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Two Decades (1990-2010) of Agricultural Entomology Research at ICAR Research Complex for Goa - A Scientific Review

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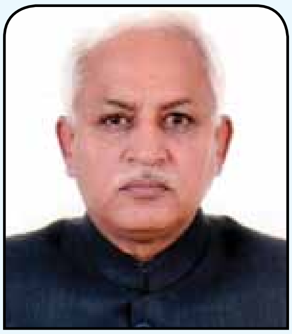

भाकृअप- केंद्रीय कीनारी शेती संशोधन सौस्थान
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डॉ. नरेंद्र प्रताप सिंह
निदेशक
Dr. Narendra Pratap Singh
Director

Foreword

INSECTS *are the most important and diversified group of organism on the planet. Goa is having a variety of flora and fauna owing to its location on Western Ghats. The climatic condition in Goa is hot and humid which is favourable for the incidence of insect pests and diseases in major crop plants causing severe loss in the production, sometimes complete crop failure. Some of the major insect pests causing more economic damage to the crops includes stem and root borer and tea mosquito bug on cashew, red palm weevil, rhinoceros beetle and eriophyid mite on coconut, fruit flies on mango and other cucurbits, leaf folder, case worm, gall midge on rice, sweet potato weevil, ground nut pod borer and bean aphid, etc.*

During last two decades, scientists of this institute have done significant research work, which are available in different annual reports of the institute and journals. Research work conducted on different area of plant protections includes survey, surveillance and monitoring of insect pests and natural enemies of different field and horticultural crops, screening and field testing of rice, ground nut, pigeon pea, cashew and coconut varieties against major insect pests.

I am happy that the scientists of this Institute have taken the initiatives to compile the research findings in the form of scientific review for easy and quick reference. I congratulate all the authors for this effort and am hopeful that this publication will be very useful to researchers, extension workers, students and farmers.

(Narendra Pratap Singh)
Director

भाकृअप- केंद्रीय कीनारी शेती संशोधन सौस्थान
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Preface

AGRICULTURE *is one of the important economic activities of the people of the Goa state. About 18% of the total work force is engaged in agricultural activities. The current cropping pattern in the region includes rice and rice based cropping systems dominating the lowlands while cashew and coconut based cropping systems in the uplands. The climatic condition in Goa is hot and humid which is favourable for the incidence of insect pests on major crop plants causing severe yield loss and sometimes complete crop failure. Some of the major insect pests causing more economic damage to the crops includes stem and root borer and tea mosquito bug on cashew, red palm weevil, rhinoceros beetle and eriophyid mite on coconut, fruit flies on mango and other cucurbits, leaf folder, case worm, gall midge on rice, sweet potato weevil, ground nut pod borer and bean aphid, etc.*

During last two decades, scientists of this institute have done significant research work, which is available in different annual reports of the institute and journals. Research work conducted on different area of plant protections includes survey, surveillance and monitoring of insect pests and natural enemies of different field and horticultural crops, screening and field testing of rice, ground nut, pigeon pea, cashew and coconut varieties against major insect pests. The research work on integrated pest management tactics includes cultural control, mechanical control, chemical control, and use of biologically derived materials, etc. Pheromone technology has been standardised for red palm weevil and fruit flies.

Therefore, effort was made to review and compile the two decades of research work on Agricultural Entomology at ICAR Research Complex for Goa and to present it in the form of a scientific review for easy and quick reference. All the information has been given in this scientific review are under different headings viz. Entomological research on rice, sweet potato, cashew, pulses and groundnut, fruit fly biodiversity and their management, pheromone technology for red palm weevil on coconut and presented along with the salient research findings and thrust areas for future research work.

We foresee that this scientific review will provide useful source of information at one place for the researchers, extension workers, integrated pest management practitioners, students and farmers.

R. Maruthadurai
R. Ramesh
Narendra Pratap Singh

Acknowledgements

WE are thankful to Dr. N. P. Singh, Director, ICAR Research Complex for Goa, Goa for taking keen interest, support and constantly encouraging for the compilation of the research findings of two decades (1990-2010) of Agricultural Entomology work at ICAR Research Complex for Goa, Goa. We are grateful to Ex-Directors of this institute for providing facilities for research work on Agricultural Entomology.

We record our deep appreciation to our renowned Agricultural Entomologists Dr. J.R Faleiro and Dr. Mani Chellappan and other scientists and workers, whose research findings have been compiled in this scientific review for their significant contributions in the field of plant protection.

