall armyworm, yield loss assessment, maize*

Introduction

Maize is a staple food crop in India, grown in an area of 8.8 million ha, ranks third in production next to wheat and paddy. At present, production of maize is significantly affected after the entry of the invasive pest, Fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae). This pest is native to the Americas and invaded into Asia during May 2018 and it was first reported on maize in Karnataka, India (Sharanabasappa *et al.* 2018). Since then, it has spread to other states *viz*., Andhra Pradesh, Telangana, Tamil Nadu, Maharashtra and Odisha. Considering the economic loss caused by FAW and its widespread across the countries, Food and Agriculture Organization (FAO) has declared FAW as food security threat and trying to find out effective solutions for the management of FAW. The information on the yield loss due to FAW in maize is scanty and an attempt was made to study the yield loss in maize due to FAW infestation.

Materials and Methods

An experimental field trial was laid out in a farmer's field at Singathakurichi, Karungulam block, Thoothukudi district (Latitude: 8.7922 N; Longitude: 77.7969 E), Tamil Nadu, India, under rainfed condition. Maize hybrid DKC 9133 was used for this study and the crop was raised during *Rabi* 2020. The treatments were imposed *viz.,* T1: Fully Protected: Recommended insecticide applied as and when FAW incidence is noticed [The insecticides *viz.,* Emamectin benzoate 5 SG @ 0.4 g/lit, Chlorantraniliprole 18.5 SC @ 0.4 ml/lit, Spinetorum 11.7 SC @ 0.5 ml/lit and Novaluron 10 EC 1 g/lit, were sprayed respectively on 18, 28, 42 and 63 days after emergence (DAE)]; T2: Window based insecticide application (Emamectin benzoate 5 SG @ 0.4 g/lit on 18 DAE and Chlorantraniliprole 18.5 SC @ 0.4 ml/lit on 42 DAE) and T3: Untreated Control. A plot size of 5x8 m^2 was maintained per replication and seven replications were maintained. Randomized block design was adopted. Twenty plants were randomly selected and observations on FAW infestation and damage rating as per TNAU score (Table 1) were recorded one day before the treatment and 7, 10, 14 days after spraying. The damage rating was made until tassel formation and finally for cob injury. The cob yield was recorded at harvest.

Results and Discussion

Fully protected maize plots (spraying insecticide immediately after seeing the incidence) and window based application of insecticides treated plots gave yields of 5290 and 4935 Kg/ha respectively. The window based application of insecticides recorded higher cost: benefit (CB) ratio of 1: 1.71, compared to 1: 1.63 in fully protected treatment. The untreated control plots recorded 2150 Kg/ha yield and a CB ratio of 1: 0.86 (Table 2). This study revealed that window based application of chemical insecticides recorded a good CB ratio compared to the fully protected condition. The yield loss was assessed as 59.36 and 56.43 per cent when compared to fully protected plots and window based insecticide applied plots. Hence application of recommended insecticides at correct stage is important to reduce the yield loss.

Table 1. Assessment of the yield loss due to FAW under rainfed condition

Treatment	Overall mean infestation* (%)	Overall mean score#	Yield (Kg/ ha)	Plant Protection charges (Rs./ha)	Income (Rs./ha)	CB Ratio
T1: Fully protected (Recommended insecticide sprayed as and when FAW incidence is noticed)	2.32[a] (8.70)	1.07[a] (1.25)	5290[a]	11050	79350	1: 1.63
T2: Window based application of insecticides	7.01[b] (15.33)	1.18[b] (1.30)	4935[b]	5900	74025	1: 1.71
T3: Untreated control	50.58[c] (45.33)	2.38[c] (1.70)	2150[c]	0	32250	1: 0.86
CD (P=0.05)	1.01	0.03	208.28	-	-	-
SEd	0.46	0.01	95.60	-	-	-

Values followed by the same alphabets in a column are not significantly different ; *Values in parentheses are arc sine transformed values; #Values in parentheses are square root transformed values Note: Maize @ Rs. 15 per Kg; Cultivation charges: Rs. 37500 per ha

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ES 02 BOPD 25

Seasonal Incidence of Major Insect Pests of Sorghum in Virudhunagar District, Tamil Nadu

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Keywords: *Sorghum, aphids, stem borer, minimum temperature, maximum temperature*

Introduction

Sorghum is an important grain and forage crop of semiarid regions due to its high adaptability and suitability to rain-fed low input agriculture. Sorghum occupies nearly 17000 ha in Virudhunagar District of Tamil Nadu. Among 11 blocks in the district, sorghum is mostly cultivated in Kariyapatti, Aruppukottai, Virudhunagar and Sivakasi blocks. However, insect pest damage poses a threat to productivity. Insect pests attack various developmental stages of the plant, from seeds to seedlings, whorls, flowering structures, and mature grain. About 150 insect species (in 29 families) affect sorghum worldwide (Jotwani and Young, 1972; Guo *et al*., 2011) and these insects can be key, secondary or occasional pests. Of which, economic importance and the major species are shoot flies, stem borers, grain midges and head bugs (Nwanze, 1985). Hence, fixed plot and roving survey was conducted at ICAR-Krishi Vigyan Kendra, Aruppukottai, Virudhunagar District during 2020-21 to study the major insect pests damaging sorghum crop with its weather parameters.

Materials and methods

For fixed plot survey, the sorghum variety Co (S) 32 was raised at KVK farm during rabi 2020. The standard agronomic practices were followed except the insecticidal spray. The insect pest damaging sorghum crop was recorded from 42nd standard week to harvest. The correlation of pest incidence with weather parameters also studied during entire cropping period. Similarly, natural enemy incidence also recorded. For roving survey, major sorghum growing blocks were covered and observation was taken once in 15 days in a month.

Results and discussion

Shoot fly, stem borer, aphids and natural enemies like coccinellid and spider were observed. Shoot fly incidence to the tune of 4.0 per cent was observed during 43rd standard week. Similar results were observed by Kanayo F. Nwanze (1988). The stem borer incidence was maximum during the month of November 2020 ranging from 6.4 – 7.2 per cent. (Table 1). The present finding is in accordance with the results of Kanayo F. Nwanze (1988), who observed the lowest stem borer infestation between January and May with maximum infestations occurring between August and October. The per cent aphid damage (12.8) was maximum during 45th std. week. Natural enemies like coccinellids and spiders were also noticed in fixed plot.

Shoot fly incidence was positively correlated with maximum and minimum temperature and negatively correlated with Morning RH, Evening RH. Stem borer was positively correlated with rainfall (0.646). Aphids and coccinellid were positively correlated with maximum and minimum temperature, rainfall and negatively correlated with RH. Spider population was positively correlated with minimum temperature (Table 2).

During roving survey, shoot fly incidence ranged from 5-10%, stem borer (7-15%) and aphid (10-20%) at Aruppukottai, Kariyapatti, Virudhunagar and Sivakasi blocks.

Table 1. Seasonal incidence of major insect pests in sorghum (Fixed plot survey)

Month	Standard week	Shoot fly (%)	Aphid Damage (%)	Stem borer damage (%)	Natural enemies observed (no/plant)		
					Coccinellids	Spiders	Others
15 Oct - 21 Oct,2020	42	2.4	8.0	0	1.2	-	-
22 Oct - 28 Oct	43	4.0	8.8	4	1.8	1.0	-
29 Oct - 04 Nov	44	3.2	11.2	6.4	3.4	-	-
05 Nov - 11 Nov	45	0	12.8	7.2	2.4	1.0	-
12 Nov - 18 Nov	46	0	8.0	6.4	1.8	-	-
19 Nov - 25 Nov	47	0	7.2	7.2	1.6	0	-
26 Nov - 02 Dec	48	0	4.2	0	1	-	-
03 Dec - 09 Dec	49	0	4.0	1.6	0.6	2.0	-
10 Dec - 16 Dec	50	0	1.6	0	0	-	-
17 Dec - 23 Dec	51	0	0	0	0	-	-
24 Dec - 31 Dec	52	0	0	0	0	-	-
01 Jan - 07 Jan,2021	1	0	0	0	0	-	-
08 Jan - 14 Jan	2	0	0	0	0	-	-
15 Jan - 21 Jan	3	0	0	0	0	-	-
22 Jan - 28 Jan	4	0	0	0	0	-	-

Table 2. Influence of weather parameters on the population of major insect pests in sorghum

Parameters	Correlation (r value)			Natural Enemies	
	Stem borer damage (%)	Aphids	Shoot fly incidence	Coccinellids	Spiders
Max. temp (x1)	0.127 NS	0.597*	0.872*	0.533*	-0.351NS
Min. temp (x2)	0.140 NS	0.574*	0.642*	0.552*	0.679 *
Morning RH (x3)	0.115 NS	-0.199 NS	-0.472 NS	-0.043 NS	0.406 NS
Evening RH (x4)	0.260 NS	-0.120 NS	-0.692*	-0.115 NS	0.473 NS
Rainfall (x5)	0.646*	0.713*	0.014 NS	0.570*	0.330 NS

Regression Equation
Stem borer = Y= 118.07-3.77(x1) +1.60 (x2)-0.33(x3)-0.23(x4) + 0.07(x5)
Aphids = Y= 54.62-2.12(x1) +1.82 (x2)-0.21(x3)-0.21(x4) +0.08(x5)
Shoot fly = Y= -129.95+3.98(x1)-1.98 (x2) +0.22(x3) +0.60(x4)-0.04(x5)
Coccinellids = Y= 19.17-0.94 (x1) +0.88 (x2)-0.11(x3)-0.03(x4)-0.22+0.01+0.05+0.62

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ES 02 BOPD 26

Extent of Damage by Avian Fauna in Pearl Millet and Measures for Management

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Keywords: *Pearl millet, avian fauna, reflective ribbon, scare crow, bird scare tape*

Introduction

Pearl millet is the main crop of Virudhunagar district of Tamil Nadu. It is grown as rainfed crop during rabi season. Most of the time the grain eating birds constitutes a serious economic problem to millet crop (Morel 1968). About 40 species of birds attack several cereal grains in African country (Schmutterer, 1969). Birds can inflict damage to the crops and a loss to the farmers in all the stages of crops right from sowing and planting till harvesting. The birds also damage fruit crops and also affect the quality of grapes which in turn reduces the quality of the wine (Loinger *et al*., 1977). Hence, the present study was carried out by ICAR-KVK, Aruppukottai with different bird scaring materials to minimize the loss caused by the granivorous birds.

Materials and methods

The pearl millet variety Co (Cu) 10 was raised at KVK farm during rabi 2020. Standard agronomic practices were followed except the insecticidal spray. For each treatment crop was raised in 5 cent area (200 m^2) and each treatment had five replications. In each plot, the number of earheads / cobs damaged by birds was counted at 5 points (four corners and one at middle) @ 50 plants /plant and then it was expressed in per cent damaged caused by birds.

Results and discussion

The number of ear head damaged was less in (10.2) reflective ribbons followed by scare crow (14). Similarly, the highest per cent over control of 65.78 was recorded with reflective ribbons, while minimum of 42.28 was recorded in bird scare tapes installed field. The highest yield of 10.92 q/ac was recorded in reflective ribbons and minimum yield of 7.5 q/ac was recorded with bird scare tapes (Table 1).

The bird species observed in pearl millet crop was house sparrows *Passer domesticus*, baya weavers, *Ploceus philippinus,* and rose-ringed parakeets *Psittacula krameri*. Similarly, Kale *et al*. (2014) recorded almost similar bird species damaging sorghum crop in Maharastra.

Table.1. Efficacy of different bird scarers against avian fauna in pearl millet

Treatment No.	Treatment	No. of ear heads damaged/ 200m^2	% ear head damage*	% reduction over control	Yield (q/acre)
T_1	Reflective ribbons	10.2	20.4 (26.85)	65.78	10.92
T_2	Bird scare tapes	17.2	34.4 (35.91)	42.28	7.5
T_3	Scare crows	14	28.0 (31.95)	53.02	9.0
T_4	Control	29.8	59.6 (50.53)	-	5.44
	CV (%)	11.37	11.37	-	5.50
	CD (P=0.5)	2.79	5.58	-	0.62
	SEm±	0.90	1.81	-	0.20

*Each value is the mean of five replications; Figures in parentheses are arc sine transformed values

Mean followed by the same alphabets in a column are not significantly different by LSD (p<0.05)

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ES 02 BOPD 27

A New Invasive Insect Pest, American Fall Armyworm, *Spodoptera Frugiperda* J.e. Smith (Noctuidae: Lepidoptera) Infestation in Maize in Pudukkottai District, Tamil Nadu

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Keywords: *Maize, Fall armyworm, roving survey, FAW score, coccinellids, spiders*

Introduction

Maize is the third largest cultivating crop next to rice and wheat globally. Maize is generally cultivated for human consumption as well as for preparation of cattle and poultry feed. In India, the area under maize cultivation was 9.38 million hectares with a total production of 28.75 million tonnes and the productivity was 3065 kg ha^{-1} during 2017-18 (Agricultural Statistics at a Glance, 2019). In Tamil Nadu, maize was cultivated in an area of 3.2 lakh hectare with production of 25.90 lakh tonnes and the productivity was 7986 kg ha^{-1} during 2017-18 contributing 9.01 per cent of total maize production. There are 141 insect pests are known to infest maize from sowing to harvest of the crop (Reddy and Trivedi, 2008). The American fall armyworm, *Spodoptera frugiperda,* an invasive pest is native to tropical and subtropical regions of the America and was first reported in Shivamogga district of Karnataka state on 18th May 2018 (Sharanabasappa *et al.,* 2018) and subsequently it was reported in other southern states of India (Padhee and Prasanna, 2019). It is a polyphagous pests reported to cause damage to 353 host plants from 76 families (Montezano1 *et al.,* 2018) surpassing 180 species reported earlier. It mainly feeds on maize, rice, sorghum, millet, sugarcane, cowpea cotton, potato, soybean, groundnut vegetable crops, cruciferous crops and cucurbits. As this is a new pest, farmers are applying inorganic insecticides without knowing the efficacy against this pest and the level of its infestation. Under these circumstances, continuous monitoring of fall armyworm in maize growing areas is of paramount importance to assess the damage level and presence of natural enemies population for formulating successful management strategies against fall armyworm.

Material and Methods

Roving survey was conducted in major maize growing blocks of Pudukkottai district *viz*., Thiruvarankulam Arimalam, Gandarvakottai and Karambakudi along with State Department of Agriculture officials during 2020-21. During survey, whorl damage and cob damage due to fall armyworm and presence of larvae were recorded in randomly selected 10 plants in three different places in the field and per cent infestation and number of larvae per plant were worked out. Based on the level of damage, TNAU FAW score was assigned from 1 to 5 (1- Nil damage to pin hole damage; 2- Circular or elongated holes with less than 1 inch on whorl leaves; 3- Elongated holes with more than 1 inch size on whorl leaves; 4-Elongated holes with 1 to 2 inch size and mild shredding on whorl leaves and 5- Severe shredding and defoliation of whorl and furl leaves) and presence of natural enemies were also recorded in randomly selected 10 plants. The Geo-coordinate were recorded during the entire survey programme.

Results and Discussion

During this survey, 15 to 65 days old maize crop was surveyed. The per cent infestation of fall armyworm was ranged between 3.33 and 26.67 in whorl damage and 3.33 to 12.0 in the tassel stage in Pudukkottai district (Table 1). The level of damage based on TNAU FAW score was ranged from 1.0 to 3.2. The damage percent was very minimum in all surveyed area except Suranviduthi of Thiruvankulam block where the infestation was high (26.67%). During the vegetative stage, the maximum larval population of 1.33 per plant was observed in Manganur of Gandarvakottai block followed by Periyavadi, Vanakkankadu of Karambakudi block with 1.30 larvae per plant and minimum larval population of 0.12 per plant was observed in Dhathchinapuram of Thiruvankulam block followed by Kanniyankollai of Karambakudi block with 0.3 larva per plant. During the reproductive stage, no larval population was observed in N.Pudupatti of Gandarvakottai block and maximum larval population of 0.82 per cob was observed in Vettukaadu of Arimalam block. The average per cent infestation of fall armyworm was 8.25 and average TNAU FAW score was 1.81 (Table 1).

As far as natural enemies, coccinellids and spiders were dominant and recoded eight and seven times respectively out of 15 surveyed areas. In Vettikadu of Arimalam block, the maximum of 1.22 coccinellids per 10 plants were recorded followed by Periyavadi, Vanakkankadu of Karambakudi block with 0.8 per 10 plants. With respect to spiders, Vettikadu of Arimalam block was recorded the maximum of 1.4 spider per 10 plants followed by Suranviduthi of Thiruvankulam block (1.33/10 plants). The average natural enemies population per 10 plants were coccinellids (0.55), hymenopterans (0.38), cricket (0.21) and spider (0.69). Vijayaakshaya Kumar *et al*., (2020) has also reported infestation of fall armyworm in maize in Perambalur district.

Table 1. Roving survey on fall armyworm infestation and its natural enemies in Pudukkottai District

Village	Block	GPS	Age of Crop	Damaged parts	FAW infestation			Natural enemies/10 plants		
					% infestation	TNAU FAW score	Larvae plant	Coccin.	Hymen.	Spiders
Kothakottai	Thiruvarankulam	10.362441 N 78.915044 E	35	Whorl	4.50	1.2	0.70			
Dhathchinapuram	Thiruvarankulam	10.3413 N 78.91912 E	15	Whorl	3.33	1.0	0.12		0.20	
Suranviduthi	Thiruvarankulam	10.345461 N 79.009431 E	35	Whorl	26.67	3.2	0.74			1.33
Manganur	Gandarvakottai	10°36′57″ N 78°58′3″ E	30	Whorl	10.00	1.8	1.33			0.60
Manganur	Gandarvakottai	10° 36′ 58″ N 78° 58′ 04″ E	40	Whorl	6.67	2.4	0.67	0.67	0.50	
Periyavadi, Vanakkankadu	Karambakudi	10° 22′ 35″ N 79° 03′ 28″ E	32	Whorl	12.00	2.3	1.30	0.80		
Kanniyankollai	Karambakudi	10° 23’ 00’’ N 79° 04’ 55’’ E	28	Whorl	10.00	1.26	0.25			0.60
Kottaikadu,Mullankuruchi South	Karambakudi	10° 24’ 36’’ N 79° 05’ 16’’ E	24	Whorl	4.00	1.1	0.30	0.50	0.30	0.40
Kottaikadu,Mullankuruchi South	Karambakudi	10° 24’ 39’’ N 79° 05’ 22’’ E	22	Whorl	8.00	1.26	0.30	0.30		0.30
Vettukaadu	Arimalam	10.2182 N 78.8815 E	65	Cob	4.60	2.6	0.82	1.20	0.60	1.40
Keelapanaiyur	Arimalam	10.2195 N 78.8948 E	70	Cob	3.33	-	0.60	0.50	0.30	
N.Pudupatti	Gandarvakottai	10° 34′ 02″ N 79° 03′ 36″ E	62	Cob	3.33	-	0			
N.Pudupatti	Gandarvakottai	10° 33′ 54″ N 79° 03′ 35″ E	65	Cob	3.33	-	0			
Vettaikadu, Mullankuruchi South	Karambakudi	10° 23’ 24’’ N 79° 05’ 09’’ E	60	Cob	12.00	-	0.12	0.20		
Kottaikadu,Mullankuruchi South	Karambakudi	10° 23’ 24’’ N 79° 04’ 09’’ E	65	Cob	12.00	-	0.12	0.20		0.20
		Average			8.25	1.81	0.49	0.55	0.38	0.69

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ES 02 BOPD 28

Management of Invasive Fall armyworm *Spodoptera frugiperda* (J.E.Smith) on Dryland Sorghum

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Keywords: *Sorghum Spodoptera frugiperda, management*

Introduction

Fall armyworm *Spodoptera frugiperda* is invasive pest that entered into India in 2018 has created potential damage to Sorghum crop along with the Maize. To alleviate the damage on sorghum and emphasize the relative cost and benefit, experimentation was done with various methods at Regional Agricultural Research Station, Nandyal, Acharya N G Ranga Agricultural University, Andhra Pradesh, India consecutively for three years from 2018 to 2020.

Materials and methods

Seven chemical insecticides (Thiodicarb 75 SP used as poison bait, Emamectin benzoate 5 SG, Lambda cyhalothrin 5 EC, Chlorantranniliprole 18.5 SC, Profenophos 40 EC+ Cypermethrin 4 EC combination chemical, Spinosad 45 SC and Dichlorovas @ 200 ml + Emamectin Benzoate 5 SG), one bio-pesticide *Bacillus thuringiensis* Kurstaki strain formulation, two botanical insecticides *viz*. Agniastram (Formulation prepared from tobacco, neem, garlic, green chilli) and Neem oil 3000 ppm and the soil slurry drenching in the sorghum whorls. Treatment imposition was done three times commencing from 20 days after sowing at fifteen days interval to 50 days of the crop growth stage. Data on percent plants infested and yield data and cost-benefit analysis were calculated.

Results and discussion

Among the twelve tested techniques percent plant infestation 14 days after three sprays was low in the poison bait with thiodicarb 75 SP (9.52 %) which was on par with spinosad 45 SC (10.68 %), chlorantraliniprole 18.5 SC (13.37 %) and emamectin benzoate 5 SG (16.21 %). In the current trial higher reduction of percent plant infestation was observed with the poison baiting with thiodicarb treated plot is in agreement with Srujana *et al* (2021) who recorded the highest reduction of fall army worm in maize crop. In an investigation done by Lunagariya *et al* (2020) poison bait with thiodicarb in the maize crop resulted in lower leaf damage, cob damage and higher yields.

The mean plant damage differed significantly between both treatments. Out of twelve treatments lowest and significant damage was noticed from poison bait (9.52%), spinosad (10.68%) and chlorantraniliprole (13.37%) treatments, while in control it was 68.19 %. Except control in all other treatments, reduction of plant damage in sorghum crop was observed from 1st spray (25 DAS) to 3rd spray (50DAS). Poison bait treatment demonstrated a considerable damage due to *S. frugiperda* in three different spray schedules.

Higher yields with greater benefit-cost ratio were noted with chlorantraliniprole 18.5 SC (5755 kg/ha; BC ratio 2.7) followed by spinosad 45 SC (5544 kg/ha; BC ratio 2.6), thiodicarb 75 SP (4940 kg/ha; BC ratio 2.3) and emamectin benzoate 5 SG (4677 kg/ha; BC ratio 2.3).

Table 1. Efficacy of treatments on Yield and Benefit-cost ratio

Treatment details	Dosage / acre	Yield (kg/ha)	Benefit Cost Ratio
Poison bait (10+1+1+0.1) Rice bran + jagerry + water +Thiodicarb 75 SP	20 Kg	4940.21	2.3
Emamectin benzoate 5 SG	80 g	4677.21	2.6
Lambda cyhalothrin 5 EC	200 ml	4242.51	2.3
Chlorantraliniprole 18.5 SC	80 ml	5755.17	2.7
Bt 127 Formulation	600 ml	4121.17	2.3
Agnastram	2 lit	3519.58	1.7
Soil Drenching	-	3536.17	1.9
Profenophos 40 EC+ Cypermethrin 4 EC	500 ml	4301.10	2.4
Spinosad 45 % SC	70 ml	5544.02	2.6
Dichlorovas @ 200 ml +Emamectin Benzoate 5 SG	80 g	4811.24	2.5
Neem oil 3000 ppm	1 lit	3626.21	1.9
Untreated control		2497.40	1.5
	CV	15.46	
	CD (5%)	1125.17	

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ES 02 BOPD 29

Screening of coriander genotypes for seed yield and their relative susceptibility against aphid population in field conditions

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Keywords: *Coriander, genotypes, seed yield, aphids and susceptible*

Introduction

Coriander (*Coriandrum sativum* L.) is an important major seed spice crop, grown for leaves as well as seed purpose. Coriander seeds and leaves contain essential oils, which account for aromatic character of the plant (Sankaracharya and Sankaranarayana, 1989). Coriander seeds are considered as carminative, diuretic, stomachic, antibilious, refrigerant and aphrodisiac (Butani, 1984).The fresh leaves are an ingredient in many South Asian foods (Moulin, 2002). Coriander is the most susceptible crop to aphids in semi-arid region, if plant protection measures are not applied on time; it causes nearly 40-50% yield losses.

Materials and Methods

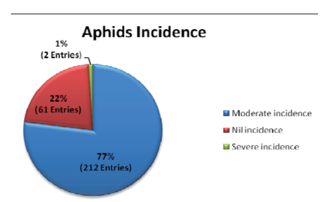
Two hundred and seventy-five coriander genotypes were maintained in the Department of Spices and Plantation Crops, Horticultural College and Research Institute, Coimbatore was used as the planting materials. The 275 genotypes were laid out in augmented block design including four check varieties *viz*., CO (CR) 4, CO 1, CO 3, and CO 2. Check varieties were randomly planted. Each genotype was sown in three rows per plot of 3m^2 at a spacing of 30 cm x 15 cm accommodating 20 plants in each row.

Results and Discussion

Evaluation of coriander genotypes for seed yield per plant revealed that 37 genotypes recorded significantly higher seed yield compared to the best check CO (CR) 4 (11.02 g/plant). The best seven genotypes in terms of seed yield per plant were CS 274 & CS 243 (16.50 g), CS 186 (15.95 g), CS 275 (15.40 g), CS 191, CS 242 (14.85 g) and CS 268 (14.80 g). Cluster analysis for grouping of coriander genotypes based on the performance of seed yield per plant revealed that 275 coriander genotypes were grouped into ten clusters, in such a way that all the accessions within the cluster had smaller values among themselves than those belonging to different clusters. Cluster IV (17.45%) comprising 48 genotypes was the biggest and showed high homogeneity among them or the least genetic variation, followed by clusters I, III, II, VII and V consisting of 41, 40, 38, 37 and 33 genotypes respectively (Fig.1). Cluster VIII and X had 13 genotypes each whereas 11 genotypes were grouped under cluster IX. The check varieties *viz.,* CO1, CO2, CO 3 and CO (CR) 4 were grouped in different clusters. However, CO2 and CO 3 found their place in cluster II which comprised 38 genotypes. Varieties CO1 and CO (CR) 4 were grouped in cluster III and IV respectively. It was interesting to note that CS 31 alone with a seed yield of 6.33 g/plant was grouped in cluster VI. Screening of the 275 genotypes for aphid population revealed that 212 entries recorded moderate incidence (3.13 – 316.6) of aphid population per plant during the study period (Fig.2). About 61 entries were observed with nil incidence of aphids and the seed yield per plant among the above 61 entries ranged from 5.50 g/plant – 13.75 g/plant. Severe incidence of more than 500 aphids per plant was observed in two genotypes *viz.,* CS 7 and CS 11 which recorded a seed yield of 6.60 g/plant. The above two genotypes had an extended period of vegetative growth exploring the possibilities of high herbage yield (leafy coriander type). This might also be considered as the reason for high number of aphid population.

Table 1. Relative incidence of aphid population in coriander genotypes grown in open field conditions

Pest reaction of entries	No. of entries
Nil incidence	61 entries (0 aphid/plant)
Moderate incidence	212 entries (3.3 to 316.6 aphids/plant)
Severe incidence	2 entries (> 500 aphids/plant)



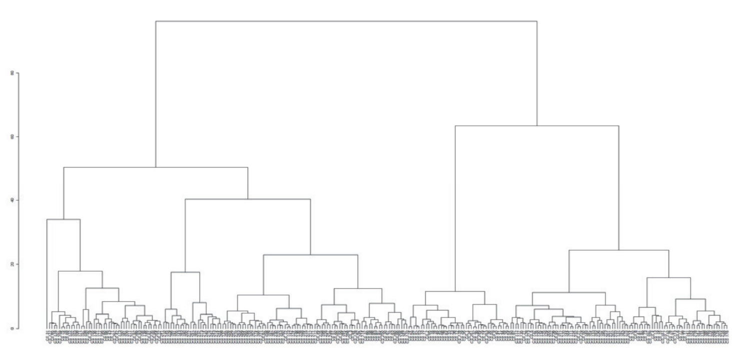


Fig 1. Dendrogram based on quantitative characters for 275 Coriander genotypes

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ES 02 BOPD 30

Evaluation of Certain Light Traps in Godown for the Management of Insects in Stored Paddy

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Keywords: *Light traps, stored product insects, rice storage godown*

Introduction

The phototactic response is an important IPM tool in the management of insects. Light traps have been used to manage stored product insects. Incandescent, fluorescent and LED sources of light have certain wavelength spectrum of effective range to attract insects (Cohnstaedt *et al.,* 2008). Inorder to explore and exploit this phenomenon, we have investigated the phototactic responses of insects that are infesting paddy storage under godown condition.

Materials and methods

For this study, trap set ups of different electrical power lights *viz*. Light Emitting Diode (LED) 15W, LED 20W, Compact Fluorescent Light (CFL) 15W, CFL 18W, Incandescent light 15W and 25W were chosen and installed in the farm godown (14.5×6.5×3.5 m^3) where paddy seeds were stored in gunny bags. All the light traps were simultaneously installed at 2 meters height from the ground level. They were operated for 12 hours from 6 pm to 6 am throughout the weekdays and observed for the number of insects trapped. The trap catches were recorded for 35 days from first week of July (SW 28) to the second week of August 2021 (SW 32). The attracted and trapped insects were observed and sorted out based on major species.

Results and Discussion

The observations of the study indicated that the light trap equipped with incandescent 25 W light effectively attracted *Rhizopertha dominica, Tribolium* spp. and *Sitotroga cerealella* to an extend up to 85.12 % of total catches followed by CFL 18W with 73.65 %. Similarly the highest proportion of *R. dominica* (29.69 %), *Tribolium* spp. (28.16 %) and *S. cerealella* (25.05 %) were trapped under the light source of incandescent 25 W (Table 1). Other light sources such as incandescent 15W, LED 15W, LED 20W and CFL 15W were less effective. The attraction of *R. dominica*, *S. cerealella*, *T. castaneum* and *Sitophilus zeamais* to light traps (6W blacklight-blue) was studied and ascertained by Nualvatna *et al.* (2003). The black light spectrum was preferred by *R. dominica* over the 6W blacklight-blue and green incandescent lamps. Duehl *et al.,* (2011) examined various wavelengths of LEDs and observed about only 20% attraction in LED which confirms the effectiveness of incandescent light source.

Table 1.The attraction and trap catches of stored product insects to different light sources in rice godown

Light Sources	Total Insect Trapped (%)	Proportion of insects attracted/trap/week (%)		
		R. dominica	*Tribolium spp.*	*S. cerealella*
LED 15W	32.96	12.26 (20.50) [d]	9.77 (18.21) [d]	10.93 (19.31) [e]
CFL 15W	30.40	6.79 (15.10) [e]	7.90 (16.33) [e]	15.71 (23.35) [c]
Incandescent 15W	42.75	16.92 (24.29) [c]	12.76 (20.93) [c]	13.08 (21.20) [d]
LED 20W	25.49	5.97 (14.15) [e]	8.31 (16.75) [e]	11.21 (19.56) [e]
CFL 18W	73.65	26.04 (30.68) [b]	28.16 (32.05) [b]	19.45 (26.17) [b]
Incandescent 25W	85.12	29.69 (33.02) [a]	30.37 (33.44) [a]	25.05 (30.03) [a]
		0.558	0.347	0.283

Values in parentheses are the arcsine transformed data

Means followed by the same letter (s) in a column are not significantly different by DMRT (P=0.05)

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ES 02 BOPD 31

A Study on the Seed Health Status of Farmers Saved Seeds Collected From Three Districts of Tamil Nadu

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Keywords: *Famers saved seeds, stored grain insects, seed health status*

Introduction

Farmer saved seed accounts for the greatest proportion of seeds used by farmers worldwide especially in low-income countries. Of the total seed requirement in the country, only less than 20 per cent good quality seeds are available to the farmers and more than 80 per cent of the requirement is met up by farmers and more than 80 per cent of the requirement is met up by the farmers saved seeds. More than 200 species of insects are associated with stored seeds. Insect infestation may cause up to 30 per cent loss in storage. A study was conducted to assess the seed health status of farm saved seeds with respect to insect infestation from three districts of Tamil Nadu.

Materials and Methods

A survey was made in the Virudhachalam (Cuddalore district), Mecheri (Salem district), Kombur (Dharamapuri district) and Athanur (Thirupattur district) of Tamil Nadu to study the seed health status of farmers saved seeds. A total of 100 seed samples comprising seven major crops *viz*., groundnut (25 samples), lab lab (20), sorghum (20), cowpea (20), horsegram (5), blackgram (5) and greengram (5) were collected during the survey. Details regarding varieties, type of storage structures, storage period and seed protection measures followed by the farmers were also collected. Seed samples were analysed to assess the storage insect pest infestation, germination, vigour and moisture content.

Results and discussion

Analysis of farmers saved seeds revealed the infestation of four species of stored grain insects *viz*., *Caryedon serratus* (Olivier) (groundnut), *Tribolium castaneum* (Herbst) (sorghum), *Sitophilus oryzae* (Linnaeus) (sorghum) and *Callosobruchus* sp (Indian bean and cowpea). In case of groundnut, out of 25 samples two samples were infested and showing insect damage higher than the permissible level (0.5 per cent) prescribed by Indian Minimum Seed Certification Standards (IMSCS). Two seed samples of lab lab, out of 20, were infested by *Callosobruchus* sp with insect damage level higher than the IMSCS(Fig 1). In sorghum, three seed samples were infested by *S. oryzae* and out of three, two samples showed insect damage higher than IMSCS. Six farm saved cowpea seed samples showed insect damage more than 1.0 per cent. Horsegram, blackgram and greengram seed samples were free from insect infestation. Solar drying of seeds, treating the seeds with botanicals *viz*., *Vitex negundo* leaf powder, sweet flag rhizome powder, mixing of *Ocimum* sp and dry chillies were the non – chemical seed protection measures adopted by the farmers. Most of the farmers used gunny bags to store the seeds.

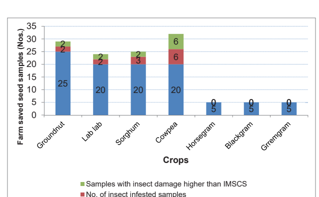

Fig. 1 Seed health status of farm saved seeds with respect to insect infestation in Tamil Nadu

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ES 02 BOPS 01

Incidence of Coconut Rugose Spiralling Whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) and its Parasitoid *Encarsia guadeloupae* Viggiani. in Kanyakumari District of Tamil Nadu

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Keywords: *Rugose spiraling whitefly, Aleurodicus rugioperculatus, Encarsia guadeloupae*

Introduction

Rugose Spiralling Whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae), is a small, sap sucking polyphagous, invasive pest. De-sapping by RSW especially from the older fronds would induce stress on the palms due to removal of water and nutrients. Due to extensive feeding and excretion of abundant honey dew which subsequently gets deposited on the upper leaf surface of lower fronds, develop dense sooty mould rapidly. In India, this pest was reported from different locations of Coimbatore district, of Tamil Nadu and Palakkad district of Kerala during July-August 2016 on coconut (Sundararaj and Selvaraj, 2017; Srinivasan *et al.,* 2016; Selvaraj *et al.,* 2016). The present investigation was carried out to assess the status of incidence of RSW in coconut and parasitisation by *Encarsia guadeloupae*at Kanniyakumari district of Tamil Nadu during 2018-19.

Materials and Methods

Roving survey was conductedat major coconut growing blocks of Kanyakumari district *viz.,* Agastheeswaram, Killiyoor, Kurunthancode, Melpuram, Munchirai, Rajakkamangalam, Thiruvattar, Thovalai and Thuckalayduring November to December 2019 to assess the percent incidence ofrugosespiralling whitefly in coconut and parasitisation of *E. guadeloupae*. The surveillance was conducted in five locations in each block. The observation on incidence and infestation grade index of RSWF and parasitisation by *E. guadeloupae* were taken in randomly selected 10 trees in a garden. The infestation grade index was calculated using the damage rating scale developed by Srinivasan *et al.* (2016).The circularexit holes of parasitoid emergence were countedunder stereozoom microscope to assess the rate of parasitisation. The parasitised nymphs were black whereas, the unparasitised nymphs were pale yellow in colour

Resultsand Discussion

The incidence of RSW was highest in Rajakkamangalam (72.6%) followed by Kunrunthancode (70.5%) and Thovalai (60.5%). The incidence was low in Thakalay (23%) compared to other blocks. The infestation grade index were high (2.7) in Rajakkamanagalam followed by Kurunthangode (2.4) and Munchirai (2.2) and it was low in Thackalay block (0.8).

The highest parasitisation of *E. guadeloupae* was observed in Thuckalay (63.7%) followed by in Melpuramblock (58.4 %) and Killiyoor (43.9 %) block. The lowest parasitisation was recorded in Rajakkamangalam block (23.7 %). The higher incidence and infestation grade index of RSW in Rajakkanmangalam, Kunthankode and Thovalai blocks might be due to low parasitisatoin by *E. guadeloupae*. The *E. guadeloupae* parasitization range from 20-60% in coconut crop ecosystem followed by 40-70% in banana crop ecosystem (Srinivasan *et al*., 2016). *E. gudelouape* is a potential parasitoid for the managemet of rugose spiralling whitefly in coconut (Alagar *et al.*, 2021; JosephRajkumar *et al*., 2019)

Table 1. Incidence of coconut rugose spiralling whitefly and its parasitisation Kanyakumari district of Tamil Nadu

Name of the block	RSW incidence (%)	RSW Infestation Grade Index	Parasitisation by Encarsia guadeloupae (%)
Agastheeswaram	53.2	1.7 (Medium)	28.2
Killiyoor	51.1	1.9 (Medium)	43.9
Kurunthancode	70.5	2.4 (High)	33.5
Melpuram	35.2	0.9 (Low)	58.4
Munchirai	52.8	2.2 (High)	31.8
Rajakkamangalam	72.6	2.7 (High)	23.7
Thiruvattar	50.8	1.8 (Medium)	34.1
Thovalai	60.5	1.3 (Medium)	37.5
Thackalay	23.7	0.8 (Low)	63.7
Mean ± SE	52.15 ± 5.1	1.75 ± 0.2	40.82 ± 4.8

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ES 02 BOPS 02

Studies on Host Preference for Citrus Butterfly, *Papilio demoleus* Linnaeus

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Keywords: *Citrus butterfly, host preference*

Introduction

Citrus is one of the most significant and widely grown fruit crops which support our agricultural economy by its abundant usage. It has a greater adaptability to various climatic conditions. Citrus industry is the third largest in the world next to banana and mango. Citrus is affected by around 165 economically important insect pests causing yield loss of about 30 per cent (Pruthi and Mani, 1945). Among the economically important pests, citrus butterfly, *Papilio demoleus* is one of the serious pests causing yield losses through defoliation. Host plant selection by herbivore insect involves not only choosing the right species of plant, but also selecting an individual plant within that species which is suitable for feeding, survival and development of immature stages. Apart from this factor, chemical profile of the plant also plays a pivotal role in host selection (Prashant *et al*., 2017). Considering the importance of this pest, the present study was investigated to generate information regarding the host preference.

Materials and Methods

An experiment was conducted at Entomology laboratory of Sethu Bhaskara Agricultural College and Research foundation, Karaikudi with five different Rutaceae host species for citrus butterfly, *P. demoleus.* Preference of *P. demoleus* to five Rutaceae plants (citrus, *Citrus aurantifolia*; mandarin, *Citrus reticulata*; bael, *Aegle marmelos*; wood apple, *Limonia acidissima*; and curry leaf, *Murraya koenigii*) was investigated in laboratory, where five second instar larvae of the citrus butterfly were transferred to each plastic trays containing leaves of different host plants. The degree of preference was determined by measuring the total leaf weight of each host before and after consumption by larvae and the leaves were renewed on a daily basis. The quantity (mg) of leaf consumed by the larvae was determined by deducting the weight of the healthy leaves. Thus, the weight (mg) of leaf consumed by larva left in the containers was recorded with the help of an electronic balance.

Results and discussion

When the second instar larvae were fed with citrus leaves, the mean leaf consumption by the larva was 441 mg which was significantly greater than other host leaves. Mean leaf consumption by the larva in mandarin and curry leaf host were 402 mg and 385 mg, respectively. This was followed by the hosts Bael and wood apple which showed 312 mg and 293 mg mean leaf consumption respectively. According to the results obtained in this study, *C. aurantifolia* and *C. reticulata* appeared to be the most favourable hosts for *P. demoleus* among the Rutaceae hosts tested and this was followed by *M. koenigii, A. marmelos* and *L. acidissima.* The present study was in coincidence with the findings of Mahesh *et al.* (2003) who reported that lemon was the most preferred and most suitable food for the development of *P. demoleus.*

Table 1. Amount of leaf consumption by citrus larvae on various hosts among citrus family

M. Host	Amount of leaves consumed by larva on different days in mg					Total consumption of leaves by larva (mg)
	1st day	2nd day	3rd day	4th day	5th day	
Citrus, Citrus aurantifolia	50	75	82	96	138	441
Mandarin, Citrus reticulata	45	62	78	91	126	402
Bael, Aegle marmelos	37	55	72	68	80	312
Wood apple, Limonia acidissima	35	53	70	64	71	293
curry leaf, Murraya koenigii	42	60	76	87	120	385

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ES 02 BOPS 03

Assessment of damage potential of green stink bug, *Nezara viridula* in green gram (*Vigna radiata* L.)

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Keywords: *Nezara viridula, green gram, damage potential.*

Introduction

Green gram (*Vigna radiata* L.) is an important pulse crop in India with an area, production and productivity of about 4 million ha, 2 million tonnes and 500kg/ha. About 64 insect species can cause damage to green gram (Lal, 1985). Southern green stink bug, *Nezara viridula* L. is a polyphagous pest belonging to the family Pentatomidae and is cosmopolitan in distribution with more than 145 host plants (Panizzi *et al*., 2000). Nymphs and adults of green stink bugs suck the sap from pods during pod formation stage resulting in chaffiness of grains. In south India, southern green stink bug has slowly gained importance as a major pest in green gram (Durairaj and Kumar, 2013). Among the pests of pulses, green stink bug is the recent emerging pest which reduces the quantity and quality of grains.

Materials and methods

Mass culturing of green stink bugs

Adults of *N. viridula* were initially collected from different host plants *viz.,* pigeon pea, pearl millet and bhendi raised in TNAU, Coimbatore to establish stock culture. Field collected adults were kept in plastic containers (20 cm length, 15 cm height and 9 cm breadth) with a dry filter paper at the base and tender bean pods were provided as food and dried pods were replaced with fresh ones on alternate days. Mouth of the plastic container was covered with a muslin cloth for good aeration and to avoid moisture condensation which also served as oviposition substrate.

Damage potential studies

To find out the damage potential of *N. viridula* in green gram, adults obtained from mass culture were used. Green gram variety, CO 6 was sown in pots (26 cm dia. and 27 cm height) under glass house conditions. Three plants were maintained per pot. At the time of flowering, plants were confined with mylar film cages (30 cm dia. and 55 cm height). The top of mylar cage was covered with muslin cloth to prevent infestation by other insects and for aeration. This setup was replicated thrice for seven population densities (0, 3, 6, 9, 12, 15 and 18 adults/ 3 plants). Adult were released into the cages when the plants were in the early pod formation stage with above population densities and allowed to feed undisturbed.

The released adults were observed periodically for survival, and the dead adults were removed and replenished with healthy ones in order to maintain the population load. When pods were in maturity stage, the cages were removed. Pods in each caged plant were collected individually in separate covers. Observations were made on total number of pods/ 3 plants, total number of seeds/ 3 plants, number of healthy and chaffy seeds/ 3 plants and weight of seeds/ 3 plants. Based on the data, regression analysis was made between adult population density vs avoidable yield losses and the intercept value was found out (Durairaj and Ganapathy, 2000).

Results and Discussion

Experimental results showed that mean total number of pods/ 3 plants was almost similar and ranged from 30.3 to 32.0/ 3 plants in different bug population densities (Table. 1). The percentage of chaffy pods varied from 0.0 to 60.0 in 3 bugs/ 3 plants and 18 bugs/3 plants respectively. In other population densities, the percent chaffy pods ranged from 8.6 to 41.9. There were no chaffy pods in plants without bug release. Similar trend was observed in chaffy seed observation also. The chaffy seed percentage was maximum (48.5 %) in the bug population of 18 bugs/ 3 plants. There were no chaffy seeds in the bug population of 3 bugs/ 25 plants. This result concluded that percentage of chaffy pods and chaffy seeds increase with bug density i.e., bug density is directly proportional to chaffy pod and seed percentage. In green gram, yield loss by pod borers and other insects were reported by many workers (Sharma, 1998). However, studies on damage potential by *N. viridula* in green gram were not made earlier. Present investigation on yield losses by *N. viridula* on green gram revealed that the percentage of chaffy pods and seed increased with increase in bug density and one bug per plant could cause 2.4 kg yield loss per hectare.

Table 1. Damage potential of *Nezara viridula* in green gram under greenhouse conditions

No. of bugs/ 3 plants	Total No. of pods $^{\#}$ / 3 plants	Chaffy pods* (%)	Total No. of seeds$^{\#}$ / 3 plants	Chaffy seeds* (%)
0	32.0	0.0	256.6	0.0
(control)	(5.7)	(4.0) ^{f}	(16.0) ^{a}	(0.6) ^{g}
3	30.3	0.0	250.0	4.0
	(5.5)	(4.0) ^{f}	(15.8) ^{bc}	(11.5) ^{f}
6	31.0	8.6	247.0	16.3
	(5.6)	(17.5) ^{e}	(15.7) ^{c}	(23.8) ^{e}
9	31.3	18.0	249.3	25.4
	(5.6)	(25.5) ^{d}	(15.8) ^{bc}	(30.2) ^{d}
12	31.6	26.3	253.0	30.5
	(5.6)	(31.1) ^{c}	(15.9) ^{ab}	(33.5) ^{c}
15	31.0	41.9	246.0	42.8
	(5.6)	(40.6) ^{b}	(15.7) ^{c}	(40.8) ^{b}

18	31.6	60.0	245.3	48.5
	(5.6)	(51.1)[a]	(15.6)[c]	(44.1)[a]
SEd	0.069	1.155	0.069	0.524
CD(p=0.05)	0.15[NS]	2.48**	0.15**	1.13**

All values are mean of three replications;

**Significant; NS- Non significant.

In a column, means followed by the common letter(s) are not significant by LSD (p <0.05).

[#] Figures in the parentheses are square root $(\sqrt{x+0.5})(\sqrt{x+0.5})$ transformed values.

* Figures in the parentheses are arc sine transformed values

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ES 02 BOPS 04

Screening of Maize Genotypes Against Maize weevil (*Sitophilus zeamais* Motschulky) under storage conditions

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Keywords: *Host plant resistance, Sitophilus zeamais, Maize genotype*

Introduction

The maize weevil, *Sitophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae) is the most economically important destructive stored product pest of grains, cereals, and other processed and unprocessed stored products worldwide. The pest is devastating and is capable of multiplying to large populations, causing enormous damage. Screening for resistant genotypes as a part of integrated pest management is advantageous, and has an important role over other methods such as chemical control in managing this pest.

Materials and methods

The work was conducted in the PG Laboratory of Department of Entomology, College of Agriculture, SVPUA&T, Meerut, Uttar Pradesh state, India at a temperature of 28±2°C and 75±5% R.H. in B.O.D incubator in completely randomized design (CRD). Ten varieties of maize were screened for *S. zeamais* resistance. About 100g seeds from each of the maize varieties were placed in a 250cm^3 plastic jar. Ten pairs of newly emerged maize weevils, *S. zeamais* were released in each jar, which were then covered with muslin cloth to allow ventilation and prevent escape of the weevils. Adult mortality was recorded 7 days after introduction of the weevils. F1 progeny: Emerging progeny were removed from each jar and counted on each assessment day. These observations were continued for 56 days until the entire first generation was expected to emerge. Weight loss: After 45 days of incubation, the clean grains were weighed and the percentage weight loss was calculated. The median development period was calculated as the time (days) from the middle of the oviposition period to the emergence of 50% of the first generation. The index of susceptibility was calculated using the method of Dobie (1974) which is based upon the number of insects emerging in the F1 and the median development time. Using this method, varieties were categorized as resistant (≤4), moderately resistant (4.1- 6.0), moderately susceptible (6.1- 8.0), susceptible (8.1 – 10) and highly susceptible (>10).

Results and Discussion

The results are presented in Table 1. The adult mortality, F1 progeny, weight loss, mean development time and index of susceptibility were highest in susceptible genotype IML-4-18-1 (4.33 per cent, 455.99 adults, 50 per cent, 31.84 days and 8.35, respectively) and lowest in resistant genotype HKI-163 (10.33 per cent, 11.69 adults, 4.67 per cent, 48.37 days and 2.19, respectively). Hiruy *et al.* (2018), screened twenty-one maize varieties for resistance against maize weevils, support the results. The result shows that the adult mortality and mean development time were low in resistant genotypes; F1 progeny, weight loss and index of susceptibility were high in the susceptible genotypes. The genotypes (HKI-163, DMRH-1308, DML-170) with maximum adult mortality and mean development time and minimum F1 progeny, weight loss and index of susceptibility showed resistance to *S. zeamais.* Their use could contribute to affordable, ecologically sound and effective management of *S. zeamais* under storage conditions in the future.

Table 1. Screening of selected maize varieties for their relative resistance/susceptibility to maize weevil, *S. zeamais*

Genotype	Adult mortality after 7 days** (%)	F1 progeny	weight loss** (%)	Mean development period* (days)	Index of susceptibility
DMRH-1301	8.33 (16.772)[b]	43.63	18.66 (25.569)[e]	44.84 (6.77)[e]	(3.65)[e]
IML-1941	6.33 (14.566)[c]	269.57	38.67 (38.444)[b]	42.27 (6.57)[d]	(5.75)[d]
HKI-163	10.33 (18.747)[a]	11.69	4.67 (12.418)[g]	48.37 (7.02)[g]	(2.19)[g]
DMRH-1308	10 (18.421)[ab]	15.47	12.66 (20.836)[f]	47.73 (6.98)[f]	(2.49)[f]
IML-4-18-1	4.33 (11.998)[e]	455.99	50 (45.000)[a]	31.84 (5.73)[a]	(8.35)[a]
DMRH-1410	4.66 (12.418)[de]	436.52	48.66 (44.236)[a]	32.98 (5.82)[a]	(8.01)[a]
BML	5.66 (13.760)[cd]	350	40.66 (39.620)[b]	40.30 (6.42)[c]	(6.31)[c]
IIMRQRP-1530	6.33 (14.510)[c]	297.00	26 (30.646)[d]	40.13 (6.41)[c]	(6.16)[c]
DML-170	9.66 (18.095)[ab]	19.37	13.33 (21.195)[f]	45.84 (6.84)[e]	(2.80)[f]
DMRPE	5.33 (13.340)[cde]	381.25	33.33 (35.257)[c]	36.40 (6.11)[b]	(7.10)[b]
CD(0.05)	1.749	1.329	3.020	0.077	0.025
SE(m)	0.589	0.447	1.017	0.026	0.008
SE(d)	0.833	0.632	1.438	0.037	0.012
C.V.%	6.684	1.090	5.624	0.694	0.622

(*)Values in parentheses are square root transformed values

(**) Values in parentheses are angular transformed values

In each column values with similar alphabet do not vary significantly at P=0.05

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ES 02 BOPS 05

Contact toxicity of methanolic extracts of some botanicals against rice weevil *Sitophilus oryzae* (L.) in stored maize and GC MS/MS analysis of *Mentha spicata*

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Keywords: *Sitophilus oryzae, methanol extracts, botanicals, contact toxicity, Mentha spicata*

Introduction

Rice weevils are internal feeders, and the entire development cycle occurs within the kernel. It is the most destructive insect pest of stored grain and cause 12.9 % loss. One pair of *S. oryzae* can reproduce about one million of its species within three months under favorable conditions. To combat these problems, botanicals can be used as an alternative strategy. With this background, the contact toxicity of methanolic extracts of botanicals was evaluated on rice weevil, *Sitophilus oryzae* and the phytochemicals present in the effective botanical was analyzed in GC-MS/MS.

Materials and methods

The toxicity of 12 botanical methanolic extracts were tested at 5% with *Acorus calamus* 1% as check and acetone alone served as control against *S. oryzae* in the Natural Pesticides Laboratory at the Department of Agricultural Entomology, Agricultural College and Research Institute Madurai during 2020 -2021. The contact toxicity of the extracts was evaluated by filter paper method. Observations were recorded on dead insects after 24, 48 and 72 hours of treatment and expressed as per cent mortality. The phytochemical present in the effective botanical was estimated in GC-MS/MS.

Result and Discussion

The results on the contact toxicity of methanol extracts against *S. oryzae* is presented in Table 1. The check 1% of *A. calamus* extract was performed better in causing the highest mortality (100%) of *S. oryzae* after 72 hours of treatment. Among the botanicals, the contact toxicity of *M. spicata* 5% extracts (96.67%) was on par with the treated check, followed by *V. negundo* 5% (93.33%) and *O.sanctum* 5% (90.00%) after 72 hrs of treatment. The current results were corroborating with the findings of Ainane *et al.* (2019) reported that the contact toxicity at the highest concentration (2µl/cm^3) of *M.spicata* essential oil caused 100% mortality against *S.oryzae*. *M. piperita* essential oil caused 90% mortality against *S.oryzae*. *M.pulegium* essential oil caused 96.66% mortality against *S. oryzae* after 24 hours of contact. Our GC-MS/MS study revealed that the presence of carvone (36.72%) phytochemical with insecticidal potential in *M. spicata*. Several authors have reported the toxic effect of *M. spicata* (Hamdi *et al*., 2021). The toxic effect of *M. spicata* is attributed to the presence of carvone (Mansoori *et al*., 2020). It is concluded that the methanolic extract of *M. spicata* is possessing toxicity effect against *S. oryzae* at 5% concentration, due to carvone.

Table 1. Contact toxicity of methanolic extract of certain botanicals against *Sitophilus oryzae* adults

Methanolic extracts	Cumulative contact mortality (%)*			Mean
	24 HAT	48 HAT	72 HAT	
T1-*C. aurantium* leaf 5%	60.00± 10.00 (50.85)[c]	70.00± 10.00 (56.99)[cde]	73.33± 5.77 (59.00)[de]	67.78 (55.62)[c]
T2- *C. longa* rhizome 5%	56.67± 5.77 (48.84)[c]	63.33± 5.77 (52.77)[de]	70.00± 0.00 (56.79)[e]	63.33 (52.80)[c]
T3- *E. globulus* leaf 5%	56.67± 5.77 (48.84)[c]	73.33± 5.77 (59.00)[cde]	80.00± 0.00 (63.43)[de]	70.00 (57.09)[c]
T4- *L. camara* leaf 5%	73.33± 5.77 (59.00)[b]	83.33± 5.77 (66.14)[bc]	86.67± 5.77 (68.85)[cd]	81.11 (64.66)[b]
T5- *M. spicata* leaf 5%	83.33± 5.77 (66.14)[ab]	90.00± 10.00 (74.83)[ab]	96.67± 5.77 (83.52)[ab]	90.00 (74.83)[a]
T6- *M. koenigii* leaf 5%	56.67± 5.77 (48.84)[c]	73.33± 5.77 (59.00)[cde]	80.00± 0.00 (63.43)[de]	70.00 (57.09)[c]
T7- *O. sanctum* leaf 5%	76.67± 5.77 (61.21)[b]	83.33± 5.77 (66.14)[bc]	90.00± 10.00 (74.83)[bc]	83.33 (67.39)[b]
T8- *R. communis* leaf 5%	53.33± 5.77 (46.92)[c]	60.00± 10.00 (50.85)[e]	73.33± 5.77 (59.00)[de]	62.22 (52.26)[c]
T9- *T. erecta* leaf 5%	73.33± 5.77 (59.00)[b]	80.00± 0.00 (63.43)[cd]	86.67± 5.77 (68.85)[cd]	80.00 (63.76)[b]
T10- *T. erecta* flower 5%	60.00± 10.00 (50.85)[c]	66.67± 11.55 (54.98)[cde]	73.33± 5.77 (59.00)[de]	66.67 (54.95)[c]
T11 - *V. negundo* leaf 5%	76.67 ± 5.77 (61.21)[b]	83.33 ± 5.77 (66.14)[bc]	93.33 ± 5.77 (77.54)[bc]	84.44 (68.30)[b]
T12-*A. calamus* 1% (Standard check)	86.67±5.77 (68.85)[a]	96.67±5.77 (83.52)[a]	100.00±0.00 (89.01)[a]	94.44 (80.62)[a]
T13-Acetone (Control)	0.00±0.00 (0.91)[d]	0.00±0.00 (0.91)[f]	0.00±0.00 (0.91)[f]	0.00±0.00 (0.91) [d]
T14- Untreated check	0.00±0.00 (0.91) [d]	0.00±0.00 (0.91)[f]	0.00±0.00 (0.91)[f]	0.00±0.00 (0.91) [d]
Mean	58.10	65.95	71.67	
SEd	3.18	4.79	4.20	

*Mean values of three replications are represented as mean ± standard deviation; HAT – Hours after treatment; Figures in the parentheses are arcsine transformed values; In a column, the mean followed by the same letter are not significantly different from each other, DMRT ($p \leq 0.05$); SEd: Standard Error of the difference.

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ES 02 BOPS 06

Endosymbiotic Profile of Larval Stage of Melon Thrips, *Thrips Palmi* from Watermelon Plants

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Keywords: *Thrips, endosymbionts, chitinase, protease and siderophore.*

Introduction

Watermelon (*Citrullus lanatus,* Family: *Cucurbitaceae*), a vine like flowering plant originated from West Africa. It is an economically important fruit crop besides good source of lycopene and citrulline. Lycopene is a carotenoid, has antioxidant properties and citrulline is a non-essential amino acid found rich in rind of water melon it helps the athletic ability and strengthening of immune system in human being. Melon thrips, *Thrips palmi* is a polyphagous pest and first recorded on tobacco plants in Sumatra during 1925. *T. palmi* consists 4 life stages, where most of the virus particles were acquired and transmitted by the larval stages of *T. palmi*. Both adult and larvae feeds on the lower surface of the leaves leads to silvering of leaves along the midrib, stunted growth and severe cases plants show bronzed appearance. Many insects harbour bacterial endosymbionts that play a major role in providing essential nutrients or resistance to insecticide application or aid in digestion and detoxification of food. Endosymbiotic bacteria present in the vector are also involved in virus transmission which can be employed for control of the virus.

Materials and Methods

Thirty-five larva of T. palmi were collected in a 0.5ml micro centrifuge tubes. Surface disinfected with 70% ethanol, followed by 5% sodium hypochlorite ($NaClO_4$) for 60 seconds and rinsed several times with sterile distilled water. Crushed with sterile micropestle with 35µl of TE buffer (10mM Tris and 1mM EDTA). Thrips homogenate (35µl) was spreaded on Petri plates containing Luria Bertani agar, Nutrient agar, Tryptone soya agar, R2A agar, Endo agar, MacConkey agar, MRS agar media and incubated for 2days at 28 ± 2°C. After incubation colonies were selected based on their unique colony morphology and identified through 16Sr DNA sequencing (de Vries et al., 2001). Chitinase activity was determined by using a spectrophotometer, and the activity was expressed in µmol/min/ml. Protease production was determined by the formation of clear zones around the colonies in skimmed milk agar plates. Siderophore production was determined by formation of deep orange-coloured zones around the colonies in basal agar media with CAS indicator solution (Abinaya et al., 2019).

Results and Discussion

Molecular characterization of bacterial isolates revealed that the cultivable gut bacterial isolates from healthy larvae of *T. palmi* belong to two different phyla, namely, Firmicutes, and Proteobacteria. Based on 16S rRNA sequencing, endosymbiotic profile of healthy larval *T. palmi* were grouped under the genera *Bacillus* and *Pseudomonas*. The number of isolates recovered from LB medium was the maximum in compared to other media. de Vries *et al.* (2001) reported gut bacteria of *Frankliniella occidentalis* grown from different enriched agar media and concluded that bacterial growth was observed higher in LB medium.

Based on the results obtained, *Pseudomonas songnenensis* HL5 showed maximum chitinase activity (1.8 **µ**mol/min/ml) compared to other isolates. All the tested bacterial isolates showed positive response towards the protease enzyme production (Indiragandhi *et al*., 2011). *Cytobacillus kochii* HL1 and *Bacillus safensis* subsp. *Safensis* HL3 found to be positive for siderophore production (Table 1).

Table 1. Functional traits of gut bacteria isolated from larval stage of *T. palmi* from watermelon plants

Closest match	Chitinase activity (µmol of N-Acetyl glucosamine released / min/ml)	Protease activity (%)	Siderophore activity (%)	NCBI Accession number
Cytobacillus kochii HL1	1.61±0.02[c]	18.18	25	MW358143
Bacillus altitudinis HL2	1.76±0.03[b]	10	ND	MW358264
Bacillus safensis sub sp. *Safensis* strain	1.75±0.0[b]	10	37.5	MW358909
Pseudomonas stutzeri HL4	1.71±0.02[b]	12.50	ND	MW380414
Pseudomonas songnenensis HL5	1.84±0.03[a]	5.26	ND	MW380416
Mean	1.73±0.021			
SED	0.03			
CD (0.05)	0.07			

Values in each column are mean of 3 replications ± SE (standard error);
Mean values superscripted by common alphabets are not significant;
ND- Not Detected

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Theme

ES 03: Harnessing the Potential of Insect Resistance in Crop Plants

ES 03 OPD 01

Proteomic Dissection of Host Plant Resistance in Rice against Brown Planthopper, *Nilaparvata lugens* (Delphacidae: Hemiptera)

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Keywords: *Nilaparvata lugens, Rice, Proteomics, HR-LCMS*

Introduction

Rice (*Oryza sativa* L.) is considered as the chief staple food for the most of the world population, especially in Asia. The brown plant hopper, *N. lugens* is the key pest of rice (Jena *et al*., 2018). Understanding on how rice plants respond to *N. lugens* infestation, will contribute a way to develop strategies for controlling *N. lugens* infestation (Anant *et al*., 2021). Hence, a proteomic approach was employed to understand the molecular mechanism of resistance in the resistant and susceptible rice genotypes against *N. lugens*.

Materials and Methods

Comparative analysis of protein levels was performed between *N. lugens* resistant and susceptible genotypes at a periodic interval to identify differentially expressed proteins. Samples were analysed by quantitative high Resolution Orbitrap MS (HR-LCMS) technique to identify the differentially expressed protein in resistant and susceptible cultivars upon to *N. lugens* infestation during different time intervals (24, 48, 72 HAI). Likewise, genes were selected for real-time PCR study on the basis of their response to *N. lugens* infestation. Subsequently, all the selected genes were subjected to gene expression analysis along with housekeeping gene, elongation factor (EF).

Results and Discussion

Nearly 100 differentially expressed proteins associated with 11 functional responses such as oxidative stress, energy, carbohydrates metabolism, amino acid metabolism, photosynthesis processes, cell growth, protein modification and metabolic processes were recorded in the resistant and susceptible rice genotypes (Fig. 1). Gene expression analysis results revealed that glutathione-S-transferase, glutathione-peroxidase, cytochrome b6, catalase, allen oxide cyclase, aldehyde dehydrogenase were significantly upregulated in the resistant variety during 24 HAI; whereas S-adenosyl methionine synthase was expressed more during later infestation period (48 & 72 HAI). Super oxide dismutase expression was upregulated in the infested plant of both susceptible and resistant variety during all the observation periods (24, 48 & 72 HAI); while peroxidase was significantly downregulated in the infested plant of both susceptible and resistant variety. Similar to our results, Wei *et al*. (2009) reported 70 up-regulated proteins and 94 down-regulated proteins in the during *N. lugens* attack in rice.

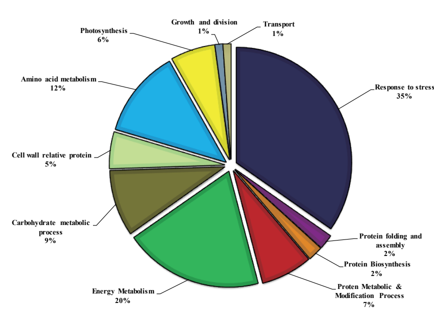

Figure 1. Differentially expressed Proteins segregated by their biological processes

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ES 03 OPD 02

Inducible direct defense responses in maize to pink stem borer (*Sesamia inferens* Walker): challenges and opportunities for sustainable solution

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Keywords: *Maize, pink stem borer, induced defense responses, host plant resistance*

Introduction

Maize (*Zea mays* L.) is the third most important cereal food crop after wheat and rice, grown in an area of 9.2 million ha with the production of 30.2 million MT (DES, 2021). Pink stem borer (PSB), *Sesamiainferens* Walker is one of the major insect pests in the winter maize resulting in 25.7-78.9 percent yield losses (Siddiqui and Marwaha, 1993). The larvae feed inside the leaf sheath in groups and subsequently bore into the central shoot resulting in deadhearts. Understanding the mechanisms of Host Plant Resistance (HPR) can provide an opportunity to manage PSB. HPR is an economically viable, environmentally friendly, and sustainable strategy and is one of the most effective components of integrated pest management (IPM) modules.Understanding the plant-insect interactions is of utmost importance for developing effective pest management approaches. Therefore, the present study was undertaken to study whether the resistance was inducted in response to plant-insect and/or non-insect interactions.

Materials and methods

The experiment was conducted in two different sets one each to record the response of genotypes upon PSB infestation and defense responses of the genotypes against different treatments in field and pot, respectively. To investigate the maize defense responses, five treatments were designed including insect and non-insect interactions namely (i) control (untreated plants) (ii) PSB larvae infestation, (iii) mechanical wounding, (iv) mechanical wounding plus PSB regurgitation, (v) exposure to methyl jasmonate.The treatments were imposed at two stages *i.e.*V3 and V6 stagesin resistant, moderately resistant and susceptible genotypes. Maize genotypes were categorized:The quantification of two major defense related cell wall bound phenolic compounds namely *p*-coumaric acid (*p*-CA) and ferulic acid (FA) was carried out through ultra-fast liquid chromatography (UFLC). The effect of induced treatments on *p*-CA and FA content at each sampling time were subjected to two-way ANOVA by using a general linear model (PROC GLM) using SAS version 9.3.

Results and Discussion

The *p*-CA content induced in leaf tissues of maize genotypes were intrinsically higher when challenged by PSB attack at V3 and V6 stages in short- and long-term responses (Fig. 1).Higher *p*-CA content was observed in stalk tissues upon wounding and regurgitation in short- and long-term responses at V3 and V6 stages. Significant accumulation of FA content was also observed in leaf tissues in response to PSB feeding at V3 stage in long-term response while at V6 stage it was observed both in short- and long-term responses (Fig. 2). In stalk tissues, methyl jasmonate induced higher FA content in short-term response at V3 stage. However, at V6 stage PSB feeding induced FA accumulation in the short-term while, wounding and regurgitation treatment-induced defense responses in the long-term.

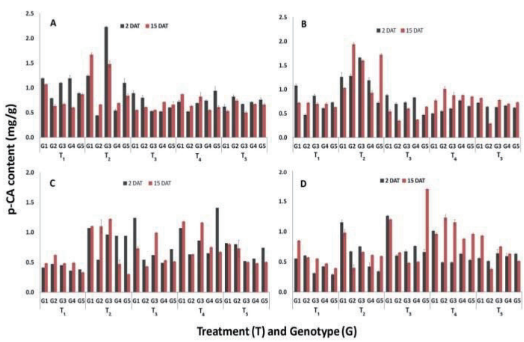

Fig. 1Changes in *p*-CA content in leaf (A, B) and stalk tissues(C,D)of maize genotypes

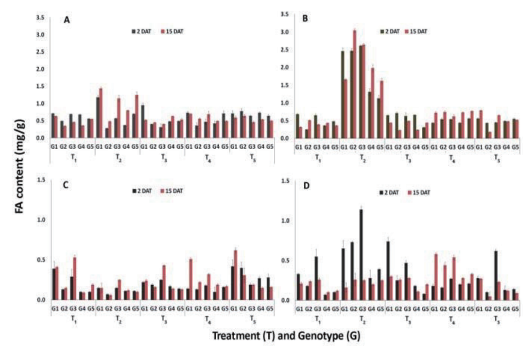

Fig. 2 Changes in FA content in leaf (A, B) and stalk tissues(C,D) of maize genotypes

The study indicates that phenolic mediated defense responses in maize are induced by PSB attack followed by wounding and regurgitation and the response observed was more in resistant genotypes compared to susceptible ones. Breeding for the restoration of these defense chemicals or cross species transfer of defense metabolite production may harness the chemical defense capabilities of maize resulting in effective pest management.

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ES 03 OPD 03

Anatomical investigation and GCMS profiling of cotton resistance against *Bemisia tabaci*

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Keywords: *Bemisia tabaci, resistance, vascular bundles, GC-MS profiling*

Introduction

Silverleaf Whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), is a highly polyphagous pest that causes substantiallosses in cotton yield both directly (feeding) and indirectly (vector). The managementof *B. tabaci* in cotton is predominantly dependent on massivespraying of synthetic insecticides and it leads to create an increased level of resistance to a wide range of insecticides. Resistance in plants offers an inexpensive preventive measure which is generally compatible with other methods of pest managements. Anatomical characters and phytochemicals are also known to play a major role in the resistance mechanism in insects. Hence, the present study was undertaken to investigate the anatomical characters and volatile profiling of cotton genotypes resistance against *B. tabaci*.

Materials and Methods

Based onthe damage symptoms (Taggar*et al*., 2012), whiteflycount and mechanisms of resistance, two genotypes *viz*., LHDP-1 (resistant) and TCH-1819 (susceptible) were selected for evaluating theanatomical characters and volatile profiling. For anatomical studies, leaf samples of both the genotypes were selected and fixed with formalin, acetic acid and 70 per cent ethanol in the ratio of 1:1:18. The fixed leaf samples were washed thoroughly with ethanol for dehydration and embedded with paraffin wax. The embedded leaf bits were cut into thin sections and stained using safranin and fast green stain. The anatomical observations were examined undera stereomicroscope (Leica M205 C, Leica Microsystems, Wetzlar, Germany) and also in scanning electron microscope (Harijan 2013). For cotton volatile collection, headspace volatiles werecollected for 24 hours and were eluted with 700 µl of hexaneusing the air entrainment method. Volatile compounds were then characterised using Gas Chromatography coupled Mass spectrometry (GC-MS) and identified using mass spectrum comparison with NIST library (national Institute of Standard and Technology).

Results and discussion

The anatomical studies showed that the distance between lower epidermis and phloem of the leaf midrib was higher in resistant genotype LHDP-1 (323.65 µ) and minimum was in susceptible genotype TCH-1819 (250.61 µ). The number of cortical cells in leaf was more in LHDP-1 while it was less in TCH-1819. The vascular bundle density was found to be more compact in LHDP-1 (63 µ) and it was loosely arranged in TCH-1819 (89 µ) (Fig. 1).The volatile profile characterisation between the cotton genotypes LHDP-1and TCH-1819 revealed nine volatile compounds that were uniquely present in either of them. The major volatile compounds present in LHDP-1 were Caryophyllene(23.05 %), 3-Cyclohexen-1-ol (20.92 %) and β-Bisabolene (10.52 %)(Fig. 2).Similarly, Jindal and Dhaliwal (2011) found that leaf toughness limit the populations build-up of *B. tabaci* in cotton. Parimala *et al*. (2013) also reported that thecompounds, α-caryophyllene, β-myrcene, β-carene, eicosaneand diethyl phthalate in cuticular wax of cotton and that may contribute for resistance against whitefly.

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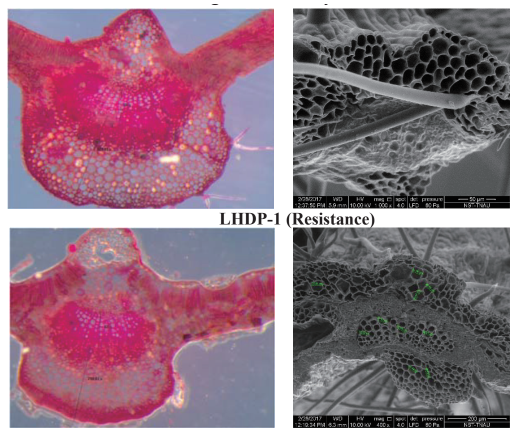
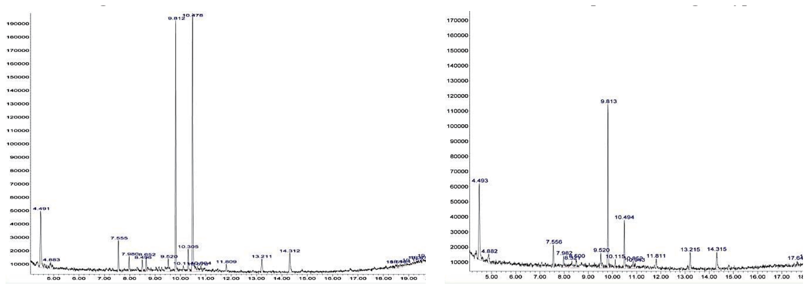


TCH-1819 (Suceptible)

Fig 1. Anatomical differences for leaf midrib in resistant and susceptible cotton genotypes



LHDP-1 (Resistance) TCH-1819 (Suceptible)

Fig. 2. Volatile profiling of resistant and susceptible cotton genotypes

ES 03 OPD 04

Impact of biophysical bases of resistance on tea mosquito bug population and dieback damage in neem

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Keywords: *Neem, tea mosquito bug, dieback, surface wax, tissue toughness*

Introduction

Helopeltis antonii Signoret is a major pest of neem (Onkarappa and Kumar, 1997). The nymph and adult feed on young and succulent parts of neem such as the shoots, young leaves, inflorescence and fruits. Their feeding causes the drying up of new flushes resulting in a scorched appearance to the trees. Hence, present study was undertaken to study the impact of surface wax and tissue toughness of neem on the damage caused by tea mosquito bug.

Materials and Methods

Nine genotypes of neem were selected to study the biophysical bases of resistance. All the nine entries were monitored at weekly intervals for the nymph and adult population of tea mosquito bug throughout the study period. In each genotype, bugs were counted on 15 cm terminal shoots on three randomly selected shoots per tree on five randomly selected trees and expressed as number of bugs per three shoots per tree. Level of damage caused by the TMB - dieback complex was assessed by visual scoring and expressed as per cent damage.

In order to determine the biophysical factors attributed to resistance or susceptibility of neem genotypes against tea mosquito bugs (TMB), shoot tissue toughness (Wanja *et al.,* 2015) and surface wax content of terminal shoots (Woodhead and Padgham, 1988) were estimated. Multiple linear regression and correlation analysis were also carried out on tea mosquito bug population and the damage due to TMB with surface wax and tissue toughness.

Results and Discussion

Screening of neem genotypes against tea mosquito bug revealed that maximum number of 8.60 tea mosquito bugs per three shoots per tree was recorded in the susceptible genotype TN-MTP-S2 as against the minimum of 0.00 per three shoots per tree in the resistant genotypes TN-MTP-R1, TN-MTP-R2 and TN-MTP-R3. Tea mosquito bug-die back damage was maximum in the susceptible genotype TN-MTP-S1 (90.00 per cent) as against the minimum of 0.00 per cent damage in the resistant genotypes TN-MTP-R1, TN-MTP-R2 and TN-MTP-R3. The biophysical parameters *viz.,* surface wax and tissue toughness were maximum in the resistant genotypes and minimum in the susceptible genotypes (Table 1). A significant negative correlation was observed between tissue toughness with tea mosquito bug (TMB) population (r= -0.954) and also with the damage caused by TMB die-back complex (r=-0.951). Results of present study are in accordance with findings of Bergvinson *et al*. (1994) who reported that leaf toughness had significant negative correlation with insect population. Results of correlation studies recorded significant negative relation of surface wax with TMB population (r=- 0.915) and TMB-dieback damage (r=-0.927). Alfaro *et al.* (2007) recorded the behaviour of aphids, *Chaitophorus leucomelas* on the dewaxed and waxed leaves of two poplar hybrids *viz.,* susceptible (TD×D) and resistant (TM×TM) and reported that aphids devoted less time in probing on the resistant hybrid with natural leaf wax when compared to the susceptible hybrids.

Table 1. Biophysical bases of resistance in neem against tea mosquito bug-die back complex

Neem genotypes	Number of tea mosquito bugs /3 shoots / tree	Damage (%)	Tissue toughness (kgf/cm^2)*					Surface wax (mg/g)*
			5 cm	10 cm	15 cm	20 cm	25 cm	
TN-MTP-R1	0.00[a]	0.00[a]	0.80[a]	0.86[a]	0.93[a]	0.99[a]	1.09[a]	11.26[a]
TN-MTP-R2	0.00[a]	0.00[a]	0.83[a]	0.87[a]	0.94[a]	0.99[a]	1.10[a]	10.94[a]
TN-MTP-R3	0.00[a]	0.00[a]	0.82[a]	0.85[a]	0.94[a]	0.99[a]	1.10[a]	10.85[a]
TN-MTP-MS1	6.20[b]	75.00[b]	0.76[ab]	0.81[a]	0.85[b]	0.96[a]	1.01[b]	8.23[b]
TN-MTP-MS2	7.60[c]	72.00[b]	0.76[ab]	0.80[a]	0.85[b]	0.96[a]	1.01[b]	8.52[b]
TN-MTP-MS3	7.90[cd]	75.50[b]	0.75[ab]	0.81[a]	0.86[b]	0.95[ab]	1.00[b]	8.72[b]
TN-MTP-S1	8.20[d]	90.00[d]	0.72[b]	0.76[b]	0.84[b]	0.90[bc]	0.98[b]	6.16[cd]
TN-MTP-S2	8.60[e]	85.00[c]	0.71[b]	0.75[b]	0.84[b]	0.89[c]	0.98[b]	6.45[c]
TN-MTP-S3	8.00[cde]	87.50[cd]	0.71[b]	0.75[b]	0.84[b]	0.90[bc]	0.98[b]	5.64[d]
S. Ed.	0.25	2.25	0.03	0.27	0.02	0.03	0.04	0.32
CD (P=0.05)	0.53	4.78	0.07	0.57	0.05	0.07	0.10	0.65

*Each value is the mean of three replications

In a column, means sharing similar letter(s) is/are not significantly different by LSD at P=0.05%

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ES 03 OPD 05

Antixenotic Studies of Bitter Gourd Fruits Against Melon Fruit Fly, *Zeugodacus cucurbitae* Coquillett (Diptera: Tephritidae)

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Keywords: *Zeugodacus cucurbitae, Momordica charantia, screening, morphological traits*

Introduction

Melon fruit fly (*Zeugodacus cucurbitae* Coquillett) is one of the most important pests of bitter gourd (*Momordica charantia* Lin.) is reported worldwide. Screening of bitter gourd accessions/ genotypes for resistance to fruit fly species and identifying morphological factors governing resistance is important for management of fruit fly. Hence, the development of genotypes/varieties resistant to melon fruit fly is an important component of Integrated Pest Management.

Materials and Methods

The bitter gourd accessions were raised in Randomized Block Design (RBD) in plot of 3.0 m ×1.5 m with 0.5 m (plant to plant) and 2.5 m (row to row) spacing in a farmer's field at Elamanam village, Tiruchirappalli District, Tamil Nadu. The marketable mature fruits were collected at weekly intervals to observe larval density and fruit fly infestation. Based on fruit infestation, the accessions were grouped as per the rating system of Nath (2017) as immune (no damage), highly resistant (1- 10%), resistant (11- 20%), moderately resistant (21-50%), susceptible (51-75%) and highly susceptible (76-100%). The morphological characters of the fruits were observed on three randomly selected fruits in three replications. The length (cm), width (cm) and diameter (cm) were measured with the help of a Vernier calliper, length of spine was measured using scale, density of spine per cm^2 was observed under magnifying lens and fruit toughness (kg/cm^2) was measured using hand penetrometer.

Results and Discussion

Screening of bitter gourd accessions for the resistance to melon fruit fly *Z. cucurbitae*

The results of fruit damage in different genotypes and variety are presented in Table 1. The fruit damage was maximum in susceptible genotype MC-41 (21.00 no. /plant) and minimum in resistant genotypes TCR-393 (4.00 no. /plant).

Influence of morphological traits of bitter gourd on infestation of melon fruit fly, *Z. cucurbitae*

The results clearly indicated that the accessions/variety showed a wide variation in their resistance to the fruit fly damage (Table 2). The CO-1 fruit recorded maximum weight and length (111.33 g and 18.50 cm) followed by MC-10 (103.33 g and 14.33 cm) and MC-41 (101.33 g and 15.57 cm). The minimum spine density was recorded in resistant accession TCR 393 (4.67 no. /cm^2) followed by Musiri local-1 (5.00 no./cm^2) and MC-10 (5.67 no./cm^2). The fruit hardness was high in TCR 393 (9.30 kg/cm^2) followed by Musiri local-1 (8.97 kg/cm^2) and MC-10 (8.83

kg/cm^2). Similar results were reported by Laskar and Hirak (2013) who showed fruit infestation with a significant positive correlation with fruit weight and length. More the weight and length of fruits maximum was the preference for oviposition. The spine density and depth were negatively correlated with fruit damage (Dhillon *et al.,* 2005).

The accessions having high spine density and fruit hardness of showed less fruit fly damage. These traits can be well utilized in the development of varieties conferring melon fruit fly resistance in the near future.

Table 1. Screening of bitter gourd accessions for resistance to melon fruit fly *Z. cucurbitae*

Bitter gourd accessions/ variety	Biological attributes			Fruit fly infestation* (%)	Resistance Index
	Total fruits* (no. /plant)	Damaged fruit* (no. /plant)	Maggots/ fruit* (no.)		
TCR-393	22.33	4.00	6.33	17.90	Resistant
Musiri local-1	25.00	5.00	6.50	20.00	Resistant
MC-10	24.67	5.67	7.25	23.00	Moderately Resistant
Ucha small	22.33	6.67	7.40	29.80	Moderately Resistant
Bikaner-2	30.33	11.67	7.80	38.50	Moderately Resistant
Musiri local-2	28.33	12.33	8.17	43.50	Moderately Resistant
Pkm local	24.33	11.67	9.16	47.90	Moderately Resistant
Co-1	31.67	15.67	9.33	49.50	Moderately Resistant
MC-39	23.67	15.67	10.10	66.20	Susceptible
MC-105	25.67	15.33	10.67	59.70	Susceptible
Paravai local	27.33	17.00	11.87	62.20	Susceptible
MC-41	27.00	21.00	13.89	77.79	Highly Susceptible

*Mean of three replications

Table2. Influence of morphological traits of bitter gourd on infestation of melon fruit fly, *Z. cucurbitae*

Bitter gourd accessions/ variety/	Morphological Traits*						Fruit infestation (%)
	Fruit weight (g)	Fruit length (cm)	Fruit width (cm)	Spine length (cm)	Spine density (no./cm^2)	Fruit hardness (kg/cm^2)	
TCR-393	93.33	15.50	4.10	3.17	4.67	9.30	17.9
Musiri local-1	80.67	12.77	3.90	3.43	5.00	8.97	20.0
MC-10	103.33	14.43	4.60	4.00	5.67	8.83	23.0
Ucha small	67.67	12.33	4.17	3.13	6.33	8.63	29.8
Bikaner-2	90.33	9.87	3.80	3.73	6.67	8.33	38.5
Musiri local-2	101.33	15.83	4.03	3.97	7.33	8.53	43.5
PKM local	70.67	11.87	3.47	3.57	6.33	8.43	47.9
CO-1	111.33	18.50	3.73	3.47	7.67	7.23	49.5
MC-39	81.67	13.47	4.13	3.77	7.33	7.43	66.2
MC-105	83.67	13.67	3.93	3.60	8.00	7.67	59.7
Paravai local	97.33	14.73	3.67	3.83	8.33	7.87	62.2
MC-41	101.33	15.57	4.17	4.17	8.67	6.87	77.79

*Mean of three replications

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ES 03 OPD 06

Characterizing the nutritional quality of mini clonal leaves of mulberry, *Morus indica*

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Keywords: *Mini clonal, apical shoots, mulberry, morus, cuttings, nutrition*

Introduction

Sericulture industry is based on the production of mulberry leaves in terms of quality and quantity. *Bombyx mori* is a monophagus insect, feeding only on mulberry. In this regard, the major aim in mulberry is concentrated towards increase the productivity of leaf biomass. Mini clonal technology is a technique which helps in the production of large number of plants in short time with limited space. This technique mainly involves treating of apical shoots in rooting medium under greenhouse equipped condition with appropriate temperature and humidity control (Parthiban and Seenivasan, 2017). Biochemical parameters of mini clonal leaves were analyzed and the leaf quality was assessed in this study.

Materials and Methods

The experimental material selected for the study consists of semi-hardwood stem cuttings from V1 (*Morus indica*). Apical shoot cuttings were excised from mother garden and the cuttings were further trimmed to mini size. The mini cuttings were subjected to various auxin treatments such as IBA and NAA (Sabarish, 2017). The apical shoot cuttings were raised in low cost poly tunnel and subsequently in mist chamber. The best performing five treatments of mini clonal mulberry leaf samples were collected at 90 DAP and shade dried for analysis. The dried leaves were powdered using mixer grinder and stored in air tight container. The studies were conducted in completely randomized design with four replications with treatments T_1 – IBA @ 3000 ppm, T_2 – NAA @ 4000 ppm, T_3 – IBA @ 2000 ppm, T_4 - IBA @ 4000 ppm, T_5 - NAA @ 3000 ppm and T_6 - Control (V1 Nursery leaf)

Results and Discussion

Mini clonal leaves were analysed for various biochemical parameters *viz.,* chlorophyll a, chlorophyll b, total chlorophyll, carotenoid content, nitrogen, phosphorus, potassium, moisture content, total protein, carbohydrate, crude protein and crude fat. Among different treatments IBA at 3000 ppm treated leaves had the highest of chlorophyll a (2.47 mg/g), chlorophyll b (0.91 mg/g), total chlorophyll (2.93 mg/g), carotenoid (1.38 mg/g), carbohydrate (18.41 mg/g) and moisture content (77.61 %). In terms of macronutrients, IBA at 3000 ppm registered 3.91 per cent nitrogen, 0.33 per cent phosphorus and 1.77 per cent potassium. Similar findings by Kumar *et. al.* (2018) confirmed that total proteins, sugars, amino acids were high in tender leaves and moisture content and moisture retention capacity were significantly high in different clones.

Table 1: Biochemical parameters of hormone treated mini clonal leaves in Soil: Coir pith: FYM medium

Treatments	MC (%)	TP (mg/g)	CHO (mg/g)	Chl a (mg/g)	Car (mg/g)	N%	P %	K%
T1	74.99	24.30	15.11	1.91	0.93	2.87	0.26	1.33
T2	75.03	25.66	15.03	2.03	1.02	2.94	0.28	1.46
T3	77.61	26.04	18.41	2.47	1.38	3.91	0.33	1.77
T4	72.31	23.31	13.78	1.56	0.77	2.60	0.26	1.38
T5	71.50	20.66	13.21	1.33	0.70	2.54	0.25	1.31
T6	76.00	28.00	17.23	2.33	1.31	3.93	0.34	1.76
SE(d)	**0.748**	**0.306**	**0.129**	**0.204**	**0.009**	**0.033**	**0.004**	**0.019**
CD @ 0.05%	**1.572**	**0.642**	**0.271**	**0.042**	**0.019**	**0.071**	**0.01**	**0.041**

*Each value is the mean of four replications ; *Each value is the mean of four replication MC - Moisture content, TP - Total protein, CHO - Carbohydrates, Chl a - Chlorophyll a, Car - Carotenoid, N - Nitrogen, P - Phosphorus, K - Potassium

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ES03 BOPD 01

Assessment of hybrids for high yield and resistance to shoot and fruit borer in Brinjal

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Keywords: *Brinjal-Hybrid -yield-fruit & shoot borer resistance-yield.*

Introduction

The eggplant, aubergine, melongena or brinjal (*Solanum melongena*) is a plant of the family Solanaceae.The fruit is botanically classified as a berry, and contains numerous small soft seeds, which are edible, but are bitter because they contain (an insignificant amount of) nicotinoid alkaloids. Different varieties of the plant produce fruits of different size, shape and color, especially purple, green, or white. Even though a wider array of brinjal hybrids are released by SAU's, ICAR's and private seed companies and their performance vary in many species.The hybrids of brinjal can be well exploited for commercial vegetable production due to the advantages such as uniformity, higher yield and good quality.The present study reported here was designed to collect information on the performance of hybrids of brinjal for higher yield and resistance to fruit and shoot borer.

Materials and methods

The experiments were carried out at Western Block of Horticultural College and Research Institute, Periyakulam. Eight hybrids were used for evaluation in the study. The hybrid trial were carried out in RBD with three replications with a spacing of 60cm x 45cm.The plot size adopted was 4 x 3.6 m. Observations were recorded on vegetative and yield characters.

Results and discussion

Among the entries evaluated, the Swarna mani (black) recorded earlier flowering (57.10 days) while the flowering was delayed in Pusa hybrid 6(62.06 days). Thangamani *et al* (2005) reported about the performance of F1 hybrids of brinjal for earliness and high yield. They reported that the hybrid COBH-1 performed better for important characters. The accession Swarna mani (black) recorded the highest yield per plot (80.12kg) and total yield per hectare (699.99q). Marketable yield /plot (56 kg), Marketable yield /ha (518.52q) were also high in Swarnamani (black). Shoot borer incidence was less in 09/BRRHYB1 (13.0 %) and highest shoot borer infestation was observed in 09/BRRHYB2 (41.0).) Raui babu *et al* (1999) evaluated M4 single pant progenies of egg plant for shoot and fruit borer and recorded least infestation compared to the control. Similar trend of results were reported by Elanchezhyan (2008), Supriya Devi and Mamocha Singh, 2019, Preneetha,2002 and Thangamani, C. (2003).Hence the hybrids 09/BRRHYB 1, 09/BRRHYB 5 and Swarna mani (black) can be used for further breeding programme.

Table 1. Evaluation of hybrids for high yield and fruit and shoot borer resistance in brinjal

Name of the entry	Days to 50% flowering (days)	No. of fruits / plot	Yield (kg / plot)	Yield (q/ha)
09/BRRHYB1	60.66	**949**	51.6	477.78
09/BRRHYB2	59.86	518	52.4	485.18
09/BRRHYB3	57.73	736	44.4	411.11
09/BRRHYB4	59.80	887	36.8	340.37
09/BRRHYB5	59.73	564	58.00	537.04
Pusa hybrid 6 C	62.06	615	10.8	98.52
KSS 224 (OPC)	59.23	839	54.2	529.63
Swarna mani (black)	57.10	440	**80.12**	**699.99**
SEd	2.34	3.75	1.65	4.68
CD (5%)	5.54	8.87	3.90	11.06

Table 2. Evaluation of hybrids for high yield and fruit and shoot borer resistance in brinjal

Name of the entry	**Marketable yield (kg/plot)**		**Marketable yield (q/ha)**		**Shoot borer incidence at 15 days interval (%)**	**Fruit borer incidence 15 days interval (%)**
	No.	**Wt.**	**No.**	**Wt.**		
09/BRRHYB1	712	38.9	6593	358.52	**13.00**	25.00
09/BRRHYB2	360	33.2	3333	307.41	41.00	37.00
09/BRRHYB3	536	32.0	4963	296.3	32.00	28.00
09/BRRHYB4	684	28.36	6335	262.59	35.00	23.00
09/BRRHY B5	396	40.6	3667	375.93	39.00	30.00
Pusa hybrid 6 C	452	7.8	4185	72.22	30.00	27.00
KSS 224 (OPC)	625	40.64	5785	376.3	38.00	29.00
Swarna mani (black)	509	**56.0**	4715	**518.52**	31.00	26.00
SEd	2.79	1.64	2.82	3.58	0.87	1.28
CD (5%)	5.98	2.52	6.05	8.48	1.99	2.35

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ES03 BOPD 02

Profiling of plant metabolites in susceptible and resistant okra genotypes against leafhopper, *Amrasca biguttula biguttula* Ishida

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Keywords: *Amrasca biguttula biguttula, okra, metabolites, GCMS*

Introduction

Okra leafhopper, *Amrasca biguttula biguttula* Ishida (Homoptera: Cicadellidae) cause damage right from early seedling stagetill fruit maturity of the crop by sucking the cell sap thereby causing typical hopperburn (Phytotoxemia) resulting in 40-50% yield reduction (Jayarao*et al.,* 2015). At present, management of this notoriоussucking pest is the use chemical method.However, the hassles for clean and ecologically sound environmental condition envisage careful planning for rationalizing the insecticidesinterventions.With the environmental friendly pest management approach, Host Plant Resistance(HPR) is one of the promising cost-effective and safemethods.In this regard, present study was conductedto identify and compare the plant metabolites in screened susceptible and resistant genotypes for improvising management practices.

Materials and Methods

Freshly collected healthy okra leaves from screened moderately resistant (AE 27, AE 65) and highly susceptible genotypes (AE 26, Pusasawani) (Prithiva*et al.,* 2019) were washed, air dried and ground to powder form. One hundred gram sample of each genotype was subjected to extraction with methanol. The solvent was evaporated under reduced pressure and stored in desiccators at 4°C. The methanol extracts of okra leaves were analyzed with GC-MS analyzer (Perkin Elmer Gas Chromatography-Mass Spectrum) with carrier gas as helium. Eight µl of methanol sample was injected to column at 250°C injector temperature. The injector temperature was set at 250°C and detector temperature at 260°C. The mass spectrum of compounds present in samples was obtained by electron ionization at 70eV and detector operates in scan mode 50 to 600Da atomic units. The total running time was 40 minutes. Interpretation on mass spectrum GC-MS was conducted using the database of National Institute of Standard and Technology (NIST). The relative percentage amount of each component was calculated by comparing its average peak area to the total area. This is done in order to determine whether this genotype contains any individual compound or group of compounds, which may substantiate its role in insect attraction or repellance.

Results and Discussion

Phytochemical compounds identified using NIST library showed wide variation in composition in okra genotypes tested. Heat map generated from data obtained depict that compounds *viz.,* sucrose, melezitose, hexadecanoic acid were commonly present in both susceptible and resistant genotypes (Fig.1,). A diterpene compound neophytadiene, phytol, fatty acid like oleic acid, 2 pentadecanone, a methyl ketone group that have repellant action against insects were found to be present in moderately resistant genotype AE 65. Betulin, an insect growth regulator compound was identified in moderately resistant genotype. Presence of these metabolite may be responsible for antibiotic effect on leafhoppers which in turn leads to population reduction.

There were phytol, neophytadiene, 6-Hydroxy-4,4,7a-trimethyl-5,6,7,7a tetrahydrobenzofuran-2(4H)-one, 2-Pentadecanone, 6,10,14-trimethyl-,3,7,11,15-Tetramethyl-2 hexadecen-1-ol, hexadecanoic acid, oleic acid, octadecanoic acid, sitosterol and campestrol metabolic compounds which were common in both highly susceptible and moderately resistant okra genotypes (AE 26 and AE 65) (Fig.1).This result is supported by findings ofKorada*et al.* (2013) who reported that neophytadiene compound may deter insect from feeding and settling on host plants. Common compounds from highly susceptible and moderately resistant genotype may have profound impact on leafhopper population. Thus, findings supports in further understanding of resistance mechanism in plants against sucking insect pests.

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ES03 BOPD 03

Screening of Coconut Cross Combinations for Resistance against Rhinoceros Beetle, *Oryctes rhinoceros* Lin.

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Keywords: *Screening, Coconut cross combinations, Oryctes rhinoceros*

Introduction

The coconut palm is susceptible to the attack of large number of pests of major and minor importance. More than 800 species of pests have been reported on coconut in India (Kurien *et al.,* 1979). Among the major pests, the rhinoceros beetle is one of the important pests of coconut palm. Considering the infestation severity and geographic distribution, rhinoceros beetle ranks first. It infests coconut palm at all stages of its growth causing direct and indirect crop loss upto 10.00 per cent and the beetle is the destructive stage of the pest. The damage causes reduction in yield to an extent of nearly 6.00 percent (Nair, 1989). The beetle breeds in decaying organic matter like cattle dung, compost pits, dead and decaying coconut logs.The injury leads to subsequent infestation by red palm weevil and invasion by fungal pathogens.

Materials and Methods

A study was conducted to screen different cross combinations planted in AICRP on coconut scheme for hybrid development at Coconut Research Station, Veppankulam for reaction against rhinoceros beetle. Observations were made in 10 years old palms in 6 cross combinations of Tall x Tall, 6 cross combinations of Dwarf x Dwarf and 4 cross combinations of Tall x Dwarf which were planted in 3 and 5 replications. Geometric leaf damage with single and multiple cut, spathe and spindle damages were the parameters observed. The total number of leaves and no. of damaged leaves were counted and the per cent damage was worked out. The data were statically analyzed by randomized block design.

Results and Discussion

Among the four cross combinations of Tall x Dwarf, Aliyar Tall x Malayan Yellow Dwarf recorded lower leaf damage of 11.3 per cent (Table 1) followed by Aliyar Tall x Malayan Green Dwarf (13.0 %), Tiptur Tall x Malayan Green Dwarf (15.0 %) and Tiptur Tall x Malayan Yellow Dwarf (15.0 %) and they are statistically on par with each other. Among 6 cross combinations of TallxTall, East Coast Tall x Laccadive Tall recorded lower leaf damage of 12.6 per cent by rhinoceros beetle and this was followed by Benaulin Green Round x Andaman Ordinary Tall (14.0 %) whereas West Coast Tall x Tiptur Tall recorded higher damage of 24.7 per cent (Table 2) as againstthe standard check, VHC 2 (19.6 %). In Dwarf x Dwarf cross combinations, Chowghat Orange Dwarf x Malayan Orange Dwarf recorded lower damage of 19.7 per cent followed by Chowghat Green Dwarf x Malayan Green Dwarf (23.1 %), Ganga Bandan Green Dwarf x Malayan Orange Dwarf (23.4 %), Malayan Yellow Dwarf x Chowghat Green Dwarf (28.0 %) whereas Chowghat Orange Dwarf x Malayan Green Dwarf (38.7 %) and Chowghat Orange Dwarf x Malayan Yellow Dwarf (52.5 %) recorded higher damage (Table 3). From this study, it is inferred that Dwarf x Dwarf cross combinations are more susceptible to rhinoceros attack when compared to Tall x Dwarf and Tall x Tall cross combinations.