Abbreviations

a.i	: Active ingredient
AM	: Ante meridian
Avg	: Average
BAT	: Bait application technique
BHC	: Benzene hexa chloride
BPH	: Brown plant hopper
Bt	: Bacillus thuringiensis
CD	: Critical difference
CGD	: Chowghat green dwarf
CV	: Coefficient of variation
D	: Dipping
DAF	: Days after flowering
DAP	: Days after pegging
DAP	: Days after planting
DAT	: Days after transplanting
DAS	: Days after sowing
DGI	: Damage grade index
DMRT	: Duncan's multiple range tests
EC	: Emulsifiable concentrates
EE	: Ether extract
g	: Gram
G	: Granules
GLH	: Green leaf hopper
GM	: Gall midge
h	: Hour
Ha	: Hector
HWT	: Hot water treatment
IPM	: Integrated pest management
Kg	: Kilogram
L	: Litre
LF	: Leaf folder
mg	: Milligram
ml	: Millilitre
mm	: Millimetre
MYD	: Malayan yellow dwarf
N	: Nitrogen
NS	: Non significant
PH	: Protein hydrolysate
PM	: Post meridian
q	: Quintal
RPW	: Red palm weevil
S	: Spray
SL	: Soluble liquids
SEM	: Standard error of mean
t	: Tons
TMB	: Tea mosquito bug
TSS	: Total soluble solids
WE	: Water extract
WP	: Wettable powder

CONTENTS

Introduction

Goa is a small state located on west coast of India. The state is flanked on the east by Sahyadri Mountains and on the west with Arabian Sea. The Northern area of Goa is bordered by Maharashtra state while Southern by Karnataka state. Goa encompasses an area of 3,702 sq. km in which forest area is 2095 sq. km. It lies between the latitudes 14°53′54″ N and 15°40′00″ N and longitudes 73°40′33″ E and 74°20′13″ E. Tourism and mining are in the forefront in terms of employment generation in Goa and agriculture is the third important economic activity providing livelihood to 18 % of the population. Agriculture along with Forests in Goa is instrumental in keeping Goa green and covers nearly 65% of the total area of the State. Goa is blessed with huge natural resources and unique climate. It receives rainfall from southwest monsoon. The average annual rainfall is 2800 mm and rainy season is spread over four months from June to September. Goa experiences warm and humid climate. The summer temperature ranges from 24^0C to 36^0C and the average relative humidity is 76%. The soils of Goa are mostly lateritic (81%). They are sandy loam to silt-loam texture, well drained and acidic in nature.

Agriculture is one of the important economic activities of the people of the state. About 18% of the total work force is engaged in agricultural activities. An area of 1.59 lakh hectares are under cultivation of different crops. Rice is the important staple food crop of the region as rice-fish curry being the main diet of the majority of the population. The cropping pattern in the region includes rice and rice based cropping systems dominating the lowlands while cashew and coconut based systems in the uplands. The cropping pattern is changing and today, the Cashew nut which is cultivated in nearly 55,000 hectares occupying the first position followed by paddy which is cultivated in 31,000 hectares. Coconut is cultivated around 25,718 hectares. Arecanut, sugarcane, mango and vegetables like brinjal, bhendi, radish, cucumber, pumpkins, and drumsticks are also cultivated in the state, though to a smaller extent. Fruit crops like banana, jackfruit, pineapple and papaya also grown in the state. Important tuber crops grown in the state includes colocasia, yam, elephant foot, dioscorea, and sweet potato etc. The traditional flowers like jasmine, marigold and crossandra are grown sporadically in the state for a long period of time. Spices include black pepper, nutmeg, kokum, turmeric, and cinnamon is grown as intercrop as well as main crop.

The climatic condition in Goa is hot and humid which is favourable for the incidence of insect pests and diseases in major crop plants causing severe loss in the production, sometimes complete crop failure. Further, intensive rainfall during June to September favours the higher incidence of insect pests and diseases during the season. Some of the major insect pests causing more economic damage to the crops include stem and root borer *Plocaederus ferrugineus* and tea mosquito bug *Helopeltis antonii* are the most serious pests on cashew and cause more economic loss to the crop. It is estimated that these pest alone cause more than 70 per cent yield loss. Red palm weevil *Rhynchophorus ferrugineus* Rhinoceros beetle *Oryctes rhinoceros* and Eriophyid mite *Aceria gurreronis* are the most destructive pests of coconut. Fruit flies are the major insect pests on mango and other cucurbits. In fruit crops, *Bactrocera dorsalis* was the most abundant species followed by *B. caryeae, B. zonata, B. affinis, B. correcta* and *B. verbicifolia*. In case of cucurbits, *B. cucurbitae* was the most dominant species followed by *B. tau, B. gavisa, B. caudate*, and *B. nigrotibialis*. It causes substantial damage (more than 20 %) to fruit crops and other hill cucurbits in Goa. The major insect pests of rice includes rice leaf folder *Cnaphalocrosis medinalis*, Case worm *Nymphula depunctalis*, Gall midge, *Orseolia oryzae*, Brown plant hopper *Nilaparvata lugens* and Gundhi bug *Leptocorisa acuta* causes moderate to severe yield losses to different varieties of rice. Sweet potato, ground nut and cowpea are the important crops of the rice based cropping system in the state of Goa. The sweet potato weevil *Cylas formacarius*, ground nut pod borer *Anisolobes stallii*, and bean aphid *Aphis craccivora* causes considerable yield loss to these crops. The pulse pod borer *Helicoverpa armigera*, *Spodoptera litura* and Tur pod fly *Melanagromyza obtuse* are the major pests of pigeon pea. Climate change resulting in increased temperature and rainfall could impact crop pest, insect populations in several complex ways. It has potential impacts on insect pests through the host crop plant, the pathogen and the natural enemies. The minor pests like aphids, mealy bugs, scales and white flies on many crops attaining the major status due to climate change.