Table 1. Rhinoceros beetle leaf damage in Tall X Dwarf coconut cross combinations

Name of the cross combination	Leaf damage (%)*
AliyarTall x Malayan Yellow Dwarf	11.3
AliyarTall x Malayan Green Dwarf	13.0
Tiptur Tall x Malayan Green Dwarf	15.0
Tiptur Tall x Malayan Yellow Dwarf	15.0
Statistical analysis	
F test significance	NS
SED	1.70
CD (5 % level)	3.71
CV	19.80

*Mean of 3 observations at 6 months interval

Table 2. Rhinoceros beetle leaf damage in Tall X Tall coconut cross combinations

Name of the cross combination	**Leaf damage (%)***
West Coast Tall x Tiptur Tall	24.7
Laccadive Tall x Andaman Ordinary Tall	20.5
Benaulin Green Round x Andaman Ordinary Tall	14.0
Andaman Ordinary Tallx East Coast Tall	19.6
East Coast Tall xLaccadive Tall	12.6
VHC 2 (ECT x MYD) Check	19.6
Statistical analysis	
F test significance	**
SED	2.37
CD (5 % level)	5.29
CV	15.73

*Mean of 3 observations at 6 months interval

Table 3. Rhinoceros beetle leaf damage in Dwarf X Dwarf coconut cross combinations

Name of the cross combination	Leaf damage (%)*
Chowghat Orange Dwarf x Malayan Yellow Dwarf	52.5
Chowghat Orange Dwarf x Malayan Green Dwarf	38.7
Malayan Yellow Dwarf x Chowghat Green Dwarf	28.0
Ganaga Bandan Green Dwarf x Malayan Orange Dwarf	23.4
Chowghat Green Dwarf x Malayan Green Dwarf	23.1
Chowghat Orange Dwarf x Malayan Orange Dwarf	19.7
Statistical analysis	
F test significance	**
SED	4.81
CD (5 % level)	10.72
CV	18.00

*Mean of 3 observations at 6 months interval

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ES03 BOPD 04

Reaction of wild groundnut species against sucking and chewing insect pests

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Keywords: *Groundnut, wild species, leafhopper, leaf miner*

Introduction

Groundnut (*Arachis hypogaea* L.) is one of the world's principal oilseed crops and its yield is limited by various factors. Pests and diseases are one among the factors in limiting the groundnut production. In groundnut,the tobacco cutworm, *Spodoptera litura* (Fab.), groundnut leafminer *Aproaerema modicella* (Deventer) are important pest. Currently, no cultivars of groundnut are known to express resistance to *S. litura*and some wild species of groundnut found resistant to *S. litura* (Mallikarjuna *et al.,* 2004).

Materials and methods

Thirty numbers of wild groundnut spp were planted in sick plots of Regional Research Station,Vridhachalam to identify the resistance sources against leaf hopper *Empoasca kerri*, groundnut leaf miner, *Aproaerema modicella* and *Spodoptera litura*. Four observations were made at monthly intervals.Percent yellowing on apical end of leaflets due to leafhopper,percent defoliation by tobacco cut worm were observed and injury rating 1-9 scale followed. Percent leaf damage byleaf miner was observed and injury rating 1-9 scale worked out.

Results and Discussion

Results revealed that leafhopper damage ranged from 2.72% to 19.21%. *Arachis villosa* (2.72%) and *Arachi shelodes* (3.41%) recorded less than 5% leaf damage. Six wild sp recorded less than 10% leaf damage (*Arachis villouslicara* (7.03%), *Arachis appressipilla* (8.46%), *Arachis marginata*(8.38%), *Arachis correntina*(8.60%), *Arachis paraguariensis* (9.19%), *Arachis hermannii* (9.21%)).Groundnut leafminer damage was ranged from 1.01 to

4.82%. *Arachis villosa*(1.01%), *Arachis posilla* (1.59%), *Arachis paraguariensis* (1.98%) recorded less than 2% leaf damage. *S.litura* leaf damage ranged inbetween 4.04 to 15.67%. *Arachis helodes* (4.04%), *Arachis villosa*(4.20%), *Arachis villouslicara* (4.64%), *Arachis rigoni* (4.97%) recorded below 5 % leaf damage.Sharna et al.,(2003) reported that, *Arachis cardenasii*, *Arachis duranensis, Arachi skempff-mercadoi, Arachis monticola, Arachis stenosperma, Arachis paraguariensis* and *Arachis pusilla* showed multiple resistance to the leafminer *Aproaerema modicella* and *Empoasc akerri*

Table 1. Reaction of wild groundnutspecies against insect pests

Wild species	Mean leaf damage (%)					
	Leaf hopper	injury rating	Leaf miner	injury rating	*S.litura*	injury rating
Arachis kempff-mercadoi	17.57	4.00	2.50	2.00	12.84	3.50
Arachis botizocoi (8201)	11.24	3.30	2.53	2.50	14.91	3.80
Arachis villosa (8144)	2.72	1.80	2.16	2.00	4.20	2.00
Arachis cardenasii (8216)	12.93	4.00	2.32	2.00	13.61	3.50
Arachis kuhlmannis	12.61	3.30	2.79	3.00	12.15	3.50
Arachis correntina	8.60	2.80	4.28	2.50	6.89	2.80
Arachis helodes (8955)	3.41	2.00	2.04	2.50	4.04	2.00
Arachis kempff-mercadoi	10.13	3.30	3.83	3.00	9.13	2.80
Arachis stenosperma (HLK410)	19.21	4.50	3.96	3.00	14.57	3.80
Arachis stenosperma (O)	14.03	4.00	4.34	3.00	14.81	3.80
Arachis pintoi(4855)	12.33	3.50	3.48	3.00	9.63	2.80
Arachis marginata	8.38	3.00	4.48	3.00	7.53	8.00
Arachis rigonii	18.21	4.50	3.59	3.00	12.73	3.30
Arachis cruziana (12984)	10.44	3.50	2.98	3.00	9.98	3.00
Arachis appressipila (8129)	8.46	2.80	2.36	2.00	8.74	2.80
Arachis duranensis	10.24	3.50	3.89	3.00	7.37	2.50
Arachis repensis	15.98	3.80	3.95	3.00	15.67	3.30
Arachis monticola (8135)	12.89	3.80	2.19	2.50	11.60	3.00
Arachis glabrata	11.11	3.50	3.98	2.50	11.57	3.00
Arachis villosa (8144)	6.70	2.80	1.01	2.00	4.80	2.50
Arachis diogoi (8962)	15.20	3.80	4.82	2.50	8.84	2.80
Arachis duranensis (8202)	15.53	4.00	3.67	2.50	9.17	3.30
Arachis posilla (4897)	11.10	3.50	1.59	3.00	6.45	2.80
Arachis paraguariensis (8130)	9.17	3.50	1.98	2.50	6.04	2.30
Arachis benensis(13214)	11.23	3.50	2.07	2.50	6.61	2.80
Arachis hermannii (13251)	9.21	3.00	2.84	2.50	5.40	2.50
Arachis villouslicara (8142)	7.03	3.00	2.38	2.50	4.64	2.50
Arachis rigoni (Auto tetraploid)	10.50	3.50	2.66	3.00	4.97	2.30
Arachis stenosperma (8125 Auto tetraploid)	13.12	3.80	2.28	3.00	9.23	2.80
Arachis otavio (8192)	13.31	4.00	2.63	3.00	11.50	3.30

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ES03 BOPD 05

Confirmation of resistance in identified elite rice genotypes for Brown planthopper (BPH) using phenotypic screening methods

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Keywords: *Brown planthopper, Bph, resistance, phenotypic screening methods*

Introduction

Rice (*Oryza sativa* L.) is the important and stable food crop of India and an approximate 52% of the total global production of rice is lost annually owing to the damage caused by biotic factors, of which nearly 21% is attributed to the attack of insect pests (Brookes and Barfoot, 2003).Among the biotic stresses, the brown plant hopper (BPH) *Nilaparvata lugens*(Stal.) is one of the most destructive monophagous insect pest, oneof the main biotic constraint of rice productivity causing huge yield losses every year in rice grown throughout tropical, subtropical and temperate areas in Asia (Park *et al*.,2008).Development of resistant rice cultivars through host plant resistance is generally considered to be the most economic and effective way for controlling BPH damage.The objective of the present effort was to evaluate and confirm the genetic variability ofalready available rice resistant genotypes based on different phenotypic screening methods.

Materials and Methods

The experiments were conducted at Tamil Nadu Rice Research Institute, Aduthurai during *rabi*2019 - 2020. The experimental material consisted of five elite resistant rice genotypes available at India, *viz.,* IR 7103315B, RP206818-3-5, PTB 33, 9-1-48, PTB41 with susceptible check (TN1) were screened against brown planthopper for antibiosis and tolerance. Initial population of BPH was collected from net house of TRRI, Aduthuai and screening was done by following four methods, standard seed box screening technique (SSST) developed at IRRI by Heinrichs et al. (1985), days to wilt, honeydew test and nymphal survival method.

Results and Discussion

The results showed that all the five entries showed grade 1. Almost all the entries took prolonged period (24.0 to 28.3 days) complete wilting. The resistant check PTB-33 plant took more than 31 days to wilt when compared to susceptible check TN1 (13.6 days). Percent nymphal survival after 11 days showed 15.00 to 30.00% survival the above entries as against the 75% nymphal survival in susceptible check TN1. The results of feeding rate assay indicates that entries IR 7103315B, PTB 33 and PTB41 had lower feeding rate reflected by lesser honey dew secretion (29mm^2, 39.00mm^2 and 34mm^2) when compared toTN1 (94.0mm^2).

Confirmation of donors for resistance and efficient screening techniques for evaluating breeding lines plays crucial role to transfer BPH resistance genes in to high yielding popular varieties and a high level of genetic diversity reduces the risk of wide spread epidemics of pests and diseases (Zhu *et al*. 2000). The seedling resistance and antibiosis effects (honey dew test and nymphal survival method) of five rice geno- types on BPH were examined in this study. High resistance (Score 1) was shown by all the five resistant entries and TN1 was found to be highly susceptible (score 9) using the three methods (SSST, honeydew test, and nymphal survival method) towards brown plant hopper infestation.

Table 1. Confirmation of resistance in identified elite rice genotypes to BPH using phenotypic screening methods

S. No	Entries Name	Grade (SSBT)	Days to wilt	Area of honey dew excreted by 5 female in 24 hrs (mm^2)	% Nymphal survival (or) no of nymphs surviving	Reaction
1	IRT103315 B	1	26.0	29	35	MR
2	RP 206818-3-5	1	22.0	78	38	MR
3	PTB 33	1	31.0	39	18.3	MR
4	9 -1-48	1	24.5	46	33	MR
5	PTB41 (Bharathi)	1	28.3	34	15	MR
6	TN 1	9	13.6	94	75	S

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ES03 BOPD 06

Consumption, digestion and utilization of PGPR treated okra plants by *Spodoptera litura* Fabricius

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Keywords: *PGPR, Okra, Spodoptera litura, Consumption indices*

Introduction

Plants defend themselves from herbivore attack through induced resistance which could be elicited by plant growth promoting rhizobacteria (PGPR). PGPR promote plant growth and confer resistance against pests and diseases by chemical signalling pathways that regulate plant hormones and result in production of secondary metabolites like alkaloids, phenols, non-volatile terpenes and volatile compounds that may be toxic to insect pests (Grobelak *et al.,* 2015). Studies on PGPR induced systemic resistance against herbivores showed that the host plants are able to withstand herbivore attack through increased production of secondary metabolites elicited upon tissue damage by insects. *Bacillus subtilis* and *Bacillus amylolique faciens* were able to control plant viral diseases vectored by insect pests. The present investigation was carried out to study the effect of PGPR on the consumption of *Spodoptera lituraon* PGPR treated plant parts.

Materials and Methods

Laboratory experiment was conducted at Department of Agricultural Entomology, Agricultural College and

Research Institute,Killikulam to study the effect of PGPR on the consumption of *S. Litura* on PGPR treated plant parts. Okra F_1 hybrid COBh4 seeds treated with talc formulations (containing $1x10^8$ cfu/g) of each PGPR @ 10 g/kg of seed were sown in earthen pots. Before sowing soil application of each PGPR talc formulation @ 5g/pot was done with 100g of well decomposed farmyard manure as mixture. The potted okra plants were sprayed with each talc formulation @5 g/lit of water using hand atomizer on 30 DAE. Imidacloprid 48 FS was used as a seed dresser @ 7g/kg of seeds and untreated control received no treatment. Third instar larvae of *S. litura* starved for 4 hours were fed with the okra leaves collected from potted the plants three days after foliar application of PGPR formulations. On a fresh weight basis, the initial and final weight of the larvae, the weight of the food given, the weight of food that remained after feeding and the faecal weight were measured using balance at every 24 h interval. The weight of ingested food was calculated from the difference between the initial and final weight of the food given. The difference between the initial and final weight of the larva was taken as the weight gain by the larva. By adding the initial and final weights and dividing by the number of weighing, the mean weight of the larvae was measured. The experiment was carried out under laboratory conditions at a temperature of 33±2°C with relative humidity of 75±5%. Each treatment was replicated thrice with ten larvae per replication.The growth indices for *S. litura* were computed as proposed by Waldbauer (1968).

Results and discussion

Consumption of okra leaves, digestion and utilization by*S. litura* on PGPR treated leaves was lessover the untreated plants (Table 1). *Spodoptera litura* consumed 1.68 g of leaves collected from plants treated with *B. subtilis* Bbv57and more consumption of leaves on fresh weight basis was observed in untreated plants (2.02g) followed by imidacloprid treatment (2.01g of leaves). The faecal weight was also low when larvae fed on *B. subtilis* Bbv57treatment (0.78g/larva) followed by*B. Amylolique faciens* (0.80 g/larva) compared to the larva fed on untreated (0.90 g/larva) and imidacloprid treated leaves (0.90 g/larva). There was a significant difference in the weight gain by *S. litura* larvae when fed on untreated plants than PGPR treated leaves. Among the treatments, *B. subtilis* Bbv57treatment recorded lower weight gain (0.47g/larva) followed by larvaprovided with leaves from *B. amylolique faciens* treated plants (0.50 g/larva). The average weight gain per larva was high onuntreated plants (0.64g/larva) and on leaves collected from imidacloprid treated plants (0.63g/larva). The feeding period also varied significantly among the treatments. The feeding period was low for *B. subtilis* Bbv57treated leaves (8.96 days) compared to imidacloprid treatment (9.99 days) and untreated plants (10.01 days). The consumption index (CI) (0.0562), growth rate (GR) (0.0162), efficiency of conversion of the digested food (ECD) (52.22%), efficiency of conversion of the ingested food (ECI) (27.98%) and the approximate digestibility (AD) (53.57 %) were low when *S.litura* fed with leaves collected from plants treated with *B. subtilis* Bbv57.Similarly the CI (0.0691), GR (0.0201), ECD (53.76%), ECI (28.90%) and AD (53.76%) were less for the larvae fed on *B. amylolique faciens* treated plant leaves. The untreated plants recorded high CI (0.0932), GR (0.0294), ECD (57.14%), ECI (31.68%) and AD (55.45%).Consumption indices could be used as indicators for the presence of antinutritional factors in the food material (Nathan and Kalaivani 2005).The reduction in consumption and growth indices may be due to the increased levels of biochemicals and defence enzymes activity. Earlier reports by Murugan*et al.* (2005) also showed a significant reduction in the growth and development of *Earias vittella* F.upon feeding with *Pseudomonas fluorescens* inoculated okra plant parts.

Table 1. Consumption, digestion and utilization of PGPR treated okra leaves by *S.litura*

Treatments	Total food consumed/ larva (g)	Weight of faeces voided/ larva (g)	Weight gain (g)	Feeding period (days)	Consumption index (CI)	Growth rate (GR)	ECD %	ECI %	AD %
Bacillus subtilis Bbv57	1.68[a]	0.78[a]	0.47[a]	8.96[a]	0.0562[a]	0.0162[a]	52.22[a]	27.98[a]	53.57[a]
Bacillus amyloliquefaciens	1.73[a]	0.80[a]	0.50[a]	9.02[a]	0.0691[a]	0.0201[a]	53.76[ab]	28.90[ab]	53.76[ab]
Rhizobium pusense	1.97[b]	0.89[b]	0.59[b]	9.76[b]	0.0850[b]	0.0250[b]	54.63[abc]	29.95[bcd]	54.82[b]
Ensifer sp.	1.95[b]	0.89[b]	0.58[b]	9.66[b]	0.0833[b]	0.0254[b]	54.72[bcd]	29.74[bc]	54.36[b]
Siphanobacter sp.	1.96[b]	0.88[b]	0.60[b]	9.78[b]	0.0861[b]	0.0263[b]	55.56[bcd]	30.61[cde]	55.10[b]
Imidacloprid 48FS	2.01[b]	0.90[b]	0.63[b]	9.99[b]	0.0894[b]	0.0281[b]	56.76[cd]	31.34[de]	55.22[b]
Untreated control	2.02[b]	0.90[b]	0.64[b]	10.01[b]	0.0932[b]	0.0294[b]	57.14[d]	31.68[e]	55.45[b]
CD (P = 0.05)	0.15**	0.075**	0.052**	0.39**	0.0071*	0.0021*	2.46**	1.51**	1.09**

In a column, means followed by common letters are not significantly different by LSD (P=0.05)

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ES03 BOPD 07

Evaluation of Rice Genotypes through field and artificial screening against Yellow Stem Borer, *Scirpophaga incertulas* W.

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Keywords: *Rice genotype, screening, Scirpophaga incertulas*

Introduction

Insect pests are important biotic stress and major cause for lower productivity in rice in India. Yellow stem borer, *Scirpophaga incertulas* Walker (Crambidae: Lepidoptera) is one of the serious insect pests as its damage causes severe yield loss. Host plant resistance (HPR) is one of the viable option and economical to the farmers. However, very few resistant varieties are available. Evaluation of rice genotypes through screening in field and confirmation through controlled or artificial screening will provide valid and durable resistant sources.

Materials and Methods

Field screening of 102 advanced rice genotypes were carried out along with susceptible checks Pusa basmati and TN-1. Entries were raised in nursery and transplanted in the main field @ two rows/entry with two replications. Deadheart and white ear symptom counts were taken @ 35, 50 DAT and before harvest and per cent damage was worked out (Heinrichs *et al.,* 1985). The entries with less or nil damage were selected for glass house screening. Freshly emerged stem borer larva were inoculated @ 2 larvae/tiller and 10 replications were maintained. Days taken for expression of dead heart symptom in the first and second tiller were observed. The morphological plant characters *viz*., plant height, stem diamete, number of internode and top internode length were recorded in the selected entries and correlated with the damage by stem borer.

Results and Discussion

The results revealed that at 35th and 50th day a maximum of 26 & 39 per cent deadheart were recorded respectively. In the susceptible check entries, maximum deadheart of 11.33 and 23.76 per cent was recorded in Pusa basmati at 35th and 50th day respectively. The white ear damage was more in Pusa basmati and TN- 1 with 17.13 and 11.73 per cent respectively. Fourteen entries were recorded without any deadheart and white ear (nil damage). The entries *viz*., ACK 14004, TR 13069, CB 13804, ADT 43, ACK 12014, AS 12006, TP 09156, ADT (R) 46, TKM (R) 12, TM 12077, Pushami, Ranjeet, RC Maniphou-11 and Varalu. These entries might be escaped from the attack of stem borer or their inherent capacity to tolerate the stem borer damage. These entries were selected for artificial screening under glass house condition.

In the glass house screening, the genotypes CB 13804 (30.10%), AS 12006 (31.20%) and Varalu (31.70%) recorded lowest deadheart damage. The susceptible Pusa basmati recorded with highest dead heart damage of 74.20 per cent. The time taken for dead heart symptoms expression in two tillers was just 3.0 days. The maximum time taken for symptom expression was 12.0 days in CB 13804 and TM 12077. The lowest damaged entries AS 12006 and Varalu took 8.5 and 7.0 days respectively for deadheart symptom expression. The physical mechanism for resistance in the entries was studied through correlation studies. Plant height (r = -0.506), number of internode (-0.523) and top internode length (-0.437) showed a significant negative correlation with the incidence (Table 1). The intermodal regions of rice stems are significant for the development of stem borer larva. If the number of internodes increases it is difficult for the larva to enter to the next node after completion of feeding of the region. It acts as important physical impediment for the larva to enter for further feeding (Rubia *et al.,* 1996). In most of wild accession or entries the intermodal regions become very short and that morphological factor act as important resistance mechanism.

Table 1. Correlation studies with morphological parameters and stem borer damage

Morphological parameters	*Correlation coefficient (r value)*
Plant height (cm)	*-0.506**
Stem diameter (cm)	*-0.237*
No. of internodes	*-0.523**
Top internode length	*-0.437**

***Significant @ p=<0.05**

The entries which had field resistant as well as tolerant mechanism under artificial screening can be utilized for further breeding programme in the development of stem borer resistant varieties.

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ES03 BOPD 08

Colonization preference of *Phenacoccus solenopsis* Tinsley on plant parts of *Gossypium* genotypes

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Keywords: *Gossypium spp., plant parts, Phenacoccus solenopsis, preference*

Introduction

Phenacoccus solenopsis Tinsley has been notified as a dreaded and regular pest of cotton (Dhawan *et al.*, 2008) and inflicted a yield loss of 30 to 47 per cent. Besides, mealy bugs release toxic substance causing curling and drying of leaves and thus drastically decrease kapas yield. Since *P. solenopsis* is a polyphagous pest, increased incidence of mealy bugs on cotton started threatening the economical production of many other crops. Even though IPM methods have been developed (Bharathi and Muthukrishnan, 2012), not much research was made to understand the colonization preference of mealy bugs on various plant parts of cotton genotypes, which would be significant in the long run to develop suitable mealy bug resistant cotton genotype. Hence, the present investigation was undertaken.

Materials and Methods

Laboratory experiment was conducted to study the developmental preference of crawlers and adults of *P. solenopsis* on shoots, leaves, upper and lower leaves, squares, flowers and bolls on 21 cotton genotypes of *Gossypium* *hirsutum, G. arboreum* and *G. barbadense*. Five potted plants containing 7-days-old plants of each genotype were placed in a row. A batch of ten newly emerged crawlers of *P. solenopsis* cultured on sprouted potato tubers at 30 ±1° C, 65 ± 5% RH and L16: D8 photo period in the laboratory were released on top leaves of the potted plants and covered with mylar film cages. The experimental set up was replicated three times for each genotype. Numbers of crawlers and adults of mealy bugs that settled on shoots, lower and upper leaves, flowers, squares and bolls (based on stage of crop) of each genotype were recorded during peak period of infestation.

Results and Discussion

Highest population range of 3.6 to 32.6 mealy bug crawlers and adults was observed on shoots, of which, 2.1 and 15.7 on the adaxial surface of the leaves and 1.5 and 11.1 on the abaxial surface of leaves. Flowers, squares and bolls of the plants registered population range of 1.3 and 8.1; 1.5 and 4.9; and 1.9 and 9.6 mealy bugs, respectively. Among the *G. hirsutum* genotypes, KC 2 and KC 3 respectively observed with minimum population of *P. solenopsis* on shoots (9.9 and 11.2/ 5 cm shoot), adaxial leaf surface (4.8 and 5.2/leaf), abaxial leaf surface (4.9 and 6.1/leaf), squares (2.7 and 1.3/square), flowers (1.9 and 3.2/flower) and bolls (3.6 and 4.2/boll) than any other genotypes. Maximum population, was noticed on SVPR 1, SVPR 2, SVPR 3, TKH 1175, MCU 5, MCU 7, MCU 12, MCU 13, MCU 5 VT, LRA 5166, Supriya, Sumangala and Surabhi genotypes.

All the three *G. arboreum* genotypes such as K11, G 27 and PA 255 respectively registered lowest population of *P. solenopsis* on shoots (5.9, 3.7 and 5.6/5 cm shoot), adaxial leaf (3.4, 2.1 and 4.6/leaf), abaxial leaf (2.8, 1.8 and 3.9/leaf), square (1.3, 1.4 and 2.6/square), flower (1.8, 1.6 and 1.9/flower) and bolls (2.2, 1.9 and 2.8/boll). Likewise, there was minimum population of *P. solenopsis* on all the three *G. barbadense* genotypes such as TCB 209 (7.7, 6.1, 3.2, 3.5, 2.7 and 4.1 crawlers and adults on shoot, adaxial and abaxial leaf surface, square, flower and boll respectively), Suvin (3.6, 2.7, 1.5, 1.8, 1.5 and 2.1 crawlers and adults on shoot, adaxial and abaxial leaf surface, square, flower and boll respectively) and RSP 4 (7.1, 5.2, 3.6, 3.7, 2.6 and 3.4 crawlers and adults on shoot, adaxial and abaxial leaf surface, square, flower and boll respectively). Adaxial leaf surface had more trichome density than abaxial surface on all the *G. hirsutum, G. arboreum* and *G. barbadense* genotypes. Thus presence of trichomes and leaf hairiness may play a major role in the colonization behaviour of mealy bugs.

Table 1. Population of *P. solenopsis* on plant parts of cotton varieties/hybrids

S. No	Cotton Varieties/ Hybrids	Number of crawlers and adults per (Mean ± SD) *					
		Shoot	Leaf		Flowers	Squares	Bolls
			Abaxial	Adaxial			
1	SVPR 1	28.8 ± 2.5	12.4 ± 1.2	9.7 ± 0.6	4.3 ± 0.7	3.7 ± 0.3	7.5 ± 0.4
2	SVPR 2	26.3 ± 1.2	9.5 ± 0.5	8.3 ± 0.8	3.3 ± 0.5	3.5 ± 1.0	7.3 ± 0.6
3	SVPR 3	30.9 ± 1.9	13.6 ± 1.8	10.9 ± 0.4	4.5 ± 1.2	4.8 ± 0.6	9.3 ± 0.5
4	KC 2	9.9 ± 0.2	4.8 ± 0.8	4.9 ± 0.9	2.7 ± 0.3	1.9 ± 0.4	3.6 ± 0.3
5	KC 3	11.2 ± 1.0	5.2 ± 0.7	6.1 ± 0.3	1.3 ± 0.1	3.2 ± 0.4	4.2 ± 0.6
6	TKH 1175	28.1 ± 2.5	10.5 ± 1.1	8.4 ± 1.1	4.5 ± 0.3	4.0 ± 0.7	7.3 ± 0.6
7	MCU 5	32.6 ± 1.6	15.5 ± 0.4	7.2 ± 0.9	5.6 ± 0.3	4.5 ± 0.6	8.8 ± 0.9
8	MCU 7	30.7 ± 3.5	15.7 ± 0.9	9.6 ± 1.3	5.7 ± 1.0	3.7 ± 1.3	9.3 ± 1.5
9	MCU 12	32.1 ± 1.2	14.3 ± 2.3	11.1 ± 0.6	8.1 ± 0.8	4.6 ± 1.1	9.6 ± 2.2
10	MCU 13	26.7 ± 1.3	10.1 ± 0.8	6.7 ± 0.4	3.1 ± 0.5	4.9 ± 0.8	6.4 ± 0.5
11	MCU 5 VT	19.7 ± 0.8	8.6 ± 0.5	5.3 ± 0.6	3.4 ± 0.1	4.2 ± 0.2	5.8 ± 0.5
12	LRA 5166	29.8 ± 0.9	11.7 ± 0.8	7.9 ± 0.8	4.1 ± 0.5	3.7 ± 0.5	8.3 ± 0.6
13	Supriya	29.7 ± 2.8	14.9 ± 0.7	6.4 ± 0.6	3.7 ± 0.8	4.3 ± 0.6	6.9 ± 1.7

14	Sumangala	27.3 ± 1.2	11.4 ± 1.0	6.7 ± 0.4	3.9 ± 0.2	4.7 ± 1.0	5.6 ± 0.9
15	Surabhi	28.8 ± 1.8	12.9 ± 1.0	7.6 ± 0.6	5.0 ± 0.6	3.5 ± 0.4	8.2 ± 0.7
16	K 11	5.9 ± 1.0	3.4 ± 0.6	2.8 ± 0.4	1.3 ± 0.1	1.8 ± 0.2	2.2 ± 0.6
17	G 27	3.7 ± 0.3	2.1 ± 0.2	1.8 ± 0.3	1.4 ± 0.2	1.6 ± 0.3	1.9 ± 0.2
18	PA 255	5.6 ± 1.0	4.6 ± 0.6	3.9 ± 0.2	2.6 ± 0.3	1.9 ± 0.2	2.8 ± 0.2
19	TCB 209	7.7 ± 1.6	6.1 ± 0.4	3.2 ± 0.6	3.5 ± 0.1	2.7 ± 0.3	4.1 ± 0.2
20	Suvin	3.6 ± 0.5	2.7 ± 0.3	1.5 ± 0.2	1.8 ± 0.4	1.5 ± 0.3	2.1 ± 0.3
21	RSP 4	7.1 ± 1.6	5.2 ± 1.1	3.6 ± 0.3	3.7 ± 0.3	2.6 ± 0.5	3.4 ± 0.9

All values are mean of three replications

Values are represented as Mean ± Standard error and Student-Newman-Keuls test, $p > 0.05$

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ES03 BOPD 09

Field screening of cotton accession against cotton stem weevil, *Pempherulus affinis*

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Keywords: *Cotton, stem weevil, Pempherulus affinis, field screening, resistant variety*

Introduction

Cotton is the 'King of Fibre' and the most economically valuable crop in the world. Among the commercially important insect species, the cotton stem weevil, *Pempherulus affinis,* has been recognised as a prominent pest in South India, alongside bollworms. The stem weevil was observed in the cotton-growing fields in the Coimbatore district throughout the season (Ayyar, 1918). Cotton stem weevil infestations develop on seedlings that are 12 to 15 days old and can result in up to 90% death. There is continuous infestation throughout the season, with a peak of 95–100 percent infestation in June (Gunathilagaraj and Nagarajan, 1985).

Materials and Methods

To find the resistant accessions from available genotypes, twenty accessions available in breeding programme were screened for their reaction to stem weevil in a replicated trial under field condition with the following score. MCU 3 and MCU5 were used as resistant and susceptible checks respectively.

Screening score (damage %)	Reaction to stem weevil
0 - 20	Resistant
20 - 40	Moderately resistant
40 - 60	Susceptible
60 - 100	Highly susceptible

Results and Discussion

Results revealed that the five cotton accessions viz., MCU7, SVPR5, SVPR4, KC3, TCH1772 and TCH13/22 were found to be resistant and five (DCH32, Suraj, TCH1807 and TCH1764)werefound to be moderately resistant. Remaining 8 accessions were susceptible to stem weevil. The similar results were reported by Douressamy*et al.* (1992). According to Chandramani*et al*. (2004), the incidence of stem weevil was higher during August-September and December-January and less during May-June.

Table 1. Screening cotton accessions against cotton stem weevil

Varieties	Damage (%)	Screening Score
KC3	14.64	Resistant
CO14	48.41	Susceptible
SVPR4	13.33	Resistant
SVPR5	12.76	Resistant
SVPR6	46.67	Susceptible
CO17	43.20	Susceptible
MCU7	5.82	Resistant
DCH32	30.30	Moderately resistant
Suraj	31.11	Moderately resistant
TCH1897	41.54	Susceptible
TCH1828	53.46	Susceptible
TCH1809	58.18	Susceptible
TCH1807	32.50	Moderately resistant
TCH1772	16.17	Resistant
TCH1764	33.75	Moderately resistant
TCH357	48.04	Susceptible
TCH13/24	46.36	Susceptible
TCH13/22	18.46	Resistant
MCU3 *	5.30	Resistant
MCU5 #	62.40	Highly Susceptible

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ES03 BOPD 10

Field screening of rice genotypes against different insect-pests of rice in Indo Gangetic Plain

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Keywords: *Rice, screening, field, leaf folder, plant hopper*

Introduction

Rice (*Oryza sativa* L.) is the most widely consumed stable food crop for a large part of the world's human population, especially in Asia and over half of the global population depends on it for their feed (Lal *et al*., 2014). India, the second largest rice growing country has a production of 104.32 million tonnes and cultivation area of about 44.6 million hectares with an average productivity of 2.34 tonnes per hectare. A critical analysis of the gap between the potential and actual rice yields across the nation would reveal that several factors act as yield constraints. Among these factors, insect-pests contribute substantially to yield loss in rice production and productivity. About 100 insect species are known to attack the rice crop (Rahaman and Stout,2019). Among these leaf folder, *Cnaphalocrocis medinalis* (Guenee), yellow stem borer, *Scirpophaga incertulas* (Walk.), brown plant hopper, *Nilaparvata lugens* (Stal.) and white backed plant hopper, *Sogatella furcifera* (Horv.) are the most important pest of rice in India. Since these pests contribute to yield losses, it is necessary to find out the sources of resistance to work out effective pest management strategy which will lead to achieve sustainable rice production.

Materials and methods

About 128 genotypes of rice were screened under field conditions during *Kharif*, 2020 at CCS Haryana Agricultural University, Rice Research Station, Kaul to evaluate their performance against leaffolder, *Cnaphalocrocis medinalis*, brown plant hopper, *Nilaparvata lugens* and white backed plant hopper, *Sogatella furcifera*. Two rows of each genotype were transplanted in two meter length at 10 x 10 cm spacing. The data on incidence of insect- pests (leaffolder and planthoppers) was recorded following Standard Evaluation System for Rice (Anonymous, 2013).

Results and discussion

Out of 128 genotypes screened against major insect-pests, 14 genotypes were found promising against leaffolder and four genotypes against WBPH and BPH (Table 1). Promising genotypes against leaffolder were HKR 16-1, HKR 16-46 (LST M, non-scented), HKR 17-35 (LST ME, non-scented), IR14L521, IR 9876-20-1-2-2 (FYT E, non-scented), HKR 07-147, HKR 09-104 (FYT M, non-scented), HKR 14-30, IR 64 (FYT ME, non-scented),HKR 17-410 (LST, scented), HKR 2018-421, HKR 2018-436 (SST, scented) and HKR 16-459, HKR 16-464 (FYT, scented). Promising genotypes against planthoppers were HKR 17-48 (FYT E, non-scented), HKR 09-93 (FYT M, non-scented), HKR 2018-421(SST, scented) and HKR 15-455 (FYT scented).These resistant genotypes would be useful for future breeding programme in achieving higher rice productivity.

Table 1: List of promising genotypes against leaf folder and plant hoppers

Sr. No.	Trial	Total genotypes evaluated	Promising against leaf folder	Promising against WBPH/BPH
1	LST (M), non-scented	10	HKR 16-1, HKR 16-46	-
2	LST (ME), non-scented	09	HKR 17-35	-
3	FYT (E), non-scented	12	IR14L521, IR 9876-20-1-2-2	HKR 17-48

4	FYT (M), non-scented	10	HKR 07-147, HKR 09-104	HKR 09-93
5	FYT (ME), non-scented	8	HKR 14-30, IR 64	-
6	SST (ME), non-scented	15	-	-
7	LST (M), non-scented	15	-	-
8	LST, scented	12	HKR 17-410	-
9	SST, scented	16	HKR 2018-421, HKR 2018-436	HKR 2018-421
10	FYT, scented	12	HKR 16-459, HKR 16-464	HKR 15-455
	Total	128	14	04

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ES03 BOPD 11

Evaluation of Sugarcane pre release Clones for Yield traits and Borer Resistance

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Keywords: *Sugarcane, clones, caneyield, sugar yield, Earlyshoot borer*

Introduction

Sugarcane (*Saccharum* spp. hybrid) is a major cash crop grown in both tropical and subtropical regions of the world for production of sugar. Sugarcane is infested by more than 200 species of insect pests (Mukunthan and Nirmala, 2002) and among them, borer pests are the most important causing heavy economic losses to farmers. Hence, the present research efforts were made to identify the sugarcane clones which are less susceptible to early shoot borer and internode borer under natural environment conditions.

Materials and Methods

The field experiments were conducted at Sugarcane Research Station, Cuddalore, Tamil Nadu during 2015-16. The experimental materials consist of ten test clones along with two standards. All the test clones are planted in Randomized Block Design with three replications. Recommended agronomic practices were carried out uniformly. The data were recorded for yield and quality parameters and statistically (Panse and Sukhatme, 1978).

Assessment of early shoot borer infestation:

From each genotype 25 plants were selected at random. In each genotype, the number of dead hearts and total number of shoots were counted on 36, 64 and 95 days after planting and finally thecumulative incidence was worked out. The clones were also grouped by using the classification described by Rao and Rao(1973).

Per cent Incidence	Resistance reaction
0-15 %	Less susceptible (LS)
– 30 %	Moderately susceptible (MS)
>30 %	Highly susceptible (HS)

Results and Discussion

The performance of ten test clones and two standards (CoC (Sc) 23 and CoC (Sc) 24) were evaluated for yield and quality traits including early shoot borer incidence and presented in Table 1. Based on Commercial Cane Sugar content (CCS %), the test clones *viz.,* C 31098 (12.90 %) and C 31075 (12.87%) recorded higher than the best standard CoC (Sc) 23 which registered 12.82% CCS.For cane yield, the clone C 31095 recorded higher yield (140.15 t/ha) followed by the clone C 31098 (138.35 t/ha) which was higher than the check variety CoC (Sc) 24 (132.72t/ha). Based on sugar yield, the clone C 31095 recorded higher sugar yield (17.95 t/ha.) followed by the clone C 31098 (17.85 t/ha.) over the best standard CoC (Sc) 24, which registered 16.65 t/ha. (Table1).

Based on the observations made on 36 DAP, 64 DAP and 95 DAP, the cumulative mean per cent damage level of early shoot borer was worked out (Table 1)and the rating was assigned to the clones/genotypes. The results showed that four clones were highly susceptible to damage by early shoot borer and eight clones registered moderately susceptible rating. Only one clone C 31087 was less susceptible to ESB with mean per cent damage of 14.75 (Table 1).

Table 1. Evaluation of sugarcane clones for yield traits and root knot nematode resistance

Genotypes / Clones	CCS (%)	Cane yield (t/ha)	Sugar yield (t/ha)	Early shoot borer (Mean % of damage level)	Damage Rating
C 30006	12.73	126.85	16.15	45.83	HS
C 31074	12.80	130.45	16.70	18.22	MS
C 31075	12.87	130.71	16.82	21.86	MS
C 31087	11.65	131.52	15.32	**14.75**	**LS**
C 31089	12.82	125.63	16.11	52.55	HS
C 31095	12.81	**140.15**	**17.95**	22.63	MS
C 31098	**12.90**	138.35	17.85	26.47	MS
C 32008	12.75	125.54	16.01	25.02	MS
C 32023	12.71	127.33	16.18	21.59	MS
C 32031	12.83	131.25	16.84	55.90	HS
Checks					
CoC (Sc) 23	12.82	125.45	16.08	51.64	HS
CoC (Sc) 24	12.55	132.72	16.65	26.12	MS
CD (0.05%)	0.43	10.35	1.22	-	-
CV (%)	1.05	6.27	4.35	-	-

CCS - Commercial Cane Sugar content

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ES03 BOPD 12

Screening of Blackgram [*Vignamungo* (L.) Hepper] Accessions against Pulse Beetle *Callosobruchuschinenesis* (L.)

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Keywords: *Pulse beetle, resistance, blackgram, oviposition, adult emergence*

Introduction

Among the pulses, blackgram *Vigna mungo* (L.) Hepper] is the highly prized pulses of South India. The quantitative avoidable losses caused by insect pest complex in black gram is up to 35 per cent. In Asia, bruchid beetle, *Callosobruchus chinensis* (Coleoptera: Bruchidae) is more severe in black gram during storage and resulted in total destruction of the seeds within six months. The available insecticide based pest management methods do not provide the effective control in addition to high cost and environmental issues. To date, no resistant varieties have been developed in black gram as there are no reliable resistance sources against bruchids. Hence identification of new sources to bruchid resistance is very essential to develop the resistant variety which will be economically viable option to reduce this pest.

Materials and Methods

Six entries from Nuclear Agriculture and Biotechnology Division, Bhabha Atomic Research Center, Trombay and five released varieties from National Pulses Research Center, TNAU, Vamban were screened against the bruchids. C. *chinensis* culture was maintained on blackgram variety VBN3 and sub culturing was done at regular intervals for continuous supply of insects for experiments. Screening was done under no choice test in a completely randomized design (CRD) with three replications during *kharif* 2017 and Rabi 2017. Male and female bruchids were sexed morphologically as described by Raina (1970).Two pairs of bruchid adults were released in the plastic container (8cm x 4cm)having one hundred numbers of black gram seeds and allowed for oviposition. Number of eggs laid were counted after five days and adults were removed. Further, observations on adult emergence and seed damage were taken on 30th, 60th and 90th days and adults were removed 35th and 65th days. Seed weight before the experiment and 30, 60 and 90 days after insect release was taken and per cent weight loss was calculated. Data collected were analyzed using AGRES software and mean separation was performed using significant difference at P= 0.05

Results and Discussion

Oviposition, adult emergence, per cent grain damage and per cent weight loss by bruchids significantly differ among blackgram germplasms during *Kharif* 2017 and *Rabi* 2017.Number of eggs laid was minimum on TU 80 (0.7) and TU 94-2 (2.00)during *Kharif* 2017 and on VBN 4 (8.00) and TU 68 (9.00) during *Rabi* 2017. The variation in oviposition might be attributed to the seed physical characters like size, colour and luster. Duraimurugan*et al.* (2014) reported that large and dull seeds facilitate the easy settling of adults for oviposition. Total number of adults emerged ranged between 0.0 to 27.0 during *Kharif* 2017, and 11 to 33.77 during *Rabi* 2017. Seasonal variation in adult emergence could be due to variation in environmental conditions. No adult emerged from TU 100 during *Kharif* 17 but adult emergence was 15.7 during *Rabi* 17.Minimum adult emergence was recorded on TU 40 (27.00) during *Kharif* 2017 and on TU 72 (11.00) and TU 80 (12.33) during *Rabi* 2017.This resistance variations and inconsistency could be attributed to the difference in chemical constituents inside the seeds which should be further investigated. Nil seed damage and minimum weight loss by bruchid on TU-100 and TU 94-2 during *kharif* 2017 is due to no egg laying and adult emergence. Per cent seed damage and weight loss was minimum in TU-80 (15.00 and 15.31) and maximum in VBN 3 (36.7 and22.03) during *rabi* 2017. It is evident from the above informations that reaction of blackgramgermplasm to pulse beetle *Callasobruchus chinenesis* vary with respect to germplasm and germplasm with significant resistant can be used for breeding programmes.

Table 1. Screening of Blackgram Entries against Pulse Beetle *Callosobruchus chinensis*

Genotype	No. of eggs laid*		Adult emergence (No.)*		Seed damage (No.) *		Weight loss (%)**	
	Kharif 2017	*Rabi* 2017	*Kharif* 2017	*Rabi* 2017	*Kharif* 2017	*Rabi* 17	*Kharif* 2017	*Rabi* 2017
TU - 40	24.30 (4.91)g	27.70 (5.00)b	27.00 (5.17)e	25.70 (5.05)de	29.30 (32.67)d	29.00 (32.52)bc	33.20 (35.13)bc	25.57 (30.30)
TU - 68	15.70 (3.94)ef	9.00 (4.32)ab	0.70 (0.74)a	22.33 (4.71)cde	0.70 (4.25)a	27.00 (31.17)bc	8.00 (14.74)a	27.09 (31.36)
TU - 72	17.30 (4.12)efg	18.00 (4.23)ab	7.30 (2.67)bc	11.00 (3.29)a	8.33 (16.60)b	16.33 (23.68)ab	21.46 (27.60)b	24.16 (29.38)
TU – 80	0.70 (0.62)a	14.00 (3.74)ab	1.00 (0.73)a	12.33 (3.41)a	1.33 (4.70)a	15.00 (22.06)a	8.56 (15.89)a	15.31 (22.65)
TU -100	7.00 (2.62)cd	19.00 (4.33)b	0.00 (0.22)a	25.70 (5.01)de	0.00 (1.28)a	28.00 (31.61)bc	4.98 (12.86)a	18.74 (25.62)
VBN 3	4.00 (1.99)bc	16.3 (3.96)ab	10.00 (3.16)cd	33.70 (5.79)e	11.33 (19.41)b	36.70 (37.24)c	27.83 (31.59)b	22.03 (27.98)
VBN 4	3.30 (1.79)c	8.00 (2.80)a	17.30 (4.14)d	14.00 (3.61)ab	19.00 (25.72)c	16.70 (23.53)ab	32.45 (34.65)bc	18.60 (25.22)
VBN 5	11.30 (3.36)de	15.70 (3.92)ab	27.00 (5.19)e	14.33 (3.77)ab	29.33 (32.77)d	18.33 (25.26)ab	41.09 (39.87)c	20.06 (26.53)
VBN 6	9.30 (3.04)d	13.7 (3.69)ab	16.00 (3.97)d	15.00 (3.82)ab	18.70 (25.49)c	20.00 (26.10)ab	32.48 (34.69)bc	18.49 (25.34)
VBN 8	20.70 (4.50)fg	21.70 (4.64)b	0.30 (1.97)b	17.00 (4.10)bc	0.33 (2.77)a	20.70 (26.93)ab	2.61 (9.14)a	18.25 (25.28)
TU -94-2	2.00 (2.81)ab	27.70 (5.26)b	0.00 (0.22)a	25.70 (5.03)cde	0.00 (1.28)a	28.00 (31.82)bc	2.85 (9.71)a	21.83 (27.79)
SEd	0.424	0.657	0.477	0.506	2.805	4.465	3.726	2.725
CD(.05)	0.879	1.363	0.989	1.057	5.817	9.261	7.727	5.652

*Figures in the parentheses are square root transformed values

**Figures in the parentheses are arc sine transformed values

Mean followed by a common letter are not significantly different by LSD (P= 0.05)

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ES03 BOPD 13

Reaction of advanced rice cultures against plant and leafhoppers

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Keywords: *Rice, BPH,WBPH, GLH, Resistance reaction, rice, advanced cultures*

Introduction

Rice (*Oryza sativa* L.) is the staple food for about 60 percent of the world population. India, the largest rice growing country, has the productivity of 2.58 t/ha which is very low when compared with China (6.71 t/ha), the country with highest productivity. One of the main reasons for low productivity is the biotic stress caused especially by the monophagous pests *viz*., stemborers and planthoppers right from seedling to maturity causing 30 and 20% yield losses, respectively. These insect pests often become unmanageable using chemical control methods due to resurgence and resistance. Host plant resistance is a useful alternate strategy that can be effectively incorporated with other eco-friendly methods of rice pest management. More than 30 potentially useful resistance gene loci and several major quantitative trait loci were identified for BPH in rice (Behera *et al*., 2018). In this context, artificial screening studies of advanced rice cultures against BPH, WBPH and GLH was proposed along with study of influence of host plant attributes conferring resistance to BPH.

Materials and Methods

Artificial screening for hopper resistance was carried out by sowing entries in portrays @ 15 sprouted seeds per entry in each slot leaving two opposite corner and middle slots for TN1 and PTB 33 / MO1, respectively. Seedlings were then inoculated with nymphs as per the procedure mentioned in SES, 2013 and damage score was taken. Feeding preference of BPH for the standard resistant and susceptible checks were studied using non preference test, honey dew test and nymphal survival test as described by Heinrich *et al*. (1985) with slight modifications.

Results and Discussion

Among the entries screened, PTB 33 and Anna (R) 4 showed resistance to BPH, WBPH and GLH (Fig.1). AD 16028 and ACK 12024 showed resistance to BPH and WBPH. CB 16763 was moderately resistant to BPH and GLH. ACK 12026, PM 16002, AS 15024, RNR 15048 and ADT 51 showed resistance to BPH while CB 16785, AS 16059 and AD 18147 showed resistance to WBPH. Host preference studies, honeydew test and nymphal survival test revealed that antixenosis and antibiosis mechanism of resistance were observed for BPH in PTB33 by showing least host preference, less honey dew excretion and less nymphal surivival (Table1)**.** Resistance reaction towards hoppers have to be confirmed using modified seed box screening wherein the reaction of the test entry at tillering stage could be determined and compared with seedling screening. Studies on resistant mechanisms suggested that breeding for partial/moderate host plant resistance is more appropriate and relevant than high levels of resistance for a particular biotic stress.

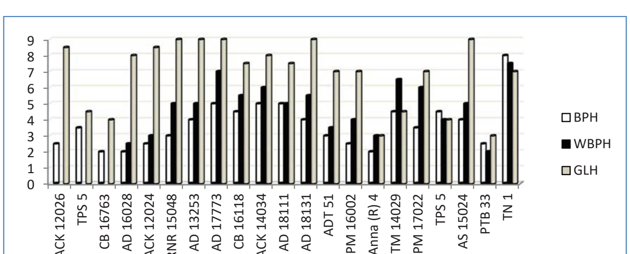

Fig.1. Selected entries with resistance scale (0-9) for BPH/ WBPH/GLH

Table 1: Observations on mechanism of resistance to BPH

Sl. No.	Variety	Antixenosis (Nos. ± SD/hill)			Antibiosis	
		24 HAI	48 HAI	72 HAI	Honeydew (mm^2± SD)	F1 nymphs (Nos. ± SD /hill)
1.	PTB33	7 ± 0.71	5 ± 1.58	3.6 ± 0.89	58 ± 1.37	5.56 ± 1.13
2.	TN1	13 ± 0.71	15 ± 1.58	16.4 ± 0.89	199 ± 1.37	31.00 ±1.13

HAI – hours after inoculation; Values represent mean ± standard deviation

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ES03 BOPD 14

Screening of Pigeonpea *Cajanus cajan* (L.). Millsp. Cultures against Pod borer Complex

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Keywords: *Pigeonpea, Maruca vitrata, Helicoverpa armigera, Screening*

Introduction

Pigeonpea is one of the important semiarid legume crop cultivated in an area of 41.92 lakh hectares and production of 35.92 lakh tonnes. In Tamil Nadu, it is being cultivated in 0.42 lakh/ha with a production of 0.44lakh tonnes. The average productivity of India and Tamil Nadu are 919 and 1047 kg/ha, respectively. Despite the fact that a large number of high yielding varieties have been released, productivity of redgram remains stagnant at around 700 kg/ha as compared to its potential yield of 1500 to 3000 kg/ha. Among the yield limiting factors, the infestation of insect pests poses major threat to pigeonpea cultivation. More than 250 insect pest species belonging to 61 families are known to cause damage to pigeonpea (Sachan *et al*., 1990). Among these the gram pod borer *Helicoverpa armigera* Hub., spotted pod borer *Maruca vitrata (*Geyer*)* and pod fly *Melanogromyza obtusa* (Malloch) are of more economic importance. Though application of chemical insecticides has been widely recommended for the management of borers in pigeonpea, cultivation of resistant cultivars is one of the integral component of IPM and which requires continuous screening of available cultivars against podborers.

Material and Methods

Field screening of early and mid-early entries of pigeonpea were carried out at Department of Pulses, TNAU, Coimbatore. During *kharif 2021*, eight early and 15 medium promising entries were screened along with CO 9 as check against pod borers and pod fly. The entries were sown in 2 lines of 2m length and replicated twice. The standard agronomic practices were followed to grow the entries and maintained without insecticide spray. The pod borer complex incidence was enumerated during flowering and pod formation stage. The cumulative pod damage due to *H. armigera*, *M. vitrata* and *M. obtusa* were recorded at the time of harvest. The Pest severity index was worked by comparing the entries with the percentage of pod damage in check variety Co 9.

Results and Discussion

Among the early entries CRG 16-05 was found to be moderately resistant to pod borers and pod fly with a PSI of 25.00 (Table 1). The medium entries CRG 19-007, CRG 18-001 and CRG 18-007 recorded PSI of 31.45, 25.81 and 27.42, respectively. These entries were moderately resistant to pod borers and pod flies (Table 1). The blue butterfly *Lampides boeticus* incidence was also noticed in all the entries.

The population of pod borers in all genotypes persisted from the 4th standard week of 2018-19 to the 12th standard week of 2018-19 (Sharma and Keval, 2021). In the present investigation also the pod borer population was recorded from the flowering stage to pod formation stage. Navneet Rana *et al*. (2017) recorded minimum larval population, minimum pod damage, minimum grain damage, least pest susceptibility rating in ICP 6996. Among the 14 genotypes screened against pod borer complex in Ranchi, PA374 recorded least pod damage of 1.7% followed by UPAS 120 (2%), PUSA 2011- 2(6.44%), PA 382 (9.22%).

Based on the results, advanced cultures *viz.,* CRG 16-05, CRG 19-007, CRG 18-001 and CRG 18-007 were moderately resistant to pod borer complex in the present study and this cultures may be forwarded to advanced yield trial.

Table 1. Performance of advanced redgram cultures against podborer complex

Entries	Flowering stage (No/ plant)		Pod formation (No/ plant)	Pod damage (%)					PSI	Grade	Category
	H. armigera	*M. vitrata*	*H. armigera*	*M. vitrata*	*H. armigera*	*M. vitrata*	*M. obtusa*	Total			
Early											
CRG 19-01	1.17	5.83	1.83	10.33	5.00	13.00	10.50	28.5	8.06	6	MS
CRG 19-04	1.11	4.94	1.33	10.42	6.00	12.50	9.75	28.25	8.87	6	MS
CRG 19-07	1.17	5.28	1.33	11.00	4.00	13.00	8.50	25.5	17.74	5	MS
CRG 19-09	1.17	4.89	2.33	8.67	4.50	13.00	8.00	25.5	17.74	5	MS
CRG 16-05	0.72	5.00	1.50	8.75	4.00	10.00	9.75	23.25	25.00	4	MR
CRG 18-02	1.06	4.00	1.67	9.67	4.50	12.00	9.25	25.75	16.94	5	MS
CRG 18-03	0.83	4.61	1.50	9.75	3.50	11.50	11.25	26.25	15.32	5	MS
CRG 18-04	0.94	5.00	1.67	11.33	3.50	11.50	10.50	25.50	17.74	5	MS
Medium											
CRG 19-001	1.06	4.39	2.00	11.58	4.50	13.50	10.75	28.75	7.26	6	MS
CRG 19-002	1.06	5.67	2.17	10.83	3.50	12.50	10.25	26.25	15.32	5	MS
CRG 19-003	1.28	5.17	1.50	9.83	5.50	12.00	12.00	29.5	4.84	6	MS
CRG 19-004	1.28	4.11	1.00	9.92	4.00	12.00	9.25	25.25	18.55	5	MS
CRG 19-005	1.11	5.39	2.33	11.42	4.00	12.50	9.00	25.5	17.74	5	MS
CRG 19-006	0.89	5.17	1.67	10.42	4.00	12.50	7.75	24.25	21.77	5	MS
CRG 19-007	1.33	5.11	1.83	8.33	4.00	10.50	6.75	21.25	31.45	4	MR
CRG 19-008	1.11	4.78	2.00	8.58	4.00	12.50	8.75	25.25	18.55	5	MS
CRG 19-009	1.06	5.17	1.50	9.17	6.00	10.50	7.25	23.75	23.39	5	MS
CRG 18-001	1.06	5.22	2.17	9.83	4.00	11.50	7.50	23.00	25.81	4	MR
CRG 18-003	1.06	5.00	1.33	11.67	4.50	11.00	8.25	23.75	23.39	5	MS
CRG 18-005	0.89	4.50	1.83	10.92	3.50	11.50	9.25	24.25	21.77	5	MS
CRG 18-006	1.11	5.72	1.83	10.17	3.50	12.00	8.50	24	22.58	5	MS
CRG 18-007	1.06	5.50	1.17	9.25	3.50	11.00	8.00	22.50	27.42	4	MR
CRG 18-010	1.06	6.17	1.33	10.58	4.00	12.00	7.50	23.50	24.19	5	MS
Co9 (Check)	1.11	5.00	1.50	20.17	4.00	16.50	10.50	31			

HS: Highly susceptible; S: Susceptible; MS: Moderately susceptible; MR: Moderately Resistant

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ES03 BOPD 15

Impact of silicon induced silicified cells on sucking insects of rice

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Key words:*silica, silicified cells, sucking insects, rice*

Introduction

The successful cultivation of rice is often hampered by an array of insect pests. The projected yield loss due to insect stress ranged from 20 to 30%. Rice is a typical silicon-accumulating plant and it may act directly and indirectly on insect herbivores.Silicon (Si) is widely considered as an activator by stimulating the expression of natural defense reaction through the production of phenolic compounds. The application of Si in crops provides a viable component of integrated management of insect pests because it leaves no insecticide residues in food or the environment, and it can beeasily integrated with other pest management practices.

Materials and Methods

Field Experiments were conducted at AC & RI, Maduraito find out the effect of silica nutrition on sucking insects of rice. The treatments included were: Rice straw 5 t / ha and 2.5 t/ha + Silicate Solubilizing Bacteria (SSB) 2kg / ha, basal application of calcium silicate – 50 kg/ha,100 kg/ha, 150 kg/ha, 200 kg/ha, foliar spray of 0.25% Sodium meta silicate (SMS), foliar spray combined with all treatments and Untreated check.Pest population count wasmade at 15 days after transplanting in each plot. Silicified cells were analyzed by safranin phenol methodin the leaf and leaf sheath samples of treated rice plantsas per the procedures standardized.

Results and Discussion

In the present investigation, calcium silicate 200kg/ha with foliar spray of 0.25% SMS treated plants recorded more silicified cells followed by calcium silicate 150kg/ha with foliar spray of 0.25% SMS treated plants and inturn incidence of BPH, GLH and earhead bugs was found to be less in these treatments(Fig 1).In present study, calcium silicate 200kg/ha with foliar spray of 0.25% SMS treated leaf analysed through scanning electron microscope (SEM), the silica bodies were recorded as dumbbell shaped cells and scattered silica cells. This is in consonance with the findings ofMa and Takahashi (2002).This is in endorsement with finding of Ram Prasad *et al.* (2010) who reported that the arrangement of silica cells were more important than silica content in relation to leaf folder resistance.

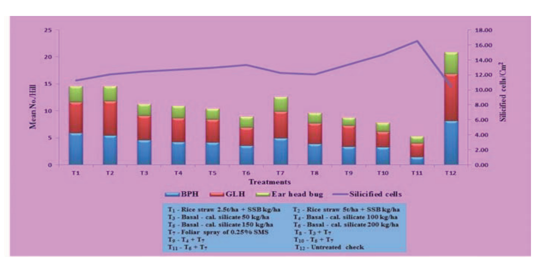

Fig 1. Sucking pest of incidence in silicon treated rice

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ES03 BOPD 16

Evaluation of Blackgram, *Vigna mungo* (L.) Germplasm against Major Insect Pests

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Keywords: *Blackgram, germplasm, stemfly, whitefly, pod bug, spotted podborer*

Introduction

Blackgram is a major pulse crop in Tamil Nadu. An array of more than 284 insect pest species belonging to 48 families causing considerable yield loss in black gram Among them stemfly *Ophiomyia phaseoli*, whitefly *Bemisia tabaci*, pod bugs *Riptortus pedestris Clavigralla gibbosa* and spotted podborer *Maruca vitrata* are the major destructive pests. Different IPM concepts, cultivation of resistant variety is one of the major components and it requires continuous screening of available cultivars in order to identify the resistant source against the major insect pests.

Material and Methods

Fifty-one blackgram entries were screened along with standard susceptible check Mash 338 and local check VBN (Bg) 3 at NPRC, Vamban during *Kharif* 2020. All the standard agronomic practices were strictly followed except insecticide sprays. Observations on per cent infestation of stemfly was calculated based on stem tunneling at 15 DAS and 30 DAS, number of whiteflies per trifoliate leaves during the vegetative stage and number of webbings of spotted pod borer, *M. vitrata* during the flowering stage of the crop in each entry was recorded.

Results and Discussion

The per cent infestation of stem fly was minimum in entries *viz*., KUE 20-1, KUE 20-50 and KUE 20-38 with 4.7, 5.0 and 5.5 respectively after 15 DAS and KUE 20-44, KUE 20-50 and KUE 20-48 viz., 7.3, 7.5 and 7.6 after 30 DAS (Table 1). The whitefly population ranged from 3.0 to 6.4 per plant in the entries as against 6.6 per plant in susceptible check Mash 338. The minimum population of whitefly was recorded in KUE 20 – 4 and KUE 20 – 43 (3.0/ 3 leaves) followed by KUE 20 – 41 (3.6/3 leaves). Population of *Maruca* larvae ranged from 0.2 to 1.2 per plant as compared to 2.0 in susceptible check Mash 338. The *Maruca* population was minimum in KUE 20 – 5 and KUE 20 – 10 (0.2/ plant).

Table 1. Performance of blackgram entries against major insect pests

Name of the entry	Stemfly infestation (%)		No. of whiteflies / trifoliate leaves	No. of *Maruca* web / plant
	15 DAS	30 DAS		
KUE 20-1	4.7	11.9	4.5	0.6
KUE 20-2	9.5	13.7	5.5	0.6
KUE 20-3	14.0	19.5	5.0	0.3
KUE 20-4	15.5	17.9	3.0	0.5
KUE 20-5	6.1	13.3	5.3	0.2
KUE 20-6	11.3	16.9	5.2	0.3
KUE 20-7	6.3	14.7	5.3	0.3
KUE 20-8	8.3	13.7	4.6	0.5
KUE 20-9	9.3	15.6	6.0	0.4
KUE 20-10	13.2	19.8	5.4	0.2

KUE 20-11	9.3	15.8	5.4	0.6
KUE 20-12	9.3	11.3	4.7	0.6
KUE 20-13	11.0	16.6	5.2	0.6
KUE 20-14	13.9	18.1	4.5	0.6
KUE 20-15	7.4	13.8	5.2	0.9
KUE 20-16	10.9	12.1	6.2	0.4
KUE 20-17	13.5	13.5	5.8	0.8
KUE 20-18	6.7	12.9	5.0	0.4
KUE 20-19	10.1	14.8	6.0	0.8
KUE 20-20	7.2	16.3	5.8	0.7
KUE 20-21	7.3	13.0	5.4	0.7
KUE 20-22	13.4	22.4	5.4	0.7
KUE 20-23	7.5	16.2	5.9	0.9
KUE 20-24	8.4	12.5	4.6	0.4
KUE 20-25	7.7	12.9	5.3	0.7
KUE 20-26	6.0	11.3	6.0	0.8
KUE 20-27	7.6	16.6	5.2	0.5
KUE 20-28	13.4	14.6	4.6	0.3
KUE 20-29	6.0	8.6	6.4	0.8
KUE 20-30	5.7	11.4	5.3	0.6
KUE 20-31	12.4	18.2	4.4	1.0
KUE 20-32	8.9	17.8	5.2	0.8
KUE 20-33	7.2	12.6	4.2	0.8
KUE 20-34	7.8	15.1	6.0	1.2
KUE 20-35	8.1	10.8	6.2	0.7
KUE 20-36	7.5	14.0	5.4	0.8
KUE 20-37	10.1	14.5	5.8	0.7
KUE 20-38	5.5	10.0	6.0	0.8
KUE 20-39	9.0	12.5	4.5	0.6
KUE 20-40	10.0	13.5	5.2	0.4
KUE 20-41	7.4	11.6	3.6	0.6
KUE 20-42	6.6	10.4	4.2	0.4
KUE 20-43	10.2	14.6	3.0	0.8
KUE 20-44	6.4	7.3	4.2	1.0
KUE 20-45	8.6	12.0	5.1	0.6
KUE 20-48	6.6	7.6	5.0	1.2
KUE 20-49	5.8	8.8	5.0	1.0
KUE 20-50	5.0	7.5	4.8	0.8
KUE 20-51	6.9	13.4	6.4	0.8
KUE 20-52	12.3	15.4	5.4	0.4
KUE 20-53	6.3	11.9	4.8	0.4
VBN(Bg)3	20.2	30.6	6.5	1.8
Mash-338	19.1	29.1	6.6	2.0

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ES03 BOPD 17

Impact of trichomes on population of leafhopper *Amrasca biguttula biguttula* Ishida in okra genotypes

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Keywords: *Amrasca biguttula biguttula, okra, trichomes, resistance*

Introduction

Amrasca biguttula biguttula Ishida (Homoptera: Cicadellidae), major sucking insect pest of okra infests entire crop phase with yield reduction of 54-66 per cent (Singh *et al.,* 2013). Among several pest control methods employed use of chemical insecticides is the primary control tactic adopted by many farmers. Use of chemical insecticides leads to resistance development which has necessitated switching over to use of resistant varieties. The morphological feature of host plant especially trichome significantly alters the behavior of the herbivores thereby playing a vital role in host plant resistance against herbivore (Lazniewska *et al.,* 2012). Therefore, an attempt was made to identify the response of leafhopper to okra genotypes and correlation of leafhopper population with trichomes density and length to determine resistance/susceptibility.

Materials and methods

Five plants from experimental field, each from 23 *okra* genotypes were selected at random and trichome density from different parts of leaf *viz.,* leaf lamina, midrib and veins were enumerated under stereozoom microscope by adopting the method suggested by Maiti *et al.* (1980). Three replicates were maintained for each leaf sample which were cut into one square centimeter bits and boiled with 20 ml of water in test tubes for 15 min in hot water bath at 85ºC. The leaf bits alone were again boiled with 20 ml of 96 % ethyl alcohol for 20 min at 80ºC. Alcohol was again added and boiled to remove the chlorophyll completely from leaves and leaf bits turned transparent. Then 90% lactic acid was added. The test tubes were stoppered and heated at 85ºC until leaf segments were fully cleared (approximately 30-45 min). Then leaf segments were mounted on clean slides using a drop of lactic acid to observe the trichome density. The number of trichomes per square centimeter area and trichome length was estimated under stereozoom microscope at 10 X magnification for each leaf sample. The trichome density and length on adaxial, abaxial surface, midrib and veins of leaves were correlated with incidence of leafhopper.

The data on leafhopper population, mean trichome density and trichome length were analyzed by LSD at 5% probability using SPSS 21.0 software. Data were subjected to square root transformation and correlation and regression analyses were carried out using SPSS 21.0 software. Multiple linear regression analysis was carried out to assess the degree and extent of influence of trichomes on population buildup of *A. biguttula biguttula* on okra genotypes.

Results and discussion

The results indicate that genotype AE 65 had more number of trichomes (102 Nos.) with less leafhopper population (2.28/plant) and genotypes, AE 26 (10.67) and Pusa Sawani (20.33) had less number of trichomes with maximum leafhopper population of 28.79 and 27.70/plant (Fig.1). Data on leafhopper population and trichome density were correlated and the results showed significant negative relationship with values of r= -0.513, -0.503, -0.260, -0.597, -0.575 respectively, on adaxial surface, abaxial surface, midrib, veins and total trichome density in the okra entries screened.

The maximum trichome length was recorded in AE 65 (72.51μm) on the adaxial surface, AE 23 (78.94 μm) on the abaxial surface, AE 65 and AE 23 (84.07 and 82.00 μm) on the midrib and AE 65 on veins (69.42 μm). The least length of trichomes was recorded in genotype AE 26, 13.28 μm on the adaxial surface, 16.07 μm on the abaxial surface, 22.73 μm on the midrib and 17.50 μm on veins, respectively (Fig.2).

The correlation studies between trichome length and *A. biguttula biguttula* population revealed that the trichome length (μm) on adaxial surface, abaxial surface, midrib and veins showed significant negative relationship (r = -0.880, -0.927, -0.914 and -0.939 respectively) in okra entries screened. Thus, trichome density and length had negative influence on leafhopper population. The present study is in line with Iqbal *et al.* (2011) who reported that hair density on midrib, veins and lamina of leaves showed a significant and negative correlation with population of leafhoppers. Hence, presence of trichomes proved the foremost resistant factor against okra leafhopper by providing first line of defense.

Fig.1. Trichome densities on okra genotypes

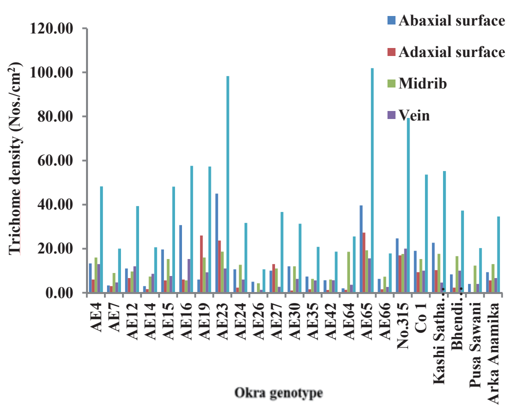
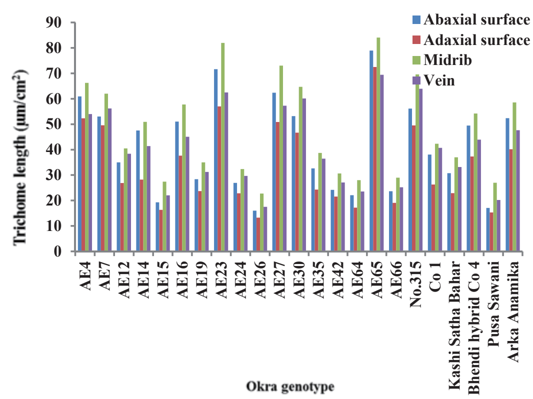


Fig.2. Trichome length on okra genotypes



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ES03 BOPD 18

Field evaluation of okra genotypes for resistance to leafhopper, *Amrasca biguttula biguttula* (Ishida) (Homoptera: Cicadellidae)

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Keywords: *Screening, Amrasca biguttula biguttula, okra, genotypes*

Introduction

Okra jassid, *Amrasca biguttula biguttula* (Homoptera: Cicadellidae) has become a serious pest of agronomic crops, vegetables and ornamental plants. It is the most destructive amongst sucking insect pests attacking the 'okra' crop. Excessive feeding damage the phloem tubes and causes hopper burn disease (phytotoxemia) the main symptom of jassid attack (Javed, 2016). Varietal resistance is one of the key IPM strategies to avoid indiscriminate use of insecticides. Development and cultivation of resistant varieties provides a suitable and desirable means of pest management. The success of such programme depends upon the extent of variability in the genotypes. In this context, this study evaluates the variability of leafhopper preference to 23 okra genotypes.

Materials and methods

Two field trials were carried out at Singanallur and Karamadai areas of Coimbatore district during 2018-2019. Randomized Complete Block design was adopted with two replications, in which after every 5 rows of test entries, two rows of susceptible check (Pusa Sawani) were raised to ensure infestation. The crop was raised at 60 x 30 cm spacing with all agronomic practices followed as per crop production techniques. Population was recorded in early morning hours by visual counting (absolute counting) at weekly intervals. For this, five plants were randomly selected, tagged and three leaves (top, middle and bottom) from each plant were assessed. The characteristic symptom of phytotoxemia (hopperburn) was used adopting 1-4 Grade scale of Indian Central Cotton Committee (ICCC) (Murugesan and Kavitha, 2010). Hopper burn index/ Leafhopper resistance index with scoring based on damage scales was calculated using the formula given by Nageswararao, 1973. The data were subjected to (ANOVA) and least significant difference (LSD, p= 0.05) using SPSS software 21.0.

Results and Discussion

Screening of genotypes revealed that the leafhopper population appeared from 35 DAS, and sharply increased after 45 DAS with a peak from 45 to 75 DAS, and then declined. The differences in the nymphal population among different genotypes were non-significant up to 30 DAS, but varied significantly among genotypes later.

Table 1 reveals that pooled mean population was maximum with AE 26 (28.79/plant) followed by Pusa Sawani (27.79/plant), AE 15 (25.83/plant), AE 64 (25.23/plant) and AE 66 (20.18/plant). Comparatively less leafhoppers were observed in AE 12 (11.97/plant) which is statistically on par with Co 1 (11.94/plant) followed by AE 14 (10.29/plant), Bhendi Hybrid Co 4 (9.28) which is on par with AE 16 (9.01/ plant) and Arka Anamika (9.00/plant). Genotypes AE 7, AE 30, AE 4, No.315, AE 27, AE 23 and AE 65 harboured very less leafhopper.

The maximum damage grade index was recorded in AE 26 (3.23), AE 15 (3.18), Pusa Sawani (3.15) and AE 64 (3.08) which indicates that these genotypes were highly susceptible (Table 1). Genotypes AE 12, AE 42, AE 24, AE 35, AE 7, AE 66, AE 19, Kashi Satha Bahar, AE 14, AE 16, Arka Anamika, Co 1, Bhendi Hybrid Co 4 and AE 30 falls under category susceptible were categorized under moderately resistant with damage index value ranging between 1.1 -2.0. None of the genotypes screened were found to be completely resistant. Throughout the study, AE 26, AE 15 and Pusa Sawani harbored the maximum nymphal population with high mean damage grading index. Whereas, AE 65 showed comparatively less population with pooled mean damage grading index of 1.18 (Moderately resistant).

Table 1. Leafhopper population and damage grade index with resistance category in okra genotypes (Pooled data of field experiment I & II)

Okra genotype	Pooled leafhopper population (No./ plant)	Pooled Damage grade index	Resistance category
AE4	5.95	1.95	MR
AE7	8.24	2.55	S
AE12	11.97	2.83	S
AE14	10.29	2.25	S
AE15	25.83	3.18	HS
AE16	9.01	2.25	S
AE19	15.24	2.45	S
AE23	3.40	1.30	MR
AE24	15.56	2.70	S
AE26	28.79	3.23	HS
AE27	4.11	1.58	MR
AE30	7.80	2.13	S
AE35	12.08	2.63	S
AE42	18.59	2.75	S
AE64	25.23	3.08	HS
AE65	2.28	1.18	MR
AE66	20.18	2.53	S
No.315	4.36	1.45	MR
Co 1	11.94	2.33	S
Kashi Satha Bahar	14.40	2.40	S
Bhendi hybrid Co 4	9.28	2.15	S
Pusa Sawani	27.79	3.15	HS
Arka Anamika	9.00	2.25	S

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ES03 BOPS 01

Evaluation of pigeonpea genotypes against larval population of Spotted pod borer, *Maruca vitrata* (Lepidoptera: Crambidae)

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Keywords: *Maruca vitrata, Pigeonpea, Genotypes, Screening*

Introduction

Pulses are an integral part of the diets of all vegetarian people all over the world and pigeonpea is the second most important crop in India after chickpea mainly cultivated in Maharashtra, Madhya Pradesh, Punjab, Gujarat, Uttar Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu, Odisha, Bihar and Haryana. Spotted pod borer, *Maruca vitrata* (Geyer) is the major insect-pest causing significant damage to this crop. The study was formulated to understand the resistance of *M. vitrata* towards pigeonpea.

Material and methods

Twenty two genotypes of pigeonpea mentioned in the Table 1 were screened against spotted pod borer during *Kharif* 2019. All the genotypes were sown on 21st June, 2019 in plots following randomized block design having three replications of each genotype. Larval population of *M. vitrata*, and webs formed by larvae of *M. vitrata* were recorded at weekly interval by visual count method, initiating from bud initiation stage till harvesting of the crop. Observations were recorded from five randomly selected and tagged plants in each replication of each genotype.

Results and Discussion

Overall, average larval numbers of *M. vitrata* were maximum and minimum in genotype, PADT 16 (0.75 larvae/plant) and CRG 2012-20 (0.08 larvae/plant) respectively. Almost all the genotypes reported higher number of larval population in comparison to check variety and it is in commensurate with the findings of Chakravarty *et al*., (2016) who reported 7.72 (PUSA2012-1) to 14.97 larvae/25 inflorescence (AL 1790) in comparison with checks (Manak and UPAS-120) i.e., 11.75 larvae/25 inflorescence and 10.75 larvae/25 inflorescences respectively. However, Rana *et al*. (2017) revealed the range of larval population of *M. vitrata* from 2.60 (ICP 6996) to 8.73 larvae per plant (ICP 7409). While Rathod *et al*. (2014) reported BSMR853 as least susceptible (1.80 larvae/plant) and ICPL-87119 (6.11 larvae/plant) as highly susceptible. However, in view of low larval load in field during the season, the levels of resistance could not be ascertained and it requires further screening.

Table 1. Population of (*Maruca vitrata*) larvae on different genotypes of pigeonpea

Pigeonpea Genotype	No. of larvae of *M. vitrata* /plant during different SMW										
	36	37	38	39	40	41	42	43	44	45	Overall Mean
AH 05-38	0.00 (1.00)	0.00 (1.00)	0.47 (1.21)	0.73 (1.31)	1.00 (1.41)	0.33 (1.15)	0.27 (1.13)	0.07 (1.03)	0.00 (1.00)	0.00 (1.00)	0.29 (1.13)
AH 9-18	0.00 (1.00)	0.00 (1.00)	0.27 (1.13)	0.40 (1.18)	0.67 (1.29)	0.60 (1.26)	0.33 (1.15)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.23 (1.11)
AH 14-01	0.00 (1.00)	0.00 (1.00)	0.20 (1.09)	0.27 (1.12)	0.53 (1.24)	0.40 (1.18)	0.27 (1.13)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.17 (1.08)
AH 14-04	0.00 (1.00)	0.00 (1.00)	0.33 (1.15)	0.53 (1.24)	0.80 (1.34)	0.33 (1.15)	0.20 (1.09)	0.13 (1.06)	0.07 (1.03)	0.00 (1.00)	0.24 (1.11)
AH 15-01	0.00 (1.00)	0.00 (1.00)	0.27 (1.12)	0.40 (1.18)	0.67 (1.29)	0.53 (1.24)	0.40 (1.18)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.23 (1.11)
AH 16-02	0.00 (1.00)	0.00 (1.00)	0.20 (1.09)	0.33 (1.15)	0.47 (1.21)	0.33 (1.15)	0.13 (1.06)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.15 (1.07)
AH 17-17	0.00 (1.00)	0.00 (1.00)	0.13 (1.06)	0.20 (1.09)	0.40 (1.18)	0.27 (1.13)	0.13 (1.06)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.11 (1.06)
AH 17-28	0.00 (1.00)	0.00 (1.00)	0.20 (1.10)	0.27 (1.13)	0.53 (1.24)	0.40 (1.18)	0.33 (1.15)	0.07 (1.03)	0.00 (1.00)	0.00 (1.00)	0.18 (1.09)
AL 1992	0.00 (1.00)	0.00 (1.00)	0.40 (1.18)	0.53 (1.24)	0.87 (1.35)	0.53 (1.24)	0.33 (1.15)	0.07 (1.03)	0.00 (1.00)	0.00 (1.00)	0.27 (1.13)
B-17200	0.00 (1.00)	0.00 (1.00)	0.13 (1.06)	0.27 (1.13)	0.67 (1.28)	0.40 (1.18)	0.33 (1.15)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.18 (1.09)
CRG-2012-20	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.07 (1.03)	0.13 (1.06)	0.20 (1.10)	0.17 (1.08)	0.13 (1.06)	0.07 (1.03)	0.07 (1.03)	0.08 (1.04)
C0RG 9701	0.00 (1.00)	0.00 (1.00)	0.47 (1.21)	0.60 (1.26)	1.00 (1.41)	0.53 (1.24)	0.27 (1.12)	0.07 (1.03)	0.07 (1.03)	0.00 (1.00)	0.30 (1.14)

H 00-15	0.00 (1.00)	0.00 (1.00)	0.07 (1.03)	0.13 (1.06)	0.20 (1.09)	0.60 (1.26)	0.40 (1.18)	0.20 (1.10)	0.13 (1.06)	0.07 (1.03)	0.18 (1.09)
H 03-29	0.00 (1.00)	0.00 (1.00)	0.07 (1.03)	0.13 (1.06)	0.20 (1.09)	0.67 (1.29)	0.33 (1.15)	0.27 (1.13)	0.13 (1.06)	0.07 (1.03)	0.19 (1.09)
H 03-41	0.00 (1.00)	0.00 (1.00)	0.07 (1.03)	0.27 (1.13)	0.33 (1.15)	0.47 (1.21)	0.27 (1.13)	0.20 (1.10)	0.13 (1.06)	0.07 (1.03)	0.18 (1.09)
H 97-24	0.00 (1.00)	0.00 (1.00)	0.07 (1.03)	0.13 (1.06)	0.47 (1.21)	0.67 (1.29)	0.53 (1.24)	0.47 (1.21)	0.33 (1.15)	0.20 (1.10)	0.29 (1.13)
ICPL 88039	0.00 (1.00)	0.00 (1.00)	0.33 (1.15)	0.47 (1.21)	0.67 (1.29)	0.40 (1.18)	0.27 (1.12)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.21 (1.10)
Manak (check)	0.07 (1.03)	0.13 (1.06)	0.27 (1.13)	0.67 (1.29)	0.13 (1.06)	0.07 (1.03)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.13 (1.07)
Paras	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.20 (1.10)	0.80 (1.34)	0.53 (1.23)	0.20 (1.09)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.17 (1.08)
PAU 881	0.00 (1.00)	0.27 (1.12)	0.40 (1.18)	0.47 (1.21)	0.67 (1.29)	0.40 (1.18)	0.13 (1.06)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.23 (1.11)
PADT 16	0.67 (1.28)	1.73 (1.65)	3.67 (2.14)	0.73 (1.31)	0.20 (1.09)	0.27 (1.13)	0.20 (1.09)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.75 (1.32)
VLA 1	0.00 (1.00)	0.00 (1.00)	0.27 (1.13)	0.33 (1.15)	0.53 (1.24)	0.33 (1.15)	0.13 (1.06)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.16 (1.08)
MEAN	0.03	0.10	0.38	0.37	0.54	0.42	0.26	0.08	0.04	0.02	0.22
C.D. (P=0.05)	(0.06)	(0.06)	(0.16)	(0.10)	(0.14)	(0.12)	(NS)	(0.05)	(0.05)	(0.04)	(0.04)
SE (m) ±	(0.02)	(0.02)	(0.06)	(0.03)	(0.05)	(0.04)	(0.04)	(0.02)	(0.02)	(0.01)	(0.02)

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ES03 BOPS 02

Impact of biophysical bases of resistance on leaf webber population and stem weevil damage in amaranthus genotypes

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Keywords: *Amaranthus, leaf webber, stem weevil, trichomes, surface wax, tissue toughness*

Introduction

Amaranthus spp. (Amaranthaceae) is a green leafy vegetable popular throughout the tropics and in many warm temperate regions. A total of 92 insect pests belonging to 11 orders have been recorded from cultivated amaranthus. Among these, leaf webber and stem weevil are considered as the most damaging pests (Aderolu *et al.,* 2013). Management of these notorious pests with chemical pesticides has produced significant health and environmental risks. Among the eco-friendly pest management approaches, Host Plant Resistance (HPR) is one of the promising cost-effective and safe methods. Under the mechanisms of host plant resistance, biophysical characters in plants act as major line of defense against insect pests. Hence, the present study was conducted to assess the impact of trichomes, surface wax and tissue toughness on leaf webber population and stem weevil damage in amaranthus.

Materials and Methods

From 86 genotypes of amaranthus, the best performing five genotypes based on yield *viz.,* A81, A59, A154, A77 and A21 along with TNAU released variety CO 1 were selected to study the biophysical bases of resistance. All the six entries were monitored at weekly intervals for the major pests *viz.,* leaf webbers and stem weevil throughout the cropping period on ten randomly selected plants in each entry and expressed as number per plant. Mean number of leaf webbers per plant and per cent damage caused by stem weevil during the entire season was worked out for further analysis.

Based on the number of leaf webbers present per plant, genotypes A81, A59 and A154 belonged to the least susceptible category and A77, A21 and CO 1 belonged to the susceptible category. Trichome density of all the six entries of amaranthus was assessed by adopting the method suggested by Maiti *et al*. (1980). Surface wax content on the leaves of amaranthus was estimated by adopting the method suggested by Woodhead and Padgham (1988). The tissue toughness of the stem was measured using penetrometer as per the procedure described by Wanja *et al*. (2015).

Results and Discussion

Screening of six amaranthus genotypes against leaf webbers revealed that maximum number of 1.88 leaf webbers per plant was recorded in the susceptible genotype A 21 as against the minimum of 0.50 per plant in the least susceptible genotype A 81. Stem weevil damage was maximum in the susceptible genotype A 21 (32.50%) as against the minimum of (12.50%) in the least susceptible genotype A 81. All the biophysical parameters *viz.,* trichome density, surface wax and tissue toughness were maximum in the least susceptible genotype A 81 and minimum in the susceptible genotype A 21. Present findings are in line with the report of Kamel and Elkassaby (1965) who reported that hairiness on cotton leaves offered resistance to cotton aphids, *Aphis gossypii*.

Table 1. Biophysical bases of resistance in amaranthus against leaf webber and stem weevil

Amaranthus genotypes	Leaf webbers / plant (No.)	Stem weevil damage (%)	Number of trichomes/cm² leaf area	Surface wax (mg/g)	Tissue toughness (N)		
					10 cm	20 cm	30 cm
A81	0.50[a]	12.50[a]	18.33[a]	0.05[a]	30.90[a]	21.55[a]	13.40[a]
A59	0.65[b]	16.25[b]	12.67[b]	0.04[b]	26.15[b]	17.90[c]	11.45[cd]
A154	0.76[c]	21.25[d]	10.67[c]	0.04[b]	25.40[c]	18.45[b]	11.30[d]
A77	1.50[e]	26.25[e]	6.00[d]	0.02[d]	22.35[d]	15.60[e]	11.75[bc]
A21	1.88[f]	32.50[f]	5.33[e]	0.03[c]	18.65[e]	13.00[f]	10.80[e]
CO1	1.06[d]	18.75[c]	5.67[de]	0.04[b]	24.85[c]	17.25[d]	12.05[b]
S. Ed	0.01	0.22	0.23	0.003	0.27	0.24	0.15
CD (P=0.05)	0.03	0.47	0.48	0.007	0.58	0.51	0.32

*All values are mean of four replications

In a column, means sharing similar letter(s) is/are not significantly different by LSD at P=0.05

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ES03 BOPS 03

Impact of biochemical bases of resistance on leaf webber population and stem weevil damage in amaranthus genotypes

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Keywords: *Amaranthus, leaf webber, stem weevil, biochemical parameters, resistance*

Introduction

Amaranthus is one of the important green leafy vegetables grown in India. However, insect pests pose a significant threat to amaranthus production, of which defoliating caterpillars and stem-boring weevils are ranked as the most destructive pests (Kagali *et al.,* 2013). Farmers mostly rely on chemical pesticides to manage these pests, but intensive use of pesticides poses human and environmental health hazards. Resistant cultivars are eco-friendly and possess significant amount of in-built mechanisms with heritable characteristics. Under the mechanisms of host plant resistance, biochemical factors in plants act as major line of defense against insects. Hence, present study was carried out to assess the impact of plant nutrition based biochemical parameters and plant defensive enzymes on leaf webber population and stem weevil damage in amaranthus genotypes.

Materials and Methods

Out of 86 genotypes of amaranthus, the best performing five genotypes based on yield *viz.,* A81, A59, A154, A77 and A21 along with TNAU released variety CO 1 were selected to study the biochemical bases of resistance. All the six entries were monitored at weekly intervals for the major pests *viz.,* leaf webbers and stem weevil throughout the cropping period on ten randomly selected plants in each entry and expressed as number per plant. Mean number of leaf webbers per plant and per cent damage caused by stem weevil during the entire season was worked out for further analysis.

Based on the number of leaf webbers present per plant (Shahiba *et al*., 2020), genotypes A81, A59 and A154 belonged to the least susceptible category and A77, A21 and CO 1 belonged to the susceptible category. Biochemical factors *viz.*, total phenols, proteins, total sugars, total free amino acids and defensive enzymes such as peroxidase, polyphenol oxidase and phenylalanine ammonia lyase on the leaves of amaranthus were estimated by adopting the methods suggested by Sadasivam (1996).

Results and Discussion

Screening of six amaranthus genotypes against leaf webbers revealed that maximum number (1.88 leaf Webbers / plant) was recorded in the susceptible genotype A 21 as against the minimum of 0.50 per plant in the least susceptible genotype A 81. Stem weevil damage was maximum in the susceptible genotype A 21 (32.50 %) as against the minimum (12.50%) damage in the least susceptible genotype A 81. Plant nutrition based biochemical parameters *viz.,* total sugars, reducing sugars, non-reducing sugars and proteins were minimum in the least susceptible genotype A 81 and maximum in the susceptible genotype A 21. Plant defensive compounds such as phenols, phenyl alanine ammonia lyase, peroxidase and polyphenol oxidase were maximum in the least susceptible genotype A 81 and minimum in the susceptible genotype A 21. The results were similar to Halder *et al.* (2006), who reported that susceptible cultivar LGG-450 had highest amount of total sugar, reducing sugar, non-reducing sugar, proteins as compared to resistant cultivar LGG-497 in mungbean, whereas, phenol was maximum in resistant cultivar LGG-497.

Table 1. Biochemical bases of resistance in amaranthus against leaf webber and stem weevil

Amaranthus genotypes	Leaf webbers / plant (No.)	Stem weevil damage (%)	Total sugars (mg/g)	Reducing sugars (mg/g)	Non reducing sugars (mg/g)	Total proteins (mg/g)	Total free amino acids (mg/g)	Total phenols (mg/g)	Phenyl Alanine Ammonia Lyase (changes in OD value /min/g of fresh leaf tissue)	Peroxidase (changes in OD value / min/g of fresh leaf tissue)	Polyphenol oxidase (changes in OD value / min/g of fresh leaf tissue)
A81	0.50[a]	12.50[a]	7.87[a]	3.50[a]	1.20[a]	7.46[b]	12.36[a]	11.25[a]	2.50[a]	1.80[a]	1.62[b]
A59	0.65[b]	16.25[b]	8.50[b]	3.78[b]	1.42[b]	7.20[a]	11.50[b]	9.20[c]	2.24[b]	1.50[b]	1.70[a]
A154	0.76[c]	21.25[d]	8.70[b]	4.24[c]	1.76[c]	7.86[c]	12.42[a]	9.75[b]	1.80[c]	1.12[c]	1.34[c]
A77	1.50[e]	26.25[e]	12.32[c]	7.50[e]	2.10[d]	9.37[d]	10.50[c]	6.80[e]	1.30[e]	0.80[e]	0.60[e]
A21	1.88[f]	32.50[f]	15.20[e]	8.27[f]	2.53[e]	12.80[f]	9.62[d]	5.46[f]	0.73[f]	0.38[f]	0.35[f]
CO1	1.06[d]	18.75[c]	12.85[d]	5.60[d]	1.75[c]	10.65[e]	10.38[c]	8.30[d]	1.50[d]	1.00[d]	0.84[d]
S. Ed	0.01	0.22	0.15	0.09	0.03	0.12	0.15	0.14	0.02	0.02	0.02
CD (P=0.05)	0.03	0.47	0.31	0.19	0.06	0.26	0.31	0.30	0.04	0.04	0.05

*All values are the mean of four replications

In a column, means sharing similar letter(s) is/are not significantly different by LSD at P=0.05

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ES03 BOPS 04

Impact of biochemical bases of resistance on tea mosquito bug population and dieback damage in neem

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Keywords: *Neem, tea mosquito bug, dieback, biochemical parameters, resistance*

Introduction

Azadirachtaindica (Meliaceae) is native to India, Pakistan, and Bangladesh and is valued for its medicinal use, pesticidal properties and timber value. The tea mosquito bug, *Helopeltis* bugs (Miridae:Heteroptera) the juice from meristematic plant tissues. Owing to the economic and ecological importance of the tree the control of the insect is of potent importance (Kumar and Gupta, 2002). Hence, the present investigation was focussed to study the impact of plant nutrition based biochemical parameters and plant defensive enzymes on tea mosquito bug- dieback damage in neem genotypes.

Materials and Methods

Nine genotypes of neem were selected to study the biophysical bases of resistance. All the nine entries were monitored at weekly intervals for the nymph and adult population of tea mosquito bug throughout the study period. In each genotype, bugs were counted on 15 cm terminal shoots on three randomly selected shoots per tree on five randomly selected trees and expressed as number of bugs per three shoots per tree. Level of damage caused by the TMB - dieback complex was assessed by visual scoring and expressed as per cent damage.

Biochemical factors *viz.* total sugars, non reducing sugars, reducing sugars, protein, total free amino acids, total phenol, phenyl alanine ammonia lyase, polyphenol oxidase and peroxidase were estimated in all the genotypes of neem by adopting the methods suggested by Sadasivam (1996). Both correlation and multiple linear regression analysis were carried out between plant nutrition based biochemical parameters and tea mosquito bug infestation and the damage in different genotypes of neem.

Results and Discussion

Plant nutrition based biochemical parameters *viz.,* total sugars, reducing sugars, non-reducing sugars and proteins were minimum in the resistant genotypesand maximum in the susceptible genotypes (Table 1). Total free amino acid content was recorded maximum in the resistant genotype TN-MTP-R1 and the lowest in TN-MTP-S3. Plant defensive compounds such as phenols, phenyl alanine ammonia lyase, peroxidase and polyphenol oxidase were maximum in the resistant genotypes and minimum in the susceptible genotypes. The results are in accordance with the findings of Haldhar*et al.* (2013) who observed similar inference in muskmelon.Alagar*et al.* (2007) also reported that the resistant and moderately resistant cultivars recorded higher activity of defensive enzymes in response to brown planthopper in rice.

Correlation analysis between total sugars, reducing sugars, non-reducing, proteins and TMB population revealed a significant positive correlation. Similarly, TMB-dieback damage was also positively correlated. Whereas, total free amino acids was negatively correlated. The results are in accordance with the findings of Halder*et al.* (2006) who reported that spotted pod borer, *Marucavitrata* in mungbean had significant positive correlation with the total sugars, reducing sugars, non reducing sugars and proteins with the maximum pod damage. Significant negative correlation existed between TMB population and total phenol, PAL, PPO and PO. Similarly, TMB-dieback damage also showed negative correlation. The results are in accordance with the findings of Soffan *et al.* (2014) who recorded significantly higher amount of PPO and PO in the resistant cultivar of faba bean, *Viciafaba*.

Table 1. Biochemical bases of resistance in neem against tea mosquito bug-dieback complex

Neem genotypes	Number of tea mosquito bugs per three shoots per tree	Damage (%)	Total sugars (mg/g)	Reducing sugars (mg/g)	Non reducing sugars (mg/g)	Total proteins (mg/g)	Total free amino acids (mg/g)	Total phenols (mg/g)	Phenyl Alanine Ammonia Lyase (changes in OD value / min/g of fresh leaf tissue)	Peroxidase (changes in OD value / min/g of fresh leaf tissue)	Polyphenol oxidase (changes in OD value / min/g of fresh leaf tissue)
TN-MTP-R1	0.00[a]	0.00[a]	7.49[b]	3.42[b]	1.10[a]	9.63[ab]	19.17[a]	11.67[a]	4.22[b]	3.74[a]	3.85[b]
TN-MTP-R2	0.00[a]	0.00[a]	6.72[a]	3.07[b]	1.38[a]	10.42[b]	17.23[b]	9.69[b]	5.20[a]	4.24[a]	4.75[a]
TN-MTP-R3	0.00[a]	0.00[a]	8.62[c]	2.18[a]	1.15[a]	9.08[a]	18.73[a]	12.00[a]	5.10[a]	3.95[a]	3.84[b]
TN-MTP-MS1	6.20[b]	75.00[b]	10.20[e]	6.20[de]	2.76[b]	17.64[d]	15.44[c]	7.22[c]	3.29[cd]	2.56[b]	1.42[d]
TN-MTP-MS2	7.60[c]	72.00[b]	10.13[e]	4.44[c]	2.64[b]	16.40[c]	17.23[b]	6.41[cd]	3.30[cd]	1.94[cd]	2.54[c]
TN-MTP-MS3	7.90[cd]	75.50[b]	9.42d[e]	5.75[d]	2.80[b]	18.29[d]	18.73[a]	6.07[d]	3.37[c]	2.52[b]	2.53[c]
TN-MTP-S1	8.20[d]	90.00[d]	11.76[f]	6.20[de]	3.72[c]	21.27[f]	14.34[d]	5.81[d]	2.70[e]	2.16[b]	1.24[d]
TN-MTP-S2	8.60[e]	85.00[c]	10.24[e]	7.45[f]	3.86[c]	19.71[e]	13.43[e]	6.02[d]	2.83[e]	1.48[cd]	1.51[d]
TN-MTP-S3	8.00[cde]	87.50[cd]	10.48[e]	6.62[e]	2.95[b]	20.03[e]	13.31[e]	6.33[cd]	2.43[e]	1.49[d]	1.24[d]
S. Ed	0.25	2.25	0.27	0.24	0.25	0.53	0.30	0.48	0.25	0.23	0.22
CD (P=0.05)	0.53	4.78	0.58	0.50	0.53	1.10	0.64	1.01	0.51	0.48	0.50

*Each value is the mean of three replications

In a column, means sharing similar letter(s) is/are not significantly different by LSD at P=0.05

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ES03 BOPS 05

Biochemical bases of corn resistance to foliage fall armyworm, *Spodoptera frugiperda* (J.E Smith) (Lepidoptera: Noctuidae)

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Key words: *Spodoptera frugiperda, Maize genotypes, Leaf injury rating, Protein content, Amino acid,*

Introduction

The fall army worm, *Spodoptera frugiperda* (J.E Smith) is an invasive polyphagous pest in India since 2018. It is emerging as the most destructive pest of maize. The biochemical factors can provide source of resistance and chemical stimuli that play a vital role in host plant selection by feeding and oviposition (Maxwell, 1982). FAW mainly attacks maize crop as a defoliator in early vegetative stage and on silk, tassel and kernel tissues in the reproductive phase (Rajisha *et al*., 2021). In the present study fifteen corn (*Zea mays*) genotypes were examined for fall armyworm resistance under field condition. Nutritional (total protein, amino acid, total carbohydrates, and reducing sugars) and biochemical (phenol, tannins, and peroxidase) properties in the seedlings of maize hybrids were examined to categorize resistance mechanisms to *S. frugiperda.*

Materials and Methods

Screening of maize hybrids under natural infestation was carried out at the research field of Tamil Nadu Agricultural University during Rabi 2019. The field experiment was laid out in a Randomized block design with three replications. Leaf injury rating was recorded as per damage scale given by Williams and Davis (1992). Later the hybrids were categorized into partially resistant, susceptible and highly susceptible. The biochemical traits were estimated by various standard methods *viz*., Reducing sugar (Nelson-Sumogyi method), total soluble protein (Bradford's method), Amino acid (colorimetric method), Total carbohydrate (Anthrone method), Tannin (Folin-ciocalteu method), and peroxidase (Method given by Ali et al., (2005)). The collected data were subjected to analysis of variance (ANOVA) (SPSS).