ICAR Research Complex for Goa, Goa has the responsibility of increasing the agricultural production and productivity by conducting strategic and applied research on potential agricultural and horticultural crops, and post harvest management. Research work has been conducted in this institute on different aspects of plant protections for successfully managing the insect pests on variety of crops. Further, in this scientific review, all information on research works conducted in this institute during last two decades (1990- 2010) has been compiled under different headings *viz*. Management of insect pests of Rice, sweet potato, weevil management, cashew, insect pests management, Management insect pests of Pulses and groundnut insect pests management, fruit fly biodiversity and their management, pheromone technology for red palm weevil on coconut and presented along with the salient research findings and thrust areas for future research work.

Management of insect pests of Rice

Screening of rice varieties against insect pests
(JR Faleiro *et al.,* 1990)

Rice (*Oryza sativa*) is an important stable food crop for Goa. This crop is infested by different group of insect pests. To manage the insect pests of rice, different research aspects like monitoring, screening and integrated control were undertaken. The incidence of insect pests and their biotic agents was recorded on 12 medium duration rice varieties, at weekly interval. Among the insect pests recorded a high incidence of case worm, *Nymphula depunctalis* was recorded at 14 and 21 days after transplanting (DAT) with variety Co-44 recording the highest average attack of case worm (6. 68 damaged leaves /m^2). The incidence of gall midge, *Orseolia oryzae*, was observed at 35 and 42 DAT, with the variety MO-5 recording the highest average incidence (0.42 silver shoot /m^2). The leaf roller, *Cnaphalocrosis medinalis* occurred at 56 DAT with the variety Co-44 recorded the highest damage (2.53 damaged leaves /m^2). Among the biotic agents observed, a group of spiders, predatory beetles, ants, dragon flies and dipteran flies were recorded.

Management of insect pests of rice
To manage the insect pests of rice a field trail was conducted with 12 insecticidal treatment combinations at four different stages of crop growth (Nursery, 25 DAT, Flowering and Ear head stage) under three levels of nitrogen (0.75 and 150 kg N / ha). Observation was recorded at weekly intervals on the incidence of major insect pests and their biotic agents from 14 to 70 DAT (Table 1). Among the major insect pests recorded, the incidence of gall midge reached a peak at 49 DAT, with a proportional increase in its incidence as nitrogen level increased. It was also seen that the insecticidal treatments did not help in reducing the gall midge population. Analysis of yield data revealed that only nitrogen application helped to record significantly different yields while difference in yield due to insecticidal treatments were statistically non significant.

Table 1. Two- way analysis of yield in relation to insecticide and nitrogen treatments in rice during kharif, 1990

Nitrogen/ insecticide	Rice yield (t/ha)			Mean
	N_O	N_1	N_2	
I_1	2.00	3.33	4.17	3.17
I_2	2.17	3.33	4.00	3.17
I_3	2.33	4.00	4.50	3.94
I_4	2.17	3.83	4.17	3.49
I_5	2.33	3.33	3.33	3.00
I_6	2.67	3.14	4.67	3.49
I_7	2.42	4.50	4.00	3.64
I_8	3.00	3.50	4.17	3.56
I_9	2.50	3.50	4.58	3.53
I_{10}	2.33	4.00	4.15	3.50
I_{11}	3.12	3.83	4.67	3.87
I_{12}	2.58	2.50	4.58	3.23
Mean	2.56	3.57	4.25	-