Results and Discussion

Among 15 hybrids evaluated, seven hybrids *viz*., CP808, S6668, Aadithya 929, Kaveri 3110, Kaveri super 244, Double somnat, Proline HP222 were categorized as partially resistant and eight hybrids namely Co 6, Co 8, CP 858, Green India Sakthi, Monsanto dekalb, Kaveri 25k55, PSC3322, Godaveri 989 were grouped as susceptible maize hybrids. None of the above hybrids were classified as either highly resistant or resistant categories. The data of protein, amino acid, reducing sugar and total carbohydrates revealed that partially resistant hybrids *viz*., CP808, S6668 and Kaveri3110 registered maximum amino acid ($F=71.65$, $P=<0.001$), while protein and reducing sugar were recorded maximum in susceptible hybrids *viz*., CP 858, CO 6, and Kaveri 25k55. There was no significant difference in total carbohydrate ($F= 1.94$, $P= 0.06$) content among maize hybrids. Total phenol ($F=2.70$, $P=0.01$) tannin ($F=19.11$, $P=<0.001$) and peroxidase activity ($F= 30.48$, $P=<0.001$) was higher in partially resistant hybrids *viz*., CP808, S6668 and Kaveri3110 (Table 1). It was observed that carbohydrates and protein were significantly and positively correlated with leaf damage. Phenol, tannins, and peroxidase were significantly and negatively correlated. Chen *et al*., (2009) reported that resistance mechanisms to *S. frugiperda* and the observed patterns of resistance were probably collective results of the Protein: carbohydrate ratio and defensive proteins.

Table 1. Biochemical traits of maize genotypes

Genotypes	Total proteins (mg/g)	Amino Acids (%)	Total carbohydrates (mg/g)	Total phenols (mg/g)	Tannin (%)	Peroxidase (moles/ min)	Reducing sugars (mg/g)
Co 6	11.20^{bc}	0.05^{ef}	16.14^{a}	54.00^{ab}	0.80^{e}	0.65^{cdef}	0.72^{bc}
Co 8	10.50^{abc}	0.07^{cd}	15.02^{a}	57.00^{ab}	1.10^{bc}	0.72^{bcd}	0.73^{c}
CP858	11.40^{c}	0.06^{de}	16.78^{a}	56.00^{ab}	1.00^{c}	0.70^{cde}	0.75^{cd}
CP808	9.67^{ab}	0.08^{b}	16.43^{a}	58.00^{a}	1.30^{a}	0.89^{a}	0.41^{a}
S6668	10.10^{abc}	0.09^{a}	15.24^{a}	59.00^{a}	1.20^{ab}	0.82^{ab}	0.49^{ab}
Aadithya929	10.25^{bc}	0.06^{de}	16.50^{a}	56.00^{ab}	0.98^{c}	0.76^{bc}	0.57^{b}
Green India sakthi	10.12^{abc}	0.05^{g}	17.23^{a}	53.00^{ab}	1.00^{c}	0.68^{cde}	0.74^{cd}
Monsanto dekalb	11.24^{bc}	0.04^{f}	16.50^{a}	53.00^{ab}	1.10^{bc}	0.67^{cde}	0.75^{cd}
Kaveri 25K55	11.00^{c}	0.05^{f}	17.24^{a}	54.00^{ab}	1.00^{c}	0.76^{bc}	0.81^{cde}
Kaveri3110	8.98^{a}	0.08^{b}	16.76^{a}	57.00^{ab}	1.00^{c}	0.89^{a}	0.56^{b}
Kaveri super244	9.50^{bc}	0.06^{de}	17.56^{a}	57.00^{ab}	1.00^{cd}	0.63^{defg}	0.61^{bc}
Double somnat	10.21^{abc}	0.07^{c}	16.32^{a}	54.00^{ab}	1.00^{c}	0.56^{fgh}	0.69^{c}
Proline HP222	10.20^{abc}	0.07^{c}	15.34^{a}	55.00^{ab}	0.97^{cd}	0.52^{h}	0.69^{c}
PSC3322	10.98^{bc}	0.04^{f}	16.10^{a}	52.00^{ab}	0.82^{de}	0.60^{efgh}	0.79^{de}
Godaveri989	10.32^{abc}	0.05^{f}	16.54^{a}	50.00^{b}	0.79^{e}	0.54^{gh}	0.78^{d}
F value	5.56	71.65	1.94	2.70	19.11	30.48	52.75
P value	<0.001	<0.001	0.06	0.01	<0.001	<0.001	<0.001

In column, means followed by common letters are not significantly different at ($P \leq 0.05$) by Tukey's honest significance difference test; N=10 plants from each hybrid

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ES03 BOPS 06

Assessment of leaf folder infestation in different rice landraces/varieties

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Keywords: *Rice IR 20, tillering stage, plant volatiles, air entrainment, GC-MS*

Introduction

Rice being an economically important crop is attacked by many insect pests that affects its production, among which rice leaffolders are also of main concern as it its reported to cause 63 to 80% yield loss and 11.8% in Tamil Nadu. Rice landraces with varied volatile profile are important for host plant resistance studies. Hence, in order to better manage the pest and to identify the best rice genotypes with pest resistance, 12 rice landraces and 4 rice varieties were selected in the present study to assess the leaffolder infestation.

Materials and methods

The study was carried out for two consecutive years (October 2018-March 2019) and October 2019- February 2020). A paddy field of 400m^2 was taken and the landraces/varieties were raised in a plot size of 25m^2 each. The crops were raised without intervention of any pesticide, the leaffolder damage was assessed at four stages by recording the number of leaf folder damaged leaves and the per cent leaffolder damage was calculated (Heinrichs *et al.*, 1995).

Results and Discussion

Maximum infestation of rice leaffolder was observed during the vegetative stage of the crop. The range of infestation was 0.74 to 36.67 percent at the early tillering stage of 1st year experiment and 1.88 to 26.11 percent at the 2nd year experiment (Table 1). The infestation percentage then gradually declined during the active tillering stage and booting stage.Similarly, the leaf folder infestation was highest in the landrace Aathira as that of TN-1 variety and lowest in the Mattaitriveni and Thavalakanan with mean infestation of 0.91 and 1.35 per cent.In agreement with the results of present study, susceptibility of TN-1 to leaf folder was also reported by Liu *et al.* (2017).

Table.1.Infestation of rice leaf folder in rice landraces/varieties

S.No.	Landraces/ Varieties	Early tillering		Active tillering		Booting		Panicle development	
		1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
1	Kallurundaikar	10.39^{a}	11.35	17.65	7.89	5.95^{ab}	1.47^{ab}	1.00^{ab}	2.98
2	Poonkar	1.67^{a}	7.97	3.38	2.65	0.00^{a}	0.21^{ab}	0.00^{a}	0.51
3	Thavalakanan	0.74^{a}	4.30	3.53	1.14	0.00^{a}	0.58^{a}	0.00^{a}	0.47
4	Kala Namak	5.45^{a}	7.88	4.98	4.29	0.00^{a}	0.56^{ab}	0.69^{ab}	1.03
5	IR 20	8.17^{a}	12.62	12.89	7.88	6.77^{ab}	0.73^{ab}	0.74^{ab}	0.91
6	Kuzhiadichan	3.33^{a}	5.98	6.42	1.78	1.74^{a}	0.60^{ab}	0.00^{a}	0.74
7	Norungan	8.10^{a}	13.90	10.79	5.41	4.22^{ab}	0.66^{bc}	1.00^{ab}	1.83
8	PTB 33	7.44^{a}	8.29	5.85	2.37	1.54^{a}	1.06^{ab}	0.00^{a}	1.83
9	Thuyamalli	5.25^{a}	5.22	7.92	1.51	6.41^{ab}	0.64^{ab}	0.00^{a}	0.84
10	TN1	17.00^{ab}	15.53	18.95	8.97	16.60^{b}	2.36^{ab}	4.00^{b}	4.53

11	Aathira	36.67[b]	26.11	24.78	8.97	17.57[b]	3.32[c]	4.95[b]	5.38
12	Varapukudaichan	2.11[a]	7.74	4.70	2.14	0.00[a]	0.63[ab]	0.00[a]	1.48
13	Sivapuchithiraikar	3.75[a]	5.23	5.69	4.02	0.00[a]	1.14[ab]	0.00[a]	0.65
14	Karuthakar	6.51[a]	4.90	9.66	3.18	2.15[a]	0.33[ab]	0.00[a]	0.44
15	CO 52	15.00[ab]	12.62	18.94	7.44	7.98[ab]	1.50[ab]	3.17[b]	3.26
16	Mattai Triveni	0.00[a]	1.88	2.31	1.05	0.00[a]	0.54[ab]	0.00[a]	1.54
	F value	1.768	1.246	1.550	1.360	2.353	2.183	2.182	2.053
	P value	0.040	0.462	0.114	0.172	0.009	0.008	0.016	0.043

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ES03 BOPS 07

Preference of cotton stem weevil, *Pempherulus affinis* on different stages of cotton

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Key words: *Cotton stem weevil, different crop stages, stage preference by cotton stem weevil, stem weevil damage*

Introduction

Cotton stem weevil is an important pest during early stage of the crop. Infestation of *P. affinis* starts in 12-15 days old seedlings as the stem portion is very soft and succulent for ovipositionand resulted in gall formation at later stages which led to plant mortality at early stage of the crop (Ayyar, 1918). The female is capable of laying upto 50 – 121 eggs (Jothi *et al*., 2011) and the egg - laying period was about 78 days (Ayyar and Maragabandhu, 1941). Considering the importance of this pest, the present study was undertaken to identify the stage of the crop for cotton stem weevil infestation to take management practices at right stage of the crop to prevent stem weevil infestation.

Materials and methods

Staggered pot culture of Co 17 was taken up at four different dates at weekly intervals. Four stages of crop ie 15days after sowing (DAS), 22 DAS, 29 DAS and 36 DAS was choosen for introduction of weevils and were replicated five times. Five pairs of male and female weevil were released at 15 days after last sowing and covered with mylar film cage. Observations were taken on number of infested plants at 15, 30, 45, 60, 75, 90 and 105 days after release (DAR) of adult weevil.

Results and Discussion

The preference of the cotton stem weevil on different stages of the crop is presented in Table 1. The overall mean revealed that the highest per cent infestation (63.57%) was found in 15 days old crop followed by 22 days old crop (53.57%). The other stages viz., 29 and 36 days old crop had minimum stem weevil damage of 43.57% and 38.57% respectively**.** The present study was in accordance with (Ayyar, 1918) who reported that the infestation of weevil was found in 12- 15 days old seedlings. The young succulent stem of early stage of the crop may be the reason for higher infestation in early stage of the crop and also it may favor the egg laying by adult weevil which can easily insert its ovipositor into the stem. Murugesan *et al*. (2010)reported that infestation by cotton stem weevil on staggered sown crop in field exhibited maximum infestation in one to two weeks old crop which supports our present findings.

Table 1. Preference of cotton stem weevil on different stages of the crop

Age of the crop	Per cent stem weevil infestation							Mean
	15 DAR	30 DAR	45 DAR	60 DAR	75 DAR	90 DAR	105 DAR	
15 days old	45.00 (41.98)[a]	60.00 (50.98)[a]	60.00 (50.98)[a]	70.00 (56.98)[a]	70.00 (56.98)[a]	70.00 (56.98)[a]	70.00 (56.98)[a]	63.57
22 days old	35.00 (35.98)[ab]	50.00 (44.98)[a]	50.00 (44.98)[ab]	60.00 (50.98)[ab]	60.00 (50.98)[ab]	60.00 (50.98)[ab]	60.00 (50.98)[ab]	53.57
29 days old	25.00 (29.98)[b]	35.00 (35.99)[b]	45.00 (41.98)[bc]	50.00 (44.98)[bc]	50.00 (44.98)[bc]	50.00 (44.98)[bc]	50.00 (44.98)[bc]	43.57
36 days old	25.00 (29.98)[b]	30.00 (32.98)[b]	35.00 (35.99)[c]	45.00 (41.98)[c]	45.00 (41.98)[c]	45.00 (41.98)[c]	45.00 (41.98)[c]	38.57
SE.d	3.354	4.242	4.242	3.968	3.968	3.968	3.968	
CD (P= 0.05)	7.110	8.994	8.994	8.413	8.413	8.413	8.413	

DAR- Days after release of weevil. Mean of five replications. Each replication is a mean of four observations. Figures in parentheses are arc sine transformed values. In columns, means followed by different letters are significantly different at 5 % level (Duncan's Multiple Range Test)

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ES03 BOPS 08

Correlation of morphological and biochemical factors responsible for jassid resistance in upland cotton hybrids (*Gossypium hirsutum* L.)

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Key words: *cotton, jassids, correlation, morphological, biochemical, hybrids.*

Introduction

Cotton (*Gossypium hirsutum* L) is a fibre crop widely cultivated in India. In early stages, sucking pests like aphids, thrips, jassids and whiteflies cause reduction in yield and quality of cotton. In the recent years, incidence of sucking pest, *Amrasca biguttula biguttula*, also called *Amrasca devastans* (Dist.), has become serious in India, Pakistan, and other South East Asian countries. In any Integrated Pest Management programme, a genetically resistant cultivar is the base over which other tactics are pyramided to have an effective pest management system. Identification and use of a resistant cultivar is of great relevance these days as it is eco- friendly and cost effective. Hence present investigation was undertaken to study biochemical and morphological factors responsible for jassid resistance in cotton.

Materials and methods

Field experimant was conducted in unprotected field condition during winter season of 2020 at Department of Cotton, CPBG, TNAU, Coimbatore. The experiment was conducted in a Randamized Block Design with ten cotton hybrids replicated twise. The hybrids*viz.,* CO 17 X RAHC 1039, TVH 002 x RAHC 1040, TCH 1894 x KC 2, RHC-H 1438 x KC 3, RHC-H 1438 x NDLH 32, GJHV 534x RAHC 1039, SHC 374 x KC 3, SHC 374 x RAHC 1039, CO 17 x KC 2and TCH 1894 x NDLH 32were grown under this field experiment. The data regarding for biochemicalparameters *viz*; gossypol, total phenols, crude protein and reducing sugar content were estimated from leaf at 120 days after sowing. Morphological characters like trichome density (no/cm2), Thickness of leaf midrib (mm), Thickness of leaf lamina (mm), leaf colour and leaf texture were also recorded.

Result and Discussion

Correlation of Jassid population with morphological and biochemical traits

Correlation studies from table 1 revealed that trichome density of cotton genotype had negative direct effect (-0.996) on jassid infestation. Thickness of leaf midrib has positive and direct effect (0.947) on jassid infestation. Thickness of leaf lamina, gossypol content and total phenols showed significant and negative correlation with jassid incidence. These results are confirmed by Ashfaq *et al* (2010) and Khan *et al* 2017. The peroxidase activity and polyphenol oxidase activity was higher in TVH 002 x RAHC 1040. Nitrogen and phosphorus content showed significant and positive correlation with jassid incidence. While potassium content indicated significant negative (-0.965) correlation with jassid incidence same result to be observed by (Kanher *et al,* 2016).In conclusion, the present studies showed those biochemical and morphological factors are considered to play major role in the resistance mechanism against Jassid. Highly susceptible entries are preferred for settling and feeding whereas varieties less preferred for settling are less preferred for oviposition too. This study would help in pest management of cotton by growing those cotton varieties showing minimum numbers of jassids.

Table 1.Correlations of different morphological and biochemical plant characters of cotton genotypes with jassid incidence.

Characters	Correlation with jassid infestation
Trichome density /cm2	-0.996**
Thickness of leaf midrib (mm)	0.947*
Thickness of leaf lamina (mm)	-0.973*
Gossypol content (mg/gm)	-0.974*
Total phenols (mg/gm)	-0.928**
Chlorophyll content	0.977*
Sugar content	0.938*
Protein content	-0.938*

* Significant at 5% ** Significant at 1%

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ES03 BOPS 09

Evaluation of brinjal entries against resistant to two spotted spider mite *Tetranychus urticae*

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Key words: *Leaf trichomes ,antixenosis, brinjal, host plant resistance, Tetranychus urticae*

Introduction

Brinjal, *Solanum melongena* L., one of the principal vegetable crops grown widely is severely infested by two spotted spider mite (TSSM), *Tetranychus urticae* Koch. The present study was undertaken to evaluate the antixenosis mechanisms of resistance with trichome density in brinjal entries against TSSM.

Materials and methods

Screening experiment was carried out against TSSM *Tetranychus urticae* (Koch) in a CRD design with two replications. This study consists of 40 brinjal entries. The mite population was assessed at 10 days interval on the top, middle and bottom leaves from 1cm^2 area. Trichome density from the leaf lamina, midrib and veins of all the brinjal entries were assessed by adopting the methodology suggested by Maite *et al*. (1980).

Results and Discussion

The maximum trichome density was recorded (719.15/0.5cm^2 leaf area) on Namakkal local and minimum (276.82/0.5cm^2 leaf area) on entry Tiruppur local (Table-1). Stellate type of trichomes were observed on all the brinjal entries. The correlation studies between the trichome density and *T. urticae* population revealed a significant negative correlation of brinjal entries screened (Table-2). Mahendrakumar, (2016) registered negative correlation between the trichome density and TSSM population. However Arka Nidhi was found to be resistant to mite population (2.07/cm^2 leaf area) with low trichome density (427.50µm)..

Table 1. Incidence of TSSM and estimation of trichome density in brinjal entries

Brinjal Entries	Mite population/ cm^2 leaf area Upper surface	Trichome density no / 0.5 cm^2 area of leaf *				Total number of trichomes/ 0.5 cm^2 area of leaf
		Lower surface	Mid rib	Veins		
Ariyalur local-1	7.42 (2.81)[ef]	152.17 (12.36)	261.32 (16.18)	184.50 (9.22)	63.00 (7.97)	560.98 (23.70)
Ariyalur local-2	16.22 (4.09)[jkl]	110.17 (10.52)	160.34 (12.68)	65.50 (8.12)	36.75 (6.10)	372.75 (19.32)
ArkaAnand	3.27 (1.94)[b]	210.00 (14.51)	304.82 (17.47)	93.25 (9.68)	72.00 (8.51)	680.07 (26.09)
ArkaHarshitha	7.28 (2.79)[def]	161.00 (12.71)	252.82 (15.92)	78.50 (8.89)	61.00 (7.84)	553.32 (23.53)
ArkaKeshav	6.82 (2.71)[cde]	151.00 (12.31))	251.50 (15.87)	73.00 (8.57)	64.50 (8.06)	540.00 (23.25)
Arka Nidhi	2.07 (1.60)[a]	140.00 (11.85)	190.00 (13.80)	48.00 (6.96)	49.50 (7.07)	427.50 (20.69)

Annamalai-1	17.9 (4.29)[m]	103.17 (10.18)	184.65 (13.61)	39.00 (6.28)	38.50 (6.24)	365.32 (19.13)
Bhavani local	6.55 (2.66)[cd]	160.17 (12.68)	280.17 (16.75)	84.92 (9.24)	62.75 (7.95)	588.00 (24.26)
CO-2	16.32 (4.10)[jkl]	111.50 (10.58)	164.00 (12.83)	70.50 (8.43)	42.75 (6.58)	388.75 (19.73)
Chinthapalli local-1	7.40 (2.81)[ef]	169.83 (13.05)	254.65 (15.97)	82.00 (9.08)	68.50 (8.31)	574.98 (23.99)
Chinthapalli local-2	2.25 (1.66)[a]	222.00 (14.92)	306.67 (17.53)	106.10(10.32)	69.00 (8.34)	703.77 (26.54)
Gottivada local	14.27 (3.84)[i]	111.17 (10.57)	160.17 (12.68)	65.25 (8.11)	40.75 (6.42)	377.33 (19.44)
Guntur local-1	15.47 (4.00)[j]	102.50 (10.15)	190.17 (13.81)	46.50 (6.86)	40.00 (6.36)	379.17 (19.49)
Guntur local-2	17.37 (4.23)[lm]	99.87 (10.02)	149.00 (12.23)	64.00 (8.03)	37.00 (6.12)	349.87 (18.72)
Haritha	7.48 (2.82)[ef]	150.00 (12.27)	247.50 (15.75)	91.25 (9.58)	61.50 (7.87)	550.25 (23.47)
Irapaduguda local	16.30 (4.10)[jkl]	92.83 (9.66)	142.00 (11.94)	56.75 (7.57)	36.75 (6.10)	328.33 (18.13)
Kovilpatti local	7.05 (2.75)[cdef]	147.67 (12.17)	244.33 (15.65)	82.75 (9.12)	59.75 (7.76)	534.50 (23.13)
Manapparai local	3.47 (1.99)[b]	194.83 (13.98)	308.17 (17.57)	104.75(10.26)	76.25 (8.76)	684.00 (26.16)
Madurai local	7.38 (2.81)[ef]	153.53 (12.41)	278.50 (16.70)	90.50 (9.54)	62.25 (7.92)	584.78 (24.19)
Mahy-91	15.52 (4.00)[j]	90.83 (9.56)	179.17 (13.40)	39.00 (6.28)	37.00 (6.12)	346.00 (18.61)
MDU-1	15.82 (4.04)[jk]	114.48 (10.72)	173.33 (13.18)	60.50 (7.81)	44.50 (6.71)	392.82 (19.83)
Musiri local-1	7.08 (2.75)[cdef]	157.5 (12.57)	246.17 (15.71)	78.50 (8.89)	61.00 (7.84)	543.17 (23.32)
Musiri local-2	7.15 (2.77)[cdef]	149.83 (12.26)	277.33 (16.67)	79.75 (8.96)	60.00 (7.78)	566.92 (23.82)
Musiri local-3	7.33 (2.8)[def]	154.83 (12.46)	252.34 (15.90)	84.50 (9.22)	64.75 (8.08)	556.42 (23.60)
Namakkal local	3.20 (1.92)[b]	227.82 (15.11)	307.83 (17.56)	106.75(10.36)	76.75 (8.79)	719.15 (26.83)
Palur-2	11.65 (3.49)[g]	120.00 (10.98)	210.17 (14.51)	72.00 (8.51)	47.75 (6.95)	449.92 (21.22)
Pusa purple long	11.48 (3.46)[g]	115.67 (10.78)	207.50 (14.42)	75.75 (8.73)	52.00 (7.25)	450.92 (21.25)
Swetha	7.72 (2.87)[f]	149.00 (12.23)	250.33 (15.84)	80.00 (8.97)	61.50 (7.87)	540.83 (23.27)
Sungro (No. 132)	18.10 (4.31)[m]	84.50 (9.22)	152.50 (12.37)	46.50 (6.86)	33.75 (5.85)	317.25 (17.83)
Simran	15.12 (3.95)[ij]	107.33 (10.38)	191.50 (13.86)	60.75 (7.83)	36.25 (6.06)	395.83 (19.91)
Surya	7.47 (2.82)[ef]	153.98 (12.43)	241.67 (15.56)	89.50 (9.49)	61.00 (7.84)	546.15 (23.38)
Telikecherla local	16.00 (4.06)[jk]	107.00 (10.37)	153.83 (12.42)	61.15 (7.85)	39.25 (6.30)	361.23 (19.02)

Tiruppur local	20.52 (4.58)[n]	85.50 (9.27)	123.32 (11.13)	36.25 (6.06)	31.75 (5.68)	276.82 (16.65)
Tuni local	6.45 (2.64)[c]	160.83 (12.70)	280.00 (16.75)	86.50 (9.33)	64.25 (8.05)	591.58 (24.33)
UGIE-4411	12.78 (3.64)[h]	121.50 (11.05)	223.83 (14.98)	76.50 (8.77)	50.00 (7.11)	471.83 (21.73)
Ujala	7.37 (2.81)[def]	161.67 (12.73)	249.68 (15.82)	81.75 (9.07)	60.50 (7.81)	553.60 (23.54)
Vijay (ARBH-905)	16.97(4.18)[klm]	109.83 (10.50)	174.50 (13.23)	56.75 (7.57)	35.75 (6.02)	376.83 (19.43)
VNR Kanchi	11.37 (3.45)[g]	126.50 (11.27)	222.83 (14.94)	77.75 (8.85)	47.75 (6.95)	474.83 (21.80)
VNR Kirti (ARBH-555)	7.03 (2.74)[cdef]	150.67 (12.29)	275.15 (16.60)	85.50 (9.27)	60.50 (7.81)	571.82 (23.92)
VNR Utkal	6.92 (2.72)[cdef]	157.00 (12.55)	254.50 (15.97)	79.75 (8.96)	60.25 (7.79)	551.50 (23.49)
SEd						0.3505
CD						0.7084

* Each value is the mean of two replications.

Figures in parentheses are square root transformed values.

Table 2. Correlation between trichome density and population of TSSM on brinjal entries

Correlation	Upper surface	Lower surface	Mid rib	Veins
T.urticae	-0.908*	-0.900*	-0.799*	-0.928*

* significant at 1% probability

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ES03 BOPS 10

Screening of okra accessions/ varieties against leafhopper, *Amrasca biguttula biguttula* (Ishida) (Hemiptera: Cicadellidae)

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Keywords: *Amrasca biguttula biguttula, Okra accessions/ varieties, Screening*

Introduction

Okra, *Abelmoschus esculentus* (L.) Moench is predominantly grown in many tropical and subtropical regions of the world and one of the important vegetables in India. Among the sucking insect pest infested in this crop, leafhopper (*A. biguttula biguttula*) is considered as the most destructive pest due to the conducive environmental conditions for pest attack and causing hopper burn symptom which resulting 55-60 per cent yield loss. The resistant okra accessions/ varieties act as an eco-friendly alternative management strategy for okra leafhopper.

Materials and Methods

Two field trials were conducted for screening of okra accessions/ varieties during 2019-2020 in the experimental farm, Department of Plant Protection, ADAC & RI, Tiruchirappalli for evaluation of 55 okra accessions along with two varieties as check entries (Arka Anamika, Co4) for their level of resistance to leafhopper. Observations on the number of leafhoppers at weekly intervals right from their appearance to last picking of fruits. Five plants were randomly selected, tagged in each test accession and three leaves *viz*., top, middle and bottom leaves from each plant were assessed early in the morning by visual counting. The characteristic symptom of hopper burn was used for adopting 1-4 Grade scale of Indian Central Cotton Committee, (1960) as given below

Grade scale	Symptoms
I	Entire foliage free from crinkling/curling with no yellowing, bronzing, browning and drying of leaves
II	Crinkling, curling of few leaves mostly in lower portion of plant, little yellowing of leaves
III	Crinkling, curling and yellowing of leaves almost all over the plant, plant growth noticeably hampered
IV	Extreme crinkling, curling, yellowing, bronzing and drying of leaves and progressive defoliation, plant growth remarkably stunted

The hopper burn index/ leafhopper resistance index (LHRI) with scoring based on damage scales calculated using the following formula (Rao, 1973; Prithiva *et al*., 2019)

$$\text{LHRI} = \frac{(G_1 \times P_1) + (G_2 \times P_2) + (G_3 \times P_3) + (G_4 \times P_4)}{P_1 + P_2 + P_3 + P_4}$$

Where, G - leafhopper injury grade, P - plant population under the grade for each category and Pi - total number of plants in Gi. The accessions were categorized using grade index value.

Results and Discussion

Among the 55 okra accessions screened, none of the accession was found completely free from the leafhopper infestation and significantly varied in their damage and number of leafhopper population. The minimum and maximum leafhopper population was recorded in the okra accession *viz*., IC 10265 (0.26 leafhoppers/3 leaves/ plant) and IC 45821 (7.00 leafhoppers/3 leaves/plant), respectively during kharif, 2019. The minimum population of 0.18 leafhoppers/3 leaves/plant was recorded in the okra accession *viz*., IC 10265, IC 45728 and maximum population of 6.86 leafhoppers/3 leaves/plant recorded in the okra accession, IC 45821 during rabi, 2019-2020. The results of both screening trials revealed that, the minimum leafhopper population was observed in modrately resistant okra accessions and ranged from 0.22-0.45. By adopting ICCC grades and based on resistance index, 30 okra accessions were graded as moderately resistant category with 1.1-2.0 leafhopper resistance index and 16 susceptible and nine highly susceptible accessions recorded with 1.1-2.0, 2.1-3.0 and 3.1-4.0 leafhopper resistance index, respectively (Table 1). Similarly, Sandhi *et al*. (2017) screened 15 okra genotypes based on the leafhopper population and injury index and categorized into resistant to highly susceptible genotypes.

Table 1. Category of okra accessions/ varieties for their reaction to *A. biguttula biguttula*

Okra Accessions/ Varieties	Grade index	Categories of Resistance
No accessions	0.1 - 1.0	Resistant
IC 24906-A, IC 27821-A, IC 27826-A, IC 29054-B, IC 29359, IC 43587, IC 43722, IC 45817, IC 45992-B, IC 45987, IC 90244, IC 03769, IC 03769-A, IC 04328, IC 12933, IC 29119-B, IC 29359-B, IC 42485-B, IC 42490, IC 43743, IC 45730 IC 18975, IC 31398-B, IC 42524, IC 42531, IC 10265, IC 12994, IC 42490-A, IC 45728, IC 45804	1.1 - 2.0	Moderately Resistant
IC 22232, IC 24903-A, IC 27877, IC 27878, IC 29136, IC 31850, IC 31850-A, IC 45815, IC 45955, IC 53399, IC 90242, IC 10256-B, IC 18960-C, IC 22237-C, IC 29168-H, IC 45813, CO4, Arka Anamika	2.1 - 3.0	Susceptible
IC 18973-A, IC 24909-A, IC 26375, IC 45895, IC 04284-A, IC 10533, IC 43746-D, IC 45814, IC 45821	3.1 - 4.0	Highly Susceptible

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ES03 BOPS 11

Mechanism of Resistance to Brown Planthopper, *Nilaparvata lugens* (Stal) in Selected Rice Entries

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Key words: *Antibiosis, molecular markers, Nilaparvata lugens, rice, resistance breeding.*

Introduction

Brown planthopper (BPH), *Nilaparvata lugens* (Stål) (Homoptera: Delphacidae) is one of the economically important pest. It is a typical phloem sap feeder that has emerged as the threat to rice production in Asia. Many conventional insecticides are recommended for manage this pest but they detrimentally affect the delicate balance between BPH and natural enemies in rice ecosystem.

Cultivation of resistant varieties is an environmentally safe strategy for management of this insect. Such varieties are minimizing the pesticide applications and for increase natural enemies population. Hence, breeding programme for development of BPH resistant varieties with different mode of host plant resistance is extremely important. Screening rice germplasm at global level and breeding BPH resistant rice varieties were initiated during 1970s, and several resistant varieties have been released for cultivation. Host plant resistant studies are valuable in resistance gene/QTL tagging and mapping (Ali and Chowdhury, 2014). So studies were conducted identify antibiosis and tolerance levels in selected rice entries.

Materials and Methods

The source BPH population was continuously reared under greenhouse conditions on 30-45 day-old TN1 rice plants as per the protocol of Heinrichs *et al* (1985). Six rice entries along with resistant and susceptible check varieties (Ptb33 and TN1) were used for experiments. All the test plants were raised in an insect-proof greenhouse. Antibiosis was measured in terms of Nymphal survival and development period, growth index, adult population (sex ratio), Feeding rate (Honeydew area), Population build-up and tolerance was measured interms of days to wilt.

Results and Discussion

N22-CC-DTM-893 showed higher antibiosis levels interms of nymphal survival, feeding rate, distorted sex ratio (female and male %) and population build-up as like

Table 1. Reaction of selected rice entries to *Nilaparvata lugens*

Rice entry	Damage score	NS (%)**	NDP*	GI*	Honeydew area*	Adult population**		Population build-up*	DW*
						Female (%)	Male (%)		
IR 71033-121-15	3.83	48.00 (43.78)	13.47 (3.80)	3.57 (2.13)	116.00 (10.64)	48.00 (43.83)	52.00 (46.13)	110.60 (10.54)	20.20 (4.59)
N22	6.96	74.00 (60.27)	10.59 (3.40)	7.00 (2.82)	123.60 (11.11)	78.25 (62.71)	21.75 (27.25)	145.60 (12.01)	14.40 (3.91)

N22-CC-TM-893	2.29	26.00 (30.54)	15.80 (4.10)	1.64 (1.62)	58.60 (7.68)	46.67 (43.03)	53.33 (46.93)	73.00 (8.56)	35.20 (6.01)
N22-MG-145	4.12	46.00 (42.62)	15.40 (4.05)	2.97 (1.98)	96.20 (9.84)	62.10 (52.00)	37.90 (37.96)	102.40 (10.04)	19.20 (4.47)
N22-MG-491	4.29	60.00 (50.85)	11.51 (3.54)	5.22 (2.49)	138.40 (11.62)	67.38 (55.23)	32.62 (34.73)	123.80 (11.12)	15.60 (4.06)
N22-MG-516	4.49	56.00 (48.72)	13.42 (3.80)	4.17 (2.26)	110.00 (10.44)	48.43 (43.96)	51.57 (46.01)	111.40 (10.57)	17.20 (4.25)
Ptb33 (Resistant check)	2.87	32.00 (34.28)	20.43 (4.63)	1.57 (1.60)	67.80 (8.26)	40.00 (35.99)	60.00 (53.99)	61.20 (7.84)	31.80 (5.72)
TN1 (Susceptible check)	9.00	84.00 (66.67)	10.29 (3.36)	8.17 (3.03)	296.00 (17.23)	83.33 (66.17)	16.67 (23.79)	240.40 (15.53)	11.00 (3.46)
SE(d)		4.99	0.06	0.13	0.90	6.09	6.10	0.74	0.23
C.D.		10.21	0.13	0.27	1.84	12.47	12.48	1.52	0.47

NS-Nymphal Survival; ND-Nymphal duration; GI-Growth index; DW-Days to wilt

* Figures in parentheses are square root transformed values

* * Figures in parentheses are arc sine transformed values

resistant check variety (Ptb33) but nymphal duration is low compared to Ptb33 (Table 1). According to Sarao and Bentur (2018) higher percentage of males were produced on the resistant genotypes than on the susceptible ones. In the present study N22-CC-DTM-893, IR 71033-121-15 and N22-MG-516 showed distorted sex ratio. The entry N22-CC-DTM-893 was taken more days for complete wilting of the plants as that Ptb33. N22-CC-DTM-145 and IR 71033-121-15 which were moderately resistant at seedling stage and showed better tolerance mechanism at advanced stage with lowerly antibiosis levels.

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ES03 BOPS 12

Assessment of Leaf Folder (*Cnaphalocrosis medinalis* Guenee) Damage in different varieties of Rice

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Key words: *Rice, leaf folder, Cnaphalocrosis medinalis, damage potential*

Introduction

Rice is the staple food of more than 60% of world population. The rice crop is subjected to attack by more than 100 insects, out of which about 20 species cause economic damage. Among the rice insect pests, leaf folder (*Cnaphalocrocis medinalis)* alone contributed to 50% yield loss under severe infestation in Tamil Nadu. Leaf folder caterpillars fold a rice leaf around themselves and attach the leaf margins together with silk strands. They feed inside the folded leaf creating longitudinal white and transparent streaks on the blade. The occurrence of leaf folder is due to heavy use of fertilizers. High humidity and shady areas of the field as well as the presence of grassy weeds in rice fields and surrounding borders favors the development of the pest.

Materials and Methods

Field observation and laboratory experiments were conducted at AC&RI Madurai to assess the leaf folder damage at in-vitro and in-vivo conditions based on feeding activity of leaf folder on rice crop. Nine rice varieties were used for field observation and laboratory analysis *viz.,* CR1009, ADT 45, ADT39, MDU 6, Pusa Basmathi, CO51, TKM 13, CORH 4 and TN 1. Twenty days old rice varieties were used to study the rice leaf folder damage. Among these TN 1 variety was used as control. Observation was done based on the folding and scrapping symptoms of leaf folder on the rice crop. In field, five plants from each varieties were randomly taken to assess the leaf folder damage symptom. In laboratory, two bits of known sized rice leaf with 5- 10 cm were kept on the petri dish. The collected larvae were released on the leaf bits. After 48 h the feeding activity of leaf folder on the leaf bits were observed. Observation were done based on the folding and scrapping symptoms on the leaf bits. The size of the scrapping symptoms were measured by using Graphical method.

Result and Discussion

The minimum percentage of leaf damage was seen in TKM 13 (3.88%) as it contains slender leaves (Banumathy *et al*., 2016) which was on par with scented variety Pusa basmathi (3.99%). This was followed by slender leaved CORH 4 (4.21%). The leaf damage was moderate in CO 51 (4.57%) might be because of high natural enemy load (Daniel *et al*., 2019) and it was on par with MDU 6 (4.62) and ADT 45 (4.76%) which was also in accordance with Sivaraman and Hari Prasad (2012). The damage in ADT 39 (5.04%) was high but it was significantly lesser than CR 1009 (5.69%). TN1 (7.27%) which was used as susceptible check was significantly differed from all other varieties with very high leaf folder damage as the leaves were broader than other varieties (Punithavalli *et al*., 2011)

Table 1. *C. medinalis* damage in nine rice varieties

S. No	Name of the variety	Leaf folder (% damage)							
		15 DAT	25 DAT	35 DAT	45 DAT	55 DAT	65 DAT	75 DAT	Mean
T_1	CO 51	1.21 (6.32)^{c}	3.82 (11.27)^{de}	5.23 (13.22)^{d}	4.21 (11.84)^{cd}	4.82 (12.68)^{b}	6.25 (14.48)^{b}	6.42 (14.68)^{b}	4.57 (12.34)^{c}
T_2	ADT 39	1.26 (6.45)^{d}	3.91 (11.41)^{ef}	5.81 (13.95)^{e}	4.86 (12.74)^{e}	5.23 (13.22)^{c}	7.01 (15.35)^{c}	7.21 (15.58)^{d}	5.04 (12.97)^{d}
T_3	CR 1009	1.67 (7.43)^{e}	4.10 (11.68)^{f}	7.25 (15.62)^{f}	5.31 (13.32)^{f}	5.89 (14.05)^{d}	7.73 (16.14)^{d}	7.89 (16.31)^{f}	5.69 (13.80)^{e}
T_4	MDU 6	1.10 (6.02)^{b}	3.67 (11.04)^{d}	5.1 (13.05)^{d}	4.4 (12.11)^{d}	4.9 (12.79)^{b}	6.45 (14.71)^{b}	6.69 (14.99)^{c}	4.62 (12.41)^{c}
T5	CORH 4	1.25 (6.42)^{cd}	2.89 (9.79)^{b}	4.22 (11.85)^{b}	3.26 (10.40)^{b}	4.78 (12.63)^{b}	6.39 (14.64)^{b}	6.65 (14.94)^{c}	4.21 (11.84)^{b}
T6	ADT 45	1.11 (6.05)^{b}	3.29 (10.45)^{c}	4.87 (12.75)^{c}	4.11 (11.70)^{c}	5.21 (13.19)^{c}	7.21 (15.58)^{c}	7.49 (15.88)^{b}	4.76 (12.60)^{c}
T7	TN 1	3.20 (10.31)^{f}	5.43 (13.48)^{g}	9.19 (17.65)^{g}	6.67 (14.97)^{g}	7.34 (15.72)^{e}	9.32 (17.78)^{e}	9.73 (18.18)^{g}	7.27 (15.64)^{f}
T8	TKM 13	1.03 (5.83)^{a}	2.91 (9.82)^{b}	4.07 (11.4)^{ab}	3.12 (10.17)^{ab}	4.19 (11.81)^{a}	5.89 (14.05)^{a}	5.98 (14.16)^{a}	3.88 (11.36)^{a}
T9	Pusa Basmathi	1.13 (6.10)^{b}	2.68 (9.42)^{a}	3.97 (11.49)^{a}	3.01 (9.99)^{a}	4.09 (11.67)^{a}	6.31 (14.55)^{c}	6.71 (15.01)^{c}	3.99 (11.52)^{a}
SEd		0.05	0.11	0.12	0.10	0.12	0.14	0.11	0.12
CD(0.05)		0.11	0.28	0.25	0.22	0.27	0.31	0.11	0.25

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ES03 BOPS 13

Comparative Biology of Whitefly, *Bemisia tabaci* Genn. on Okra Genotypes under Glasshouse Condition

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Key words: *Abelmascus esculentus, Bemisia tabaci, comaparative biology*

Introduction

The silver leaf whitefly, *Bemesia tabaci* Gennadius (Hemiptera: Aleyrodidae) is an important sucking pest of many crops in the world. It attacks more than 500 species of plants (Greathead,1986) from 63 plant families (Mound and Halsey, 1978). The whiteflies cause directly by sucking the plant sap or indirectly through transmission of plant viruses. *Okra* (*Abelmascus esculentus* (L.) Moench) is one of the vegetable crops largely affected by whitefly by both direct feeding and transmission of *bhendi yellow vein mosaic* virus disease, that reduce yield. The aim of the present study is to investigate the biology on selected okra genotypes for their influence on its development.

Materials and methods

Six *okra* genotypes (EC 305607, EC 359995, EC 306703, EC 014026, AE 65 and Arka Anamika) were grown in earthen pots and placed in a screen house to avoid any outside whitefly infestation. After 15 days, fully opened top leaf was selected and covered with a clip cage. From lab culture three pairs of gravid adults were transferred and retained for 24 hours. Then the cage and insects were removed, the leaf area was marked and carefully observed under 40X magnification for eggs. From the mass of stalked eggs, only 10 were retained and rest were brushed off. Development of eggs was carefully observed daily and developmental parameters were recorded. Such observations were also made on three plants as replications.

Results and Discussion

The egg period was invariably around 5 days in all genotypes. Nymphal period ranged from 15.45 to 20.4 days (Table.1). Fecundity ranged from 30.0 to 60.5 eggs per female in the genotypes. Longevity of females was longer than males. Females were alive for 5-10 days whereas males lived for 3-5 days only. The variation in developmental parameters among okra genotypes might be attributed to biophysical or biochemical characteristics of the genotypes involving both antixenosis and antibiosis. Earlier, Salas and Mendosa (1995) and Musa and Ren (2005) studied the biology on tomato and bean reported similar results.

Table 1. Development periods of immature stages of *Bemisia tabaci* in selected okra genotypes

Okra genotype	Egg period (days)	Nymphal period (days)-Instar				Total (in days)	Fecundity (Eggs/ female)	Adult longevity (in days)	
		I	II	III	IV			Male	Female
Arka Anamika	5.63± 0.22	5.50 ± 0.22^{b}	3.86 ± 0.19^{c}	5.66 ± 0.18^{b}	3.56 ± 0.17^{b}	18.58 ± 0.47^{b}	43.75 ± 2.30^{b}	4.0 ± 0.08^{c}	9.12 ± 0.10^{c}
EC 359995	5.40± 0.20	4.83 ± 0.23^{c}	3.23 ± 0.12^{e}	4.63 ± 0.14^{e}	2.76 ± 0.15^{d}	16.61 ± 0.47^{c}	60.5 ± 2.84^{c}	5.25 ± 0.08^{e}	10.81 ± 0.10^{d}
AE 65	5.77± 0.19	6.06 ± 0.21^{a}	4.26 ± 0.17^{b}	6.06 ± 0.21^{a}	4.03 ± 0.21^{a}	20.41 ± 0.48^{a}	26.5 ± 1.75^{a}	3.06 ± 0.10^{a}	5.31 ± 0.05^{a}
EC 014026	5.56± 0.25	5.23 ± 0.27^{b}	3.36 ± 0.17^{e}	4.96 ± 0.18^{d}	3.06 ± 0.17^{c}	15.45 ± 0.44^{c}	38.5 ± 1.48^{b}	3.43 ± 0.10^{b}	6.56 ± 0.10^{b}
EC 306703	5.47± 0.24	5.20 ± 0.18^{b}	3.63 ± 0.20^{d}	5.33 ± 0.19^{c}	3.33 ± 0.14^{b}	17.49 ± 0.44^{b}	54.5 ± 2.51^{c}	4.68 ± 0.05^{d}	10.81 ± 0.19^{d}
EC 305607	5.97± 0.19	5.56 ± 0.20^{b}	4.53 ± 0.17^{a}	6.16 ± 0.22^{a}	3.90 ± 0.21^{a}	20.15 ± 0.43^{a}	30 ± 1.46^{a}	3.25 ± 0.08^{ab}	5.43 ± 0.10^{a}
SEd	0.166	0.143	0.120	0.111	0.114	0.269	0.259	0.259	0.224
CD (P = 0.05)	0.365	0.314	0.265	0.244	0.251	0.557	0.547	0.547	0.474

Mean of three replications

Mean followed by the common letter(s) are not significantly different at 5% level by LSD

Values are Mean ±SD

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Theme

ES 04: Biorational and Organic Pest Management

ES 04 OPD 01

Eco-friendly Management of Two Spotted Spider Mite, *Tetranychus urticae* Koch on Carnation under Protected Cultivation

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Key words: *Two spotted spider mite, carnation, eco-friendly management, protected cultivation*

Introduction

Of the more than 1,200 species of spider mites described, two-spotted spider mite (TSSM) *Tetranychus urticae* Koch (Acari: Tetranychidae) is the most economically important phytophagous mite pest in the world (Adesanya *et al*., 2021). *T. urticae* infestation in carnation grown under poly house resulted in yellowing and bronzing of leaves, stunted growth and reduction in yield and quality of marketable flowers. Indiscriminate use of pesticides has led to development of resistance of *T. urticae* to acaricides, affected human health, destroyed natural enemies and caused environmental pollution. To avoid long term adverse effects of these chemicals, the determination of safer and more cost effective and eco-friendly alternative approaches for the management of this pest are desirable. One of the best available options to be exploited is the use of botanicals and acaropathogenic fungi. In this context, an experiment was laid out to develop eco-friendly management strategies for the management of *T. urticae* on carnation under protected cultivation.

Materials and methods

The field experiment was carried out at Kothagiri in carnation grown under polyhouse to evaluate the efficacy of acaricides, acaropathogenic fungi and plant products against two spotted mite *T. urticae* (Koch). The treatments include *viz*., T_1-azadirachtin 10000 ppm @ 2ml/lit, T_2-*Beauveria bassiana* formulation 3ml/lit, T_3-*Hirsutella thompsonii* formulation 3ml/lit, T_4-fenazaquin 10 EC @ 1.5 ml/ lit, T_5 -propargite 57 EC @ 2 ml/lit, T_{6-}azadirachtin 10000 ppm @ 2ml/lit + propargite 57 EC @ 2 ml/lit, T_{7-}azadirachtin 10000 ppm @ 2ml/lit + propargite 57 EC @ 2 ml/lit and T_8 untreated check. Two rounds of spray application were given at fortnightly interval. The experiment was conducted in RBD with three replications. The population of eggs, nymphs and adults of mites were assessed in the top, middle and bottom leaves of ten randomly selected plants at 0, 3, 7, 10 and 14 days interval after each spraying. Flower yield was recorded at each plucking.

Results and discussion

The results revealed that, after first round of spraying least mite population was 11.25 nos/leaf with 59.11 per cent reduction in plot sprayed with propargite @ 2ml/lit followed by fenazaquin @ 1.5ml/ lit (11.63 nos/leaf) with 57.71 per cent reduction in mite population. However, spraying of biopesticide, azadirachtin 10000 ppm @ 2ml/lit twice at 15 days interval resulted in 48.17 per cent reduction of mite population followed by acaropathogenic fungi, *B. bassiana* formulation @ 3ml/lit (32.28 %) and *H.thompsonii* formulation @ 3ml/lit (29.86 %) (Fig.1).

After second spraying least mite population of 10.84 nos/ leaf in plots treated with propargite @ 2ml/lit with 71.69 per cent reduction in mite population followed by fenazaquin @ 1.5ml/lit (11.45 nos/leaf) with 70.11 per cent reduction in mite population. However, spraying of biopesticide, azadirachtin 10000 ppm @ 2ml/lit twice at 15 days interval resulted in 60.4 per cent reduction in mite population followed by acaropathogenic fungi, *Beauveria bassiana* formulation @ 3ml/lit (46.63 %) and *H. thompsonii* formulation @ 3ml/lit (43.97 %) (Fig. 1).

Cumulative mean of first and second spray revealed that, least mite population of 11.05 nos/ leaf in plots treated with propargite @ 2ml/lit with 65.40 per cent reduction followed by fenazaquin @ 1.5ml/lit treated plots

(11.54 nos/leaf) with 63.91 per cent reduction in mite population. However, spraying of biopesticide, azadirachtin 10000 ppm @ 2ml/lit twice at 15 days interval resulted in 54.29 per cent reduction in mite population followed by acaropathogenic fungi, *B. bassiana* @ 3ml/lit (39.46 %) and *H. thompsonii* @ 3ml/lit (36.92 %). Carnation flower yield was the highest in propargite 57 EC @ 2ml/lit. (92333 no. of flowers/ 0.5 ac) followed by fenazaquin 10 EC @ 1.5ml/lit. (92166 no. of flowers/ 0.5 ac) and the benefit cost ratio was also found to be high in the above said treatments (Table. 1).

Cut flowers yield was the highest in propargite 57 EC @ 2ml/lit. sprayed plot (92333 no. of flowers/ 0.5 ac) followed by fenazaquin 10 EC @ 1.5ml/lit. sprayed plot (92166 no. of flowers/ 0.5 ac) and the benefit cost ratio was also found to be high in the above said treatments (Table 1). Propargite 57 EC recorded significantly highest mite reduction over all other treatments (Sandeepa *et al*., 2017).

Table 1. Yield and economics in mite management trial

Treatments	Yield -No. of flowers/ m^2	Yield -No. of flowers / 0.5ac	BC ratio	Increase in yield (%)
Azadirachtin 10000 ppm @ 2ml/lit.	85.67	85667	4.20	16.03
Beauveria bassiana formulation @ 3ml/lit.	82.17	82167	4.19	11.29
Hirsutella thompsonii formulation @ 3ml/lit.	81.50	81500	4.15	10.38
Fenazaquin 10 EC @ 1.5ml/lit.	92.17	92167	4.53	24.83
Propargite 57 EC @ 2ml/lit.	92.33	92333	4.64	25.06
Azadirachtin 10000 ppm @ 2ml/lit + Fenazaquin 10 EC @ 1.5ml/lit.	89.50	89500	4.43	21.22
Azadirachtin 10000 ppm @ 2ml/lit +Propargite 57 EC @ 2ml/lit.	90.50	90500	4.53	22.57
Control	73.83	73833	3.99	-
SE (d)	-	3282.34	-	-
CD (P=0.05)	-	7070.70	-	-

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ES 04 OPD 02

Studies on the Effect of Eco-friendly Pesticides for the Management of Leaf folder *Cnaphalocrocis medinalis* (Guenee) in Organic Rice

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Key words: *Organic Rice, Pest management, Eco-friendly pesticides*

Introduction

Rice is the staple food crop for more than half of the world's population though it is cultivated in only 11% of the world's cultivable land. Several pests attack rice in different ways at different stages. Among the insect pests, rice leaf folder alone causes up to 80% yield loss (Rajendran *et al.,* 1986). Increased reliance on pesticides for pest control is found to be unsustainable and cost-ineffective. So, Ecofriendly pesticides were evaluated for the management leaf folder in rice.

Materials and Methods

Field experiments were conducted continuously for two years during *Rabi* 2015-16 and 2016-17 in wetland paddy fields, Tamil Nadu Agricultural University, Coimbatore. The experiment with eight treatments was laid out in RBD with three replications. Extent of infestation by leaf folder in pre and post treatments was recorded in five randomly selected hills after counting the number of leaves having more than $^1/_3$ damaged leaf area (DL %). The DL (%) was calculated following the formula:

$$\text{Per cent damage} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves}} \times 100$$

Results and Discussion

The overall leaf folder damage of the experimental field was more (5.63-12.17%) during the first year (2015-16) compared to second year (2016-17) where the damage level was in the range of 4.64-7.35 per cent. In first year, the pre-treatment damage per cent ranged from 5.63 to 5.80. Whereas, in post treatment count at 7 DAS, the per cent leaf damage was minimum (2.54) in Spinosad 45 SC application which was on par with 2% *Beauveris bassiana* (2.92) and 5% NSKE application (2.97). Whereas at 14 DAS, the chemical Spinosad 45 SC was on par with 2% *B. bassiana* (2.07%), 5% NSKE (2.12%) and Neem oil 1% + Pungam oil 1% application (2.28%).

In second year, the pre-treatment damage per cent was in the range of 5.27-5.63. Whereas, in post treatment count at 7 DAS, application of Spinosad 45SC @ 125 ml/ha recorded the lowest damage (2.24%) which was at par with *B. bassiana* applied treatment (2.78%). The next best treatment was 5% NSKE spray (3.01%) which was on par with % neem oil + 1% pungam oil application (3.23%) and neem oil alone (3.51%). At 14 DAS, also the Spinosad 45 SC recorded the lowest damage per cent of (1.56) which was at par with *B. bassiana* (1.89), 5% NSKE (2.32%) and 1% each of neem and pungam oil application (2.69%). The per cent reduction over control (PROC) was more during first year compared second year. In both the years the PROC was more for Spinosad which was 86.11 and 84.07% respectively, for first and second year. Among the botanicals the PROC was better in *B. bassiana* applied treatments and this might be due to the prevalence of favourable weather conditions for better performance of entomopathogenic fungus during winter (*Rabi*) season. These findings are similar to those of Shakir *et al.* (2015).

Table 1. Effect of eco-friendly pesticides on *Cnaphalocrocis medinalis* in organic rice

Treatment	Leaf folder damage percentage											
	First year				Second year				Mean of 2 years			
	PT	7 DAT	14 DAT	PROC	PT	7 DAT	14 DAT	PROC	PT	7 DAT	14 DAT	PROC
T_1-Neem oil @ 2%	5.63 (2.53)	3.18 (1.61)	2.53 (1.25)	79.21	4.91 (2.21)	3.84 (1.95)	3.63 (1.89)	50.61	5.27 (2.37)	3.51 (1.78)	3.08 (1.57)	68.44
T_2-Pungam oil @ 2%	6.05 (2.56)	3.37 (1.56)	3.52 (1.59)	71.08	5.20 (2.28)	4.57 (2.11)	4.86 (2.19)	33.88	5.63 (2.42)	3.97 (1.84)	4.19 (1.89)	57.07
T_3-Neem oil @ 1% + Pungam oil 1%	5.90 (2.68)	3.13 (1.70)	2.28 (1.34)	81.27	4.82 (2.19)	3.33 (1.81)	2.90 (1.70)	60.54	5.36 (2.44)	3.23 (1.76)	2.59 (1.52)	73.46
T_4-NSKE @ 5%	5.66 (2.61)	2.97 (1.68)	2.12 (1.31)	82.58	4.64 (2.14)	3.05 (1.73)	2.52 (1.56)	65.71	5.15 (2.38)	3.01 (1.71)	2.32 (1.44)	76.23
T_5-Sweet flag 10% D @ 25kg/ha.	5.92 (2.56)	4.33 (1.78)	3.48 (1.44)	71.41	5.31 (2.30)	4.92 (2.01)	4.25 (1.71)	42.18	5.62 (2.43)	4.63 (1.90)	3.87 (1.60)	56.80
T_6-*Beauveria bassiana* @ 2%	5.96 (2.67)	2.92 (1.78)	2.07 (1.57)	82.99	4.92 (2.21)	2.64 (1.61)	1.71 (1.30)	76.73	5.44 (2.44)	2.78 (1.70)	1.89 (1.44)	80.64
T_7-Spinosad 45% SC @ 125ml / ha.	6.08 (2.71)	2.54 (1.79)	1.69 (1.39)	86.11	5.02 (2.24)	1.94 (1.37)	1.42 (1.17)	80.68	5.55 (2.48)	2.24 (1.58)	1.56 (1.28)	84.07
T_8-Untreated check	5.80 (2.55)	7.72 (3.01)	12.17 (4.45)	-	5.15 (2.26)	6.48 (2.53)	7.35 (2.69)	-	5.48 (2.41)	7.10 (2.77)	9.76 (3.57)	-
S Ed	-	0.22	0.52	-	-	0.41	0.64	-	-	0.32	0.61	-
CD (0.05)	-	*0.48*	0.72	-	-	0.88	1.37	-	-	0.68	1.31	-

PT - Pre-treatment; PROC- Per cent Reduction over Control; Figures in parenthesis are square root transformed values.

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ES 04 OPD 03

Efficacy of Insecticides and Botanical Spray Modules in Rice against Major Insect-pests for Sustainable Crop Production

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Keywords: *Oryza sativa, botanicals, neem, Eucalyptus*

Introduction

Rice (*Oryza sativa* L.), is the staple food for more than half of the world population and an important target to secure food security and livelihoods for millions of people. Rice production in India is constrained by a large number of biotic, abiotic and socio-economic constraints and the insect -pests being the major factors cause economic losses to the tune of 10-25 per cent. About 100 insect species are known to attack the rice crop from nursery to maturity and 20 of them are consistently reported as major pests of economic importance (Rahaman, and Stout, 2019). Use of plant extracts or botanicals is one of the earliest and traditional practices in control of insect- pests of crops. Integration of botanicals in rice IPM will reduce pesticide load in environment, prevent insecticide resistance and help in conserving natural enemy populations. Hence, it was felt necessary to test combination of insecticide and botanical modules against major insect-pests of rice in order to identify the effective combination and strategically integrate use of botanicals for ideal rice IPM.

Materials and methods

An experiment consisting of various treatments having combinations of effective and commercially available oils with recommended insecticides was conducted during *kharif,* 2020 at CCS Haryana Agricultural University, Rice Research Station, Kaul. Four combination modules consisting of three insecticides- Chlorantraniliprole 20% SC, Cartap hydrochloride 50% SC and Triflumezopyrim 10% SC, one commercial *neem* formulation - *Neemazal* and two oils - *Neem* and *Eucalyptus* oil were compared along with untreated control (only water spray). There were five treatments replicated four times and laid out in Randomized Complete Block Design (RCBD). Spray applications of the treatments were done based on pest incidence exceeding the economic threshold level guidelines at 10-15 day interval. All the treatments were applied as high-volume sprays @ 500 litres of spray fluid/ha. Standard observation procedures were followed to record insect-pest incidence at regular intervals throughout the crop growth period. Population of different insect pests was recorded on ten randomly selected hills. Plant hoppers population was recorded at one day before and 3 days after each application. Population of leaf folder was recorded one day before and 7 days after each application. White ears at the time of harvest were recorded. Data on natural enemies, phyto-toxicity and grain yield were also recorded.

Results and Discussion

The results indicate that based on the performance of the various treatment combinations, all insecticides module was found to be superior in reducing different insect-pests damage compared to other insecticide-botanical modules and was the most effective treatment at both vegetative and reproductive phases. Insecticide and botanical combination treatments were found moderately effective in reducing insect-pests damage. There was significant difference in natural enemy (mirid bug and spider) populations among treatments. Among various treatments, all insecticidal treatment recorded highest yield of 73.20q/ha followed by treatment with applications of *neemazal, neem oil* and triflumezopyrim showing yield of 69.90 q/ha. No phyto-toxicity was observed in any of treatment. Similar findings by Chakraborti, (2003) confirmed that in rice, integrated treatments with *neem* components plus one or two synthetic chemical applications were found very effective in controlling the pest populations build up as compared to chemical control. It is concluded that there is scope to utilize the plant products and potential use in the insect-pest management in rice.

Table 1. Insect-pests incidence in different treatments in insecticides-botanicals during *kharif,* 2020

Treatment		Stem borer damage (% white ears)	Leaf folder damage (%)	Brown plant hopper (No./10 hills)	White backed plant hopper (No./10 hills)	Mirid bugs (no./ 10hills)	Spiders (no./10 hills)	Yield (q/ ha)
T1	Botanicals-insecticides	3.4[b]	4.9[b]	14.5[b]	12.5[b]	7.2[ab]	6.0[a]	69.40[b]
T2	Botanicals-Insecticides	3.3[b]	4.5[b]	12.0[bc]	8.7[c]	6.2[ab]	4.7[bc]	69.90[b]
T3	All botanicals	3.3[b]	4.8[b]	15.0[b]	13.0[b]	6.7[ab]	5.7[ab]	69.30[b]
T4	All insecticides	2.8[c]	2.0[c]	9.5[c]	7.7[c]	5.5[b]	4.2[c]	73.20[a]
T5	Untreated control	7.5[a]	8.4[a]	43.2[a]	29.2[a]	7.5[a]	6.7[a]	61.90[c]

Values within the same column followed by the same letter(s) are not significantly different at (P≤0.05) according to Duncan's Multiple Range Test.

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ES 04 OPS 01

Comparison of volatile profiles of rice landrace Varappu kudaichan and variety IR 20

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Keywords: *Rice landrace, volatile organic compounds, air entrainment, GC-MS*

Introduction

Rice is an economically important food crop feeding more than half of the global population. However, extensive cultivation for more than thousand years and intensive breeding of researchers created a major shift in the farmers cultivation preferences from wild rice and landraces to modern rice varieties. Though these are good on one hand, it has led to the decrease or disappearance of certain resistant traits that the traditional landraces possessed. Since plant volatile profile play an important role in insect communication by the attraction of natural enemies (Reuolin *et al*., 2021), comparison of headspace volatiles was made between rice landrace and variety. The results obtained will help to better understand the differential attraction of insect pests between them.

Materials and methods

The plant volatile collection was done using the air entrainment method (Birkett *et al*., 2004). The volatile collection system consists of a cylindrical glass tube with two raised ports at the top. Pure and humidified air was passed through one port and the volatiles were collected using the super Q porapak adsorbent trap placed at the other port. Headspace volatiles were collected for 24 hours and were eluted with 700 µl of hexane. Volatile compounds were then characterised using Gas Chromatography coupled Mass spectrometry (GC-MS) and identified using mass spectrum comparison with NIST library.

Results and Discussion

The volatile profile characterisation between the rice variety IR 20 and landrace Varappu kudaichan revealed significant differences between them except seven common compounds (Table 1). Remaining volatile compounds were uniquely present in either of them. Among the volatile compounds identified most of the compounds belonged to acid group and notably rice varieties were observed to release higher amount of acid compounds compared to the landraces (Fig.1). This was also similar to the reports of Ashokkumar *et al.* (2020). Certain chemical group compounds like esters and amides were predominant in the modern rice variety while terpene compounds were released only in the landrace Varappu kudaichan. Since, terpene compounds give protection to the plants against harmful insect pests (Dudareva *et al.*, 2013), it might be the reason for the increased resistance of rice landraces to insect pests compared to the modern cultivated varieties.

Table 1. Volatile compounds identified in IR 20 and Varappu kudaichan

Name	Total	Elements
IR 20 and Varappu kudaichan	7	Dodecanoic acid, Eicosanoic acid, Propanoic acid, 2-(3-acetoxy-4,4,14-trimethylandrost-8-en-17-yl)-, Tetradecanoic acid, Pentadecanoic acid, n-Hexadecanoic acid, 17-Pentatriacontene.
IR 20	24	Oxalic acid, cyclohexyl nonyl ester, Hexadecanamide, 1-Hexadecanol, 2-methyl-, 7,9-Di-tert-butyl-1-oxaspiro(4,5)deca-6,9-diene-2,8-dione, Octadecanoic acid, 2-hydroxy-1,3-propanediyl ester, Heptadecanoic acid, Hexadecanoic acid, methyl ester, 9-Octadecenoic acid (Z)-, hexadecyl ester, 4-Octadecenal, 2,2'-(Ethane-1,2-lbis(oxy))bis(ethane-2,1-diyl)dibenzoate Z-(13,14-Epoxy) tetradec-11-en-1-ol acetate, Tetratetracontane, Cyclopentadecanone, 2-hydroxy, 9-Octadecenamide, (Z), Heptadecane, 9-hexyl, cis-13-Eicosenoic acid, Hexadecenoic acid, Z-11, 1-Eicosanol, 4-Methyloctanoic acid, Docosanoic acid, 1,2,3-propanetriyl ester, n-Nonadecanol-1, 13-Heptadecyn-1-ol, 9-Octadecenoic acid, (E)-, Hexadecanoic acid, (2-phenyl-1,3-dioxolan-4-yl) methyl ester, cis.
Varappu kudaichan	14	1-Heptatriacotanol, 17-Octadecynoic acid, 2-Hexen-1-ol, Squalene, Stigmasterol, 26-Nor-5-cholesten-3á-ol-25-one, Dimethoxylycopene, 2,2,4-Trimethyl-3-(-3,8,12,16-tetramethyl-heptadeca-3,7,11,15-tetraenyl)-cyclohexanol, Octadecanoic acid, Decane, 2-Myristynoyl pantetheine, Octadecane,3-ethyl-5-(2-ethylbutyl), Octadecanal 2-bromo, 16-Hydroxyhexadecanoic acid.

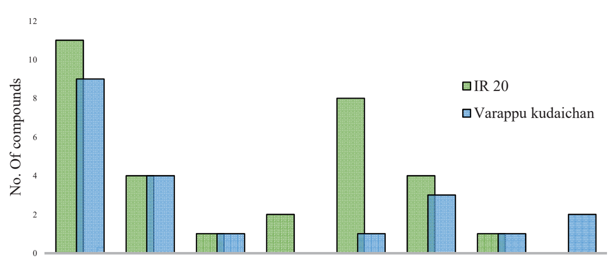

Fig.1. Comparison of volatile profile between IR 20 and Varappu kudaichan

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ES 04 OPS 02

Development of nano-emulsion of marine macro algal extracts, azadirachtin and β-asarone mixtures and its efficacy against a cosmopolitan pest, *Spodoptera litura* Fabricius.

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Keywords: *Nano-emulsion, macro algae, azadirachtin, β-asarone, Spodoptera litura, Insecticidal action.*

Introduction

The indiscriminate use of synthetic pesticides causes hazards to the environment and poses serious ill effects to humans. Of several alternate options, macroscopic marine algae, one of the important living resources of ocean showed promising pesticidal properties. Also, the active principles *viz.,* azadirachtin and β-asarone from *Azadirachta indica* and *Acorus calamus* respectively, possess various biological activities including anti-feedant, larvicidal, insecticidal, insect growth regulatory, nematicidal, antimicrobial, *etc.,* that offer novel approaches in Integrated Pest Management. The objective of the present study was to study the combination toxicity of azadirachtin, β-asarone and macro algal extracts in nano emulsion against *Spodoptera litura* (Fab.) (Noctuidae: Lepidoptera) under laboratory condition.

Materials and Methods

Preparation of Nano-emulsion The emulsion was prepared using the extracts of red macro algae (Rhodophyta), *Amphiroa fragilissima,* and brown macro algae (Phaeophyceae) *Sargassum weightii* with active principles: azadirachtin, β-asarone and a non-ionic surfactant (Tween 80) with Hydrophile-Lipophile Balance (HLB) value 15. The emulsion was developed at 1:1 ratio (v/v) of oil and surfactant. The prepared micro-scale emulsion was subjected to sonication using Ultra high frequency sonicator, 20 kHz and power output of 1500 W for 10 minutes. The particle size was measured using a practical size analyzer.

Bioassay The prepared solutions at various concentrations (Table 1) were sprayed on castor leaf discs of 4 cm diameter and shade dried (dry film technique). Ten treated leaf discs were kept in each Petri plate and ten second instar of *S. litura* pre starved for 4 hours were allowed to feed and an untreated control was maintained. Data on the anti-feedant affect and toxicity (mortality) of larvae were recorded every 24, 48 and 72 hours.

Results and Discussion

The anti-feedant and mortality of *S. litura* were observed from 24 to 72 hours after treatment with the developed nano-emulsion concentration varying from 50 to 1000 ppm. The anti-feedent action gradually increased with increase in the concentration, *i.e*., 23.76 per cent to 96.4 per cent. The larval mortality was initiated from 24 HAT and lasts up to 72 HAT. At the end of 72 hours, the maximum mortality due to anti-feedant action (94.4%) at 800 ppm and the lowest mortality (16.67%) was observed at 50ppm (Table 1). The lethal concentration (LC_{50}) for 72 hours exposure period was 256ppm (Table 2).

Tab 1: Anti-feedant and toxicity of nano-emulsion of macro algae, azadirachtin and β-asarone mixtures against *Spodoptera litura*

Dose (ppm)	Anti-feedant (%)	Mortality (%)			Percent reduction over control
		24 HAT	48 HAT	72 HAT	
1000	96.40	30.00 (1.73)[a]	70.00 (2.64)[a]	90.00 (2.99)[a]	94.44
900	91.60	30.00 (1.73)[a]	70.00 (2.64)[a]	90.00 (2.99)[a]	94.44
800	89.39	20.00 (8.00)[b]	60.00 (2.44)[a]	90.00 (2.99)[a]	94.44
700	90.60	10.00 (1.39)[c]	40.00 (1.98)[b]	80.00 (2.82)[ab]	83.33
600	77.80	5.00 (0.70)[d]	40.00 (1.98)[b]	80.00 (2.82)[ab]	83.33
500	76.36	5.00 (0.70)[d]	40.00 (1.98)[b]	80.00 (2.82)[ab]	83.33
400	73.25	5.00 (0.70)[d]	30.00 (1.732)[b]	60.00 (2.44)[b]	61.11
300	46.58	5.00 (0.70)[d]	30.00 (1.715)[b]	60.00 (2.44)[b]	61.11
200	48.14	5.00 (0.70)[d]	10.00 (1.04)[c]	40.00 (1.98)[c]	38.89
100	36.61	5.00 (0.70)[d]	5.00 (0.70)[c]	20.00 (1.38)[d]	16.67
50	23.76	5.00 (0.70)[d]	5.00 (0.70)[c]	20.00 (1.38)[d]	16.67
Control	5.63	5.00 (0.70)[d]	5.00 (0.70)[c]	5.00 (0.70)[e]	0.00
SEd	-	0.15	0.15	0.18	-
CD (0.05)	-	0.32	0.33	0.39	-

Tab 2. Median lethal concentration (LC_{50}) of nano-emulsion

Hours after treatment	χ2 Value	Regression equation	LC_{50}	Fiducial limits	
				Lower	Higher
72	4.22	y = 2.157x - 0.206	256.64 ppm	214.57	306.96

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ES 04 OPS 03

Evaluation of Biointensive Pest Management Modules against major insect pests of Ash gourd, *Benincasa hispida* Thunb.

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Keywords: *Ash gourd, insect pests, BIPM, BCR*

Introduction

Ash gourd, *Benincasa hispida* Thunb is one of the most important vegetable crops, being cultivated throughout the humid tropical and sub tropical regions. In India, the production of ash gourd is hampered by many insect pests and non-insect pests. Since the ash gourd is consumed for its medicinal properties, avoiding the usage of chemical pesticides and adopting integrated management practices assumes significance. Hence the present study was undertaken to study the efficacy of different biointensive pest management modules against major pests of ash gourd.

Materials and Methods

Field experiment was carried out during June-August 2019 in farmer's holdings at Kaliyavur of Thoothukudi district, Tamil Nadu to study the efficacy of following BIPM modules in comparison with untreated check and farmer's practice against major pests of ash gourd.

Module I	Application of Poultry manure @ 5.0 t/ha - Installation of sticky traps (white colour-25/ha and yellow colour–25/ha)-Azadirachtin 3000 ppm @ 2 ml/lit- Imidacloprid17.8 SL@ 0.2 ml/lit – Chlorantraniliprole 18.5 SC @ 0.3 ml/lit
Module II	Application of Poultry manure @ 5.0 t/ha - Installation of sticky traps (white colour-25/ha and yellow colour–25/ha)-Azadirachtin 3000 ppm @ 2 ml/lit - Thiamethoxam 25 WG@ 0.2 g/lit – Flubendiamide 480 SC @ 0.1 ml/lit
Module III	Application of FYM @ 12.5 t/ha - Installation of sticky traps (white colour-25/ha and yellow colour–25/ha)-Azadirachtin 3000 ppm @ 2 ml/lit Imidacloprid17.8 SL@ 0.2 ml/lit – Chlorantraniliprole 18.5 SC @ 0.3 ml/lit
Module IV	Application of FYM @ 12.5 t/ha - Installation of sticky traps (white colour-25/ha and yellow colour–25/ha)-Azadirachtin 3000 ppm @ 2 ml/lit - Thiamethoxam 25 WG@ 0.2 g/lit – Flubendiamide 480 SC @ 0.1 ml/lit
Farmer's practice	Application of Dimethoate 30 EC @ 2 ml/lit - Application of Chlorpyriphos 20 EC @ 2 ml/lit - Application of Profenophos 50 EC @ 2 ml/lit

The recommended doses of organic amendments were applied during last ploughing and ridges and furrows (2 m×60 cm) were formed. Sticky traps were installed (1 foot above the canopy) and insecticidal treatments were imposed when the insect pest population reached the economic threshold. The incidence of insect pests is expressed as number of insects per five plants and leaf damage by *Liriomyza trifolii* is expressed as per cent leaf damage per five plants. Observations were recorded on cost of cultivation including plant protection measures and benefit cost ratio (BCR) was worked out for each BIPM module following standard protocols.

Results and discussion

The field experiment revealed that BIPM module comprising of application of Poultry manure @ 5.0 t/ha - Installation of sticky traps (white colour - 25 Nos/ha and yellow colour - 25 Nos/ha) -Spraying of azadirachtin 3000 ppm @ 2 ml/lit - Spraying of imidacloprid 17.8 SL @ 0.2 ml/lit - Spraying of chlorantraniliprole 18.5 SC @ 0.3 ml/lit recorded low pest population and highest yield (41.75 t/ha), net income (₹ 167100/ha) and benefit cost ratio (1:2.84). Farmer's practice recorded higher BCR than module III and IV, however the yield, gross income, net income were higher in those modules. The untreated check recorded low yield (23.85 t/ha) and BCR (1:2.39) (Table 1).The higher benefit cost ratio in Farmer's practice may be due to the low cost of chemical pesticides. However, in BIPM modules yield, gross income and net income were higher compared to untreated check and Farmer's practices. The present findings are in line with Haldhar *et al.* (2014) and Birah *et al.* (2015).

Table 1: Evaluation of BIPM module against major pests of ash gourd - yield and economics

Modules	Mean number of insects or per cent leaf damage/5 plants				Yield (t/ha)	Cost of cultivation (₹/ha)	Gross income* (₹/ha)	Net income (₹/ha)	BCR
	Myzus persicae[#]	*Liriomyza trifolii*[$]	*Aulacophora foveicollis*[#]	*Diaphania indica*[#]					
Module I	0.25 (0.84)[a]	2.50 (9.07)[a]	0.75 (1.06)[a]	0.00 (0.71)[a]	41.75[a]	87900	255000	167100	1:2.84
Module II	0.25 (0.84)[a]	2.75 (9.54)[a]	1.25 (1.31)[ab]	0.25 (0.84)[a]	41.25[a]	87850	247500	159650	1:2.81
Module III	0.50 (0.97)[a]	4.50 (12.22)[b]	2.00 (1.56)[bc]	0.25 (0.84)[a]	39.25[ab]	92900	235500	142600	1:2.53
Module IV	0.75 (1.10)[a]	4.25 (11.86)[b]	2.50 (1.73)[cd]	0.25 (0.84)[a]	38.15[b]	92850	228900	136050	1:2.46
Farmer's practice	2.25 (1.65)[b]	11.50 (19.82)[c]	2.75 (1.80)[cd]	0.50 (0.97)[a]	30.85[c]	71280	185100	113820	1:2.60
Untreated check	36.50 (6.08)[c]	19.75 (26.39)[d]	3.75 (2.05)[d]	1.75 (1.49)[b]	23.85[d]	59900	143100	83200	1:2.39
CD (p=0.05)	0.36	1.08	0.40	0.33	2.54				

[#]Figures in parentheses are $\sqrt{x+0.5}$ $\sqrt{x+0.5}$ transformed values [$]Figures in parentheses are arc sine transformed values

*Ash gourd fruits are sold @ Rs. 6000/tonne

In a column, means followed by common letters are not significantly different by LSD (P=0.05)

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ES 04 BOPD 01

Oriental response of the *Systasis dasyneurae* Mani to the Herbivore Induced Volatiles (HIPV) from jasmine (*Jasminum sambac* L.) to manage blossom midge (*Contarinia maculipennis* Felt)

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Keywords: *Jasmine, midge, parasitoid*

Introduction

Induction of plant defense in response to herbivore involves the emission of volatile compounds called synamones that act as attractants for natural enemies. Herbivore induced volatiles produced by plants are reported to be very significant in eliciting host-seeking response in several natural enemies. Jasmine, *Jasminum sambac* L. is a traditional flower crop, commercially cultivated for its fragrant flowers, is ravaged by several pests, of which blossom midge, *Contarinia maculipennis*, poses severe threat, as it damages the economic part of the plant, the flower buds. The parasitoid, *Systasis dasyneurae* (Mani) (Pteromalidae: Hymenoptera) is a general midge parasitoid found in different agro-ecosystems, reported to be a potent candidate in checking the menace of blossom midge naturally. It has the potential to parasitize on the larval stages of midges. The larvae of this wasp parasitize the midge larvae in the buds, attaching to the midges and extracting body fluids from its host. Each wasp larva can destroy 3-4 midge larvae. Level of parasitization of late instar midge larvae can exceed 50 per cent. Therefore, a study was undertaken to investigate the response of *S. dasyneurae* to Herbivore-induced plant volatiles (HIPVs) of jasmine pests, with special reference to jasmine blossom midge.

Materials and methods

Extraction of herbivore induced volatile extracts: A volatile collection unit (VCU) was used for collection of head space volatiles. The potted plant of *Jasminum sambac* with flower buds was kept inside an air-tight glass jar and one maggot/ bud was placed inside each bud using a camel hair brush and the maggots were allowed to feed overnight. Air was pumped into the jar through activated charcoal at the rate of 100 ml/min. Head space volatiles from the damaged jasmine plants were collected on to the adsorption tubes. Both sides of the adsorption tube were fitted with steel mesh grids to prevent the adsorbent falling apart. Head space volatiles were trapped for 2h and stopped for half an hour and again collected for another 2 h. Each time a new adsorption tube was used for collection of head space volatiles. The adsorbed volatiles were eluted immediately with 20 ml HPLC grade hexane. The eluted hexane extract was concentrated and then injected into GC-MS. Volatile extracts were also collected from other jasmine pests, budworm, leaf webworm, and two spotted mites for comparison by releasing 1 budworm/bud, 1 leaf webworm/leaf and 10 mites/leaf. Each time the adsorption tubes were cleaned with 5 ml of acetone (two times) and dried at 240 ^{o}C.

Behavioural bioassay of the parasitoid: The orientation behavior of the parasitoid, towards the herbivore induced volatile fractions was studied using eight arm olfactometer under laboratory condition at 26±2^{o}C and 65±5% RH and 150 lux light density. The four volatile test fractions from four pests of jasmine, healthy jasmine plant for comparison @ 50 µl each and a positive control with water and a negative control with hexane were placed on filter paper strips of 30 mm x 10 mm (odour source) separately at the eight arms. After permitting the solvent to evaporate for 2 minutes, fifty adult parasitoids of *S. dasyneurae* were released from the top of the olfactometer through the circular entrance and the number of parasitoids opting for each volatile fractions was recorded. Observations were taken at 2h and 4h after release. Vacuum cleaning was done before and after completion. Three replicates were maintained.

Results and discussion

The oriental response of the parasitoid, *Systasis dasyneurae* to its host blossom midge HIPV extracts displayed an optimistic response (Table 1). More number of midge parasitoids oriented on blossom midge infested jasmine plant extracts; 16 and 23 wasps oriented after 2 and 4 hours of treatment witnessing an average of 19.5 wasps. The parasitoids also responded positively to the healthy jasmine plant extracts with 9 and 11 wasps settled after 2 and 4 hours respectively. Next level of orientation was observed in budworm infested jasmine plant extracts with 8 and 7 parasitoids oriented respectively after 2 and 4 hours of treatment. The leaf extracts of jasmine damaged by leaf feeders showed a negligible response with a mean of 6 and 6 parasitoids oriented after 4 hours towards extracts of leaf webworm and two spotted mite infested jasmine plants respectively. The positive and negative control had only one parasitoid oriented 4 HAT respectively.

Plants respond to herbivory through different defensive mechanisms. The induction of volatile emission is one of the important and immediate response of plants to herbivory. Chemical signals play an important role in the interactions between plants, insects, and their natural enemies (Ahmed *et al*. 2004). The presence of *Systasis dasyneure* as parasitoid of blossom midge in jasmine ecosystem was reported by Kalshoven (1950). It is a specific parasitoid of blossom midge and its orientation on blossom midge infested bud extracts clearly reveals the role of herbivore induced volatiles produced due to blossom midge herbivory in tritrophic interactions. Further, the GC-MS analysis of blossom midge extracts revealed the presence of several compounds with potential ability to attract natural enemies' *viz.,* allyl isothiocyanate, styrene, benzoic acid, linalool, naphthalene, methyl salicylate and methyl anthranilate. The chemical signaling role of each of these chemicals have to explored more to understand the chemically mediated trophic level interactions of jasmine, blossom midge and its parasitoid, *S. dasyneure.*

Table 1. Evaluation on the attraction of the parasitoid, *Systasis dasyneure* to Herbivore Induced Volatile Extracts from jasmine pests

T.No.	Treatment details	No. of parasitoids attracted (HAT)		Mean*
		2	4	
T_1	Healthy jasmine plant	9.00 (1.72)[b]	11.00 (3.31)[a]	10.00 (3.16)[b]
T_2	Budworm infested jasmine buds	8.00 (1.64)[b]	7.00 (2.64)[b]	7.50 (4.46)[b]
T_3	Midge infested jasmine buds	16.00 (1.94)[a]	23.00(4.79)[a]	19.50 (3.24)[a]
T4	Leaf webworm infested jasmine leaves	8.00 (1.61)[b]	4.00 (2.00)[b]	6.00 (2.12)[d]
T_5	Mite infested jasmine leaves	8.00 (1.65)[b]	4.00(2.00)[b]	6.00 (1.87)[d]
T_6	Negative control (Hexane)	0.00 (0.00)[c]	1.00 (1.00)[c]	0.50 (1.00)[e]
T_7	Positive control (Water)	0.00 (0.00)c	1.00(1.00)[c]	0.50 (0.71)[e]
SE	CD(0.05)	0.1225 0.2627	0.1260 0.2672	0.1216 0.2579

Mean of three replications; Figures in these parentheses are square root transformed values.

In a column, means followed by common letter(s) are not significantly different by LSD (P= 0.05)

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ES 04 BOPD 02

Life stages of blossom midge of jasmine, *Contarinia maculipennis* Felt (Diptera: Cecidomyiidae) in *Jasminum sambac*

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Keywords: *Jasmine, blossom midge, life stages*

Introduction

Understanding on the on-life history as well as the life-table of any pest on the host plant and varied cultivars is an important factor required for better management of pests by developing proper IPM strategies. The knowledge of the sequence of developmental stages, their duration, and number of generations and method of overwintering is essential to know the 'weakest link' in the life-cycle. This would help to aim control measures effectively at the most vulnerable stage of the pest. Jasmine (Jasminum sambac L.) is traditionally as well as commercially cultivated for its sweet-scented flowers. Since recent past, this commercial jasmine is affected by a number of pests of which blossom midge, Contarinia maculipennis Felt is attaining the status of major pest recently. The blossom midge maggots feed inside unopened flower buds, causing deformed, discolored buds and blossoms, and in severe infestations, premature bud or blossom dropped. Except for the adult, all stages of the blossom midge are secluded within the bud as maggots or in the soil as pupae. When laying eggs, the adult female blossom midge is unable to penetrate plant tissues, but rather inserts its ovipositor into the open end of a bud. The adult midge avoids late-stage buds and prefers to lay eggs in young buds to ensure an optimal food source and moist environment for the maggot until it matures. The midge larva is most prevalent inside unopened flower buds and a serious infestation can be devastating and rapidly destroying an entire flowering (Kamala, 2018).

Materials and methods

A detailed laboratory study was conducted at the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore at conducive weather conditions of temperature 27^{o}C and relative humidity 61 per cent. The rearing cage of size 50 × 45 × 45 cm were utilized in the biology study to rear the midges. Medium sized conical flasks (250 ml) filled with water plugged with adsorbent cotton and inserted with fresh *J. sambac* branches with flowers and buds were kept inside the cages to facilitate oviposition and ten pairs of adult midges were introduced into the rearing cage. The lower surface of the rearing cage was filled with moist sand, planted with three-fourth mature flower buds to facilitate pupation of the maggots. The buds were checked for eggs and the life history was studied. The parameters recorded were: egg period, larval period, pupal period, adult period and total lifecycle of pest in three replicates. The data on egg, maggot, pupal and adult longevity periods were recorded on daily basis. Jasmine branches with flower and buds were replaced daily with fresh branches with flower buds.

Results and discussion

The extensive details of life stages of Jasmine blossom midge is furnished in Table 1. The morphology of life stages is detailed here under:-

Eggs: The eggs were elongate and cylindrical laid on the inner whorls of the petals in groups of 10-13 during night times. The eggs hatched in one to two days. The average egg period was 1.3 days in *J. sambac*.

Maggot: The larval stages of midges are called maggots. There were totally four larval instars. The maggots were narrow with pointed anterior and posterior end. The maggots on eclosion were dull white in colour and turned yellow as the development progressed. The maggots scraped the petals, stamen and stigma and suck sap from the flower buds. The larval period lasted for 4 to 5 days. The average larval period observed in *J. sambac was* 4.4 days respectively.

Pupa: The maggots turned orange yellow before pupation. Pupation occurred in the top superficial layer of soil in a thin white case. The pupal period lasted for 7 – 8 days. The average pupal period was 7.5 days in *J. sambac.*

Adult: The adults were minute and delicate flies. The females had a black head and yellowish-brown body and were characterized by a distinct long ovipositor. The males were brownish and shorter than females. The moniliform antennal segments adorned with hairs in whorls were short and cylindrical in males, long and spherical in females. The adults usually lived for one to two days and for three days in rare cases. In an average the adult period was observed to be 2.0days in J. sambac.

Total life span: The total duration taken to complete egg to adult stage was 15. days in J. sambac,.The average egg, maggot, pupal and adult period were 1.3, 4.4, 7.3 and 2.0 days in J. sambac. The findings were in agreement with (David et al., 1991) who reported that cecidomyiid eggs hatched in 1.4 days and the larval stage lasted 4-5 days and adults emerged in 7-8 days. Neelima (2005) studied on the life stages of C. maculipennis and evolved the same results.

Table 1. Life stages of blossom midge, *Contarinia maculipennis* in *Jasminum sambac*

S.No.	Particulars	Period (days)		
		Minimum	Maximum	Average
1	Egg	1	2	1.30±0.483
2	Maggot	4	5	4.40±0.737
3	Puparia	7	8	7.30±0.674
4	Adult	1	3	2.03±0.874
5	Total lifecycle	13	18	15.20±14.24
6	Fecundity (No. of eggs/female)	43	102	83.00±15.09

* Mean of three observations

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ES 04 BOPD 03

Identification of saturated hydrocarbon profile of kairamonal extract of two spotted mite, *Tetranychus urticae* Koch of Jasmine (*Jasminum sambac* L.) through GC-MS Analysis

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Keywords: *Tetranychus urticae, jasmine, kairomonal extract*

Introduction

The cultivation of the traditional flower crop, jasmine (*Jasminum sambac*) is threatened by several factors, of which insects and mites tops the list. *Tetranychus urticae* Koch commonly known as two-spotted mite is a species of plant-feeding mite, a known member of the family Tetranychidae or spider mites. These tiny eight-legged arthropods lay eggs on the underside of leaves and suck sap from cells on the underside of plant leaves, in the early stages and characteristic white speckles can be seen from the upper leaf surface. As mite number increases, these white speckles also increase and the leaf exhibits a bleached appearance. In case of severe infestation, the whole plant becomes pale in colour, and affects production and size of the flower buds (Zhang, 2003). Alternatives to chemicals in managing this pest involves understanding the role of the signaling chemicals for natural enemies to reach this pest by identifying the saturated hydrocarbons of the host insect, the present study was designed to analyze body extracts of two spotted mite in GC- MS.

Materials and methods

Extraction of kairamone: From the mass cultures maintained, adult blossom midges were collected and immobilized by placing them in refrigerator. One gram of immobilized adult mites were collected and placed in a test-tube containing one ml of analytical grade hexane and shaken vigorously at the room temperature of 24±2°C for 2 min to extract the body wash. The washings were then filtered through a Whatman No. 1 filter paper. The extract was subsequently concentrated by vacuum evaporation and stored at −20°C.

GC-MS Analysis: The extracts were analyzed in GC-MS with mass selective detector (70eV) equipped with a 10:1 split injector. One microlitre of the extract was injected using auto sampler in split 10:1 mode. Injected sample is separated into various constituents with different retention time which were detected by mass spectrophotometer. The compounds of interest were identified using standard NIST mass spectral (NIST MS 2) library. The chromatogram, a plot of intensity against retention time was recorded by the software attached to it. From the graph, the compounds were identified by comparing the data with the existing software libraries.

Results and discussion

Kairamonal extracts of host insects contain characteristic hydrocarbons, fatty acids and proteins present in their body or byproduct, which act as stimulants or arrestants to the parasitoids to intensify their search in the near vicinity of the host (Tumlinson *et al.,* 1992). The hydrocarbon profile of mite body wash exposed the presence of 29 hydrocarbon compounds in GC-MS Analysis (Table 1) *viz.,* cyclohexanol, 3-hexanol 5 methyl-, glutaric acid, 2-methyl butanoic anhydride, silane ethenyl trimethyl-, azetidine 1, 2 dimethyl, oxalic acid, cyclo hexane, 1 propenyl aziridine, methoxy acetic acid, trichloro acetic acid, dodecyl isobutyl carbonate, octacosanol, phenol, 2,6-bis (1,1-dimethylethyl), pentafluoro propanoic acid, hentriacontane, heptadecane 9 -octyl-, phytol, benzaldehyde 4 nitro-, silicic acid, carvacrol, 2- etyl acridine, silicic acid dimethyl bis-, thymol, carvacrol, fumaric acid, eicosyl isopropyl ether, silicic acid, carvacrol, bis (2 ethyl hexyl phthalate), tetracosane and nonacosane. Oxalic acid was detected at 5.965 in maximum quantity in a peak area of 20516145 mm^2 representing 18.60 per cent in mite body wash. Oxalic acid is found to be present in abundance in mite body wash, which could attract its natural enemies, which is supported by Karatolo and Hatcher (2008), that the foliar application of oxalic acid has the potential to induce indirect plant defences against aphids by encouraging aphid parasitisation by its parasitoid *Aphidius colemani* Viereck. Analyzing the identified chemical constituents of the mite kairomones will aid to recognize the chemicals responsible for attraction of its natural enemies in tri trophic interactions and potential compounds can be formulated as lures to artificially trap the natural enemies in jasmine ecosystem.

Table 1. Saturated hydrocarbon profile of the kairamonal extract of two spotted mite, *T.urticae*

RT (min)	Area (mm^2)	Name of the compound	RT (min)	Area (mm^2)	Name of the compound	RT (min)	Area (mm^2)	Name of the compound
4.310	1746487	Cyclohexanol	17.059	190423	Trichloro acetic acid	28.078	923632	Carvacrol
4.690	3951188	3-Hexanol 5 methyl-	17.125	181862	Dodecyl isobutyl carbonate	28.399	1895216	2- Etyl acridine
4.890	1172807	Glutaric Acid	17.125	181862	Octacosanol	28.687	205920	Silicic Acid dimethyl bis-
5.032	11990584	2-Methyl butanoic anhydride	17.360	118004	Phenol, 2,6-bis (1,1-dimethylethyl)	29.619	5075255	Fumaric Acid
5.468	12226262	Silane ethenyl trimethyl-	19.556	294042	Pentafluoro propanoic acid	29.925	451043	Eicosyl isopropyl ether
5.673	8476422	Azetidine 1,2 dimethyl	21.009	1161572	Hentriacontane	30.021	1831990	Silicic Acid
5.965	20516145	Oxalic Acid	21.009	1161572	Heptadecane 9 –octyl-	30.352	173482	Carvacrol

7.790	4194864	Cyclo hexane	21.164	391802	Phytol	31.975	1250210	Bis (2 ethyl hexyl phthalate)
7.790	4194864	1 Propenyl aziridine	21.701	116862	Benzaldehyde 4 nitro-	33.570	15691575	Tetracosane
8.157	418868	Methoxy acetic Acid	27.563	943430	Silicic Acid	33.570	15691575	Nonacosane

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ES 04 BOPD 04

Food Bait - Generalized Fruit Fly Attractant in Gourds

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Keywords: *Food bait, attractants, fruit fly, gourds*

Introduction

The melon fruit fly, *Zeugodacus cucurbitae* (Coq.) (Diptera: Tephritidae) is a pest of quarantine significance, causing 30-100 % losses to vegetable crops in tropical, subtropical, and temperate zones of the world. Also, the lesser pumpkin fly, *Dacus ciliatus* Loew is becoming a silent threat in cucurbits. *Z. cucurbitae* male lures have earned extensive research attention, leading to the development of male attractants like cue-lure and melo-lure and raspberry ketone derivatives. On the other hand, *D. ciliatus* adults are not attracted to these parapheromones. Food baits have neither sex nor species-specific attraction in trapping programs. In consequence, the current study was formulated on evaluation of food bait for the attraction of fruit flies in melons.

Materials and methods

The present study was conducted during 2019- 2020 at Orchard, TNAU, Coimbatore and farmer's field, Pollachi. An indigenous low cost fruit fly trap was designed in this study and evaluated against fruit flies on gourds. The fully ripened fruits were pureed by hand and additives were added in a dry clean plastic container. This mixture was allowed for fermentation and then kept in each bait station tied to the grid at a distance of 13 m width with 1.2 m height from the ground level. After 24 hours the trapped fruit flies were collected using ethyl acetate dipped cotton. The following were the food baits selected,

B_1	-	Guava (30 g) + Yeast (0.3 g) + FGA (10 ml) + CS (3 g) + ProtineX® (3 g)
B_2	-	Musk melon (40 g) + Yeast (0.4 g) + Beer (10 ml) + CS (4 g) + ProtineX® (4 g)
B_3	-	Guava + Musk melon (20 + 20 g) + Yeast (0.4 g) + FGA (10 ml) + CS (4 g) + ProtineX® (4 g)

The presence of complex species of fruit flies in the food bait traps was assessed. The attracted fruit fly species were identified using the taxonomical keys given by David and Ramani, (2011). The percentage of each fruit fly species over the total fruit fly species collected were worked out.

Results and discussion

The relative incidence of various fruit fly species in guava (B_1), musk melon (B_2), and guava + musk melon (B_3)

based food baited traps at four experimental sites from January to April 2020 over the 12 weeks are provided in Figure 1. At site 1 (TNAU orchard, Coimbatore- Snake gourd), *Z. cucurbitae* was the most attracted species by B_1 (76 %), B_2 (74 %), and B_3 (75 %) followed by *Z. tau* (10, 10, and 11 %), *B. diversa* (8, 9 and 8 %) and *D. ciliatus* (6, 7 and 6 %) for B_1, B_2 and B_3 respectively. In site 2 (Farmer's field, Sundrapuri, Pollachi, Coimbatore- Ridge gourd), the percent incidence was higher for *Z. cucurbitae* (79, 77 and 77 %) than *D. ciliatus* (13, 14, and 14 %), *B. diversa* (4, 5 and 5 %) and *Z. tau* (4, 4 and 4 %) in B_1, B_2 and B_3 baited traps respectively. *In gourds, the dominance of Z. cucurbitae over other species was reported by* Ganie *et al.* (2013). In total, about 75 % of collected fruit flies were *Z. cucurbitae*, 10 % *D. ciliatus*, 7 % *Z. tau,* and 6 % *B. diversa*. Similarly, Nair *et al.* (2017) recorded the association of *B. diversa, Z cucurbitae,* and *Z. tau* to several cucurbits. With food baited traps, adult females and males of four fruit fly species *viz., Z. cucurbitae, D. ciliatus*, *Z. tau and B. diversa* were collected. This provides an advantage over cue-lure which attracts only *Z. cucurbitae* (Kishor *et al.*, 2018). Parapheromones like cue-lure used in gourds were not suitable for trapping several fruit fly species. This was supported by White and Elson-Harris (1992) who reported that parapheromone lures were not attractive to *D. ciliatus*, which was the second major species attacking cucurbits.