For nitrogen- SEM = 0.20 and CD (P=0.05) = 0.58
For insecticide and nitrogen x insecticide – Non significant
N_o = 0 kg N / ha, N_1 = 75 kg N / ha, N_2 = 150 kg N /ha
I_1 = Carbofuran 3G, 1 kg a.i / ha (nursery); I_2 = Carbofuran (nursery) + Monocrotophos 0.05% (25 DAT); I_3 = Carbofuran (nursery) + Monocrotophos 0.05% (25 DAT) + Carbofuran 1 kg a.i / ha (flowering); I_4 = Carbofuran (nursery) + Monocrotophos 0.05% (25 DAT) + Carbofuran 1 kg a.i / ha (flowering) + BHC 10% 25 kg/ ha (earhead stage); I_5 = Monocrotophos (25 DAT); I_6 = I_5 + Carbofuran (flowering); I_7 = I_6 + BHC 10% (earhead stage); I_8 = Carbofuran (flowering); I_9 = I_8 + BHC 10% (earhead stage); I_{10} = Monocrotophos (25 DAT) + BHC 10% (earhead stage); I_{11} = BHC 10% (earhead stage); I_{12} = Control (no insecticide).

Survey/ Surveillance of insect pest of rice (JR Faleiro *et al.*, 1991)

In order to monitor the insect pests of rice and their natural enemies a surveillance programme was organised. Regular surveys were conducted from July to September, 1991 along with the officials of IPM Centre, Margao. A moderate to high intensity of brown plant hopper (*Nilaparvata lugens*) damage was observed in many parts of the state particularly in Tiswadi and Pernem Taluka. A severe incidence of leaf folder was noticed in Benaulim, (early tillering), Curtorium, Macazana, Ambeli and Velim (late tillering and early booting). (Table 2). Severe incidence of the Gundhi bug was noticed in Chinchinim (mid tillering). A moderate incidence of BPH was noticed in Calangute and Porvorim (booting and heating). Besides the above mentioned pests, useful biocontrol agents like the Coccinelid, Carabid, Staphytimid beetles, spiders and dragon flies were also observed.

Table 2. Insect pest survey in rice

Crop stage	Name of the insect pest recorded	Severity
Early tillering	Leaf folder	Moderate to severe
Early to mid tillering	Gall midge, Hispa, case worm, whorl maggot	Moderate
Mid tillering	Whorl maggot, Gall midge, Hispa, Case worm, grasshopper, leaf folder	Traces to moderate
Majority in tillering followed by heading, booting and milk stage	Leaf folder, Gall midge, stem borer, green leafhopper, Gundhi bug	Traces
Booting followed by heading	Leaf folder, Gall midge, army worm, green leafhopper, Gundhi bug, thrips	Traces
Milky stage followed by heading and booting	Brown leaf hopper, gall midge, army worm	Moderate Traces
Mature to milk stage	Gundhi bug, BPH, GLH,	Moderate Traces
Mature	Green leafhopper	Traces

Cumulative damage due to insect pests on short duration rice varieties

Cumulative damage and yield was assessed on different short duration varieties and presented in Table 3. The results revealed that the lowest cumulative damage due to case worm was observed in the variety Aditya. The variety Neela was found to be most tolerant to whorl maggot and leaf folder attack. Analysis of yield data revealed that that the variety Mahaveera gave the highest yields of 5.67 t/ ha and was statistically at par with Vikas.

Table 3. Cumulative damage due to insect pests and yield of short duration rice varieties (kharif, 1991)

S. No.	Variety	Cumulative leaf damage / m²			Yield t/ ha
		Case worm	Leaf folder	Whorl maggot	
1	Vikas	0.85	1.04	0.87	5.59
2	Aditya	0.76	0.94	0.83	2.09
3	Neela	0.83	0.88	0.77	2.93
4	Tara	0.85	0.93	0.82	3.46
5	Kaling-1	0.87	1.01	0.86	4.04
6	Jyoti	0.94	0.92	0.93	4.43
7	Annada	0.84	0.99	0.88	3.34
8	Mahaveera	0.87	0.96	0.84	5.67
9	ASD-16	0.93	1.02	0.87	4.88
10	Narendra-2	0.83	10.97	0.93	4.03
	SEM			0.03	0.37
	CD (P = 0.05)	NS	NS	0.09	1.10

Data transformed using $\sqrt{x} + 0.5$ where x = damage/m^2

Cumulative damage due to insect pests on medium duration rice varieties

Different medium duration rice varieties were screened against insect pest and yield was reported in Table 4. Among the medium duration varieties, Vibhava was most tolerant to case worm and whorl maggot, while MO-6 recorded the lowest cumulative damage due to leaf folder. The highest yield among medium duration varieties was recorded by Vikramarya.