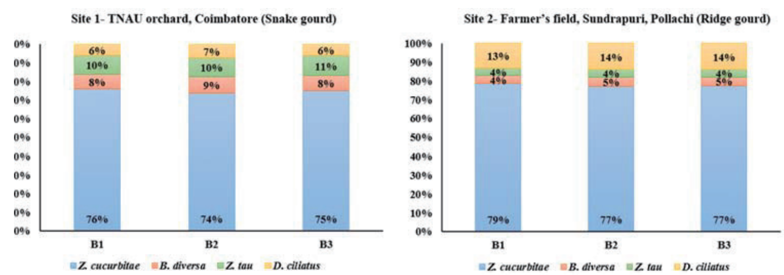

Figure 1. Fruit fly species complex in gourds

The key characters (Plate 1) observed in each collected fruit fly species are presented hereunder.

Wings with costal band and a band in r-m crossvein and anal streak,…...***Z. cucurbitae***

The abdomen with lateral black patches on tergites III, ……………………… ***Z. tau***

The abdominal tergites overlapped…………………………………………..***B. diversa***

Devoid of medial and lateral post sutural vitta, ….…………………...………. ***D. ciliatus***

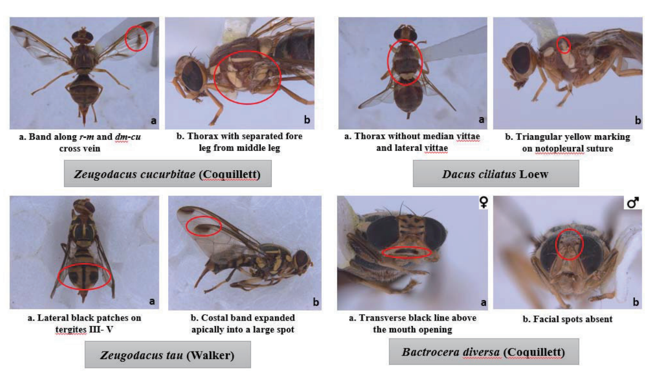

Plate 1. Fruit fly species showing key taxonomic characters

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ES 04 BOPD 05

Influence of antibiotic materials on the biological fitness parameters of rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae)

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Keywords: *Rugose Spiralling Whitefly, gut bacterial isolates, antibiotics, parafilm feeding method,fitness parameters*

Introduction

Rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus* Martin is an invasive polyphagous insect pest. Its high fecundity and enormously producing honeydew leads to sooty mould, which negatively affects plant growth. Whiteflies suck the phloem sap, which has higher amounts of carbohydrates and lesser amounts of essential amino acids. This nutritional deficiency is compensated by the endomicrobial communities of whiteflies. Antibiotic materials with different mode of action alters the endosymbiont population of the whiteflies (Costa *et al*., 1997) which is essential for the growth, offspring emergence and honeydew secretion. The present study investigated the effect of antibiotics against gut symbionts *vis-à-vis* on bionomics of RSW in rugose spiralling whitefly.

Materials and Methods

Effect of antibiotics on RSW oviposition

Efficacy of antibiotic treatments (T1–Carbenicillin 100 µg/mL (CB^{100}), T2- Ciprofloxazin 5 µg/mL (CIP^5); T3- Erythromycin 15 µg/mL (E^{15}); T4- Cefotaxime 30 µg/mL (CTX^{30}); T5- Carbenicillin 100 µg/mL + Ciprofloxazin 5 µg/mL (CB^{100} + CIP^5); T6- Carbenicillin 100 µg/mL + Erythromycin 15 µg/mL (CB^{100} + E^{15}); T7- Carbenicillin 100 µg/mL + Cefotaxime 30 µg/mL (CB^{100}+CTX^{30}); T8- Ciprofloxazin 5 µg/mL + Erythromycin 15 µg/mL (CIP^5 + E^{15}); T9- Ciprofloxazin 5 µg/mL + Cefotaxime 30 µg/mL (CIP^5 + CTX^{30}); T10- Erythromycin 15 µg/mL + Cefotaxime 30 µg/mL (E^{15} + CTX^{30}) and T11-Control were added to 20% sugar solution. RSW adults were allowed to feed the antibiotic feeding solution for 24 - 48 h using parafilm feeding chamber method adopted by Ruan *et al.* (2006) and transferred to clip cages. Then, clip cages were placed on four host plants for oviposition and the percentage of egg hatchability, nymphs developing into adulthood, developmental time from nymphal to adult stage and fecundity of RSW was observed**.**

Results and Discussion

Among the antibiotic treatment, CB^{100} + CIP^5 (Carbenicillin 100 µgml^{-1} + Ciprofloxacin 5 µgml^{-1}) prolonged the developmental time (32.69 ± 0.83 days) from nymph to adult and reduced the percentage of egg hatchability (59.44 ± 0.59%), nymphs developing into adulthood (31.67 ± 0.40%) and fecundity (82.00 ± 0.09 eggs). The results indicated that the combination of CB^{100} + CIP^5 was the most effective in reducing the host fitness parameters through the elimination of gut bacteria associated with RSW.

Similarly, curing of secondary symbionts through antibiotics on *B. tabaci* may cause negative effects on host insect (Shan *et al*. 2016). Rifampicin and oxytetracycline treatment on *B. tabaci* negatively affect the growth and development of the offspring (Costa *et al*. 1997; Ruan *et al*. 2006; Xue *et al*. 2012). In conclusion, antibiotic treatment CB^{100} + CIP^5 significantly influenced the RSW development and oviposition. Antibiotic based materials are the effective way to reduce the RSW fecundity. Understanding the effect of antibiotics on host insects is a novel tool for the sustainable management of whiteflies through endosymbionts.

Table 1. Effect of antibiotics on biological fitness parameters of rugose spiralling whitefly

No	Antibiotic treatments	(Mean ± SE)			
		Egg hatchability (%)	Nymphs reaching adulthood (%)	Developmental time (Nymph-adult) (Days)	Fecundity (Eggs/female)
1	CB^{100}	81.25 ± 0.90^{c}	43.33 ± 0.81^{e}	29.77 ± 0.69^{bc}	103.00 ± 0.12^{f}
2	CIP^{5}	88.89 ± 0.51^{bc}	56.67 ± 0.83^{d}	27.05 ± 0.17^{de}	110.00 ± 1.03^{def}
3	E^{15}	95.00 ± 2.60^{ab}	66.67 ± 0.66^{c}	24.08 ± 0.11^{gh}	131.00 ± 2.52^{b}
4	CTX^{30}	90.00 ± 2.70^{bc}	63.33 ± 0.79^{c}	28.08 ± 0.47^{cd}	125.00 ± 0.85^{bc}
5	$CB^{100} + CIP^{5}$	61.54 ± 1.92^{d}	16.67 ± 0.43^{i}	34.10 ± 0.57^{a}	62.00 ± 0.26^{h}
6	$CB^{100} + E^{15}$	93.75 ± 2.69^{cd}	36.67 ± 0.80^{fg}	31.05 ± 0.37^{b}	112.00 ± 0.80^{de}
7	$CB^{100} + CTX^{30}$	94.12 ± 2.82^{ab}	40.00 ± 0.98^{ef}	25.76 ± 0.21^{efg}	94.00 ± 0.78^{g}
8	$CIP^{5} + E^{15}$	94.74 ± 2.96^{ab}	33.33 ± 0.35^{gh}	26.07 ± 0.54^{ef}	117.00 ± 0.77^{cd}
9	$CIP^{5} + CTX^{30}$	80.00 ± 1.38^{c}	30.00 ± 0.14^{h}	30.07 ± 0.01^{bc}	87.00 ± 1.86^{g}
10	$E^{15} + CTX^{30}$	90.48 ± 2.13^{bc}	76.14 ± 0.51^{b}	24.77 ± 0.22^{fgh}	108.00 ± 2.19^{ef}
11	Control	100.00 ± 0.29^{a}	100.00 ± 1.61^{a}	23.45 ± 0.28^{h}	266.00 ± 3.7^{4}a

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ES 04 BOPD 06

Effect of pheromone trap height on brinjal shoot and fruit borer trapping efficiency *Leucinodes orbonalis* Guenee

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Keywords: *trap height, pheromone water trap, brinjal, shoot and fruit borer, plant canopy*

Introduction

Brinjal, *Solanum melongena* L., is one of South Asia's three most significant vegetables, accounting for over half of the world's cultivated land (Alam et al., 2003). It is also known as the "King of Vegetables." Throughout the year, this crop is widely farmed in a variety of agro-climatic settings. The most devastating borer key pest in the brinjal crop is the brinjal shoot and fruit borer BSFB, *Leucinodes orbonalis*, which bores the shoots and fruits and expels the faeces through the bore holes. It damages fruit to a greater extent (more than 90%). Through monitoring and mass capturing, sex pheromone water traps play a significant role in integrated pest management throughout the cropping period (transplanting to harvest). In the BSFB catch, many trap components such as trap design, trap position, and so on play a key role. With this knowledge, effect of trap height on moth trapping efficiency was tested in this experiment.

Materials and methods

In the year 2015, this field experiment was conducted at the Agricultural College and Research Institute in Killikulam. The effective commercial water trap with lucin lure was tested for moth catch at different trap heights: above plant canopy, below plant canopy, and at plant height. Four replications were used in the Randomized Block Design (RBD) experiment. The traps were set at a distance of 10 metres, and weekly observations of mean moth catches were recorded and compared.

Results and Discussion

The position of the pheromone traps *i.e.* elevation from crop canopy level is also important in the effectiveness of the pheromone (Ali Ziazea and Stafford, 1972). In the present study, the water trap was tested for its efficacy under different trap heights for retaining more adults. The results indicated that the traps positioned above canopy level have attracted more moths ranging from 7.86 moths / trap during 1st week to 4 moths/ trap during 4th week of installation. The trap placed below the crop canopy level recruited less number of moths. Hence, it is inferred that for effective capture of moths in a crop season, the height of the trap need to be adjusted at least two times according to the crop growth stages. The present findings are in line with Pushpakumari and Tiwari (2005) who stressed for adjusting and maintaining the trap at 30 cm above the crop canopy level for maximum moth trapping.

The height of trap also reported to influence moth catches. Cork *et al.* (2003) reported that the traps placed at crop canopy level caught significantly more male moths than traps placed 0.5 m above or below the crop canopy while as per Alam *et al*. (2003) reported that the traps installed 0.25 m above crop canopy caught higher moths than either at crop canopy or at 0.25 m below crop canopy level.

Table 1. Studies on impact of trap positioning on moth catches in water trap

Trap position	Mean number of moth catches / trap			
	I Std. week	II Std. week	III Std. week	IV Std. week
T1	3.57^{c} ± 0.45	2.43^{c} ± 0.25	1.71^{c} ± 0.35	2.86^{c} ± 0.32

T2	5.29^{b} ± 0.35	4.29^{b} ± 0.35	3.57^{b} ± 0.36	4.00^{b} ± 0.38
T3	7.86^{a} ± 0.42	6.14^{a} ± 0.49	4.43^{a} ± 0.25	5.00^{a} ± 0.38
SE	0.42	0.42	0.38	0.39
CD (0.05)	0.92	0.93	0.84	0.86

* Means followed by different letters within a row indicate significantly different (P<0.05; LSD)

(T1-Below plant canopy and center of the plot, T2-At plant canopy and center of the plot, T3-Above plant canopy and center of the plot)

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ES 04 BOPD 07

Evaluation of adjuvants on moth retention efficiency of pheromone water trap

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Keywords: *adjuvant, brinjal, shoot and fruit borer, pheromone water trap, moth catch*

Introduction

Brinjal shoot and fruit borer BSFB, *Leucinodes orbonalis* is an obnoxious key pest on brinjal, that degrades the quality and quantity of brinjal. As part of an integrated pest management programme, sex pheromone traps greatly reduced fruit damage and enhanced yield (Rashid et al., 2003). The usage of sex pheromone becomes prospective alternative to sole use of chemical pesticides. Trap catches have also been used for timing insecticide applications, mass trapping and assessing the efficacy of mating disruption (Rice 1990). The water trap showed to be the most successful among the several trap designs for the control of brinjal shoot and fruit borer (Cork *et al.,* 2003). With this information, water trap adjuvants were applied to boost trapping efficiency and trap captures were observed.

Materials and methods

In this field experiment, commercial water traps were used with three different types of adjuvants: castor oil with water, detergent powder with water, and a trap without any adjuvant (water alone). In the Randomized Block Design (RBD) experiment, commercially available PVC pheromone dispensers were employed in the pheromone water traps and replicated five times. The traps were set at a distance of 10 meters, and observation on trap catches was recorded on weekly basis and compared for moth retention efficiency over the course of a month. The field experiment was carried out during the year 2015 at Agricultural College and Research Institute, Killikulam.

Results and discussion

The result of the experiment showed a significant improvement in trapping efficiency of the water trap due to the use of adjuvant. The commercial water trap model tested with castor oil as water adjuvant retains maximum number of *L. orbonalis* adult moths. The moth retention ranged from 6.86 moths / trap during III week to 8.29 moths during the V week. Use of detergent powder as water adjuvant also resulted in a maximum moth catch on par with castor oil. The moth attracted in water trap having detergent as water adjuvant ranged from 5.14 in III week to 6.86 during V week. The trap with water having no adjuvant retained comparatively a minimum number of moths ranging from 2.14 moths / trap during II week to 3.43 per moths during the V week. The similar results were observed in all weeks. Though the use of detergent powder as water adjuvant also resulted in maximum moth retention on par with castor oil, because of the organic nature, castor oil is considered. The use of castor oil as water adjuvant also has the complimentary effect on the moth retention efficiency of the trap. Addition of castor oil along with water in water traps may increase the efficiency of moth catches.

Table 1. Influence of water adjuvant on moth retention efficiency in water trap design

Adjuvant in water trap	Mean number of moth catches / trap				
	I Std. week	II Std. week	III Std. week	IV Std. week	V Std. week
T1	$2.43^{b} \pm 0.92$	$2.14^{b} \pm 0.73$	$3.29^{b} \pm 1.06$	$4.43^{b} \pm 0.99$	$3.43^{b} \pm 0.80$
T2	$7.43^{a} \pm 1.87$	$7.86^{a} \pm 1.64$	$6.86^{a} \pm 1.05$	$7.14^{a} \pm 1.18$	$8.29^{a} \pm 0.99$
T3	$6.14^{a} \pm 1.80$	$5.57^{a} \pm 0.59$	$5.14^{ab} \pm 0.73$	$6.71^{a} \pm 0.52$	$6.86^{a} \pm 0.42$
SE	1.32	1.42	1.13	0.89	0.90
CD (0.05)	2.89	3.10	2.47	1.94	1.98

Means followed by different letters within a row indicate significantly different (P<0.05; LSD)

[T1-Water without adjuvant, T2 -Water + Castor oil, T3-Water + Detergent powder]

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ES 04 BOPD 08

Influence of sowing intervals on the incidence of spotted podborer, *Maruca vitrata* Geyer in Pigeonpea

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Key words: *Pigeonpea varieties, spotted podborer, M. vitrata, sowing time*

Introduction

Pigeonpea (*Cajanus cajan* L) is the second most important pulse crop of India after chickpea. Pod borer, *Maruca vitrata* (Geyer) is the major limiting constraint as the larvae feed by remaining inside the webbed mass of leaves, flowers and pods and leads to difficulty in management. Pigeonpea genotypes with determinate growth habit, where pods are bunched together at the top of the plant are more prone to damage than in the determinate ones. With the introduction of short-duration genotypes for cultivation, *M. vitrata* has emerged as one of the major constraint because of the coincidence of high humidity and moderate temperature in September - October with the flowering of crop in India. In these circumstances, the investigation on spotted podborer needs to be strengthened as the pest is dominant nowadays in this crop. To overcome the problem of indiscriminate use of pesticides, eco-friendly approach such as alteration on date of sowing in order to escape the peak activity may be followed. Early planted crops have less harbored with lowest pest population with the corresponding increase in the yield than the late planted crops (Ambulkar *et al*. 2011). Hence, it is essential to find out optimum sowing dates where the crop can escape damage of insect pests for the development of IPM module in pigeonpea pest management.

Materials and Methods

A field experiment was laid out with four pigeonpea varieties of short duration *viz*., Co (Rg) 7 and VBN 3 and long duration *viz*., (CO 8 and LRG 41) in a randomized block design with two replications sown at fortnight intervals from June – September during the *kharif* 2020 and the incidence of spotted pod borer, *M. vitrata* was taken at flowering, pod formation and maturity stage from all the varieties tested to assess the activity of peak incidence. Pods attacked by *M. vitrata* were identified with relatively small holes with scrapped margins, plugging of entrance hole with larval excreta and the data thus obtained were analyzed using MS Excel 2010.

$$\text{Percent pod damage} = \frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

Results and discussion

The results are presented in Table 1 and revealed that there existed a significant difference among the varieties as well as the sowing time on the incidence of spotted pod borer in pigeonpea. Observation on the incidence was taken at flowering, pod formation and at harvest stage of the crop. Among the varieties, CO 8 variety recorded lowest mean population (0.86 No/plant) when sown during June 2020. With respect to sowing time, the highest mean population was recorded when sown during September second fortnight 2020. The short duration varieties suffered with highest mean population Co7 (2.83 Nos/plant) followed by VBN 3 (2.61 Nos/plant). The spotted podborer damage at harvest was recorded and the mean lowest damage was recorded in LRG 41 (10.00%) with the lowest being recorded in August II fortnight, September first and second fortnight (7.00 %) with its highest during July II fortnight sown crop (18.00%). With respect to short duration, the lowest damage was recorded in Co 7 (10.87%). Gopali *et al.* (2010) also reported that the incidence of spotted podborer was high in early (130-140 days) and late maturity (190-220 days) varieties and moderate in medium duration (170-180 days).

Table 1. Effect of sowing time and variety on the incidence of spotted pod borer, *Maruca vitrata* (*Kharif* 2020)

Varieties	June Ist FN	June IInd FN	July Ist FN	July IInd FN	August Ist FN	August IInd FN	September Ist FN	September IInd FN	Mean
Flowering stage									
VBN3	0.55	0.49	3.75	1.85	2.55	3.74	3.26	4.74	**2.61^{c}**
CO(Rg)7	0.34	0.49	3.74	1.84	2.15	5.49	2.85	5.74	**2.83^{d}**
LRG 41	0.25	0.41	0.92	2.15	1.65	0.91	1.58	3.58	**1.43^{b}**
CO(Rg)8	0.00	0.17	0.66	0.91	0.72	0.77	1.24	2.41	**0.86^{a}**
SED									0.04
CD<0.05									0.08
Pod formation stage									
VBN3	1.70	2.49	1.58	2.29	2.70	2.29	1.58	1.29	**1.99^{c}**
CO(Rg)7	2.29	1.58	2.16	2.33	1.16	2.58	1.41	1.70	**1.90^{bc}**
LRG 41	0.58	1.16	1.58	1.16	2.16	3.04	2.29	2.29	**1.78^{b}**
CO(Rg)8	0.29	1.70	1.58	1.58	2.16	1.95	1.29	1.16	**1.46^{a}**
SEd									0.09
CD<0.05									0.20
At Harvest									
VBN3	7.0	15.0	12.0	13.5	11.0	15.0	16.0	7.0	**12.06^{c}**
CO(Rg)7	8.0	13.0	18.0	19.0	15.0	5.0	5.0	4.0	**10.87^{ab}**
LRG 41	13.0	11.0	10.0	18.0	14.0	5.0	5.0	4.0	**10.00^{a}**
CO(Rg)8	13.0	11.5	18.0	17.0	11.0	7.0	7.0	7.0	**11.43^{bc}**
SEd									0.46
CD<0.05									0.95

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ES 04 BOPD 09

Field evaluation of sex pheromone in mass trapping of inter node borer, *Chilo sacchariphagus indicus* (K.) (Lepidoptera, Crambidae) in sugarcane

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Keywords : *Sugarcane, inter node borer, sex pheromone trap, mass trapping, field efficacy*

Introduction

Sugarcane is infested by more than 200 species of insect pests. Among them, borer pests are the most important which cause heavy economic losses to farmers. Borers, comprising of early shoot borer, inter node borer and top borer causing damage to sugarcane to a tune of 22-33 per cent, 34-88 per cent and 21-37 per cent, respectively. Several management strategies including cultural, mechanical, biological and chemical methods have been evolved from time to time as a result of research and development work over the years. Pheromone trapping can be used as complement to field scouting to determine the distribution of borer complex and optimizes control tactics. With a view to address these issues, field evaluation of sex pheromone traps for mass trapping of inter node borer, *Chilo saccharipahgus indicus* in sugarcane was carried out to optimize the number of traps for effective mass trapping of male moths.

Material and methods

Field experiments were carried out during 2020 at Edakkal village, Thandrampattu block of Thiruvannamalai District. The sugarcane variety Co86032 planted during April with a spacing of 0.9 m between rows with a plot size of 50 m^2 and all the recommended package of practices was adopted. There were four treatments including control as listed in table 1 which were replicated five times in randomized block design. The treatments were imposed in the fourth week of September. Sex pheromone traps were installed at a height of 3 m and with a distance of 15m between two traps. Observations on the damage level of inter node borer was recorded at 30 and 60 days after installation (DAI) of trap and finally at the time of harvest during February 2021.Weekly moth catches in the installed traps were also recorded and cane yield was recorded at harvest. The data on cane yield were subjected to x+ 1 square root transformation. These transformed data were subjected to analysis of variance and Duncan's Multiple Range Test was used to determine the significance in different treatments.

Results and Discussion

The results of the study on the damage level of inter node borer in sugarcane in the plots installed with sex pheromone traps revealed that the mean per cent damage level of inter node borer was found significantly low in T_3-Sex pheromone trap @ 20/acre (17.38 %) at harvest followed by T_2-Sex pheromone trap @ 15/acre(21.37%). The per cent decrease of damage level of inter node borer was high in T_3-Sex pheromone trap @ 20/acre (25.74) followed by T_2 Sex pheromone trap @ 15/acre (17.45).Regard to the cane yield, T_3-Sex pheromone trap @ 20/acre recorded significantly highest yield (89.99 t ha^{-1}) , followed by T_2-Sex pheromone trap @ 15/acre (86.08 MT/ha) and the control recorded lowest yield (75.54 t ha^{-1}). Highest BC ratio of 1.70 was recorded in T_3 -Sex pheromone trap @ 20/acre (Table 1). The overall mean inter node borer moth catches /trap was found higher (4.58) in T_3-20 traps/acre followed by T_2-15 traps/acre (3.51). Hari Chand *et. al*.(2018) reported that the pheromone trap @ 21/ha reduced the incidence of early shoot borer, top borer and stalk borer to an extent of 55.33, 47.77 and 58.86 per cent, respectively, with 8.08 per cent increase in cane yield as compared to without pheromone traps. The mean moth catch increased from 2.95 to 3.80, when the distance between the traps was reduced from 25 to 16 meters. During 1984, 80600 moths were trapped in 247 traps. The incidence of the pest was reduced and consequently there was an increase in the cane yield and ccs/plot as observed by David *et al*. (1985). Based on the present findings, it was concluded that the mass trapping with pheromone lures @ 20/ acre can be included as one of the IPM practices for the effective management of inter node borer of sugarcane.

Table.1 Damage level of inter node borer in different level of installation of sex pheromone trap

Treatment	Mean per cent INB damage						Cane **yield (t ha^{-1})	BC Ratio
	Pre Treatment*	30DAI*	60DAI*	Harvest*	Pooled mean	% decrease over control		
T_1-Sex pheromone trap @10/acre	13.62 (21.64)a	15.56 (23.26)a	19.93 (26.49)b	21.53 (27.62)b	19.01	14.90	83.04 (9.11)c	1.59
T_2- Sex pheromone trap @15/acre	13.73 (21.72)a	14.78 (22.63)a	19.16 (25.99)b	21.37 (27.56)b	18.44	17.45	86.08 (9.28)b	1.64
T_3- Sex pheromone trap @20/acre	14.75 (22.63)a	15.72 (23.34)a	16.69 (24.12)a	17.38 (24.65)a	16.59	25.74	89.99 (9.49)a	1.70
T_4-Control	14.10 (22.06)a	19.80 (26.42)b	21.88 (27.90)c	25.35 (30.26)c	22.34	-	75.54 (8.69)d	1.48
SEM±	0.22	0.24	0.19	0.47			0.03	
CD at 5%	0.69	0.73	0.57	1.44			0.09	

In a column means followed by a common alphabet are not significantly different by 5 % DMRT.

*Figures in parentheses are arcsine transformed values

** Figures in parentheses are square root transformed values.

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ES 04 BOPD 10

Combined effect of bio rational insecticides and botanicals on pod borers in Redgram

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Key words: *Redgram, bio rational insecticides, pod borer*

Introduction

Redgram is the most important pulse crop having high nutritive value and widely cultivated in India. In pulse cultivation, insect damage is a serious limiting factor leading to reduced production and productivity. Redgram is damaged by an array of insect pests from sowing to harvest in the field as well as in the harvested produce in storage (Prasad and Singh, 2004). Among these, during the flowering stage, spotted pod borer, *Maruca vitrata* Geyer., gram pod borer, *Helicoverpa armigera*, blue butterfly *Lampides boeticus*, plume moth, *Exelastis atomosa*, redgram pod fly, *Melanagromyza obtusa* and pod sucking bugs are considered to be important in causing economic losses to the farmers. Overuse and frequent misuse of insecticides has led to problems like development of resistance and elimination of natural enemies. Hence, an attempt was made to manage the above insect pests in redgram by the combined use of insecticides and botanicals.

Materials and methods

A field experiment was laid out at National Pulses Research Centre, Vamban with the redgram variety, VBN (Redgram) 3 in a randomized block design with three replications. The treatments T1-rynaxypyr 18.5 SC 15g a.i/ha + azadirachtin 1%, T2-indoxacarb 15.8 EC 36.5 a.i/ha + azadirachtin1%, T3-acetamiprid 20SP 10g ai/ha + azadirachtin 1%, T4-rynaxypyr 18.5 SC 30g ai/ha, T5-indoxacarb 15.8 SC 30g ai/ha, T6-acetamiprid 20 SP 20g ai/ha, T7- azadirachtin 1% were sprayed at flowering stage and T8-untreated check also maintained. At the time of harvest, 300 pods were collected from each treatment and the per cent pod damage by spotted pod borer, gram pod borer, blue butterfly and plume moth was recorded. Yield also recorded in each treatment.

Results and Discussion

Application of indoxacarb 15.8 EC 36.5 a.i/ha + Azadirachtin 1% was very effective to suppress the spotted pod borer damage to the tune of 18.30 percent while in untreated check it was 42 % (Table 1.). This treatment also recorded 1.3 percent pod damage by *Helicoverpa* and 4.7 percent pod damage by blue butterfly while in untreated check 14.70% and 31.7 % respectively. This was superior than the full dose of indoxacarb 15.8 EC 73 a.i/ha, rynaxypyr, acetamiprid, azadirachtin. Spraying of spinosad (0.045%) and indoxacarb (0.015%) attributed to higher yield and lesser spotted pod borer larval incidence (Srinivasan, 2008). Minimum plume moth damage was recorded in rynaxypyr 18.5 SC 15 a.i/ha + azadirachtin1% formulation and acetamiprid 20SP 10g ai/ha + azadirachtin 1% formulation. The highest yields of 494.8 and 475.8 kg/ha were recorded in the treatment of rynaxypyr 18.5 SC 15 a.i/ha + azadirachtin1% formulation and indoxacarb 15.8 EC 36.5 a.i/ha + azadirachtin1% formulation respectively. Similar findings were also observed by Sambathkumar *et al*., (2015). The lowest yield of 264.2 kgs/ha was recorded in untreated check.

Table 1. Effect of bio-rational insecticides combinations against redgram pod damage

S. No.	Treatment Details	Mean percent pod damage				Yield* kg/ha
		Maruca	*Helicoverpa*	Blue butterfly	Plume moth	
T1	Rynaxypyr 18.5SC 15g a.i/ha + Azadirachtin 1% spray	22.30 (28.17)[b]	3.70 (11.09)[c]	12.00 (20.26)[c]	1.70 (7.49)[a]	494.8 (22.36)[a]
T2	Indoxacarb 15.8 EC 36.5 a.i/ha + Azadirachtin1% spray	18.30 (25.32)[a]	1.30 (6.54)[b]	4.70 (12.52)[a]	3.30 (10.46)[c]	475.8 (21.90)[b]
T3	Acetamiprid 20SP 10g ai/ha + Azadirachtin 1% spray	22.00 (27.97)[b]	0.30 (3.13)[a]	10.70 (19.09)[b]	2.70 (9.45)[b]	453.7 (21.44)[c]
T4	Rynaxypyr 18.5 SC 30g ai/ha spray	25.70 (30.46)[d]	6.70 (15.00)[d]	17.30 (24.57)[f]	5.30 (13.31)[d]	400.0 (20.00)[d]
T5	Indoxacarb 15.85 SC 30g ai/ha spray	26.70 (31.11)[e]	13.00 (21.13)[e]	15.30 (23.02)[e]	7.00 (15.34)[e]	395.0 (20.00)[e]
T6	Acetarmiprid 20 SP 20g ai/ha spray	24.30 (29.53)[c]	14.30 (22.22)[f]	13.70 (21.72)[d]	7.70 (16.11)[f]	401.50 (20.24)[d]
T7	Azadirachtin 1% spray	28.30 (32.14)[f]	14.70 (22.54)[g]	15.30 (23.02)[e]	8.00 (16.43)[g]	358.30 (18.97)[f]
T8	Untreated Check	42.00 (40.39)[g]	18.30 (25.32)[h]	31.70 (34.26)[g]	13.30 (21.38)[h]	264.20 (16.43)[g]

Values in the paranthesis are arc sign transformed.

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ES 04 BOPD 11

Efficacy of botanicals against major insect pests of sesame

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Key Words: *Botanicals, Bio Efficacy, Shoot webber, Leaf hopper, Sesame, Pest Suppression*

Introduction

Sesame, *Sesamum indicum* Linn. is the most indigenous oilseed crop of the world and also a major oilseed crop of India. Among the various insect pests of sesame, shoot webber and capsule borer, *Antigastra catalaunalis* Duphonchel and leafhopper *Orosius albicinctus* Distant, are the most important in causing economic damage. *Antigastra* causes damage starting from second week of sowing to capsule stage. Nymphs and adults of leaf hopper suck the cell sap from leaves, flowers and pods. Eco friendly method of insect pest management involving botanicals enhances pest control to achieve sustainable yield and quality. Keeping this in view, investigations were undertaken to manage sesame pests at Regional Research Station, Vriddhachalam.

Materials and Methods

Field experiments were conducted to assess the bio efficacy of botanicals on sesame insect pests. The treatments were azadirachtin 10000 ppm @ 1.5 ml/lit, PODF @ 1 ml, 2 ml and 3ml/lit, quinalphos 25 EC @ 2ml/lit and untreated check. The six treatments were replicated four times in a Randomized Block Design with a plot size of 5.4 x 4 m. All the recommended package of practices was followed except plant protection measures. Ten plants were selected randomly for observation during vegetative, flowering and capsule stages in each replication. Observations on the incidence of *Antigastra* population, and its damage (%), leaf hopper population were recorded. Pooled mean was worked out.

Results and Discussion

Quinalphos 25 EC @ 2 ml/lit recorded the lowest mean population of shoot webber (0.91 no./plant) followed by azadirachtin 10000 ppm @ 1.5 ml/lit and PODF@3 ml/lit (1.03 &1.05 no./plant), respectively. The same trend was observed in leaf hopper also (1.15, 1.28 &1.33 no./plant), respectively. Regarding plant damage, quinalphos 25 EC@ 2 ml/lit recorded lowest mean damage of 9 per cent followed by azadirachtin 10000 ppm @ 1.5 ml/lit (11.7%). Azadirachtin was found on par with PODF@3 ml/lit. Ahirwar *et al,* (2010) reported that the incidence of sucking pests of sesame, jassid, mirid bug and whitefly may be managed by two foliar sprays of natural and indigenous products, *viz*. Neem seed kernel extract (in cow urine) @ 30 ml/l, Neem oil @ 10 ml/l and Neem leaf extract (in cow urine) 30 ml/l. Oil formulation of PONNEEM (Pungam and neem) exhibited good ant-feedant and growth regulation activities against *Spodoptera litura* larvae (Soosaimanickam and Ignacimuthu).

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Table 1. Bio efficacy of Botanicals against major insect pests of sesame (Pooled mean of *kharif* 2019 and *rabi* 2020)

S.No.	Treatment	Shoot webber, *Antigastra catalaunalis*										Leaf Hopper			
		No. of larvae/plant					Per cent damage					No./plant			
		PTC (30 DAS)	Plant (37 DAS)	Flower (45 DAS)	Capsule (70 DAS)	Mean	PTC (30 DAS)	Plant (37 DAS)	Flower (45 DAS)	Capsule (70 DAS)	Mean	PTC (30 DAS)	Plant (37 DAS)	Flower (45 DAS)	Mean
T_1	Azadirachtin 10000 ppm @ 1.5 ml/lit	1.80 (1.67)	1.15 (1.46)	1.08 (1.44)	0.85 (1.36)	1.03 (1.42)	17.53 (24.70)	14.19 (22.07)	15.54 (23.16)	5.41 (13.17)	11.71 (19.93)	1.90 (1.70)	1.05 (1.43)	1.50 (1.58)	1.28 (1.50)
T_2	PODF @ 1 ml/lit	1.70 (1.64)	1.38 (1.54)	1.33 (1.52)	1.03 (1.42)	1.25 (1.50)	18.61 (25.51)	15.03 (22.75)	17.43 (24.63)	6.64 (14.73)	13.03 (21.09)	1.75 (1.66)	1.20 (1.48)	2.20 (1.75)	1.70 (1.64)
T_3	PODF @ 2 ml/lit	1.65 (1.63)	1.25 (1.50)	1.25 (1.50)	0.93 (1.39)	1.14 (1.46)	19.33 (26.04)	14.35 (22.20)	16.14 (23.63)	7.12 (15.30)	12.54 (20.66)	1.78 (1.66)	0.95 (1.39)	1.80 (1.64)	1.38 (1.54)
T_4	PODF@ 3 ml/lit	1.60 (1.61)	0.98 (1.40)	1.18 (1.47)	1.00 (1.41)	1.05 (1.43)	18.16 (25.18)	16.00 (23.52)	14.86 (22.61)	4.51 (11.87)	11.79 (20.00)	1.60 (1.61)	0.95 (1.39)	1.70 (1.62)	1.33 (1.52)
T_5	Quinalphos 25 EC @ 2ml/lit	1.70 (1.64)	0.85 (1.36)	1.08 (1.44)	0.80 (1.34)	0.91 (1.38)	16.54 (23.95)	11.00 (19.28)	12.06 (20.24)	3.94 (10.93)	9.00 (17.33)	1.85 (1.69)	0.90 (1.37)	1.40 (1.55)	1.15 (1.46)
T_6	Untreated check	1.90 (1.70)	2.18 (1.78)	2.85 (1.96)	3.33 (2.08)	2.79 (1.94)	17.99 (25.05)	24.79 (29.83)	26.03 (30.65)	13.26 (21.28)	21.36 (27.49)	1.83 (1.68)	2.60 (1.90)	6.00 (2.48)	4.30 (2.30)
	C.D.	0.003	0.013	0.015	0.022	0.022	0.059	0.313	0.284	1.049	0.38	0.00	0.02	0.16	0.03
	SE(d)	0.001	0.006	0.007	0.01	0.01	0.028	0.146	0.132	0.488	0.177	0.00	0.01	0.08	0.01

*Figures in parenthesis are square root/arc sin transformed values

PDOF- Pongamia Oil Derived Formulation

ES 04 BOPD 12

Efficacy of botanicals against major insect pests of sesame

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Introduction

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Materials and Methods

Field experiments were conducted to assess the bio efficacy of botanicals on sesame insect pests. The treatments were azadirachtin 10000 ppm @ 1.5 ml/lit, PODF @ 1 ml, 2 ml and 3ml/lit, quinalphos 25 EC @ 2ml/lit and untreated check. The six treatments were replicated four times in a Randomized Block Design with a plot size of 5.4 x 4 m. All the recommended package of practices was followed except plant protection measures. Ten plants were selected randomly for observation during vegetative, flowering and capsule stages in each replication. Observations on the incidence of *Antigastra* population, and its damage (%), leaf hopper population were recorded. Pooled mean was worked out.

Results and Discussion

Quinalphos 25 EC @ 2 ml/lit recorded the lowest mean population of shoot webber (0.91 no./plant) followed by azadirachtin 10000 ppm @ 1.5 ml/lit and PODF@3 ml/lit (1.03 &1.05 no./plant), respectively. The same trend was observed in leaf hopper also (1.15, 1.28 &1.33 no./plant), respectively. Regarding plant damage, quinalphos 25 EC@ 2 ml/lit recorded lowest mean damage of 9 per cent followed by azadirachtin 10000 ppm @ 1.5 ml/lit (11.7%). Azadirachtin was found on par with PODF@3 ml/lit. Ahirwar *et al,* (2010) reported that the incidence of sucking pests of sesame, jassid, mirid bug and whitefly may be managed by two foliar sprays of natural and indigenous products, *viz*. Neem seed kernel extract (in cow urine) @ 30 ml/l, Neem oil @ 10 ml/l and Neem leaf extract (in cow urine) 30 ml/l. Oil formulation of PONNEEM (Pungam and neem) exhibited good ant-feedant and growth regulation activities against *Spodoptera litura* larvae (Soosaimanickam and Ignacimuthu).

Table 1. Bio efficacy of Botanicals against major insect pests of sesame (Pooled mean of *kharif* 2019 and *rabi* 2020)

S.No.	Treatment	Shoot webber, *Antigastra catalaunalis*										Leaf Hopper			
		No. of larvae/plant					Per cent damage					No./plant			
		PTC (30 DAS)	Plant (37 DAS)	Flower (45 DAS)	Capsule (70 DAS)	Mean	PTC (30 DAS)	Plant (37 DAS)	Flower (45 DAS)	Capsule (70 DAS)	Mean	PTC (30 DAS)	Plant (37 DAS)	Flower (45 DAS)	Mean
T_1	Azadirachtin 10000 ppm @ 1.5 ml/lit	1.80 (1.67)	1.15 (1.46)	1.08 (1.44)	0.85 (1.36)	1.03 (1.42)	17.53 (24.70)	14.19 (22.07)	15.54 (23.16)	5.41 (13.17)	11.71 (19.93)	1.90 (1.70)	1.05 (1.43)	1.50 (1.58)	1.28 (1.50)
T_2	PODF @ 1 ml/lit	1.70 (1.64)	1.38 (1.54)	1.33 (1.52)	1.03 (1.42)	1.25 (1.50)	18.61 (25.51)	15.03 (22.75)	17.43 (24.63)	6.64 (14.73)	13.03 (21.09)	1.75 (1.66)	1.20 (1.48)	2.20 (1.75)	1.70 (1.64)
T_3	PODF @ 2 ml/lit	1.65 (1.63)	1.25 (1.50)	1.25 (1.50)	0.93 (1.39)	1.14 (1.46)	19.33 (26.04)	14.35 (22.20)	16.14 (23.63)	7.12 (15.30)	12.54 (20.66)	1.78 (1.66)	0.95 (1.39)	1.80 (1.64)	1.38 (1.54)
T_4	PODF@ 3 ml/lit	1.60 (1.61)	0.98 (1.40)	1.18 (1.47)	1.00 (1.41)	1.05 (1.43)	18.16 (25.18)	16.00 (23.52)	14.86 (22.61)	4.51 (11.87)	11.79 (20.00)	1.60 (1.61)	0.95 (1.39)	1.70 (1.62)	1.33 (1.52)
T_5	Quinalphos 25 EC @ 2ml/lit	1.70 (1.64)	0.85 (1.36)	1.08 (1.44)	0.80 (1.34)	0.91 (1.38)	16.54 (23.95)	11.00 (19.28)	12.06 (20.24)	3.94 (10.93)	9.00 (17.33)	1.85 (1.69)	0.90 (1.37)	1.40 (1.55)	1.15 (1.46)
T_6	Untreated check	1.90 (1.70)	2.18 (1.78)	2.85 (1.96)	3.33 (2.08)	2.79 (1.94)	17.99 (25.05)	24.79 (29.83)	26.03 (30.65)	13.26 (21.28)	21.36 (27.49)	1.83 (1.68)	2.60 (1.90)	6.00 (2.48)	4.30 (2.30)
	C.D.	0.003	0.013	0.015	0.022	0.022	0.059	0.313	0.284	1.049	0.38	0.00	0.02	0.16	0.03
	SE(d)	0.001	0.006	0.007	0.01	0.01	0.028	0.146	0.132	0.488	0.177	0.00	0.01	0.08	0.01

*Figures in parenthesis are square root/arc sin transformed values

PDOF- Pongamia Oil Derived Formulation

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ES 04 BOPD 13

Efficacy of plant derived materials on oviposition, adult emergence, survival of pulse beetle, *Callosobruchus maculatus* Fab.

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Keywords: *Blackgram, pulse beetle, botanicals*

Introduction

Pulses are an important group among staple crops, next to cereals for human diet, especially for the vegetarian population across the world as they are considered to be the main source of vegetable protein. It is recorded that 55- 60 per cent loss in seed weight and 45.50 to 66.30 per cent loss in protein content of pulses is due to infestation caused by pulse beetle or bruchids, *Callosobruchus maculatus* Fab. It is vital need to find out a safe and sound method to protect the stored products in storage. Hence the study was undertaken to test the efficacy of plant derived materials on oviposition, adult emergence, survival of pulse beetle of pulse beetle.

Materials and Methods

Twenty grams of black gram seeds were treated with following plant materials and kept in plastic containers. The completely randomized block design (CRD) was adopted with three replication. Five pairs of adult beetle were released in each container, covered with muslin cloth and were observed at one, three and five days after treatment to record the mortality of adult beetles in different treatments *viz.,* T1- Neem oil 5ml/kg, T2- Castor oil 10ml/kg, T3- Deltamethrin 11 EC 2.5ml/kg, T4- Acetone 4ml/kg, T5- Pungam oil 5ml/kg, T6- Turpentine oil 1ml/kg, T7- Control. All the adults were removed after 5 days. The number of eggs laid on grains in each treatment was counted. Fifteen days onwards treatments were observed daily to record the number of beetles emerged in each treatment and survival percentage was worked out. The data obtained from experiments were subjected to ANOVA (Analysis of variance). The data on percentage and population in numbers were transformed into arcsine and square root values, respectively before statistical analysis.

Results and discussion

The experimental results revealed deltamethrin 11 EC @ 2.5ml/kg recorded less number of pulse beetle eggs (12.33) followed by other treatments which were on par (28.67- 45.67) and control (79.33) (Table 1). .The adult emergence was low in seeds treated with deltamethrin 11 EC @ 2.5ml/kg (1.67 nos.) followed by pungam oil @ 5ml/kg and turpentine oil @ 1ml/kg (5.33 nos.), whereas in castor oil @ 10ml/kg, neem oil @ 5ml/kg and acetone @ 4ml/kg, the emergence was 7.33, 8.67 and 12.33, respectively. Survival percentage was low in all the treatments *viz.,* deltamethrin 11 EC @ 2.5ml/kg (12.00%), turpentine oil @ 1ml/kg (14.67%), acetone and pungam oil @ 5ml/kg (16.00%), neem oil @ 5ml/kg and castor oil @ 10ml/kg (17.00%) whereas in control it was high (24.33%). Choudhury (1992) also found that vegetable oils on chickpea against *C. chinensis* showed significant reduction in the number of eggs laid, adult emergence and seed damage and a laboratory experiment conducted on pre-storage seed treatment of gram (*Cicer arietinum*) with the oils of karanj, eucalyptus, neem, palas, citronella and anona against *C. chinensis* and reported that citronella and neem oil at 2.5 and 5.0 ml/kg of seed effectively controlled *C. chinensis* population by reducing oviposition rate (Biswas and Biswas 2005).

Table 1. Efficacy of plant derived materials on oviposition, adult emergence, survival of pulse beetle

Treatments	No. of eggs laid (nos)	Adult emergence (nos)	Per cent survival
T1- Neem oil @ 5ml/kg	38.33 (6.19)[bc]	8.67 (3.02)[bc]	17.00 (24.31)[a]
T2- Castor oil @ 10ml/kg	37.67 (6.14)[bc]	7.33 (2.79)[bc]	17.00 (24.23)[a]
T3- Deltamethrin @ 11 EC 2.5ml/kg	12.33 (3.50)[a]	1.67 (1.39)[a]	12.00 (20.17)[a]
T4- Acetone @ 4ml/kg	45.67 (6.75)[c]	12.33 (3.57)[c]	16.00 (23.56)[a]
T5- Pungam oil @ 5ml/kg	34.33 (5.83)[bc]	5.33 (2.39)[b]	16.00 (23.49)[a]
T6- Turpentine oil @ 1ml/kg	28.67 (5.33)[b]	5.33 (2.34)[b]	14.67 (22.42)[a]
T7- Control	79.33 (8.87)[d]	21.00 (4.63)[d]	24.33 (29.51)[b]
SEd	0.48	0.38	2.15
CD (0.05)	1.04	0.82	4.61

Figures in the parentheses are square root (nos) and arc sine (Per cent) transformed values.Means followed by same alphabet in a column do not differ significantly.

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ES 04 BOPD 14

Evaluation of plant origin oil against yellow stem borer, *Scirpophaga incertulas* Wlaker (Lepidoptera: Crambidae)

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Keywords: *Yellow stem borer, Camphor oil, Scirpophaga incertulas, dead heart, white ear*

Introduction

Rice production and productivity is affected by many biotic and abiotic factors. Insect pest and disease are the major biotic factors limiting rice productivity. Among the stem borers, the yellow stem borer (YSB) *Scirpophaga incertulas* Walker (Lepidoptera: Crambidae) is the dominant species in India (Sigsgaard, 2000) and the extent of damage caused by the yellow stem borer in rice ranges from 3 to 95 per cent in different areas of India and YSB is a chronic, monophagous pest of rice and incidence varies between fields, locations, seasons and period (Bandong and Litsinger, 2005).

Use of plant extracts or botanicals is one of the earliest and traditional practices in control of insect pests of crops. Botanicals can play a key role in management of rice pests as they are environment-friendly, safe, renewable and cost effective. Integration of botanicals in rice IPM will reduce pesticide load in environment, prevent insecticide resistance and help in conserving natural enemy populations. An alternate spraying for neem formulation is needed against yellow stem borer and the present study was conducted to identify the efficacy of camphor oil comparison with recommended neem product and chemical each.

Materials and Methods

The experiment was conducted at Tamil Nadu Rice Research Institute, Aduthurai during *rabi* 2019- 20 in Randomized Block Design (RBD), having 4 treatments which were replicated five times. The treatments were: T1- Camphor oil (1000 ml/ha); T2- Neem azal (1000 ml/ha); T3- Chlorantraniliprole-150 ml/ha; T4- untreated control. After 30 days of transplanting, first spraying was done. Observations were recorded on per cent stem borer incidence at 7 and 14 days after first spray. At 45 days after transplanting, second spraying was done. Observations were recorded on per cent stem borer incidence at 7 and 14 days after second spray and at harvest stage and the results are given below.

Results and Discussion

First spray of camphor oil and Neemazal - 1000 ml/ha showed moderate incidence (14.65 and 12.80 %) when compared to control (26.0 – 41.33 %) at 7 and 14 DAS. The Camphor oil - 1000 ml/ha application results were on par with the Neemazal - 1000 ml/ha spray and least incidence was observed in Chlorantraniliprole-150 ml/ha spray (2.40- 5.55%) at 7 and 14 DAS. White ear incidence (%) after second spray and during harvest also showed on par results with the insecticide, Chlorantraniliprole-150 ml/ha spray (3.83- 8.0 %) at 7 and 14 DAS. Highest yield was recorded in Chlorantraniliprole-150 ml/ha treated plots (6359kg/ha) followed by Neemazal - 1000 ml/ha (5974 kg/ha) and Camphor oil - 1000 ml/ha (5944 kg/ha) when compared to control (5620 kg/ha). Hence, Camphor oil 1000 ml/ha is very effective in controlling stem borer, cost effective and safe to predators and parasitoids in rice ecosystem. It also serves as a good alternate to azadirachtin 1% @ 1000 ml/ha. Multiple mode of action, *i.e.* larvicidal, repellent and ovicidal activities of many essential oils already tested and recommended to minimize the various insect pests infestation (Sarwar and Salman, 2015; Murray, 2000).

S. No.	Treatment	Dead heart incidence (%) after I spray			White ear incidence (%) after II spray			White ear incidence (%) at harvest	Yield
		7 DAS	14 DAS	mean	7 DAS	14 DAS	mean		
1	Camphor oil – 1000 ml/ha	17.3 $_b$ (22.8)	12.0 $_b$ (19.3)	14.65 (21.0)	8.62$_b$ (14.3	9.0 $_a$ (10.0)	8.8 (12.15)	4.87 $_a$ (13.0)	5944 $_a$ (5982)
2	Neemazal – 1000 ml/ha	16.60 $_b$ (22.7)	9.0 $_b$ (20.2)	12.80 (21.45)	6.53 $_a$ (16.8)	10.0 $_a$ (11.8)	8.3 (11.30)	3.61$_a$ (9.4)	5974 $_a$ (6051)
3	Chlorantraniliprole-150 ml/ha	5.55 $_a$ 12.6)	2.40 $_a$ (10.3)	3.90 (11.40)	3.83 $_a$ (13.0)	8.0 $_a$ (9.8)	5.9 (11.4)	2.21$_a$ (8.0)	6359 $_a$ (6158)
4	Untreated control	26.00$_c$ (27.50	41.33 (33.2)^c	33.60 (29.90)	23.25$_c$ (28.4)	22.0 $_b$ (24.6)	22.60 (26.5)	25.80$_b$ (32.9)	5620 $_b$ (4640)
	SED	2.56	3.18		1.78	2.51		2.28	339.00
	CD (0.05)	5.57	6.93		3.88	5.47		4.96	681.48
	CV (%)	17.66	23.64		15.74	25.50		23.25	8.66

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ES 04 BOPD 15

Assessment of the efficiency of neem and pungam soaps in the management of red gram pod borers

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Key words: *Red gram, pod borers, neem soap, pungam soap*

Introduction

Red gram is one of the most important pulse crops grown in many parts of India particularly under rainfed conditions. As this crop can thrive under various climatic conditions and can improve the soil fertility, it is a most preferable crop among the dry land farmers. However, low yields are being realized by the farmers due to the attack of multiple numbers of pod borers from the initiation of flowering to harvest. Among the pod borers, spotted pod borer was considered unmanageable because of its concealed feeding habit (Sharma, 1998). To manage these insects, farmers mainly rely on application of insecticides which resulted in environmental disturbances, detrimental effects on non target organisms, pest resurgence, pest resistance, insecticide residues etc. Hence, an attempt was made for exploring the use of botanical soaps of neem and pungam in the management of red gram pod borers.

Materials and methods

This trial was conducted during the kharif season in (2014-15) and (2015-16) at National Pulses Research Centre, Vamban with the red gram variety, VBN 3. The treatments included two sprays of neem soap (10 g/lt), two sprays of pungam soap (10 g/lt), two sprays of NSKE (5%), I spray with neem soap & II spray with indoxacarb (0.5 ml/lt.), I spray with pungam soap & II spray with indoxacarb, I spray with NSKE & II spray with indoxacarb and control. I spray was given at full flowering stage and II spray after fifteen days. Pretreatment and post treatment counts were taken before spraying and after each spray respectively. At harvest, per cent damage was recorded individually for each pod borer in the harvested pods. Two years data was pooled, analysis and interpreted.

Results and Discussion

I spray with neem soap (10 g/lt) & II spray with indoxacarb 15.8 EC (0.5 ml/lt) reduced the population of red gram pod borers effectively with 70.7% reduction over control and was followed by I spray with NSKE (5%) & II spray with indoxacarb (63.7% reduction). Two sprays of neem soap treatment was effective with 59.3% reduction in pod borers and the next best was I spray with pungam soap & II spray with indoxacarb with 58.9% reduction. Observations at harvest also revealed the superiority of I spray with neem soap & II spray with indoxacarb in reducing the pod damage. Next to this, I spray with NSKE & II spray with indoxacarb and I spray with pungam soap & II spray with indoxacarb were equally effective. Botanicals alone treatment i.e., two sprays of neem soap was equally effective as I spray with NSKE & II spray with indoxacarb and I spray with pungam soap & II spray with indoxacarb in reducing the damage of spotted pod borer. The present findings were in accordance with Pandey and Das (2016) who reported that neem and pungam soaps @ 10g/l were effective against gram pod borer in red gram.

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Table 1. Efficacy of botanical soaps against pod borers of pigeon pea in field and at harvest (Pooled data of 2014 to 2015 & 2015 to 16)

S. No.	Treatment	No. of pod borer complex / 5 rachis					Per cent reduction over control	% damage at harvest			
		PTC*	I spraying		II spraying			*H.armigera*	*M.vitrata*	Plume moth	Blue butterfly
			7 DAS	14 DAS	7 DAS	14 DAS					
1.	Neem soap (10 g/lt) – 2 sprays	18.9	9.0 (3.00)^{ab}	10.3 (3.21)^{ab}	6.3 (2.52)^{cd}	5.3 (2.31)^{c}	59.3	5.0 (12.92)^{bc}	7.0 (15.34)^{c}	4.7 (12.52)^{c}	4.3 (11.97)^{b}
2.	Pungam soap (10 g/lt) – 2 sprays	18.0	11.0 (3.32)^{c}	12.0 (3.46)^{b}	8.3 (2.89)^{e}	7.0 (2.65)^{c}	49.6	6.3 (14.54)^{c}	8.0 (16.43)^{c}	5.7 (13.81)^{c}	4.7 (12.52)^{b}
3.	NSKE (5%) – 2 sprays	18.2	10.0 (3.16)^{bc}	10.7 (3.27)^{ab}	7.3 (2.71)^{de}	6.0 (2.45)^{c}	55.3	6.0 (14.18)^{c}	8.3 (16.74)^{c}	5.3 (13.31)^{c}	4.3 (11.97)^{b}
4.	Neem soap (10 g/lt) followed by Indoxacarb 15.8 EC (0.5 ml/lt)	18.0	8.3 (2.89)^{a}	9.0 (3.00)^{a}	3.3 (1.83)^{a}	1.7 (1.29)^{a}	70.7	2.7 (9.46)^{a}	3.3 (10.47)^{a}	2.7 (9.46)^{a}	2.7 (9.46)^{a}
5.	Pungam soap (10 g/lt) followed by Indoxacarb 15.8 EC (0.5 ml/lt)	17.3	11.3 (3.37)^{c}	11.3 (3.37)^{b}	5.3 (2.31)^{bc}	3.3 (1.83)^{b}	58.9	4.3 (11.97)^{b}	5.7 (13.81)^{b}	4.3 (11.97)^{bc}	2.3 (8.72)^{a}
6.	NSKE (5%) followed by Indoxacarb 15.8 EC (0.5 ml/lt)	17.9	10.3 (3.21)^{bc}	11.0 (3.32)^{b}	4.0 (2.00)^{ab}	2.3 (1.53)^{ab}	63.7	4.0 (11.54)^{b}	5.3 (13.31)^{b}	2.7 (9.46)^{ab}	2.3 (8.72)^{a}
7.	Untreated control	18.2	20.0 (4.47)^{d}	22.0 (4.69)^{d}	17.7 (4.20)^{f}	16.3 (4.04)^{d}	--	12.7 (20.88)^{d}	14.0 (21.97)^{d}	10.7 (19.09)^{d}	7.0 (15.34)^{c}
	SEd	NS	0.13	0.14	0.14	0.20		0.93	0.67	1.25	0.83
	CD (P < 0.05)		0.29	0.30	0.32	0.44		2.03	1.46	2.74	1.82

* Pre-treatment count Figures in parenthesis are transformed value DAS - Days after spraying

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Efficacy of certain plant extracts against red spider mite *Tetranychus cinnabarinus (Biosd)* (Acarina: Tetranychidae) in *rabi*/summer groundnut

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Keywords: *Bael, Basil, Notchi, NSKE, leaf extract, propargite*

Introduction

Research conducted during the recent years has focused more on the selective use of botanical pesti- cides, because they are generally perceived to be safersearch conducted during the recent years has focused more on the selective use of botanical pesti-cides, because they are generally perceived to be safer Botanical pesticides are important alternatives to synthetic pesticides since they possess an array of beneficial properties including repellence, antifeedant, IGR activity and toxicity to insect and mite pests (Prakash *et al*., 2008). Research conducted during the recent years has focused more on the selective use of botanical pesticides, because they are generally perceived to be safer. Since, extensive and repeated spraying of synthetic pesticides over a long period of time leads to undesirable 4 R effects such as resistance in insects, residues in an environment & fresh produces and resurgence of insects pests and finally the reduction in natural enemies population. In light of this, we tested certain plant extracts against red spider mite *Tetranychus cinnabarinus* in groundnut. *T. cinnabarinus* is causing severe damage during water stress condition, which usually occurs during *rabi*/summer season (Nandagopal and Gedia, 1995).

Materials and Methods

A field experiment was conducted with groundnut variety VRI 2 during *rabi*/summer 2019-2020. The experiment was laid out simultaneously in two locations, one in farm field in Regional Research Station, Vriddhachalam and Farmer's field in Pudhukooraipet village in Vriddhacalam Taluk, Cuddalore district. Incidence of red spider mite was noticed on 70 DAS. The treatments (as in table 01) were imposed and observation on mite population no. per cm^2 was counted 24 hr before and 96 hr after imposing the treatments. The treatments were replicated thrice in a RBD. The significant effect of different treatments were statistically analysed using OPSTAT (Sheoran *et al*., 1998).

Results and Discussion

The mite infested leaves showed stippling followed by light yellowing and finally almost white with brown patches. The mite infested plants showed extensive webbing and tips of the plant appeared reddish because of the assemblage of large number of mites on them in untreated control plots as against the treated plots. Results of this experiment conducted at two locations indicated that the basil leaf extract 5% found to be an effective treatment for reducing mite population in groundnut about 82.30% followed by notchi leaf extract 5% (81.21%). However, the synthetic acaricide propargite 57 EC @ 2.5ml /lit, which reduced 92.24% mite population on 96 hr after spraying. All the treatment effects were statistically significant from each other. In could be inferred that based on the reduction (%) in mite population, yield parameters and cost economics (Table 01) three plant leaf extracts in the order of effectiveness basil leaf extract 5%>NSKE 5% > Notchi leaf extract 5% may be recommended for managing red spider mite in groundnut during *rabi*/summer season. Adulticidal toxicity, ovicidal effect and antifeedant activity of certain botanicals against the red spider mite was reported in tea for *Oligonychus coffea* (Handique *et al*., 2017) and in rose for *Tetranychus urticae* (Ragavendra *et al*., 2017).

Table 1. Management of red spider mite in groundnut during *rabi* season (Mean of two trials)

Treatment Details	Mite Population/cm^2 of leaflet		Reduction over control (%)	Yield (kg/ha)		BCR
	PTC	PST		Pod	Haulm	
T_1 - Basil leaf extract 5%	18.65	4.08	82.30	1213	2475	1:2.45
T_2 - NSKE 5%	17.26	4.37	81.07	1175	2496	1:2.37
T_3 - Bael leaf extract 5%	18.25	5.03	78.29	1199	2316	1:2.41
T_4 - Notchi leaf extract 5%	17.82	4.35	81.21	1191	2474	1:2.40
T_5 - Propargite 57 EC @ 2.5ml /lit	17.85	1.58	92.24	1183	2582	1:2.33
T_{6} - Control	18.25	23.12	-	963.00	1660	1:1.97
C.D.		0.20	-	60.93	114.86	-
SE(m)		0.06	-	19.09	35.98	-
SE(d)		0.09	-	27	50.89	-
C.V.		4.18	-	2.939	2.66	-

Values are mean of three replications for each trial. Values in the paranthesis are square root transformed values. PTC-Pre-treatment Count; PST-Post-treatment count.

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ES 04 BOPD 17

Efficacy of Plant powders on the mortality of rice weevil, *Sitophilus oryzae* L. in stored sorghum

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Key words*: Plant powders, Sitophilus oryzae, Sorghum.*

Introduction

Sorghum, *Sorghum bicolor* L is the fifth most important crop in the world after rice, wheat, corn and barley (Selva Rani *et al.,* 2019). Grater losses are inflicted during storage. Losses of food grains in the farmer holding in Tamil Nadu sorghum (16%), rice 12.9%) pearl millet (14%) and maize (12. 7%) (Suleiman and Rugumamu. 2017). The rice weevil, *Sitophilus oryzae* L. (Colepotera: Curculionidae) is a serious pest of various food grains like rice, wheat and maize under storage. At present, pest control measures in storage rely on the use of synthetic insecticides and fumigants, which is the quickest and surest method of pest control but it is also not advised to mix the insecticides with food grains. The present study has been focused to investigate the comparative effectiveness of different insecticidal plants against the rice weevil *S. oryzae*

Materials and methods

Laboratory studies were conducted at Department of Crop Protection, Agricultural College and Research Institute, Valavachanur – 606 753, Thiruvannamalai District during 2017-2018. Parts of ten plants, Black pepper seed, Chilli fruit, Neem leaf, Sankupuspam leaf, Akathi leaf, Senna leaf, Tulasi leaf, Tulasi leaf, Lantana leaf and The experiment on insecticidal (% mortality) twenty grams of stored sorghum seeds were taken in plastic container powder of various plant parts at the rate of 2: 100 (w/w) was added to sorghum seeds and shaken thoroughly. Untreated check was maintained. Thirty newly emerged adults weevils were released in to each plastic container and kept in laboratory. Mortality (lack of locomotion and/ or response to repeated probing) was recorded at one day intervals for up to seven days. The experiment was laid out in Completely Randomized Design (CRD) with three replication for each treatments. Per cent mortality was compared with untreated control as per Suleiman and Rugumamu (2017).

Results and discussion

Among the plant powders, *P. nigrum* 2 % seed powder registered 100.00 per cent mortality at 1 DAT while in control no mortality was observed. The similar result were reported by (Oguntola *et al.,* 2019). At 7 DAT, highest mortality (95.55%) was observed in *C. annum* which was followed by *A. indica* (89.99 %) and *S. grandiflora* (89.99 %) among the plant powders minimum % mortality was observed in *C. angustifolia* (45.55 %) as compared to untreated control 49.99 % mortality was recorded (Table 1).

Table 1. Effect of plant powders on the mortality of rice weevil, *Sitophilus oryzae* *in stored sorghum*

Treatments	Adult mortality (%) – Days after treatments (DAT)*							MEAN
	1 DAT	**2 DAT**	**3 DAT**	**4 DAT**	**5DAT**	**6 DAT**	**7 DAT**	
Piper nigrum 2 %	100.00 (89.47)	100.00 (89.47)	100.00 (89.47)	100.00 (89.47)	100.00 (89.47)	100.00 (89.47)	100.00 (89.47)	100.00 (89.47)
Capsicum annum 2 %	5.55 (13.47)	31.11 (33.89)	54.44 (47.55)	62.21 (52.09)	77.77 (61.88)	91.11 (72.72)	95.55 (77.99)	59.67 (51.37)

Azadirachta indica 2 %	4.44 (11.49)	42.22 (40.52)	49.99 (45.00)	67.77 (55.82)	78.88 (63.73)	85.55 (68.24)	89.99 (72.31)	59.87 (51.09)
Clitoria ternatea 2 %	5.55 (13.47)	15.55 (23.19)	27.77 (31.76)	36.36 (37.25)	46.66 (43.08)	73.33 (58.93)	82.22 (65.08)	14.10 (38.97)
Abutilon indicum 2 %	4.44 (11.99)	19.99 (26.51)	26.66 (31.06)	38.88 (38.57)	49.99 (44.99)	66.66 (54.75)	75.55 (60.44)	40.31 (38.33)
Sesbania grandiflora 2 %	12.22 (20.32)	28.88 (32.47)	44.44 (41.80)	81.10 (64.37)	83.33 (65.97)	85.55 (67.68)	89.99 (71.72)	60.78 (52.02)
Cassia angustifolia 2 %	2.22 (7.18)	19.99 (26.42)	19.99 (26.51)	31.11 (33.89)	38.88 (38.57)	42.22 (40.52)	45.55 (42.44)	28.56 (30.79)
Ocimum canum 2 %	7.77 (16.11)	11.11 (19.42)	19.99 (26.51)	29.97 (33.17)	43.33 (41.11)	59.99 (50.77)	73.33 (58.93)	35.07 (35.15)
Leucas aspera 2 %	4.44 (11.99)	18.88 (25.68)	27.77 (31.76)	44.44 (41.80)	47.77 (43.72)	53.33 (46.91)	65.65 (54.06)	37.45 (36.56)
Lantana camara 2 %	4.44 (11.99)	24.44 (29.25)	47.77 (43.72)	59.99 (50.77)	69.69 (56.87)	74.44 (59.67)	83.33 (65.97)	52.05 (45.46)
Untreated control	0.00 (0.52)	16.66 (24.0	25.44 (30.21)	32.24 (34.53)	39.99 (39.22)	46.66 (43.08)	49.99 (44.99)	30.14 (30.94)

**Mean of three replication,* DAT- Days After Treatment,

Figures in parentheses are transformed arcsine values

SED	CD (0.05)	
Treatment	0.87	1.81 **
Period	0.64	1.36**
Treatment x period	2.06	5.00**

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ES 04 BOPD 18

Efficacy of Plant Powders on adult emergence and seed weight loss Pulse beetle, *Callosobruchus maculatus* (F.) in black gram

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Key words: *Plant products, pulse beetle, black gram seeds*

Introduction

Bruchids are known to inflict quantitative and qualitative losses to stored pulses. *Callosobruchus maculatus* is one of the most serious pests brought into storage containers with harvested black gram that can cause total loss of the stored crop in a few months. Plant products are cheap and are easily accessed by farmers. The plant products such as leaf, bark, powder or extracted oils reduced the oviposition rate, inhibited the adult emergence of bruchids, and decreased the seed damage rate (Soe *et al.,* 2020). Therefore, present study seven plant powders were tested for the adult emergence and seed weight loss against caused by *C.maculatus* infesting stored black gram seeds.

Materials and methods

Laboratory experiments were carried out at of Crop Protection, Agricultural College and Research Institute, Vazahavacnur during 2018 – 2019. Seven insecticidal plants Black pepper seeds, Akathi leaf, Tutti leaf, Kolinci leaf, Neem leaf, Kovai kai leaf and *Acalypha* leaf powders are collected, washed with distilled water and shade dried at room temperature for seven days and used for conducting experiments. Twenty grams of black gram seeds were taken in glass bottles. The powder of various plant parts at the rate of 2 :100 (w/w) were added to black gram seeds and shaken thoroughly. Then the glass bottles were covered firmly using muslin cloth. Five pairs of newly emerged adults of male and females *C. maculatus* were released to each glass bottle, covered firmly and kept in laboratory at ambient conditions. Three replications were maintained for each treatment. Numbers of eggs laid on the seeds were counted on third day after the release of beetles. On 5th day after the release of beetles counts on translucent unhatched eggs and opaque hatched eggs were taken and hatchability percentage was worked out. On 15 th day after the release of beetles all the dead insects were removed from the bottles to prevent them from the mixing with first generation (F1) offspring. The number of newly emerged adults were counted and removed from the bottle once in three days till the complete emergence of F1 offspring (up to 30 days after treatment)

Seed weight loss

The weight of the seed was taken on 30, 45 and 60 after the treatment and seed weight loss percentage was worked out.

$$\text{Percent weight loss} = \frac{\text{Initial weight of grain} - \text{Final weight loss of grain}}{\text{Initial weight of grain}} \times 100$$

The experiment was laid out in Completely Randomized Design with three replication were maintained for each treatments.

Results and discussion

P. nigrum seed powder 2 per cent seed powder acted as best oviposition deterrent compared to untreated control.

The present findings also collaborate with the findings of Manju, *et al.,* (2019). Next effective treatment was neem, *Azadirachta indica* treated seeds distinct in reducing the oviposition with only 42.33 eggs on treated black gram seeds followed by *Coccinia indica* (47.66Nos) Regarding the adult emergences, no adult beetle emergence was recorded in *P. nigrum* and it was significantly different from other treatments. The present findings are in agreement with the reports of Emeasor and Chukwu, (2019) who found that 2g of *P. nigrum* powder admixed with 20 g of mung bean seeds resulted complete inhibition of adult beetle emergences of *C. macultus*.

Table 1. Effect of insecticidal plant powders on oviposition, hatchability and adult emergence of *Callosobruchus maculatus* (F.)

Treatments***	No. of eggs laid /5 females *	Hatchability** %	No. of adults emerged *	% Seed weight loss**		
				30 DAT	45DAT	60DAT
Piper nigrum 2%	0.00 (0.00)a	0.00 (0.52)a	0.00 (0.00)a	0.00 (0.52)a	0.00 (0.52)a	0.00 (0.52)a
Sesbania grandiflora 2%	72.33 (1.24)e	82.59 (65.65)d	49.00 (1.70)d	26.25 (30.71)e	28.26 (31.79)d	33.22 (37.77)d
Abutilon indicum 2%	55.00 (1.73)c	74.64 (59.87)c	29.66 (1.46)bc	12.45 (20.64)c	14.84 (22.39)b	22.84 (23.41)c
Tephrosia purpurea 2%	68.33 (1.83)d	66.91 (54.91)b	23.66 (1.51)b	12.88 (21.02)c	15.48 (22.95)b	19.50 (25.55)c
Azadirachta indica 2%	42.33 (1.62)b	77.81 (62.00)c	32.00 (1.50)c	10.15 (18.57)b	13.88 (22.02)b	15.51 (22.98)b
Coccinia indica 2 %	47.66 (1.67)bc	75.28 (60.25)c	26.66 (1.42)b	17.20 (24.49)d	20.97 (26.93)c	22.50 (32.40)c
Acalypa indica 2%	64.44 (1.80)d	69.29 (56.41)b	31.00 (1.49)c	16.46 (23.93)d	24.64 (27.87)cd	28.55 (32.66)d
Control	107.00 (2.07)f	90.73 (72.27)e	90.00 (1.96)e	34.26 (35.82)f	39.22 (37.82)e	45.26 (46.37)e

DAT- Days after treatments, *Figures in parentheses are transformed square root values, ** Figures in parentheses are transformed arcsine values ,*** Mean of three replications

In a column means followed by same letter(s) are not significantly different (p=0.05) by DMRT

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ES 04 BOPD 19

Evaluation of Poly-herbal Formulation as a Green gram (*Vigna radiata*) Seed Protectant against Pulse beetle *Callosobruchus chinensis* (L.) (Coleoptera: Bruchidae)

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Key words: *Cleome viscosa, Pongamia pinnata, Azadirachta indica, Callosobruchus chinensis green gram seed,*

Introduction

Green gram is attacked by many as 65 different insect species at its different pre- and post-harvest stages (Lal babu *et al.,* 2017). Among these, the pulse beetle, *Callosobruchus chinensis* (L.) (Coleoptera : Bruchidae) is the major and most destructive pest causing 50 to 60% damages in greengram seeds under storage condition (Ramzan *et al.,* 1990). During post-harvest handling stage 20 -30% of our production is lost due to stored grain insects, notably bruchid beetles. The larvae, being internal feeders, are difficult to control with chemical insecticides. The pest can cause up to 100% loss of stored pulses seeds in a few months in tropical climatic condition.

Materials and methods

In order to find out the suitability of effective combination of poly-herbal as a green gram seed protectant, seed storage experiment was conducted for a period of ten months with following treatments T1 – Seed treated with poly-herbal formulation @ 5ml/kg of seed, T2 - Seed treated with poly-herbal formulation @ 10ml/kg of seed, T3 - Seed treated with Malathion EC @ 10ml/kg of seed, T4 - Seed treated with Pongamia oil @ 10ml/kg of seed and T0 – Control. These treatment were evaluated to study their efficacy in two packing materials *viz.,* cloth bag (C1) and polylined bags (C2) Based on the insecticidal activity bio-assay results, ideal combination of poly-herbal formulation having insecticidal activity was identified and was used for storage experiment in two different doses. One kilogram of seeds were used for each replication. The study was carried out in Completely Randomised Block design with four replications for each treatment. The seeds were treated by uniformly coating the formulations in a plastic container and transferred to the respective packing bags and sealed.

Results and Discussion

Effect of poly-herbal formulation-based pre-storage treatment on weight loss during storage

The treatment imposed on the green gram seeds showed significant difference in seed content loss by weight throughout the storage period in the seed stored due to the infestation of the beetles and the damage caused by different stages of the pulse beetle on the. Significant difference was noticed among the packaging materials used for storing the green gram seeds during different storage period from 0 to 10 months of storage. Among the treatment T2 poly herbal @ 10ml/kg was found to be the most effective treatment recording a weight of 836 and 932.14g in cloth bag and polylined bags, respectively after 10 months of storage. The untreated control recorded a weight of 430.25g which was stored in cloth bag which amounts to a loss of 569.72 g during storage. Among the interaction between the treatment, package material and period of storage, $T_2C_2P_{10}$ recorded the highest weight of seeds 932.14g. Plant material based essential oils are target specific, nontoxic to human and beneficial organisms, less prone to insect resistance and resurgence, biodegradable and less expensive and therefore act as promising grain protectants (Said and Pashte, 2015). . Toxicity of menthol, methonene, limonene, α-pipene, β-pipene and linalool against S. oryzae is proved to its effect on acetylcholinesterase enzyme activity (Lee *et al.,* 200

Effect of poly-herbal formulation based pre-storage treatment on Weight loss during storage

Trt	Weight (g)																	
	Period of storage																	
	P0			P2			P4			P6			P8			P10		
	C1	C2	Mean	C1	C2	Mean	C1	C2	Mean	C1	C2	Mean	C1	C2	Mean	C1	C2	Mean
T0	1000 (31.63)	1000 (31.63)	1000 (31.63)	930.53 (30.51)	940.26 (30.67)	935.40 (30.59)	843.65 (29.05)	863.21 (29.38)	853.43 (29.00)	730.63 (27.03)	750.67 (27.40)	740.65 (27.72)	605.25 (24.61)	632.65 (25.16)	618.95 (24.88)	430.25 (20.75)	486.23 (22.06)	458.24 (21.42)
T1	1000 (31.63)	1000 (31.63)	1000 (31.63)	985.63 (31.40)	972.30 (31.18)	958.97 (30.97)	910.32 (30.17)	920.17 (30.34)	915.25 (30.26)	850.63 (29.16)	877.77 (29.63)	864.20 (28.40)	783.26 (27.99)	830.72 (28.83)	806.99 (28.40)	723.25 (26.90)	765.24 (27.67)	744.245 (27.29)
T2	1000 (31.63)	1000 (31.63)	1000 (31.63)	1000 (31.63)	1000 (31.63)	1000 (31.63)	972.36 (31.19)	985.77 (31.40)	979.07 (31.29)	946.32 (30.77)	963.23 (31.04)	954.78 (30.90)	938.15 (30.63)	938.25 (30.63)	926.2 (30.44)	863 (29.38)	932.14 (30.53)	897.57 (29.96)
T3	1000 (31.63)	1000 (31.63)	1000 (31.63)	1000 (31.63)	1000 (31.63)	1000 (31.63)	943.23 (30.72)	963.12 (31.04)	953.18 (0.71)	903.45 (30.06)	921.07 (30.35)	912.26 (0.70)	857.65 (29.29)	876.52 (29.61)	867.08 (0.70)	818.02 (28.60)	836.22 (28.92)	827.12 (28.76)
T4	1000 (31.63)	1000 (31.63)	1000 (31.63)	983.00 (31.36)	978.32 (31.28)	935.40 (30.59)	950.07 (30.83)	965.33 (31.07)	957.70 (30.88)	913.77 (30.23)	930.80 (30.51)	922.29 (30.21)	878.33 (29.64)	898.13 (29.97)	888.23 (28.66)	836.03 (28.92)	856.34 (29.27)	846.18 (29.09)
Mean	1000 (31.63)	1000 (31.63)	1000 (31.63)	964.75 (31.06)	970.25 (31.15)	958.97 (30.57)	923.93 (30.40)	939.52 (30.65)	931.72 (30.53)	868.96 (29.48)	888.71 (29.81)	878.83 (29.65)	806.528 (28.40)	835.25 (28.90)	820.89 (28.65)	734.11 (27.10)	775.23 (27.8519)	754.67 (27.48)

	T	C	P	TxC	PxC	TxP	TxCxP
SEd	0.4745	0.00608	0.0105	0.4746	0.0149	0.4751	0.4321
CD (p=0.05)	1.0944	10.1205	0.0208	1.0945	0.0295	1.0952	1.251

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ES 04 BOPD 20

Antifeedant effect of ethyl acetate extract of certain botanicals against maize fall armyworm, *Spodoptera frugiperda* (J.E.Smith)

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Keywords: *Spodoptera frugiperda, ethyl acetate, botanicals, antifeedant, Sweiteinia macrophylla, Simaruba glauca, Melia azaderach*

Introduction

In Tamil Nadu, fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) is an introduced insect pest of maize in recent days. During July-August 2018, their incidence ranged from 9.0 to 62.5 percent at various locations in India. It attacks almost all stages of maize with high damage of 77.2% (Suby *et al.,* 2020). As the continuous use of insecticides by farmers will lead to adverse impact on human health, insecticide resistance, insecticide residue, we have planned to find ecofriendly solutions for its management by evaluating the effect of certain botanicals against *S. frugiperda*.

Materials and methods

The test plant powders of seven botanicals *viz*., seed of *Swietenia macrophylla*, leaf *Andorgraphis paniculata*, *Vitex negundo*, *Clerodendron inerme, Melia azaderach, Simaruba glauca* and *Anisomalis malabarica* were extracted using ethyl acetate in reflux apparatus for 6 hours. The extract was collected, condensed and the residue were collected for further evaluation. The botanical extracts at 5% were tested for their antifeedant effect against third instar larva of *S. frugiperda* by leaf dip bioassay during 2020 at Natural Pesticides Laboratory, Department of Agricultural Entomology, Agricultural College and Research Institute, Madurai. The extracts were dissolved in solvent, DMSO 1% and mixed with adjuvant Tween 20 (0.01%) and water before treatment. Totally there were nine treatments, including azadirachtin 1 EC 2 ml/lit as treated check and untreated check. Each treatment was replicated three times with five larvae per replication. The experiment was conducted under Completely Randomised Block Design. Observations were made on the leaf fed area by the larva after 24, 48, 72 hours of exposure and absolute antifeedant index was estimated.

Results and discussion

When the third instar larvae were fed with *C. inerme* 5% treated leaf, the area of leaf fed was minimum (33.33 mm^2) at 24 hours after treatment (HAT) followed by *Swietenia macrophylla* (39.0 mm^2) (Table 1) while untreated control recorded 189.67 mm^2 at the same time. Whereas, *M. azaderach* 5% recorded only 22.13 mm^2 leaf area fed, at 48 HAT followed by *Swietenia macrophylla* (46.90 mm^2). Similar trend was noted at 72 HAT, while, the standard check, Azadirachtin 1% recorded the minimum leaf area fed (1.93 mm^2). With the increase in time of exposure, the area of leaf fed was minimized in test botanicals, viz., *M. azaderach* 5% and *S.macrophylla* 5%, whereas, in *C. inerme* 5%, with increase in time, the antifeedant efficacy was declining. Considering the cumulative leaf area fed, it was minimum in *S. macrophylla* 5% (108.57 mm^2) and *M. azaderach* 5% (121.73 mm^2). *M. azaderach* 5% was statistically on par with the standard check, Azadirachtin 1% (135.93 mm^2), while untreated check recorded the maximum leaf area fed (922.27 mm^2). Antifeedant index was more (78.94%) in *S. macrophylla* 5% and *M.azaderach* 5% (76.68%). *M.azaderach* 5% was on par with Azadirachtin 1% (74.31%). This finding was supported by the reports of Rajasekaran and Kumaraswami (1985) and Alvarez *et al*. (2021), who stated that extract of *S. macrophylla* seeds and twigs showed the most promising antifeedant activity against *S. litura* and *S. frugiperda,* respectively.

Table 1. Antifeedant effect of ethyl acetate extracts of botanicals (5%) against *S. frugiperda*

S. No.	Treatments	Mean leaf area fed/larva (mm^2)[#]				Antifeedant index	% reduction over control
		24 HAT	48 HAT	72 HAT	Cumulative leaf area fed		
1	*Swietenia macrophylla* 5% SE	39.00 (6.24)[b]	46.90 (6.84)[c]	22.67 (4.76)[c]	108.57 (10.41)[a]	78.94 (8.88)[a]	88.23
2	*Andrographis paniculata* 5% LE	157.67 (12.55)[f]	324.00 (18.00)[g]	157.87 (12.56)[e]	639.53 (25.28)[h]	18.10 (4.25)[h]	30.66
3	*Vitex negundo* 5% LE	167.60 (12.94)[g]	179.20 (13.38)[f]	195.47 (13.98)[f]	542.27 (23.28)[f]	25.95 (5.09)[f]	41.20
4	*Clerodendron inerme* 5% LE	33.33 (5.77)[a]	124.03 (11.13)[d]	124.73 (11.16)[d]	282.10 (16.79)[d]	53.15 (7.29)[c]	69.41
5	*Melia azaderach* 5% LE	92.73 (9.62)[e]	22.13 (4.70)[a]	6.87 (2.62)[b]	121.73 (11.03)[b]	76.68 (8.76)[ab]	86.80
6	*Simaruba glauca* 5% LE	73.00 (8.54)[c]	270.77 (16.45)[k]	272.48 (16.50)[g]	616.25 (24.82)[g]	19.89 (4.46)[g]	33.18
7	*Anisomelis malabarica* 5% LE	169.27 (13.01)[h]	166.63 (12.90)[e]	154.60 (12.43)[e]	490.50 (22.14)[e]	30.56 (5.53)[d]	46.81
8	Azadirachtin 1% (2 ml/lit.)	89.27 (9.44)[d]	44.73 (6.68)[b]	1.93 (1.38)[a]	135.93 (11.65)[c]	74.31 (8.62)[b]	85.26
9	Untreated control	189.67 (13.77)[i]	426.53 (20.65)[h]	306.07 (17.49)[h]	922.27 (30.36)[i]	--	
	CD (0.5)	0.09**	0.14**	0.11**	0.18**	0.14**	
	SEd	0.1985	0.2894	0.2220	0.3778	0.0671	

[#] Mean of three replications; SE – Seed extract, LE – Leaf extract, HAT – Hours After Treatment. Figures in the parentheses are square root transformed values. In the column, the means followed by same letters are not significantly different from each other by LSD (P=0.05)

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Acaricidal property and chemical profiling of ethanolic fruit extract of *Citrullus colocynthis* (L.) on two spotted spider mite, *Tetranychus urticae* Koch

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Keywords: *Citrullus colocynthis, ethanolic fruit extract, Tetranychus urticae, mortality, CRD, GC-MS*

Introduction

The two spotted spider mite, *Tetranychus urticae* (Acari: Tetranychidae) is a major pest in many field and horticultural crops which could cause 50% yield loss. The bitter apple, *Citrullus colocynthis* (L.) (Family: Cucurbitaceae) is a wild perennial vine plant and distributed largely in the desert areas, native of the Mediterranean Basin and Asia, especially Turkey and Nubia. The insecticidal property of stem, leaves, fruits and seeds of *C. colocynthis* was reported earlier. The seed oil consists of 67–73% linoleic acid, 10–16% oleic acid, 5–8% stearic acid and 9–12% palmitic acid, which were reported to possess insecticidal property (Rahuman *et al.,* 2008). Hence, the present study was aimed to evaluate an efficacy of ethanolic fruit extract of *C. colocynthis* against *T. urticae.*

Materials and Methods

The active principle was extracted from *C. colocynthis* fruit powder (ripened, unripened and mixed fruit) using ethanol (1:10) in rotational orbital shaker at 50°C for 6 days. The residue was collected by filtration and subjected to rotary vacuum evaporation at 60°C for 2 hrs at 110-120 rpm and the weight of the residue was recorded after complete drying. The leaf dip bioassay technique was followed to assess the acaricidal activity of *C. colocynthis* ethanolic extract against two spotted spider mite, *T. urticae*. The treated leaves were placed upside down over a tissue paper saturated with tap water at the base of the Petri dish (90 × 17 mm). Twenty adult female mites were transferred to the treated surface using fine sable hair brush and incubated at 26±1° C temperature and 70±10 % RH. The mortality of mites was determined after 24 hrs of exposure. An experiment was laid out in Completely Randomized Design (CRD) with three replications. An untreated control was maintained by dipping leaf discs in distilled water. The median lethal concentration (LC_{50}) was determined by Finney's Probit analysis method. The phytochemicals present in the ripened fruit was analyzed in GC-MS-MS.

Results and discussion

The toxicity test revealed that the mixed fruit extract at 5% could inflict cent per cent mortality of mites, while the ripened fruit could able to produce cent per cent mortality at 4% itself and whereas the unripened fruit 5% caused 96.65% mortality after 24 hours of exposure. The observed LC_{50} value was 0.495% (ripened fruit), 1.064% (unripened fruit) and 1.482% (mixed fruit). Similarly, the methanolic extract of *C. colocynthis* was found to be effective against adult grasshopper (*Chrotogonus trachypterus*) and house fly (*Musca domestica* L.) larvae and pupae. Different solvent extracts (n-hexane, methylene chloride, chloroform and ethanol) of *C. colocynthis* fruits were tested against *Aphis craccivora* and the highest insecticidal effect (LC_{50} 11003 ppm) was obtained from the ethanol extract. Chinniah *et al.* (2020) also reported 74.90% reduction of citrus mite, *Panonychus citri* by spraying *C. colocynthis* fruit 5% ethanol extract. The major phytochemical constituents present in the ripened fruit were 9,12-Octadecadienoic acid (34.44% area), Ethyl 9.cis.,11.trans.-octadecadienoate (16.19% area) and Linoleic acid (10.13% area). This result was supported by the report of Patil and Kutemate (2018), who stated that Linoleic and Oleic acids isolated from petroleum ether fraction of *C. colocynthis* seeds showed larvicidal activity against mosquitoes. It is concluded that the methanolic extract of ripened fruit had LC50 of 0.495%, possessed the insecticidal phytochemicals.

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Table 1. Efficacy of *C. colocynthis* fruit extract against *Tetranychus urticae*

Treatments	N	Slope ± SE	χ^2	LC_{50} (%)	50% fiducial limits		LC_{95} (%)	95% fiducial limits	
					LL	UL		LL	UL
Mixed fruit	360	2.531 ± 0.074	0.708	1.482	1.059	2.074	6.742	4.819	9.433
Ripened fruit	360	1.560 ± 0.126	0.969	0.495	0.280	0.875	5.658	3.204	9.992
Unripened fruit	360	2.461 ± 0.080	0.977	1.064	0.742	1.526	5.012	3.497	7.185

N - Number of mites tested, SE - Standard Error, LC_{50} - Median lethal concentration,

LL - Lower limit, UL - Upper limit

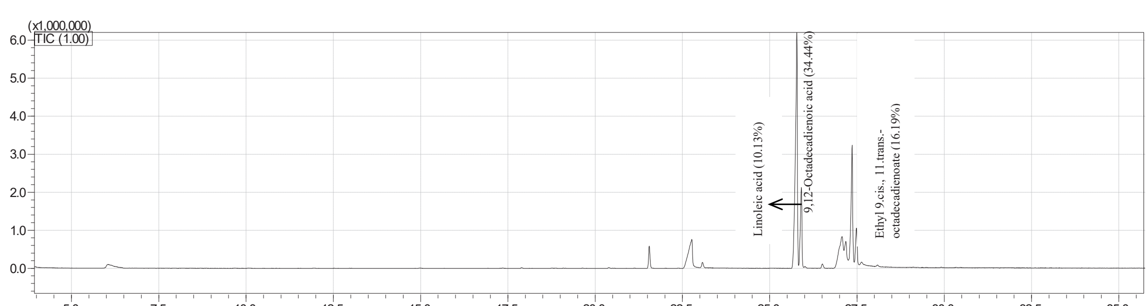

Fig 1. GC-MS chromatogram of ripened ethanolic fruit extract of *Citrullus colocynthis*

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Evaluation of green insecticides for management of spotted pod borer, *Maruca vitrata* in Pigeon pea

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Key words: *Pigeon pea, Spotted pod borer, M. vitrata, Green insecticides, evaluation*

Introduction

Pigeon pea (*Cajanus cajan* L) is the second most important pulse crop of India after chickpea and the losses due to insect pests are much higher in pulses than cereals. The losses due to insect pests are much higher in pulses due to the feeding of economic parts *viz.,* buds, flowers and pods. Among the insect pests, legume pod borer, *Maruca vitrata* (Geyer), gram pod borer, *Helicoverpa armigera* (Hubner) and pod fly, *Melanagromyza obtusa* (Malloch) are the major biotic constraints. In the recent years, *M. vitrata* is the major limiting constraint, as the larvae feed by remaining inside the webbed mass of leaves, flowers and pods. Due to pesticide resistance in pod borer complex and subsequent promotion of organic pest management (IPM), the need for the development of safe, economic and effective pest management strategies have become serious issues. Keeping this in view, evaluation of green insecticides as an eco-friendly strategy has to be evolved and tested to assess its yield on pigeon pea.

Materials and Methods

A field experiment was conducted at Agricultural Research Station, Virinjipuram to evaluate the efficacy of various biological and botanical insecticides towards *M. vitrata.* An experiment was laid out using CO (Rg) 7 with eight treatments (Table 1) and three replications in a randomized block design during *kharif* 2020. All the agronomic practices were followed as per Tamil Nadu Agricultural Crop production guide, 2020. Totally three sprays were scheduled and first spray commenced at 50 per cent flowering stage with 10 days interval. Observations on the pre-count population, 3, 7 and 10 days after spray (DAS), pod damage and grain yield was recorded the data thus obtained were analyzed using MS Excel 2010.

Results and Discussion

The precount larval population of *M. vitrata* ranged from 5.10-5.33 (Nos/plant). After first spray at 10 DAS, there existed a significant difference in the larval population among the treatments with a population of 5.10-5.66 nos per plant and the untreated plots recorded with 6.61 Nos per plant. After second application of treatments, at 3 DAS, *Bacillus thuringiensis var. kurstaki* @ 2.0 g l^{-1} recorded with the lowest population of 0.44 No. per plant followed by Azadirachtin 1% @ 2.0 ml l^{-1} (1.00 No/plant). The pod damage at the time of harvest was also recorded in various treatments with the lowest pod damage in spinosad @ 0.5 ml l^{-1} (10.6 %) treated plots followed by Emamectin benzoate @ 0.4 g l^{-1} (12.6 %) and *Bacillus thuringiensis var. kurstaki* @ 2.0 g l^{-1} (14.6 %). The highest grain yield was recorded in spinosad @ 0.5 ml l^{-1} treated plots 677.67 kg/ha. The same author, Thilagam *et al*. 2020 and Ojha *et al*., 2018also reported similar findings with superiority of biopesticides especially *Bacillus thuringiensis* var *kurstaki* and *Beauveria bassiana* in controlling podborer complex.

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Table 1. Evaluation of eco-friendly approaches for the management of spotted pod borer, *Maruca vitrata*

Treatments	Dose (ml or g/ L)	*M. vitrata* larval population (No./plant)										Pod damage (%)	Grain Yield (Kg/ ha)
		I spray				II spray			III spray				
		Precount	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS		
T1: *Bacillus thuringiensis* var.*kurstaki*	2.0	5.66	1.99 (1.41)[a]	1.77 (1.33)[a]	5.66 (2.38)[a]	0.44 (0.67)[a]	4.89 (2.21)[a]	4.44 (2.11)[a]	1.22 (1.10)[a]	4.00 (2.00)[a]	3.88 (1.97)[ab]	14.6[b]	573.3
T2: *Beauveria bassiana*	5.0	5.66	1.77 (1.33)[ab]	1.99 (1.41)[b]	5.31 (2.30)[a]	1.22 (1.11)[ab]	5.33 (2.31)[a]	6.00 (2.45)[ab]	1.00 (1.00)[a]	4.88 (2.21)[ab]	4.55 (2.13)[bc]	18.6[c]	520.0
T3: Emamectin benzoate	0.4	5.33	1.55 (1.24)[ab]	2.44 (1.56)[c]	5.33 (2.31)[a]	1.11 (1.05)[ab]	4.44 (2.11)[a]	7.00 (2.65)[b]	0.89 (0.94)[a]	4.44 (2.11)[ab]	4.33 (2.08)[ab]	12.6[b]	650.0
T4: Spinosad	0.5	5.55	1.93 (1.39)[ab]	2.76 (1.66)[d]	5.54 (2.35)[a]	1.22 (1.11)[ab]	5.11 (2.26)[a]	6.11 (2.47)[ab]	0.89 (0.94)[a]	3.55 (1.89)[a]	3.22 (1.79)[a]	10.6[a]	677.7
T5: Neem leaf extract	20.0	5.10	2.10 (1.45)[ab]	2.44 (1.56)[c]	5.10 (2.26)[a]	0.89 (0.94)[ab]	6.66 (2.58)[a]	6.89 (2.62)[b]	0.66 (0.81)[a]	6.67 (2.58)[c]	6.00 (2.45)[cd]	26.0[d]	526.7
T6: Azadirachtin 1%	2.0	5.10	2.55 (1.60)[b]	3.12 (1.77)[e]	5.14 (2.27)[a]	1.00 (1.00)[b]	5.66 (2.38)[a]	6.55 (2.56)[b]	1.00 (1.00)[a]	5.78 (2.40)[bc]	4.89 (2.21)[bc]	20.6[c]	566.7
T7: NSKE 5%		5.33	3.33 (1.82)[b]	3.73 (1.93)[f]	5.29 (2.30)[a]	1.45 (1.20)[b]	7.55 (2.75)[a]	6.77 (2.60)[b]	1.00 (1.00)[a]	5.89 (2.43)[bc]	6.33 (2.52)[d]	24.6[d]	473.3
T8: Untreated check	-	5.33	6.40 (2.53)[c]	6.44 (2.54)[g]	6.61 (2.57)[b]	3.66 (1.91)[c]	11.56 (3.40)[b]	11.77 (3.43)[c]	9.88 (3.14)[b]	11.33 (3.37)[d]	11.89 (3.45)[e]	51.3[e]	403.3
SEd		0.02	0.19	0.02	0.07	0.21	0.28	0.19	0.23	0.18	0.14	1.16	27.05
CD<0.5 %		0.05	0.41	0.05	0.15	0.16	0.61	0.41	0.50	0.38	0.31	2.49	58.03

Values in parenthesis are square root transformed values

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Evaluation of organic production practices for the management of fall army-worm, *Spodoptera frugiperda* (JE Smith) (Noctuidae: Lepidoptera) infesting maize, *Zea mays* L.

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Key words: *Maize, fall armyworm, organic management, silicon, damage assessment*

Introduction

Maize (*Zea mays* L.) is the most important cereal crop being cultivated in an area of 180.63 m ha in 165 countries across the world with a production of 1134 million tonnes (APEDA, 2019). Fall armyworm, *Spodoptera frugiperda* (J E Smith) is emerging as the most destructive pest of maize in India since its report during May 2018. Its rapid spread to more than 90 per cent of maize growing areas of diverse agro-ecologies of India within a span of 16 months presents a major challenge to smallholder maize farmers, maize-based industries as well as food and nutritional security (Suby *et al*., 2020). Fall armyworm is predicted to cause 21 to 53 per cent loss in annual maize production in the absence of control measures (Day *et al*., 2017). In agricultural systems, silicon is applied as a crop protection treatment and maize is one of the major crops that respond to silicon application (Liang *et al*., 2015). Hence, present study was undertaken to test the efficacy of silicon in the management of fall armyworm.

Materials and Methods

Field experiment was conducted to evaluate organic management practices for the management of fall armyworm infesting maize with ten treatments replicated thrice with COHM 6 maize hybrid. Silicon powder was applied thrice at 20, 40 and 60 days after sowing (DAS) and silicon granules were applied in the leaf whorl thrice at knee high, tasseling and milking stage. Intensity of damage caused by fall armyworm was assessed using 1-5 scale developed by the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore.

Results and Discussion

Pre-treatment damage intensity assessment at 15 DAS revealed that the damage was in the range of 3.7 to 4.1 scale in different treatments and was statistically non-significant. At 20 DAS, the damage was recorded to be in the range of 3.2 to 4.5 scale, with the lowest damage scale of 3.2 in the plots treated with foliar application of 5% neem leaf extract @ 15 DAS + use of pheromone traps + application of silicon powder @ 25 kg/ha + application of silicon granules @ 125 kg/ha (T_{10}), as against 4.5 in absolute control (T_1). At 40 DAS, the damage was recorded to be in the range of 2.1 to 4.4 scale, with the lowest damage of 2.1 scale in T_{10}, as against 4.4 in T_1. At 60 DAS, the damage was recorded to be in the range of 1.3 to 3.4 scale, with the lowest damage of 1.3 in T_{10}, as against 3.4 scale in T_1. Similar trend was observed at 80 DAS with the damage ranging from 1.0 to 2.1 scale. The results are in agreement with the findings of Ye *et al*. (2013) who have reported that silicon was able to prime jasmonate-mediated defense responses and rice defense against the rice leaf folder, *Cnaphalocrocis medinalis*.

Plant height at harvest was recorded to be the maximum of 219.1 cm in T_{10} as against 165.8 cm in T_1. Maximum number of 15.7 leaves per plant was recorded in T_{10} as against 13.1 leaves per plant in T_1. Grain and straw yield were recorded to be the maximum in T_{10} (4905 and 6676 kg/ha, respectively) with the B: C ratio of 1.81 as against the lowest grain and straw yield of 3,653 and 4,694 kg/ha, respectively with the B: C ratio of 1.45.

Table 1. Evaluation of organic practices in the management of fall army worm, *Spodoptera frugiperda* infesting maize

Treat-ments	Damage caused by fall armyworm (1-5 scale)					Plant height (cm)	Number of leaves / plant	Grain yield (Kg/ha)	Straw yield (Kg/ha)	B:C ratio
	PTC	20 DAS	40 DAS	60 DAS	80 DAS					
T_1	4.0	4.5^{e}	4.4^{e}	3.4^{g}	2.1^{d}	165.8^{i}	13.1^{d}	3653^{i}	4694^{g}	1.45
T_2	4.1	4.2^{de}	4.0^{de}	3.4^{fg}	1.9^{cd}	189.9^{h}	13.8^{bcd}	3799^{h}	4974^{fg}	1.49
T_3	4.1	4.0^{cd}	3.8^{de}	3.3^{fg}	1.7^{bcd}	192.8^{g}	13.7^{cd}	4027^{g}	5068^{efg}	1.56
T_4	3.9	3.9^{cd}	3.8^{de}	3.1^{efg}	1.6^{bcd}	198.4^{e}	14.4^{abcd}	4103^{e}	5377^{def}	1.59
T_5	3.9	3.9^{cd}	3.6^{cde}	2.8^{def}	1.6^{bc}	196.6^{f}	14.6^{abcd}	4065^{f}	5439^{de}	1.53
T_6	3.7	3.8^{bcd}	3.5^{cd}	2.7^{de}	1.5^{bc}	198.7^{e}	14.6^{abcd}	4122^{e}	5496^{cd}	1.54
T_7	3.9	3.6^{abc}	3.2^{bcd}	2.4^{cd}	1.4^{abc}	209.4^{d}	14.9^{abcd}	4534^{d}	5909^{bc}	1.69
T_8	3.8	3.6^{abc}	2.8^{abc}	1.9^{bc}	1.4^{abc}	212.5^{c}	15.0^{abc}	4699^{c}	6073^{b}	1.73
T_9	3.8	3.4^{ab}	2.4^{ab}	1.6^{ab}	1.2^{ab}	218.3^{b}	15.2^{ab}	4864^{b}	6238^{b}	1.80
T_{10}	4.0	3.2^{a}	2.1^{a}	1.3a	1.0^{a}	219.1^{a}	15.7^{a}	4905^{a}	6679^{a}	1.81
S. Ed	**0.18**	**0.22**	**0.43**	**0.28**	**0.22**	**0.16**	**0.71**	**12.34**	**197.81**	-
CD (P=0.05)	**NS**	**0.46**	0.91	0.59	0.47	0.34	1.50	25.92	415.59	-

PTC - Pre-treatment count; DAS - Days after sowing

In a column, means followed by common letter(s) are not significantly different by LSD

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ES 04 BOPD 24

Bio-efficacy of ginger, garlic and green chilli (3G) extract in the management of sucking pests of organic cotton

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Key words: *Cotton, organic pest management, 3G extract, sucking pests, natural enemies*

Introduction

Cotton ecosystems throughout the world harbour a wide variety of insects. Estimates of the number of pests species range from 20 to 60, but significant damage is caused by 5-10 key pests in most production systems (Luttrell *et al.,* 1994). One hundred and sixty two species of phytophagous insects have been recorded on cotton in India, of which 24 species have attained pest status and nine are key pests in one or more cotton growing zones of the country (Dhawan, 2000). Despite heavy use of pesticides, losses caused by insect pests continue to be unacceptably high. In India, the insect pests reduce cotton crop production by around 50 per cent (Dhaliwal and Arora, 2001). Organic cotton production combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved (IFOAM, 2014). Hence, the present study was carried out to test the bio-efficacy of ginger, garlic and green chilli (3G) extract in the management of insect pests of organic cotton.

Materials and Methods

Field experiments were conducted at TNAU, Coimbatore, ARS, Bhavanisagar and CRS, Vepanthattai to study the bio-efficacy of 3G extract in the management of insect pests of organic cotton. The experiments were laid out with the three treatments replicated seven times using RBD with the variety Surabhi during September, 2020 at a spacing of 90 x 45 cm. Ginger, garlic and green chilli extract was prepared using cow urine. Observations on insect pests and their natural enemies were taken by following standard procedures. The pooled mean of all the three locations were worked out along with per cent reduction over control. Pooled mean of yield and benefit cost ratio was also calculated.

Results and Discussion

i. Efficacy of 3G extract on sucking pests of cotton

Population of aphids was in the range of 4.44 to 15.98 per three leaves per plant. 3G extract 5% (T_1) and NSKE 5% (T_2) were statistically on par with each other with the mean population of 4.46 and 4.44 aphids per three leaves per plant, respectively, as against 15.98 in untreated control. Population of leafhoppers was in the range of 1.79 to

6.86 per three leaves per plant. T_1 and T_2 were statistically on par with each other with the mean population of 1.79 and 1.80 leafhoppers per three leaves per plant, respectively, as against 6.86 in untreated control. T_1 and T_2 were statistically on par with each other with the mean thrips population of 4.96 and 5.40 thrips per three leaves per plant, respectively, as against 13.99 thrips in untreated control.

Regarding whiteflies, T_1 and T_2 were statistically on par with each other with the mean population of 0.87 and 0.98 whiteflies per three leaves per plant, respectively, as against 2.77 whiteflies in untreated control. The results are in accordance with the findings of Rizvi *et al*. (2016), who have reported the efficacy of ginger, garlic and tobacco extracts on cabbage looper.

ii. Efficacy of 3G extract on the population of natural enemies

Pooled mean of all the three locations revealed that the population of coccinellid beetles was in the range of 0.33 to 0.76 per plant. T_1 and T_2 were statistically on par with each other with the mean population of 0.13 and 0.18 beetles per plant, respectively, as against 0.50 beetles in untreated control. Similarly, the population of predatory spiders was in the range of 0.51 to 0.79 per plant. T_1 and T_2 were statistically on par with each other with the mean population of 0.51 and 0.578 spiders per plant, respectively, as against 0.79 spiders in untreated control.

iii. Effect of 3G extract on yield and economics of organic cotton

Kapas yield was in the range of 1290 to 2051 kg per ha in three different treatments. T_1 and T_2 were statistically on par with each other with the mean kapas yield of 2051 and 1947 kg/ha, respectively, as against 1290 kg/ha in untreated control. NSKE 5% sprayed plots recorded the maximum mean Benefit: Cost ratio of 1.68 and was found to be on par with 3G extract 5% sprayed plots with the BC ratio of 1.66, as against 1.12 in untreated control.

Table 1. Efficacy of 3G extract in the management of sucking pests of cotton

Treatments	Sucking pests (No./3 leaves/plant)*				Predators (No./plant)*		Yield* (kg/ha)	B:C Ratio*
	Aphids	Leafhoppers	Thrips	Whiteflies	Coccinellids	Spiders		
T_1 - 3G Extract 5%	4.46^a	1.79^a	4.96^a	0.87^a	0.33^a	0.51^a	2051^a	1.66
T_2 - NSKE 5%	4.44^a	1.80^a	5.40^a	0.98^b	0.40^a	0.57^a	1947^a	1.68
T_3 - Control	15.98^b	6.86^b	13.99^b	2.77^c	0.76^b	0.79^a	1290^b	1.12
S. Ed.	0.17	0.32	0.28	0.04	0.14	0.18	214.01	-
CD (P=0.05)	0.36	0.69	0.61	0.09	0.30	0.37	466.66	-

*Pooled mean of three locations

In a column, means sharing similar letter is not significantly different

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ES 04 BOPD 25

Efficacy of tree based bio-pesticides on diamondback moth, *Plutella xylostella* Linn. infesting cauliflower

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Key words: *Cotton, organic pest management, 3G extract, sucking pests, natural enemies*

Introduction

Cauliflower, *Brassica oleracea* var. *botrytis* L. is an important cruciferous vegetable in India. Diamondback moth, cabbage leaf webber, tobacco caterpillar and mustard aphid are major pests of cabbage of which diamondback moth, *Plutella xylostella* (Plutellidae: Lepidoptera) is the major destructive pest on cruciferous crops such as cauliflower, cabbage and mustard (Zalucki *et al*., 2012). Increasing awareness on the deleterious effects of insecticides paved the way for integrated and eco-friendly pest management. One such method is the use of botanical pesticides, which are safe and eco-friendly, can overcome many problems associated with chemical insecticides especially in the vegetables. Hence, the present study was undertaken to test the efficacy of tree bio-pesticides as a potential alternative to chemical pesticides.

Materials and Methods

Field experiment was laid out to test the efficacy of tree based bio-pesticides on diamondback moth, *Plutella xylostella* infesting cauliflower with the following six treatments replicated four times. T_1 - Cow urine extract of *Cleistanthus collinus* leaves 5%; T_2 - Cow urine extract of *Strychnus nux-vomica* leaves 5%; T_3 - Cow urine extract of *Vitex negundo* leaves 5%; T_4 - Azadirachtin 10,000 ppm @ 1%; T_5 - Emamectin Benzoate 5 SG @ 0.4 g/l and T_6 - Untreated control. Observations on population of insect pests and natural enemies were recorded as per the standard procedures.

Results and Discussion

i. Efficacy of tree based bio-pesticides on diamondback moth, *Plutella xylostella*

Before imposing the treatments, the population of diamondback moth was in the range of 6.23 to 6.68 larvae per plant. Mean number of diamondback moth larvae per plant was recorded to be the lowest in T_5 (1.34), followed by 2.25 and 2.74 per plant in T_4 and T_2, respectively. Maximum reduction in the diamondback moth larval population of 80.90 per cent was recorded in T_5, followed by 67.90 and 61.30 per cent in T_4 and T_2, respectively (Table 1). The results are in accordance with the findings of Selvaraj *et al*. (2017 and 2018), who reported the larvicidal action of nux-vomica against diamondback moth.

ii. Impact of tree based bio-pesticides on natural enemies

Mean number of syrphids after two sprays revealed that T_1 (0.123) recorded the lowest number of syrphids followed by T_4 (0.128) and T_2 (0.133) as against 0.653 syrphids in untreated control. Maximum of 81.30 per cent reduction in the population of syrphids was recorded in T_1, followed by 80.40 and 79.60 per cent in T_4 and T_2, respectively. Among the tree based biopesticides, T_3 was recorded to be superior in the conservation of syrphids, the efficient predator on aphids infesting cauliflower.

Mean number of coccinellid beetles after two sprays revealed that T_5 (0.05) recorded the lowest number of beetles followed by T_1 (0.07) and T_3 (0.09) as against 0.36 beetles in untreated control. Maximum of 85 per cent reduction in the population of coccinellid beetles was recorded in T_5, followed by 81.0 and 74.9 per cent in T_1 and T_3, respectively. Among the tree based biopesticides, T_2 was recorded to be superior in the conservation of coccinellid beetles, the efficient predator on aphids infesting cauliflower (Table 1).

iii. Effect of tree based bio-pesticides on yield and economics of cauliflower

Among the treatments, curd yield was recorded to be the maximum (162.65 kg per plot and 32,530 kg/ha) in emamectin benzoate treated plots (T_5), followed by 31,535 kg per ha in azadirachtin treatment (T_4). Among the tree based biopesticides, cow urine based extract of *Strychnus nux-vomica* leaves 5% (T_2) recorded to be superior with the curd yield of 28,920 kg/ha as against the lowest yield of 16,856 kg/ha in the untreated control.

The highest benefit: cost ratio of 3.34 was recorded in emamectin benzoate treatment (T_5), followed by 3.23 in azadirachtin treatment (T_4). Among the tree based biopesticides, cow urine based extract of *Strychnus nux-vomica* leaves 5% (T_2) recorded to be superior with the BCR of 3.04 as against the lowest BCR of 1.80 in the untreated control (Table 1).

Table 1. Efficacy of tree based bio-pesticides on *Plutella xylostella* infesting cauliflower

Treatments	No. of DBM larvae/plant*		No. of syrphids/ plant*		No. of coccinellids/ plant*		Yield and Economics	
	Mean	PROC	Mean	PROC	Mean	PROC	Yield (kg/ ha)	B:C ratio
T_1	3.56	49.20	0.123	81.3	0.07	81.0	28,219[c]	2.97
T_2	2.74	61.30	0.133	79.6	0.11	70.3	28,920[c]	3.04
T_3	3.64	48.07	0.152	76.8	0.09	74.9	24,227[d]	2.55
T_4	2.25	67.88	0.128	80.4	0.10	70.9	31,535[b]	3.23
T_5	1.34	80.88	0.154	76.4	0.05	85.0	32,530[a]	3.34
T_6	7.01	-	0.653	-	0.36	-	16,856[e]	1.80
S. Ed	-	-	-	-	-	-	380.13	-
CD (P=0.05)	-	-	-	-	-	-	810.24	-

*Mean of four replications; PROC - Per cent reduction over control;

In a column, means sharing similar letter is not significantly different

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ES 04 BOPD 26

Efficacy of pongamia oil derived formulation (POD) for the management of major pests of groundnut (*Arachis hypogaea* L.)

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Key words: *Groundnut, thrips, leafhopper, leafminer, pongamia oil, management*

Introduction

Groundnut *(Arachis hypogaea* L.) is one of the major oilseed crops cultivated in about eight million hectares, with an annual production of over nine million tonnes of pods, contributing 45% of oilseed production in India. In India, which is mainly grown in the Southern and North–Western states *viz.,* Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Maharastra, and Madhya Pradesh, together occupying about 90 percent of the groundnut area in the country (Indiragandhi, 2020). Insect pest menace is one of the major factor for lower yield. Thrips, *(Frankliniella hultzeri* Trybom, *Thrips palmi* Karny and *Scirtothrips dorsalis* Hood), leafhoppers, (*Empoasca kerri* Pruthi) Leaf miner *Aproaeroma modicella* Deventer and *Spodoptera litura* Fab. are considered as important destructive pests on this crop. Plant Protection must also ensure healthy, ecofriendly and sustainable food supply to us. The use of botanical resources for agrochemical purpose is one of the important alternatives to manage insect-pests in place of synthetic insecticides (Isman, 2006; Pavela, 2012. Keeping this in view, a study was undertaken to test the efficacy of pongamia old derivatives against these pests in groundnut.

Materials and methods

Field trial was conducted at Coconut Research Station, Aliyarnagar during *Rabi* 2019 - 20 with VRI 2 groundnut variety to evaluate the efficacy of pongamia oil derived formulation (POD) along with insecticide and azadirachtin formulation for the management of major pests of groundnut at field condition. Post treatment observations taken on 7 and 14 Days After Spray (DAS). The data were analyzed using AGRES statistical package and means were compared using Least Significant Difference (LSD).

Results and discussions

The results from table 1 revealed that significantly the lowest population of thrips (2.1 no./leaflet) was recorded in POD@3 ml/lit, followed by in POD @2ml/lit. (2.3 no./leaflet) when compared to the control where it was significantly the highest (4.8 No./leaflet) at 14 DAS. Similarly the leaf hopper population was also significantly reduced from 6.0 to 3.2 No./plant compared to the control (6.6 no./plant) at 14 DAS. The significantly the lowest percent infestation of leafminer was recorded (0.7%) in POD@3 ml/lit. when compared to control where it was 2.2% at 14 DAS. The *S. litura* infestation was significantly lowest (0.9%) in POD@3 ml/lit. All the pests were significantly reduced in the insecticide check quinalphos@2ml/lit. Based on above results it could be inferred that the pongamia oil derived formulation @ 3 ml /lit found to be effective against major pests in groundnut.

Table 1. Pongamia oil derived formulation (POD) for managing major pests of groundnut, at CRS, Aliyarnagar

Treatments	Sucking pest population						Defoliator damage (%)					
	Thrips (No./leaflet)			Leafhopper (No./plant)			leafminer			*S. litura*		
	PTC	PSC		PTC	PSC		PTC	PSC		PTC	PSC	
		7DAS	14DAS		7DAS	14DAS		7DAS	14DAS		7DAS	14DAS
T1- Azadirachtin 10000 ppm @ 1.5 ml/lit	4.1 (2.3)	1.3 (1.2)	2.7 (1.9)	6.5 (2.7)	2.8 (1.9)	4.1 (2.3)	1.5 (7.0)	1.3 (6.5)	1.3 (6.5)	1.6 (7.3)	1.4 (7.3)	1.4 (7.3)
T2-POD @ 1 ml/lit	4.3 (2.3)	1.8 (1.7)	2.6 (1.9)	5.7 (2.6)	3.4 (2.2)	3.8 (2.2)	1.7 (7.5)	1.5 (7.0)	1.5 (7.0)	2.1 (8.3)	1.9 (8.3)	1.6 (7.2)
T3-POD @ 2 ml/lit	4.3 (2.3)	1.8 (1.7)	2.3 (1.8)	5.8 (2.6)	3.4 (2.1)	3.6 (2.1)	1.5 (7.0)	1.3 (6.5)	1.1 (6.1)	1.9 (7.8)	1.6 (7.9)	1.2 (6.2)
T4-POD@ 3 ml/lit	4.6 (2.4)	2.0 (1.8)	2.1 (1.8)	6.0 (2.7)	3.2 (2.1)	3.2 (2.0)	1.3 (6.5)	1.2 (6.3)	0.7 (4.9)	1.6 (7.3)	1.5 (7.3)	0.9 (5.3)
T5-Quinalphos 25 EC 2ml/lit	3.7 (2.2)	1.8 (1.7)	1.9 (1.7)	5.5 (2.5)	3.3 (2.1)	2.7 (1.9)	1.4 (6.8)	1.0 (5.8)	0.5 (4.1)	1.8 (7.6)	1.3 (7.6)	0.6 (4.5)
T6-Control	4.1 (2.3)	4.4 (2.3)	4.8 (2.4)	5.8 (2.61)	6.7 (2.78)	6.6 (2.8)	1.6 (7.2)	1.4 (6.7)	2.2 (8.5)	2.0 (8.1)	1.8 (8.0)	2.8 (9.6)
C.D.	0.06	0.07	0.07	0.05	0.06	0.06	NS	NS	0.76	0.62	0.66	0.64
SE(m)	0.02	0.02	0.02	0.02	0.02	0.02	0.25	0.27	0.25	0.20	0.22	0.21
SE(d)	0.03	0.03	0.03	0.03	0.03	0.03	0.35	0.38	0.35	0.29	0.31	0.30
C.V.	1.84	2.63	2.29	1.34	1.73	1.69	7.01	8.23	8.09	5.22	6.03	6.33

PTC- Pre Treatment Count, PSC- Post Treatment Count

DAS-Days After Spray, Values are mean of four replications. Values in the paranthesis are square root transformed for population and arcsine transformed for damage percent.

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Efficacy of various biopesticides against red pumpkin beetle (*Aulacophora foveicollis*) in bitter gourd (*Momordica charantia* L.)

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Keywords: *Bittergourd, M. anisopliae, NSKE, Red pumpkin beetle*

Introduction

Red Pumpkin Beetle (*Aulacophora foveicollis*) has been reported as a destructive insect pest of cucurbitaceous vegetables. The adult beetles feed on the leaf lamina making irregular holes and also attack the flowers. They eat seedlings, young and tender leaves and flowers (Rahaman and Prodhan, 2007). Yield loss up to 30-100% have been reported by Alam, 1969. The pest is occurring throughout the year which causes serious damage to the crops. Keeping the above facts and figures this study was conducted to compare the efficacy of different biopesticides against red pumpkin beetle in bittergourd.

Materials and Methods

Field experiment was conducted in the farmer's holdings at Thuyyaneri Village, Madurai District during Aug 2017 to December 2017. The following treatments were adopted, T_1 - Neem Seed Kernel Extract (NSKE) @5%, T_2 - Neem oil 3% , T_3 - Notchi (*Vitex negundo*) leaf extract @ 10% , T_4 - Neem soap @ 10 g/litre of water , T_5 - Pungam Soap @ 10 g/litre of water, T_6 - *Bt* @ 2g/litre of water , T_7 T_{1-} *Metarrhizium anisopliae* - 1x10^8 CFU/ ml and T_{8-} Malathion 50 EC@ 500ml/ha as Standard check. The first spray was given as an when the pest population reaches the ETL level and thereafter another spray was given at 15 days interval with a high volume sprayer using 500 lit of spray fluid per ha. The control plot was maintained without any spraying. The above observations was recorded on prior to spraying and 3rd,7th ,10th and 14th days after spraying . Number of adult beetle per plant were recorded in randomly selected ten plants expressed as numbers per plant.

Results and Discussion

The population of beetle ranged from 2.57 to 3.19 per plant before imposing the treatments in the first field experiment. The mean population was the lowest in *M. anisopliae* 1 x 10^8 CFU/ml (0.99 beetles/plant) with the corresponding per cent reduction over control was 78.14 %. This was followed by NSKE 5% and Neem oil 3% treatments which gave 76.15 and 73.06 % per cent reduction of beetle population over control. The untreated check recorded the highest mean population of 4.53 beetles/plant (Table 1). The population reduction of red pumpkin beetle over control was found to be maximum in *M. anisopliae* and NSKE 5%. The results here were in accordance with the findings of Rathod *et al*., (2009) in which maximum mortality was found in neem formulation. This was also in agreement with the findings of Khan *et al*., 2012 who observed the maximum repellancy against beetles in NSKE treatment.

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Table 1. Population of *A. foveicollis* as influenced by biopesticides in bitter gourd (Aug 2017 – Dec 2017)

Treatment	Dosage	Number of adult / leaves*										
		PTC	I Spray				II Spray				Mean	Reduction over control (%)
			3 DAS	7 DAS	10 DAS	14 DAS	3 DAS	7 DAS	10 DAS	14 DAS		
T1-Neem seed kernel extract	5%	2.63	1.34 (1.16)^{b}	0.89 (0.94)^{b}	1.24 (1.11)c	1.68 (1.30)^{c}	0.81 (0.90)^{b}	0.55 (0.74)^{b}	0.82 (0.91)^{b}	1.32 (1.15)^{c}	1.08 (1.04)^{c}	76.15
T2-Neem oil	3%	2.84	1.56 (1.25)^{c}	0.97 (0.98)^{d}	1.38 (1.17)^{d}	1.72 (1.31)^{cd}	1.02 (1.01)^{c}	0.76 (0.87)^{d}	0.97 (0.98)^{c}	1.4 (1.18)^{cd}	1.22 (1.11)^{d}	73.06
T3-Notchi leaf extract	10%	2.57	1.68 (1.30)^{de}	1.27 (1.13)^{f}	1.53 (1.24)^{e}	1.79 (1.34)^{d}	1.28 (1.13)^{e}	0.94 (0.97)^{f}	1.1 (1.05)^{e}	1.47 (1.21)^{d}	1.38 (1.18)^{f}	69.53
T4-Neem soap	10g/l	3.19	1.64 (1.28)^{d}	1.02 (1.01)^{e}	1.43 (1.20)^{d}	1.74 (1.32)^{cd}	1.18 (1.09)^{d}	0.83 (0.91)^{e}	1.04 (1.02)^{d}	1.42 (1.19)^{d}	1.29 91.13)^{e}	71.52
T5-Pungam soap	10g/l	2.88	1.73 (1.32)^{e}	1.42 (1.19)^{g}	1.71 (1.31)^{f}	2.08 (1.44)^{e}	1.59 (1.26)^{g}	1.32 (1.15)^{h}	1.67 (1.29)^{f}	1.94 (1.39)^{e}	1.68 (1.30)^{h}	62.91
T6-***Bacillus thuringiensis***	2g/l	2.95	1.67 (1.29)^{de}	1.31 (1.14)^{f}	1.74 (1.32)^{f}	1.98 (1.41)^{e}	1.46 (1.21)^{f}	1.28 (1.13)^{g}	1.62 (1.27)^{f}	1.86 (1.36)^{e}	1.62 91.27)^{g}	64.23
T7-***Metarrhizium anisopliae***	1x10^{8} CFU/ml	3.17	1.29 (1.14)^{b}	0.83 (0.91)^{b}	1.06 (1.03)^{b}	1.48 (1.22)^{b}	0.78 (0.88)^{b}	0.66 (0.81)^{c}	0.81 (0.90)^{b}	1.00 (1.00)^{b}	0.99 (0.99)^{b}	78.14
T8-Standard check -Malathion 50 EC	500 ml/ ha	2.91	1.16 (1.08)^{a}	0.75 (0.87)^{a}	0.94 (0.97)^{a}	1.37 (1.17)^{a}	0.73 (0.85)^{a}	0.31 (0.56)^{a}	0.67 (0.82)^{a}	0.89 (0.94)^{a}	0.85 (0.92)^{a}	81.23
T9-Control	-	3.13	3.34 (1.83)^{f}	3.87 (1.97)^{h}	4.12 (2.03)^{g}	4.38 (2.09)^{f}	4.82 (2.20)^{h}	4.99 (2.23)^{i}	5.27 (2.30)^{g}	5.41 (2.33)^{f}	4.53 (2.13)i	-
S.Ed	-	-	0.013	0.009	0.017	0.016	0.012	0.008	0.012	0.015	0.008	-
CD(0.05)	-	-	0.029	0.019	0.036	0.034	0.027	0.018	0.025	0.033	0.018	-

PTC=Pre Treatment Count, DAS= Day(s) after spraying, NS – Non significant

*Each value is the mean of three replications

Figures in parenthesis are square root transformed values

In a column, means followed by same letter(s) are not significantly different by LSD (p= 0.05)

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Assessment of phytotoxic effect of botanicals used for the control of tea mosquito bug on cashew

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Keywords: *Assessment, cashew, botanicals, foliage pests, phytotoxicity*

Introduction

Cashew (*Anacardium occidentale* L.) is an export oriented crop of India. Production of cashew is greatly influenced by a number of biotic and abiotic factors like good quality planting materials, soil health, insect pests and diseases. The crop is attacked by array of insects in different stages of its growth. Overuse and misuse of synthetic pesticides can result in harmful effects on humans and the environment and toxicity to non-target organisms(Misra,2000). Plants with bioactive compounds have been used to manage different crop pests. In recent years, plant extracts and botanical pesticides have showed great importance in agricultural fields due to their cheap and low expenses, with no residual effects, environmentally friendly, and highly toxic against major sucking pests (Stumpf and Nauen, 2001). Contrary to the chemical pesticides, biopesticides are eco-friendly as the non-target organisms and human beings are less affected (Begum *et al*., 2013). Current research was undertaken to investigate and identify the phytotoxic effect if any for the botanicals used for managing the Tea mosquito bug and foliage pests in cashew under field conditions.

Materials and methods

The field experiment was conducted during 2019-2020 in crop protection experimental plots of cashew plantations at Regional Research Station, Vridhachalam. A ten year old VRI 3 variety was evaluated. The infested cashew trees with the damage symptoms like drying of leaves, twigs, webbing of leaves and shoots, leaf mining symptoms were selected for this study. Botanicals were evaluated for its efficacy against the foliage pests which causes damage to cashew trees and also the reactions of any phytotoxic symptoms if any developed was observed and recorded. The experiment was laid out under randomized block design with four replications and each replication repeated with two infested trees. Ten Different botanicals formulations were prepared as treatments given.

Botanicals preparation methodology

T1- Leaves of each of 500 grams of Adathoda, Datura, Vitex, Calotropis and Neem was grinded and leaf extracts of Adathoda, Datura, Vitex, Calotropis, Neem was soaked in 10 litres of water and fermented for 15-20 days, and the supernatant was used for spraying; T2- Neem Seed Kernal Extract 5% was prepared and used; T3- Deshi Cow urine 100 ml/litre of water; T4- Seeds of Nerium, Pongam, Tobacco waste and Pods of Datura (Each 500 g), Lime - 250 g, Cow urine - 5 lit., Soaked in Mud pot with 10 litres of water for seven days, and supernatant was used for spraying; T5- Rhizomes of Acorus 5% soaked overnight and supernatant was used for spraying; T6-Pongam oil 5 %; T7-Citrus peel extract and Leaf extracts of Tulsi, Custard apple and Chrysanthemum flowers (Each 250 grams), Lime - 250 g, Cow urine - 5 lit. Soaked in Mud pot with 10 litres of water for seven days; T8- Botanical formulation Supplied by Mr. Ajith Paul @ 64 grams in 16 litres of water; T9- Standard treated check (Spraying of Lambda Cyhalothrin 5% EC @ 0.6 ml/lit of water);T10-Untreated check. For all the treatments khadhi soap@ 1g/ litre of water was added for spraying.

Evaluation of phytotoxicity of botanicals on cashew

As per the technical Programme, in Botanicals field experiments, symptoms like leaf injury, wilting, vein learing, necrosis, epinasty and hyponasty were observed in each trees at 1,3,5,7,10 and 14 days after spraying as per the protocol of Central Insecticide Board and Registration Committee (CIB and RC).

Method of assessment

Leaf injury was assessed by visual rating in a 0-10 scale. 0 - No phytotoxicity;1= 0-10(%); 2=11-20 (%); 3=21-30 (%); 4=41-50 (%); 5=51-60 (%); 6=61-70 (%); 7=71-80 (%); 8=81-90 (%); 9=91-100 (%).

Results

The results on the investigations of the phytotoxic effect of botanicals sprayed for the management of foliage pests on cashew at fortnight intervals during flushing, flowering and fruit formation stage on cashew variety VRI-3 showed that none of the botanical treatments caused any phytotoxic symptoms such as injury to leaf tip and leaf surface, wilting, vein clearing, necrosis, epinasty and hyponasty. Hence, it was concluded that these botanical treatments did not inflict any phytotoxic effect on cashew.

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ES 04 BOPD 29

Studies on the Impact of Ginger-Garlic-Green chilli (3G) Extract for the Management Sucking Pests in Organic Cotton

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Key words: *Organic cotton, Pest management, Ginger-Garlic-Green chilli extract impact study*

Introduction

Cotton is an important fiber crop of India attacked by many insect pests. Management of insect pests in conventional farming with synthetic insecticides led to hazards in human health and environment. Moreover, the organic cotton is highly warranted in baby and band-aid clothing industries and the world organic cotton demand is also on increasing trend with an 84% increase in the demand by 2030 compared to a 2019/20 baseline (Lisa Barsley Sarah *et. al.,* 2021). Considering the necessity of an alternative approach for pest management in organic cotton, a cow urine based ginger-garlic-green chilli extract was studied.

Materials and Methods

Field experiments were conducted in black cotton soil, Eastern Block Farm, Tamil Nadu Agricultural University, Coimbatore continuously for two years during *Rabi* 2018-2019 and 2019-2020. Cow urine based ginger-garlic-green chilli extracts were prepared in the laboratory and used for the study. For preparation 50 g of fresh ginger / peeled bulbs of garlic / green chilli / neem seed kernel was ground in one liter of fresh cow urine, allowed for fermentation for five days with stirring. Pre-treatment pest count was taken and sprayings were given when the pest population reached the Economic Threshold Level. The post treatment pest counts were done on 7 and 14 DAS by following standardized procedure. The population reduction of jassids, thrips and whiteflies over control was calculated and the date are given in Table 1.

Results and Discussion

Before imposing the treatments, less population of whiteflies, medium population of jassids and more population of thrips were observed in the experimental field. In jassids, the pre-treatment mean population ranged from 2.02 to 2.13 no./leaf. Whereas, in post treatment count, the jassid population was in decreasing trend in all the treatments except untreated control which was in increasing trend where the jassid population was in the ranges of 0.84-2.39 nos./leaf at 7 DAS and the corresponding ranges on 14 DAS count was 0.65-3.83 nos./leaf. At 7 DAS, among the treatments, the minimum jassid population of 0.84 nos./leaf was registered in ginger, garlic and green chilli extract (5%) application which was on par with NSKE (5%) application (0.92 nos./leaf) against the highest population (2.39 nos./leaf) in untreated check. The same trend was observed 14 DAS jassids count also. The mean per cent reduction of jassids over the control was more (60.63) in cow urine based ginger-garlic-green chilli (5%) extract application followed by NSKE 5% application (58.26) and ginger (5%) extract spray (32.31).

The thrips population in pre-treatment count ranged from 3.03-3.36 nos./leaf. In post treatment count at 7 DAS, the numbers were less (1.41 nos./leaf) in ginger-garlic-green chilli extract (5%) applied plots which was on par with NSKE (5%) application (1.81 nos./leaf) with more population (3.89 non./leaf) in untreated control. The same tend was noticed in 14 DAS count also. The mean post treatment population reduction of thrips was more (50.35%) in ginger-garlic-green chilli (5%) application followed by NSKE (5%) application (48.66%) and garlic extract (28.69%).

The whitefly population in pre-treatment count ranged from 1.01 to 1.11 nos./leaf. Whereas in post treatment count, the population was in decreasing trend at 7 DAS and in increasing trend at 14 DAS. Among the treatments, ginger-garlic-green chilli extract (5%) recorded the lowest whitefly population (0.47 nos./leaf) which was at par with NSKE (5%) application (0.50 nos./leaf) with the highest population of on 7 DAS post treatment count. The same trend was observed on 14 DAS whitefly population. The mean reduction of whitefly population in post treatment counts over the untreated control was more 62.74 % in ginger-garlic-green chilli extract (5%) application followed by NSKE 5% spray (58.64%) which was less (20.59%) in green chilli extract (5%) applied treatment. Overall the cow urine based ginger-garlic-green chilli extract was more effective in reducing the population of sucking pests in organic cotton. Geraldin *et.al.,* (2020) also recorded similar findings earlier.

Table 1. Effect of treatments on insect population (No./leaf) in cotton (Mean of 2 years)

Treatments	Jassids (No.)			Mean % Redn.	Thrips (No.)			Mean % Redn.	Whitefly (No.)			Mean % Redn.
	PT	7 DAS	14 DAS		PT	7 DAS	14 DAS		PT	7 DAS	14 DAS	
T_1 - Ginger extract 5%	2.06	1.41	1.36	32.31	3.36	2.44	2.72	28.57	1.08	0.81	1.17	27.23
T_2 - Garlic extract 5%	2.02	1.34	1.35	33.56	3.03	2.24	2.60	28.69	1.03	0.75	1.06	28.97
T_3 - Green chilli extract 5%	1.99	1.53	1.58	23.20	3.09	2.35	3.06	24.24	1.01	0.78	1.31	20.59
T_4 - Ginger + Garlic + Green chilli extract 5%	2.09	0.84	0.65	60.63	3.31	1.70	1.41	50.35	1.11	0.47	0.51	62.74
T_5 - Cow urine alone 5%	2.13	1.85	1.94	15.22	3.12	2.80	3.79	12.96	1.03	0.97	1.56	6.04
T_6 - NSKE 5% (Std. check)	2.08	0.92	0.62	58.26	3.24	1.81	1.71	48.66	1.06	0.5	0.54	58.64
T_7 - Untreated check	2.04	2.39	3.83	-	3.20	3.89	6.33	-	1.06	1.58	2.42	-
S Ed	0.24	0.25	0.22	-	0.28	0.55	0.60	-	0.27	0.18	0.25	-
CD (P=0.5)	NS	0.54	0.47	-	NS	1.19	1.30	-	NS	0.4	0.54	-

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ES 04 BOPD 30

Volatile Profile of termite bait material: A natural phagostimulant

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Key words: *Plant materials, Volatile Organic Compounds, termite attractant*

Introduction

Termites are social insects inhabiting tropical to temperate region. Their ability to degrade or digest lignocellulose make them as a potential pests of crops and wooden structures. Though several management strategies were developed against termites, still it is challenge for complete eradication of termites because of extensive foraging behavior of termites. Over a three decades, significant method for termite management is baiting technology (Paton and Miller, 1980). Baiting is most environmentally safe technique and mostly comprises cellulosic material and toxicant. For enhancing the bait efficacy to attract termites, natural phagostimulant can be used as an attractant. In this point of view, the present study was conducted to identify the Volatile Organic Compounds (VOC) present in coconut leaf, coconut loose sheath and paddy straw which may pave a way for innovation in termite bait technology.

Materials and Methods

A volatile collection unit was used for the extraction of volatiles from the samples of coconut leaf, coconut loose sheath and paddy straw. Initially the air was made to pump inside the chamber followed by creation of vacuum. The plant material was kept inside the air tight glass jar and air was pumped into the jar through activated charcoal at the rate of 100 ml/ min. The volatiles were collected onto adsorption tubes (Gainesville, FL (352) 283-0133; P/N: VCT-1/4-4-POR-Q;1/4"ODx4"L VCT). The adsorbed volatiles were eluted immediately using 20 ml HPLC grade hexane. The eluted extract was concentrated to 1 ml. The crude extract thus obtained was injected into GC-MS/MS for identification of the volatile compounds.

Result and Discussion

The paddy straw volatiles had compounds *viz.,* 1 methoxy 2,2 di methyl propane, tetracosane and docosane. Docosane was identified at the peak area of 81933 at 21.179 retention time. Similarly, tetracosane was identified with the peak area and retention time of 169499 and 21.179 respectively.

The volatile compounds *viz.,* lauric acid, lathydrazide, and 2,2 dichloro 1 hydroxy ethyl 2,2 di methyl propane were identified from coconut leaf. The compound lathydrazide had highest peak area of 391510 with the retention time of 2.115. The peak area of 2,2 dichloro hydroxyl ethyl 2,2 dimethyl propane was 238324 and retention time was 5.226. The compounds identified from coconut loose sheath were 1 ethyl 1 methyl cyclopropane, phosphono acetic acid and hexahydroxypyridine. The phosphono acetic acid had peak area of 3252481 and retention time as 28.075. The peak area and retention time for hexahydroxy pyridine was 1482259 and 26.390 respectively.

In general, termites behavior of attraction is towards the aromatic compounds, cuticular hydrocarbons and fatty acids. Yuki Mitaka *et al*. (2020) reported that the presence of 2- phenyl undecane an aromatic compound, pentacosane and heptacosane of cuticular hydrocarbons and palmitic acid and Trans vaccenic acid of fatty acids group in aggregation pheromone group of *Reticulitermes speratus*. The present study also found that the lauric acid (fatty acid), docosane (hydrocarbon) and aromatic compounds in coconut leaf, paddy straw and coconut loose sheath respectively. Hence, these natural materials can be effectively utilized in termite bait system for the management of termites.

Table 1. Identification of Volatiles in GC MS MS

S. No.	Coconut leaf			Coconut loose sheath			Paddy straw		
	Retention time (minutes)	Area	Compound name	Retention time	Area	Compound name	Retention time	Area	Compound name
1.	2.115	391510	lacthydrazide	28.075	3252481	Phosphono acetic acid	8.017	229904	1 methoxy 2,2 di methyl propane
2.	5.226	238324	2,2 dichloro 1 hydroxy ethyl 2,2 di methyl propane	26.390	1482259	hexahydropyridine	21.179	169499	tetracosane
3.	16.316	84276	Lauric acid	18.670	73075	1 ethyl 1 methyl cyclopropane	21.179	81933	Docosane

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ES 04 BOPD 31

Management of Brinjal shoot and Fruit borer *Leucinodes orbonalis* through biorational approaches

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Keywords: *Shoot and fruit borer, L. orbonalis, Brinjal, % shoot damage, % fruit damage*

Introduction

Brinjal, *Solanum melongena* (Family: Solanceae) is native to India. It has a high nutritional value. It is grown throughout the country except in hilly areas. The brinjal crop is attacked by a number of insect-pests right from young seedling to harvesting of the crop. Among which the most fearsome is the shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae), inflicting yield losses as high as 85-90 per cent (Patnaik, 2000) has now been considered as the key pest of brinjal. In Ramanathapuram district, brinjal mainly grown in Bogalur and Nainarkoil blocks. The desi variety Pandiyur local is mostly cultivated by the farmers which is susceptible to the brinjal shoot and fruit borer. Hence, the present study was undertaken by the ICAR-Krishi Vigyan Kendra, Ramanathapuram in the farmer's field to demonstrate the IPM modules recommended by the TNAU.

Materials and methods

The experiment was conducted at farmer's field at Ramanathapuram district during 2018-19. The main aim of the study was to find out better solution to minimize the damage caused by the brinjal shoot and fruit borer. The thirty days old seedlings (Pandiyur Local) were transplanted in the main field with spacing of 75×50 cm. Irrigation was given immediately after transplanting of the seedlings. After that irrigation was given as per the requirement. The other intercultural operations were done as per the TNAU Crop Production Guide for Horticultural Crops. The IPM modules consists of spraying of Neem oil 3% , installation of pheromone trap @ 5 nos./ac, release *Trichogramma chilonis* @ 1 cc/ac after each brood emergence of moths (5-6 release) and need based spraying of thiodicarb 75 WP 2 g/l in demonstration fields, whereas in check fields farmer's practice was followed. The incidence of *L. orbonalis* in shoot was recorded from twenty randomly selected plants in each field and fruit damage was recorded as number of infested fruit in twenty randomly selected fruit in each field. Both the observations were converted into per cent infestation. The collected data were statistically analysed to draw conclusion.

Results and discussion

The per cent shoot and fruit damages in demonstration field were 4.23-8.06 and 8.89-11.62 respectively, while it was 8.89-13.15 and 13.18-21.67 in check field. The less per cent shoot and fruit damage in demo field was 4.23 and 9.35 respectively, whereas it was 8.89 and 21.67 in check field (Table 1). The maximum per cent mean shoot damage (drooping) was observed up to 1-1.5 month old crop; afterwards drooping injury was much reduced. The extent of fruit damage was very serious from third picking onwards. Umamahesh *et al*., (2018) recorded similar shoot damage in young brinjal crop which is in accordance with the present findings.

The average yield recorded demonstration field was 153.13 q/ha whereas it was only 141.76 q/ha in check field with the per cent increase over control of 8.02. The highest BCR of 3.44 was recorded in demo field and 2.98 in check field (Table 2).

Table 1. Efficacy of IPM modules against brinjal shoot and fruit borer

Demo field (IPM module)			Check field (Farmer's practice)		
Field No & Location	**% shoot damage**	**% Fruit damage**	**Field No & Location**	**% shoot damage**	**% Fruit damage**
Field I Pandiyur	6.54 (14.74)	8.89 (17.25)	Field I Pandiyur	8.89 (17.25)	14.24 (22.11)
Field II Chinna Akiramesi	6.95 (15.15)	11.58 (19.84)	Field II Chinna Akiramesi	9.78 (18.20)	13.18 (21.20)
Field III Manjakollai	8.06 (16.45)	9.70 (18.18)	Field III Manjakollai	11.60 (19.85)	18.33 (25.30)
Field IV Akiramesi	4.23 (11.82)	9.35(17.67)	Field IV Akiramesi	13.15 (21.17)	21.67 (26.48)
Field V Siragikottai	7.56 (15.92)	11.62 (19.86)	Field V Siragikottai	12.11 (19.90)	20.00 (26.43)
CD (5%)	2.60	3.63	CD (5%)	3.88	4.20
CV (%)	8.51	9.85	CV (%)	10.02	10.40

Figures in the parentheses are arc sine transformed values

Table 2. Economics of brinjal cultivation in demo and check fields

Yield (q/ha)				% Increase in yield	Economics of demonstration (Rs./ha)				Economics of check (Rs./ha)			
Demo (IPM module)			Check		Gross Cost	Gross Return	Net Return	BCR	Gross Cost	Gross Return	Net Return	BCR
High	Low	Avg.										
161.90	144.50	153.13	141.76	8.02	88975	306260	217285	3.44	94900	283510	188611	2.98

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ES 04 BOPD 32

Integrated Effect of Silica with Certain Organic Approaches on Major Insect Pests of Brinjal

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Key words: *Brinjal, insect pests, silica, flower extract, essential oil*

Introduction

Brinjal, *Solanum melongena* L.,the "King of vegetables" is being grown throughout the year under irrigated condition and hence it is subjected to attack by number of insect pests right from nursery stage till harvesting.Now-a-days farmers apply chemicals at frequent intervals to combat the pests.Average pesticide usage in brinjal has been estimated and it was 4.64 kg active ingredient per hectare. On an average, 15 applications are given in cauliflower and brinjal. Organic products are the important alternatives to minimize or replace the use of synthetic pesticides as they possess an array of properties including toxicity to the pest, repellency, antifeedance, insect growth regulatory activities against pests of agricultural importance.

Materials and methods

A field experiment was conducted during November 2015 to March 2016 (Rabi season) at Vaigasipatti village of Alanganallur block, Madurai district. The design adopted was Randomized block design (RBD) using a local variety (Varikkai) with fourteen treatments (RHA – Rice husk ash, CFE – Chrysanthemum flower extract, PF – Pseudomonas fluroscens, SSB – Silicate soil bacteria, LCE – Lantana camera extract, OO – Orange oil, CO – Citronella oil, LCFE) and replicated twice (Fig. 1). All the agronomic practices were followed uniformly in all the plots with plot size of 5 x 4 m^2.The incidence of major pests as well as the natural enemies was recorded in five plants selected at random in each plot at weekly interval.

Result and discussion

The results revealed that the incidence of shoot and fruit borer, hadda beetle, leaf hopper, whitefly and mite was significantly less in plants treated with organic sources of silica, flower extract, PGR and essential oilsas compared to untreated check. The incidence of the major pests of brinjal was significantly less in the basal application of

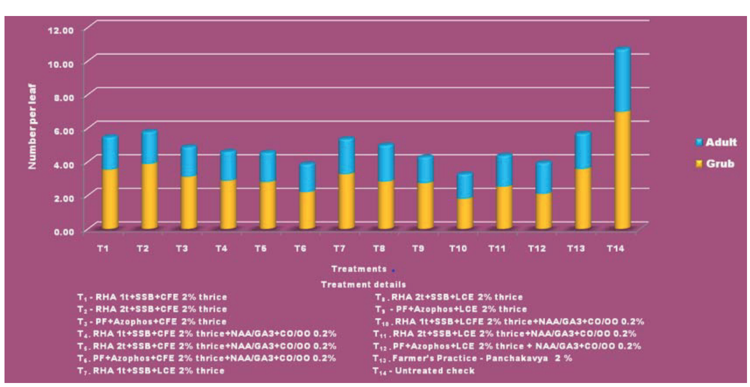

Fig 1. Effect of organic sources of silica, flower extracts, PGR and essential oils on Hadda beetle in brinjal

RHA1t + SSB with foliar application of *Lantana* flower extract 2% + NAA/ GA_3 10ppm + orange peel oil + citronella oil 0.2% sprayed during critical phases of the crop (Fig 1). Mohanchander *et al.* (2013 earlier evaluated antifeedant activities of essential oil formulations *viz.,* orange oil, basil oil, zinger oil and lemon oil against hadda beetle and found that these oils would be a good alternatives for chemical pesticides. The present results on sucking insects is identical with findings of Jaimie Zinski (2014) reported that orange oil work by asphyxiating the aphids and it has low oral and dermal toxicities and therefore was registered for use against fleas, aphids, and mites.

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ES 04 BOPD 33

Biointensive management of tomato pinworm, *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae)

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Keywords: *Tomato pinworm, Tuta absoluta, BIPM, management*

Introduction

Tomato is ravaged by several insect pests, of which the invasive South American tomato leaf miner, *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) is assuming serious pest status in India. It was also reported to cause 87 per cent yield loss in Shivakote, Karnataka (Sridhar *et al*., 2014) and 14.4 to 97.9 per cent at Vegetable Research Station, Telangana (Kumari *et al*., 2015). Application of chemical insecticides is the most commonly recommended practice for the management of *T. absoluta*. However, considering the ill effects of the pesticides on environment, natural enemies and human health, alternate ecofriendly strategies for the management of *T. absoluta* has to be worked out. Keeping this in view, the present investigation was carried out on tomato against *T. absoluta.*

Materials and methods

A field trial was conducted at Madampatti village of Coimbatore district during 2020-2021 to evaluate the efficacy of three biointensive modules in comparison with two modules exclusively with insecticides and an untreated control with four replications. The details of the modules are; M1 - Pheromone trap @ 40 / ha + *Trichogramma achaea* @ 5 cc / ha + *B. bassiana* foliar spray @ 4 g / lit + Azadiractin 1% @ 1 lit / ha; M2 - Pheromone trap @ 40 / ha + *Trichogramma achaea* @ 5 cc / ha + Azadiractin 1% @ 1 lit / ha + flubendiamide 20 WG @ 100 g / ha; M3 - Pheromone trap @ 40 / ha + *Trichogramma achaea* @ 5 cc / ha + spinetoram 11.7 % SC @ 500 ml /ha + cyantraniliprole 10.26 OD @ 150 ml / ha; M4 - chlorantraniliprole 18.5 SC @ 150 ml / ha + flubendiamide 20 WG @ 100 g / ha + spinetoram 11.7 % SC @ 500 ml /ha + cyantraniliprole 10.26 OD @ 150 ml / ha; M5 - cyantraniliprole 10.26 OD @ 150 ml / ha; M6 - Untreated control. The observations on live larval population during vegetative stage and fruit damage percentage at fruiting stage was assessed before imposing treatment and 7, 14 days after application / release from ten randomly selected plants in each plot and expressed as larval population / fruit damage per plant. Based on the result, per cent reduction in larval population and fruit damage over control, yield data were also recorded.

Results and Discussion

Among the modules tested, Module 3 (Pheromone trap @ 40 / ha + *Trichogramma achaea* @ 5 cc / ha + spinetoram 11.7 % SC @ 500 ml /ha + cyantraniliprole 10.26 OD @ 150 ml / ha) recorded highest per cent reduction in larval population (60.02%) and fruit damage (60.58%) over control with highest fruit yield of 15.06 t ha^{-1} than other modules (Table 1). Under field conditions, pest stages will be occurring in a staggered manner due to overlapping generations. Hence, release of single parasitoid or predator or pathogens alone may not have the expected result as they are effective only at a particular point of time. Hence, combination of two or three agents may be more viable which was evident from the present investigation. The present findings are in confirmation with Khidr *et al*. (2013) who reported the efficacy of combination of *B. thuringiensis* + *T. evanescens* + mass trapping with sex pheromone (90.18 and 86.03%) against *T. absoluta* in both summer and spring crops under open field conditions. Large scale validation of present findings may pave way for confirming the efficacy against *T. absoluta.*

Table 1. Effect of different management modules against *T. absoluta* on tomato

Treatment	PTC (no. of larvae / plant)	Pooled mean after two rounds of spray / release (no. of larvae / plant)*	% reduction over control	Pooled mean after three rounds of spray / release (fruit damage %)*	% reduction over control	Fruit Yield t ha^{-1}
M1	11.50	8.75^{d} (3.04)	43.12	15.06^{d} (22.83)	44.62	12.50^{b}
M2	11.50	7.06^{b} (2.74)	54.11	11.78^{b} (20.07)	56.68	13.75^{a}
M3	12.75	6.06^{a} (2.55)	60.62	10.72^{a} (19.11)	60.58	15.06^{a}
M4	11.75	7.75^{c} (2.87)	49.63	12.78^{c} (20.94)	53.00	13.13^{a}
M5	12.50	11.94e (3.51)	22.37	18.97^{e} (25.82)	30.23	11.31^{b}
M6	11.75	15.38f (3.98)	-	27.19^{f} (31.43)	-	10.25^{b}
SED		0.106		0.272		1.094
CD (0.05)		0.227		0.579		2.332

*Mean of five replications; Figures in the parentheses are $\sqrt{x+0.5}\sqrt{x+0.5}$ and arcsin transformed values; Means followed by common letter (s) are not significantly different at P=0.05 level by LSD

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ES 04 BOPD 34

Biointensive management of leafminer (*Liriomyza trifolii* B.) infesting cucumber (*Cucumis sativus* L.) under protected cultivation

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Keywords: *cucumber, leaf miner, protected cultivation, management*

Introduction

Cucumber, *Cucumis sativus* L. a member of Cucurbitaceae family, is one of the most important vegetables being grown widely under protected structures and medicinally popular crop for its crisp texture and taste. This crop is infested by many pests, causing a considerable damage in quantity and quality as well. Adult female *Liriomyza* species make feeding and oviposition punctures on the upper surface of the leaf as very small bleached spots (Parrella, 1987). The larva feeds inside the leaf, by making narrow serpentine mine that appears to be whitish when seen from the upper surface. (Parrella, 1995). Application of bio-control agents for insect pest management in greenhouses has been proved effective and its use is steadily increasing (Perdikis *et al.*, 2008). Hence, the present study was focused on various biopesticides against leafminer infesting cucumber under protected cultivation

Materials and Methods

Two field experiments were conducted, at Veerachikkampatti from Aug - Oct (2017) and Dec 2017 - Feb 2018 in a randomized block design with eight treatments, replicated thrice in farmers holding to evaluate the efficacy of bio pesticides against leafminer infesting cucumber under protected condition. The following treatments were imposed T_1 - *Lecanicillium lecanii* , T2 -*Beauvaria bassiana* , T_3 - Neem soap , T_4 -*Bacillus thuringiensis* , T_5 -Fish oil rosin soap, T_6-NSKE 5% and T_7 -Standard check (Dimethoate 30EC). Spraying was carried out as an when the pest population reaches the ETL. The infestation of leaf miner populations were recorded from ten randomly selected plants. The above observations were recorded on prior to spraying and 3rd, 7th, 10th and 14th days after spraying and the percent reduction over control was worked out.

Results and Discussion

In first field experiment, the highest population reduction over control was recorded in the dimethoate 30 EC 1.5 ml/ l treatment (80.62 %). The next effective treatments were NSKE 5% (77.59 %) and neem soap @ 10 g/ l (75.30 %), fish oil rosin soap 25 g/ l (72.83 %), *B. thuringiensis* 1 ml/ l (69.24 %) and *Lecanicillium lecanii* 10^8 CFU/ ml (65.35 %) (Table 1). The results of field experiment II, revealed that dimethoate EC 1.5 ml/ l recorded highest percent reduction (83.35 %). The next effective treatments are NSKE 5% (81.38 %), followed by neem soap 10 g/ l (75.83 %) and fish oil rosin soap @ 25 g/ l (73.81 %) (Table 2). It is evident from the experiment that the population of leaf miner is significantly reduced by NSKE 5% which is in agreement with the earlier report of (Larew *et al.*, 1985). These findings are corroborated with the results of (Choudary and Rosaiah, 2001) who reported that multi neem, NSKE 5 % and neem azal are effective neem products against *Liriomyza trifolii* and significantly produce result in yield.

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Table 1. Population of *Liriomyza trifolii,* as influenced by bio-pesticides in polyhouse cucumber at Veerachikkampatti - Field experiment I (Aug - Oct 2017)

Treatment	Treatment details	PTC	Mean no. of live larvae / plant*								Mean	Reduction over control (%)
			I Spray				II Spray					
			3 DAT	7 DAT	10 DAT	14 DAT	3 DAT	7 DAT	10 DAT	14 DAT		
T_1	*L. lecanii* @ 10^8 CFU/ ml	9.67 (3.11)	9.16 (3.03)^{f}	8.52 (2.92)^{f}	7.53 (2.74)^{f}	8.16 (2.86)^{e}	8.26 (2.87)^{f}	7.82 (2.80)^{e}	6.58 (2.57)^{f}	6.95 (2.64)^{e}	8.01 (2.83)^{f}	65.35
T_2	*B. bassiana* @ 10^8 CFU/ ml	10.53 (3.24)	10.34 (3.22)^{g}	9.57 (3.09)^{g}	8.51 (2.92)^{g}	9.28 (3.05)^{f}	8.86 (2.98)^{g}	8.39 (2.90)^{f}	7.54 (2.75)^{g}	7.83 (2.80)^{f}	8.69 (2.95)^{g}	62.41
T_3	Neem soap @ 10 g/ l	8.27 (2.88)	7.23 (2.69)^{c}	6.45 (2.54)^{c}	5.28 (2.30)^{c}	6.72 (2.59)^{c}	5.25 (2.29)^{b}	5.06 (2.25)^{bc}	4.43 (2.10)^{c}	5.22 (2.28)^{b}	5.71 (2.39)^{c}	75.30
T_4	*Bt* @ 1ml/ l	9.25 (3.04)	8.56 (2.93)^{e}	7.25 (2.69)^{e}	6.28 (2.51)^{e}	8.96 (2.99)^{f}	7.52 (2.74)^{e}	6.54 (2.56)^{d}	5.35 (2.31)^{e}	6.43 (2.54)^{d}	7.11 (2.67)^{e}	69.24
T_5	FORS @ 25 g/ l	8.92 (2.99)	7.85 (2.80)^{d}	6.81 (2.61)^{d}	5.75 (2.40)^{d}	7.53 (2.74)^{d}	6.37 (2.52)^{d}	5.36 (2.32)^{c}	4.89 (2.21)^{d}	5.68 (2.38)^{c}	6.28 (2.51)^{d}	72.83
T_6	NSKE 5 %	6.81 (2.61)	5.93 (2.44)^{b}	5.21 (2.28)^{b}	4.82 (2.20)^{b}	6.25 (2.50)^{b}	5.82 (2.41)^{c}	4.67 (2.16)^{b}	3.85 (1.96)^{b}	4.92 (2.22)^{b}	5.18 (2.28)^{b}	77.59
T_7	Dimethoate @ 1.5 ml/ l	6.40 (2.53)	5.27 (2.30)^{a}	4.52 (2.13)^{a}	3.36 (1.83)^{a}	5.83 (2.41)^{a}	4.96 (2.23)^{a}	4.25 (2.06)^{a}	3.27 (1.81)^{a}	4.37 (2.09)^{a}	4.48 (2.12)^{a}	80.62
T_8	Control	12.36 (3.52)	14.53 (3.81)^{h}	16.28 (4.03)^{h}	19.87 (4.46)^{h}	22.25 (4.72)^{g}	24.36 (4.94)^{h}	26.97 (5.19)^{g}	29.24 (5.41)^{h}	31.49 (5.61)g	23.12 (4.81)^{h}	-
	SEd	NS	0.016	0.030	0.031	0.028	0.021	0.043	0.032	0.033	0.029	-
	CD	NS	0.035	0.065	0.067	0.060	0.046	0.093	0.069	0.071	0.062	

*Mean value of three replications; DAT - Days after treatment; PTC - Pre-treatment count; Figures in parenthesis are square root transformed values; In a column, means followed by same letter are not significantly different at P = 0.05 as per LSD

Table 2. Population of *Liriomyza trifolii*, as influenced by bio-pesticides in polyhouse cucumber at Veerachikkampatti - Field experiment II (Dec 2017 – Feb 2018)

Treatment	Treatment details	PTC	Mean no. of live larvae / plant*								Mean	Reduction over control (%)
			I Spray				II Spray					
			3 DAT	7 DAT	10 DAT	14 DAT	3 DAT	7 DAT	10 DAT	14 DAT		
T_1	*L. lecanii* @ 10^8 CFU/ ml	12.28 (3.50)	10.34 (3.22)^{e}	8.85 (2.97)^{e}	7.28 (2.70)^{d}	9.75 (3.12)^{e}	8.54 (2.92)^{f}	6.34 (2.52)^{f}	6.13 (2.48)^{f}	8.31 (2.88)^{f}	8.19 (2.86)^{f}	66.33
T_2	*B. bassiana* @ 10^8 CFU/ ml	11.38 (3.37)	10.83 (3.29)^{d}	9.47 (3.08)^{f}	8.85 (2.97)^{e}	10.84 (3.29)^{f}	9.62 (3.10)^{g}	7.41 (2.72)^{g}	6.85 (2.62)^{g}	9.54 (3.09)^{g}	9.18 (3.03)^{g}	62.26
T_3	Neem soap @ 10 g/ l	10.36 (3.22)	8.25 (2.87)^{b}	7.53 (2.74)^{c}	5.94 (2.44)^{c}	6.25 (2.50)^{c}	5.27 (2.30)^{c}	4.65 (2.16)^{c}	3.48 (1.87)^{c}	5.63 (2.37)^{c}	5.88 (2.42)^{c}	75.83
T_4	*Bt* @ 1ml/ l	11.92 (3.45)	9.57 (3.09)^{d}	8.31 (2.88)^{d}	6.89 (2.62)^{d}	7.65 (2.77)^{d}	6.83 (2.61)^{d}	5.62 (2.37)^{e}	5.29 (2.30)^{e}	7.86 (2.80)^{e}	7.25 (2.69)^{e}	70.20
T_5	FORS @ 25 g/ l	9.47 (3.08)	8.85 (2.97)^{c}	7.26 (2.69)^{c}	6.17 (2.48)^{c}	6.48 (2.55)^{c}	6.02 (2.45)^{e}	5.28 (2.30)^{d}	4.52 (2.13)^{d}	6.35 (2.52)^{d}	6.37 (2.52)^{d}	73.81
T_6	NSKE 5 %	8.83 (2.97)	7.92 (2.81)^{b}	5.28 (2.30)^{a}	4.82 (2.20)^{b}	5.94 (2.44)^{b}	3.62 (1.90)^{b}	2.35 (1.53)^{b}	1.83 (1.35)^{b}	4.51 (2.12)^{b}	4.53 (2.13)b	81.38
T_7	Dimethoate @ 1.5 ml/ l	9.72 (3.12)	7.25 (2.69)^{a}	6.53 (2.56)^{b}	4.31 (2.08)^{a}	5.52 (2.35)^{a}	2.18 (1.48)^{a}	1.83 (1.35)^{a}	1.04 (1.02)^{a}	3.72 (1.93)^{a}	4.05 (2.01)^{a}	83.35
T_8	Control	12.35 (3.51)	15.53 (3.94)^{f}	17.28 (4.16)^{g}	19.87 (4.46)^{f}	23.25 (4.82)^{g}	26.96 (5.19)^{h}	28.83 (5.37)^{h}	30.54 (5.53)^{h}	32.37 (5.69)^{h}	24.33 (4.93)^{h}	-
	SEd	NS	0.041	0.040	0.039	0.023	0.028	0.021	0.025	0.028	0.027	-
	CD	NS	0.090	0.086	0.083	0.049	0.061	0.045	0.048	0.060	0.057	

*Mean value of three replications; DAT - Days after treatment; PTC - Pre-treatment count; Figures in parenthesis are square root transformed values; In a column, means followed by same letter are not significantly different at P = 0.05 as per LSD

ES 04 BOPD 35

Evaluation of an efficient type of pheromone trap for Brinjal Shoot and fruit borer and its management by pheromone mediated mass trapping

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Key words: *Brinjal shoot and fruit borer, Pheromone mass trapping, suitable pheromone trap*

Introduction

Use of pheromone for attraction of target insect pest is influenced by variety of factors which can either increase or reduce trap efficiency considerably. Among such factors the important are trap configuration and trap deployment. *Nandagopal et al. (2006)* have developed a viable efficient sex pheromone trap for groundnut leaf miner. Althrough different types of traps viz., Delta traps, Funnel traps, Baffle traps, Wota traps etc., were available in the market, the information on suitable trap for the moth catch in brinjal in scanty, so this work has been contemplated.

Materials and method:

The field studies were conducted in the farmers fields of Ananthapuram district and Four types of traps (Table No.1) were evaluated with 6 replications. The data on moth catch per trap was collected daily and tabulated standard week wise. The total trap catch was also given over the crop period from 10 DAT to harvest after following the statistical procedures. Seven traps of each design for one replication were placed randomly in a randomized block design maintaining at a distance of 60 m between them. All the traps were kept in position by hanging them to a 1.5 m bamboo sticks and positioned at crop canopy level. Lures were replaced after every 22 days.

Results and discussions: The adult trap catches was presented standard week wise from 34th std. week to 45th standard week. In all the standard weeks, the polythene sleeve traps attracted significantly highest number of brinjal shoot and fruit borer adults *i.e.* from 83.8 moths / trap (34th week) to 1.80 moths per trap (45th standard week). The total number of moths trapped also were significantly high in polythene sleeve traps (242.4 moths/trap). The wota traps recorded the lowest number of adult moths per trap (85.6) and all the other traps were significantly superior over this trap (Table 1). The results obtained in the present investigation are in accordance with the earlier report. Rai *et al.,* (2000) suggested that for *Helicoverpa armigera* Hub, in cotton sleeve and funnel traps were superior to sticky traps.

The experiments were also conducted to explore the feasibility of employing pheromone mass trapping techniques for BSFB management in brinjal in the farmers fields. The pheromone sleeve traps were installed @ 25 per ha within 10-15 days of transplanting of brinjal seedlings. Significant differences were recorded in the incidence of BSFB in terms of shoot and fruit damage in the fields of pheromone mass trapping and farmers practice methods. The mean per cent shoot and fruit damage of 2.98 and 12.4 were observed in the pheromone mass trap method as against 8.87 and 39.74 percent in the farmers practice. The additional benefit was Rs. 60,000/- per ha realized by the farmers in the villages of Pheromone mass trapping method.

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Table 1. Evaluation of different pheromone traps in brinjal shoot and fruit borer (*Leucinodes arbonalis*)

Different Traps	Std.week												
	34(20-26Aug)	35(27-2Sep)	36(3-9Sep)	37(10-16Sep)	38(17-23Sep)	39(24-30Sep)	40(1 -7 oct)	41(8 -14 oct)	42(15 -21 oct)	43(22 -28oct)	44(29 -4 Nov)	45(4 -11 Nov)	Total
Delta traps	27.6 (5.24)b	50.6 (6.92)c	20.4 (4.2)b	5.4 (1.99)a	2.4 (1.66)c	4.8 (2.22)b	1.8 (1.50)b	4.4 (1.95)b	3.2 (2.20)b	2.2 (1.60) ab	1.6 (1.43)b	1 (1.19) ab	127 (11.15) bc
Sleeve traps	83.8 (9.01)a	70.6 (8.42)b	32.8 (5.7)ab	2 (1.56)bc	6.2 (2.54)ab	5 (2.32)b	4.2 (2.13)a	20.4 (4.55)a	8.8 (3.04)a	3.4 (1.96)a	3.4 (1.96)a	1.8 (1.50) a	242.4 (15.53) a
Wota traps	5.8 (2.45)c	37.8 (6.13)c	16.8 (4.01)b	2.6 (1.73)ab	6 (2.52)b	9 (3.06)a	0 (0.7)c	2.2 (1.63)bc	1.6 (1.43)c	2 (1.54) bc	1.6 (1.43)bc	0.2 (0.83) bc	85.6 (9.25)c
Baffle traps	12.6 (3.45)bc	97.2 (9.87)a	41.2 (6.22)a	2 (1.54)c	7.2 (2.67)a	1.8 (1.49)c	2 (1.54)b	1.6 (1.43)c	1.6 (1.43)c	1.8 (1.50)c	1.4 (1.37)c	0.2 (0.83) c	174 (13.18) a
CD	1.82	1.36	1.73	1.13	0.84	0.56	0.39	0.90	0.41	0.43	0.24	0.72	11.81
CV	26.32	12.64	24.83	48.15	25.9	17.9	19.6	27.3	14.7	19.0	11.1	48.2	69.7

ES 04 BOPS 01

Evaluation of organic amendments against onion thrips (*Thrips tabaci*) on onion under field condition.

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Keywords: *Onion, Thrips tabaci, neem cake, pungam cake, vermicompost, biofertilizer.*

Introduction

Onion, *Allium cepa* L., is a common and an important commercial vegetable belongs to the family Alliaceae. The onion thrips, *Thrips tabaci* (Thysanoptera: Thripidae) is the most serious one inflicting significant yield reduction. Organic amendments in the pest management considered as an ecologically viable proposition which avoid environmental pollution (Rajendran, 1993). Hence the present study was designed to evaluate the impact of organic amendments in the management of thrips population in onion field.

Materials and Methods

The treatments evaluated were T_1 -*Pseudomonas fluorescens*(5 g/kg) +Neem cake (250 kg/ha), T_2 - Bio fertilizer (2 Kg/ha) + Neem cake (250 kg/ha), T_3 -Bio fertilizer (2 Kg/ha) + Pungam cake (250 kg/ha), T_4 -Vermicompost (1 t/ha) + Bio fertilizer (2 Kg/ha) + Neem cake (250kg/ha), T_5 -Vermicompost (1 t/ha) + Bio fertilizer (2 Kg/ha) + Pungam cake (250 kg/ha), T_6 -*Pseudomonas fluorescens*+ Neem cake (125kg/ha) + Pungam cake (125kg/ha), T_7 -Vermicompost (1 t/ha) + Bio fertilizer (2 Kg/ha) +Neem cake (125kg/ha)+ Pungam cake (125kg/ha), T_8 -NPK as inorganic form (30:60:30) and untreated control. Observation on thrips population was recorded from 15 to 74 days after planting at seven days interval on ten plants selected randomly.

Results and Discussion

Among the various organic amendments evaluated, Vermicompost + Biofertilizer + Neem cake was significantly effective and recorded minimum number of thrips population (13.30 and 14.33 thrips/plant) and significantly superior over NPK (23.91 and 24.95 thrips/plant) throughout the period of observation (Table 1) followed by Vermicompost + Biofertilizer + Neem cake + Pungam cake (15.29 and 16.46 thrips/plant) during the two seasons respectively. The per cent reduction of onion thrips was also maximum (46.54 and 44.02%) in treatment with Vermicompost + Biofertilizer + Neem cake. The present findings are in accordance with Chandrakumar, (2008) who reported that Vermicompost + Biofertilizer combined with neem cake was effective in reducing all major insect pests of brinjal.

Table 1. Field evaluation of organic amendments against onion thrips on both season I and season II

Treatments	SEASON I		SEASON II	
	Grand mean of thrips population after 15,22, 29, 36, 43, 50 and 74 days after planting (thrips /plant*)	Per cent reduction over control	Grand mean of thrips population after 15,22, 29, 36, 43, 50 and 74 days after planting (thrips /plant*)	Per cent reduction over control
T_1. *Pseudomonas fluorescence* + Neem cake (FD)	20.82 (4.52)^{f}	16.33	21.27 (4.61)^{e}	16.91
T_2. Biofertilizer (Azospirillum) + Neem cake (FD)	18.58 (4.27)^{d}	25.34	19.20 (4.38)^{cd}	25.00
T_3. Biofertilizer (Azospirillum) + Pungam cake (FD)	19.19 (4.34)^{de}	22.89	19.64 (4.43)^{d}	23.28
T_4. Vermicompost + Biofertilizer (Azospirillum) + Neem cake (HD)	13.30 (3.60)^{a}	46.54	14.33 (3.79)^{a}	44.02
T_5 . Vermicompost + Biofertilizer (Azospirillum) + Pungam cake (HD)	17.30 (4.12)^{c}	30.44	18.22 (4.27)^{c}	28.83
T_6. *Pseudomonas fluorescence* + Neem cake (HD) + Pungam cake (HD)	20.19 (4.45)^{ef}	18.87	21.05 (4.59)^{e}	17.77
T_7. Vermicompost + Biofertilizer (Azospirillum) + Neem cake (HD) + Pungam cake (HD)	15.29 (3.86)^{b}	38.56	16.46 (4.06)^{b}	35.70
T_8. Nitrogen,Phosphorus and Potash	23.91 (4.84)^{g}	3.89	24.95 (5.00)^{f}	2.54
Untreated control	24.88 (4.99)^{g}	-	25.60 (5.06)^{f}	-
SEd	0.06	-	0.06	-
CD (0.05)	0.12	-	0.12	-

FD- Full dose ; HD- Half dose

*Mean of three replications. Values in parentheses are transformed.

In a column, mean followed by same letter(s) are not significantly different at (P = 0.05) by LSD.

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ES 04 BOPS 02

Evaluation of different bait and attractant combinations in male annihilation of Pumpkin Fruit fly, *Zeugodacus* (*Zeugodacus*) *tau* (Walker) (Diptera: Tephritidae)

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Introduction

Pumpkin fruit fly, *Zeugodacus (Zeugodacus) tau* (Walker) (=*Bactrocera (Zeugodacus) tau*) damages a number of host plants species belonging to 23 families, but plants belonging to the family Cucurbitaceae are the most preferred(Agarwal, 2019). The arrays of control methods include; insecticide sprays to foliage and soil, bait-sprays, male annihilation techniques, releases of sterilized flies and parasitoids, and cultural controls (Vargas *et al*., 2015). Efforts have been made to manage fruit flies by using insecticides, baits either in trap or as cover spray, male annihilation technique (MAT) using attractant and combined use of bait and attractant. The present work has been taken up to evaluate the efficiency of different bait and attractant combinations.

Materials and methods

The experiment was conducted at Dr. Rajendra Prasad central University Samastipur during 2018-2019. For annihilation of males, self made plastic bottle traps were used (made of 1 liter mineral water bottle). Inside the bottle trap plywood block soaked in combination consisting of ethanol + cue-lure + dichlorvos 76% EC (6:4:1 V/V) + bait (5 per cent) were used for trapping of flies. These traps were hung below the trees at about 2 m height in places having no direct sunlight in a bitter gourd garden. The five different treatments were; T_{1}-control (Cue-lure + Dichlorvos + Ethanol), T_2 (Protein hydrolysate + Cue-lure + Dichlorvos + Ethanol), T_3 (Jaggery + Cue-lure + Dichlorvos + Ethanol), T_4 (Fruit pulp + Cue-lure + Dichlorvos + Ethanol) and T_5 (Molasses + Cue-lure + Dichlorvos + Ethanol). The treatments were replicated four times. Impregnated plywood blocks were replaced at fortnightly interval and the number of flies trapped was counted at weekly intervals.

Results and Discussion

It was found that bait enhanced the annihilation rate of flies during its peak population. Treatment T_2 (with protein bait) was significantly superior over others. Maximum flies were annihilated in T_2 with protein bait and this treatment was significantly superior over others. Treatments T_3 (with jaggery) and T_4 (with fruit pulp) were at par and similarly Treatments T_1 (without bait) and T_5 (with molasses) were also at par. However, treatments T_5 (with molasses as bait) and T_1 (without bait) were at par and showed no significant difference.

Therefore, it was conducted that molasses was not effective bait in terms of its efficacy in annihilation of males of *Z. tau* while protein bait was the most effective treatment.

Mean number of ***Zeugodacus tau*** annihilated (males/trap/month) with different formulations

Month	Treatment*					SEm (±)	C.D. (P=0.05)
	T_1	T_2	T_3	T_4	T_5		
April, 2018	25.50 (3.23)	71.00 (4.26)	46.75 (3.84)	43.75 (3.77)	36.00 (3.58)	2.070 (0.72)	6.449 (1.86)
May	109.25 (4.69)	213.25 (5.36)	125.75 (4.83)	109.00 (4.69)	77.50 (4.35)	6.883 (1.92)	21.445 (3.06)
June	54.50 (3.99)	103.25 (4.63)	57.50 (4.05)	84.50 (4.43)	56.50 (4.03)	6.067 (1.80)	18.900 (2.93)

July	21.25 (3.05)	33.25 (3.50)	30.00 (3.40)	34.50 (3.54)	30.25 (3.40)	4.123 (1.41)	NS
August	32.00 (3.46)	33.00 (3.49)	31.50 (3.44)	35.00 (3.55)	26.50 (3.27)	3.208 (1.16)	NS
September	24.00 (3.17)	29.50 (3.38)	36.00 (3.58)	26.50 (3.27)	26.25 (3.26)	2.971 (1.08)	NS
October	31.25 (3.44)	53.50 (3.97)	40.00 (3.68)	30.75 (3.42)	34.75 (3.54)	3.038 (1.18)	9.446 (2.24)
November	60.50 (4.10)	80.75 (4.39)	55.50 (4.01)	50.25 (3.91)	62.00 (44.27)	4.670 (1.54)	14.548 (2.67)
December	9.25 (2.22)	15.75 (2.75)	13.50 (2.60)	10.50 (2.35)	12.25 (2.50)	2.078 (0.73)	NS
January, 2019	1.00 (0.0)	2.25	0.75	1.00 (0.0)	1.00 (0.0)	0.454	NS
February	6.75 (1.90)	27.25 (3.30)	16.75 (2.81)	12.50 (2.52)	9.75 (2.27)	0.173	3.653 (1.27)
March	25.00 (3.21)	70.50 (4.25)	49.00 (3.89)	40.25 (3.69)	35.25 (3.56)	1.902 (0.64)	5.926 (1.77)
* Mean of four replications							
Figures in parentheses are $\log_e$ transformed values							
NS= Non-significant							

T1-Cue-lure +Dichlorvos + Ethanol; T2-Cue-lure +Dichlorvos + Ethanol+ Protein hydrolysate;T3-Cue-lure +Dichlorvos + Ethanol+ Jaggery; T4-Cue-lure +Dichlorvos + Ethanol+ Fruit pulp; T5-Cue-lure +Dichlorvos + Ethanol+ Molasses

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ES 04 BOPS 03

Evaluation of botanical extracts and essential oils for the management of lesser wax moth, *Achroia grisella* F. (Lepidoptera: Pyralidae) under stored condition

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Key words: *Lesser wax moth, Achroia grisella F, solvent extracts, steam distillates, larval mortality.*

Introduction

Honey bees (*Apis* spp.) are the proven pollinators, responsible for pollination of about 70% of major crops grown across the globe (Steffan-Dewenter *et al*., 2006). Among several biotic factors challenging bee keeping, two species of wax moths *viz*., Greater wax moth, *Galleria mellonella* L. and Lesser wax moth, *Achroia grisella* F. are considered to be serious under field and storage conditions. Use of chemical pesticides in a bee hive is impracticable due to the high sensitiveness of bees besides toxicity hazards (Pinto *et al*., 2010).

Materials and Methods

The bio-efficacy experiments involving steam distillates and solvent extracts were carried out at the apiary, TNAU during April 2021. As the role of botanicals and their products has got ample scope in the management of wax moths in a beehive (Farghaly *et al*., 2017), four plant extracts (*Acorus calamus, Curcuma longa, Coleus forskohlii* and *Ocimum basilicum*) and three essential oils (derived from *Mentha piperita, Eucalyptus globulus* and *Cymbopogan citratus*) were evaluated against wax moths under storage conditions. The plant extracts were obtained by using microwave assisted extraction unit and essential oils were extracted by steam distillation method. About one year old, relatively darker, honey harvested combs with uniform size and weight (10gm) were placed inside the insect cages and lesser wax moth larvae at 20 numbers per comb were released. The botanical extracts and essential oils at 5% dose were sprayed by an atomiser and observations on the larval mortality at 48 hours after spraying was recorded.

Results and discussion

Evaluation of botanical extracts against the larvae of lesser wax moth, *A. grisella*

The efficacy of selected plant extracts against *A. grisella* showed the effectiveness of *O. basilicum* with 84.05% larval mortality (82.56 % reduction over control) followed by, *A. cala* *Corresponding Author Email: *mus* with 74.99% kill *C. forskohlii* (73.56%) and *C. longa* (66.66%). Among the essential oils tested (steam distillates @ 5%), *M. piperita* was found to be highly effective against lesser wax moth larvae, affording 79.04% kill of larvae (77.08% reduction over control), followed by *E. globulus* and *C. citratus* with 74.99% and 70.71% larval mortality respectively (Table 1).

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Table 1. Efficacy of botanical extracts and essential oils against different larval instars of lesser wax moth, *A. grisella* under stored conditions.

Treatment	% mortality of larval instars of *A. grisella* *±S.D							Overall Mean	Reduction over control (%)
	I	II	III	IV	V	VI	VII		
Solvent extract at 5%									
1. *Acorus calamus*	100.0±0.00 (89.71)[a]	93.30±5.77 (77.62)[ab]	85.00±5.00 (67.40)[b]	78.33±2.89 (62.29)[bc]	70.00±5.00 (56.84)[bc]	53.33±5.77 (46.92)[bc]	45.00±5.00 (42.12)[cd]	74.99	72.65
2. *Curcuma longa*	91.66±2.87 (73.40)[c]	88.33±2.89 (70.12)[b]	75.00±5.00 (60.08)[c]	65.00±5.00 (53.76)[d]	65.00±5.00 (53.76)[c]	43.33±2.89 (41.16)[c]	38.33±2.89 (38.25)[d]	66.66	63.54
3. *Ocimum basilicum*	100.00±0.00 (89.71) [a]	98.33±2.89 (85.50) [a]	91.66±2.89 (73.40) [a]	88.33±2.89 (70.12) [a]	80.00±5.00 63.55) [a]	70.00±5.00 (56.84) [a]	60.00±5.00 (50.79)[a]	84.05	82.56
4. *Coleus forskohlii*	100.0±0.00 (89.71)[a]	91.66±2.89 (73.40)[b]	81.66±2.89 (64.69)[bc]	80.00±5.00 (63.55)[bc]	68.33±2.89 (55.77)[bc]	50.00±5.77 (46.95)[bc]	43.33±2.89 (41.16)[cd]	73.56	71.09
Steam distillate at 5%									
5. *Eucalyptus globulus*	96.66±2.89 (81.29)[b]	93.30±2.89 (75.24)[ab]	83.33±5.77 (66.15)[b]	80.00±5.77 (63.93)[abc]	68.33±2.89 (55.77)[bc]	55.00±5.00 (47.88)[b]	48.33±2.89 (44.04)[bc]	74.99	72.65
6. *Mentha piperita*	100.0±0.00 (89.71)[a]	95.00±5.77 (79.45)[ab]	86.66±2.89 (68.66)[ab]	81.66±2.89 (64.70)[ab]	71.66±2.89 (58.93)[b]	65.00±7.64 (55.85)[a]	53.33±2.89 (46.91)[ab]	79.04	77.08

7. *Cymbopogan citratus*	93.33±2.89 (75.24)[c]	91.66±2.89 (73.40)[b]	80.00±5.00 (63.55)[bc]	71.66±2.89 (57.86)[cd]	66.66±2.89 (54.75)[bc]	51.66±7.64 (45.97)[bc]	40.00±5.00 (39.21)[d]	70.71	67.97
8. Control (Water)	11.66±2.89 (19.88)[d]	8.30±2.89 (16.56)[c]	8.33±2.89 (16.60)[d]	8.33±2.89 (16.60)[e]	8.33±2.89 (16.60)[d]	8.33±2.89 (16.60)[d]	6.60±2.89 (14.76)[e]	8.55	-
SEm±	9.97	9.05	11.75	13.18	6.86	14.99	5.85	-	-
C.D (p= 0.05)	5.47	4.56	5.93	6.28	4.53	6.70	4.19	-	-

Note: * Mean of three replications for each instar. Figures in parentheses are arc sine transformed values; S.D: Standard Deviation; SEm: Standard Error of mean; C.D: Critical Difference. Figures are not having the same alphabetical letters in a same column differ significantly at $p < 0.05$.

ES 04 BOPS 04

Insecticidal and insect growth inhibitory activities of colloidal chitosan against Diamondback Moth, *Plutella xylostella* L. (Lepidoptera: Plutellidae) on cauliflower

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Keywords: *Cauliflower, Plutella xylostella, colloidal chitosan, acute toxicity, growth and development*

Introduction

Diamondback moth *Plutella xylostella* L. invasive and economically important pest of crucifers in Tamil Nadu. It causes 50 to 80% annual yield loss in crucifers (Gautam *et al.*, 2018). Farmers always resort to application of insecticides at 6 to 10 days interval for 6 to 8 times. Using insecticides in higher rates cause many detrimental effects such as residue, resurgence, resistance and environmental hazards. An alternative method of control using insect growth inhibitors can be tried. In this study, colloidal chitosan was evaluated for its acute toxicity, growth and development inhibitory effect against second instar larvae of *Plutella xylostella* L.

Materials and methods

The effect of colloidal chitosan on growth and development of *P. xylostella* was estimated by allowing the larvae to feed colloidal chitosan treated cauliflower leaves (leaf dip bioassay) for the first three days, later the larvae were allowed to feed on untreated leaves till pupation.

The colloidal chitosan was dissolved in the 1 per cent aqueous acetic acid and mixed with surfactant, Tween 80 0.05% to prepare different concentrations *viz.,* 3000, 5000, 8000, 10000 ppm, Tween 80 0.05% used as negative check and Azadirachtin 1 EC @ 2 ml lit^{-1} was kept as treated check, untreated check was also maintained for comparison. The leaf bits (5x4 cm), prepared from tender cauliflower leaves were used for the bioassay. Each treatment was replicated thrice and for each replication 10 second instar larvae were released. Larval weight was recorded daily, pupal and adult weights were also noted. Larval, pupal period and adult life span was recorded (Tian *et al*., 2020).

Result and Discussion

The acute feeding of *P. xylostella* on colloidal chitosan treated leaves, at all concentrations, resulted in efficient reduction in growth and development of larva compared to untreated check. The weight gain of the larva fed on colloidal chitosan 10000 ppm (0.093 mg) and azadirachtin 1 EC @ 2 ml l^{-1} (0.063 mg) was very minimum and finally resulted in cent per cent mortality after sixth days and fourth days, respectively. While, the pupal (2.63 mg) and adult weight (1.49 mg) was reduced at 8000 ppm on compared with untreated check (4.85 mg and 3.20 mg, respectively).

Consequently, the larval period of *P. xylostella* was prolonged by three days, when fed with colloidal chitosan 8000 ppm treated leaves (13 days) compared to untreated check (10.66 days) and the pupal period was extended by two days when treated at 8000 ppm (6.66 days) compared to control (4.66 days). In case of adult life span, no significant difference was found among the treatments. An early study of *N*-alkyl chitosan (NAC) derivatives against *S.litura* reported that insect growth was significantly decreased and the normal ecdysis process was affected, with symptoms of inhibition of feeding and weight gain, and the larvae were very small compared with the control (Rabea *et al*., 2005). Uddin *et al.* (2021) reported that the unmodified chitosan was active against *S.litura* larvae, with 62.72% mortality after seven days of treatment and also reduced the larval growth, with more than 27%. Moorthy *et al*. (2021) also reported the antifeedant index of 85.96% when fed on colloidal chitosan at 7% treated leaf by first instar larva of *Spodoptera frugiperda*. It is concluded that the colloidal chitosan is possessing insecticidal and growth inhibitory effect on *P. xylostella*.

Table 1. Impact of colloidal chitosan on weight and developmental period of *P.xylostella* due to acute feeding

Treatments	Larval weight gain over initial weight (mg)*	Pupal weight (mg)*	Adult weight (mg)*	Average larval period (days)*	Average pupal period (days)*	Average adult longevity (days)*
T1- Colloidal chitosan 3000 ppm	3.91±0.12 (1.97)[d]	3.62±0.01 (1.90)[c]	2.05±0.18 (1.43)[c]	10.66±0.57 (3.26)[c]	4.33±0.57 (2.08)[c]	14.00±0.00 (3.74)
T2- Colloidal chitosan 5000 ppm	2.81±0.29 (1.67)[c]	3.59±0.20 (1.89)[c]	1.98±0.27 (1.40)[c]	12.00±0.00 (3.46)[b]	5.66±0.57 (2.38)[b]	14.66±0.57 (3.3.78)
T3- Colloidal chitosan 8000 ppm	2.22±0.14 (1.49)[b]	2.63±0.20 (1.62)[b]	1.49±0.32 (1.22)[b]	13.00±0.00 (3.60)[a]	6.66±0.57 (2.58)[a]	14.33±0.57 (3.87)
T4- Colloidal chitosan 10000 ppm	0.093±0.03 (0.17)[a]	0.00±0.00 (0.71)[a]	0.00±0.00 (0.71)[a]	0.00±0.00 (0.71)[d]	0.00±0.00 (0.71)[d]	0.00±0.00 (0.71)
T5- Acetic acid 1%	5.40±0.03 (2.32)[e]	4.81±0.13 (2.19)[d]	3.19±0.04 (1.78)[d]	10.33±0.57 (3.21)[c]	4.33±0.57 (2.08)[c]	14.66±0.57 (3.82)
T6- Tween80 0.05%	5.62±0.01 (2.37)[e]	4.88±0.12 (2.20)[d]	3.20±0.01 (1.78)[d]	10.33±0.57 (3.21)[c]	4.00±0.00 (2.00)[c]	14.00±0.0 (3.74)[b]
T7- Azadirachtin (1%) 2 ml/lit	0.063±0.01 (0.25)[a]	0.00±0.00 (0.71)[a]	0.00±0.00 (0.71)[a]	0.00±0.00 (0.71)[d]	0.00±0.00 (0.71)[d]	0.00±0.00 (0.71)
T8- Untreated check	5.55±0.01 (2.35)[e]	4.85±0.06 (2.20)[d]	3.20±0.03 (1.78)[d]	10.66±0.57 (3.26)[c]	4.66±0.57 (2.16)[c]	14.33±0.57 (3.78)
SEd	0.054	0.026	0.045	0.05	0.07	NS (0.04)
F Value	513.53	1341.58	248.32	1255.16	187.05	2357.89

* Mean values of three replications are represented as mean ± standard deviation; SEd: Standard Error of the difference; Figures in the parentheses are square root transformed values; Mean followed by the same letter are not significantly different from each other, DMRT ($p \leq 0.05$);

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ES 04 BOPS 05

Effect of Chitosan-O-Arginine on consumption and utilization of food by Diamondback moth, *Plutella xylostella* L. (Lepidoptera: Plutellidae) on cauliflower

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Keywords: *Plutella xylostella, Chitosan-O-Arginine, Cauliflower, Consumption and Utilization*

Introduction

Diamondback moth, *Plutella xylostella L.* (Lepidoptera: Plutellidae) is a widespread major pest of cultivated and wild crucifers and can cause high yield loss of 91.2% (Elizeu *et al.*, 2020). Hence, farmers often resort to prophylactic and calendar-based insecticides application, which lead to resurgence, resistance, residue problem and environment pollution. As cauliflower is a vegetable crop, finding suitable ecofriendly management is highly important. In this context, the marine waste of chitinous solid were available in plenty (60,000 to 80,000 tons/annum) **(**Ibrahim *et al*., 1991**)**, it would cause pollution and pose a great threat to the environment, if they are not disposed properly. As chitosan and their derivatives were reported to possess insecticidal/ antifeedant efficiency (Uddin *et al.*, 2021: Moorthy *et al.,* 2021), this study was carried out to investigate the influence of Chitosan-O-Arginine on the food consumption and utilization efficiency of *P. xylostella*.

Materials and Method

In a laboratory experiment conducted at Natural Pesticides Laboratory, Department of Agricultural Entomology, Agricultural College and Research Institute, Madurai during 2020 -2021, the fourth instar larvae of *P. xylostella* were fed with Chitosan-O-Arginine treated leaves for 48 hours, to understand their influence on nutritional parameters of consumption, digestion and utilization of treated food (on wet basis) (Waldbauer, 1968; Koul *et al.*, 2004). It was tested at nine different concentrations *viz*, 100, 300, 500, 700 and 1000 ppm, with Tween 80 0.05% as an adjuvant and Azadirachtin 1 EC @ 2 ml/lit as a treated check, in comparison with untreated check. Three replications were maintained @ 10 larvae/ replication. Observations were made on the initial and final weight of leaf, larva and weight of faeces produced at 24 and 48 hours of feeding, using digital weighing balance (0.01 mg precision). The nutritional indices *viz*., Growth Rate (GR), Consumption Rate (CR), Consumption Index (CI), Approximate Digestibility (AD), Efficiency of Conversion of Ingested food (ECI) and Efficiency of Conversion of Digested food (ECD) were estimated.

Results and Discussion

The results indicated that Chitosan-O-Arginine have significantly ($P < 0.05$) reduced the nutritional indices. Generally, it was observed that the Chitosan-O-Arginine at higher concentration (1000 ppm) significantly affected the consumption index (2.01%) with lower consumption rate of 0.19% and approximate digestibility of 8.44%, compared to untreated check (14.95%, 7.77% and 79.41%, respectively). No growth of larva was recorded in Chitosan-O-Arginine at 1000 ppm treatment, it was expressed as 0.00% relative growth rate, efficiency of conversion of ingested food and efficiency of conversion of digested food. Similar performance was recorded in the treated check, *Azadirachtin* 1 EC @ 2 ml l^{-1}.

This finding is supported by the report of Ahmad *et al.* (2012), who stated that the significant reduction in consumption and utilization of food in *P. xylostella* larvae was due to less food consumption when fed on the neem treated cauliflower plants than on the control plants. The quantity and quality of diet intake by larvae impact their rate of growth, developmental period, weight of body, and survival. The results infer that when the larvae provided with Chitosan-O-Arginine 1000 ppm treated leaves, they consumption on the treated leaves was very minimum, hence there was no growth in the larva. The next best concentrations were Chitosan-O-Arginine 500 and 700 ppm. Hence, it is concluded that Chitosan-O-Arginine shall be used as one of the components in the management of *P. xylostella*.

Table 1. Nutritional indices of *Plutella xylostella* larvae fed on Chitosan-O-Arginine treated cauliflower leaves

Treatments	Consumption and Utilization indices*					
	CI^{+}	GR^{+}	CR^{+}	ECI$^{@}$	ECD$^{@}$	AD$^{@}$
T1- CS-O-Arg 100ppm	13.52±1.00 (3.67)^{c}	0.35±0.02 (0.59)^{d}	3.46±0.11 (1.86)^{e}	10.18±0.32 (18.61)^{d}	15.13±0.52 (22.89)^{c}	67.30±0.88 (55.12)^{c}
T2- CS-O-Arg 300ppm	13.20±1.13 (3.63)^{c}	0.26±0.04 (0.50)^{c}	2.88±0.23 (1.69)^{d}	8.97±0.78 (17.43)^{c}	14.15±1.15 (22.10)^{c}	63.40±2.16 (52.77)^{c}
T3- CS-O-Arg 500ppm	10.99±0.69 (3.31)^{b}	0.13±0.01 (0.36)^{b}	2.18±0.16 (1.47)^{c}	6.09±0.13 (14.29)^{b}	12.01±0.96 (20.28)^{b}	50.90±3.59 (45.51)^{b}
T4-CS-O-Arg 700ppm	10.09±0.57 (3.17)^{b}	0.09±0.01 (0.30)^{b}	1.30±0.06 (1.14)^{b}	5.59±0.66 (13.68)^{b}	11.66±0.51 (19.97)^{b}	47.84±3.72 (43.76)^{b}
T5- CS-O-Arg 1000ppm	2.01±0.37 (1.41)^{a}	0±0.00 (0.91)^{a}	0.19±0.03 (0.43)^{a}	0.00±0.00 (4.05)^{a}	0.00±0.00 (4.05)^{a}	8.44±1.95 (16.89)^{a}
T6-Glacial Acetic acid 1%	15.01±1.40 (3.87)^{c}	1.05±0.05 (1.02)^{e}	7.85±0.30 (2.80)^{f}	10.96±0.63 (19.33)^{e}	17.24±1.47 (24.53)^{d}	78.42±1.83 (62.32)^{d}
T7-Tween 80 0.005%	14.87±1.12 (3.85)^{c}	1.09±0.08 (1.04)^{e}	7.77±0.28 (2.78)^{f}	11.15±0.96 (19.56)^{e}	18.06±1.07 (25.15)^{d}	78.06±1.68 (62.07)^{d}
T8-Azadirachtin 1 EC @ 2 ml/lit	1.72±0.10 (1.31)^{a}	0±0.00 (0.91)^{a}	0.16±0.01 (0.40)^{a}	0.00±0.00 (4.05)^{a}	0.00±0.00 (4.05)^{a}	9.95±3.28 (18.39)^{a}
T9-Untreated check	14.95±0.97 (3.86)^{c}	1.14±0.03 (1.06)^{e}	7.77±0.22 (2.78)^{f}	11.60±0.29 (19.92)^{e}	18.50±1.23 (25.48)^{d}	79.41±0.53 (63.01)^{d}
SEd	0.10	0.01	0.03	0.43	0.59	1.46
F value	185. 3	580.5	1256.7	615.0	559.0	297.6

*Mean values of three replications are represented as mean ± standard deviation; $^{+}$Figures in the parentheses are square root transformed values +(√x+0.5); $^{@}$Figures in the parentheses are arc sine transformed values @ (x+0.5); the mean followed by the same letter are not significantly different from each other, DMRT ($p \leq 0.05$); SEd: Standard error of the difference.

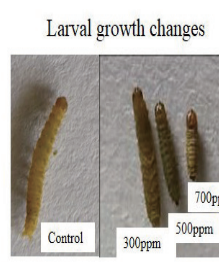

Fig. 1. Impact of Chitosan-O-Arginine on growth and development larva of *P.xylostella*

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ES 04 BOPS 06

Studies on performance of *L. orbonalis* sex pheromone under cluster bean intercropped system

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Key words: *Cluster bean, brinjal, pheromone, moth catches, intercropping.*

Introduction

Brinjal is one of the most popular and economically important vegetable crop. Brinjal is reported to be infested by 142 species of insects, four species of mites and three species of nematodes (Wall *et al*., 1983). Among them, the fruit and shoot borer is considered to be the most serious insect pest of brinjal in all parts of India (Isahaque *et al*., 1984). The average pesticide consumption in India is around 0.381 kg a.i./ha occupying 14 per cent of pesticides in the country against vegetables, predominantly on chilli (5.13%) followed by brinjal (4.6%) as compared to world average of 0.5 kg a.i./ha. The frequently used insecticides like synthetic pyrethroids lead to resurgence on the sucking insect's viz*.,* aphid, whitefly and leafhopper. Considering this situation, present study was focussed towards the cultivation of organic brinjal by incorporating biorational and inter cropping management strategies to reduce the use of insecticides for the management of brinjal shoot and fruit borer.

Materials and Methods

The brinjal (cv Manaparai local) crop of one acre was planted and divided into four equal quarters in which cluster bean (cv MDU 1) was raised as intercrop at 4:1 ratio in diagonal quarters. Remaining two diagonal quarters having sole crop was considered as control for comparison. The influence of intercrop on pheromone trap catches was assessed by placing 28 traps uniformly over the entire one acre of cropped area. A trap density of 7 traps/ quarter was maintained. Moth catchs data from traps placed in intercropped plot and sole crop was recorded on weekly basis throughout the cropping period for comparison.