Table 4. Cumulative damage due to insect pests and yield of medium duration rice varieties (kharif, 1991)

S. No	Variety	Cumulative leaf damage / m²			Yield t/ ha
		Case worm	Leaf folder	Whorl maggot	
1	Vikramarya	0.85	1.06	0.86	7.01
2	Sasyasree	0.86	1.04	0.84	3.99
3	Tulsi	0.93	1.00	0.88	6.56
4	Vibhava	0.78	0.99	0.83	5.59
5	Jaya	0.91	0.99	0.96	3.99
6	Karna	0.86	0.99	0.99	5.37
7	Co-44	0.89	0.99	0.88	4.03
8	MO-6	0.87	0.95	0.98	4.21
9	MO-7	0.83	1.03	0.94	4.92
10	Pusa-205	0.79	1.04	0.88	5.23
11	Sarjoo – 52	0.82	1.02	0.89	4.43
	SEM	NS	NS	0.03	0.62
	CD (P = 0.05)			0.09	1.30

Data transformed using $\sqrt{x} + 0.5$ where x = damage/m²

Assessment of crop loss due to leaf folder attack on rice
(KD Patil *et al*., 1992-93)

In order to assess the loss in yield due to leaf folder attack in rice, 92 rice plants (Jaya) were randomly selected in the field during Kharif 1992 (Table 5). The number of damaged and healthy leaves per marked plant/hill was recorded at 50 DAT, when infestation due to leaf folder attack reached the peak. Data on rice yield (9 t /ha) and percent leaf folder infestation was subjected to correlation and regression analysis using the linear model (Y = a + bx). Correlation between yield and leaf folder infestation resulted in a negative r value of (-0.61). The estimated yield and loss in yield at different levels of damage are given below.

Table 5. Yield differentials at varying levels of leaf folder infestation

Percent infestation	Yield (t/ha)	loss on yield (t/ha)
0	10.10	-
1	9.87	0.23
2	9.64	0.46
3	9.41	0.69
4	9.18	0.92
5	8.95	1.15
10	7.80	2.30
15	6.65	3.45
20	5.50	4.60
25	4.35	5.75
30	3.20	6.90

Management of insect pests of rice (KD Patil *et al.*, 1992-93)

A field trail was conducted with four treatments (i) Neemrich-1 (ii) Neemrich-1 + Monocrotophos 36 SL (alternate sprays) (iii) Monocrotophos (iv) Control during kharif 1992. The crop was sprayed as per the above treatments at 15 days interval beginning from 30 DAT up to 75 DAT. Observation on the incidence of insect pests was recorded at weekly intervals from 28 DAT up to crop maturity. The lowest cumulative damage due to leaf folder attack was 4.33% leaves/hill observed in the crop receiving neemrich-1 and monocrotophos as alternate sprays and was closely followed by Neemrich-1 (4.95% damage). The lowest cumulative damage due to gall midge *Orseolia oryzae* was observed for monocrotophos (0.44%).

Evaluation of Neem products on rice pests

(KD Patil *et al.*, 1993-94)

Leaf folder is one of the major pests on rice. Four neem based insecticides *viz.*, Limnool, Neem rich-II, Nimbecidine and Achook were evaluated with Monocrotophos for the control of leaf folder, (*Cnaphalocrocis medinalis*) in rice variety Jaya. Three sprays of the above insecticides were given at 30, 45 and 60 days after transplanting. The results revealed that (Table 6) a peak infestation occurred between 49 and 56 days after transplanting. All the neem based compounds *viz.*, Limnool, Neem rich-II, Nimbecidine and Achook were equally effective and their yields were similar to that of monocrotophos treatment.

Table 6. Evaluation of Neem based insecticides in rice (variety - Jaya)

S. No	Treatment	Mean leaf damage due to leaf folder attack per m²							Yield t/ha
		Days after transplanting							
	21	28	35	42	49	56	63		
1	Neem rich II	0.02	0.00	0.00	0.02	0.42	0.52	0.20	2.7
2	Limnool	0.00	0.04	0.02	0.00	0.34	0.50	0.20	3.4
3	Nimbecidine	0.04	0.02	0.04	0.02	0.30	0.58	0.20	3.3
4	Achook	0.00	0.02	0.02	0.00	0.34	0.54	0.50	3.6
5	Monocrotophos	0.04	0.02	0.00	0.02	0.32	0.38	0.24	3.6
6	Control	0.02	0.04	0.02	0.00	0.46	0.42	0.32	3.0

Performance of different rice varieties to major insect pests

(JR Faleiro *et al.,* 2000)

The incidence of gall midge, *Orseolia oryzae* and leaf folder, *Cnaphalocrocis medinalis* was recorded in four different groups of rice varieties *viz.*, short duration, medium duration, hybrids and scented varieties at 30, 45, 60 and 75 DAT. The reaction of different rice varieties to gall midge and leaf folder is presented in Table 7. The incidence of gall midge and leaf folder was comparatively more in the short duration and hybrid varieties, respectively.

Performance of rice varieties to major insect pests

(JR Faleiro *et al*., 2003-04)

Field reaction of rice varieties in three major groups viz, medium duration (14), scented varieties (7) and hybrids (14) were assessed against three major insect pests. Observation on incidence of the pests was recorded at 15, 30, 45 and 60 days after DAT. Results presented in the Table 8, indicate that the damage was well below the economic threshold values, and also statistically non significant.

Table7. Performance of different rice varieties to major insect pests

Short duration varieties	Cumulative damage/m²		Medium duration varieties	Cumulative damage/m²		Hybrid varieties	Cumulative damage/m²		Scented varieties	Cumulative damage/m²	
	G.M	L.F		G.M	L.F		G.M	L.F		G.M	L.F
IET-16825	0.25	5.25	4001		3.25	ADTRH-1	0.50	7.25	Pusa basumathi	0.75	3.50
IET-16826	1.00	4.00	4002		2.00	APHR-2	0.00	5.50	Karnal local	1.25	3.25
IET-16827	0.00	6.00	4003		3.25	CNRH-3	1.00	7.00	IET-13549	1.25	3.75
IET-16828	1.00	4.00	4004		2.50	CORH-2	0.50	5.25	IET-15392	0.25	2.50
IET-16829	5.25	5.00	4005	0.25	4.00	DDRH-1	0.00	5.25	IET-15390	1.00	3.50
IET-16830	1.50	5.25	4007	0.25	2.25	KRH-2	0.25	7.50	IET-13548	0.25	3.75
IET-16831	0.75	4.25	4008	0.75	3.25	NSD-2	0.25	4.75	IET-15391	1.50	4.25
IET-16832	0.00	4.50	4009		3.00	PSD-1	0.25	6.75	IET-14131	0.50	3.50
Gautam	1.75	4.75	4010		4.50	Sahyadri	0.00	6.75			
Krishna Hansa	0.75	8.00	4011		2.25	PA-6201	0.25	6.75			
IR-64	0.25	5.75	Jaya		3.00	PHB-71	0.50	5.50			
IR-12875	1.75	5.75				Jaya	0.00	5.75			
						Sasyasri	0.50	6.50			
						IET-12875	0.25	6.75			
						Jyoti	0.00	6.50			

Table 8. Cumulative damage in rice varieties due to major insect pests

A) Medium duration rice varieties

Variety	Gall midge	Leaf folder	Case worm
	Mean cumulative damage per m sq.		
	No of silver shoots	Damaged leaves	Damaged leaves
Suraksha	0.76 (0.08)	0.90 (0.31)	1.11 (0.73)
IET-17521	0.79 (0.13)	0.87 (0.26)	1.09 (0.50)
IET-17522	0.76 (0.08)	0.92 (0.35)	1.13 (0.79)
IET-17527	0.83 (0.18)	0.90 (0.30)	1.10 (0.71)
IET-175528	0.75 (0.06)	0.95 (0.41)	1.18 (0.88)
IET-17114	0.50 (0.12)	0.95 (0.41)	1.130.79
IET-16521	0.84 (0.21)	0.97 (0.45)	1.04 (0.59)
IET-17113	0.76 (0.08)	0.92 (0.34)	1.12 (0.75)
IET-17127	0.80 (0.15)	0.84 (0.20)	1.90 (0.68)
IET-17128	0.81(0.16)	0.87 (0.25)	1.05 (0.58)
IET-17136	0.85 (0.23)	0.88 (0.27)	1.14 (0.79)
IET-17544	0.85 (0.23)	0.90 (0.32)	1.14 (0.81)
IET17536	0.83 (0.20)	0.89 (0.28)	1.12 (0.76)
Jaya	0.84 (0.21)	0.89 (0.30)	1.07 (0.67)
CD (P =0.05)	0.05	NS	NS

B) Hybrid rice

Variety	Gall midge	Leaf folder	Case worm
	Mean cumulative damage per m sq.		
	No of silver shoots	Damaged leaves	Damaged leaves
Sahyadri	0.86 (0.24)	0.87(0.26)	1.08 (0.68)
KRH-2	0.84 (0.24)	0.91 (0.34)	1.04 (0.58)
EXPH-258	0.90 (0.31)	0.92 (0.34)	1.13 (0.77)
EXPH-361	0.89 (0.29)	0.89 (0.30)	1.09 (0.70)
EXPH-455	0.89 (0.30)	0.93 (0.36)	1.14 (0.80)
INDAM-200-011	0.85 (0.23)	0.93 (0.38)	1.13 (0.79)
INDAM-200-012	0.73 (0.03)	0.90 (0.32)	1.09 (0.70)
PRH-125	0.89 (0.31)	0.89 (0.29)	1.13 (1.05)
RH-204	0.85 (0.23)	0.87 (0.25)	1.11 (0.74)
MRP-5401	0.87(0.27)	0.92 (0.35)	1.17 (0.87)
Pusa RH-10	0.82 (0.18)	0.87 (0.25)	1.03 (0.56)
Triguna	0.76 (0.09)	0.92 (0.34)	0.98 (0.49)
Jaya	0.87 (0.25)	0.95 (0.40)	1.15 (0.82)
Jyothi	0.83(0.19)	0.90 (0.32)	1.12 (0.76)
CD (P =0.05)	NS	NS	NS