Results and Discussion

The moth catches data count was observed on weekly basis throughout the cropping period. The maximum level of moth catches was seen with 160 moths/ 7 traps during fourth std. week from sole crop plot and 58 moths from cluster bean intercropped plots (Table 1). The minimum level of moth catches recorded as 4 moths/ 7 traps 45 std. week in brinjal sole crop plot and 2 moths in intercropped plots. Overall mean of moth catches in brinjal sole crop was 72.66 and compared to 44.41 moths catches in intercropped plot. Aiyer (1949) indicated that the olfactory stimulus offered by main crop could be camouflaged by various intercrops. Relay intercropping with coriander in the standing crop of brinjal caused reduction of *L. orbonalis* damage in the main crop and also elucidated oviposition effect (Dominic *et al*., 2018).

Table 1. Moth catches in sole and cluster bean, *C. tetragonaloba* intercropped brinjal ecosystem

S. No	Month (week) 2018 - 19	Mean no. of moth caches/7 traps/ week	
		Sole crop plot	Intercropped plot
1.	45 std. week	4	2
2.	46 std. week	10	8
3.	47 std. week	17	11
4.	48 std. week	49	45
5.	49 std. week	42	49

6.	50 std. week	77	70
7.	51 std. week	84	63
8.	52 std. week	95	61
9.	1 std. week	63	42
10.	2 std. week	144	60
11.	3 std. week	157	64
12.	4 std. week	160	58
Mean		**72.66**	**44.41**

Mean number of seven replications.

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ES 04 BOPS 07

Development of eco-friendly pest management module for the management of major pests of amaranthus

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Keywords: Amaranthus, leaf webber, stem weevil, ash weevil, natural enemies, IPM

Introduction

Amaranthus (*Amaranthus spp*), a member of the Amaranthaceae family is commonly cultivated as a green leafy vegetable in India. Despite its positive potential in human health and nutrition, its production is hindered by insect pest complex (Kagali *et al.,* 2013). Pesticide residue is becoming a big concern, particularly in green leafy vegetables. Considering the significance of this crop, the present study was undertaken to develop Integrated Pest Management (IPM) module for the management of major pests of amaranthus.

Materials and Methods

Field experiment was conducted in the farmer's holdings at Papampatti, Coimbatore district to develop IPM module against major pests of amaranthus. The experiment was laid out using RBD with the following seven treatments replicated thrice. T_1 - Designer seed treatment [Polymer (3g) - thiamethoxam 5 FS (5g) - azospirillum (120g) - *Trichoderma viridie* 4 g per kg of seed]; T_2 - T_1 + Foliar application of azadirachtin 10,000 ppm at 1 ml/litre; T_3 - T_1 + Foliar application of spinosad 45 SC @ 75 ml per acre; T_4 - Eco-friendly pest management module comprising of designer seed treatment [Polymer (3g) - thiamethoxam 5 FS (5g) - azospirillum (120g) - *Trichoderma viridie* 4 g per kg of seed] - border cropping with coriander - erecting yellow sticky traps at 12/ha - need based application of azadirachtin 10,000 ppm at 200 ml/acre; T_5 - Eco-friendly pest management module comprising of designer seed treatment [Polymer (3g) - thiamethoxam 5 FS (5g) - azospirillum (120g) - *Trichoderma viridie* 4 g per kg of seed] - border cropping with coriander - erecting yellow sticky traps at 12/ha - need based application of spinosad 45 SC @ 75 ml per acre; T_6 - Farmer's practice (Chemical control); T_7 - Untreated control

Insecticides were sprayed when the pest population crossed the economic threshold level. From each plot ten plants were selected randomly and the population of insect pests and natural enemies were recorded at weekly intervals. Leaf yield was recorded from each plot at harvest. The data obtained from the field experiment were analyzed using AGRES ver. (7.01), Pascal international solutions.

Results and Discussion

Among the eco-friendly pest management strategies evaluated against the major pests of amaranthus, the IPM module comprising of designer seed treatment [Polymer (3 g) - thiamethoxam 5 FS (5 g) - azospirillum (120 g) - *Trichoderma viridie* (4 g) per kg of seed] - border cropping with coriander - erecting yellow sticky traps at 12/ha - need based application of spinosad 45 SC (T_5) was adjudged as the best treatment which recorded the lowest number of leaf webbers (0.13 per plant) with 89.96 per cent reduction over untreated control. IPM module with spinosad 45 SC also recorded the lowest stem weevil damage (2.59 per cent) with 79.41 per cent reduction over untreated control. Similar trend was recorded for ash weevil also. IPM module border cropped with coriander not only reduced the pest population but also conserved the population of natural enemies such as spiders and coccinellid beetles. IPM module with spinosad 45 SC registered the maximum leaf yield of 14.8 t/ha with the B: C ratio of 2.28 (Table 1). The results are in agreement with the findings of Muralikrishna *et al.* (2019), who have reported that spraying of spinosad 45 SC @ 0.015% recorded the per cent mortality of *Hymenia recurvalis* in amaranthus at 36 hours after spraying. Khan *et al.* (2020) reported that growing of coriander as companion crop in cruciferous plants maintained higher population of spiders when compared to the sole crop. Sujayanand *et al.* (2016) also reported that the highest number of 0.76 coccinellids per plant was recorded in okra intercropped with coriander.

Table 1. Efficacy of pest management practices against major pests of amaranthus

Treatments	No. of leaf Webbers/ plant		Stem weevil damage (%)		Ash weevil damage (%)		No. of spiders/plant		No. of coccinellids/ plant		Leaf yield (t/ha)	B:C ratio
	Mean	PROC	Mean	PROC	Mean	PROC	Mean	PROC/ PIOC	Mean	PROC/ PIOC		
T_1	0.95 $(1.20)^{e}$	22.82	9.26 $(17.72)^{e}$	26.47	10.75 $(19.14)^{c}$	9.92	0.18 $(0.83)^{d}$	- 11.41	0.49 $(0.99)^{cd}$	- 5.56	8.6 $(3.02)^{a}$	1.44
T_2	0.25 $(0.87)^{d}$	79.51	6.30 $(14.54)^{d}$	50.00	6.65 $(14.94)^{b}$	44.31	0.15 $(0.80)^{c}$	- 28.80	0.34 $(0.92)^{c}$	- 34.78	11.5 $(3.46)^{b}$	1.76
T_3	0.21 $(0.84)^{c}$	82.66	5.56 $(13.64)^{c}$	55.88	6.43 $(14.69)^{b}$	46.11	0.11 $(0.78)^{b}$	- 47.83	0.26 $(0.87)^{b}$	- 49.03	11.8 $(3.51)^{b}$	1.82
T_4	0.15 $(0.81)^{b}$	87.63	2.96 $(9.91)^{ab}$	76.48	5.63 $(13.72)^{a}$	52.84	0.24 $(0.86)^{g}$	+ 18.48	0.57 $(1.03)^{e}$	+ 9.90	14.2 $(3.83)^{c}$	2.17
T_5	0.13 $(0.79)^{a}$	89.96	2.59 $(9.26)^{a}$	79.41	5.37 $(13.40)^{a}$	54.96	0.23 $(0.85)^{f}$	+ 10.33	0.55 $(1.02)^{de}$	+ 5.56	14.8 $(3.91)^{c}$	2.28
T_6	0.16 $(0.82)^{b}$	86.51	3.33 $(10.51)^{b}$	73.54	5.82 $(13.95)^{a}$	51.26	0.03 $(0.73)^{a}$	- 83.70	0.15 $(0.80)^{a}$	- 71.50	12.5 $(3.61)^{b}$	1.92
T_7	1.20 $(1.32)^{f}$	-	12.59 $(20.78)^{f}$	-	11.93 $(20.21)^{d}$	-	0.20 $(0.84)^{e}$	-	0.52 $(1.01)^{d}$	-	8.2 $(2.95)^{a}$	1.38
S. Ed	0.009	-	0.310	-	0.337	-	0.003	-	0.007	-	0.066	-
CD (P=0.05)	0.019	-	0.675	-	0.743	-	0.006	-	0.015	-	0.146	-

PROC - Percent reduction over control; PIOC - Percent increase over control; (-) Percentage reduction over control; (+) Percentage increase over control; In a column, means followed by common letter(s) are not significantly different by LSD

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ES 04 BOPS 08

Standardisation of artificial diet for laboratory maintenance of Cucurbit fruit fly, *Zeugodacus cucurbitae* (Coquillett)

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Keywords: *Melon fly, artificial diet, standardization*

Introduction

Melon fly/cucurbit fruit fly, *Zeugodacus cucurbitae* (Coquillett) is known to damage over 81 plant species and a major pest of cucurbits causing 30 -100 per cent yield loss. Among several management practices chemical methods are more relied upon resulting in residue and resistance problems. While for testing methods like, male sterile technique and laboratory evaluation of entomopathogens, continuous availability of insect stages in large numbers is a major requirement, making it necessary to develop and test different artificial diets for laboratory rearing of *Z. cucurbitae*.

Materials and Methods

The proportion of various ingredients used in preparation of artificial diets I to VI are shown in Table 1. AD - I is a liquid diet proposed by Chang *et al*. (2004). Pumpkin, in all the solid diets AD II-VI, was washed and surface sterilized using sodium hypochlorite (5 %), skin peeled off; cut into pieces and boiled in microwave oven for 20 minutes in a glass beaker and homogenised. Agar and pumpkin/common bean powder/yeast extract/sucrose were boiled in separate containers, mixed together, allowed to cool, and then anti-microbial agents and vitamins were added and blend again, distributed in to containers.

Experiments were carried out at laboratory conditions of 25 ± 2°C and 60 ± 5 % RH. Maggots @ 10/box were reared in plastic boxes (400 maggots per diet; 100 maggots/replication; 4 replications) and observations were recorded on larval duration, pupal recovery, pupal period and adult emergence. Natural host cucumber was used as control.

Results and Discussion

None of the larvae, reached the pupal stage when fed with AD I to AD V. However, in AD-VI, pupal recovery (82.95 %) and adult emergence (84.73 %) were found to be on par with cucumber (84.07 % and 85.29 % respectively) without any bias in sex ratio (Table 2). Liu *et al.* (2020) reported that pupal recovery was significantly lower in liquid diet. Thus, the solid diet AD-VI can be used for mass rearing of *Z. cucurbitae* maggots.

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Table 1. Composition of artificial diets for *Z. cucurbitae* maggots

Diet ingredient	Composition of artificial diets (AD)					
	AD I	AD II	AD III	AD IV	AD V	AD VI
Pumpkin	-	10 g	2.52 g	10 g	2.52 g	2.52 g
Common bean powder		-	-	-	8.84 g	8.84 g
Yeast extract powder	14.20 g	-	-	14.20 g	2.27 g	2.27 g
Sugar (Sucrose)	7.35 g	-	-	7.35 g	3.53 g	3.53 g
Agar	-	0.63 g	0.63 g	0.63 g	0.63 g	0.63 g
Ascorbic acid*	-	-	-	-	0.25 ml	-
Sorbic acid*	-	0.13 ml	-	0.13 ml	0.13 ml	-
Methyl p- hydroxyl benzoate*	0.11 g	0.2 g	-	0.11 g	0.2 g	-
Formaldehyde (40 %)*	-	200 µl	-	200 µl	200 µl	-
Streptomycin sulphate* (400 mg/ml)	-	10 µl	-	10 µl	10 µl	-
Bavistin/Carbendazim 50 % WP (5g/10 ml)*	-	100 µl	-	100 µl	100 µl	-
Vitamin E capsule	-	-	-	-	0.21 g	0.21 g
Zincovit	-	-	-	-	200 µl	200 µl
Sodium benzoate*	0.11 g	0.11 g	-	0.11 g	-	-
Citric acid	2.32 g	-	-	2.32 g	-	-
Wheat germ oil	-	200 **µl**	-		-	-
Distilled water	100 ml	100 ml	100 ml	100 ml	100 ml	100 ml

*Antimicrobial agents

Table 2. Effect of diets on development of *Z. cucurbitae*

Diet	**Development parameters (mean of four replications)**			
	Larval duration* (days)	**Pupation (%)**	**Pupal duration* (days)**	**Adult emergence (%)**
AD VI	5.5 (2.45)a	82.95 (65.61)a	8.53 (3.00)b	84.73 (66.99)a
Cucumber	5.25 (2.40)a	84.07 (66.47)a	8.45 (2.99)a	85.29 (67.45)a
SEd	0.024	0.008	0.136	0.230
CD (p=0.05)	0.051	0.017	0.282	0.479

*Based on maggot/pupa reaching next stage; Figures in parentheses are square root and arcsine transformed values for number and per cent values respectively; In a column, means followed by similar letters are not statistically different (p=0.05)

ES 04 BOPS 09

Exogenous methyl jasmonate and salicylic acid induces volatile emissions in maize plants

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Key words: *Maize, Spodoptera frugiperda, methyl jasmonate, Salicylic acid, volatile semiochemicals*

Introduction

Plants attacked by arthropod herbivores respond by activating a number of defense mechanisms, including the emission of volatile organic compounds (VOCs) that attract predatory and parasitic arthropods (Dicke, 2009). In maize, these herbivore- induced plant volatiles comprise mainly green leaf volatiles (GLVs), mono-, homo- and sesquiterpenes, as well as aromatic compounds. Volatile emission can be induced by exogenous application of plant signalers, jasmonic acid and salicylic acid (Merey et al., 2012). In the present study, foliar applications of methyl jasmonate (MeJA) and Methyl salicylic acid (MeSA) in eliciting defence related volatiles in maize crop was observed.

Materials and Methods

Two to three week old maize (CO 6) plants with 3-4 fully expanded leaves were used in the experiment. Maize was grown in the green house at 27±2°C under a 13-hr photoperiod, in the mud pots, filled with sterilized soil mixture. Pot and soil were completely covered with aluminum foil to minimize possible effects of volatiles emitted by soil and compost. Three replications were maintained for each treatment. For jasmonic acid treatment plants were sprayed with 15 ml of 5mM JA and for salicylic acid treatment 15ml of 100mg/L MeSA. Volatiles emanated from the healthy potted plants (control), maize plants (20-25 days after planting) sprayed with best doses of JA and MeSA (1 day after spray), and S. frugiperda damaged plants were trapped, eluted and analyzed using GC -MS –TD.

Results and discussion

Differences in volatile emissions were observed for maize plants damaged by *S. frugiperda* larvae, treated with MeJA, MeSA, or undamaged controls (Table 1). Control plants emitted much lower amounts of volatiles as compared to herbivore damaged plants. Plants treated with MeJA or MeSA emitted elevated levels of trans-á-Ocimene, o-Cymene, α-Phellandrene, (E, E)- α-farnesene and Nonanal compared to untreated control. These compounds are commonly referred to as inducible because they are synthesized *de novo* by herbivore-damaged maize plants. MeJA and MeSA did not cause the emission of any of the stored terpenes such as α-Pinene, 3-Carene, α-Myrcene, Limonene, Caryophyllene, and α –Longipinene, commonly referred to as constitutive, emitted in relatively large amounts due to the physical disruption by the herbivores. Hexanal, (z)-1-hexenol, LOX pathway compounds were detected in response to herbivore damage but not in response to MeJA and MeSA treatment. These compound results from the breakdown of stored lipids and released during insect damage. Similarly Dicke *et al*. (1999) showed that Lima beans treated with JA or MeJA produced a volatile blend that is similar to plants infested with the two-spotted spider mite *Tetranychus urticae* Koch.

Table 1. Characterisation of plant volatiles from HIPV elicitor treated maize plants using GCMS-TD

Compound	Peak Area (%)			
	JA 5mM	MeSA 150mg/L	*S. frugiperda* damaged	Healthy plant
Trans-α-Ionone	0.32	0.19	0.00	0.00
α -Phellandrene	0.54	0.11	0.27	0.00
3-Carene	0.00	0.00	0.46	0.00
α-Pinene	6.54	0.00	0.46	0.22
trans-á-Ocimene	6.50	3.43	0.46	0.22
Benzaldehyde	0.00	0.00	0.46	0.56
α –Myrcene	0.00	0.00	0.27	0.00
o-Cymene	0.05	0.3	1.19	0.00
(E, E)- α-farnesene	0.12	0.32	0.11	0.00
Limonene	0.00	0.00	0.23	0.00
Eucalyptol	0.32	0.47	0.77	0.35
Dodecane	0.00	0.00	0.64	0.38
Undecane	0.00	0.22	1.42	1.2
ç-Terpinene	0.00	0.00	0.32	0.00
2-Nonanol	0.56	0.31	0.52	0.00
Nonanal	0.00	0.17	0.63	0.3
α –Copaene	0.23	0.43	0.12	0.00
Benzothiazole	0.00	0.00	0.33	0.355
α -Cubebene	0.34	0.00	0.00	0.00
ç-Muurolene	0.20	0.23	0.00	0.00
Ylangene	0.34	0.00	0.00	0.00
α -Longipinene	0.54	0.42	0.32	0.00
Caryophyllene	0.00	0.00	0.42	0.00
(z)-1-hexenol	0.00	0.00	1.45	2.34
1-Pentanol	9.42	21.23	0.00	3.1
Hexanal	0.00	0.00	6.74	0.00

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ES 04 BOPS 10

Impact of aqueous plant extracts against the leaf hopper of brinjal (*Solanum melongena* L.)

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Keywords: *Brinjal, leaf hopper, plant products*

Introduction

Brinjal (*Solanum melongena* L.) belonging to Solanaceae is one among the top ten vegetables produced in the world. Vegetables shares an important source of phytoneutraceuticals such as vitamins, minerals, dietary fibres and free radical scavenging antioxidants. Fruits and vegetables have a quite broad range of nutrient content, yet they are still a major source of potassium and dietary fibre. Besides its significance in global trade, brinjal is susceptible to number of sucking pests like aphid, jassid and whitefly, mealy bug and red spider mite.

Materials and Methods

An experiment was conducted to evaluate the efficacy of botanicals at farmer field, Keezhaveliyur, Karur during March – July 2021. The field experiment was laid out in Randomised Block Design (RBD) with ten treatments with three replications. All the treatments were imposed once after the pests reached its threshold level. The treatment includes plant extracts of two different concentrations along with standard insecticide check thiamethoxam 25 WG and untreated check. From each test plot five plants were randomly chosen and tagged for registering the pest observations. From each tagged plants three leaves (one from bottom, one from middle and one from top) were taken and population of nymphs and adults of jassids was counted.

Results and Discussion

The plot sprayed with Neem Seed Kernel Extract (NSKE) 5% recorded maximum reduction of hopper (63.48 %) followed by Ginger, Garlic and Green chilli extract (3G) 5% of 61.75 % which was on par with NSKE 5% (Table 1). Karkar *et al*., 2014 reported that the NSKE 5% was significantly reduced the population of leaf hoppers (2.27 numbers/leaf) than leaf extracts of neem, jatropha, naffatia, custard apple and ailanthus each at 10 per cent concentrations in brinjal plants. The results were evidenced by Khanzada and Khanzada, 2018 who observed that the maximum reduction in jassid population over control (64.28 %) was noticed in Neem Seed Kernel Extract treated plots, followed by Garlic extract (57.13 %) at vegetative stage of brinjal. The insecticide Thiamethoxam 25 WG registered highest reduction of hopper (80.99%) with mean hopper population of 1.07 numbers/leaf/plant and found superior over all the treatments tested. Azadirachtin 0.03% EC ranked second effective treatment next to Thiamethoxam with 69.54 % reduction.

Table 1. The efficacy of aqueous plant extracts against the leaf hopper in brinjal

S. No	Treatment	Leaf hoppers (number/ 3leaves)*						
		Pre –treatment population	3 DAT	7 DAT	10 DAT	14 DAT	Mean	% reduction over control
T1	3G extract @ 3%	4.55	2.68 (1.78)^{bc}	2.32 (1.67)^{b}	2.08 (1.60)^{bcd}	2.86 (1.83)^{bc}	2.48	56.05
T2	NSKE @ 5%	4.86	2.11 (1.61)^{b}	2.04 (1.59)^{ab}	2.00 (1.58)^{bc}	2.10 (1.61)^{ab}	2.06	63.48

T3	*Citrullus* extract @ 3%	5.16	3.32 (1.95)^{bc}	3.13 (1.90)^{bc}	3.05 (1.88)^{cde}	3.48 (2.02)^{bc}	3.36	40.49
T4	Azadirachtin 0.03% EC (5ml/L)	4.13	2.02 (1.58)^{b}	1.82 (1.52)^{ab}	1.80 (1.51)^{b}	2.31 (1.67)^{abc}	1.72	69.54
T5	Panchakavya @ 3%	5.11	3.54 (2.00)^{bc}	3.43 (1.98)^{bc}	3.18 (1.91)^{e}	3.99 (2.11)^{c}	3.53	37.48
T6	3G extract @ 5%	5.49	2.17 (1.63)^{ab}	2.10 (1.61)^{ab}	2.07 (1.60)^{bcd}	2.11 (1.61)^{ab}	2.16	61.75
T7	*Citrullus* extract @ 5%	4.81	3.02 (1.87)^{bc}	2.86 (1.83)^{b}	2.71 (1.79)^{bcde}	2.90 (2.01)^{bc}	2.87	49.20
T8	Panchakavya @ 5 %	5.14	3.02 (1.87)^{bc}	3.01 (1.87)^{bc}	3.10 (1.89)^{de}	3.43 (2.11)^{c}	3.24	42.66
T9	Thiamethoxam 25 WG (0.4 g/L)	5.83	0.83 (1.15)^{a}	0.72 (1.10)^{a}	0.97 (1.21)^{a}	1.78 (1.50)^{a}	1.07	80.99
T10	Control	5.06	4.99 (2.34)^{c}	5.26 (2.4)^{c}	6.05 (2.55)^{f}	6.32 (2.611)^{d}	5.65	
	SEd **	NS	0.23	0.26	0.15	0.22		
	CD (p = 0.05)	NS	0.49	0.55	0.31	0.46		

* Mean of population of leaf hopper per three leaves; ** Significant at 0.01%; NS - Non-significant;

Figures in the parentheses are square root transformed values i.e.$\sqrt{x+0.5}$.

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ES 04 BOPS 11

Olfactometer studies on the attraction of melon fruit fly, *Zeugodacus cucurbitae* (Coquillet) to protein and food baits

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Key words: *Melon fruit fly, protein bait, food bait, olfactometer*

Introduction

The fruit fly family, Tephritidae with about 4500 species, is one of the largest families of Diptera of which 250 species are economically important (David, 2011 Depending on the crop and season, melon fruit fly, *Zeugodacus cucurbitae* caused 30 to 100 per cent yield loss in various cucurbitaceous crops. At present, the most popular management method to control the fruit fly population is deployment of parapheromone traps. However, they are useful to attract only male fruit flies (Royer, 2015). Epsky *et al.,* 1999 emphasized the need of attracting female fruit flies because of their pivotal role in the multiplication of this insect. Female fruit fly adults require water and protein-rich foods to reach sexual maturity and egg maturation. This is taken into account while luring the female fruit flies to a source of food and protein. Fruit flies can be trapped by the odours of different food or protein attractants. Fruit flies respond to different olfactory cues like volatiles from food and protein sources. These responses can be confirmed by the olfactometer.

Materials and methods

To confirm the trapping efficiency of the protein and food baits in the laboratory, choice studies were conducted with four arm olfactometer. Fruit flies were mass reared in the laboratory from the infested bitter gourd & snake gourd fruits and emerged adults were used for the studies. Sponge bits of 6x2 cm were saturated with baits which served as the bait volatile supply. Adult fruit flies were subjected to a 12 hour fast before conducting the experiment. Proteinex, soybean and yeast powders @ 10% were mixed with jaggery (10%), ammonium acetate (5%), borax (2%) and malathion 50 EC (0.01%) to prepare the protein baits. Food baits were prepared with banana, tomato and bitter gourd pulps @ 10% mixed with jaggery (10%), borax (2%), yeast (0.5%) and citric acid (5%). The above protein and food baits were evaluated for their attraction to melon fruit flies and these baits were compared with negative control in which only base materials were mixed. During the experimentation, a dark cloth was covered on the olfactometer to prevent the phototrophic movement of adults. Six observations were recorded on the settlement of fruit flies towards the baits at an interval of ten minutes. The data was analysed and interpreted.

Results and Discussion

Attraction of adult fruit flies was comparatively high in proteinex bait with 4.4, 5.2, 5.4, 5.6, 7.2 and 8.4 attracted fruit flies in 10, 20, 30, 40, 50 and 60 minutes respectively. Following the proteinex bait, soybean bait attracted more fruit flies *i.e.,* 2.4, 4.2, 4.6, 5.6, 6.4 and 6.8 adults in 10, 20, 30, 40, 50 and 60 minutes respectively. Mubashar *et al*., 2020, backed up this conclusion that in the laboratory studies, protein hydrolysate, yeast and ammonium acetate-based lures captured comparatively more number of *Z. cucurbitae* adults. Soybean bait was followed by yeast bait, which attracted 4.4 fruit flies in 60 minutes. Negative control attracted fewer flies *i.e.,* 2.20 in 60 minutes. Among the food baits tested, adult fruit flies were highly attracted to the tomato pulp bait with 2.20, 3.20, 3.40, 5.26 and 5.80 fruit flies attracted in 10, 20, 30, 40, 50 and 60 minutes respectively. The next best bait was banana which attracted 1.20, 2.20, 2.40, 3.20, 4.00 and 4.40 adult fruit flies in 10, 20, 30, 40, 50 and 60 minutes respectively. At 60 minutes, both the tomato and banana baits were found to be on par in terms of appeal. Negative control attracted 1 fruit fly in 60 minutes.

Table 1. Attraction of fruit fly adults to protein baits in olfactometer

Treatment	No. of fruit flies attracted after					
	10 min	20 min	30 min	40 min	50 min	60 min
Protein baits						
Soybean bait	2.40 (1.70)[b]	4.20 (2.17)[ab]	4.60 (2.26)[ab]	5.60 (2.47)[a]	6.40 (2.63)[a]	6.80 (2.70)[ab]
Yeast bait	2.40 (1.70)[b]	2.80 (1.82)[bc]	3.00 (1.87)[bc]	3.60 (2.02)[ab]	4.20 (2.17)[b]	4.40 (2.21)[bc]
Proteinex bait	4.40 (2.21)[a]	5.20 (2.39)[a]	5.40 (2.43)[a]	5.60 (2.47)[a]	7.20 (2.77)[a]	8.40 (2.98)[a]
Negative control	2.00 (1.58)[b]	1.80 (1.52)[c]	1.60 (1.45)[c]	2.20 (1.64)[b]	3.20 (1.92)[b]	2.20 (1.64)[c]
SE(d)	0.42	0.47	0.80	0.72	0.66	1.01
Food baits						
Tomato bait	2.20 (1.64)[a]	3.20 (1.32)[a]	3.40 (1.97)[a]	5.20 (2.39)[a]	6.00 (2.55)[a]	5.80 (2.51)[a]
Banana bait	1.20 (1.30)[ab]	2.20 (1.64)[a]	2.40 (1.70)[a]	3.20 (1.92)[b]	4.00 (2.12)[b]	4.40 (2.21)[a]
Bitter gourd bait	0.80 (1.14)[b]	1.00 (1.22)[b]	1.00 (1.22)[b]	1.40 (1.38)[c]	0.80 (1.14)[c]	0.80 (1.14)[b]
Negative control	1.00 (1.22)[b]	0.40 (0.95)[b]	0.80 (1.14)[b]	0.80 (1.14)[c]	1.00 (1.22)[c]	1.00 (1.22)[b]
SE (d)	0.37	0.32	0.45	0.46	0.21	0.60

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ES 04 BOPS 12

Efficacy of crude extracts of certain medicinal herbs against major sucking pests

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Keywords: *Botanicals, medicinal plants, eco-friendly pest management*

Introduction

Increasing awareness about the deleterious effects of insecticides paved the way for integrated and eco-friendly pest management. One such method is the use of botanical insecticides, which are safe and eco-friendly, can overcome many problems associated with chemical insecticides especially in the medicinal plants ecosystem (Isman, 2013). Since the medicinal plants are consumed directly or indirectly, eco-friendly pest management is the best alternative for the chemical insecticides. In this context, a field experiment was conducted to assess the efficacy of crude extracts of certain medicinal herbs against thrips and aphids infesting the major medicinal plants *viz*., Black nightshade, *Solanumnigrum L*.

Materials and Methods

The leaves of Adhatoda, Coleus, Notchi and Datura were collected, washed properly and dried under shade for 7days. The dried material of each plant part was grinded separately with pestle and mortar into fine powder. 10% stock solution of each plant extract was prepared. T1- Adathoda 10% crude extract, T2- Coleus 10% crude extract, T3- Notchi 10% crude extract, T4- Datura10% crude extract, T5- Thiamethoxam@0.5g/lit,T6 Untreated control. Field experiments were conducted in the medicinal plants park, TNAU Botanic garden to assess the efficacy of selected medicinal plantsagainst thrips, aphids on *Solanumnigrum*. The experiment was laid out in randomized block design with 6 treatments and 4 replications.

Results and Discussion

In *S. nigrum*, maximum population reduction of aphids was observed in standard chemical check thiamethoxam, where the population of aphids reduced to 0.7 aphids/plant followed by datura leaf extract (12.1 aphids/plant), adathoda 10% extract (14.3 aphids/plants). In *S. nigrum*, maximum reduction of thrips was observed in the standard chemical check fipronil @ 0.5ml/lit (0.3 thrips/plant) followed by notchi and coleus leaf extracts (10%) with a population of 2.9 and 3.1 thrips/ top three leaves/plant, respectively. The extracts of adathoda and datura leaf extracts could be exploited to develop potent botanical insecticides against aphids. Similarly, notchi and coleus leaf extracts could be isolated and exploited against thrips. Various plant products have been assessed for their pesticide potential worldwide (Klock, 1987). These potential botanical insecticides may fit well in IPM programs designed to control aphids and thrips in a eco-friendly way.

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Table 1. Efficacy of crude leaf extract of certain medicinal herbs against thrips on *S. nigrum*

Treatments	No. of thrips/top three leaves/plant#						Mean*
	PTC	1 DAT	3 DAT	5 DAT	7 DAT	14 DAT	
T1- Adathoda 10% crude extract	11.5	4.1 (2.0)c	7.9 (2.8)d	5.1 (2.2)b	5.5 (2.3)c	6.1 (2.4)c	5.7
T2- Coleus 10% crude extract	10.1	3.1 (1.7)b	3.0 (1.7)b	3.1 (1.7)b	2.7 (1.6)b	2.5 (1.6)b	2.9
T3- Notchi 10% crude extract	9.7	2.9 (1.7)b	2.8 (1.6)b	2.7 (1.6)b	2.9 (1.7)b	2.7 (1.6)b	2.8
T4- Datura10% crude extract	9.5	4.5 (2.1)c	5.1 (2.2)c	4.3 (2.0)c	4.1 (2.0)c	4.5 (2.1)c	4.3
T5- Fipronil @ 0.5g/lit	8.9	0.3 (0.5)a	0.0 (0.0)a	0.0 (0.0)a	0.0 (0.0)a	0.5 (0.7)a	0.2
T6- Untreated control	11.9	10.8 (3.3)d	12.1 (3.5)d	13.7 (3.7)d	14.1 (3.8)d	14.4 (3.7)d	13.02
S.Ed	NS	0.20	0.11	0.30	0.20	0.10	
CD (P=0.05)	NS	0.26	0.20	0.32	0.21	0.14	

*Mean of 4 replications and values in parentheses are square root transformed; PTC - Pre treatment count; DAT - Days after treatment # - Values in parentheses are square root transformed

Table 2. Efficacy of crude leaf extract of certain medicinal herbs against aphids on *S. nigrum*

Treatments	No. of aphids/three leaves/plant#						Mean*
	PTC	1 DAT	3 DAT	5 DAT	7 DAT	14 DAT	
T1- Adathoda 10% crude extracts	21.3	12.3 (3.5)b	7.9 (2.8)b	2.8 (1.7)b	1.6 (1.3)b	3.1 (1.8)b	5.94
T2- Coleus 10% crude extract	22.7	15.1 (3.8)b	8.1 (2.8)b	3.6 (1.9)c	3.3 (1.8)c	4.1 (2.0)c	6.84
T3- Notchi 10% crude extract	21.7	17.3 (4.1)c	9.1 (3.0)c	3.1 (1.8)b	3.9 (1.9)c	5.7 (2.4)c	7.74
T4- Datura10% crude extract	23.4	12.1 (3.4)b	7.1 (2.7)b	2.3 (1.5)b	1.3 (1.1)a	3.3 (1.8)b	5.22
T5- Thiamethoxam@0.5g/lit	24.7	0.7 (0.8)a	0.0 (0.0)a	0.0 (0.0)a	0.0 (0.0)a	0.3 (0.5)a	0.20
T6- Untreated control	25.0	27.1 (5.2)d	25.6 (5.1)d	29.1 (5.4)d	27.8 (5.3)d	26.4 (5.1)d	27.2
S.Ed	NS	0.10	0.10	0.31	0.21	0.10	
CD (P=0.05)	NS	0.24	0.20	0.32	0.21	0.14	

*Mean of 4 replications and values in parentheses are square root transformed; PTC - Pre treatment count; DAT - Days after treatment # - Values in parentheses are square root transformed

Early tillering

Active tillering

ES 04 BOPS 13

Comparison of volatile profiles of early and active tillering stages of rice variety IR 20

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Keywords: *IR 20, tillering stages, plant volatiles, air entrainment, GC-MS*

Introduction

Rice is a crop of high significance facing several challenges for increased production notably insect pests. Since the occurrence of pest and natural enemies are observed to vary according to the stages of the rice crop (Reuolin *et al*., 2021), understanding the volatile profile differences between the plant growth stages is essential to monitor as it will help us gain more insight to the role of volatiles in the attraction of insect pest. Hence, the present study is formulated to understand major differences in the release of plant volatile compounds at two different stages (early and active tillering) of rice plant.

Materials and methods

The plant volatile collection was done using the air entrainment method (Birkett *et al.*, 2004). The volatile collection system consists of a cylindrical glass tube with two raised ports at the top. Pure and humidified air was passed through one port and the volatiles were collected using the super Q porapak adsorbent trap placed at the other port. Headspace volatiles were collected for 24 hours and were eluted with 700 µl of hexane. Volatile compounds were then characterised using Gas Chromatography coupled Mass spectrometry (GC-MS) and identified using mass spectrum comparison with NIST library.

Results and Discussion

The comparison of volatile profile of IR-20 plants from early and active tillering stages showed significant differences among them. Only four compounds were common to both stages of rice plant (Table 1). Hydrocarbon compounds (33%) were the predominant ones in the early tillering stage whereas it decreased as the crop matures (Fig.1.). Wheareas, the compounds belonging to acid group increased from the early tillering to the active tillering stage. This increase in fatty acid group compounds as the crop ages was also previously reported in grapes by Ju *et al*. (2016). Terpenes, ketones and aldehyde group compounds also decreased significantly as the crop matures. Presence of higher amount of terpenes at the early and young stages of plants is to protect them from harmful pests as they lack the natural compensation ability (Dudareva *et al*., 2013).

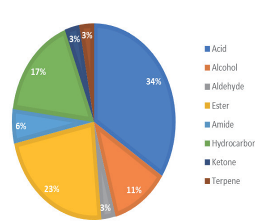

Fig.1. Comparison of volatiles of IR-20 early and active tillering stage plants

Table 1. Volatile compounds identified at early and active tillering stages of IR-20

Name	Total	Elements
Active tillering Early tillering	4	Oxalic acid, cyclohexyl nonyl ester; Z-(13,14-Epoxy)tetradec-11-en-1-ol acetate; Heptadecane 9-hexyl-; n-Hexadecanoic acid
Early tillering	26	1,2-Benzenedicarboxylic acid, bis(2-methylpropyl) ester; 2,2,4-Trimethyl-1,3-pentanediol diisobutyrate; Nonanal; 2-Propyl-1-pentanol Bicyclo[2.2.1]heptan-2-one; 1,7,7-trimethyl-, (1S)- Ethanone, 1-(2,4,6-trimethylphenyl)-; 1,2-Benzenedicarboxylic acid, butyl octyl ester; Cyclohexane, 1-methyl-4-(1-methylethylidene)- Undecane; D-Limonene; Benzene, 4-ethyl-1,2-dimethyl-; Mesitylene; 2,2-Dimethyl-1-phenyl-1-propanol; Decanal; Octadecane, 1-(ethenyloxy)-; Olean-12-ene, 3-methoxy-; (3Ã¡)- Methanone, (2,2-dichlorocyclipropyl)(2,4,6- trimethylphenyl)-; Octadecanoic acid; 24-Noroleana-3,12-diene; Hexadec-9-enoicacid; Decane; 3,5-di-tert-Butyl-4-hydroxyphenylpropionic acid; Propanoic acid, 2-methyl-, 3-hydroxy-2,2,4- trimethylpentyl ester; Heptadecane, 2,6,10,15-tetramethyl-; Benzene, 1,3-dichloro-; Naphthalene
Active tillering	27	1-Hexadecanol; 2-methyl- Hexadecanamide; 7,9-Di-tert-butyl-1-oxaspiro(4,5)deca-6,9-diene-2,8-dione; Octadecanoic acid; 2-hydroxy-1,3-propanediyl ester; Heptadecanoic acid; Hexadecanoic acid, methyl ester; 9-Octadecenoic acid (Z)-, hexadecyl ester; 4-Octadecenal; Dodecanoic acid; 2,2'-(Ethane-1,2-diylbis(oxy)) bis(ethane-2,1-diyl)dibenzoate Eicosanoic acid; Propanoic acid, 2-(3-acetoxy-4,4,14-trimethylandrost-8-en-17-yl)-; Tetratetracontane; Cyclopentadecanone; 2-hydroxy- 9-Octadecenamide; (Z)- Tetradecanoic acid; Pentadecanoic acid; cis-13-Eicosenoic acid; Hexadecenoic acid, Z-11-; 1-Eicosanol; 17-Pentatriacontene; 4-Methyloctanoic acid; Docosanoic acid, 1,2,3-propanetriyl ester; n-Nonadecanol-1; 13-Heptadecyn-1-ol; 9-Octadecenoic acid; (E)- Hexadecanoic acid; (2-phenyl-1,3-dioxolan-4-yl)methyl ester, cis-

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ES 04 BOPS 14

Ginger and Tulsi oils as Oviposition Deterrent Effect against Pulse Beetle, *Callosobruchus chinensis* L. in Chickpea

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Keywords: *Chickpea, ginger oil, tulsi oil, oviposition inhibition, adult emergence*

Introduction

Chickpea, *Cicer arietinum* L. is a highly nutritional pulse cultivated throughout the world and placed third in the importance list of the legumes. During, the past four decades (1979-2019), chickpea production in central and southern India increased by 445% (from 1.27 to 6.95 million MT) and 97% increase in yield (527 to 1036 kg/ha). During 2020-21, chickpea had a share of 49.3% in the total pulses production. According to an estimate, 60 per cent of whole production that produced is destroyed by insect pests in which storage insect-pest play an important role. Among various pest these, the pulse beetle, *Callosobruchus chinensis* is most important damaging insect which cause infestation to pulse both in field as well as in ambient storage. This pest was first of all described in China in the year 1758 where the beetle gets its species name (Singh *et al.,*2017). This study had been investigated the antibiotic effect of Ginger oil and Tulsi oil on the biology of *C. chinensis* such as oviposition deterrent effect, adult emergence in chickpea seeds.

Materials and methods

Mass culturing of *Callosobruchus chinensis* was done on the chickpea seeds by releasing 50 pairs of adults in the jars. Using ginger oil and tulsi oil at different concentrations were tested against the oviposition and adult emergence effect of *C. chinensis*. The study was done with the 5µl, 10 µl and 15 µl of ginger oil and tulsi oil and made into 50 µl using ethanol. Fifty chickpea seeds were taken and evenly treated with the oils. After 24 hours, freshly stocked ten pair of adults were released in the respective treatments. After the oviposition, the number of eggs in each treatment were carefully counted and allowed for progeny emergence. The total progeny emergence was observed in the respective treatments. Necessary data transformation was made before analysis and the computer based OPSTAT package was used for the analysis.

Results and Discussion

The results confirmed that the gravid females in the ginger oil and tulsi oil @ 15 µl had very low per cent of progeny emergence (1%) and high per cent of hatching inhibition rate were observed at ginger oil @ 15 µl (16%) respectively. In untreated seeds, more eggs with high per cent of progeny emergence (100 %) and without of oviposition inhibition effect (0.00) respectively. Ginger oil and tulsi oil @ 15 µl exhibited maximum oviposition inhibition and adult emergence followed by least in ginger oil and tulsi oil @ 5 µl in the pulse beetle.

Table 1. Deterrent effect of Ginger oil and Tulsi oil against *C. chinensis*

Treatments		Oviposition Inhibition (%)	Adult emergence (%)	Per cent Deterrency
T_1	Ginger oil @ 5 µl	31.58 (34.17)[e]	8.33 (16.76)[c]	91.67
T_2	Ginger oil @ 10 µl	21.88 (32.49)[de]	6.33 (14.56)[b]	93.67
T_3	Ginger oil @ 15 µl	16.66 (23.84)[c]	1.33 (6.53)[a]	98.67
T_4	Tulsi oil @ 5 µl	35.55 (36.55)[e]	8.66 (17.10)[c]	91.34
T_5	Tulsi oil @ 10 µl	31.66 (34.21)[e]	6.66 (14.94)[b]	93.34
T_6	Tulsi oil @ 15 µl	22.22 (27.94)[cd]	1.66 (7.33)[a]	98.34
T_7	Standard - Ethanol	1.33 (6.53)[b]	95.00 (77.09)[d]	5.00
T_8	Untreated	0.00 (0.00)[a]	100.0 (90.00)[e]	0.00
SEd		2.26	0.77	
CD (0.05)		4.83	1.05	

In a column, values with different alphabets differ significantly (CD= 0.05).

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ES 04 BOPS 15

Effect of N alkyl chitosan on consumption and utilization of food by maize fall armyworm (FAW), *Spodoptera frugiperda* (J E Smith) (Lepidoptera: Noctuidae)

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Keywords: *Spodoptera frugiperda, Alkyl chitosan, Consumption and Utilization.*

Introduction

Maize fall armyworm (FAW), *Spodoptera frugiperda* (J.E.Smith) (Lepidoptera: Noctuidae) is the recently invaded insect pest, causing threat to grain/ fodder production. It is a long-distance migratory insect pest, reported in India at Karnataka district during July 2018, later it has spread all over India (Kalleshwaraswamy *et al.*, 2019). Quick dispersal of fall armyworm warranted frequent spraying of chemical pesticides in Indian subcontinent. Due to these continuous spraying, there is a possibility for adverse impact on human health, insects developing resistance against insecticides, insecticide residue in food/ fodder and land, which also have negative effect on biodiversity. Hence, environmental friendly, low-cost option, agro ecological methods for promoting soil fertility and natural enemies is needed for management of fall armyworm. In this study chitosan derivative was evaluated for its food consumption and utilization of the maize fall armyworm.

Materials and Methods

Laboratory experiment was conducted to study the nutritional parameters of consumption, digestion and utilization of treated food (on wet basis), when the *S. frugiperda* larvae were fed with alkyl chitosan derivative, (Waldbauer, 1968). Maize leaf discs were treated and fed to larvae. There were six treatments *viz*, 1000 ppm, 2000 ppm, 3000 ppm, 4000 ppm and 5000 ppm and untreated check and three replications, fourth instar larva was used and each larva represent one replication. The experiment was conducted for three days, in Completely Randomized Block Design. Initial and final weight of leaf, larva and weight of feces produced were recorded at 24, 48 and 72 hours of feeding, using digital weighing balance and expressed in milli grams. The weight of food eaten and weight gained by the larvae were estimated with the recorded data. From this parameters food utilization by *S. frugiperda* were analyzed by using nutritional indices *viz.,* Growth Rate (GR), Consumption Rate (CR), Consumption Index (CI), Approximate Digestibility (AD), Efficiency of Conversion of Ingested food (ECI) and Efficiency of Conversion of Digested food (ECD).

Result and Discussion

When the *S. frugiperda* larvae were fed on leaves treated with N alkyl chitosan for three days, the consumption rate, consumption index, growth rate was significantly reduced at higher concentration of alkyl chitosan derivative. Efficiency of conversion of digested food, efficiency of conversion of ingested food and approximate digestibility of N alkyl chitosan treatments were much lower than untreated check at different periods of observation, *viz*., 24, 48 and 72 hours after feeding. It is speculated from the findings of Binod *et al.* (2007) that the larval feeding on chitinase-treated leaves led to the disruption of peritrophic membrane in digestive system of *H. armigera*, which eventually caused the larvae to consume lesser food and consequently resulted in reduced growth rate.

Table 1. Nutritional indices of maize fall armyworm larvae feeding on N alkyl chitosan treated maize leaves

Concentration of N-alkyl chitosan derivative	Consumption and Utilization*					
	CI^{+}	GR^{+}	CR^{+}	ECI$^{@}$	ECD$^{@}$	AD$^{@}$
1000 ppm	0.92±0.12 (0.80)^{bc}	70.13±1.23 (8.37)^{d}	52.80±1.46 (7.27)^{d}	38.81±0.74 (6.23)^{d}	61.02±0.60 (7.81)^{e}	38.81±0.74 (6.23)^{d}
2000 ppm	0.81±0.04 (0.87)^{b}	68.85±4.37 (8.30)^{d}	46.56±1.82 (6.82)^{c}	37.47±0.51 (6.12)^{cd}	57.58±0.48 (7.59)^{d}	37.47±0.51 (6.12)^{cd}
3000 ppm	0.77±0.07 (0.88)^{ab}	60.76±2.14 (7.79)^{c}	44.07±3.14 (6.64)^{c}	36.69±1.63 (6.06)^{c}	56.14±3.50 (7.49)^{c}	36.69±1.63 (6.06)^{c}
4000 ppm	0.75±0.02 (0.90)^{ab}	46.53±2.07 (6.82)^{b}	34.65±2.41 (5.89)^{b}	34.53±1.09 (5.88)^{b}	47.10±0.65 (6.86)^{b}	34.53±1.09 (5.88)^{b}
5000 ppm	0.64±0.13 (0.96)^{a}	30.88±1.24 (5.56)^{a}	26.95±2.93 (5.19)^{a}	26.34±1.34 (5.13)^{a}	32.36±1.80 (5.69)^{a}	26.34±1.34 (5.13)^{a}
Untreated check	1.03±0.05 (1.02)^{c}	86.10±1.76 (9.28)^{e}	69.32±0.89 (8.33)^{e}	42.84±1.87 (6.55)^{e}	76.95±3.57 (8.77)^{f}	42.84±1.87 (6.55)^{e}
Mean	4.92	60.54	45.72	36.11	55.19	36.11
SEd	0.40	0.13	0.17	0.71	0.89	0.71

*Mean values of three replications are represented as mean ± standard deviation; $^{+}$Figures in the parentheses are square root transformed values +($\sqrt{x}$+0.5); $^{@}$Figures in the parentheses are arc sine transformed values @ (x+0.5); the mean followed by the same letter are not significantly different from each other, DMRT ($p \leq 0.05$); SEd: Standard error of the difference.

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ES 04 BOPS 16

Anti-insect effects of acetone extract of *Senna alata* L. on third instar *Spodoptera litura* Fab. (Noctuidae; Lepidoptera)

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Keywords: *Senna alata*, *Spodoptera litura, Anti-insect effects, acetone*

Introduction

The tobacco caterpillar, *Spodoptera litura* is one of the most important insect pests of agricultural crops in the Asian tropics. It is widely distributed throughout tropical and temperate Asia, Australasia and the Pacific Islands. *S. litura* is polyphagous (Ahmad *et al.,* 2013) and host range of *S. litura* covers at least 120 species. Legume pests are increasing in economic importance throughout Asia due to the destruction of natural control systems, and the build-up of insecticide resistance. The green revolution in Asia brought with it an increased awareness of the potential of insecticides for increasing the sustainability. Hence the present study Anti-insect effects of *Senna alata* L. acetone extract on third instar *Spodoptera litura* is aimed at screening of acetone extract of different plant parts of *Senna alata* for their anti insect properties and deducing mode of action against polyphagous pest, *Spodoptera litura* Fab. (Noctuidae: Lepidoptera).

Materials and Methods

Senna alata seed, flowers and leaf were collected and shade dried for 10 days. These plant parts were powdered in a wiley mill. The powdered plant materials of *S. alata* were extracted by using acetone solvent in soxhlet for period of three days with intermittent shaking and filtered through whatman no 40 filter paper.

A no choice leaf disc assay was carried out using 4hrs pre starved third instar *S. litura* larva. Castor leaf disc were cut out and treated on different plant part solvents. Treated leaf discs were collected after six hours. Then, the leaf area fed was measured graphically and per cent leaf area protection over absolute control was computed and feeding deterrence activity was worked out (Ojewole *et al*., 2000). The larva alive was reared using untreated castor leaves till adult emergence and mortality and malformations were recorded periodically.

Results and Discussion

The acetone extract was found mainly to impart feeding deterrence activity. The maximum feeding deterrence activity was noticed in seed (98.01%) followed by leaf (53012%). This treatment alone 20 per cent adult emergence observed. Although the leaf extract imparted more than 50 per cent feeding deterrence activity, it recorded 80 per cent adult emergence. The similar report was given by Guerrero *et al*. (2015) who showed anti insect effect in seeds of *Senna alata* seeds. They also identified the presence of 0.44 per cent to 0.50 per cent of alkaloids in seed oil on a V/V basis.

Table 1. Anti-insect effects of *Senna alata* L. acetone extract on third instar *Spodoptera litura* Fab.

Plant parts	Per cent feeding deterrence activity	Per cent mortality		Per cent malformation			Per cent adult emergence
		Larva	Pupa	Larva	Pupa	Adult	
Seed	98.01 (81.87)^a	50 (46.78)^a	0 (0.0)	20 (26.56)^a	40.12 (39.29)^a	0 (0.0)^c	20 (26.56)^a
Leaf	53.12 (46.78)^b	20 (26.56)^b	0 (0.0)	20 (26.56)^a	0 (0.0)^d	10 (18.44)^b	80 (63.44)^b

Flower	21.21 (27.42)[e]	0 (0.0)	0 (0.0)	0 (0.0)[b]	0 (0.0)[d]	10 (18.44)[b]	90 (71.56)[c]
Solvent control	0 (0.0)[f]	0 (0.0)	0 (0.0)	0 (0.0)[b]	0 (0.0)[d]	0 (0.0)[c]	90 (71.56)[c]
Absolute Control	0 (0.0)[f]	0 (0.0)	0 (0.0)	0 (0.0)[b]	10 (18.44)[c]	0 (0.0)[c]	90 (71.56)[c]
S.Ed	0.699	0.123	-	0.134	0.121	0.119	0.105
CD (p=0.05)	1.541	0.271	-	0.296	0.266	0.202	0.231

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ES 04 BOPS 17

Methanol extract of *Senna alata* L. and its Anti-insect effects on third instar larvae of *Spodoptera litura* Fab. (Noctuidae; Lepidoptera)

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Keywords: *Methanol*, *Senna alata*, *Spodoptera litura, anti-insect effects*

Introduction

The tobacco cutworm, *Spodoptera litura*, has become a major pest of pulse crop throughout its Indian range. With a changing climate, there is the potential for this insect to become an increasingly severe pest in certain regions due to increased habitat suitability. Out of 112 globally recorded host plants of *S. litura*, 60 are known only from India (Ahmad *et al*., 2013). In this study, the insecticidal effect of *Senna alata* L. (Family: Fabaceae) was studied against *S. litura* larvae.

Materials and Method

Senna alata seed, flowers and leaves were collected and shade dried for 10 days. The powdered plant materials of *S. alata* were extracted by using methanol solvent in soxhlet for period of three days with intermittent shaking and filtered through what man no 40 filter paper. A no choice leaf disc assay was carried out using 4hrs pre starved third instar *S. litura* larvae. Castor leaf disc were cut out and treated on different plant part solvents. Treated leaf discs were collected after six hours. Then pre starved third instar *S. litura* larvae were allowed to feed, the leaf area fed was measured graphically and per cent leaf area protection over absolute control was computed and feeding deterrence activity was worked out (Owoyale *et al*., 2000). In the untreated control, larvae were maintained till adult emergence and mortality and malformations were recorded periodically.

The use of conventional insecticides has raised some concern about their threat to the environment and development of insecticide resistance in insects, there is an imperative need for the development of safer, alternative crop protectants such as botanical insecticides.

Result and Discussion

Superior insecticidal activity (80%) was noticed in methanol extract of seed. The seed extract also imparted 20 per cent pupal malformation resulting in nil adult emergences. It also imparted 20 per cent (79.93%) feeding deterrence activity. The reason for such results may be due to presence of more amounts of alkaloids in seeds. The similar report was given by Guerrero *et al*. (2015) showed supreme anti insect effect in seeds of *Senna alata* seeds. He suggested that utilization of methanol as the best solvent for initial extraction of protoberberine alkaloids. They also identified the presence of 0.44 per cent to 0.50 per cent of alkaloids in seed oil on a V/V basis.

Table 1. Anti-insect effects of *Senna alata* L. methanol extraction on third instar *Spodoptera litura* Fab.

Plant parts	Per cent feeding deterrence activity	Per cent mortality		Per cent malformation			Per cent adult emergence
		Larva	Pupa	Larva	Pupa	Adult	
Seed	79.93 (63.44)[a]	80 (63.44)[a]	0 (0.0)[b]	0 (0.0)[c]	20 (26.56)[a]	0 (0.0)[b]	0 (0.0)[a]
Leaf	40.12 (39.29)[b]	20 (26.56)[b]	20 (26.56)[a]	0 (0.0)[c]	20 (26.56)[a]	0 (0.0)[b]	40.12 (39.29)[b]
Flower	23.17 (28.79)[d]	0 (0.0)[c]	20 (26.56)[a]	0 (0.0)[c]	0 (0.0)[c]	0 (0.0)[b]	80 (63.44)[d]
Solvent control	0 (0.0)[e]	0 (0.0)[c]	0 (0.0)[b]	0 (0.0)[c]	10 (18.44)[b]	0 (0.0)[b]	90 (71.56)[e]
Absolute Control	0 (0.0)[e]	0 (0.0)[c]	0 (0.0)[b]	10 (18.44)[b]	0 (0.0)[c]	0 (0.0)[b]	90 (71.56)[e]
S.Ed	0.093	0.123	0.134	0.122	0.166	0.104	0.168
CD (p=0.05)	0.205	0.271	0.296	0.282	0.279	0.272	0.371

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ES 04 BOPS 18

Identification of food bait volatiles targeting female melon fruit fly, *Zeugodacus cucurbitae* (Coq.) (Tephritidae: Diptera) in gourds

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Keywords: *Zeugodacus cucurbitae, food bait volatiles, tenax trapping, GC-MS, Principal Component Analysis*

Introduction

The melon fruit fly, *Zeugodacus cucurbitae* (Coq.) (Tephritidae: Diptera) is a major devastating pest in vegetable crops ranked among the world's most serious pest of horticultural ecosystem (Sohrab and Hasan, 2018). Extent of loss inflicted by the melon fruit fly ranges from 30-100% which varies depending upon the season of attack and host species (Dhillon *et al.*, 2005). Focusing on female melon fruit fly management, food baits were developed.

For more insight into it, current study deals with collection of volatiles from the food baits which were further subjected to gas chromatography- mass spectrometry (GC-MS) analysis for determining the compounds responsible for the attraction of fruit flies.

Materials and Methods

Focusing towards trapping of female fruit flies, food baits *viz*, Food bait 1(B1) –Guava (30g) + Cane Sugar (3g) + Yeast (0.3g) + Food Grade Alcohol (10ml), Food bait 2(B2)-Muskmelon (40g) + Cane Sugar (4g) + Yeast (0.4g) + Food Grade Alcohol (10ml) and Food bait 3(B3)- Guava (20g) + Muskmelon (20g) + Cane Sugar (4g) + Yeast (0.4g) + Food Grade Alcohol (10ml) were developed. Fruits were washed, peeled and ground. To the pureed pulp, respective quantity of bait additives such as cane sugar, yeast and food grade alcohol were added and allowed for 48 hrs of fermentation. After 48 hrs of fermentation, food bait volatiles were collected through **Tenax** trapping. After 2.5 hours of collection, Tenax tubes were removed aseptically and further used for GC-MS analysis (Zhou *et al.*, 2012). Volatile extracts were analysed in PERKIN ELMER CLARUS SQ8C. Compounds from all three bait volatiles were numbered and further subjected to Principal Component Analysis (PCA).

Results and discussion

Based on qualitative and quantitative differences of the compounds obtained from the volatile profiles, the food baits were separated (Fig. 1). The scree plot obtained tends to deviate at PC2 as well as PC1 and PC2 accounted 97% of cumulative proportion of variance, which depicts the high reliability of the analysis. A total of 29 volatile compounds were identified from food bait 1 [Guava (30g) + Cane Sugar (3g) + Yeast (0.3g) + Food Grade Alcohol (10ml)]; a total of 24 compounds were identified from the volatile of food bait 2 [muskmelon (40g) + cane sugar (4g) + yeast (0.4g) + food grade alcohol (10ml)] and a total of 32 volatile compounds were identified from food bait 3 [guava (20g) + muskmelon (20g) + cane sugar (4g) + yeast (0.4g) + food grade alcohol (10ml)] Principal Component Analysis showed that food bait 1 (guava-based food bait) had higher percentage of 2 methyl-1-butanol (9), 1,3- pentadiene (3), β-thujene (38), α-ocimene (40) followed by ethyl butanoate (15) and limonene (37). Similar group of compounds were reported as constituents of guava fruit (Soares *et al.*, 2007). Higher occurrence of 1-pentanol (8) was noticed in food bait 2 (muskmelon-based food bait), followed by benzene (4), o-cymene (36); Pang *et al.*, (2012) observed similar group of compounds were reported as constituents of muskmelon fruit. In food bait 3 (combination of guava and muskmelon-based food bait), maximum amount of c-terpinene (42), 4-methoxy-2-methylbutane (5), ethyl hexanoate (7), n-hexadecane (49) was found followed by 1-Pentanol (8) and ά-Ocimene (40). A similar presence of ethyl hexanoate was observed in volatile profiling of fruits (Jayanthi *et al.*, 2012), (Siderhurst and Jang, 2006). This compound was also found to have female-based attraction in various fruit flies.

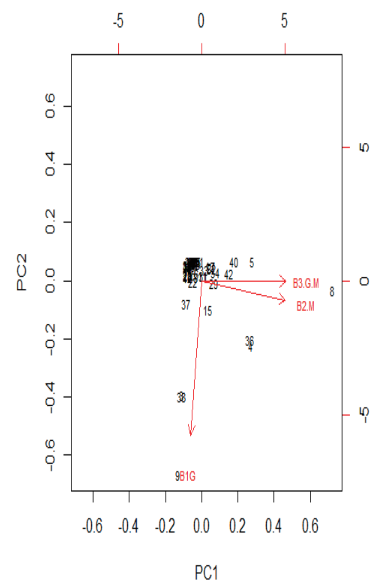

Fig 1. Biplot for the compounds analysed from food baits through GC-MS

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ES 04 BOPS 19

Evaluation of the efficacy of bio foliar formulations in controlling mulberry sucking pests and its impact on cocoon traits

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Key words: Mulberry, organic formulations, panchagavya and sucking pests

Introduction

Utilization of organic formulations in pest management is a cheap, environmentally friendly alternative to chemical pesticides. This study was designed to evaluate the effect of bio-foliar formulations on mulberry sucking pests and to study the impact on cocoon traits when silkworm fed with treated mulberry leaves.

Materials and Methods

A field experiment was conducted with irrigated V1 mulberry variety at the Department of Sericulture, Forest College and Research Institute, Mettupalayam which was laid out in Randomized Block Design with five treatments and four replications. Applicationof bio-foliar formulations were given thrice at 15, 30 and 45 days after pruning using knapsack sprayer and data on pest population was counted weekly for two seasons. After 10 days of application, treated mulberry leaves were collected and fed to silkworm and observed the larval and cocoon traits. The data were analyzed statistically and grouped by LSD through SPSS software.

Result and Discussion

The results revealed that the minimum damage by different pests viz., Pseudodendrothrips mori and Aleurodicus dispersus were observed in panchagavya and EM applied plants (Fig 1). It was supported by Sudhakar et al., (2018) who found that the lesser incidence of thrips (2.79 %) in the panchagavya treated plots in mulberry. Table 1 shows the bio-foliar formulations treated mulberry leaves when fed silkworm had larval weight (3.95 g), Effective Rate of Rearing (ERR) (92.05 %), cocoon weight (1.60 g), shell weight (0.379 g), shell ratio (23.78 %) and cocoon yield by weight (21.78 kg) which were found to be statistically higher in the larval batch treated with panchagavya. Samuthiravelu et al., (2012) observed the positive effect on cocoon traits due the foliar application of panchagavya and vermiwash on mulberry leaves.Thus the foliar application of panchagavya was an eco-friendly approach to control sucking pests and uphold the production of good quality cocoons for high grade silk productivity.

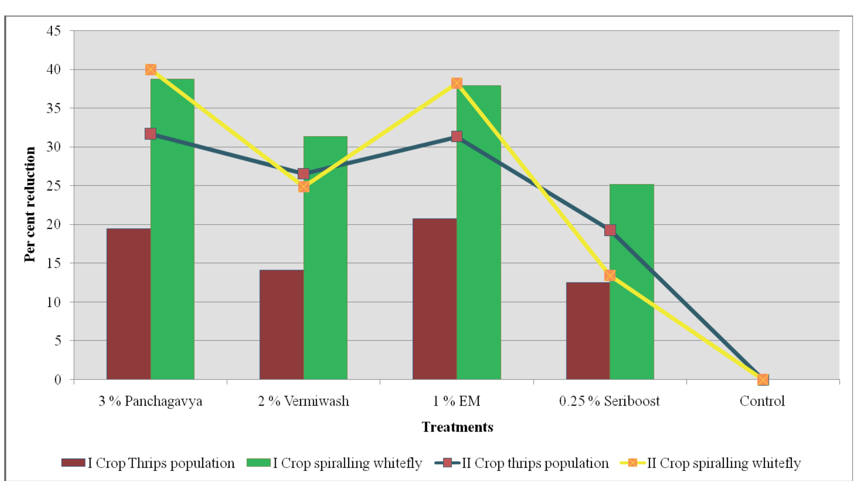

Fig1. Per cent reduction of pest population against bio-foliar formulations

Table 1. Impact of bio-foliar formulations on silkworm and cocoon traits

Treatments	Matured larval weight (g)	ERR (%)	Cocoon weight (g)	Shell weight (g)	Shell ratio (%)	Cocoon yield/ 10000 larvae by weight (kg)
Panchagavya @ 3%	3.95[a]	92.05[a]	1.60[a]	0.379[a]	23.68[a]	21.78[a]
Vermiwash @ 2%	3.66[b]	90.14[b]	1.46[b]	0.325[b]	22.26[ab]	18.91[bc]
EM @ 1%	3.60[b]	89.16[b]	1.49[b]	0.344[b]	23.08[a]	19.64[b]
Seriboost @ 0.25%	3.48[c]	87.99[c]	1.38[c]	0.302[c]	21.88[b]	17.52[d]
Control	3.08[d]	85.90[d]	1.30[d]	0.278[d]	21.38[b]	17.02[d]
SEd	0.03	0.55	0.03	0.016	0.80	0.61
CD(P=0.05)	0.07*	1.11*	0.07*	0.030*	1.58*	1.20*

*Significant. Each value is the mean of four replications.

Mean followed by same alphabets are on par with each other.

ERR - Effective Rate of Rearing, EM – Effective Microflora

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ES 04 BOPS 20

Bio rational pesticides against *Aphis gossypii* Glover on water melon, *Citrullus lanatus* Thunb Matsum and Nakai

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Key words: *watermelon, Citrullus lanatus, Aphis gossypii, bio-rational pesticides*

Introduction

Water melon is an important commercial horticultural crop grown for consumption and export purpose. It is a staple food both in fresh and preserved form. In India water melon is cultivated to an extent of 1.03 lakh ha with an annual production of 25.04 lakh mt/ha and it is cultivated in an area of 6.420 ha in Tamil Nadu with annual production of 1.75 lakh mt/ha with an average productivity of 32 t/ha (Potnuru Santosh Kumar and Kulkarni, 2018). During cultivation water melon is being attacked by several insect pests at various stages. Among these, *Aphis gossypii* is found to infest severely and cause economic damage. Hence present study was undertaken to evaluate certain bio rational pesticides against aphid to prevent the pest damage.

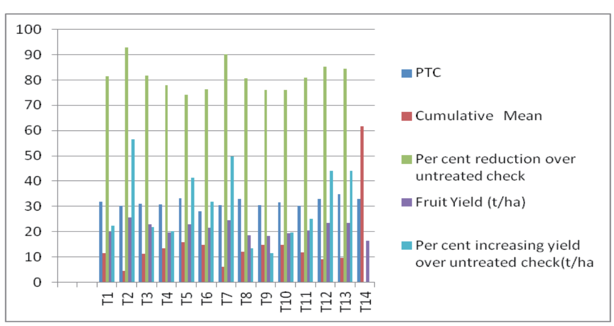
Material and Methods

The field experiment was carried out in farmer's field at Konur village (11° 12'30" N, and 78°4'41"E"), Namakkal district during kharif season 2020 to evaluate certain bio rational pesticides against aphids on watermelon in comparison with farmers practice in Randomized Block Design (RBD) with fourteen treatments viz; (T_1-*Vitex negundo* leaf decoction 5% ,T_2- *Azadirachta indica* Oil 3% ,T_3-*Pungamia pinnata* leaf decoction 3%, T_4- *Ocimum sanctum* leaf decoction 5%,T_5- *Ricinus communis* Oil 3%,T_6- *Eucalyptus globules* leaf decoction 3%, T_7-*Beauveria bassiana* ($1x10^8$cfu spores)8g/lit, T_8-*Metarhizium anisopliae*-($1x10^8$cfuspores)8g/lit, T_9-*Paceilomyces fumosoroseus* ($1x10^8$cfu spores)8g/lit,T_{10}-*Lecanicillium lecanii* ($1x10^8$cfu spores) 8g/lit, T_{11}-*Emamectin benzoate* 5%EC@0.4g/lit, T_{12}-Spinosad45% SC@0.3ml/lit, T_{13}-Imidacloprid17.8%SL@0.3ml/lit (Treated check) and T_{14}-Untreated check (Water spray -200ml/acre)), Three replications and other recommended packages of practices were adopted. *Aphis gossypii* population were recorded from three leaves in infested branches .The observations on *Aphis gossypii* infestation category was also observed by using population level of *Aphis gossypii* as per Sikha Deka *et al.* (2016) given as (<1.No. of aphid -Negligible), (1-10. No. of aphids -Low), (11-30 -No. of aphids -Moderate) (31-40. No. of aphids- Severe), (>50.No. of aphids -Very Severe).The most effective treatments and their means were compared by significant difference at $p<0.05$ ANOVA following by Tukeys' Honest Significant Difference test.

Results and discussion

The lowest *Aphis gossypii* population was recorded in *Azadirachta indica* oil @ 3% (4.39/leaf) followed by *Beauveria bassiana* @8g/lit containing ($1x10^8$cfu spores) (6.01/leaf) and spinosad 45% SC@0.3ml/lit (Treated check) (9.16/leaf). The percent reduction over untreated check was the highest in *Azadirachta indica* 3% (92.89 %) followed by *Beauveria bassiana* (90.27%) and spinosad (85.17%).The observation on *Aphis gossypii* population was lowest category in *Azadirachta indica* followed by *Beauveria bassiana* and spinosad. The observation of *Aphis gossypii* population very severe in the untreated check respectively. A significantly higher yield of fruits (25.5t/ha) and per cent increase in yield (56.44%) were recorded in *Azadirachta indica* oil treated plot.

Present finding is comparable with the records of Khadija Javed., *et al.* (2019) on *B. bassiana and (*Naeem *et.al.,* 2012) for *Azadirachta indica*. From the results it is inferred that among the bio rational pesticides evaluated, *Azadirachta indica* oil 3%,*Beauveria bassiana* ($1x10^8$cfu spores) 8g/lit and spinosad 45% SC@ 0.3ml/lit were found to be good for the management *Aphis gossypii* in watermelon



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ES 04 BOPS 21

Management of potato leaf miner, *Liriomyza huidobrensis* Blanchard by using botanical insecticides

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Keywords: *leaf miner, botanical, management, potato, efficacy*

Introduction

One of the world's four major food crops is the potato (*Solanum tuberosum* L.; Solanaceae). Potatoes are fourth in terms of global production behind wheat, maize, and rice. Insect pests are the most serious threat to potato productivity as well as quality. Potatoes are currently under threat from the pea leaf miner (*Liriomyza huidobrensis* Blanchard), an invasive, extensively polyphagous, and chemically resistant pest that attacks a wide range of crops, ornamental plants, and weeds (Parrella and Bethke, 1984). *L. huidobrensis* has been detected in the potato-growing districts of the Nilgiris recently. As a result, a study was conducted to determine the efficacy of several botanicals often found in Nilgiri's potato belt against the leaf miner, *L. huidobrensis.*

Materials and Methods

Two field experiments at two different locations *viz.,* Ooty and Kotagiri, Nilgiris District, Tamil Nadu during the year 2021 were conducted in a randomized block design replicated thrice with seven treatments *viz.,* Neem oil @ 2 %, Neem Seed Kernel Extract (NSKE) @ 5 %, *Eupatorium adenophorum* @ 5 %, *Ruta chalepensis* @ 5 %, Azadirachtin 0.15 EC (Commercial formulation) @ 2500 ml. ha^{-1}, Profenofos 50 EC @ 1000 ml. ha^{-1} and control. Fresh leaves of *E. adenophorum* and *R. chalepensis* were collected, washed, shade dried and used. Neem seed kernels were pulverized into fine powder and 500g of leaf/kernel powder was soaked in 1 litres of water overnight and the volume made up to 10 litres. Observations were made on day before and three, five, seven, and fourteen days after the first and second sprays and per cent leaf damage was calculated using the formula

$$\text{Per cent infestation} = \frac{\text{Number of infested leaves}}{\text{Total number of leaves per plant}} \times 100$$

The percent infestation data was transformed into an Arc sine (Angular) transformation before analysis. The modified data was then subjected to an analysis of variance (ANOVA). Duncan's Multiple Range Test (DMRT) was used to differentiate the means of the significantly different treatments ($P < 0.05$). The level of significance was fixed at $\alpha = 0.05$. All these procedures were carried out using SPSS software.

Results and discussion

On one day before first spray, the per cent leaf damage recorded in different treatments was 23.35, 26.12, 22.05, 25.29, 27.09, 26.02 and 25.12 per cent and 35.31, 36.84, 38.05, 40.15, 39.03, 34.91 and 38.11 per cent at Ooty and Kotagiri respectively (Table 1). However, the per cent leaf damage in all the treatments were significantly less than the untreated control. The order of effectiveness of different treatments were determined based on the mean per cent reduction in leaf damage compared to the untreated control as follows: Profenofos 50 EC @ 1000 ml. ha^{-1} (82.63%), Azadirachtin 0.15 EC (Commercial formulation) @ 2500 ml. ha^{-1} (87.38%) > by NSKE @ 5 % (83.91%) > *R. chalepensis* @ 5 % (82.77%) > *E. adenophorum* @ 5 % (76.61 %) > Neem oil @ 2 % (76.53%) at Ooty and Azadirachtin 0.15 EC (Commercial formulation) @ 2500 ml.ha^{-1} (77.95%) > NSKE @ 5 % (74.30%) > *R. chalepensis* @ 5 % (74.50%) > *E. adenophorum* @ 5 % (65.64 %) > Neem oil @ 2 % (62.96%) at Kotagiri respectively. Based on the findings, it was determined that the efficacy of Azadirachtin 0.15 EC (Commercial formulation) @ 2500 ml. ha^{-1} and NSKE @ 5 % was comparable to *R. chalepensis* @ 5 %, at both the locations and that they can be investigated further and used in the management of *L. huidobrensis*, and IPM in particular, as a novel botanical for potato ecosystem. Weintraub and Horowitz, (1997) also reported similar results that neem-based insecticides like azadirachtin are expanding the spectrum of compounds available to control *L. huidobrensis.* The efficiency of neem seed kernel extract 4 % against *L. trifolii* on tomato was also documented by Viraktamath *et al.* (1993).

Table 1. Bio efficacy of botanicals on leaf miner, *L. huidobrensis* affecting potato

Treatments	Ooty			PRC	Kotagiri			PRC
	PTC	Mean of I Spray	Mean of II Spray		PTC	Mean of I Spray	Mean of II Spray	
Neem oil @ 2%	23.25 (28.81)	19.71 (26.73) d	11.78 (20.00) c	76.53	35.31 (36.44)	30.62 (34.04) d	19.07 (25.72) a	62.96
NSKE @ 5%	26.12 (30.72)	17.47 (25.57) e	8.08 (16.46) b	83.91	36.84 (37.35)	27.19 (32.36) bc	13.23 (21.02) c	74.30
E. adenophorum @ 5%	22.05 (27.99)	19.13 (26.26) d	11.74 (19.95) c	76.61	38.05 (38.07)	30.99 (34.51) d	17.69 (24.69) a	65.64
R. chalepensis @ 5%	25.29 (30.18)	16.91 (25.19) b	8.65 (16.99) b	82.77	40.15 (39.30)	28.05 (33.13) b	13.36 (21.19) c	74.05
Azadirachtin 0.15 EC @ 2500 ml. ha^{-1}	27.09 (31.35)	15.53 (24.44) a	6.34 (14.42) a	87.38	39.03 (38.65)	26.87 (32.37) b	11.35 (19.39) b	77.95
Profenofos 50 EC @ 1000 ml. ha^{-1}	26.02 (30.66)	21.04 (27.83) f	8.72 (16.61) b	82.63	34.91 (36.20)	24.42 (30.61) a	9.13 (17.25) a	82.26
Untreated control	25.12 (30.06)	34.72 (35.05) g	50.21 (45.10) d	-	38.11 (38.11)	42.42 (40.21) e	51.48 (45.83) d	-
SE(d)	0.70	0.89	1.02	-	0.52	0.69	0.85	-
CD(0.05)	1.55	1.84	2.12	-	1.14	0.14	1.76	-

* PTC – Pre-treatment count; PRC – Percent reduction over untreated control. Figures in parentheses are Arc sine transformed values. Treatment means with letter(s) in common are not significant by DMRT at 5% level of significance.

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ES 04 BOPS 22

Correlation of yellow sticky trap catches with the population of leaf miner, *Liriomyza* spp. in potato (*Solanum tuberosum*)

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Keywords: *Correlation, leaf miner, trap, weather parameter, potato*

Introduction

eaf miners of the genus *Liriomyza* (Agromyzidae: Diptera), an introduced pest of India in the 1990s, have been recorded as pests of a wide range of horticulture crops, and their incidence has recently been observed in potato. Potatoes are currently threatened by leaf miner, *Liriomyza* spp. an exotic, exceedingly polyphagous, and chemically resistant pest that attacks a wide range of crops, ornamental plants, and weeds. The population of leaf miner in potato has to be monitored for implementation of the timely control measures accurately. The present research aimed to study the population correlation of leaf miner, *Liriomyza* spp. with weather parameters to understand the population fluctuation of leaf miners during two different seasons at two different locations *viz*, Ooty and Kotagiri at Nilgiris, Tamil Nadu.

Materials and Methods

Two field experiments were conducted on the potato variety Kufri Jyoti with yellow sticky trap replicated thrice with a plot size of 25 m^2. The experiment was carried out during February-May (as an irrigated crop) at Kappachi, Ooty (11.43°N 76.76°E; 2,209 m) and during April-July (as a summer crop) at Kookal village, Kotagiri (11.46°N 76.88°E; 1,847 m). The experimental site was kept free from pesticides, and no chemical treatments were given in the selected potato fields. Weekly trap collections of leaf miners were visually examined and trap counts were made for 10 cm^2 of the trap for leaf miner adult populations. The weather parameters like maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, rainfall was obtained during different months and the derived parameters like diurnal variation (DV), relative temperature Disparity (RTD) and growing degree days (GDD) were subjected to correlation with the trap catches of leaf miner.

Results and discussion

The trap catches of yellow sticky trap were compared with abiotic factors, to study the influence of the key meteorological parameters on the incidence of leaf miner. Simple correlation matrices were calculated between the adult trap catches (as dependent variables) and the weather parameters (as independent variables). When potato was grown as an irrigated crop at Kappachi, Ooty, the population reached its peak in the second week of March, which coincided with the tuber developmental stage of the crop. The correlation studies revealed a significant positive correlation of trap catches with maximum temperature (°C) and growing day degrees (GDD) and a positive correlation with minimum temperature (°C), rainfall (mm) and diurnal variation (DV). Relative humidity (%) and Relative temperature disparity (RTD) were negatively correlated with trap catches (Table 1). Similarly, at Kookal, Kotagiri, during the summer season, the peak population (52.33 adults/10 cm^2 area) was observed during the third week of June (24^{th} standard week), which coincides with the tuber formation stage. The correlation studies revealed a positive correlation with minimum temperature, relative humidity, rainfall, relative temperature disparity (RTD) and a significant and positive correlation with maximum temperature (°C), diurnal variation (DV) and growing day degrees (GDD) (Table 1). The multiple regression equation fitted with weather parameters for trap catches, Y_1 = 5.901 + 2.015 (T.max) – 0.564 (GDD) + 3.145 and Y_2 = -30.880 – 163.415 (T.max) – 80.500 (DV) + 1680224 (GDD) + 4.666 contributing 46.1 % and 65.5% of the fluctuation in the adult leaf miner population (Table 2). Similar finding was reported by Galande *et al.* (2004) reported that *L. trifolii* population was found to be peak during January to April in tomato crop and the maximum temperature showed significant and positive correlation (0.872), whereas morning relative humidity showed significant but negative correlation (-0.578) with *L. trifolii* incidence. The findings also support the result of Reddy and Kumar (2005), who indicated that the peak incidence of *Liriomyza* during March-April, which coincided with the vegetative and reproductive stages.

Table 1. Correlation of trap catches of yellow sticky trap and weather parameters in potato

Weather parameter	Correlation of Trap catches (r)	
	Ooty	Kotagiri
Maximum temperature	0.674*	0.727*
Minimum temperature	0.490^{NS}	0.299^{NS}
Morning relative Humidity	-0.259^{NS}	0.284^{NS}
Rainfall	0.301^{NS}	0.194^{NS}
Diurnal variation (DV)	0.195^{NS}	0.667*
Relative temperature disparity (RTD)	-0.322^{NS}	0.531^{NS}
Growing degree days (GDD)	0.608*	0.771*

*Significant at 5%; NS – Non-Significant

Table 2. Regression equation and coefficient of determination (R^2) of leaf miner in relation to weather parameters at two locations in the Nilgiris

Location of Trap catches of adult leaf miner	Regression equation	Correlation Coefficient (R)	Coefficient of determination (R^2)
Ooty	Y_1 = 5.901 + 2.015 (T.max) – 0.564 (GDD) + 3.145	0.679	0.461
Kotagiri	Y_2 = -30.880 – 163.415 (T.max) – 80.500 (DV) + 1680224 (GDD) + 4.666	0.809	0.655

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ES 04 BOPS 23

Olfactory response of *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae) to the volatiles of healthy and herbivore damaged maize plants

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Keywords: *Spodoptera frugiperda, olfactory response, plant volatiles, maize*

Introduction

Fall Armyworm, *Spodoptera frugiperda* (J E Smith) (Lepidoptera: Noctuidae) is an invasive pest introduced to India in 2018. It is a serious pest of maize and is also reported to damage more than 100 hosts in its place of origin, *i.e.* the tropical and subtropical region of America. With the reports of R-strain and M-strain in the populations of fall armyworm and failure of management practices, it is important to develop accurate and precise formulation of pheromone for fall armyworm under Indian conditions. Study of the olfactory response of both male and female *S. frugiperda* (Smith) (Lepidoptera: Noctuidae) to the volatiles of healthy and damaged maize plants will provide an insight towards the management of this pest with eco-friendly management strategies.

Materials and methods

Spodoptera frugiperda egg masses were collected from maize growing research plots at Tamil Nadu Agricultural University campus, Coimbatore and upon hatching, reared in TNAU FAW artificial diet and healthy and *S. frugiperda* damaged, 15, 30 and 45 days old maize plants (Variety- COHM-8) raised in pots were used for olfactometer studies. The olfactory response of 3- 5 days old gravid females with no previous experience of host plant volatile exposure were studied in two- choice tests using Y- tube olfactometer. The treatments compared were 15 days old, 30 days old and 45 days old healthy and *S. frugiperda* damaged maize plants. Percentage of *S. frugiperda* female and male moths responding to plant volatiles were compared pairwise among experimental treatments using a Chi-square test.

Results and discussion

Results indicated that gravid female *S. frugiperda* moths preferred healthy maize plants over *S. frugiperda* larva damaged plants. In fifteen days old maize plants, female moths showed specific preference to healthy plants over clean air (T1: χ^2=8.53, p=0.003), healthy plants over damaged plants (T3: χ^2=8.53, p= 0.003) and clean air over damaged plants (T2: χ^2=2.13, p=0.144). Healthy plants were preferred over damaged plants (T6: χ^2=10.80, p=0.001) and over clean air (T4: χ^2=6.53, p=0.011) in thirty days old maize plants. In forty-five days old maize plants, 86.67 per cent of the female moths released showed high preference to healthy plants over damaged plants (T9: χ^2=16.13, p=0.000) and 80 % of the female moths released preferred healthy plants over clean air (T7: χ^2=10.80, p=0.001). The present findings are in line with the results of Signoretti *et al* (2012), who reported that the female moths showed great response to undamaged plant volatiles over herbivore-induced plant volatiles in maize plants. This preference is due to the adaptive strategy of female moths to safeguard its offsprings from natural enemies and competitors. Block *et al*., (2021) found out that *S. frugiperda* females show specific oviposition preference to healthy plants over *S. frugiperda* larva infested plants. Similarly, De Moraes *et al*., (2001) reported that *Heliothis virescens* females were highly repellent to certain herbivore-induced plant volatiles released exclusively during the night due to the feeding of *H. virescens* larva in *Nicotiana tabacum*.

Table. 1. Preference of female moths to the odour source combinations in a Y-tube olfactometer

Treatment		Mean per cent moths' response ± SE (for respective combinations)		Probability (P-value)
15 days old plant				
T1	Clean air Vs Healthy plants	23.33	76.66	0.0034
T2	Clean air Vs Damaged plants	63.33	36.66	0.1441
T3	Healthy plants Vs Damaged plants	76.66	23.33	0.0105
30 days old plant				
T4	Clean air Vs Healthy plants	26.66	73.33	0.0105
T5	Clean air Vs Damaged plants	53.33	46.66	0.7150
T6	Healthy plants Vs Damaged plants	80.00	20.00	0.0034
45 days old plant				
T7	Clean air Vs Healthy plants	20.00	80.00	0.0010
T8	Clean air Vs Damaged plants	60.00	40.00	0.2733
T9	Healthy plants Vs Damaged plants	86.66	13.33	0.0002

*Response of 30 moths

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ES 04 BOPS 24

Bioefficacy of *Annona squamosa* L. seed extracts against *Callosobruchus maculatus* F. (Coleoptera:Bruchidae)

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Key words: *Annona squamosa seed extract, Callosobruchus maculatus, Green gram seed*

Introduction

In India, pulses are the good source of protein, vitamin, mineral, fiber and also enrich the soil fertility. India is the world's largest producer as well as consumer of green gram and India contributes 70% of world's green gram production. But, this production was lost upto 8.5% at the time of storage and postharvest handling (Kosar and Srivatsava, 2016). The pulse beetle attacks grain legumes at both pre and postharvest stages. The beetle lays eggs on the outerside of the pod/grains. Custard apple, *Annona squamosa* is a tropical and sub-tropical crop and the seeds, leaves, bark, twigs, fruits, flowers and roots of this plant are reported to have toxicity against insect pests of crops in field and storage. The acetogenins present in *A. squamosa* have been proved to have antimicrobial and insecticidal activities. The present study is undertaken to study the ovipositional deterrent activity of *A. squamosa* seed extracts against *C. maculatus.*

Materials and Methods

Custard apple seeds were separated from the fruits and powdered for extraction. Five different solvents were used for extraction using Soxhlet apparatus (30g seed power: 300 ml solvent). Tested insects were mass cultured at Insectary at controlled condition. Green gram seeds (50g) were taken and treated with solvent extract of *A. squamosa* seeds at different concentration *viz.,* 1, 5, 10, 15 and 20 per cent concentration. The treated seeds were taken in a plastic container and 10 pairs newly emerged beetles were released. The NSKE (0.5g) were used as a standard check for the experiment. Each treatment was replicated four times. The observation was taken after seven days of adult release. The eggs of the *C. maculatus* were counted using hand lens. The reduction in oviposition was calculated using the formula reported by Neog and Singh (2013).

Results and Discussion

The results of the experiments revealed that, all the treatments registered more than 30 per cent reduction in fecundity (Table 1). Among the five different extracts, *A. squamosa* methanol extract (20%) showed 90.64 per cent reduction in fecundity which was followed by ethyl acetate extract that resulted in 77.92 per cent reduction. The hexane and chloroform extracts (20%) showed 75.35 per cent and 66.60 per cent reduction in fecundity, respectively. The least per cent oviposition deterrence was observed with acetone extract (65.26%).The standard botanical check, neem seed kernel powder showed 63.16 per cent oviposition deterrent activity.

The observation on ovipositional deterrent activity of *A. squamosa* seed extract revealed that, the plant extracts were effective against *C. maculatus* with more than 50 per cent oviposition deterrent activity at higher concentrations. This was in accordance with Chudasama *et al.* (2015) who reported that *A. squamosa* seed and leaf extract caused maximum oviposition deterrence of *C. maculatus.*

Table 1. Oviposition deterrence effect of *A. squamosa* seed extracts against *C. maculatus*

Treatments	Per cent oviposition deterrent at different concentrations				
	1%	5%	10%	15%	20%
T1- Methanolic seed extract	67.27 (55.10)[a]	75.35 (60.23)[a]	79.28 (62.92)[a]	84.61 (66.90)[a]	90.64 (72.18)[a]
T2- Ethyl acetate seed extract	57.95 (49.57)[b]	62.68 (52.35)[b]	67.24 (55.08)[b]	69.29 (56.34)[b]	77.92 (61.97)[b]
T3- Hexane seed extract	51.28 (45.73)[c]	59.90 (50.71)[b]	63.36 (52.75)[b]	69.27 (56.33)[b]	75.35 (60.23)[b]
T4- Chloroform seed extract	42.60 (40.74)[d]	51.30 (45.74)[c]	55.92 (48.40)[c]	62.65 (52.32)[c]	66.60 (54.69)[c]
T5- Acetone seed extract	33.31 (35.25)[e]	42.60 (40.74)[d]	51.97 (46.13)[c]	58.59 (49.95)[c]	65.26 (53.89)[c]
T6 – NSKE 0.5g	63.16 (52.63)[ab]	63.16 (52.63)[b]	63.16 (52.63)[b]	63.16 (52.63)[c]	63.16 (52.63)[c]
T7- Untreated check	0.00 (0.64)[f]	0.00 (0.64)[e]	0.00 (0.64)[d]	0.00 (0.64)[d]	0.00 (0.64)[d]
SEd	1.64	1.75	1.64	1.65	1.78
CD (0.05)	3.42	3.65	3.41	3.44	3.71

All values are mean of four replications

Figures in parenthesis are arcsine transformed values.

In a column, means followed by the same letter are not significantly different by DMRT.

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ES 04 BOPS 25

Bioefficacy of botanicals against tea mosquito bug, *Helopeltis theivora* Waterhouse under laboratory condition

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***Keywords**: Bio efficacy, botanicals, tea, tea mosquito bug, sucking pests*

Introduction

Tea, *Camellia sinensis* (L.) O. Kuntze, is an intensively managed perennial monoculture crop cultivated on large scale and small-scale plantations. The tea mosquito bug, *Helopeltis theivora* (Waterhouse) (Heteroptera: Miridae) is one of the major sucking pests of tea throughout India (Mukhapadhyay and Roy, 2013). More than 80% of tea cultivation area is being affected by the nymph and adults of *H. theivora*, leading to dark brown shrunken spots in young foliage, no shoot formation, delayed flushing, stunted growth and die back of stems. A major problem in the control of *H. theivora* is its capability to develop resistance quickly to frequently used insecticides. The present study is focused on the effect of certain botanicals against tea mosquito bug for effective management.

Material and Methods

Field populations of *H. theivora* were collected and bouquet bioassay method was used to test the efficacy. Eight botanicals with three replications (15 shoots/ replication) and Completely Randomized Design (CRD) was followed. The treatments include T1- Pungam oil @ 20ml/lit., T2- Fish Oil Rosin Soap @ 25ml/lit., T3 - Extracts of *Vitex negundo* @ 50ml/lit., T4 - Iluppai oil @ 20ml/lit., T5- Azadirachtin 10000 ppm @ 2ml/lit., T6- Punnai oil @ 20ml/lit., T7- Extracts of *Clerodendrum viscosum* @ 20ml/lit., T8- Control (Water). Tritox X-100 @ 0.01% was used as adjuvant in all the treatments. Ten bugs were introduced in each treatment. The shoots were sprayed with hand atomizer. The observations on per cent adult mortality and feeding puncture/shoots were recorded at 24, 48 and 72 hours after treatment (HAT). Moribund insects were considered as dead and data were analyzed statistically.

Results and Discussion

The results on the efficacy of botanicals against TMB revealed that Punnai oil 2% treated tea shoots has less no of feeding punctures (269.00 Nos) with 98.23 per cent adult mortality followed by Pungam oil 2% (94.74%), Azadirachtin 10000 ppm (84.21%), Iluppai oil 2% (80.70%), Extracts of *Vitex negundo* 5% (70.18%) and extracts of *Clerodendrum viscosum* 2% (70.18%), Fish Oil Rosin Soap (24.56%) and control (feeding punctures was more 421.00 Nos) **(Table 1).** The present finding was supported by the field studies of Roy *et al*. (2010) and Hazarika *et al.,* (2009). The present studies conclude that the application of Punnai oil @ 20ml/lit. followed by Pungam oil @ 20ml/lit, in rotation effectively control *H. theivora* in tea. Thus pungam oil @ 20ml/lit was recommended for widespread application to successfully manage the tea mosquito bug.

Table.1. Bio efficacy of botanicals against Tea mosquito bug under laboratory condition

Treatment details	Dose (ml or g/Lit.)	Adult mortality %			% reduction over control	Feeding punctures	% reduction over control
		24 HAT	48 HAT	72 HAT		72 HAT	
Pungam oil	20	41.67±0.20[a]	65.00±0.21[ab]	95.00±0.09[a]	94.74	272.00±0.37[d]	40.67
Fish Oil Rosin Soap	25	15.00±0.00[b]	18.33±0.10[d]	28.33±0.08[c]	24.56	382.33±0.32[b]	12.65
Extracts of *Vitex negundo*	50	31.67±0.16[a]	48.33±0.07[bc]	71.67±0.16[b]	70.18	301.67±0.24[c]	34.00
Iluppai oil	20	38.33±0.20[a]	55.00±0.07[abc]	81.67±0.06[ab]	80.70	289.00±0.21[cd]	36.69
Azadirachtin 10000 ppm	2	38.33±0.08[a]	61.67±0.06[abc]	85.00±0.09[ab]	84.21	283.33±0.29[cd]	38.31
Punnai oil	20	45.00±0.12[a]	68.33±0.16[a]	98.33±0.10[a]	98.25	269.00±0.33[d]	41.67
Extracts of *Clerodendrum viscosum*	20	28.33±0.08[a]	45.00±0.12[c]	71.67±0.16[b]	70.18	304.67±0.12[c]	34.29
Control(Water)	-	5.00±0.00c	5.00±0.00[e]	5.00±0.00[d]	-	421.00±0.31[a]	-
CD (P=0.05)	-	0.39	0.36	0.32	-	0.86	-
SE(d)	-	0.18	0.17	0.15	-	0.40	-

HAT- Hours After Treatment

Means ± SE within a column followed by the same letter are not significantly different from each other at 5% level of significance (LSD test)

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ES 04 BOPS 26

Evaluation of *Erythrina variegata* and *Momordica balsamina* proteinase inhibitors on nutritional indices of Fall Armyworm, *Spodoptera frugiperda* (J.E. Smith)

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Keywords: *Proteinase inhibitors, Erythrina variegata, Momordica balsamina, Consumption indices, Spodoptera frugiperda*

Introduction

Spodoptera frugiperda (J.E. Smith), a polyphagous invader to India and became a major challenge for maize farmers. As this crop is mainly cultivated for fodder purpose, spraying of insecticides is not advisable. Exploiting plant proteinase inhibitors (PIs) as pest management tactic will be one of the ecofriendly methods (Santamaria *et. al.*, 2012). PIs from plants bind with the protease enzymes present in the gut of herbivore (insects) and inhibit amino acid production which is essential for the growth and development of insects and its deficiency ultimately results in decreased development and in some cases, it causes death of insects (Zhao *et. al.*, 2019). Our previous study on screening of serine proteinase inhibitor activity in 38 plant seeds revealed that the *Erythrina variegata* and *Momordica balsamina* possessed the highest inhibitory activity (Manoramya *et. al.,* 2020). So the present study was aimed to evaluate PIs from *E. variegata* and *M. balsamina* on nutritional indices of FAW.

Materials and Methods

Newly moulted fifth instar larvae were fed with different concentrations of partially purified PIs from *E. variegata* (EvPI), and *M. balsamina* (MbPI) (1%, 3% and 6% each) and a combination of EvPI and MbPI (6% + 6%) treated maize leaves. Observations like initial and final weight of leaf, larva and weight of faeces produced were recorded at 12, 24 and 36 hours of feeding and nutritional indices viz., Consumption Index (CI), Growth Rate (GR), Efficiency of Conversion of Ingested Food (ECI), Efficiency of Conversion of Digested Food (ECD), and Approximate Digestibility (AD) were calculated from these observations.

Results and Discussion

When the larvae fed with EvPI and MbPI, nutritional parameters like CI and AD got increased and other parameters like ECI, ECD and GR got decreased and more pronounced results were in MbPI 6% and in combination treatment (Table 1). Increased CI showed that to compensate the protein requirement the larvae started eating more (Slansky Jr, 1993). As PIs prevented the growth of larvae by binding with the protease enzyme which leads to amino acid deficiency which in turn showed decreased growth rate (GR). Inhibition of gut proteolytic activity (trypsin, chymotrypsin and total proteolytic activity) of *S. litura* was occurred when the gut enzymes incubated with PIs from *Adenanthera pavonina* (Velmani *et. al.,* 2019). Increased AD might be due to larvae produced more digestive enzymes to compensate for amino acid deficiency (Reese and Beck, 1976). As more food was metabolized for energy which required for compensating amino acid loss and less food only converted into body mass, ECD and ECI got reduced (Wheeler and Isman, 2001). These results showed that as the combination of both PIs has negative effect on food utilization, it can be used as a formulated product or as transgenic source for the control of *S. frugiperda.*

Table 1. Effect of EvPI and MbPI on nutritional indices of *S. frugiperda*

Treatments	CI*	GR (mg/day)*	ECI (%)*	ECD (%)*	AD (%)*
EvPI 1%	2.89±0.02 (1.70)^{d}	1.04±0.01 (1.02)^{d}	36.14±0.44 (36.95)^{d}	97.61±1.03 (81.11)^{d}	37.02±0.50 (37.48)^{c}
EvPI 3%	2.89±0.09 (1.70)^{d}	0.98±0.01 (0.99)^{c}	34.06±0.59 (35.70)^{c}	91.22±7.12 (72.77)^{cd}	37.46±2.40 (37.74)^{bc}
EvPI 6%	3.01±0.02 (1.73)^{abc}	0.95±0.02 (0.98)^{b}	31.61±0.70 (34.21)^{b}	77.97±3.64 (62.01)^{ab}	40.57±1.02 (39.56)^{a}
MbPI 1%	3.00±0.08 (1.73)^{bc}	0.96±0.01 (0.98)^{b}	31.91±1.27 (34.40)^{b}	85.23±6.64 (67.40)^{bc}	37.52±1.41 (37.77)^{bc}
MbPI 3%	3.03±0.02 (1.74)^{ab}	0.96±0.01 (0.98)^{bc}	31.67±0.11 (34.25)^{b}	80.28±3.12 (63.64)^{ab}	39.50±1.66 (38.94)^{abc}
MbPI 6%	3.09±0.02 (1.76)^{ab}	0.90±0.01 (0.95)^{a}	29.19±0.47 (32.70)^{a}	72.94±4.02 (58.66)^{a}	40.10±2.30 (39.29)^{ab}
EvPI 6% + MbPI 6% (1:1)	3.10±0.06 (1.76)^{a}	0.91±0.02 (0.95)^{a}	29.33±0.17 (32.79)^{a}	71.63±0.72 (57.82)^{a}	40.95±0.24 (39.79)^{a}
Untreated check	2.94±0.03 (1.17)^{cd}	1.04±0.01 (1.02)^{d}	35.46±0.51 (36.55)^{d}	94.65±3.38 (76.63)^{d}	37.49±1.05 (37.75)^{bc}

*Mean values of three replications, mean ± standard deviation; Figures in the parentheses are arcsine transformed values; the mean followed by the same letter are not significantly different from each other, DMRT ($p \leq 0.05$) (CI- Consumption Index, GR- Growth Rate, ECI- Efficiency of Conversion of Ingested Food, ECD- Efficiency of Conversion of Digested Food, AD- Approximate Digestibility)

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ES 04 BOPS 27

Insecticidal and Oviposition Deterrent Property of Certain Plant Extracts against Pulse Beetle, *Callosobruchus chinensis* Linn. (Coleoptera: Bruchidae)

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Keywords: *Plant extracts, ovipositional deterrent, Pulse beetle, Azadirachtin*

Introduction

The bruchid *Callosobruchus chinensis* (L.) is one of the major store grain pest of pulses capable of attacking wide range of legumes *viz.,* green gram, black gram, chick pea and pigeon pea and causes 50 per cent damage during storage within 3 to 4 months. The infestation starts in the field, but heavy damage is done in storage. Hence, the current study was aimed to evaluate the insecticidal and oviposition deterrent of certain plant extracts against pulse beetle, *C. chinensis* under storage condition.