C) Scented rice varieties

Variety	Gall midge	Leaf folder	Case worm
	Mean cumulative damage per m sq.		
	No of silver shoots	Damaged leaves	Damaged leaves
Pusa sugandh	0.82 (0.18)	0.88 (0.27)	1.04 (0.60)
Mugad sugandh	0.80 (0.14)	0.94 (0.32)	1.06 (0.63)
Pusa basmati	0.83 (0.20)	0.93 (0.37)	1.27 (0.85)
Vasumati	0.78 (0.11)	0.89 (0.29)	1.11 (0.75)
Tarori basmati	0.80 (0.14)	0.94 (0.41)	1.22 (0.64)
Pusa RH-10	0.89 (0.30)	0.85 (0.23)	1.03 (0.56)
Kasturi	0.83 (0.20)	0.86 (0.23)	1.09 (0.69)
CD (P =0.05)	NS	NS	NS

Field reaction of rice varieties in three important groups *viz*., hybrids, scented and red kernel varieties was assessed against three major insect pests *viz*., gall midge *Orseolia oryzae*, case worm *Nymphula depunctalis* and leaf folder *Cnaphalocrocis medinalis* during 2004, 2005 and 2008. Results indicated that the damage was well below the economic threshold values, and was also statistically at par.

Sweet potato - weevil management

Chemical control of sweet potato weevil

(JR Faleiro, 1990-91)

Sweet potato is an important crop of the rice based cropping system in the state of Goa. This crop is heavily infested by the sweet potato weevil *Cylas formacarius*. A field trail of sweet potato variety (local white) was undertaken with five insecticidal treatments *viz*., Dimethoate 30 EC (0.05%), Monocrotophos 36 SL (0.05%), Phosphamidon 85 EC (0.05%), BHC 50 WP (0.2%) and Control (Table 9). Sweet potato cuttings of the local white cultivar were dipped in the above mentioned insecticides for one hour before plantings. The highest per cent infestation of tubers was recorded in the control plot (28.68). Plots treated with Monocrotophos and Phosphamidon recorded 15.70 and 15.56 per cent infested tubers and was statistically at par. Further it was seen that when 100 g of the yield (tubers), were stored in paper bags at room temperature for one month, 13.00 adult weevils emerged from tubers of plots which received no insecticides, while those treated with Monocrotophos and Phosphamidon recorded 2.75 and 6.75 adult weevils, respectively.

Table 9. Chemical control of sweet potato weevil

Treatment	Sprouted cuttings/ plot (%)	Infested tubers (%)	Number of adult weevils emerged after storing
Dimethoate	50.60	3.87 (1.46)	1.5 (1.17)
Monocrotophos	58.40	15.70 (4.00)	2.75 (1.70)
Phosphamidon	67.00	15.56 (3.51)	6.75 (2.20)
BHC 50 WP	33.66	3.33 (1.40)	1.25 (1.12)
Control	58.40	28.68 (5.19)	13.00 (3.37)
SEM	6.10	0.65	
CD (P =0.05)	18.29	1.95	NS

Chemical control of sweet potato weevil (JR Faleiro, 1992-93)

To manage the sweet potato weevil, *C. formacarius* 13 insecticidal treatment including control was evaluated. Insecticidal applications were made at four major stages of growth *viz*., (i) At planting, by dipping plant cuttings in Monocrotophos 36 SL (0.05%) for 30 minutes before plantings (ii) spraying Endosulfan 35 EC (0.07%) at 30 DAP and (iii) drenching the soil with Endosulfan (200 ml/plant) at 50 and 70 DAP. The damage grade index (DGI) due to weevil attack was calculated for the crown and tubers separately and presented in Table 10. Analysis of data showed that significantly highest per cent marketable tubers (93.95%) were obtained when plots are treated at planting (dipping of cuttings in Monocrotophos) and also sprayed and trenched with Endosulfan at 30 and 50 DAP, respectively. The least tuber infestation (6.05%) was also seen in plots receiving the above treatments at planting and at 30 + 50 DAP. The weevil infestation could be effectively controlled by dipping plant cuttings in Monocrotophos 36 SL (0.05%) for 30 minutes before planting together with a spray and soil drench (200 ml/plant) of Endosulfan 35 EC (0.07%) at 30 and 50 DAP, respectively.