Materials and methods

Seeds of green gram, black gram and bngal gram were taken @ 10gram in each plastic container. Plant extracts were added to the pulse seeds in each container individually at concentration of 10% and shaken thoroughly. Ten newly emerged adults of *C.chinensis* were released in each plastic container with treated seeds and were covered firmly and kept at the room temperature. Untreated pulse seeds were maintained as control and Azadirachtin was used as a standard check. Mortality (lack of locomotion and/or response to repeated probing) was recorded at 24 h interval for three days. The experiments were conducted in complete randomized block design (CRBD) with six treatments and four replications (T1- *Vitex negundo*, T2 – *Pongamia glabra*, T3- *Cassia angustifolia*, T4- *Calotropis gigantea*, T5- *Azadirachta indica*, T6- Control).

Results and discussion

The mortality rate after 72HAT was 85.8-87.5% with *V. negundo*, followed by *C. angustifolia* (73.33-80.00%) and *P. glabra* (70.0-75.0%). Azadirachtin gave 100% mortality of the beetle (Table 1). The oviposition deterrence percentage for pulse beetle, *C. chinensis* was found to be highest in *Calotropis gigantea* (37.66-68.16%) followed by *Pongamia glabra* (30.91-41.50) and *Vitex negundo* (7.58- 46.75) per cent, respectively (Table 2). Similar effects were observed by Gautham *et al*. (2003) in which they reported 51.7% mortality of *Spodoptera litura* at 6% aqueous extract of *V. negundo* leaves. Elhag (2000) studied the oviposition deterrence of nine plant materials on *C. maculatus* and found seed treatment with 0.1% crude extract resulted in significant reduction in egglaying by the bruchid.

Reference

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Table 1: Insecticidal activity of 10% aqueous plant extracts on *Callosobruchus chinensis*

Treatments (10% aqueous plant extracts)	Cumulative mortality of *C. chinensis*											
	Green gram				Black gram				Bengal gram			
	24 HAT	48 HAT	72 HAT	Mor (%)	24 HAT	48 HAT	72 HAT	Mor (%)	24 HAT	48 HAT	72 HAT	Mor (%)
Vitex negundo	72.5^{d} (58.38)	92.5^{d} (74.12)	97.5^{d} (80.96)	87.5	72.5^{d} (58.32)	90^{d} (71.52)	97.5^{b} (80.06)	86.6	72.5^{c} (80.90)	87.5^{b} (69.29)	97.5^{b} (81.61)	85.8
Pongamia glabra	57.5^{c} (49.31)	77.55^{c} (61.32)	85.0^{c} (67.28)	73.33	55.0^{c} (47.87)	77.5^{c} (61.68)	92.5^{c} (74.12)	75	62.5^{b} (74.14)	70.0^{c} (56.79)	77.5^{d} (61.70)	70
Cassia angustifolia	52.5^{b} (46.43)	80.0^{b} (63.43)	87.55^{b} (69.39)	73.33	57.5^{b} (49.31)	75.0^{b} (60.01)	90.0^{d} (70.36)	74.1	62.5^{b} (71.56)	87.5^{b} (69.32)	90.0^{c} (71.67)	80
Calotropis gigantea	7.5^{e} (15.84)	15.0^{e} (22.78)	27.5^{e} (31.62)	6.66	12.5^{e} (20.73)	32.5^{e} (34.75)	40.0^{e} (36.06)	28.3	12.5^{d} (39.23)	15.0^{d} (22.78)	27.5^{d} (31.62)	18.3
Azadirachta indica	100^{a} (84.04)	100^{a} (84.04)	100^{a} (84.04)	100	100^{a} (84.04)	100^{a} (84.04)	100^{a} (84.04)	100	100^{a} (84.04)	100^{a} (84.04)	100^{a} (84.04)	100
Control	0.00^{f}	0.00^{f}	0.00^{f}	0.00	0.00^{f}	0.00^{f}	0.00^{f}	0.00	0.00^{f}	0.00^{e}	0.00^{e}	0.00
CD (5%)	1.378	1.891	2.071	-	0.468	0.356	0.285	-	1.199	1.524	1.965	-
SEd	0.626	0.86	0.941	-	0.213	0.62	0.13	-	0.545	0.693	0.893	-

Mean of four replications; HAT – Hours after treatment

Table 2: Ovipositional deterrent efficiency of 10% aqueous plant extracts on *C. chinensis*

Treatments (10% aqueous plant extracts)	Ovipositional detterent (%)											
	Green gram				Black gram				Bengal gram			
	24 HAT	48 HAT	72 HAT	OD (%)	24 HAT	48 HAT	72 HAT	OD (%)	24 HAT	48 HAT	72 HAT	OD (%)
Vitex negundo	39.25 (6.25)^{c}	41.75 (6.45)^{c}	44.5 (6.66)^{b}	54.66	31.25 (5.58)^{c}	49.75 (7.04)^{c}	59.25 (7.68)^{c}	51.25	6.75 (2.59)^{e}	8.00 (2.82)^{e}	8.00 (2.82)^{e}	91.86
Pongamia glabra	37.75 (6.13)^{c}	39.50 (6.27)^{c}	41.75 (6.45)^{c}	57.01	32.50 (5.69)^{c}	40.00 (6.31)^{d}	52.00 (7.20)^{c}	56.73	24.25 (4.91)^{c}	30.00 (5.47)^{c}	38.50 (6.19)^{c}	66.82
Cassia angustifolia	40.25 (6.33)^{c}	42.50 (6.51)^{c}	44.25 (6.64)^{c}	68.56	36.00 (5.99)^{c}	47.00 (6.64)^{c}	58.00 (7.60)^{c}	50.65	9.50 (3.07)^{d}	11.25 (3.35)^{d}	12.25 (3.49)^{d}	88.19
Calotropis gigantea	61.25 (7.82)^{b}	68.0 (8.24)^{b}	75.25 (8.67)^{b}	26.11	45.00 (6.70)^{b}	56.75 (7.52)^{b}	70.00 (8.36)^{b}	40.30	29.00 (5.38)^{b}	36.50 (6.03)^{b}	47.50 (6.88)^{b}	59.57
Azadirachta indica	7.50 (2.73)^{a}	7.75 (2.78)^{a}	7.75 (2.78)^{a}	91.70	7.75 (2.78)^{a}	7.50 (2.73)^{a}	7.25 (2.69)^{a}	92.18	3.50 (1.87)^{a}	3.00 (1.73)^{a}	4.50 (2.12)^{a}	96.07
Control	88 (9.37)^{d}	92.5 (9.61)^{d}	96.25 (9.80)^{d}	0	90.5 (9.50)^{d}	98.15 (9.90)^{e}	99.05 (9.95)^{d}	0	90.50 (9.50)^{f}	92.25 (9.60)^{f}	96.50 (9.81)^{f}	0
CD (5%)	0.448	0.456	0.478	-	0.411	0.475	0.527	-	0.317	0.340	0.367	-
SEd	0.204	0.207	0.217	-	0.187	0.216	0.240	-	0.144	0.155	0.167	-

Mean of four replications; HAT – Hours after treatment

Figures in parenthesis are arcsine transformed values

ES 04 BOPS 28

Evaluation of sticky traps against major sucking pests of Ash gourd, *Benincasa hispida* Thunb

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Keywords: *Ash gourd, sucking insects, sticky trap*

Introduction

In India, the production of ash gourd is hampered by many sucking insect pests *viz.,* aphids, *Aphis gossypii* Glover and *Myzus persicae* Sulzer (Aphididae: Hemiptera), whitefly, *Bemisi atabaci* Gennadius (Aleyrodidae: Hemiptera), leafhopper, *Amrasca devastans* Distant (Cicadellidae: Hemiptera), thrips, *Scirtothrips dorsalis* Hood (Thripidae: Thysanoptera) (Atwal, 1993). Farmers mostly rely on the synthetic chemical insecticides for the control of sucking pests which disturbs the natural enemy fauna and results in toxic residues. Hence as an alternate strategy for the management of sucking pests, sticky traps of different colours were evaluated under field conditions.

Materials and methods

Cylindrical shaped sticky traps of different colours were evaluated against the sucking pests *viz., B. tabaci* and *S. dorsalis*. Cylindrical shaped containers of 45.47 cm^2 dimension were taken and painted with yellow, blue and white colours each. They were coated with castor oil as a sticking agent and kept in field (1 foot above the crop canopy) at a distance of 5 m to avoid trap interactions. Weekly observations were made for trap catches and expressed as number of insects per trap.

Results and discussion

The trap catches of alate forms of *M. persicae* were recorded from 2 weeks after sowing (WAS) to 8 WAS. The trap catches were highest in white sticky traps as compared to blue and yellow sticky traps. The trap catches of *L. trifolii* adults were recorded from 2 WAS to 6 WAS and yellow sticky traps recorded highest catches as compared to blue and white sticky traps (Table 1). The present findings are in confirmatory with Arida *et al.* (2013) who reported that yellow sticky traps are more attractive to *L. trifolii* adults than blue, purple or white traps in onion. Sticky traps are efficient in attracting winged forms of aphids which is in confirmation with earlier findings of Elango *et al.* (2017).

Table. 1 Efficacy of cylindrical sticky traps against major pests of ash gourd

Treatments/ Weeks of observation	Number of insects/trap*					
	T1-Yellow sticky trap		T2-Blue sticky trap		T3-White sticky trap	
	L. trifolii	*M. Persicae*	*L. trifolii*	*M. Persicae*	*L. trifolii*	*M. Persicae*
2 WAS	2.50	0.00	2.30	1.00	1.90	1.20
3 WAS	3.10	1.90	2.90	2.20	2.50	3.50
4 WAS	2.40	5.10	1.80	6.50	1.60	6.70

5 WAS	2.20	5.90	1.00	7.00	0.80	7.20
6 WAS	1.20	3.70	0.60	4.50	0.20	4.70
7 WAS	0.00	2.10	0.00	3.40	0.00	4.00
8 WAS	0.00	1.20	0.00	1.90	0.00	2.00

WAS- weeks after sowing *Mean of seven replications.

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Theme

ES 05: Biological Pest Management

ES 05 OPD 01

Efficacy of *Beauveria bassiana* inoculated cotton plants against sucking pests of cotton under field condition

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Keywords: *B. bassiana, A. gossypii, A. bigutulla bigutulla, B. tabaci, Cotton*

Introduction

Recently, several studies have shown that many entomopathogenic fungi also possess the potential to colonize plant tissues and thus to grow as an endophyte inside different plant species. *Beauveria bassiana* (Bals.) Vuill. (Ascomycota: Hypocreales) is a well-known entomopathogenic fungus for a diverse range of arthropod species. Besides an entomopathogen, this fungus is known to occur also as part of the natural endophytic community of certain plant species. Moreover, *B. bassiana* has been successfully established as an endophyte *via* an artificial application in a variety of crop plant species. The entomopathogenic fungus, *B. bassiana* has been endophytically introduced with success in different plant species and has shown activity against different pests (Jaber and Ownley, 2017). Accordingly, endophytic establishment and entomopathogenic activity of endophytic *B. bassiana* in a given crop plant represents an alternative strategy with a high potential for development of new and sustainable crop protection strategies. With this background, study was conducted with the objective to evaluate the efficacy of *B. bassiana* inoculated plants against sucking pests of cotton under field condition.

Materials and methods

Field experiments were conducted during 2015-16 to evaluate efficacy of eight *B. bassiana* isolates against insect pests of cotton. Based on the results, five *B. bassiana* isolates shortlisted for 2016-17 field experiment. Five *B. bassiana* fungal endophytes were grown on nutrient agar broth. Conidial suspensions for experiments were obtained from 15-day-old cultures. Viable conidia containing $1x10^8$ spores/ml was prepared into an aqueous solution of 0.002% Tween 80 and utilized for the experiment. Three methods *viz*., Seed coating, Soil Drenching and Foliar applications were followed to inoculate the *B. bassiana* into cotton plant. Observation on the sucking pests *viz*., *Aphis gossypii* (Glover), *Amrasca bigutulla bigutulla* (Ishida), *Bemisia tabaci* (Gennadius) were carried out at fortnightly interval from 60 days after sowing (DAS) onwards from 3 leaves / plant in randomly selected 5 plants.

Results and discussion

A. gossypii population was low (4.04) in plants inoculated with *B. bassiana* 4 isolate. *A. bigutulla bigutulla* (2.27) and *B. tabaci* (0.93) population was low in plants treated with isolate of *B. bassiana* 7. Among the method of treatment, foliar spray recorded with lowest population followed by soil drench and seed coating method (Table 1). Endophytes have been found to alter the volatile profile by altering the physiology of the plant. This altered physiology also affects herbivore food utilization. In addition, endophytes also induce production of feeding–deterrent alkaloids. These alkaloids make the host plants toxic or distasteful to herbivores. Therefore, plants infested by endophytes are usually more resistant to insects (Lopez and Sword, 2015; Shrivastava *et al*., 2015).

The future use of biological control involving endophytes along with IPM reduces cost of production and environmental impact, while allowing the biological agent to build up for insect pest control.

Table 1. Efficacy of *B. bassiana* endophytes against sucking pests population under field condition*

Treatments	*A. gossypii*				*A. bigutulla bigutulla*				*B. tabaci*			
	Seed coating	Soil drench	Foliar spray	Mean	Seed coating	Soil drench	Foliar spray	Mean	Seed coating	Soil drench	Foliar spray	Mean
B. bassiana 1	7.48	6.52	1.40	5.13	3.50	2.70	2.07	2.76	1.15	1.08	1.00	1.08
B. bassiana 2	7.25	3.98	4.85	5.36	2.27	2.87	2.34	2.49	1.58	1.05	0.94	1.19
B. bassiana 4	5.00	4.33	3.00	4.11	2.65	2.60	1.55	2.27	1.28	0.92	0.58	0.93
B. bassiana 7	5.97	3.87	2.28	4.04	2.22	2.35	2.57	2.38	0.93	1.07	1.00	1.00
B. bassiana 8	6.48	7.27	3.20	5.65	2.85	2.35	2.35	2.52	1.25	1.32	0.83	1.13
Control	7.67	6.08	4.52	6.09	3.47	3.63	2.98	3.36	2.00	1.68	1.57	1.75
	SED	CD 5%			SED	CD 5%			SED	CD 5%		
T	0.27	0.55	NS		0.37	0.15	S		T	0.05	0.11	S
M	0.19	0.39	S		0.05	0.10	S		M	0.04	0.08	S
TM	0.47	0.95	NS		0.13	0.26	NS		TM	0.09	0.19	NS

* Mean value of eight replications

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ES 05 OPD 02

In silico molecular docking of bioactive metabolites of *Lecanicillum saksenae* (Kushwaha) Kurihara and Sukarno as potential inhibitors of acetyl cholinesterase (*Dm* AChE)

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Key words: *Lecanicillium saksenae, HRLCMS analysis, in silico docking, secondary metabolites*

Introduction

Entomopathogenic fungi are rich source of bioactive metabolites that exhibit remarkable spectrum of biological activities. Structure based virtual screening is the most widely used strategy to identify the most promising molecules with novel mode of action. *Lecanicillium saksenae* is a new indigenous isolate from Kerala, India, pathogenic to homopteran and heteropteran bugs. (Sankar and Rani, 2018). Quick kill effect, characterised by convulsions and paralysis observed in rice bug *Leptocorisa acuta* (Thunberg) exposed to culture suspension of *L. saksenae* prompted the investigations on the metabolite profile of *L. saksenae*. Hence the present study was undertaken to explore and identify the secondary metabolites of *L. saksenae* and to study the interaction of these molecules with the target sites of acetyl cholinesterase using *in silico* molecular docking techniques.

Materials and methods

Lecanicillum saksenae was cultured in Czapek Dox broth in order to extract the secondary metabolites. The acidified culture filtrate was subjected to solvent extraction followed by vacuum evaporation under pressure. The dried extract was subjected to HRLCMS analysis. *In silico* analysis was carried out with selected metabolites from HR-LCMS data as ligands and acetyl cholinesterase (*Dm* AChE, PDB Code 1QON) as the receptor protein. Each ligand was docked with the target protein and the interacting ligands were scored using CDOCKER programme. Wet lab studies were conducted to confirm the insecticidal effect of the crude toxin on different life stages of brinjal mealybug *Coccidohystrix insolita*.

Results and discussion

In silico molecular docking of insecticidal metabolites of *L. saksenae* and protein, acetyl cholinesterase revealed that out of the 40 metabolites of HR-LCMS spectrum, eighteen compounds were found interacting with acetyl cholinesterase enzyme at specific sites of the catalytic triads. Among the metabolites, 3-hydroxy-2-methyl pyridine exhibited the highest binding energy (-133.24 kcal mol^{-1}) and highest interaction with AChE followed by 2- hydroxy benzamide (-131.48 kcal/ mol), 6 hydroxy picolinic acid (-121.21 kcal/ mol) and picolinic acid N-oxide (-113.28 k cal/ mol) (Table1). The acetyl cholinestarse activity of the fungal extract was revealed through the toxicity of crude toxin to different life stages of *C. insolita*. A mortality of 95.98 and 100 per cent was observed at 1000 ppm in 3rd instar nymphs at 48 and 72 h after treatment respectively. The corresponding mortality in adults was 85.51 and 89.04 per cent.

Keppanan *et al*. (2018) reported the interaction of mycotoxin, bassianolide with insect defense protein in diamond back moth through docking studies. Secondary metabolites of *Pencillium* inhibited acetyl cholinesterase activity in 4th instar larvae of *C. quinquefasciatus* (Say) (Ragavendran *et al*., 2019). An insight into the insecticidal metabolites produced by entomopathogenic fungi and their active site of interaction within the host cell would help to identify insecticidal molecule for safer pest management.

Table 1. Docking scores of metabolites of *Lecanicillium saksenae* and the protein target acetyl cholinesterase for their inhibitory property

Protein PDB ID	Ligand	(-) C docker energy (Kcal)	(-) C docker interaction energy (Kcal)	H bond amino acid residue	Hydrogen bond distance (A°)	Binding energy (Kcal)
AChE,(PDB Code 1QON)	3-Hydroxy-2-methylpyridine	25.8203	28.9507	SER238	1.85532	-133.24
				HIS480	2.02604	
				HIS480	2.26632	
				TYR370	1.99321	
	2-Aminobenzoic acid	21.0629	25.8711	SER238	2.41947	-111.212
				SER238	2.11311	
				HIS480	2.33956	
	6- Hydroxy picolinic acid	24.0854	25.4103	SER238	2.16393	-121.211
	2- Hydroxy benzaldehyde)	29.2461	30.0365	SER238	1.8434	-131.485
				HIS480	2.09465	
	Picolinic acid N-oxide	25.2795	27.6947	SER238	2.07954	-113.28
				SER238	1.95494	
				HIS480	2.47054	
				GLU237	2.01465	
	4- Amino benzoic acid	23.9896	25.6474	SER238	2.09453	-107.182
				HIS480	2.49788	
				GLY151	2.4589	

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ES 05 OPD 03

Risk assessment of insecticides on *Trichogramma japonicum* Ashmead, an egg parasitoid of rice yellow stem borer, *Scirpophaga incertulas* (Walker)

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Keywords: *Insecticides, toxicity, Scirpophaga incertulas, Trichogramma japonicum, Risk*

Introduction

Rice dominates the cropping pattern throughout the country and more than 100 species of insects are known to attack this crop; about 20 are of economic importance. Rice yellow stem borer, *Scirpophaga incertulas* (Walker) is a major constraint responsible for low production of rice yields in almost all the rice ecosystems, causing 3.95 per cent yield losses in India. Most major groups of insecticides have been used against this insect pest and the impact of synthetic pesticides on beneficial arthropods and the human health risks posed by exposure to these chemicals are issues of growing concern. The egg parasitoid, *Trichogramma japonicum* Ashmead is being used for the management of yellow stem borer, *S. incertulas* as an effective IPM component. Biological control and selective insecticides proved to be compatible tactics in Integrated Pest Management (IPM) programs and hence the selectivity of the insecticides to *T. japonicum* is evaluated in the present investigation.

Materials and Methods

The filter paper disc bioassay method and dry film residue bioassay method was adopted for assessing the toxicity of insecticides to *S. incertulas* and *T. japonicum*, respectively. Preliminary range finding tests were conducted to fix the test concentrations and different concentrations of insecticide solutions were prepared using acetone and water in the ratio of 80:20 and used for bioassays. Each treatment was replicated thrice. Observations were recorded on the mortality of test insects at 24 hour after treatment (HAT). Median lethal concentrations (LC_{50}) of insecticide used were determined by Finney's probit analysis. Different risk assessment methods *viz.*, selectivity ratio and hazard quotient were calculated based on the LC_{50} values at 24 HAT.

Results and Discussion

The results revealed that among the five tested insecticides belonging to four different groups *viz*., diamides (chlorantraniliprole and flubendiamide), oxadiazine (indoxacarb), phenyl pyrazole (fipronil) and organophosphate (chlorpyriphos), the order of toxicity of different insecticides to rice stem borer based on LC_{50} was chlorantraniliprole > indoxacarb > flubendiamide > fipronil > chlorpyriphos. The organophosphorous compound, chlorpyriphos was found to be the most toxic to egg parasitoid, *T. japonicum.* The order of toxicity to the egg parasitoid, *T. japonicum* based on LC_{50} values (ppm): chlorpyriphos (0.039) > fipronil (0.358) > indoxacarb (0.840) > flubendiamide (2.148) > chlorantraniliprole (3.131). All the five tested insecticides were found to be non selective and based on hazard quotient, the diamide insecticides *viz.*, chlorantraniliprole and flubendiamide were found to be harmless whereas, indoxacarb and fipronil were slightly to moderately harmful and chlorpyriphos was the dangerous insecticide to *T. japonicum* (Table 1).

The efficacy of chlorantraniliprole against rice yellow stem borer is in accordance with the results of Omprakash *et al.* (2017) who stated that treatment with chlorantraniliprole 0.4 G and 18.5 SC against *S. incertulas* recorded low level of damage. The toxicity of chlorpyriphos and fipronil were already reported by Zhao *et al.* (2012) who stated that organophosphates and carbamates exhibited the highest intrinsic toxicity to *T. japonicum* followed by antibiotics and phenyl pyrazoles. The present study revealed that the anthranilic diamide insecticide, chlorantraniliprole was found to be the selective insecticide for the management of *S. incertulas* which was similar to the results of Uma *et al.* (2014) who reported that among eighteen different insecticides tested, chlorantraniliprole caused the lowest mortality of 21.25 per cent to the adults of *T. japonicum.* The present finding on hazard quotient is in line with the findings of Zhao *et al.* (2012) who reported chlorpyriphos as the dangerous chemical to *T. japonicum*.

Table 1. Risk assessment of different insecticides on *Trichogramma japonicum*

Insecticides	Recommended dose (g. a.i./ ha)	LC_{50} values		Selectivity		Hazard quotient	
		Scirpophaga incertulas	*Trichogramma japonicum*	Selectivity ratio	Category	Hazard quotient	Category
Chlorantranili prole	30	4.118	3.131	0.760	Non-Selective	9.582	Safe
Flubendiamide	24	22.398	2.148	0.096	Non-Selective	11.173	Safe
Indoxacarb	50	22.222	0.840	0.038	Non-Selective	59.524	Slightly to moderate harmful
Fipronil	50	72.845	0.358	0.005	Non-Selective	139.665	Slightly to moderate harmful
Chlorpyriphos	250	213.241	0.039	0.000	Non-Selective	6410.256	Dangerous

Selectivity ratio - 1 & < 1 (Non - Selective); >1 (Selective)

Hazard quotient - <50 (Safe); 50 - 2500 (Slightly to moderately harmful); > 2500 (Dangerous)

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ES 05 OPS 01

Assessment of microbials and botanicals against tobacco leaf eating caterpillar, Spodoptera litura on soybean, Glycine max (L.) Merril.

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Keyword: *Beauveria bassiana, Nomuraea rileyi, Dashparni extract, NSKE @ 5%, soybean.*

Introduction

Soybean [Glycine max (L.) Merril], a legume is one of the important oilseed crops of Maharashtra and other state. Soybean is cultivated on 320.15 million ha in the world. India ranks 5th in soybean cultivated area and production. In India, it is grown over an acreage of 116.285 lakh ha with a yield 667 kg per ha and 73.797 lakh MT annual production. Madhya Pradesh is major growing state contributing about 61.65% of total soybean followed by Maharashtra 25%, Rajasthan 7.8% and others 4.72% (Anonymous, 2015). One of the major pests associated with soybean crops are tobacco leaf eating caterpillar, Spodoptera litura (Sontakke and Mishra, 1991). To overcome the losses caused by tobacco leaf eating caterpillar, Spodoptera litura, various control measures have been recommended. Integrated Pest Management is perceived as the only alternative to combat these problems. (Rao et.al., 1999). Therefore, it is necessary to consider those strategies which are eco-friendly and environmentally safe as well as control the pests efficiently.

MATERIAL AND METHODS

The experiment was carried out at Research farm, Department of Agricultural Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, in Randomized Block Design with 9 treatments and 3 replications. Total of four sprays as per treatments were undertaken at 15 days interval starting from 15 days after emergence of the crop. Observations on tobacco leaf eating caterpillar *Spodoptera litura*, was recorded 24 hours before and after 3,7,10, and 14 days after each spray. The Observations on the larval population of defoliators was recorded from each one-meter row length (m) by randomly selecting five spots of one meter row length in each plot and average number of larvae /m was worked out.

RESULT AND DUSCISSION

Results reveled that *Beauveria bassiana* @ 7.5 g/l (0.79 larvae/m) and *Nomuraea rileyi,* @ 5 g/l (1.43 larvae/m) and neem seed kernel extract 5 % were most effective in reducing the population of tobacco leaf eating caterpillar with highest yield of soybean. These results are in line with (Ahirwar *et al.* 2014, Patil and Hegde 2009, Santhosh 2008). The neem seed kernel extract 5 % was economically most effective treatment against soybean defoliators followed by *N. rileyi* @7.5 g/l.

Table 1. Effect of various treatments on population of soybean *S. litura.*

Tr. No.	Treatments	Concentrations	Dose (g or ml/l)	Average Population of *Spodoptera*/m				Mean
				3 DAS	7 DAS	10 DAS	14 DAS	
T_1	Beauveria bassiana	(1x10^8 CFUml^{-1})	5	1.51 (1.22)	1.62 (1.27)	1.62 (1.27)	1.51 (1.29)	1.57 (1.26)
T_2	Metarhizium anisopliae	(1x10^8 CFUml^{-1})	5	1.82 (1.34)	1.93 (1.39)	1.89 (1.37)	1.73 (1.37)	1.84 (1.37)
T_3	Nomuraea rileyi	(1x10^8 CFUml^{-1})	5	1.27 (1.12)	1.44 (1.20)	1.58 (1.24)	1.44 (1.26)	1.43 (1.21)

T_4	Beauveria bassiana	(1x10[8] CFUml[-1])	7.5	0.71 (0.84)	0.87 (0.93)	0.84 (0.89)	0.76 (0.95)	0.79 (0.90)
T_5	Metarhizium anisopliae	(1x10[8] CFUml[-1])	7.5	1.67 (1.28)	1.56 (1.24)	1.73 (1.31)	1.27 (1.19)	1.56 (1.25)
T_6	Nomuraea rileyi	(1x10[8] CFUml[-1])	7.5	1.18 (1.08)	1.20 (1.08)	0.98 (0.96)	1.13 (1.13)	1.10 (1.04)
T_7	Dashparni extract	15 % AE	12.5	2.29 (1.51)	2.04 (1.43)	2.07 (1.43)	1.84 (1.41)	2.06 (1.45)
T_8	Neem seed extract	5 % AE	5	1.16) (1.06	1.18 (1.08)	1.07 (1.00)	1.09 (1.11)	1.12 (1.06)
T_9	Untreated control	-		2.62 (1.61)	2.78 (1.66)	2.80 (1.67)	2.56 (1.65)	2.69 (1.65)
F test				**Sig**	**Sig**	**Sig**	**Sig**	**Sig**
SE (m±)				0.07	0.07	0.08	0.07	0.07
CD at 5%				0.20	0.20	0.23	0.20	0.21

DAS-Days after spray, m - meter.

Figures in parenthesis are square root transformed values.

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ES 05 OPS 02

Field evaluation of T405 talc based *Bt* formulation against the maize fall armyworm, *Spodoptera frugiperda* (J.E. Smith)

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Keywords: *T405 Bt talc formulation, field evaluation, effectiveness, fall armyworm, maize*

Introduction

The fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) is a migratory insect pest, native to the Americas. The distribution of FAW was seen across the globe because of long distance movement and lack of adult diapauses. FAW threatens the food security of millions of people in a region that will likely have a provoked drought due to climate change. In the absence of control methods, FAW has the potential to cause estimated losses of 8.3 to 20.6 million tonnes of maize per annum (Abrahams *et al*., 2017) Farmers solely rely on synthetic insecticides for the management which aggravates residue, resistance and resurgence problems. Microbial bio-pesticides like *Bacillus thuringiensis* (*Bt*) application could be a best option at the early stages for FAW management. Hence, the present study was aimed to utilize an effective *Bt* formulation, T405 against the FAW.

Material and Methods

The present investigation was carried out in farmer`s field at Vattamalaipalayam, Idigarai, Coimbatore, India during 2020-21. Maize hybrid CoHM8 was sown and maintained with standard agronomic practices. The treatments are as follows, T1- T405 talc based *Bt* formulation @ 1.3×10^{7} spores/ml without phago-stimulant; T2- T405 talc based *Bt* formulation @ 1.3×10^{7} spores/ml with phago-stimulant (crude sugar @ 0.1%); T3- T405 spore crystal mixture @ 1.3×10^{7} spores/ml without phago-stimulant; T4- T405 talc based *Bt* formulation @ 1.3×10^{7} spores/ml with phago-stimulant (crude sugar @ 0.1%); T5- Commercial *Bt* formulation (Mahastra) @ 2g/litre without phago-stimulant; T6- Commercial *Bt* formulation (Mahastra) @ 2g/litre with phago-stimulant (crude sugar @ 0.1%); T7- chlorantraniliprole 18.5SC @ 0.4ml/lit (Insecticide check) and T8- untreated control. The experiment was laid out in Randomized Block Design with three replications. The treatments were imposed 15 and 25 days after emergence and observations were recorded at 3rd, 5th and 7th day after imposing treatments. The infestation levels were recorded on ten plants selected at random per replication and per cent infestation was calculated. The data gathered were transformed to arc sin values for statistical scrutiny, wherever necessary.

Results and Discussion

In the first spray, T405 talc formulation @ 1.3×10^{7} spores/ml with 0.1% crude sugar (phago-stimulant) (T2) and T405 talc formulation @ 1.3×10^{7} spores/ml without crude sugar (T1) reduced 64.29% and 61.56% infestations, respectively at 7th DAS. The Bt formulations were not effective at 25 DAS. This may be due to the occurrence of later larval stages of FAW. Devi and Vineela (2014) tested DOR Bt-1 formulation against *H. armegera* and found 17.60 - 26.60% larval incidence on sunflower at 3 DAS. This is in concordance with the present findings wherein, 22.15% - 27.89% FAW infestation levels were noticed on 3 DAS during first spray.

Table 1. Field evaluation of *Bt* T405 talc based formulation against the maize fall armyworm

S. No.	Treatment	I spray				II spray		
		PTC*	3DAS**	5DAS**	7DAS**	3DAS**	5DAS**	7DAS**
1.	T405 talc formulation @ 1.3×10^{7} spores/ml without phago-stimulant	8.57 (2.93)	23.84 (29.20)^{bc}	36.42 (37.11)^{b}	38.44 (38.31)^{bc}	18.94 (25.75)^{b}	85.09 (67.97)^{b}	90.25 (72.70)^{b}
2.	T405 talc formulation @ 1.3×10^{7} spores/ml with 0.1% crude sugar (phago-stimulant)	10.0 (3.17)	22.15 (28.06)^{b}	36.05 (36.90)^{b}	35.71 (36.67)^{b}	22.33 (28.19)^{b}	87.87 (73.12)^{bc}	91.74 (76.41)^{b}
3.	T405 SC mixture @ 1.3×10^{7} spores/ml without phago-stimulant	10.23 (3.19)	25.01 (29.93)^{c}	39.33 (38.83)^{bc}	40.22 (39.35)^{c}	21.34 (26.70)^{b}	98.40 (83.97)^{cd}	99.20 (85.72)^{de}
4.	T405 SC mixture @ 1.3×10^{7} spores/ml with 0.1% crude sugar (phago-stimulant)	10.95 (3.31)	27.89 (31.88)^{de}	45.69 (42.52)^{d}	42.12 (40.46)^{c}	36.01 (33.15)^{c}	97.31 (84.31)^{cd}	98.92 (86.36)^{cde}
5.	Commercial *Bt* formulation (Mahastra) @ 2g/litre without phago-stimulant	11.93 (3.43)	28.90 (32.49)^{e}	47.39 (43.50)^{d}	41.87 (40.32)^{c}	35.60 (36.6)^{cd}	95.93 (78.94)^{bcd}	96.02 (79.00)^{bcd}
6.	Commercial *Bt* formulation (Mahastra) @ 2g/litre with 0.1% crude sugar (phago-stimulant)	11.54 (3.39)	25.37 (30.23)^{cd}	43.35 (41.23)^{cd}	41.43 (40.07)^{c}	39.07 (38.69)^{d}	88.97 (71.09)^{b}	92.65 (74.75)^{bc}
7.	Chlorantraniliprole 18.5SC @ 0.4ml/lit (Insecticide check)	11.74 (3.42)	2.00 (8.09)^{a}	4.88 (12.72)^{a}	10.72 (19.06)^{a}	1.59 (7.24)^{a}	4.71 (12.12)^{a}	9.86 (18.25)^{a}
8.	Untreated control	10.65 (3.26)	42.51 (40.9)^{f}	62.76 (52.40)^{e}	59.82 (50.66)^{d}	67.85 (51.31)^{e}	99.27 (86.97)^{d}	100.00 (89.71)^{e}
	CD (P=0.5)	NS	1.76	3.24	2.43	4.74	12.28	9.59
	CV (%)	-	3.49	4.84	3.64	8.74	10.04	7.51
	SEm±	-	1.01	3.41	1.92	7.33	49.12	29.97

PTC- Pre-treatment Count; DAS- Days After Spraying; *Figures in the parentheses are square root transformed values. ** Figures in the parentheses are arc sin transformed values.

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ES 05 OPS 03

Parasitic potential of *Bracon brevicornis* Wesmael (Hymenoptera: Braconidae) on *Spodoptera frugiperda* (J. E. Smith, 1797)

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Keywords: *S. frugiperda, B. brevicornis, parasitic potential, parasitoid:host ratio*

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops grown throughout the plains. Fall armyworm *Spodoptera frugiperda* (J. E. Smith, 1797) (Lepidoptera: Noctuidae) is one of the most devastating invasive pests of maize causing severe damage and heavy economic loss. Larval parasitoid, *Bracon brevicornis* (Hymenoptera: Braconidae) is found to parasitize the larvae of *S. frugiperda* under laboratory conditions. In this context, the parasitic potential and biology of *B. brevicornis* on different instars of *S. frugiperda* larva was assessed under laboratory conditions.

Materials and Methods

The experiments were carried out in a plastic container of 18 x 12 cm size, by sandwich method (Jhansi, 1984) with four replications as free choice test under laboratory conditions. The III, IV, V and VI instar larvae of *S. frugiperda* were subjected to parasitization by gravid females of *B. brevicornis* at different parasitoid: host ratios (1:1, 1:2, 1:3, 1:4, 1:5). The larvae were separated from each other by cardboard strips to prevent cannibalism among the host larva. After 24 hours of exposure observations were made on per cent parasitization.

The best parasitoid: host ratio was identified and utilized for further studies on biology of *B. brevicornis* on *S. frugiperda.* For the study on the biology, different instars of *S. frugiperda* larva (II instar, III instar, IV instar, V instar and VI instar) were subjected to parasitization by gravid females of *B. brevicornis* under no choice test at the best parasitoid: host ratio. The biological parameters of *B. brevicornis* viz., number of eggs / larva, number of grubs / larva, number of cocoons / larva and number of adults emerged / larva were recorded.

Results and Discussion

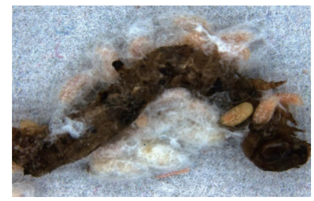
Laboratory experiment on the parasitic potential study indicated the highest parasitization at the parasitoid: host ratio of 1:1 with 98.60 % parasitization on the VI instar followed by 97.05 % on the V instar, 88.80 % on the IV instar and 63.45 % on the III instar (Table 1) which revealed that the parasitic potential of *B. brevicornis* was directly proportional to the increased parasitoid densities.

The 1: 1 ratio recorded the highest number of eggs (32.00), grub (30.75), cocoon (29.75) and adults (28.00) of *B. brevicornis* on sixth instar larva of *S. frugiperda* followed by fifth instar larva of *S. frugiperda*. The size of the host larva was directly proportional to the parasitic potential of *B. brevicornis* (Table 2).

Our findings are in line with the findings of Temerak (1983) who recorded that the parasitic potential of the parasitoid was influenced by the nutritional value of the host insect. The current findings are in accordance with the Thanavendan and Jeyarani. (2009) also who reported that later instars of lepidopteran larvae were preferred most by the parasitoids. Early instars were killed by mutilation of the parasitoid but biological stages of *B. brevicornis* were absent in the early instars (II instar).

Eggs of *Bracon brevicornis*

Grubs of *Bracon brevicornis*



Cocoons of *Bracon brevicornis*

Table 1. Parasitic potential of *Bracon brevicornis* on larvae of *Spodoptera frugiperda*

Parasitoid: Host ratio	% Parasitization (or) % Mortality*			
	III instar	IV instar	V instar	VI instar
1: 1	63.45 (52.80) a	88.80 (70.47) a	97.05 (80.43) a	98.60 (81.12) a
1: 2	58.65 (47.61) ab	79.70 (63.60) b	95.0 (72.49) ab	95.65 (78.03) b
1: 3	53.40 (46.95) c	64.50 (53.47) c	87.25 (69.26) b	91.10 (72.97) c
1: 4	45.60 (44.25) cd	60. 35 (45.03) d	77.30 (61.76) c	84.90 (67.38) cd
1: 5	33.05 (35.06) e	50.05 (45.29) e	58.45 (49.89) d	75.35 (65.51) d
SE (d)	1.93	2.20	1.33	2.20
CD (0.05)	4.12	4.69	2.83	4.69

*Figures in parentheses are arcsine values transformed

Table 2. Biology of *B. brevicornis* on larvae of *Spodoptera frugiperda*

Instar	% Parasitization or % Mortality*	Life stages of *Bracon brevicornis* (No. / larva) @ 1: 1			
		Egg	Grub	Cocoon	Adult
II instar	50.05 (45.29) e	0.00 (0.71) e	0.00 (0.71) e	0.00 (0.71) d	0.00 (0.71) d
III instar	60.45 (50.80) d	4.75 (2.29) d	3.75 (2.06) d	3.25 (1.94) c	3.25 (1.94) c
IV instar	85.80 (67.40) c	12.25 (3.57) c	10.75 (3.35) c	9.50 (3.16) b	8.75 (3.04) b
V instar	95.05 (78.43) b	27.75 (5.32) b	26.50 (5.20) b	25.50 (5.10) a	24.50 (5.00) a
VI instar	97.60 (80.25) a	32.00 (5.70) a	30.75 (5.59) a	29.75 (5.50) a	28.00 (5.34) a
SE(d)	3.61	0.16	0.18	0.21	0.16
CD (0.05)	7.59	0.33	0.37	0.45	0.34

*Figures in parentheses are arcsine values transformed

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ES 05 BOPD 01

Biological Control of Pink Bollworm *Pectinophora gossypiella* (Saunders) using *Trichogrammatoidea bactrae* Nagaraja in Cotton

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Key words: *Cotton, egg parasitoid, pink bollworm, Trichogrammatoidea bactrae*

Introduction

Pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) is a pest of great economic importance in many cotton-growing countries that causes loss both in terms of quantity as well as quality. It is a worldwide key pest of cotton and its larvae burrow into cotton bolls to feed on the seeds (Sarwar, 2017). The egg parasitoid, *Trichogrammatoidea bactrae*, was imported into California from Queensland, Australia during 1985 as a potential biological control agent of PBW (Naranjo *et al.,* 1992). *T. bactrae* is widely distributed in the orient (India, Pakistan, China, Malaysia, Taiwan and Indonesia). It is adapted to terrestrial humid habitats and is known to attack various pests of cotton, sugarcane, fruits and vegetables (Nagaraja, 1978). Field experiments were conducted during 2020-21 at Department of Cotton, Tamil Nadu Agricultural University, Coimbatore to evaluate the field efficacy of egg parasitoid, *Trichogrammatoidea bactrae* Nagaraja through inundative releases against pink bollworm, *Pectinophora gossypiella* (Saunders) in cotton for two successive seasons.

Materials and Methods

Field experiments with Boll guard II cotton was laid out at Department of cotton, TNAU, Coimbatore in randomized block design. The *T. bactrae* was released @ 40000 eggs per ha at 15 days interval three times starting from 45th day after sowing. The egg cards were cut into small pieces and stappled to cotton leaves. The pink bollworm incidence started at flowering stage (45 days) as indicated by the rosette flowers. The presence of pink bollworm adults were monitored using Delta traps (Pectino lure) @ 12 per ha. The presence and establishment of the parasitoids in the cotton fields was confirmed using pink bollworm egg cards. These cards were left in the field for 24 h and then brought back to the laboratory. The assessment was repeated every week. The mean of two seasons (two years) were subjected for statistical analysis after appropriate transformations.

Results and Discussion

The preliminary studies showed that there were no parasitised eggs in pink bollworm egg cards, before the release of *T. bactrae*. The results suggested that, *T. bactrae* is not present naturally in the field. Among the 1,000 pink bollworm eggs released, 685 to 952 eggs were recovered in the field. Others were probably destroyed by predators (Henneberry and Clayton, 1982). Percent parasitism gradually increased from flowering stage to harvesting stage (Table 1). Asha *et al.,* (2019) conducted the laboratory studies to evaluate the parasitising efficacy of four *Trichogramma* species against the eggs of pink bollworm *P. gossypiella* (Saunders) and the maximum (>87%) parasitism was observed in *T. bactrae*.

Table 1. Mean percent parasitism by *Trichogrammatoidea bactrae* after releases into cotton fields

Month	Pink bollworm eggs tested in the field (in Numbers)*	Eggs recovered from field (in Numbers)*	Number of (black) parasitised eggs (in Numbers)*	Parasitism (%)
August	100	89.65	0.00	0.00^{f}
September	100	78.40	0.00	0.00^{f}
October	100	68.70	2.30	3.35^{e}
November	100	95.20	15.20	15.97^{d}
December	100	87.45	19.80	22.65^{c}
January	100	68.55	20.40	29.78^{b}
February	100	71.20	23.70	33.29^{a}

* Mean of one season data

Malik (2001) observed that, when *T. bactrae* was released in cotton field, the total parasitism percentage in pink bollworm eggs were from 14.72 to 18.53 %. The present results are in accordance with Malik (2001). The egg parasitoid, *T. bactrae* is proved as an effective biological agent and can be used in IPM of cotton for the management of *P. gossypiella* (El-Hafez and Nada, 2000).

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ES 05 BOPD 02

Effects of flubendiamide and lactic acid bacterial formulation on *Tetrastichus schoenobii* and *Telenomus* sp., in rice

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Keywords: *Flubendiamide, lactic acid bacteria, Tetrastichus schoenobii, Telenomus sp.*

Introduction

Rice (*Oryza sativa* L.) is the staple food for nearly half of the world's population, closely associated with food security. The yellow stem borer (YSB), *Scirpophaga incertulas* Walker is the most widespread and destructive pest limiting the productivity of rice causing 'dead hearts' and 'white ears. Improper and extensive use of pesticides destroys *Telenomus dingus, Tetrastichus schoenobii* and *Trichogramma japonicum*, the three important egg parasitoids, which play a pivotal role in YSB population regulation. These parasitoids should be conserved to check the buildup of YSB population. The probiotic lactic acid bacteria (LAB) have been exploited in crop production as biofertilizers, phytostimulators, rhizoremediators and biopesticides, which are capable of degrading pesticides also. This study was undertaken to lessen the impact of a commercially available formulation of flubendiamide, one of the recommended insecticides against *S. incertulas* on egg parasitoids of *S. incertulas* by using a home-made preparation of LAB formulation without affecting the efficacy of flubendiamide.

Materials and Methods

Field experiments were conducted at the Paddy Breeding Station of TNAU, Coimbatore, one each during

Kharif and *Rabi* seasons (2018 - 2019) with six treatments replicated four times in a RBD design with rice var. Co 51. The lactic acid bacterial formulation was prepared by mixing 100 g milk powder and 1.0 kg cane jaggery, 100 ml one-day fermented grape juice and a beaten egg in a discriminate fermentation process. This semisolid product containing LAB ferments was first diluted in 4 parts of water, left overnight for rapid LAB multiplication, and sprayed at 2.5 per cent the next day. Two rounds of foliar spray were made at 2-week interval, starting at 35 days after transplanting. Stem borer egg masses along with leaf bits (5-7 cm) were collected from each plot at weekly interval and were maintained individually in cloth-covered test tubes secured with rubber band (12 mm dia., 5 cm length) under laboratory conditions (34 ^{0}C, 80 % RH) until the parasitoids and/or the host larvae emerged out from the egg masses. The emerged parasitoids and the stem borer larvae were counted under a low power stereo zoom microscope and per cent parasitization was calculated.

Results and Discussion

Parasitization of the YSB eggs by *T. schoenobii* was significantly minimum in plots treated with flubendiamide 20 WG @ 50 g a.i. ha^{-1} with or without LAB (17.25 – 19.58 %), followed by flubendiamide 20 WG @ 25 g a.i. ha^{-1} in mixture with or without LAB (23.70 – 32.82 %). Parasitization by *T. schoenobii* was significantly highest in plots where LAB was sprayed alone (52.08 %), followed by control (39.05%). The pooled two-season data also indicated the same trend in parasitization by *Telenomous* sp., significantly higher in LAB spray (24.85 %) and control (18.71 %), and significantly lower in flubendiamide sprays with or without LAB (6.93 – 17.21 %).

Generally, YSB egg masses are parasitized by more than one species of parasitiods, *viz*., *Trichogramma* spp. + *Telenomus spp* (3.46%), *Telenomus* + *Tetrastichus* (21.06%) and *Trichogramma* + *Tetrastichus* (2.35%), the extent of parasitism ranging from 4.0 % to 97.2 % in different parts of India (Senapati *et al.*, 1999; Chakraborty, 2012). Arulkumar *et. al*., 2019 observed that LAB has reduced flubendiamide toxicity only to beneficial insects, but not to *S. incertulas*. It may be concluded that *S. incertulas* can be managed more effectively by spraying flubendiamide 20 WG @ 25 or 50 g a.i. ha^{-1} in combination with formulated LAB ferments at 2.5 per cent which is comparatively safer to egg parasitoids, *T. schoenobii* and *Telenomus* sp.

Table1. Effect of flubendiamide 20 WG and lactic acid bacteria (LAB) on *T. schoenobii* and *Telenomus* sp.

Treatments	Mean per cent parasitization (%)					
	T. schoenobii			*Telenomus* sp		
	1st Spray Mean	2nd Spray Mean	Pooled Mean	1st Spray Mean	2nd Spray Mean	Pooled Mean
Flubendiamide 20 WG @ 25 g a.i. /ha	21.81 (27.65)	25.60 (30.18)	23.70 (28.91)	10.76 (18.86)	11.73 (19.90)	11.24 (19.38)
Flubendiamide 20 WG @ 50 g a.i. /ha	17.43 (24.44)	17.07 (24.28)	17.25 (24.36)	7.07 (14.97)	6.80 (14.96)	6.93 (14.97)
Flubendiamide 20 WG @ 25 g a.i. /ha +LAB @ 2.5% /ha	30.49 (33.42)	35.15 (36.30)	32.82 (34.86)	15.82 (23.23)	18.60 (25.41)	17.21 (24.32)
Flubendiamide 20 WG @ 50 g a.i. /ha +LAB @ 2.5% /ha	21.09 (27.12)	18.08 (24.95)	19.58 (26.04)	8.76 (17.00)	9.69 (17.98)	9.22 (17.49)
LAB alone @ 2.5% /ha	50.60 (45.35)	53.56 (47.06)	52.08 (46.21)	23.56 (28.93)	26.15 (30.68)	24.85 (29.82)
Untreated check	36.57 (37.13)	41.53 (40.10)	39.05 (38.61)	18.20 (25.15)	19.21 (25.88)	18.71 (25.51)
CD (0.05)	0.55	0.55	0.95	0.40	0.40	0.70
SE.d	0.28	0.28	0.48	0.20	0.20	0.35

(Values in parentheses are *arc sine* transformed values; mean of four replications)

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ES 05 BOPD 03

Proteolytic activation of Cry protoxins by larval gut juice proteases from *Plutella xylostella*

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Keywords : *Bacillus thuringiensis, protoxin, larval gut juice, Plutella xylostella*

Introduction

The crystal proteins produced by *Bacillus thuringiensis* (Bt) are toxic to variety of insects, such as lepidopterans, coleopterans, dipterans and hemipterans (Schnepf *et al.,* 1998). The bipyramidal parasporal inclusions of subsp. *kurstaki* HD-1 contain three Cry1A insecticidal proteins with similar molecular weights about 130 kDa which are toxic to Lepidopteran larvae (Hofte and Whiteley, 1989). After being ingested, the parasporal inclusions are dissolved in larval midgut juice and release protoxins which can be cleaved into 55- to 70-kDa toxic core fragments by midgut proteases. The activated toxins interact with the larval epithelium membrane and induce pore formation in the membrane, which ultimately lead to insect death (Gill *et al.,* 1992). Although Cry1Ac and Cry2Ab toxins have been widely used to control lepidopteran pests, their proteolytic cleavage sites targeted by larval midgut proteases are still not clearly defined. In the present work, we investigated the proteolysis of Cry1 and Cry2 protoxins *by Plutella xylostella* gut juice *in vitro* and detected the proteolysis by SDS-PAGE.

Materials and Methods

Insect cultures of *P. xylostella* were maintained at *Bt* laboratory at CPMB&B under controlled environment at 26 ± 1 ^{o}C with a photoperiod of 16:8 h (Light: Dark). Larval gut juice was extracted from fore and mid gut of larvae by using 20 mM Phosphate buffer with 0.1% Triton X-100 (pH 7.5) and preserved in -20 ^{o}C freezer. Two indigenous *Bt* isolates *viz*., T355 and T357 were selected based on their toxicity against target insect and universal *Bt* strain HD1 was used as positive check. Spore crystal mixture (protoxins) was isolated from 48 hours grown lysed cultures. Two micro litres of each protoxin was mixed with five micro litres of larval gut juice separately and the final volume was made up to 20 µl. Samples were incubated at room temperature at different intervals *viz*., 1, 3, 6, 9, 12 and 24 hrs. The samples were separated by 10 % SDS-PAGE and stained with Coomassie brilliant Blue R-250 for 1 hr. Separated proteins were visualized by destaining with acetic acid and methanol solutions.

Results and discussion

Protoxins of *Bt* isolates T355, T357 and *Bt* strain HD-1 were digested with gut juice of *P. xylostella* with different hours of incubation at room temperature. Analysis of SDS PAGE showed digestion of Cry1 protoxin with gut juice of *P. xylostella* resulted in doublet bands of ~75 and ~80 kDa and digestion of Cry2 protoxin resulted in band of ~50 kDa in size in HD1, T355 and T357 (Fig. 1.). Release of active protoxins were observed in treated samples up to 12 hrs of incubation, whereas degradation in released active protoxins were observed in 24 hrs of incubation. The cleavage sites of protoxins can be determined by N-terminal sequencing of activated Cry1 and Cry2 protoxins. Liu *et al*. (2020) reported that the N-terminal end of amino acid sequences indicated that proteolysis by the midgut juice proteases of *H. armigera* cleaved Cry1Ac protoxin at Arg28 and Cry2Ab protoxin at Arg139 which were predicted as putative trypsin cleavage sites. Identification of the exact sites of N-terminal activation of Cry1 and Cry2 protoxins will provide a basis for a better understanding of the mode of action and resistance mechanisms. This knowledge in turn will help in identification and use of novel toxins.

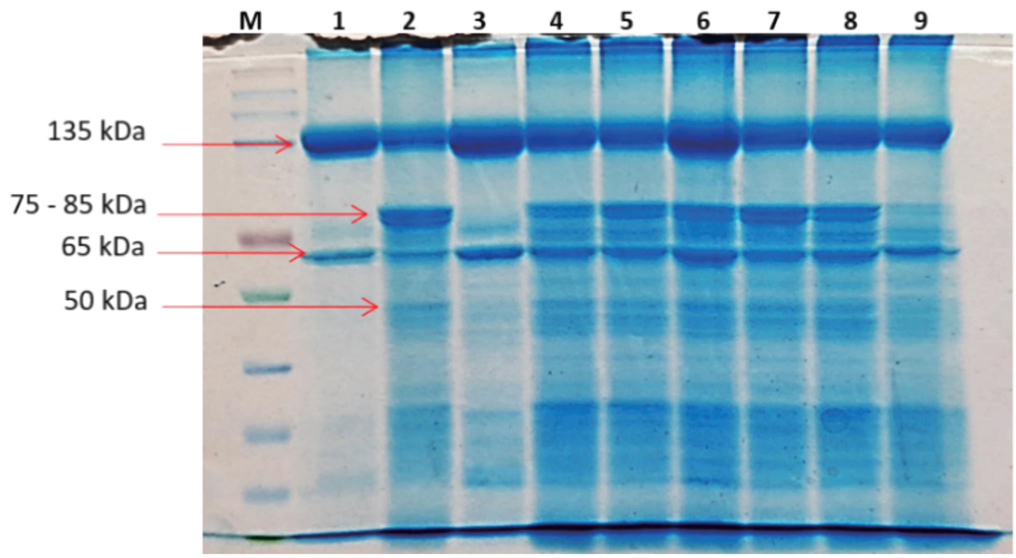

Fig. 1. SDS-PAGE analysis proteolytic digestion of protoxins by *P. xylostella* larval gut juice Lane M – Protein marker; Lane 1 - HD1; Lane 2 – HD1 + gut juice; Lane 3 – T355; Lane 4 – T355 + gut juice (1hr); Lane 5 - T355 + gut juice (3hr); Lane 6 - T355 + gut juice (6hr); Lane 7 - T355 + gut juice (9hr); Lane 8 - T355 + gut juice (12hr); Lane 9 - T355 + gut juice (24hr)

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ES 05 BOPD 04

Screening of indigenous *Bacillus thuringiensis* isolates against cabbage leaf webber *Crocidolomia binotalis* Zeller (Lepidoptera: Pyralidae)

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Keywords: *Bacillus thuringiensis, Crocidolomia binotalis, Cauliflower, Bio-assay*

Introduction

Cabbage leaf webber *Crocidolomia binotalis* is emerging as primary pest in the recent years causing yield loss upto 70 per cent. *Bacillus thuringiensis* (*Bt*) is an entomopathogenic, rod shaped, gram positive, aerobic bacterium which produce parasporal insecticidal protein crystals or δ-endotoxins during the sporulation stage. *Bt* is considered as the most successful bio-insecticide available as an alternative to chemical insecticide (Lacey *et al*., 2015). The present study was conducted to check the toxicity of indigenous *B. thuringiensis* isolates against cabbage leaf webber, *C. binotalis.*

Materials and methods

C. bionotalis larvae were collected from cauliflower field in TNAU orchard and maintained with fresh cauliflower leaves at Bio-assay lab, CPMB&B, TNAU, Coimbatore. The succeeding generations of *C. binotalis* were used for toxicity test against ten indigenous *Bt* isolates *viz*., T15, T20, T28, T29, T32, T134, T142, T355, T356, and T357 along with positive check HD1. Bioassays were conducted by leaf disc method in a plastic container. Cauliflower leaf discs of 2cm dia were smeared with 20 µl of spore crystal mixture (5.0µg/ml) on both sides of leaves, air dried and10 neonate larvae of C. *binotalis* were released. Mortality was observed at 24, 48, and 72 hours after treatment. Cumulative mortality data of 72 hrs was subjected to ANOVA analysis.

Results and Discussion

Bio-assay result showed mortality ranging from 16.67 - 100 per cent. Among the ten *Bt* isolates, the isolate T15, T20, T28, T32, T355, T355, T356 and T357 produced cent per cent mortality against *C. binotalis*, whereas T134 and T142 isolate showed 43.33 and 60.00 per cent mortality, respectively (Table 1). Nethravathi *et al.* (2009) found that the cabbage leaf webber was susceptible to *Bt* isolate 2422/C collected from Chikkamagalur to an extent of 80 per cent. Prabhakar *et al*. (2014) reported that isolates DBT-763, DBT-787, DBT-754 and DBT-2370 produced 86.67 per cent mortality of *C. binotalis*. Based on the results, the indigenous *Bt* isolates were found to be toxic to *C. binotalis* and detailed dose mortality test can be done to select a most effective isolate for further formulation studies.

Table 1. Efficacy of indigenous *Bt* isolates against cabbage leaf webber, *Crocidolomia binotalis*

Isolate name	Mean per cent mortality (hours after treatment)		
	24	48	72
T15	89.33 (70.93)[a]	93.33 (75.03)[a]	100.00 (89.47)[a]
T20	93.33 (75.03)[a]	96.66 (79.47)[a]	100.00 (89.47)[a]
T28	76.66 (61.11)[c]	83.33 (65.90)[c]	100.00 (89.47)[a]

T29	80.00 (63.43)[c]	86.66 (68.57)[b]	100.00 (89.47)[a]
T32	90.00 (71.56)[d]	96.66 (79.47)[a]	100.00 (89.47)[a]
T134	16.67 (24.09)[e]	26.66 (31.08)[e]	43.33 (41.16)[c]
T142	26.66 (31.08)[d]	46.66 (43.08)[d]	60.00 (50.76)[b]
T355	83.33 (65.90)[b]	90.00 (71.56)[b]	100.00 (89.47)[a]
T356	90.00 (71.56)[a]	96.66 (79.47)[a]	100.00 (89.47)[a]
T357	86.66 (68.57)[b]	93.33 (75.03)[a]	100.00 (89.47)[a]
HD1	90.00 (71.56)[a]	93.33 (75.03)[a]	100.00 (89.47)[a]
Control	0.00	0.00	0.00
S.ED	1.96	1.69	0.57
CD at 1%	5.59	4.82	1.63

* Values within parentheses are arcsine transformed values

Within a column value superscripted by same alphabet are statistically on par with each other by DMRT.

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ES 05 BOPD 05

Predatory potential of *Amblyseius largoensis* (Muma) (Acaridae: Phytoseiidae) against *Tetranychus urticae* Koch infesting brinjal

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Keywords: *Predatory potential, Amblyseius largoensis, Tetranychus urticae and brinjal*

Introduction

The tetranychid mites, well known as red spider mites, constitute one of the dreaded pests of agricultural crops and the manifestation of their pest status is due to high biotic potential, fecundity, short generation time, wide geographic distribution, highly polyphagous nature, etc. (Helle and Sabelis, 1985; Seeman and Beard, 2011). As a better and safe substitute to overcome the hazards of synthetic pesticides, biological control through inoculative release of natural enemies has been practiced in various countries (Helle and Sabelis, 1985). Among the natural enemies of pest mites, predatory mites of the family Phytoseiidae have been proved to be highly promising against phytophagous mites like spider mites (McMurtry and Croft, 1997; Puchalska and Kozak, 2016). Studies on the potential of these mites as predators have a great significance in manipulation of their behaviour so that it could successfully be employed for the control of phytophagous mites and small soft bodied insects.

Material and methods

The experiment to determine the feeding potential of predatory mite, *A. largoensis* was carried out in the biosystematics laboratory in the Department of Agricultural Entomology, TNAU. Predator, *Amblyseius largoensis* and its prey, *Tetranychus urticae* collected from the fields were utilized to maintain stock culture in the laboratory at 25± 1ºC, 80±5% RH and 12L:12D photoperiod in petri dishes containing brinjal leaves infested with spider mites. Withered and drying leaves were regularly replaced. From the stock culture both predator and prey mites were transferred onto fresh brinjal leaves placed on moistened cotton pads (1.5 cm thick) in perforated plastic containers.

For evaluating the feeding potential *Amblyseius largoensis* was introduced on to the individual leaf discs provided with different stages of prey mite (eggs-10, protonymph-5, deutonymph-5, quiescent-5 and adult-5) for each replication and observations were made under a stereomicroscope to record the response of the predator to the individual life stage of the pest mite (*Tetranychus urticae*) The number of prey stages consumed by the predator on individual leaf disc was recorded for a time interval of 24 hrs and the rate of consumption on individual prey instar was calculated. Data obtained on feeding potential were subjected to Two-way ANOVA for testing the significance.

Results and Discussion

Results of laboratory studies on the predatory potential of *A. largoensis* on various life stages of pest mite revealed that the feeding activity was initiated up on contact with the prey. The predatory mite was found to make active prey searching movement randomly, in and around the prey patches. The adult female of *A. largoensis* showed a specific preference to feed on the egg stage of the prey mite while the *A. largoensis* nymph exhibited preference to the nymphal stages of the prey. A decreasing sequence in the order of egg > larva > nymphs> adult was recorded in the feeding preference of the adult predator *A. largoensis* towards life stages of the prey mite. The per cent consumption by the male, female, protonymph and deutonymph of *A. largoensis* on egg, larva, nymphs and adult female stages of prey was 44, 57, 27 and 34, respectively. Data gathered on consumption rates of the predator upon statistical analysis revealed a significant variation towards different stages of predators thereby establishing a specific preference to prey eggs by the predator (Table 1).A similar feeding preference to prey mite eggs was recorded in several phytoseiids studied earlier (Badii *et al.,* 2004; Mohamed Liyaudheen *et al.,* 2014; Ganjisaffar and Perring, 2015; Mandape Sanchit and Abhishek Shukla, 2016; Jyothis and Ramani, 2019).

Table 1. Feeding potential of *Amblyseius largoensis* (Muma) (Acaridae: Phytoseiidae) on *Tetranychus urticae* Koch

Predator (*Amblyseius largoensis)* life stage	Prey (*Tetranychus urticae)* life stages				
	Number of prey stages consumed				
	Egg (10)	Proto-nymph (5)	Deuto-nymph (5)	Quiescent (5)	Adult (5)
Adult Male	7 (2.7)[a]	2.7 (1.8)[b]	3 (1.9)[b]	0.0 (0.7)[d]	0.7 (1.1)[c]
Adult Female	9 (3.1)[a]	4.3 (2.2)[b]	2.7 (1.8)[c]	0.0 (0.7)[d]	1.0 (1.2)[c]
Protonymph	4.3 (2.2)[a]	2.7 (1.8)[b]	1.0 (1.2)[c]	0.0 (0.7)[d]	0.0 (0.7)[d]
Deutronymph	6.3 (2.6)[a]	2.0 (1.6)[b]	1.3 (1.4)[b]	0.0 (0.7)[d]	0.7 (1.1)[c]

Figures in the parentheses are transformed values ; Means followed by the common letter(s) are not significantly different at 5% level by LSD

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ES 05 BOPD 06

Plant oil based *Beauveria bassiana* (Balsamo) bio-formulation against tomato fruit borer

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Keywords: *Bio-formulation, Beauveria bassiana, fruit borer, Helicoverpa armigera, tomato*

Introduction

Tomato (*Solanum lycopersicum* Mill.) is one of the most important vegetable crops in the world. It is cultivated for its fleshy fruits and the area under its cultivation is increasing day by day due to its nutrient value, demand and high yield. The production and productivity of the crop is greatly hampered by the fruit borer, *Helicoverpa armigera* (Hubner) which causes damage to the developing fruits and results in yield loss ranging from 20 to 60 per cent (Tewari and Krishnamoorthy 1984; Lal and Lal, 1996. The mass propagation of fungi for use as biopesticide is a goal for investigators, because include advantages as mainly on the processes of scaling which are relatively easy, as well as the control of parameters such as temperature, aeration and pH.

Materials and Methods

Oil based bioformulations were prepared according to modified method of Batta 2004. Thirteen types of oils with different combinations were used for preparation of oil formulation of *B. bassiana* isolate TBb8. The aqueous phases as well as oil phase of different oils were prepared as explained in below the Table 1. The ingredients of each phase of the oil being investigated were first mixed separately and then combined in a 50: 50 per cent ratio by adding the aqueous phase into the oil phase to obtain a water- in-oil formulation. The mixture was then homogenized mechanically using a homogenizer. The aqueous phase and oil phase were mixed in a round bottom flask of one lit and sterilized under autoclave at 120°C, 15 lb pressure for 20 min. The sterilized mixtures containing oil and aqueous phases were inoculated with a conidia suspension of 7 days old cultures of TBb8 in laminar air flow chamber and kept for incubation at 28 ± 2ºC in optical shaker with a speed of 120 rpm under storage conditions.

Table 1. Population of *Beauveria bassiana* in different oil formulations

Days	Population cfu/ml)								
	GN	Coconut	Neem	Musturd	Pinnaigai	Mahuva	Pungam	Gingelly	Corn
0th day	$4.5x10^8$	$4.6x10^8$	$4.1x10^8$	$4.3x10^8$	$4.2x10^8$	$4.35x10^8$	4.3x108	$4.5x10^8$	$4.6x10^8$
2nd day	$7.2x10^8$	$7.8x10^8$	$6.9x10^8$	$7.4x10^8$	$7.1x10^8$	$7.5x10^8$	7.0x108	$7.2x10^8$	$6.5x10^8$
5th day	$2.2x10^9$	$4.5x10^8$	$4.5x10^{10}$	$5.2x10^8$	$1.1x10^{10}$	$4.5x10^7$	3.8x107	$5.6x10^7$	$3.0x10^{10}$
15th day	$5.0x10^7$	$6.2x10^7$	$3.5x10^{10}$	$5.8x10^5$	$6.5x10^9$	$2.5x10^5$	3.4x105	$6.1x10^4$	$2.6x10^{10}$
30th day	$4.5x10^6$	$5.5x10^6$	$2.5x10^{10}$	-	$5.1x10^9$	-	-	-	$1.2x10^{10}$

45th day	1.5 x10^6	2.5X10^6	1.2x 10^{10}	-	1.5 x 10^{10}	-	-	-	2.2x10^{10}
60th day	7.5 x10^5	6.5X10^5	1.0×10^{10}	-	1.1x10^{10}	-	-	-	2.1x10^{10}
90thday	-	-	9.2×10^9	-	9.1x 10^9	-	-	-	2.2x10^{10}
120th day	-	-	9.2×10^9	-	8.9x 10^8	-	-	-	2.0x10^{10}
150th day	-	-	8.8×10^9	-	8.5 x10^8	-	-	-	1.5x10^{10}
180th day	-	-	8.0-×10^9	-	8.0 x 10^8	-	-	-	1.0x10^{10}
210th day	-	-	-	-	3.67x10^8	-	-	-	7.0x10^9

*Mean of values three replications

Results and Discussion

It was found that *B. bassiana* (TBb8) was highly effective on third instar larvae of *H. armigera* with a larval mortality of 88.21 per cent under in vitro and glasshouse conditions. This finding is in accordance with Sivasundaram (2006), where *B. bassiana* (B2) was tested against rice leaffolder and also found to be effective against BPH. Similarly Saravanan, (2007) also found that Bb10 isolate was effective for managing the population of *H. armigera* in pigeonpea under *in vitro* and glasshouse conditions.

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ES 05 BOPD 07

Influence of Different Floral Feeds on the Biological Attributes of *Chrysoperla carnea* Stephens (Chrysopidae : Neuroptera)

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Keywords: ***Biology, Chrysoperla carnea, floral feeds***

Introduction

Chrysoperla carnea is an important predator of soft bodied insects (aphids, mealy bugs, scale insects, jassids etc.) and the eggs of lepidopterous pests. In India, 65 species of Chrysopids belonging to 21 genera have been recorded from various crop ecosystems, the dominant genera, than can be used in augmentation programmes (Gautam, 1994). The *Chrysoperla* larvae are predatory, while adults are not predacious but feed on pollen, nectar which are necessary for gametogenesis.and the fecundity of *C. carnea* was influenced considerably by the quality of adult food.

Materials and Methods

The research was carried out at Indian Agricultural Research Institute, New Delhi to study the biology of adult *C. carnea* on eightfloral feeds *viz., Hibiscus rosasinensis, Gossypium hirsutum* (Malvaceae), *Cannabis sativa* (Cannabaceae), *Zea mays* (Graminae), *Cicer arietinum* (Fabaceae), *Brassica campestris* (Cruciferae), *Gladiolus callianthus* (Iridiaceae) and *Ricinus communis* (Euphorbiaceae) along with a control with 50 per cent honey solution was maintained for comparison. The cocoons of *C. carnea* were seperated and kept inside a glass jar (21 cm high, 18 cm dia) at 25±1^{0}C and 60±5% R.H. After adult emergence, one pair of newly emerged adults (0-24 hrs) released in glass tubes (3.5 cm dia, 6 cm high) and covered with black muslin cloth. The experiment was conducted with 9 treatments and ten replications. Biochemical analysis of floral feeds were carried out to know the nutritional status of the floral feeds. The data collected on the preoviposition period, oviposition period, per cent hatchability, fecundity, male and female longevity were subjected to analysis of variance.

Results and Discussion

Detailed biology of *C. carnea* was studied an eight floral feeds of different families and genera. The pre-oviposition period was very less(3.10 days) in the case of adults fed on flowers of *Hibiscus rosasinensis* followed by flowers of *Cannabis sativa* (3.70 days) as against 8.30 days obtained on *Cicer arietinum.* The highest per cent hatchability (97.00%) was observed when they fed on flowers of *Ricinus communis* compared to control (44%). There was many-fold increase in fecundity (eggs/female) when female fed on floral feed. *R. communis* (310.90), *Brassica campestris* (297.70) as against the lowest eggs(20.60 egg/female) in adult fed on control. Lowest longevity of males (23.70 days) and females (28.20 days) was observed when they fed on control followed by *Cicer arietinum* and longest longevity of males (52.80 days) was observed when they fed on *R. communis* and *Z. mays* floral feed and longest longevity of female (55.90 days) when they fed on floral feed *R. communis.* This result is in conformity with the findings of Gautam and Paul (1988).

The total soluble sugar, total soluble protein content and free amino acid content was highest in pollens of *R. communis,* while lowest in pollens of *Cicer arietinum.* The highest fecundity and longevity of *C. carnea* was observed when the adults were offered the flowers of *R. communis* as compared to *Cicer arietinum,* where comparatively lowest fecundity and longevity was recorded. Cook *et al*. (2003) observed that the free amino acid content of oil seed rape contain essential amino acids required by honey bees suggesting that oil seed rape pollen is greater nutritional quality for honey bees. Thus the pollen grains of *R. communis* is greater nutritional quality for *C. carnea* followed by *B. campestris, C. sativa* and *Z. mays* pollen and can be exploited in the mass-multiplication programmes of *C. carnea.*

Table 1. Biochemical analysis of promising floral feeds

S.No	Floral feeds	Total soluble sugar (mg/g)	Total soluble protein (mg/g)	Free amino acid (mg/g)
1	*Ricinus communis*	4.50	0.90	8.1
2	*Brassica campestris*	3.80	0.76	6.50
3	*Gladiolus*	3.55	0.50	6.40
4	*Zea mays*	3.49	0.46	6.39
5	*Cannabis sativa*	3.33	0.53	5.80
6	*Hibiscus rosasinensis*	3.56	0.38	5.30
7	*Gossypium hirsutum*	3.46	0.43	4.80
8	*Cicer arietinum*	3.50	0.75	3.90

Table 2. Promising floral feeds on the biology of *Chrysoperla carnea*

Treatments	Pre- oviposition period (days)	Oviposition period (days)	% hatch-ability	Fecundity	Male longevity (days)	Female longevity (days)
Hibiscus rosasinensis	3.100	35.50	93.400	166.500	41.600	45.200
Cannabis sativa	3.700	36.20	96.400	177.400	46.900	48.100
Zea mays	7.200	31.40	93.600	223.700	52.800	48.300
Gossypium hirsutum	7.200	25.40	91.200	136.700	41.300	51.300
Cicer arietinum	8.300	14.90	90.200	127.700	24.800	28.800
Brassica campestris	7.00	30.70	94.000	297.500	44.700	43.100
Gladiolus	4.00	35.40	85.400	236.300	41.700	43.900
Ricinus communis	7.00	43.60	97.000	310.900	52.800	55.900
Control	4.600	12.40	4.000	20.600	23.700	28.200
SEm.	0.144	1.963	1.653	7.169	0.536	0.948
CD 5 %	0.522	7.138	6.010	26.060	1.950	3.448
CD 1%	0.564	7.716	6.496	28.175	2.107	3.727

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ES 05 BOPD 08

Field evaluation of bio inoculants against white grub, *Holotrichia serrata* F. (Coleoptera, Scarabaeidae) in sugarcane

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Key words: Sugarcane, white grub, field efficacy, bio inoculants

Introduction

Sugarcane crop is infested with more than 200 species of pests. Among the pests, the subterranean white grub has potential to cause 80-100% damage to sugarcane crop. White grubs (Coleoptera: Scarabaeidae) are soil inhabiting and root feeding immature stages of scarab beetles. Application of chemical is practically uneconomical, difficult and associated with high cost, environmental pollution and other problems. With a view to address these issues, field evaluation of bio inoculants *viz*., *Meatrhizium anisopliae, Beauveria bassiana* and *B.brongniarti* against white grub in sugarcane was carried out.

Material and Methods

Field experiments were carried out during 2019 in two locations at Thenkarumbalur village, Thandrampattu block of Thiruvannamalai District (Location I) and Kizhpappampadi village, Gingee block of Villupuram District (Location II). The sugarcane variety Co86032 with I Ratoon crop during March with a spacing of 0.9 m between rows with a plot size of 5 x 5 m and all the recommended package of practices were adopted except for white grub management. There were four treatments including control as listed in table 1 and were replicated six times in randomized block design. The treatments were imposed in the second week of September. Talc formulations of *M. anisopliae*, *B. bassiana* and *B. brongniarti* each @ 4 X 10^9 cfu/g-5 kg ha^{-1} were applied to the root zone by mixing with well decomposed Farm Yard Manure. Observations on the number of white grubs per meter row in the root zone were recorded a day before and 15 and 30 days after treatment (DAT), cane yield was also recorded at harvest. The data on the number of grubs were subjected to square root transformation. These transformed data were subjected to analysis of variance and Duncan's Multiple Range Test was used to determine the significance in different treatments.

Results and Discussion

The results of the field trial in Location I and II revealed that soil application of *M. anisopliae* @ 4 X 10^9 cfu/g-5 kg ha^{-1} was significantly effective in reducing white grub population (75.49% and 61.82 %) with highest cane yield (95.10 t ha^{-1} and 88.20 t ha^{-1}) with highest B:C ratio (1.85 and 1.55), respectively (Table 1). It was followed by *B. brongniarti* which registered 55.88% reduction in white grub population with cane yield of 85.16 t ha^{-1} with B: C ratio of 1.65 compared to the untreated control in Location I and 51.16% reduction in white grub population with cane yield of 78.63 t ha^{-1} with B: C ratio 1.55 compared to the untreated control in Location II. Thamarai Chelvi *et al.* (2010) reported that the biopesticide *M. anisopliae* at the concentration of $8x10^9$ conidia per ml found to be effective in controlling the population of white grub and also reported that yield and quality parameters recorded were higher in treated plots compared to control plots. The higher colony-forming unit counts of *M. anisopliae* found in association with plant roots and root exudates suggest these fungi may be capable of survival in soils without an insect host (Hu and St Leger, 2002). The results of the field experiments to control sugarcane white grub have demonstrated the utility of using bio inoculant, *M. anisopliae* as a control tool against white grub without any hazardous chemical pesticides.

Table.1 Efficacy of bio inoculants against white grub of sugarcane (Mean of six replications)

Treatments	Dosage	Number of white grubs/m row (Pooled Mean)		% reduction over control		Cane yield (t ha^{-1})		BC ratio	
		Loc. I	Loc. II	Loc. I	Loc. II	Loc. I	Loc. II	Loc.I	Loc.II
T_1-*M. anisopliae*	4 X 10^9 cfu/g-5 kg	1.00 (1.00)a	1.47 (1.21)a	75.49	61.82	95.10 (9.75)a	88.20 (9.41a	1.85	1.75
T_{2-} *B.bassiana*	4 X 10^9 cfu/g-5 kg	2.22 (1.49)c	2.28 (1.51)c	45.58	40.77	81.17 (9.00)c	74.90 (8.65c	1.58	1.48
T_{3-} *B. brongniarti*	4 X 10^9 cfu/g-5 kg	1.80 (1.34)b	1.88 (1.37)b	55.88	51.16	85.16 (9.22)b	78.63 (8.87b	1.65	1.55
T_{4-}Untreated control		4.08 (2.02)d	3.85 (1.96)d	-	-	74.63 (8.63)d	69.06 (8.31d	1.46	1.40
CD at 5%		0.08	0.06			0.04	0.07		
SEM		0.04	0.02			0.01	0.02		

In a column means followed by a common alphabet are not significantly different at 5 % level by DMRT. Figures in the parentheses are square root transformed values.

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ES 05 BOPD 09

Infectivity of *Steinernema glaseri* formulated in sodium alginate beads and water dispersible granules against brinjal ash weevil (*Myllocerus subfasciatus*)

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Keywords: *Steinernema glaseri, Alginate beads, Water Dispersible Granules, Brinjal ash weevil*

Introduction

Entomopathogenic nematodes are considered as potential biocontrol agents of major insect pests of cultivated crops. *Steinernema glaseri* effectively controls Lepidopterans pests, (*Helicoverpa armigera*), Coleopteran pests, (*M. subfasciatus*) and Scarabidae pests, (*Holotrichia consanguinea* and *Holotrichia serrata*). Two different formulations of entomopathogenic nematodes in sodium alginate gel and water dispersible granular were developed and their infectivity against brinjal ash weevil, *Mylocerus. subfasciatus* was studied.

Materials and methods

Two formulations *viz.,* alginate beads and water dispersible granules were developed. Alginate gel was prepared using 3g of sodium alginate in 100ml of water. *Steinernema glaseri* suspension was added to the sodium alginate gel, mixed thoroughly and added to calcium chloride drop by drop and kept undisturbed for 15 minutes for formation of beads (Navon *et al.*, 2002). Water dispersible granules of *S. glaseri* were prepared using autoclaved clay soil, bentonite powder and starch. The granules were kept overnight for air drying and stored in an air tight container (Shapiro and McCoy, 2000).

The formulations of *S. glaseri* in alginate beads and water dispersible granules were evaluated in a soil column assay. Red soil, sand and FYM (2:1:1 ratio) were autoclaved and filled in plastic cups and ten third instar larvae of *M. subfasciatus* were placed in the soil. Observations on grub mortality were recorded after 24, 48, 72 and 96 h. The presence entomopathogenic nematodes population in soil was assessed by soil baiting with *C. cephalonica* (Nagesh *et al.*, 2016). The numbers of infective juveniles per sodium alginate gel and water dispersible granules were calculated.

Results and Discussion

A single sodium alginate bead contained 350 infective juveniles and the weight of a single bead ranged between 30 to 50mg .Weight of one water soluble granule ranged between 80 to 250 mg and each granule contained 180 infective juveniles of *S. glaseri*. Application of alginate beads and water dispersible granules formulation containing infective juveniles of *S. glaseri* was observed to cause death of *M. subfasciatus* grubs. After 24 h of application of sodium alginate containing *S. glaseri* formulations there was 32 per cent grub mortality. The percentage of grub mortality increased with time of exposure. After 96 h 90.00 per cent grub mortality was observed. Similarly, water dispersible granules containing *S. glaseri* caused 26 per cent, 52 per cent and 70.00 per cent grub mortality after 24, 48, 72 h, respectively. There was 86.00 per cent grub mortality after 96 h compared to untreated control. In carbofuran 3G treated soil 34 to 98.00 per cent mortality was recorded between 24 to 96 h. In untreated soil there was no grub mortality observed. Formulation of EPNs using sodium and calcium alginate and water dispersible granules containing EPNs were developed by many scientists for the management of insect pests (Kary *et al.,* 2017) and are being widely used for the successful control of many agriculturally important insect pests in various.

Table 1. Efficacy of different formulations of *S. glaseri* on *Myllocerus subfasciatus* grub mortality in soil column assay

Treatments	Initial grub population	Grub mortality percentage			
		24 hours	48 hours	72 hours	96 hours
T_1-Alginate gel containing 2000 IJs	10.00	32.00	54.00	74.00	90.00
T_2-Water dispersible granules containing 2000 IJs	10.00	26.00	52.00	70.00	86.00
T_3-Carbofuran 3G	10.00	34.00	68.00	85.00	98.00
T_4-Untreated control	10.00	0.00	0.00	0.00	0.00

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ES 05 BOPD 10

Effect of Crop Matrix on Insect – Plant Interaction under Two Environmental Regimes on Cowpea

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Key words: *In land ecosystem (Srivilliputtur), Coastal ecosystem (Kamuthi), Cowpea, Insect pests, Intercrop.*

Abstract

The results revealed that inland ecosystem (Srivilliputtur) during summer 2017, cowpea + sorghum intercrop system recorded low numbers aphid, thrips and pod bug *viz.,* (7.52/10 cm twigs, 0.96/10 flowers and 0.94/plant respectively) followed by cowpea + pigeonpea (8.65, 1.30 and 1.08 respectively) compared to pure crop of cowpea (12.11/10cm twigs, 2.02/10 flowers and 2.19/plant respectively). In inland ecosystem during winter 2017, the mean number of leaf hopper low in intercropped with cowpea + pigeonpea (0.87/3 leaves) during summer 2017.where as in coastal ecosystem (Kamudhi) during summer 2017, lLeaf hopper, aphid, thrips and pod bug *viz.,* (0.57/3leaves, 7.06/10 cm twig, 0.88/10 flower and 0.75/plant respectively) were low with cowpea + sorghum followed by cowpea + pigeonpea (0.85/3leaves, 8.72/10 cm twig, 1.12/10 flowers and 0.86/plant respectively) which was significantly minimum than pure crop of cowpea (1.21/ 3 leafhopper, 11.39/10 cm twigs, 1.81/10 flowers and 1.86/plant respectively).

Introduction

Pulses are the major source of protein in the vegetarian diet in our country; besides being a rich source of protein, they maintain soil fertility through biological nitrogen fixation in soil and thus play a vital role in furthering sustainable agriculture. In India, pest damage varies considerably in different agro climatic regions across the country mainly due to differential impacts of several abiotic factors such temperature, humidity and rainfall (Sharma, 2010). This has major implication for the intensification of yield losses due to potential changes in crop diversity and increased incidence of insect-pest in the context of impending climate change. With this background, the proposed study focuses on the effects of climate change on insect pests and their associated food webs in cowpea crops.

Material and Methods

The field experiments were conducted at farmer's field during summer season (February to April 2017) under two environmental regimes at Srivilliputtur (Latitude, 9.512° N, Longitude, 77.633° E, Altitude, 252 m MSL, distance from seashore 132 km) and at Kamuthi (Latitude, 9.419° N, Longitude, 78.370⁰ E and Altitude, 40 m MSL, distance from seashore 30 km) in Tamil Nadu, India with six treatments and replicated four times. Five intercrops *viz.,* sorghum, (*Sorghum bicolor*) (K 8); maize, (*Zea mays*) (TNAU maize hybrid CO 6); castor, (*Ricinuscommunis*) (CO 1); Pigeonpea,(*Cajanuscajan*)(VBN (Rg) 3); bajra,(*Pennisetumglaucum*)(CO 7) at 4:1 with cowpea VBN 2 (*Vignaunguiculata* (L.) Walp. Each treatment was raised in plot size of 5 x 4 m^2 in RBD with spacing 45 x 10 cm. The experimental area was kept free from insecticidal spray throughout the crop season in order to record the incidence of insect pests. Weekly observations were made on the incidence of insect pests and natural enemies on five randomly selected plants in each plot of cowpea by direct count to till harvest.

Results and Discussion

In inland ecosystem during summer 2017, cowpea + sorghum intercrop system recorded low numbers aphid, thrips, pod bug *viz.,* (7.52/10 cm twigs, 0.96/10 flowers and 0.94/plant respectively) followed by cowpea + pigeonpea (8.65, 1.30 and 1.08/plant respectively) compared to pure crop of cowpea (12.11/10cm twigs, 2.02/10 flowers and 2.2.19/plant respectively). In inland ecosystem during summer 2017, the mean number of leaf hopper low in intercropped with cowpea + pigeonpea (0.87/3 leaves) and intercropped with cowpea+ sorghum was low (0.92/ 3 leaves) (Table 1). In coastal ecosystem during summer 2017, Leaf hopper, aphid, thrips and pod bug *viz.,* (0.57/3leaves, 7.06/10 cm twig, 0.88/10 flower, 0.75/plant respectively) were low with cowpea + sorghum followed by cowpea + pigeonpea (0.85/3leaves, 8.72/10 cm twig, 1.12/10 flowers, 0.86/plant respectively) which was significantly minimum than pure crop of cowpea (1.21/ 3 leafhopper, 11.39/10 cm twigs, 1.81/10 flowers and 1.86/ plant respectively) (Table 1). These results are in conformity with Hassan (2013) who reported that the population of aphids (*Aphis craccivora* Koch.) and thrips (*M.sjostedi*) were significantly low in cowpea + sorghum intercropping than sole cowpea crop.

Table 1. Effect of intercrops on sucking insect pests in cowpea (cv. VBN 2) under two ecosystems (Summer, 2017)

Intercrops	Cumulative mean of sucking pests*							
	Inland ecosystem (Srivilliputtur)				Coastal ecosystem (Kamuthi)			
	Leaf hopper (No./ 3 leaves)	Aphid (No./10 cm twig)	Thrips (No./10flower)	Pod bug (No./ plant)	Leaf hopper (No./ 3 leaves)	Aphid (No./10 cm twig)	Thrips (No./10 flower)	Pod bug (No./ plant)
Cowpea + Sorghum	0.92[b] (0.96)	7.52[a] (2.74)	0.96[a] (0.98)	0.94[a] (0.97)	0.57[a] (0.75)	7.06[a] (2.66)	0.88[a] (0.94)	0.75[a] (0.87)
Cowpea + Maize	1.09[c] (1.04)	8.95[c] (2.99)	1.48[c] (1.22)	1.40[c] (1.15)	1.00[d] (1.00)	8.26[b] (2.87)	1.33[d] (1.15)	0.93[c] (0.96)
Cowpea + Castor	1.26[d] (1.12)	10.45[d] (3.23)	1.59[d] (1.26)	1.80[e] (1.34)	0.92[c] (0.96)	9.41[d] (3.07)	1.47[e] (1.21)	1.56[e] (1.25)
Cowpea + Pigeonpea	0.87[a] (0.93)	8.65[b] (2.94)	1.30[b] (1.14)	1.08[b] (1.04)	0.85[b] (0.92)	8.72[c] (2.95)	1.12[b] (1.06)	0.86[b] (0.93)
Cowpea + Bajra	1.23[d] (1.11)	8.91[bc] (2.98)	1.46[c] (1.21)	1.50[d] (1.22)	1.02[d] (1.01)	8.96[c] (2.99)	1.29[c] (1.14)	1.31[d] (1.14)
Cowpea (Pure crop)	2.12[e] (1.46)	12.11[e] (3.48)	2.02[e] (1.42)	2.19[f] (1.48)	1.21[e] (1.10)	11.39[e] (3.37)	1.81[f] (1.35)	1.86[f] (1.36)
SE.d	0.007	0.021	0.008	0.009	0.006	0.021	0.006	0.007
CD (P=0.05)	0.015	0.045	0.018	0.019	0.013	0.045	0.013	0.007

*Mean of four replications and 5 plants per replication; significant at 5%; figures in parentheses are square root transformed; in a column, means followed by a common letter(s) are not significantly different by DMRT (P = 0.05); *Mean of 15 DAS, 15 DAS, 36 DAS and 36 DAS observation

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ES 05 BOPD 11

Effect of various temperature regimes on the growth and development of *Cryptolaemus montrouzieri* on *Planococcus citri*

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Keywords: Cryptolaemus montrouzieri, Planococcus citri, temperature, growth and Development

Introduction

Guava trees are attacked by more than 80 species of insects, of which fruit flies (*Bactrocera dorsalis* Hend), coccoids (*Chloropulvinaria psidii* Mask) and castor capsule borer (*Conogethes punctiferalis* Guen) are of major importance. In recent years, the mealybugs, *Planococcus citri* Risso and *Ferrisia virgata* Ckll. have become serious pests of guava by attacking the foliage and fruits (Chattopadhyay, 2003). Temperature is a crucial factor, which influences the bio-attributes of predatious coccinellids. The study has been formulated to know the influence of temperature on coccinellids.

Materials and Methods

To determine the most optimum temperature for the development of *C. montrouzieri*, petridishes containing egg batches (20 nos./ batch) were kept in B.O.D incubator at four temperature regimes *viz*, 20°C, 25°C, 30°C, and 35°C. The incubation period was determined in terms of days. The newly emerged grubs (20 nos) from each temperature regime were taken in 5cm glass vials and covered with black muslin cloth. Colonies of mealybugs *P. citri* were introduced into the vials with predator grubs and then closed. The observations on the pupal period, longevity of male and female in each temperature were recorded. The emerged females were collected from the stock culture and kept individually with one male for copulation for 24 h. The mated females were placed individually in petri dishes containing mealybugs and kept in two temperature levels *viz*, 20°C and 30°C. The total number of eggs laid by each female was counted every day and the females were removed to fresh petri plates containing fresh colonies of mealybugs with ten replications and fecundity was recorded.

Results and Discussion

Data presented in Table 1 revealed that the developmental periods egg, larval, pre pupal and pupal stages with a total life span of 22.7 days was 3.4, 13.1, 1.6, and 4.6 days respectively, when exposed to 35°C. On other temperature levels *viz.*, 20°C, 25°C and 30°C the developmental period was prolonged to an extent of 39.0, 34.4 and 28.2 respectively. At all the temperatures, the total life span varied significantly. The optimum temperature required for the development of *C. montrouzieri* was 30°C. The decrease in egg period with increase in temperature may be attributed to the accelerated embryogenesis, which probably caused early hatching of neonate instars. The decreased larval period of *C. montrouzieri* with increase in temperature may be attributed to the increased metabolic rates which lead to early completion of the larval period. Studies on the *C. montrouzieri* with reference to different temperature proved that 25°C was the favourable temperature as the longevity of male and female was extended upto 47.4 and 51.2 days respectively (Veeravel and Baskaran, 1996). The decreased survival rate at high temperature would have been detrimental to the adults of *C. montrouzieri*. So, the present findings suggested the release of *C. montrouzieri* adults @ 30°C might be favourable for the better establishment under field condition to reduce mealybug population. The results corroborate with findings of Babu and Azam (1988).

Table 1. Effect of various temperature regimes on the growth and development of *C. montrouzieri*

Stages	Temperature levels*			
	20°	25°	30°	35°
Egg	7.4^{e}	6.2^{c}	4^{b}	3.4^{b}
Grub I instar	5.6^{b}	5.2^{b}	4.4^{b}	3.6^{b}
II instar	3.6^{a}	2.6^{a}	2.2^{a}	1.6^{a}
III instar	5.6^{b}	4.8^{b}	4.4^{b}	3.7^{b}
IV instar	6.4^{c}	6.0^{c}	5.0^{c}	4.2^{c}
Total Grub period	21.2^{f}	18.6^{e}	16^{e}	13.1^{e}
Prepupa	3.2^{a}	2.4^{a}	2.2^{a}	1.6^{a}
Pupa	7.2^{d}	7.2^{d}	6^{d}	4.6^{d}
Total developmental period	39.0^{g}	34.4^{f}	28.2^{f}	22.7^{f}

*Mean of five replications ; In a column/row means followed by the same small letter(s) are not significantly different by DMRT (P=0.05)

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ES 05 BOPD 12

Natural occurrence of Papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae) and its parasitoid *Acerophagus papayae* in *Plumeria*

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Keywords: *Papaya mealybug, Paracoccus marginatus, Acerophagus papayae, confined, outdoor*

Introduction

Papaya mealybug, *Paracoccus marginatus* is a serious pest of papaya and other economically important fruits, vegetables and ornamentals. There are about 79 species recorded from the genus *Paracoccus*. Muniappan *et al.* (2008) was the first to report *P. marginatus* in Indonesia and India. The infestation started increasing with the onset of dry spell during the winter months. The plants which were attacked during March-April could recover from damage even after complete defoliation on receiving the pre-monsoon shower. The *Plumeria* plant was taken for study since it is hardy, needs zero maintenance, easily infested by papaya mealybug, withstands and recovers heavy infestation. It also acts as a natural mass multiplication center for the parasitoid *Acerophagus papayae*.

Materials and Methods

To study parasitization potential of *A. papayae* observations were made in 25 potted *Plumeria* plants each under confined (shade net) and outdoor conditions. The population of the mealybug were recorded at weekly intervals for 14 weeks from January to April, 2017 at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu, India. The population of mealy bug was recorded in one leaf/ plant. The number of mealybug (which includes egg masses, crawlers, II and III instars and adults), number of parasitoids and number of parasitized crawlers were counted in 5 veins of leaf.

Results and Discussion

The *A. papayae* was more under confined condition. During first week, no activity of parasitoid was recorded. The population of parasitoids under shade net conditions reached the highest in the 9th week at 1.89 and lowest in the 2nd week at 0.10. The population decreased from 9th to 14th week of observation. The percentage parasitization was higher under shade net conditions (21.58%) than outdoor conditions (15.13%). The parasitoid activity corresponds with pest population as it remains high when the pest population is more. Kumar *et al.* (2014) reported that the population of parasitoid was positively correlated with the population of papaya mealybug. Pena *et al.* (2005) revealed that the population of papaya mealybug was more during July to September.

Table 1. Parasitization potential of *Acerophagus papayae* under confined and outdoor conditions

Standard Week	Confined conditions		Outdoor conditions	
	Parasitoids (no./leaf)	Parasitization (%)	Parasitoids (no./leaf)	Parasitization (%)
2	0.00	0.00	0.00	0.00
3	1.10	0.58	0.00	0.00
4	1.12	7.39	0.28	6.25
5	1.70	15.99	0.16	3.64
6	1.48	7.52	1.40	6.64
7	0.56	6.90	0.52	4.53
8	0.94	12.05	2.56	43.54
9	0.75	45.73	0.25	5.39
10	1.89	98.97	0.78	43.33
11	0.44	21.57	0.21	10.10
12	0.18	10.71	0.11	8.33
13	0.20	10.26	0.32	29.91
14	0.17	7.83	0.31	14.09
15	0.12	16.67	0.60	36.14
Mean	0.69	21.58	0.54	15.13

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ES 05 BOPD 13

Seasonal dynamics of parasitization by *Chelonus* sp. (Braconidae: Hymenoptera) on fall armyworm *Spodoptera frugiperda* (J.E. Smith) (Noctuidae: Lepidoptera)

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Key words: *Chelonus sp., fall armyworm, maize, parasitization, weather parameters*

Introduction

Fall armyworm (FAW) *Spodoptera frugiperda* (J. E. Smith) (Noctuida: Lepidoptera), is an invasive alien pest that attacks mainly maize crop and threatens the maize cultivation in India. Considering the problems encountered by the repeated use of pesticides and the resultant environmental concerns, natural enemies will play a vital role in the management of FAW. Egg larval parasitoid, *Chelonus* sp. (Braconidae: Hymenoptera) is the most predominant parasitoid against FAW in many part of theworld. The natural parasitism by the *Chelonus* sp. on *S. frugiperda* was surveyed in Cauvery Delta zone.

Materials and Methods

Random survey was conducted during *Kharif* 2019and *Rabi* 2019 - 20 in maize growing tracts of Cauvery Delta Zone in six locations *viz*., Devanur, Kuvagam, Sendurai, Sengunam, Vallikandapuram and Veppanthattai. In each location three fields with high incidence of *S. frugiperda* were surveyed. Parasitized first, second and third instar larvae of *S. frugiperda* with dullness and poor feeding capacity were collected and reared under laboratory condition. Emerged parasitoids were collected at 24 hours interval in 70% ethanol and identified. Data on abiotic factors *viz*., maximum and minimum temperature, wind speed, relative humidity and rainfall were collected from NASA ARC POWER website for different locations and their relationship with parasitism was analyzed.

Results and Discussion

The results pertaining to parasitic potential of *Chelonus* sp. on *S. frugiperda* indicated that the occurrence was mostly depended on climatic factors and weather parameters. The average parasitic percentage of *Chelonus* sp. on *S. frugiperda* was higher during *Kharif* 2019 (11.26 to 16.85) compared to *Rabi* 2019-20 (2.06 to 4.75) at different locations of CDZ. During *Kharif* 2019 the parasitic potential of *Chelonus* sp. was maximum during 30th SMW (27.93 per cent to 8.28 per cent) and minimum during 27th SMW (7.07 per cent to 13.44 per cent) in various locations. During *Rabi* 2019-20 the parasitic percentage was maximum during 47th SMW (1.97 to 8.57) and minimum during 42nd SMW (0.00 to 6.45). In India *Chelonus formosanus* was earlier reported by Gupta *et al.* (2020) and *Chelonus* sp. can be a good agent for biological control of fall armyworm in India. The natural parasitism by *Chelonus* sp. on *S. frugiperda* had significant and positive association with maximum temperature during *Kharif* 2019 and had significant and negative correlation with rainfall during *Rabi* 2019-20 at all locations.At higher temperature, spread of kairomone is fast as air density is less and spread is slow at low temperature due to higher air density (Hance *et al.,* 2007). The R2 value ranged from 0.38 to 0.85 during *Kharif* 2019 and 0.42 to 0.78 during *Rabi* 2019 – 2020 which implied that parasitization by *Chelonus* sp. was influenced by above said weather parameters from 38 to 85 per cent during *Kharif* 2019 and from 42 to 78 per cent during *Rabi* 2019 – 2020.

Table 1. Effect of weather parameters on parasitization *by Chelonus* sp. on *S. frigiperda*

Location	*Kharif* 2019						*Rabi* 2019 - 20					
	Correlation coefficient (r)					R2	Correlation coefficient (r)					R2
	Max. temp.	Min. temp.	RH	Rain fall	Wind veloc.		Max. temp.	Min. temp.	RH	Rain fall	Wind veloc.	
Devanur	0.74*	0.45	-0.39	-0.26	-0.055	0.69	0.43	-0.14	-0.08	-0.64*	0.02	0.74
Kuvagam	0.69*	0.11	0.14	-0.44	-0.09	0.80	0.19	-0.31	-0.37	-0.53*	0.26	0.50
Sendurai	0.53*	0.14	-0.05	-0.31	0.084	0.38	0.36	-0.05	-0.14	-0.51*	0.41	0.44
Sengunam	0.56*	0.23	0.11	-0.36	-0.46	0.58	0.25	-0.28	-0.21	-0.60*	0.16	0.67
Vallikandapuram	0.66*	0.39	0.10	-0.07	-0.42	0.77	0.20	-0.33	-0.55*	-0.71*	-0.09	0.42
Veppanthattai	0.59*	0.20	0.52*	-0.47	0.09	0.85	0.07	-0.36	-0.42	-0.58*	0.45	0.78

*Significant at 0.05% level of significance

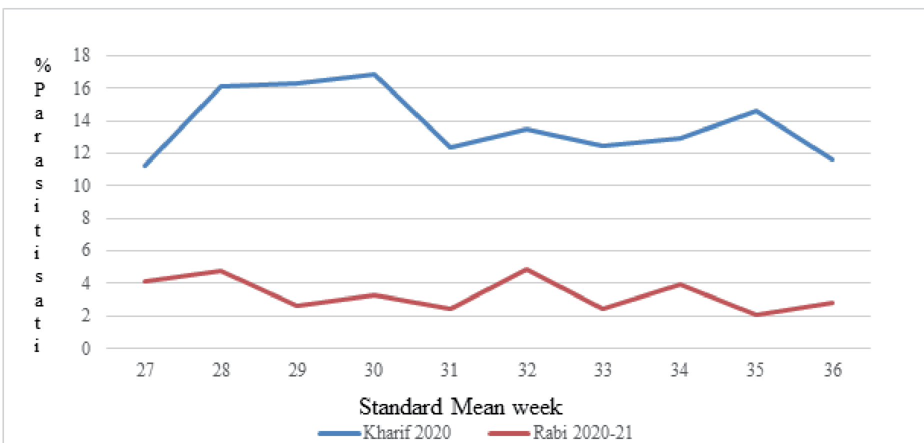

Fig 1. Seasonal dynamics of parasitization by *Chelonus* sp. on *S. frugiperda*

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ES 05 BOPD 14

Isolation and Characterization of symbiotic bacteria associated with the entomopathogenic nematode *Steinernema carpocapsae CPCRI SC1*

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Keywords: *Entomopathogenic nematode, Steinernema, Symbiotic bacteria, Xenorhabdus*

Introduction

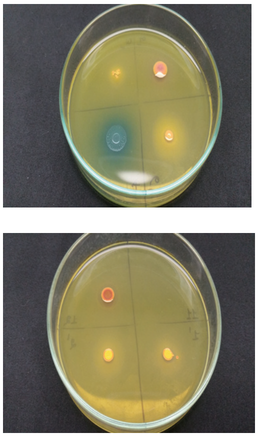
Entomopathogenic Steinernematid nematodes were discovered by Glaser in 1932. In 1966, Poinar and Thomas revealed the bacterial symbiotic association with the infective juveniles (IJs) of the entomopathogenic nematodes (EPNs), by which these nematodes are able to infect and reproduce in the insect host. The infective juveniles of the EPNs enter through natural openings (mouth, anus, spiracles) vectored these symbiotic bacteria and released into the haemocoel of the host. Rapid proliferation of bacteria in the host results in the cytotoxic effect yielded haemolymph septicemia and production several metabolic compounds by the bacteria affects the immunity response of the insect host and the produced toxins kill the insect within 24 to 48 hours. The bacteria eventually enters the stationary phase of its life cycle, and secretes several products, including broad spectrum antibiotics to transform the host cadaver internal environment into favorable niche for the proliferation of the nematodes and symbiotic bacteria (Akhurst, 1980; Poinar, 2006). The EPN associated *Xenorhabdus and Photorhabdus* are gaining considerable attention for their specific to their superior insecticidal activity against insect pests. Further these bacteria forms an integral component of sustainable biological control of pests in the soil environment without causing any harmful effects on human and non-target ecosystem. Characterization of bacteria associated with indigenous EPN is an important research area that brings novel insights for microbiology. It is logical to explore a novel *Enterobactericeae* species from a newly isolated *Steinernema* from various agro climatic crop ecosystems because of their mutualistic symbiotic association has evolved exquisitely balanced.

Materials and Methods

Isolation of bacterial symbiont was performed from the hemolymph of the entomopathogenic *Steinernema carpocapsae* CPCRI1 nematode infected surface sterilized insect cadaver and cultured on NBTA medium (Akhurst, 1980). The colony morphology of the *Steinernema carpocapsae* associated bacterial isolates was studied on the NBTA and MacConkey agar plates. The biochemical characterization like catalase, oxidase, gelatinase, urease, nitrate reduction, MR-VP test and carbon utilization of the symbiotic bacterium was performed for determining bacterial identity (Thomas and Poinar, 1979).The insecticidal activity of the symbiotic bacteria was verified against *G. mellonella* larvae. Genomic DNA of the insecticidal potential pure cultured symbiotic bacterial isolate was extracted using the QIAamp® DNA minikit following the manufacturer's instructions and 16S rDNA was PCR-amplified using using the *27f* (5′-GAG AGT TTG ATC CTG GCT CAG-3′) and *1495r* (5′-CTA CGG CTA CCT TGT TAC GA-3′) primer pair, PCR products were purified with the QIAquick® PCR purification Kit and sequenced. The Obtained 16S rDNA nucleotide sequence aligned to corresponding sequences from the NCBI GenBank database by BLAST.

Results and Discussion

The EPN *Steinernema carpocapsae* CPCRI1 associated bacteria were isolated from the surface sterilized infected cadaver in NBTA medium (Fig. 1). Based on colony morphology, characteristics 12 isolates were selected, and studied their different key biochemical characteristics. The insecticidal activity of bacteria was tested by assessing the larvicidal activity of the native symbiotic bacterial isolates associated with *Steinernema carpocapsae* CPCRI1 against *Galleria mellonella* larvae and confirmed. The 16S rRNA of the selected elite bacterial isolate ScSB2 was sequenced. The sequence alignment and phylogenetic analysis with different *Xenorhabdus* spp. indicated that the elite isolate has the highest similarity with *X. indica* strain. Based on cultural, biochemical and molecular identification, we identified the symbiotic bacteria of *Steinernema carpocapsae* CPCRI1 as *X. indica* (*Xenorhabdus indica* - strain ScSB2; GenBank: MK530424.1) (Fig. 2). Somvanshiet et al. (2006) first reported *Xenorhabdus indica* sp. nov., symbiotic association with entomopathogenic nematode *Steinernema thermophilum*.



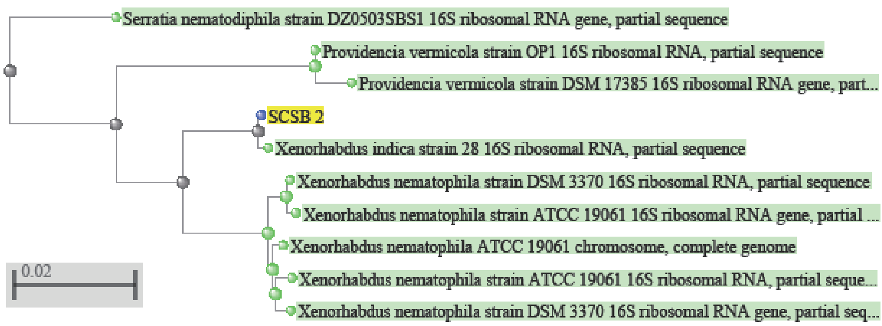


Fig.1. EPN associated bacterial isolates in NBTA media	**Fig.2. Phylogenetic tree of *Steinernema carpocapsae CPCRI SC1* symbiotic bacteria strain ScSB2**

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ES 05 BOPD 15

Evaluation of Toxicity of Acetamiprid 20 Sp To The Egg Parasitoid, *Trichogramma chilonis* (Ishii).

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Key words: *Toxicity, Acetamiprid, Egg parasitoid, Trichogramma chilonis*

INTRODUCTION

Cotton (*Gossypium hirsutum* Linn.) is an important agricultural crop cultivated in India for more than 5000 years. It plays a pivotal role in our national economy by providing livelihood for 60 million people. It suffers from the ravages of several insect and mite pests, right from germination to harvest, resulting in about 15 - 40 per cent yield loss, particularly the sucking pests at early stage of the crop cause significant damage. The yield loss assessed due to sucking pest alone is 46.5 %. Acetamiprid is one of the new chemical class belongs to neonicotinyl compound provide translaminar action, an excellent control against sucking pests in cotton (EFSA, 2012). Though the uses of insecticides remain as an important component of integrated pest management (IPM), biological suppression of insect pest is another tool considered to be equally important in pest management. Egg parasitoid, *Trichogramma chilonis* (Ishii) is very important in cotton ecosystem. These parasitoids are exposed directly to insecticides during spraying, as well as to the left over insecticides on the crop. Hence, laboratory experiment was conducted to assess the toxicity of acetamiprid 20 SP to egg parasitoid, *T. chilonis*.

MATERIALS AND METHODS

Laboratory experiment was conducted at the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore with seven treatments replicated three times to assess the safety of acetamiprid 20 SP to the egg parasitoid, *T. chilonis*. The experiment consisted of treatments such as acetamiprid 20 SP @ 10, 20, 40 and 80 g a.i./ha, pride 20 SP @ 20 g a.i./ha, a standard insecticide, monocrotophos 36 SL @ 200 g a.i./ha and Untreated control.

Effect of acetamiprid on the egg parasitoid, *T. chilonis*

The eggs of *C. cephalonica* were pasted on paper cards of 18x30 cm size having thirty 7 x 2 cm rectangles. These egg cards were placed in plastic bags along with the nucleus card at 6:1 ratio for parasitization. The parasitized egg cards were cut into one cm^2 bits and three days old hundred per cent parasitized eggs (eggs appearing black) were sprayed with insecticides at different concentrations using an atomizer. For untreated check, only distilled water was sprayed. The treated egg cards were shade dried for 10 minutes and then kept in a test tube of 10 x 1.5 cm size. The number of parasitoids that emerged from each treatment was recorded after 24 and 48 h of treatment and per cent emergence was worked out using the formula,

$$\text{Per cent emergence} = \frac{\text{No. of wasps emerged}}{\text{Total no. of eggs in 1 cm}^2} \times 100$$

Fresh eggs were provided to these parasitoids at 6:1 ratio and the number of parasitized eggs (eggs appearing black) were recorded after 24 and 48 h of treatment and the per cent parasitization was worked out using the formula,

$$\text{Per cent parasitization} = \frac{\text{No. of parasitized eggs}}{\text{Total no. of } \textit{Corcyra} \text{ eggs}} \times 100$$

RESULTS

The results on the effect of acetamiprid 20 SP on *T. chilonis* (Table.1) revealed that acetamiprid 20 SP at 10, 20, 40 and 80 g a.i./ha had little adverse effect on adult emergence after 24 h (69.00 and 77.00%) and 48 h (81.33 and 91.00%) of treatment, and there was no significant difference between pride 20 SP at 20 g a.i./ha and acetamiprid 20 SP at 20 g a.i./ha which recorded 74.00 and 87.00 per cent and 74.33 and 87.33 per cent, adult emergence respectively after 24 and 48 h. Monocrotophos 36 SL at 200 g a.i./ha was relatively more toxic, where the adult emergence was 56.00 and 74.33 per cent, respectively when compared to untreated check which recorded 86.67 and 96.67 per cent adult emergence after 24 and 48 h of treatment, respectively.

Effect of acetamiprid on oviposition (parasitization)

The highest parasitisation (81.00 and 91.33%) was recorded in the untreated check which differed significantly from other treatments followed by acetamiprid 20 SP at 10 g a.i./ha (73.00 and 86.00%). The recommended dose of acetamiprid 20 SP (20 g a.i./ha) recorded 69.00 to 81.67 per cent parasitization comparable with that of pride 20 SP (68.67 to 81.33%) after 24 and 48 h of treatment. Monocrotophos 36 SL at 200 g a.i./ha greatly reduced the per cent parasitization by 42.33 and 63.33 per cent, after 24 and 48 h of treatments respectively (Table.1).

Literature on the effect of acetamiprid on beneficial organisms is scanty. In the present study, acetamiprid, did not show ovipositional deterrence to *Trichogramma chilonis* (Ishii) which recorded more than 72.00 per cent parasitism. Similarly, adult emergence was not affected. Treatment of parasitized eggs with acetamiprid did not cause any ill effect to the developing parasitoids, adult emergence and emerged adults. This suggests that acetamiprid may be failed to penetrate the chorion of the host eggs, and hence safe to the developing stages of this parasitoid.

Table 1. Effect of acetamiprid 20 SP on the egg parasitoid, *Trichogramma chilonis* (Ishii)

T. No.	Treatment	Adult emergence (%)		Parasitization (%)	
		24 HAT	48 HAT	24 HAT	48 HAT
T_1	Acetamiprid 20 SP @ 10 g a.i./ha	77.00 $(61.36)^{b}$	91.00 $(72.56)^{b}$	73.00 $(58.70)^{b}$	86.00 $(68.05)^{b}$
T_2	Acetamiprid 20 SP @ 20 g a.i./ha	74.33 $(59.57)^{bc}$	87.33 $(69.16)^{c}$	69.00 $(56.17)^{c}$	81.67 $(64.65)^{c}$
T_3	Acetamiprid 20 SP @ 40 g a.i./ha	71.33 $(57.63)^{cd}$	84.00 $(66.44)^{cd}$	62.67 $(52.34)^{d}$	77.33 $(61.57)^{d}$
T_4	Acetamiprid 20 SP @ 80 g a.i./ha	69.00 $(56.17)^{d}$	81.33 $(64.41)^{d}$	60.00 $(50.77)^{d}$	72.00 $(58.06)^{e}$
T_5	Pride 20 SP @ 20 g a.i./ha	74.00 $(59.36)^{bc}$	87.00 $(68.89)^{c}$	68.67 $(55.96)^{c}$	81.33 $(64.41)^{c}$
T_6	Monocrotophos 36 SL @ 200 g a.i./ha	56.00 $(48.45)^{f}$	74.33 $(59.57)^{e}$	42.33 $(40.59)^{f}$	63.33 $(52.74)^{f}$
T_7	Untreated control	86.67 $(68.62)^{a}$	96.67 $(79.66)^{a}$	81.00 $(64.16)^{a}$	91.33 $(72.92)^{a}$

(Mean of three replications)

HAT – Hours After Treatment; In a column, means followed by a common letter are not significantly different by DMRT (P = 0.05); Values in the parentheses are arc sine transformed values

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ES 05 BOPD 16

Population dynamics of important insect pests and natural enemies on black gram, *Vigna mungo* (L.) in relation to weather parameters

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Keywords: *Blackgram, Whitefly, Pod bug, Pod borer, Coccinellids, Spiders*

Introduction

Blackgram is a one of the major pulse crops cultivated an area of 29.46 million hectares with production of 22.95 tonnes and an average productivity of 779 kg ha^{-1} during 2017-18 in India. In Tamil Nadu blackgram was cultivated in an area of 4.41 lakh hectare with the production of 2.74 lakh metric tonnes and an average productivity of 622 kg ha^{-1} during 2018-19 occupying 51.88 per cent area among other pulse crops. The blackgram is infested by more than 284 insect pest species belonging to 48 families. The borers and sucking pests are responsible for severe yield loss causing on an average of 2.5 to 3.0 million tonnes of pulses annually (Rabindra *et al.,* 2004). Keeping this in view, the present study was conducted to know the population dynamics of insect pests and natural enemies on black gram in relation to weather parameters.

Material and Methods

This experiment was conducted at NPRC experimental farm, Vamban during *Kharif* 2020. The individual plot size was 6x4m with spacing of 30×10 cm in Randomized Block Design (RBD) and replicated four times. The major pests (gram caterpillar, spotted pod borer, whitefly) and natural enemies (coccinellids, rove beetle, hymenopteran and spiders). The data on insect pests and natural enemies population were subjected to correlation analysis after necessary transformation using the daily weather parameters like temperature (maximum and minimum), relative humidity and rainfall.

Results and Discussion

The infestation of flea beetle damage was started from 7 DAS and leaf webber, leafhopper, whitefly and grasshopper were started from 15 DAS and continued till 35 DAS. *Spodoptera litura* infestation started from 21 DAS to till 49 DAS. Pentatomid bug infestation was started from 21 DAS to till 42 DAS. Pod bug infestation started from 35 DAS and continued to exist till 70 DAS. *Maruca* infestation started from 35 DAS and continued to exist till 63 DAS. Blue butterfly infestation started from 28 DAS and continued to exist till 70 DAS. Blister beetle was observed from 28 DAS to 56 DAS. All the recorded pests except *Helicoverpa, Maruca* and blue butterfly were positively correlated to maximum temperature. Relative humidity was negatively correlated except *Helicoverpa, Maruca* and blue butterfly. Rainfall was negatively correlated to leafhopper, grasshopper and aphids population. As far as natural enemies are concerned, coccinellids were observed from 15 DAS to 49 DAS. *Rhynocoris* was observed during 21 and 28 DAS. Rove beetles were observed during 21 DAS to 70 DAS. Hymenopterans were observed during 21 to 56 DAS (Table 1). Spiders were observed starting from 7 DAS to till 70 DAS. Coccinellids, cricket, hymenopteran and spiders were positively correlated to maximum temperature and rainfall. Rove beetle was positively correlated to minimum temperature and rainfall (Table 2).

The aphid population was found to be negatively and significantly correlated with relative humidity and rainfall (Kundu *et al.,* 2021). The population of whitefly showed non-significant positive correlation with maximum temperature and showed non-significant negative correlation with relative humidity (Singh and Kumar, 2011; Yadav *et al.,* 2015 and Kumar and Singh, 2016). This study on seasonal incidence of insect pests is the basis for any pest management programme and correlation study of insect pests and natural enemies with weather parameters provides information on influence of weather parameters on insect pest population.

Table 1. Correlation-coefficient between insect pests and weather parameters

Pests	Temperature		RH	RF
	Max.	Min.		
Flea beetle damage	0.60	0.36	-0.67*	0.36
Leaf webber	0.73*	-0.10	-0.73*	0.31
Tobacco caterpillar	0.38	-0.15	-0.45	0.25
Whitefly	0.33	-0.24	-0.34	0.24
Leafhopper	0.78**	0.10	-0.93**	-0.09
Grasshopper	0.54	-0.12	-0.75*	-0.56
Pentatomid bug	0.65*	0.02	-0.79*	0.01
Aphids	0.38	0.13	-0.67*	-0.66*
Other defoliators	0.46	0.19	-0.75*	-0.31
Pod bug	0.16	-0.37	-0.08	0.56
Blue butterfly	-0.07	-0.06	0.10	0.17
Blister beetle	0.57	-0.21	-0.45	0.45
Spotted podborer	-0.12	0.06	0.15	0.45
Gram podborer	-0.27	0.13	0.27	0.27

Table 2: Correlation-coefficient between natural enemies and weather parameters

Natural Enemies	Temperature		RH	RF
	Max.	Min.		
Coccinellids	0.66*	-0.06	-0.76*	0.16
Dragonfly & Damselfly	0.38	0.31	-0.12	0.27
Rhynocoris	0.23	0.14	-0.57	-0.49
Cricket	0.35	-0.21	-0.22	0.73*
Rove beetle	-0.02	0.24	-0.10	0.34
Hymenopterans	0.42	0.02	-0.63*	0.10
Spiders	0.34	-0.18	-0.33	0.53

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

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ES 05 BOPD 17

Optimization of media supplements in enhancing the culture characteristics and biochemical profile of three strains of the entomopathogenic fungi, *Beauveria bassiana* (Balsamo) Vuillemin

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***Keywords**: Beauveria bassiana, Chitin, chitosan, yeast, Plutella xylostella*

Introduction

Entomopathogens are gaining momentum as an indispensable component of Integrated Pest Management (IPM) and organic farming practises (Butt *et al.,* 2001). The entomopathogenic fungi, *Beauveria bassiana* is a widely exploited member of microbial biocontrol agent. Growth, sporulation and enzymatic activity are the virulence determining factors of this fungus. The present study was conducted with a view to enhance the virulence of three strains of *B. bassiana* by enriching the growth media with different supplements.

Materials and methods

The basic culture media, Potato Dextrose Broth was amended with chitin (0.05%), chitosan (0.05 %) and yeast (1 %) and the effect of these supplements on biomass, sporulation, enzyme activity and pathogenicity was evaluated for three strains of *B. bassiana viz.,* TM (MH590235), BR (MK918495) and BbI8 (KX263275)**.** Mycelial mat collected from 14 day old cultures was dried at 100 º C for 24 h and weighed for biomass assessment. Culture filtrates from 14 day old cultures of three strains of *B. bassiana* cultured on different growth media were used for assessment of spore load (using improved Neubauer haemocytometer) and pathogenicity on second instar larvae of Diamondback moth, *Plutella xylostella*. The level of production of cuticle degrading enzymes, *viz*., lipase and protease under enriched growth conditions were assessed through plate assay method. Lipolytic activity was assessed by estimating the zone of fatty acid precipitation with Tween-20 (1 %) as substrate (Hasan *et al*. 2013). Zone of degradation of proteins after addition of the substrate skimmed milk (1 %) was estimated for protease activity (St.Leger *et al*. 1999). The treatments were analysed using split plot CRD in STAR version 2.0.1 software (2014) developed by International Rice Research Institute (IRRI), Biometrics and Breeding Informatics Plant Breeding, Genetics, and Biotechnology unit, Manila, Philippines.

Results and discussion

The results of study revealed that significant variation existed among the three strains in terms of biomass, sporulation, enzyme activity and pathogenicity with TM being the promising strain. Among the amendments, yeast addition was found to enhance the performance of all the three strains. TM recorded highest protease production (2.23 cm) in yeast followed by BR (1.73 cm) and Bb18 (1.47 cm). Maximum production of lipase by TM was noticed in chitin, chitosan and yeast amended media (2.18 cm, 2.08 cm, 2.15 cm respectively) followed by BR 1.00 cm, 0.83 cm, 0.60 cm respectively in chitin, chitosan and yeast amended media.

Among the isolates, TM recorded higher biomass (3.33 g), spore production (10.84 x 10^9 spores ml^{-1}), protease activity (2.53 cm), lipase activity (2.15 cm) compared to unamended control (1.57 g, 0.89 x 10^9 spores ml^{-1}, 1.87 cm and 2.13 cm respectively). Addition of yeast and chitosan to media was found to cause 100 per cent mortality of *P. xylostella* larvae by TM within five days of treatment (Fig. 1). Reduction in median lethal time was observed in *Isaria javanica* against *Bemisia tabaci* on amending with yeast extract by Xie *et al.* (2016). Variation among strains in production of enzymes observed in this study was in agreement with Gupta *et al.* (1992) who observed a surprising degree of strain variability in the production of insect cuticle degrading enzymes by *B. bassiana.* This study proved that the deliberate exogenous supplementation of media can play significant role in enhancing virulence of entomopathogenic fungi. The findings of this study can give an insight about the factors to be considered for mass production of EPF which in turn can lead to increased efficacy of these fungal BCAs in an IPM programme.

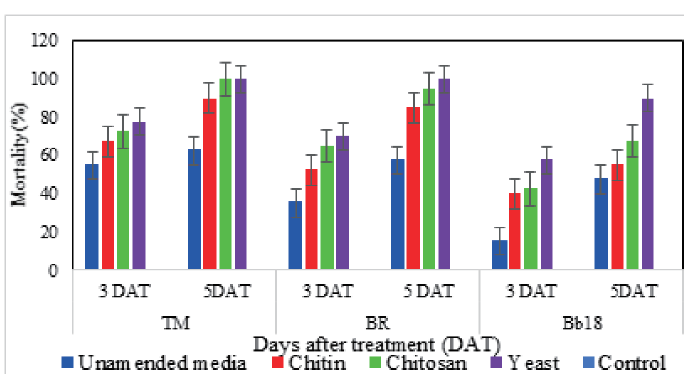

Fig. 1. Per cent mortality of *P. xyllostella* **treated with three isolates of** *B. bassiana* **grown under different media**

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ES 05 BOPS 01

Effect of chemicals on *Galleria mellonela* infectivity of entomopathogenic nematode, *Steinernema glaseri* (Glaser, 1932)

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Keywords: *Steinernema glaseri, Galleria mellonela, chemicals, entomopathogenic nematodes, infective juveniles*

Introduction

Entomopathogenic nematodes act as good biocontrol agents to manage lepidopteron and coleopteran pests. *Steinernematidae* and *Heterorhabditae* are considered as important families in the entomopathogenic nematodes group. Third stage juveniles (J3) is the infective stage of entomopathogenic nematodes. *Xenorhabdus* and *Photorhabdus* are the bacterium associated with the intestinal region of *Steinernema* and *Heterorhabditis.* Infectivity of entomopathogenic nematodes were enhanced by physical and chemical stressors in *Tenebrio molitor* larvae (Brown, Shapiro-Ilan and Gaugler, 2006). Based on these facts, *in-vitro* study was undertaken with the following objectives to assess the influence of stressors on entomopathogenic nematodes, *Steinernema glaseri* in Wax moth, *Galleria mellonella.*

Materials and methods

Culture of entomopathogenic nematodes, *Steirnernema glaseri* infective juveniles (IJs) were maintained at the Department of Nematology, TNAU, Coimbatore. Different chemicals *viz.,* Poly Ethylene Glycol (4%PEG), 1.75mM Magnesium sulphate and 0.65Mm Manganese sulphate were used as chemical stressors. Each chemical (0.5 ml) was pipetted out using micropipette and placed at the centre of Whatmann No. 1 filter paper. Five final instar larvae of *G. mellonella* were placed on the Whatmann filter paper No. 1 separately. After five minutes of incubation, 0.5 ml of *S. glaseri* IJs was inoculated on the filter paper. These plates were then incubated for three days. After the infection of entomopathogenic nematodes, infected larvae were placed on modified White's trap for harvesting of *S. glaseri.* Totally four treatments and six replications were maintained for each experiment. The experiment was maintained in Completely Randomized Block Design was used as a statistical method.

Results and Discussion

Exposure of *G. mellonella* larvae to different chemicals increased the number of infected larvae as well as number of infective juveniles emerged out. The results revealed that the treatment under $MnSO_4$ resulted in the highest number of infected larvae (4.67 larvae out of 5). Among all the chemicals tested, PEG at 4 per cent exposure showed the higher IJs emergence of *S. glaseri* from cadaver which was about 40.5 per cent increase over control (distilled water). In contrast the results of (Kawaka *et al.,* 2014) reported that higher concentration carbon, nitrogen, phosphorus reduced the entomopathogenic nematodes.

Table 1. Infection of *S. glaseri* on chemicals exposed *G. mellonella*

Treatments	Means of six replications	
	No. of *S. glaseri* infected larvae[1]	No. of infective juveniles in 20 ml of *S. glaseri* suspension[2]
T1 – PEG 4%	4.15 (2.10)	6597.83[a] (3.81)
T2 – $MgSo_4$	4.16 (1.66)	3708.0[c] (3.56)
T3 – $MnSO_4$	4.67 (2.15)	2124.16[d] (3.32)
T4 – Control (distilled water)	3.34 (1.71)	4694.4[b] (3.61)
SEd	0.14	0.003
CV (%)	12.39	0.18
CD (p=0.01)	0.41NS	0.01

[1]&[2]-Figures in parentheses are square root and Log transformed value respectively. In a column, means followed by common alphabet are not significantly different from each other at 1% level by DMRT. NS- Non significant

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ES 05 BOPS 02

Comparative biology and Parasitic potential of *Bracon brevicornis* on *Spodoptera frugiperda* (Lepidoptera: Noctuidae) larval instars

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Key words: *Fall armyworm, Bracon brevicornis*

Introduction

Maize *Zea mays* L. is a leading staple food crop cultivated all over the world. Fall armyworm was a major economic insect pest of various crops and its damage is severe in maize crop. Pests and natural enemies have co-evolved in the natural ecosystem. *Bracon brevicornis* (Hymenoptera: Braconidae) is a cosmopolitan, gregarious, ecto-parasitoid that parasitizes on the larval stage of several Lepidopterous species. In this study, parasitizing ability of *B. brevicornis* on larval instars of fall armyworm was carried out under laboratory conditions.

Materials and Methods

Third, fourth and fifth instar larvae of fall armyworm were utilized to examine the biological parameters of *B. brevicornis* in a controlled laboratory condition (70 ± 5% R.H, 25 ± 1ºC) at Entomology laboratory, Anbil Dharmalingam Agricultural College and Research Institute, Trichy. The experiment was carried out in plastic jars (15 × 30 cm). Five pairs of 24 hour old, gravid *B. brevicornis* adults were released into the plastic jars with 50% honey dipped cotton swab as adult food inside the jar. Five third instar fall armyworm larvae were sandwiched over the jar and tightened to keep the larvae in the same position for parasitization for 24 hours. Four replications were used for each treatment with five larvae per replication. The parasitized host larvae were carefully removed and maintained in petri dishes (10 × 30 cm) after 24 hours of parasitism. Observation on number of parasitoid larvae emerged, pupated, adult emerged and their longevity were recorded. Separate set of experiments were conducted for fourth and fifth instar fall armyworm larvae by adopting similar procedure. The collected data was statistically analyzed in Complete Randomized Design for laboratory experiments. The percentage data and data gathered were subjected to arc sine and square root transformation. The statistical analysis was carried out in AGRES software.

Results and Discussion

Table 1: Comparative biology and Parasitic potential of *B. brevicornis* on *S. frugiperda* larval instars

Larval instar	Developmental period of *B. brevicornis* on fall armyworm		Parasitic potential of *B. brevicornis* on fall armyworm		
	Total developmental period (Days)	Adult longevity (Days)	Number of bracon larvae/ host larva	Number of bracon pupae/ host larva	Number of bracon adults emerged/ host larva
Third instar	14.29 (3.86)^{c}	10.6 ± 0.8 (3.25)^{c}	6.8 ± 0.37 (2.60)^{c}	4 ± 0.31 (1.99)^{c}	2.6 ± 0.24 (1.60)^{c}
Fourth instar	11.38 (3.38)^{b}	14.4 ± 0.5 (3.79)^{b}	10.4 ± 0.5 (3.22)^{b}	6.6 ± 0.24 (2.56)^{b}	4.3 ± 0.2 (2.06)^{b}
Fifth instar	10.28 (3.29)^{a}	19.4 ± 0.6 (4.40)^{a}	18.4 ± 0.5 (4.28)^{a}	13.6 ± 0.4 (3.68)^{a}	10.8 ± 0.37 (3.28)^{a}
SEd	0.02	0.02	0.03	0.02	0.01
CD (0.1)	0.08	0.04	0.07	0.04	0.02

Each value is a mean of four replication with standard deviation ; Figures within parentheses are square root transformed values

The parasitic potential of *B. brevicornis* on third, fourth and fifth instar larvae of fall armyworm was assessed. The total developmental period ranged from 10.28 to 14.29 days. The number of *B. brevicornis* larva and pupa emerged from host larva was ranged between 6.8 to 18.4 and 4 to 13.6 respectively. Total number of adults emerged from single host larvae ranged from 2.6 to 10.8. Present study indicated that comparative life cycle parameters are useful for the assessment of fall armyworm larval instar preference by *B. brevicornis*.

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Malesios, G. A. and D. A. Prophetou-Athanasiadou. 2014. Development of the parasitoid *Bracon brevicornis* on different larval instars (L2-L5) of the Indian meal moth *Plodia interpunctella. Entomologia Hellenica,* 23 (2), pp.59-64.

Sree Latha, E., K. Sneha Madhuri, S. Jesu Rajan, N. Lavanya and G. Ravi. 2019. Efficacy of *Bracon hebetor* Say on *Spodoptera frugiperda* (JE Smith) evaluated with *Helicoverpa armigera* (Hub.), *Spodoptera litura* Fabricius and *Corcyra cephalonica* Stainton as alternate hosts. *Journal of Entomology and Zoology studies,* 7(3), pp.1309-1313.

ES 05 BOPS 03

Comparative biology and Parasitic potential of *Bracon brevicornis* on *Spodoptera frugiperda* (Lepidoptera: Noctuidae) larval instars

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Key words: *Fall armyworm, Bracon brevicornis*

Introduction

Maize *Zea mays* L. is a leading staple food crop cultivated all over the world. Fall armyworm was a major economic insect pest of various crops and its damage is severe in maize crop. Pests and natural enemies have co-evolved in the natural ecosystem. *Bracon brevicornis* (Hymenoptera: Braconidae) is a cosmopolitan, gregarious, ecto-parasitoid that parasitizes on the larval stage of several Lepidopterous species. In this study, parasitizing ability of *B. brevicornis* on larval instars of fall armyworm was carried out under laboratory conditions.

Materials and Methods

Third, fourth and fifth instar larvae of fall armyworm were utilized to examine the biological parameters of *B. brevicornis* in a controlled laboratory condition (70 ± 5% R.H, 25 ± 1ºC) at Entomology laboratory, Anbil Dharmalingam Agricultural College and Research Institute, Trichy. The experiment was carried out in plastic jars (15 × 30 cm). Five pairs of 24 hour old, gravid *B. brevicornis* adults were released into the plastic jars with 50% honey dipped cotton swab as adult food inside the jar. Five third instar fall armyworm larvae were sandwiched over the jar and tightened to keep the larvae in the same position for parasitization for 24 hours. Four replications were used for each treatment with five larvae per replication. The parasitized host larvae were carefully removed and maintained in petri dishes (10 × 30 cm) after 24 hours of parasitism. Observation on number of parasitoid larvae emerged, pupated, adult emerged and their longevity were recorded. Separate set of experiments were conducted for fourth and fifth instar fall armyworm larvae by adopting similar procedure. The collected data was statistically analyzed in Complete Randomized Design for laboratory experiments. The percentage data and data gathered were subjected to arc sine and square root transformation. The statistical analysis was carried out in AGRES software.

Results and Discussion

The parasitic potential of *B. brevicornis* on third, fourth and fifth instar larvae of fall armyworm was assessed. The total developmental period ranged from 10.28 to 14.29 days. The number of *B. brevicornis* larva and pupa emerged from host larva was ranged between 6.8 to 18.4 and 4 to 13.6 respectively. Total number of adults emerged from single host larvae ranged from 2.6 to 10.8. Present study indicated that comparative life cycle parameters are useful for the assessment of fall armyworm larval instar preference by *B. brevicornis*.

Table 1. Comparative biology and Parasitic potential of *B. brevicornis* on S. frugiperda larval instars

Larval instar	Developmental period of *B. brevicornis* on fall armyworm		Parasitic potential of *B. brevicornis* on fall armyworm		
	Total developmental period (Days)	Adult longevity (Days)	Number of bracon larvae/host larva	Number of bracon pupae/ host larva	Number of bracon adults emerged/host larva
Third instar	14.29 (3.86)^{c}	10.6 ± 0.8 (3.25)^{c}	6.8 ± 0.37 (2.60)^{c}	4 ± 0.31 (1.99)^{c}	2.6 ± 0.24 (1.60)^{c}
Fourth instar	11.38 (3.38)^{b}	14.4 ± 0.5 (3.79)^{b}	10.4 ± 0.5 (3.22)^{b}	6.6 ± 0.24 (2.56)^{b}	4.3 ± 0.2 (2.06)^{b}
Fifth instar	10.28 (3.29)^{a}	19.4 ± 0.6 (4.40)^{a}	18.4 ± 0.5 (4.28)^{a}	13.6 ± 0.4 (3.68)^{a}	10.8 ± 0.37 (3.28)^{a}
SEd	0.02	0.02	0.03	0.02	0.01
CD (0.1)	0.08	0.04	0.07	0.04	0.02

Each value is a mean of four replication with standard deviation ; Figures within parentheses are square root transformed values

References

Malesios, G. A. and D. A. Prophetou-Athanasiadou. 2014. Development of the parasitoid *Bracon brevicornis* on different larval instars (L2-L5) of the Indian meal moth *Plodia interpunctella. Entomologia Hellenica,* 23 (2), pp.59-64.

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ES 05 BOPS 04

Scanning electron microscopic studies for confirmation of endophytic colonization of *Beauveria bassiana* in maize

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Key words: *Beauveria bassiana, Endophyte, Maize, Scanning Electron Microscopy*

Introduction

Beauveria bassiana (Balsamo) Vuillemin (Ascomycota: Hypocreales) is the most extensively studied entomopathogenic fungus for biological control of a wide range of insect pests. It has the characteristic feature of colonising as an endophyte when inoculated artificially and exhibit defence against insect pests. *Beauveria bassiana* established as an endophyte by artificial inoculation in maize and has also been used as a biocontrol agent for management of insect pests like *Spodoptera frugiperda* (Mwamburi, 2021), *Chilo partellus* (Renuka *et al*., 2017) and *Ostrinia nubilalis*. The current study was taken up to confirm the colonization of *B. bassiana* in maize tissues through scanning electron microscopic techniques.

Materials and Methods

Seeds of maize variety CO6 (TNAU, Coimbatore, India) was used for the experiment. Before inoculation of BR *B. bassiana* strain, seeds were surface sterilized with 3% sodium hypochlorite for two minutes, then with 70% ethanol for two minutes followed by three times rinsing with sterile distilled water. The seeds were then kept in laminar air flow chamber for 30 min to dry. For seed inoculation treatment, 30 seeds were soaked in 5 ml of 1×10^8 conidial suspension of *B. bassiana* overnight. After that they were placed on sterile wet filter paper in sterile petriplates. Control seeds were treated similarly with 0.002% Tween 80. Seeds were plated for germination on three Petri dishes, 10 seeds each, with a piece of wet filter paper in humid conditions (100% RH). After germination five small seedlings randomly selected from each replicate with two cotyledons. Establishment of *B. bassiana* in maize seedlings was determined 7 days post inoculation. Plumule, radicle and cotyledon samples for scanning electron microscope were collected for observation on conidial attachment and germination. The specimens were observed on SEM at Department of nanotechnology, TNAU, Coimbatore and the images were taken at 2000x-5000x.

Results and discussion

In SEM study, the conidial attachment of *B. bassiana* on the seed coat was observed after 48 hours of treatment. Figure 1a showed the hyphal ramification on seed coat as well as conidia and phialides that differentiated from a germ tube. SEM studies of cross section of plumule and radicle showed the colonization of *B. bassiana* in intercellular spaces of parenchymatic cells (fig1c and fig1d). While intracellular colonization was not found. Some hyphae were detected growing through the xylem vessels, which could enable the fungus to travel within the plant, and ultimately to provide overall insecticidal protection (fig 1d). No *B. bassiana* colonization was observed in untreated control. *B.*

bassiana showed colonization in the parenchyma and in the vascular tissue of date palm petioles (Vidal *et al.,* 2006). Wagner and Lewis (2000) observed the hyphae and conidia of *B. bassiana* in the parenchyma tissue and xylem vessels in corn through TEM.

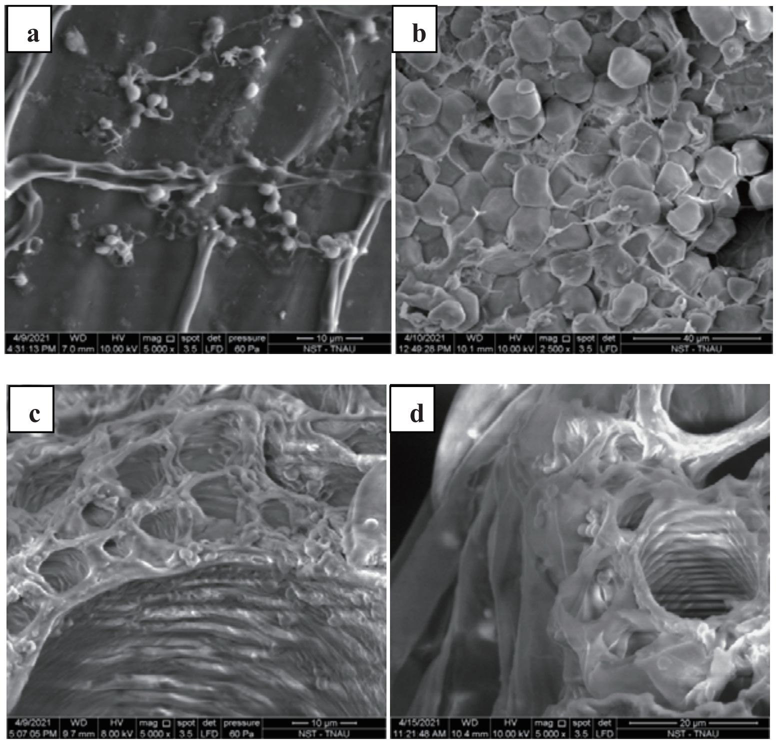

Fig 1. SEM images of Bb-BR isolate: (a) Seed coat- Conidiophore and phialides that formed from hypha. (b) Cotyledon- Hyphal ramification. (c) Radicle - Hyphae in intercellular spaces of parenchymatic cells. (d) Plumule - Hyphae and conidia of *B. bassiana* in the parenchyma tissue and xylem vessels.

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ES 05 BOPS 05

Toxicity of native *Bacillus thuringiensis* isolates against fall armyworm, *Spodoptera frugiperda* (J.E. Smith)

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Keywords: *Fall armyworm, Bacillus thuringiensis, bioassay, cry genes, PCR, SDS PAGE*

Introduction

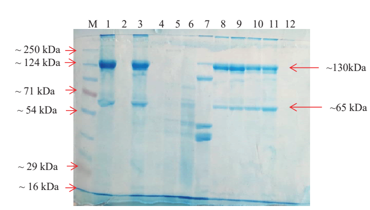
Fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) has its root of origin from the tropical and sub-tropical areas of America. It was first reported in India at College of Agriculture, Shivamogga, Karnataka during May- June, 2018 and at Erode and Karur districts of Tamil Nadu in November, 2018. The yield loss recorded by *S. frugiperda* was around 49 per cent in maize. It is a highly polyphagous pest and its control measure relies mostly on the usage of chemical pesticides which led to the development of resistance. *Bacllius thuringeinsis* is a spore forming soil bacterium that can be used a alternative bio pesticide due to its specificity and effectiveness.

Materials and Methods

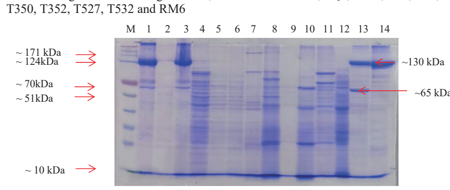
Insect culture of *S. frugiperda* was maintained on TNAU diet at the Bioassay laboratory of Department of Plant Biotechnology. Twenty indigenous *Bt* isolates along with standard strain (HD1), positive check (T405) and negative check (4Q7) were received from the Department of Plant Biotechnology and maintained on T3 medium. The colony morphology of the isolates was observed visually and the spore crystal mixture was harvested by the protocol followed by Ramalakshmi and Udayasuriyan (2010). SDS PAGE was performed with standard protocol of Laemmli (1970) to observe the protein profile of the *Bt* isolates. The quantified spore crystal mixtures were further used to conduct the leaf dip bioassay against the neonates of *S. frugiperda* with 20 µl of 25 µl/ml of protein. PCR screening was performed with specific primers of lepidopteran toxic protein encoding genes *viz., cry1 (cry1Aa, cry1Ab, cry1Ac), cry2 (cry2Aa, cry2Ab), cry9* and *vip3A.*

Results and Discussion

Out of 20 isolates tested, isolates T350 and T352 produced 100 % mortality, isolates T527 and T532 produced 96 % mortality, T543 and T236 produced 83 % and 30 % mortality, respectively. PCR results showed the presence of both *cry1* and *cry2* genes in all the effective isolates except T236, in which only *cry1Ac* was found to present. Among 20 isolates tested, *vip3A* gene was found in T350, T527 and T532 alone. SDS PAGE analysis showed the presence of both Cry1 and Cry2 proteins of ~130 kDa and ~65 kDa size in all effective isolates except T236 where only Cry1 protein of ~130 kDa size was present. Kaviyapriya *et al.* (2018) reported that the *Bt* isolate T29 showed 100 per cent mortality against *S. frugiperda* and PCR screening confirmed the presence of *cry1, cry2Aa* and *vip3A* genes. In another report, five *Bt* isolates *viz.,* SWK1, KS2-3, 2M-6, KS2-6 and QZ-19 effective against *S. litura* produced protein bands of 135 and 65 kDa size and also found PCR positive for *cry1, cry2Aa* and *cry2Ab* genes (Reyaz *et al*. 2017).



Lane M - high molecular range marker, Lane 1 to 12 - HD1, 4Q7, T405, T44, T73, T161, T210, T350, T352, T527, T532 and RM6



Lane M - high molecular range marker, Lane 1 to 12 - HD1, 4Q7, T405, T341, T342, T343, T345, T346, T347, T348, T349, T351, T543 and T236.

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ES 05 BOPS 06

Dominance of *cry1* genes in indigenous isolates of *Bacillus thuringiensis* toxic to *Plutella xylostella* (Linnaeus)

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Keywords: Dominance, Plutella xylostella, Bacillus thuringiensis, Toxicity

INTRODUCTION

Bacillus thuringiensis (*Bt*) has the ability to synthesize crystalline protein (δ-endotoxins) during the sporulation process and in certain cases due to the production of vegetative insecticidal proteins (VIPs). The insecticidal properties of δ-endotoxin from the bacterium *Bacillus thuringiensis* (*Bt*) have been recognized commercially for over 40 years. Some *Bt* strains are widely used to control Lepidoptera, Diptera and Coleoptera pests, and those in other invertebrates like nematodes. There has been intense interest in recent years in collecting, analysing and screening of *Bt* isolates. The aim of this study was to check the type of *cry* genes present in indigenous *Bt* isolates toxic to of Diamondback moth, *Plutella xylostella* larvae.

MATERIALS AND METHODS

Test isolates (58 indigenous *Bt* isolates), standard strain HD1 and acrystalliferous negative check 78/11 were obtained from Department of Plant Biotechnology, TNAU, Coimbatore, India and maintained in T3 media/broth for genomic DNA extraction and production of spore crystal mixture. Total Genomic DNA used as a template for the amplification of *cry1*, *cry2* and *vip3A1* genes. The isolated DNA was quantified through Nanodrop (Genova nano, Genway) and the integrity was evaluated by agarose gel electrophoresis (1%). Each polymerase chain reaction (PCR) mixture contained, 20-50 ng template DNA, 1 µM of each primer (Ben-Dov *et al.,* 1997) and 10 µl of 2 x PCR Master Mix (Smart prime) consisting of dNTPs, Taq polymerase, PCR buffer and the final volume was made up to 20 µl with sterile distilled water. PCR amplification was performed in a thermal cycler (ProFlex PCR system, Applied Biosystems). The PCR amplicons were separated along with 1kb DNA ladder in 1 % agarose gel. The amplified products were visualized under UV transilluminator (Bio-Rad).

RESULTS AND DISCUSSION

PCR analysis for four lepidopteran specific genes (*cry1*, *cry2*, *cry9* and *vip3A1*) showed the presence of only *cry1*, *cry2* and *vip3A1* genes but not *cry9* gene. Out of fifty-nine isolates, *cry1* gene family was found to be present in 30 isolates (Table 1). Fourteen isolates showed the presence of more than one gene, in different combinations. In our study, *cry1* was more prevalent than *cry2* and *vip3A1* genes, in accordance with earlier reports (Lone *et al*., 2017). Among all the *Bt* isolates, only sixteen showed the presence of single gene, while other positive isolates confirmed the presence of both *cry* and *vip* genes in combinations. Ben-Dov *et al*. (1997) has reported the tendency of occurrence of *cry1* and *cry2* genes together. *Bt* isolates containing inter group crystalline protein encoding genes are ideal candidates for the development of broad-spectrum biopesticides. All the twelve isolates that showed 100 per cent mortality including positive control (HD1) were PCR positive for *cry1*. In the present study, *vip3A1* positive isolates have been identified to contain *cry1* and *cry2* genes as similar with previous studies (Sahin *et al*., 2018).

Table 1. Distribution of *cry* genes in native *Bt* isolates

S. No	Cry gene screened	No of positive isolates (n= 59)
1.	*cry1*	30
2.	*cry2*	9
3.	*cry9*	0
4.	*vip3*	9
5.	*cry1 + cry2*	10
6.	*cry1 + cry2 + vip3*	5
7.	*cry1 + vip3*	9
8.	*cry2 + vip3*	5

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ES 05 BOPS 07

Prevalence of entomopathogenic nematodes (Rhabditida :Steinernematidae and Heterorhabditidae) against insect pest in vegetable growing region of Tamil Nadu

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Keywords: *Survey, Entomopathogenic nematodes, Steinernema, Heterorhabditis, molecular characterization, horticultural crops*

Introduction

Horticultural crops constitute a necessary share for total agricultural production in India. In Tamil Nadu with different agro climatic conditions and varied soil types it is highly suited for the production of horticultural crops. The entomopathogenic nematodes present in all climatic zones and they occur in natural and terrestrial ecosystem such as forests, horticultural and agricultural fields. The species and isolates exhibit considerable variation in terms of host range, reproduction, infectivity and conditions for survival (i.e. temperature, soil moisture, etc.) (Gaugler& Kaya, 1990). A systemic survey is needed for the naturally occurring beneficial nematode population in the cultivated crops, because the native species of entomopathogenic nematodes will be effective for the management of insect pests.

Materials and methods

A total of 80 samples were collected from Dharmapuri, Krishnagiri, Salem, Coimbatore, Thirupur, Namakkal, Thirunelveli, Erode, Trichy, Theni, Dindigul and Nilgris districts of Tamil Nadu. Samples were collected at hills, cultivated area and different agro climatic conditions, soil types, moisture and temperature regions of Tamil Nadu**.** Entomopathogenic nematodes were recovered from the soil samples by using the last instar larvae of *C. cephalonica* as insect bait instead of *Galleria mellonella* by Bedding and Akhurst (1975).Newly isolated entomopathogenic nematodes *viz*., *Heterorhabditis* spp. and *Steinernema* spp. were continuously sub-cultured on larvae of rice meal moth, *C. cephalonica*. The nematodes isolates were identified based on morphologicaland molecular characterization. Morphological and morphometric characters and rRNA ITS gene sequences were used to identify the isolates. The nematode species used to testing the virulence against insect pests.

Results and Discussion

A total of 80 soil samples were collected for the presence of EPN from twelve districts positive for occurrence. Among ten positive isolates, six isolates recovered were steinernematids, five isolates recovered were heterorhabditids and one isolates recovered from undescribed belonging to *Oscheius* genus. Based on morphometrics and internal transcribed spacer (ITS) sequence data, recovered isolates were identified as, *Steinernema siamkayai*, *S. carpocapsae* and two *Heterorhabditis* isolates identified as *Heterorhabditis indica, H. bacteriophora*, *Heterorhabditis* sp. (unidentified species). One isolates of *Oscheius* species were identified as new undescribed species. *H. indica*, *S. siamkayai* and *Oscheius* species were spread in diverse habitats of vegetable ecosystems **(Table 1).** The earlier study reported *S. siamkayai* prevalence more from Indian soil sample (Maheswari*etal*., 2005). Prevalence of entomopathogenic nematodes more in vegetable growing regions of Tamil Nadu, the soil loamy soil with pH of 4.5 to 8.5 and organic matter content ranging from 0.85 to 2.62.Raizia *et al*., 2011 reported that nematode positive soil pH range from 4.6 to 8.0. Soil pH ranged from 6-7 for steinerematidis positive soils. These nematode isolates *S. siamkayai* and *Heterorhabditis* spp were more effective against *C cephalonica*, *G. mellonella* and *Spodoptera frugiperda*. Natural distribution of native isolates of entomopathogenic nematodes used to insect pest management.

Table 1. Diversity of entomopathogenic nematodes in horticultural ecosystems of Tamil Nadu

S. No	Locality	Crops sampled	Isolated Nematode species	Isolates with Accession No
1	Tirunelveli	Tomato	*Heterorhabditis indica*	TN-1(MK463944)
2	Tiruppur	Brinjal	Steinernema siamkayai	PC-1(MK494943)
3	Coimbatore	Chilies	S. siamkayai	CO-1(MK610674)
4	Erode	Cabbage	*Heterorhabditis bacteriophora*	OH-1(MN450298)
5	The Nilgiris	Nutmeg	*Heterorhabditis* sp.	BH-1(MN450297)
6	The Nilgiris	Bitter gourds	S. siamkayai	OS-1(MN450296)
7	Thiruvanamalai	Curcurbits	*Oscheius* sp.	GT-1(MN450295)
8	Salem	Brinjal	S. siamkayai	NB1(MN635765
9	Dharmapuri	Tomato	*Heterorhabditis* sp.	DH-1(MN635764)
10	Trichy	Tomato	S. siamkayai	TRS-1(MN704735)

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ES 05 BOPS 08

Efficacy of *Beauveria bassiana* isolates against the Fall Army worm, *Spodoptera frugiperda* (J.E. Smith) under laboratory conditions

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Keywords: *Beauveria bassiana, Spodoptera frugiperda, bioassay,* LC_{50}

Introduction

Maize (*Zea mays* L.) is the third most important cereal crop in India after rice and wheat which accounts for around 10 per cent of total food grain production in the country. The Fall Armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) of the family Noctuidae, Lepidoptera is a serious yield constraint in this crop (Sparkes, 1986). The white muscardine fungus, *Beauveria bassiana* (Balsamo) Vuillemin is the most studied entomopathogenic fungi widely applied against agricultural insect pests due to broader host range (Wraight *et al*., 2000). In the present investigation, five indigenous isolates of *Beauveria bassiana* were evaluated for pathogenicity and endophytic activity in maize against *S. frugiperda* under controlled laboratory conditions.

Materials and methods

Pathogenicity test

Fungal spore suspension of the five isolates were prepared by scrapping spores from sporulated plates and were suspended in 10 mL sterile distilled water containing 0.05 per cent Tween 80®. The spore count in the liquid suspension was assessed using improved Neubauer haemocytometer. Maize leaf bits were treated with different concentration of *B. bassiana* isolates containing 0.05 per cent Tween 80®. Leaf bits dipped in 0.05 per cent Tween 80® served as untreated control. Treated leaf bits were placed over wet filter paper disc of 6 cm size kept on the petri plates. The experiment was performed in completely randomized design with seven treatments replicated three times. Thirty number of different instars (first, second and third) were released for each treatment and incubated at room temperature of 25±2°C. Percentage mortality was corrected (Abbott, 1925) and statistically analyzed after necessary transformation.

Endophytic study using seed treatment method

Maize seeds are superficially disinfected using 2% sodium hypochlorite, 70% ethanol and several washes of distilled water. Seeds are immersed in 0.4% carboxymethyl cellulose (CMC) as adherent, placed on sterile filter paper and allowed to dry for 10 minutes. Under laminar flow hood, seeds were placed on sporulating *B. bassiana* cultures and shaken for 5 minutes. Treated seeds are placed on pots with double times autoclaved sterile soil. After 30 days, plant parts from the treated seeds *viz.,* root, stem and leaves are cut into small pieces and surface sterilized with 70 per cent ethanol, 1.5 per cent sodium hypochlorite followed by thrice washing with sterile distilled water. Sterilized plant parts were inoculated in plates with SMAY medium and observed for the growth of fungus (Ramirez-Rodriguez and Sanchez-Pena, 2016).

Details of *B. bassiana* isolates used in the present study.

S. No.	Isolate	Substrate / host	Location	Accession number
1.	TM	*Helicoverpa armigera*	Dharmapuri	MH590235
2.	BR	*Leucinodes orbonalis*	Coimbatore	MK918495
3.	Bb FAW	*Spodoptera frugiperda*	Dharmapuri	MZ853723
4.	Bb DBM	Plutella xyllostella	Coimbatore	MZ749648
5.	Bb HEL	*Hellula undalis*	Coimbatore	MZ749646

Results and Discussion

Among the five isolates tested, the results revealed that TM isolate (MH590235) is capable of causing infection and mortality against *S. frugiperda* under laboratory conditions. None of the *B. bassiana* isolates showed endophytic activity in maize plants. Larval mortality was dose dependant and percent mortality increased with concentration and time of treatment. At nine days after treatment, mortality ranged from 20.00 to 66.67 per cent, 13.33 to 60.00 per cent, 10.00 to 53.33 per cent for first, second and third instar, respectively. Highest mortality of 66.67 per cent was recorded for first instar at 10^8 conidia/ ml after nine days after treatment. Concentration mortality responses of first, second and third instar to TM isolate (MH590235) showed that LC_{50} values of 2.51 x 10^5, 2.05 x 10^6, 4.56 x 10^7 conidia/ml with a fiducial limit of 10^3 – 10^7, 10^4 – 10^7 and 10^6 – 10^8 conidia/ml. Reports by Carneiro *et al*. (2008) also confirmed that *B. bassiana* isolates were pathogenic to Fall Armyworm.

Table 1. Dose-mortality responses of FAW treated with TM isolate (MH590235)

Dose (Spores ml^{-1})	Mortality (%) (9 DAT)		
	First instar	Second instar	Third instar
1 x 10^8	66.67 (54.74) ^{a}	60.00 (50.77) ^{a}	53.33 (46.91) ^{a}
1 x 10^7	63.33 (52.74) ^{b}	56.67 (48.84) ^{b}	43.33 (41.17) ^{b}
1 x 10^6	53.33 (46.91) ^{c}	46.67 (43.09) ^{c}	33.33 (35.27) ^{c}
1 x 10^5	46.67 (43.09) ^{d}	40.00 (39.23) ^{d}	23.33 (28.88) ^{d}
1 x 10^4	33.33 (35.27) ^{e}	23.33 (28.88) ^{e}	13.33 (21.41) ^{e}
1 x 10^3	20.00 (25.56) ^{f}	13.33 (21.41) ^{f}	10.00 (18.44) ^{f}
Control	0.00 (0.63) ^{g}	0.00 (0.63) ^{g}	0.00 (0.63) ^{g}
SED	0.2933	0.5620	0.4533
CD (0.05)	0.6292	1.2054	0.9724

Figures in parentheses are angular transformed values. Number of insects per replication:10. DAT- Days after treatment. Values sharing same alphabets are statistically on par based on ANOVA

Table 2. Concentration mortality response of *S. frugiperda* to *B. bassiana* (MH590235)

Larval instar	Heterogenicity	Regression equation	LC_{50} (spores ml^{-1})	Fiducial limit (spores ml^{-1})
I	0.9568	y = 0.2527x + 3.5268	2.51 x 10^5	4.20 x 10^3 to 1.50 x 10^7
II	0.9057	y = 0.3337x + 2.7799	2.05 x 10^6	7.94 x 10^4 to 5.29 x 10^7
III	0.9934	y = 0.2843x + 2.8303	4.56 x 10^7	2.79 x 10^6 to 7.42 x 10^8

References

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ES 05 BOPS 09

Efficacy of talc-based formulation of *Beauveria bassiana* (Bals.) Vuill (MZ749636) against two spotted spider mite, *Tetranychus urticae* Koch on bhendi nunder glass house condition

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Key words: *Beauveria bassiana, Efficacy testing, talc formulation, Two spotted spider mite*

Introduction

The two spotted spider mite (TSSM), *Tetranychus* spp (Acari: Tetranychidae) is an economically important polyphagous, cosmopolitan pest of vegetables, fruits and ornamental crops causing damage to a wide range of crops including tomato, bhendi, cucumber, beans, peppers, strawberry and rose. Insect pathogens, especially entomopathogenic fungi (EPF) such as *Beauveria bassiana, Metarhizium anisopliae, Hirsutella* spp and *Lecanicillium lecanii* have been used to manage a variety of insect pests, particularly mites. Among 700 EPF reported, *B. bassiana* is the most promising EPF (Khachatourians *et al.*, 2001). The present study was carried out to evaluate the efficacy of the talc- based formulation of *B. bassiana* against *T. urticae*.

Materials and Methods

The mycelial mat from the fully sporulated *B. bassiana* was ground and the conidial strength was assessed using the improved Neubaeur haemocytometer and then the broth was mixed with autoclaved talc @ 1:2 ratio (500 ml:1 kg). To the mixture, 10 g of CMC (carboxy methyl cellulose), 15 g of calcium carbonate and 1 g of citric acid were added and dried in shade for 72 hours and the number of colony-forming units present in the talc formulation was determined using serial dilution method. The efficacy of the talc formulation of *B. bassiana* MZ749636 was tested on the population of TSSM in pot-culture studies along with, fenazaquin 10 EC @ 1.5 ml/l, azadirachtin 3000ppm @2ml/l, crude formulation of *B. bassiana* MZ749636 isolate and untreated control.

The initial population of the TSSM were counted from each plant in the replication. Three leaves one each from, top, middle and bottom of each plant were observed for the live mite population, on the surface of the leaves in an area of 4 cm^2.The mite was assessed at 3, 5, 7, 9, 11, 13 and 15 days after spraying. The mortality per cent and per cent reduction over control was calculated.

Results and discussion

The pre-treatment count of *T. urticae* were in the range of 16.93 to 17.67 and were found to be non- significant. After the first spray, the population of mites started to reduce significantly. Highest per cent reduction of 71.13 per cent reduction over the control was recorded in the fenazaquin 10EC @1.5ml/l treatment. It is followed by 63.85 per cent reduction over control in azadirachtin 3000ppm@2ml/l treatment. The talc formulation of *B. bassiana*, recorded 57.93 per cent mite population reduction over control after first spray. After second spray, fenazaquin 10EC @1.5ml/l treatment resulted in 90.27 per cent reduction over control with a cumulative reduction of 80.07 per cent over control. Azadirachtin 3000ppm@2ml/l treatment resulted in 78.26 per cent reduction over the control after second spray with a cumulative reduction of 71.06 per cent over control. The talc formulation of *B. bassiana* resulted in 69.72 per cent reduction over control after second spray with a cumulative reduction of 62.83 per cent over control. The crude formulation of *B. bassiana* resulted in a cumulative reduction of 58.12 per cent reduction over the control. The present results were in accordance with the results of Mohan *et al.* (2014) in which talc formulation of *Hirsutella thompsonii* recorded 70-80 per cent control of coconut eriophyid mite. The results of Singh and Joshi (2020) was also in accordance to the results of the present study, where in the talc formulation of *Lecanicillium lecanii* resulted in 61.6 per cent reduction of aphid in green house conditions. The results were also in agreement with the results of Kumar *et al.* (2019) in which the *M. anisopliae* caused 71.00 per cent reduction of *Nilaparvata lugens*.

Table 1. Efficacy of talc-based formulation of *B. bassiana* (MZ749636) against *T. urticae* on bhendi plants after two rounds of spraying under pot culture conditions

Treatment	Pre-treatment count (No of mites/4cm^2)	Per cent reduction over control (after first spray)	Per cent reduction over control (after second spray)	Cumulative per cent reduction over control
T1-Crude formulation of *B. bassiana*, MZ749636 @ 1x 10^8 conidia/ml	16.93	52.48	63.75	58.12
T2- Talc formulation of *B. bassiana*, MZ749636 @ 2.1x 10^8 cfu/g	17.07	57.93	69.72	62.83
T3- Fenazaquin 10 EC @ 1.5 ml/l	17.33	71.13	90.27	80.07
T4- Azadirachtin 3000 ppm @ 2ml/l	17.47	63.85	78.26	71.06
T5- Control (Water spray)	17.67	52.48	63.75	58.12

*Number of mites per 4 cm^2 is the average number of mites present in the top, middle and bottom leaf

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ES 05 BOPS 10

Effectiveness of native *Bacillus thuringiensis* strains on *Spodoptera frugiperda* (J. E. Smith)

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Keywords: *Native Bacillus thuringiensis strains, Spodoptera frugiperda, Bioassay*

Introduction

The fall armyworm, Spodoptera frugiperda is a major pest of maize, cotton, rice, sorghum, sugarcane and in India, S. frugiperda is recently reported in Karnataka, Tamil Nadu and Telangana infesting maize crop (Kalleshwaraswamy et al., 2018). S. frugiperda feeds on maize cob or kernel and it reduced the grain yield of maize upto 34%. Nowadays, some methods, solely or together, get the satisfactory control of S. frugiperda. Among the entomopathogenic agents used in biological control of lepidopterous pests the Bacillus thuringiensis Berliner bacterium (Bt) has gained special attention as an alternative method. To combat these problems, there is a need to isolate native strains of B. thuringiensis with insecticidal activity.

Materials and Methods

Nineteen new B. thuringiensis strains isolated from the native soil of Tirunelveli and Tuticorin districts and identified based on the crystal morphology were used for the present study. Different stages of S. frugiperda larvae were collected from maize field at AC&RI, Killikulam and cultured on semi synthetic diet (CIMMYT diet). The culture was maintained at 25±1°C with 75±5 % relative humidity (Prasanna et al., 2018). Preliminary bioassays were carried out to screen the virulent strains of isolated B. thuringiensis by leaf disc method against neonate larvae of S. frugiperda. Larval mortality was observed periodically upto 3 days. Per cent mortality in the treatments was corrected by using Abbott's (1925) formula.

$$\text{Per cent mortality} = \frac{\text{Number of dead/ marbed larvae}}{\text{Total number of larvae released}} \times 100$$

Results and Discussion

Among nineteen isolates, KKM 14 (62.33%), KKM 2 (60.67%), KKM 4 (58.67%) and KKM 7 (56.67%) strains were on par with each other with highest per cent mortality. The per cent mortality recorded by *B. thuringienis* strains was inferior to reference strain *Bt*-HD1 (90.00%). KKM 5, KKM 17 and KKM 18 isolates were on par with each other which showed lowest per cent mortality (16.67%) (Figure.1). Similarly, Jara *et al.* (2006) reported that sixty-five per cent of the isolates obtained from phylloplane and twelve per cent of the isolates from soil showed toxicity towards *S. frugiperda*. Monnerat *et al.* (2006) reported that susceptibility of *S. frugiperda* populations differs with the different *B. thuringiensis* strains. CIBCM-166, S811, IB412, and LBIT27 and 147-5501 were the most toxic strains against *S. frugiperda.*

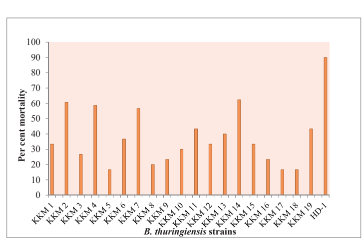

Figure 1. Per cent mortality caused by ***B. thuringiensis*** strains against neonate larvae of ***S.Frugiperda***

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ES 05 BOPS 11

Biosafety of *Bacillus thuringiensis* strains on honey bee and silkworm

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Keywords: *B. thuringiensis strains, Biosafety, Non- target organisms*

Introduction

Microbial based pesticides are used as an alternative to chemical insecticides. Indiscriminate use of chemical insecticides leads to the development of resistance in agricultural pests and vectors of human diseases. It also pollutes the environment and cause adverse effects on non-target beneficial organisms, human and animal health. For this reason, biocontrol agents are used over the synthetic insecticides for controlling insect pests in agriculture. Among biocontrol agents, *Bacillus thuringiensis* (*Bt*) has been successfully used as microbial pesticide due to its specific activity and ecofriendly nature. Safety of biopesticides should be known before they are applied in the field and it should not affect the non-target beneficial organisms.

Material and Methods

Nineteen native *Bt* strains were tested against beneficial organisms like silkworms, honey bees to check the biosafety of *B. thuringiensis* strains. *Bt*-HD1 was used as a reference strain along with control in this study. Mulberry leaf smeared with 2.5 µl of distilled water with 2.5 µl spore crystal mixtures of *Bt* strains and air dried. Fourth instar larvae were fed with treated mulberry leaves (Rai *et al.,* 2015). Newly emerged adults of *Apis cerana indica* were fed with 50% sugar syrup which was contaminated with 20 µl suspensions of *Bt* strains. Per cent mortality was analyzed for silkworm and *Apis cerana indica.* For this study, three replications per treatment were maintained and ten beneficial organisms were released per treatment. Observations were recorded at 12 hours interval upto 72 hours.

Results and Discussion

Safety of *Bt* strains were evaluated on the basis of per cent mortality for silkworm. Among nineteen *Bt* strains, KKM 14 recorded 83.3% mortality in fourth instar larvae of silkworm followed by KKM 2 (76.67 %). Similarly, Rai *et al*. (2015) reported that commercial formulations of *Bt* showed highest toxicity (95%) in third instar larvae of *Bombyx mori*. In honey bees, there was no significant difference found between the isolates. Dai *et al.* (2012) also reported the similar result in their study. In evaluating safety of nineteen *Bt* strains, it was found that there were no adverse effects on honey bees whereas the silkworms were vulnerable to the *Bt* strains (Table.1).

Table 1. Safety of different strains of *B. thuringiensis* on silkworm and honey bees

S.No.	Isolates	Per cent Mortality	
		Silkworm	Honey bees
1	KKM 1	60.00 (50.85)^{def}	3.33 (6.14)

2	KKM 2	76.67 (61.22)[bc]	6.67 (12.29)
3	KKM 3	36.67 (37.22)[h]	3.33 (6.14)
4	KKM 4	66.67 (54.78)[cde]	6.67 (12.29)
5	KKM 5	43.33 (41.15)[h]	3.33 (6.14)
6	KKM 6	56.67 (48.85)[efg]	3.33 (6.14)
7	KKM 7	70.00 (57.00)[cde]	3.33 (6.14)
8	KKM 8	40.00 (39.15)[h]	6.67 (12.29)
9	KKM 9	56.67 (48.93)[efg]	3.33 (6.14)
10	KKM 10	63.33 (52.78)[cdef]	3.33 (6.14)
11	KKM 11	73.33 (59.00)[bcd]	3.33 (6.14)
12	KKM 12	70.00 (56.79)[cde]	3.33 (6.14)
13	KKM 13	63.33 (53.07)[cdef]	3.33 (6.14)
14	KKM 14	83.33 (66.14)[b]	3.33 (6.14)
15	KKM 15	56.67 (48.85)[efg]	3.33 (6.14)
16	KKM 16	50.00 (45.00)[fgh]	3.33 (6.14)
17	KKM 17	50.00 (45.00)[fgh]	3.33 (6.14)
18	KKM 18	43.33 (41.15)[gh]	3.33 (6.14)
19	KKM 19	70.00 (56.79)[cde]	3.33 (6.14)
20	HD-1	93.33 (77.71)[a]	3.33 (6.14)
21	Control	0.00 (1.65)[i]	0.00 (1.65)

Values in parenthesis are arcsine transformed.

In a column means followed by common letters are not statistically different at P=0.05.

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ES 05 BOPS 12

Biosafety of *Bacillus thuringiensis* strains on *Trichogramma chilonis*

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Keywords: *B. thuringiensis strains, Biosafety, Non- target organisms*

Introduction

Indiscriminate use of chemical insecticides leads to the development of resistance in agricultural pests and vectors of human diseases. For this reason, biocontrol agents are used over the synthetic insecticides for controlling insect pests in agriculture. Among the biocontrol agents, *Bacillus thuringiensis* (*Bt*) has been successfully used as microbial pesticide due to its specific activity and ecofriendly nature. Safety of biopesticides should be known before they are applied in the field and it should not affect the non-target beneficial organisms. With this view, the present investigation was carried out to study the safety of *Bt* strains on *Trichogramma chilonis.*

Material and Methods

Nineteen native *Bt* strains were tested against the egg parasitoid, *T. chilonis* to check the biosafety of *Bt* strains. *Bt* - HD1 was used as a reference strain along with untreated control in this study. *T. chilonis,* was allowed to parasitize the *Corcyra cephalonica* egg card which was sprayed with 20 µl *Bt* strains and emergence per cent of *T. chilonis* was calculated. For this study, three replications per treatment were maintained. Observations were recorded at 12 hours interval upto 72 hours.

Results and Discussion

Among nineteen *Bt* strains tested, KKM 11 (84.00 %) showed highest per cent emergence of *T. chilonis*. Nascimento *et al.* (2018) also reported that *Bt* suspensions sprayed on the eggs of *H. zea* did not affect the parasitism of *T. pretiosum* Riley (Table.1).

Table 1. Safety of different strains of *B. thuringiensis* on *T. chilonis*

S.No.	Isolates	Emergence Per cent of *T. chilonis*
1	KKM 1	74.67 (59.83)^{abcd}
2	KKM 2	82.67 (65.43)^{g}
3	KKM 3	72.00 (58.05)^{g}
4	KKM 4	86.00 (68.04)^{abcde}
5	KKM 5	79.00 (62.75)^{bcdef}
6	KKM 6	78.67 (62.53)^{abcd}
7	KKM 7	83.33 (66.02)^{abcd}

8	KKM 8	78.00 (62.03)[def]
9	KKM 9	71.00 (57.42)[abc]
10	KKM 10	77.00 (61.35)[abcd]
11	KKM 11	84.00 (66.50)[fg]
12	KKM 12	73.67 (59.13)[abcd]
13	KKM 13	77.33 (61.60)[bcde]
14	KKM 14	82.67 (65.41)[ab]
15	KKM 15	77.00 (61.35)[abcd]
16	KKM 16	78.00 (62.03)[def]
17	KKM 17	78.00 (62.03)[abcd]
18	KKM 18	79.67 (62.03)[cdef]
19	KKM 19	74.33 (59.57)[abcde]
20	HD-1	86.00 (68.05)[bcde]
21	Control	95.00 (77.08)[a]

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ES 05 BOPS 13

In-vitro evaluation of synthetic insecticides against the growth of *Bt* isolate, T405 using Poison food technique

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***Keywords**: In-vito compatibility, T405, synthetic insecticides*

Introduction

Fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) is the most destructive invasive pest of maize native to Western hemisphere. It is highly polyphagous in nature and feed on more than 350 host plants (Maino *et al*., 2021). In maize, when larval damage is severe, the yield loss range between 17 to 72% (Murua *et al*., 2015). Insecticide application is often required to keep this pest population below economic threshold level (ETL). On the other hand, *Bt* formulation is also widely recommended to combat this pest as part of IPM. Farmers have the tendency of mixing two or more insecticides for the effective management. In this context, the compatibility of synthetic insecticides and *Bt.* has to be studied to include in the FAW management package. Hence, the present investigation was aimed to evaluate the compatibility of insecticides commonly used against the FAW with *Bt* isolate, T405 through *in-vitro* poison food technique.

Material and methods

The present experiment was carried out at the *Bt* laboratory, Department of Plant Biotechnology, Centre for Plant Molecular Biology & Biotechnology, Tamil Nadu Agricultural University, Coimbatore. T_3 media (For one litre: 3.0g tryptone, 2.0g tryptose, 1.5g yeast extract, 6.9g sodium di-hydrogen phosphate, 8.9g di-sodium hydrogen phosphate, 0.005g manganese chloride were mixed in water and 20g agar, pH adjusted to 6.8-7.0) was prepared, transferred 60ml to the 100ml conical flasks and autoclaved. Half, actual and double doses (Table 1) of insecticide were measured accurately (dose calculated for 60ml media), added to the individual conical flask containing T3 media and allowed to solidify. To each plate, T405 *Bt* culture suspension @100µl (1×10^4 spores/ml) was added and incubated for 24 hours at 30ºC. The colony counts in each plate (three replications) were taken and per cent growth inhibition was also calculated.

Results and Discussion

The results of the study revealed that, chlorantraniliprole 18.5SC has the least antagonist effect on the growth of *Bt* in all the three doses. In half dose, the colony count was 34.70 with 6.97% inhibition. Actual dose also did not have much antagonism on *Bt* growth (31.70 colonies with 15.01% inhibition) whereas, double dose showed 33.33% inhibition of *Bt* colony growth. Spinetoram11.7SC recorded 20.70, 22.00 and 8.80 colonies in half, actual and double doses, respectively. Flubendiamide 480SC, emamectin benzoate 5SG, novaluran 10EC and azadirachtin 1EC were found to inhibit the growth of *Bt* even at the half dose itself and very high inhibition in the double dose. In the untreated control, 37.30 *Bt* colonies were recorded. The results were comparable with Agostini *et al*. (2014), in which spiromesifen (tetronic acid derivatives) reduced the *Bt* development by 40-60%. They also reported bifenthrin and carbosulfan were found highly toxic to *Bt* which is partially true with the present findings. The insecticides novoluran 10EC and emamectin benzoate 5SG inhibited the colony growth to 84.17 and 90.08 per cent, respectively.

Table 1: In-vitro evaluation of antagonism between synthetic insecticides and Bt isolate, T405

S. No.	Treatment	Trade name	Dose (g/ml lit^{-1})			Half dose		Actual dose		Double dose	
			Half dose	Actual dose	Double dose	CC*	PIC	CC*	PIC	CC**	PIC
1.	Flubendiamide 480SC	Fame	0.2	0.4	0.8	25.30 (5.00)^{bc}	32.17	20.70 (4.54)^{cd}	44.50	3.50 (1.86)^{c}	90.74
2.	Chlorantraniliprole 18.5SC	Coragen	0.2	0.4	0.8	34.70 (5.81)^{ab}	6.97	31.70 (5.57)^{ab}	15.01	25.20 (5.01)^{b}	33.33
3.	Spinetoram 11.7 SC	Deligate	0.25	0.5	1.0	20.70 (4.53)^{cd}	44.50	22.00 (4.67)^{bc}	41.02	8.80 (2.84)^{c}	76.72
4.	Emamectin benzoate 5SG	Proclaim	0.2	0.4	0.8	15.70 (3.95)^{d}	57.90	3.70 (1.82)^{e}	90.08	0.50 (0.71)^{d}	98.68
5.	Novaluran 10EC	Rimon	1.0	2.0	4.0	13.00 (3.60)^{d}	65.15	5.70 (2.34)^{e}	84.71	0.50 (0.71)^{d}	98.68
6.	Azadirachtin 1EC	Neemazol	1.0	2.0	4.0	18.00 (4.23)^{cd}	51.19	13.00 (3.56)^{d}	93.75	6.20 (2.34)^{c}	83.60
7.	Untreated control	-	-	-	-	37.30 (6.10)^{a}	-	37.30 (6.10)^{a}	-	37.80 (6.14)^{a}	-
	CD (P=0.5)	-	-	-	-	1.01	-	1.02	-	1.04	-
	CV (%)	-	-	-	-	11.91	-	13.68	-	18.66	-
	SEm±	-	-	-	-	0.34	-	0.35	-	0.36	-

CC- Colony Count; PIC- Per cent inhibition over control; * Figures in the parentheses are square root transformed values. **Figures in the parentheses are plus 0.5 square root transformed values

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ES 05 BOPS 14

Efficacy of bio-formulations of *Photorhabdus luminescens* Poinar against spider mite, *Tetranychus truncatus* Ehara

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Introduction

Spider mites of family the Tetranychidae are considered as one of the most serious sucking pests of crops worldwide. Among different species of spider mites, *Tetranychus truncatus* Ehara has emerged as the predominant mite species infesting economically important crops of Kerala (Bennur *et al.,* 2015, Arumima, 2017). Sole dependence on synthetic acaricides for mite management has resulted in development of resistance in spider mites, which demands alternative eco-friendly pest management strategies.

Recent studies conducted in the Department of Agricultural Entomology, College of Agriculture, Vellanikara showed that the entomopathogenic bacteria *Photorhabdus luminescens* is a potential candidate in biological control of the mite *T. truncatus*. However, very few studies have been conducted on development and evaluation of bioformulations of *P. luminescens* for use in mite management. Hence, an attempt has been made to formulate the liquid as well as wettable powder formulations of *P. luminescens* and evaluate them against *T. truncatus* in the laboratory.

Materials and methods:

P. luminescens ODA strain isolated from the EPn, *Heterorhabditis* sp. Which was isolated from the soil collected from the Aromatic and Medicinal Plants Research Station, Odakkali, KAU was used for the preparation of bio formulations in the laboratory. Stock culture of the bacterium was maintained on NBTA broth at 27^0C for 72h up to a concentration of 10^8 CFU/ml.

Adjuvants such as polyvinylpyrrolidine-PVP (2.5%), glycerol (10mM), trehalose (15 mM) and starch and tween 20 (0.8%) were supplemented along with NBTA broth (Gopal and Baby, 2016) for the preparation of different liquid formulations. Starch (808g/L), and talc (3.3 Kg/L) were used as carrier material for the preparation of wettable powder (WP) formulations.

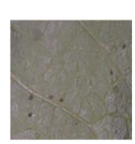
Laboratory bio assays were conducted to identify the most promising *P. luminescens* bioformulations against *T. truncatus.* Ovicidal and adulticidal effects of four liquid as well as two WP formulations were carried out separately, following topical application. Experiment included 6 treatments and 3 replications along with an absolute control. Observations on mortality of egg and adult were recorded at 24, 48 and 72 h after treatment.

Results and discussion



Bio assay **WP formulation** **Liquid formulation**





Healthy adults **Dead eggs** **Dead adults**

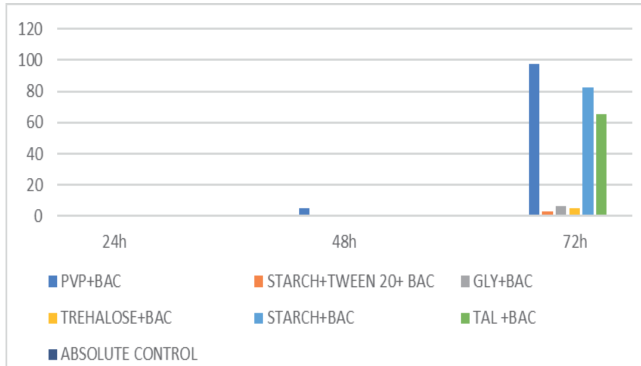


Fig 1: Ovicidal effect of *P. luminescens* formulations

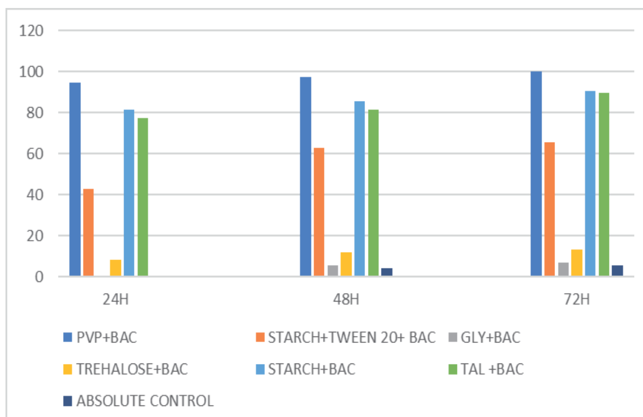


Fig 2: Adulticidal effect of *P. luminescens* formulations

Bacterial formulations showed significant ovicidal and adulticidal properties. Highest mortality rate of mites was observed in liquid formulation supplemented with PVP (2.5%), which recorded 97.33 and 100.00 per cent mortality of eggs and adults respectively. WP formulation prepared by adding starch as carrier material showed 82.66 and 90.66 per cent mortality of eggs and adults respectively, after 72 h of treatment. However, the control treatment recorded zero mortality of eggs and 5.33 per cent of adults (Fig. 1 & 2).

PVP has a high-water binding capacity, which could maintain water around the cells for their metabolism (Singleton *et al.,* 2002, Deaker *et al.,* 2004) and improve the bacterial toxicity and viability. According to Bashan *et al.* (2002) starch reduce the physical stress to microbial cells and significantly improve their survival rate. The results of the present study are in agreement with the above findings, as the formulations supplemented with PVP and starch recorded highest mortality of eggs and adults of *T. truncatus*.

Conclusion

The study resulted in the development of two formulations of entomo-pathogenic bacteria, *P. luminescens* with appreciable acaricidal property which can be exploited as a potential biopesticide against mite pests of crops.

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ES 05 BOPS 15

Evaluating the efficacy of plant derivatives for the management of brinjal shoot and fruit borer, *Leucinodes orbonalis*.

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Keywords: *BSFB, Leucinodes orbonalis, kharif, plant derivatives, shoot and fruit infestation, weight basis.*

Introduction

Among the insect pests infesting brinjal, the shoot and fruit borer, *Leucinodes orbonalis* Guenee (Pyraustidae: Lepidoptera) is the most destructive and the major limiting factor in quantative as well as qualitative harvest of brinjal fruits. Chemical control is widely used for managing insect pests in brinjal. Repeated use of broad spectrum synthetic chemicals also result in environmental contamination, bioaccumulation and biomagnifications of toxic residues and disturbance in ecological balance (Dadmal *et al*., 2004). With the views, research was carried out to find ecofriendly solution for this destructive pest. In this study certain plant derivatives are used for the management of brinjal shoot and fruit borer.

Materials and methods

Eight plant products which are indigenous and locally available were collected (Table 1). Plant parts like leaves / seeds were shade dried, before preparing the ethanolic extracts, by Soxhlet's apparatus. The natural oils used in the study were purchased from commercial vendors which were diluted Emulsions of different concentrations were prepared by dilution method for conducting the field trials. The observations of shoot infestation were recorded on 7 and 14 days after each spray. At each fruit picking the weight of healthy and infested fruits were recorded on ten plants from each treatment. The per cent shoot and fruit infestation was calculated and pooled data was subjected for statistical analysis.

Results and Discussion

Among the treatments evaluated Annona seed extract 2% recorded a cumulative mean fruit damage (11.28 %) on weight basis after four rounds of harvest and significantly superior over untreated control (37.23 %). Annona seed extract 2% recorded the highest fruit yield 17.69 t/ha (Table 1).

The present findings are in agreement with the reports of Ghatak *et al.* (2009) that reduction of fruit infestation treated with seed extracts of *Annona squamosa* L. were better than seed extract of *Strychnos nuxvomica* L in brinjal.

Table.1. Bio- efficacy of certain plant derivatives against fruit infestation (Weight basis) of brinjal shoot and fruit borer *Leucinodes orbonalis* (L) Gue. Season – Kharif 2018.

T. No.	Treatments	Pre- Treatment Count	Percent fruit infestation *						Yield* (t/ha)	Increase Over Control
			Weight basis							
			1st picking	2nd picking	3rd picking	4th picking	Mean	ROC		
T_1	Notchi leaf extract	13.37 (21.45)	16.96 (24.32)^{c}	19.99 (26.56)^{e}	25.67 (30.44)^{e}	28.74 (32.42)^{e}	22.84 (28.55)^{f}	38.65	12.10 (3.48)^{f}	33.19
T_2	Annona seed extract	12.09 (20.35)	12.10 (20.35)^{a}	7.67 (16.08)^{b}	12.10 (20.36)^{a}	13.26 (21.35)^{a}	11.28 (19.63)^{a}	69.69	17.69 (4.21)^{a}	54.30
T_3	Tulsi leaf extract	13.97 (21.95)	21.05 (27.31)^{e}	22.26 (28.15)^{f}	26.62 (31.06)^{e}	36.32 (37.06)^{g}	26.56 (31.02)^{g}	28.65	10.50 (3.24)^{g}	22.96
T_4	Adathoda leaf extract	12.91 (21.05)	16.03 (23.60)^{c}	17.48 (24.72)^{d}	24.25 (29.50)^{d}	30.33 (33.41)^{f}	22.02 (27.99)^{e}	40.85	12.89 (3.59)^{e}	37.28
T_5	Garlic bulb extract	12.11 (20.36)	24.07 (29.38)^{f}	16.99 (24.34)^{d}	19.96 (26.54)^{c}	23.26 (28.83)^{c}	21.07 (27.32)^{d}	43.40	14.77 (3.84)^{cd}	45.24
T_6	Iluppai oil	12.95 (21.09)	14.16 (22.11)^{b}	11.73 (20.03)^{b}	12.01 (20.28)^{a}	19.30 (26.05)^{b}	14.30 (22.22)^{b}	61.59	16.91 (4.11)^{b}	52.17
T_7	Pungam oil	12.27 (20.51)	18.72 (25.63)^{d}	14.99 (22.78)^{c}	15.41 (23.11)^{b}	24.95 (29.97)^{d}	18.52 (25.49)^{c}	50.26	15.33 (3.92)^{c}	47.26
T_8	Neem oil (standard check)	21.20 (27.41)	19.15 (25.95)^{d}	17.15 (24.47)^{d}	20.84 (27.16)^{c}	26.22 (30.80)^{d}	20.84 (27.16)^{d}	44.02	14.38 (3.79)^{d}	43.77
T_9	Untreated check	17.36 (24.62)	25.65 (30.43)^{g}	36.67 (37.27)^{g}	41.86 (40.32)^{f}	44.73 (41.97)^{h}	37.23 (37.60)^{h}		8.09 (2.84)^{h}	
SEd			0.46	0.30	0.53	0.67	0.38			
CD (p=0.05)			0.97	0.65	1.13	1.43	0.81			
CV%			2.99	2.03	2.97	3.00	2.17			

ROC-Reduction Over Control *Each value is the mean of three replications. Figures in parentheses are arc sine transformed values. In each column, means with similar alphabets do not vary significantly at P=0.05 and P=0.01 by LSD. T_1- Notchi leaf extract @ 5%; T_2 Annona seed extract @ 2%; T_3- Tulsi leaf extract @ 5%; T_4 – Adathoda leaf extract @ 5%; T_5- Garlic bulb extract @ 2%; T_6- Iluppai oiL @ 3%; T_7- Pungam oil @ 3%; T_8- Neem oil(standard check) @ 3%; T_9 - Untreated check

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ES 05 BOPS 16

Toxicity of native *Bt* isolates against pigeon pea gram pod borer, *Helicoverpa armigera*

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Introduction

Pigeon pea, *Cajanus cajan* L. is a major tropical and subtropical legume crop cultivated on nearly 4.8 million hectares, which ranks third in legume crop production in the world. The Indian subcontinent produce and consume around 70 per cent of the world's total production of pigeon pea. The productivity of pigeon pea is heavily infested by the gram pod borer *Helicoverpa armigera*. It is estimated that the infestation of one larva per plant on pigeon pea can cause yield loss of 1015 kg/ha (Smith-Pardo *et al*., 2014). Management of this pest relies mainly upon inorganic pesticides which may lead to resistance development and environmental pollution. *Bacillus thuringiensis* is a successful biocontrol agent available as an alternative to chemical pesticides.

Materials and methods

H. armigera cultures were obtained from NBAIR, Bangalore and maintained at *Bt* laboratory, CPMB&B, TNAU, Coimbatore. The second and third generations of *H. armigera* were used for toxicity test against ten indigenous *Bt* isolates *viz*., T371, T372, T373, T374, T375, T377, T378, T379, T383 and T384. PCR were carried out for lepidopteran specific *cry* and *vip3A* genes *viz., cry1, cry 1A, cry1Ab, cry 2, cry 2A, cry2Aa, cry 2Ab* and *vip3A* and protein profiling was analysed by SDS-PAGE. Bioassay were conducted by leaf disc method with spore-crystal mixtures of *Bt* isolates. A total of 20 µl of spore-crystal mixtures was smeared on both sides of the leaf disc and 10 neonate larvae were released per disc. Larval mortality was observed upto 72 hours after treatment and expressed in percentage.

Results and Discussion

Bio-assay results revealed that the *Bt* isolate T375 and T384 caused cent per cent mortality against *H. armigera*. Whereas, the *Bt* isolates T374, T377, T378, T379 and T383 isolates were produced 60, 72, 66, 90 and 89 per cent mortality, respectively (Table 1). PCR for *cry* genes and *vip3* gene results showed that the *cry1, cry1Ab, cry1Ac, cry2, cry2Aa, cry2Ab* and *vip3A1* genes were amplified in the tested isolates which caused toxicity to *H. armigera.* The protein profile analysis showed different banding sizes of about 140, 135, 90, 85, 65 and 40 kDa among the *Bt* isolates tested (Table 1). Lone *et al*., (2017) reported that, twenty-six isolates were collected from agricultural fields of Kashmir valley and the PCR analysis showed to contain either or both the *cry* genes tested, while 18 isolates did not show the presence of the genes. Compared to *cry2* gene, *cry1* genes were found to be more abundant and in most of the isolates (12) they were found together. Baig *et al*., (2010) found that the bioassays with spore-crystal mixtures of *Bt* isolates SBS-Bt4, 8, 17, 21 and 26 harbouring *cry1* against neonate larvae of *H. armigera* recorded LC (50) 1288, 1202, 467·7, 524·8 and 108·5 µg/ml. The SBS-Bt26 showed fourfold higher toxicity than the *cry1Ac* harbouring positive control, HD-73. Based on the results, the indigenous *Bt* isolate are found to be toxicity against *H. armigera*. The detailed dose mortality test has to be done to select a most effective isolate for further formulation studies.

Table 1. Characterization and toxicity of native *Bt* isolates against Gram pod borer, *Helicoverpa armigera*

S. No.	Bt Isolates	Gene profiling	Protein profiling (kDa)	Larval mortality (%)
1	T371	Not identified	40	15.00 (22.78)
2	T372		-	9.00 (17.45)
3	T373		-	36.00 (36.87)
4	T374	*cry1, cry1Ab cry1Ac, cry2, cry2Aa, cry2Ab* and *vip3A1*	135 and 70, 65	66.00 (50.76)
5	T375		135 and 65	100.00 (89.50)
6	T377		135 and 70, 65	76.00 (58.05)
7	T378		140	66.00 (54.33)
8	T379		135 and 65	93.00 (71.56)
9	T383	*cry1, cry1Ab, cry1Ac, cry2, cry 2Aa* and *cry2Ab*	85 and 90	90.00 (70.63)
10	T384		85 and 90	100.00 (89.50)
11	HD1	*cry1, cry1Ab cry1Ac, cry2, cry2Aa, cry2Ab* and *vip3A1*	135 and 65	100.00 (89.50)
12	Control	---		0.00

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ES 05 BOPS 17

Predatory potential of coccinellids on pink mealybug, *Maconellicoccus hirsutus* (Green)

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Introduction

The coccinellid predators play an important role in agriculture ecosystem as biological control agents. Aphids have been documented as the primary food source for most of the Coccinellid predators (Slipinski, 2007). Recently a lot of interest has been shown on the use of *Cryptolaemus montrouzieri* for the suppression of grape mealybug, *Maconellicoccus hirsutus* Green. The predation of mealy bugs by *Coccinella septempunctata* was 20 per cent after 24 hours and also it increased to 84.70 per cent after 96 hours (Shera *et al.* 2010). The present study was carried out to observe the development and feeding potential of these coccinellids on different stages of the pink mealybug (*Maconellicoccus hirsutus*).

Materials and Methods

Lab studies were conducted at RVS Agricultural College, Thanjavur district, Tamil Nadu, India during 2019-20. The inoculum of mealy bugs were collected from the orchards and introduced in the sterilized pumpkins kept inside the cages. The collected egg mass of each species of coccinellid beetle (*Coccinella septempunctata* and *Cryptolaemus montrouzieri)* was kept in a separate ventilated plastic container (6.5 x7.5 cm) and observed twice a day (morning and evening) for hatching. Then, I, II, III, IV and adults of coccinellids were released on the mealy bug infested pumpkins and the consumption potential of coccinellids on different stages of mealy bugs were observed. The experiment was replicated 15 times and analysed with CRD design.

Result and Discussion

Predatory potential of different stage of *C. septempunctata* and *C. montrouzieri* on pink mealybug are shown in Table 1. Maximum predatory potential was observed in I, II and III intars of *C. septempunctata* (2.75, 4.52, 8.32 nos. of prey) compared to *C. montrouzieri.* In contrast, IV instar and adults of *C. montrouzieri* recorded highest predatory potential compared to *C. septempunctata* on pink mealy bug. Ali *et al*. (2014) also reported maximum predatory potential by the adults of *Coccinella septumpunctata* while minimum potential in larval stages. However, similar predatory potential was observed in III instars of both *C. septempunctata* and *C. montrouzieri.* The results revealed that predatory potential of *C. septempunctata* decreased from I instars to adults compared to *C. montrouzieri* on pink mealy bug.

Table 1. Predatory potential of *C. septempunctata* and *C. montrouzieri* on pink mealybug

Larval instars	No. of Prey consumed	
	C. septempunctata	*C. montrouzieri*
I	2.75a	1.85b
II	4.52a	3.05b
III	8.32a	8.66a
IV	15.32b	18.52a
Adult	32.81b	38.18a

All values are mean of 15 replications. In a column, mean followed by a common letter are not significantly different by DMRT

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AUTHOR INDEX


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