Table 10. Chemical control of sweet potato weevil

Treatments	Performance of parameters			
	Damage crown	Grade index tuber	Tuber infestation (%)	Marketable tubers (%)
Dipping cuttings in Monocrotophos 36 SL (0.05% for 30 minutes) (D)	1.64 (2.23)	1.35 (1.33)	3.98 (15.75)	9.20 (84.25)
D + spray Endosulfan 35 EC (0.07%)at 30 DAP	1.03 (0.63)	0.96 (0.43)	4.09 (16.44)	9.16 (83.56)
D + 30 + soil drench with Endosulfan at 70 DAP	1.07 (0.67)	0.73 (0.03)	2.55 (6.05)	9.17 (93.95)
D + 30 + 50 + soil drench with Endosulfan at 70 DAP	1.08 (0.70)	0.86 (0.27)	2.57 (6.40)	9.70 (93.59)
30	1.14 (0.83)	1.01 (0.56)	3.34 (14.07)	0.28 (85.95)
30 + 50	1.14 (0.80)	0.98 (0.47)	3.44 (11.56)	9.43 (88.44)
30 + 50 + 70	1.43 (1.60)	0.83 (0.20)	3.20 (10.62)	9.47 (89.38)

D + 50	1.04 (0.53)	0.81 (0.17)	3.50 (12.77)	9.36 (87.23)
50	1.12 (0.80)	0.93 (0.37)	3.65 (12.93)	9.36 (87.14)
50 + 70	1.12 (0.77)	0.84 (0.23)	3.29 (10.46)	9.49 (89.24)
D + 70	1.52 (1.87)	1.14 (0.80)	3.72 (13.49)	9.33 (86.51)
70	1.37 (1.40)	0.92 (0.37)	3.98 (15.45)	9.23 (84.55)
Control	1.77 (2.63)	1.34 (1.33)	5.64 (32.06)	8.25 (67.94)
SEM	0.10	0.07		0.20
CD (P = 0.05)	0.29	0.20	N S	0.58

Data transformed using square root transformation of x + 0.5 where x is the original value. Figures in parenthesis are mean original values.

Use of Neem based insecticides and sex pheromone in the management of sweet potato weevil (Mani Chellappan, 1994-95)

Environment friendly neem based insecticides (Nimbecidine and Limnool) and male sex attractants were employed for the management of sweet potato weevil during 1994-95. The vines were dipped in the neem insecticide (0.5 %) and monocrotophos (0.05%) solution for 1h prior to planting. Pheromone septa were mounted in locally fabricated traps and placed 100 sq. m apart and 45 cm above the crop canopy, immediately after planting. The results (Table 11) revealed that more marketable tubers (72.04%) were obtained in nimbecidine + pheromone combination followed by monocrotophos + pheromone (70.27%). In individual treatment, nimbecidine was the most effective (70.09%). Altogether, there was a significant increase in the marketable tubers when compared to the control (43.05%). The neem based pesticides has performed as good as monocrotophos treatment and the pheromone traps might play as an effective tool in the integrated management of the sweet potato weevil.

Table 11. Effect of neem pesticides and sex pheromone on the sweet potato weevil infestation

Treatment No	Particulars	Mean tuber yield (%)	
		Infested	Marketable
1	Nimbecidine + pheromone	9.0 (17.46)	91.0(72.54)
2	Limnool + pheromone	22.7 (22.45)	77.3 (61.55)
3	Monocrotophos + pheromone	11.4 (19.73)	88.6 (70.27)
4	Pheromone	27.2 (31.44)	72.8 (58.56)
5	Nimbecidine	11.6 (19.95)	88.4 (70.09)
6	Limnool	27.8 (31.82)	72.2 (58.18)
7	Monocrotophos	22.0 (27.97)	78.0 (62.03)
8	Control	55.4 (48.10)	46.6 ()43.05

Chemical control of sweet potato weevil

(JR Faleiro and AR Desai, 1999-2000)

A field trail involving 14 treatments was undertaken to manage sweet potato weevil. The four stages of crop growth *viz*., at planting (zero days), 30 DAP, 50 DAP and 70 DAP were treated with insecticide in different combinations. Plant cuttings were dipped in 0.1% solution of dimethoate 30 EC for 10 minutes before planting. Also, soil trench of 0.07% Endosulfan 35 EC was applied @ 1000 L/ ha at 30, 50 and 70 DAP. The least average damage grade index values were obtained by protecting the crop at planting and 30 DAP.

Cashew - insect pests management

Management of cashew tea mosquito bug, *Helopeltis antonii*

(Mani Chellappan and Chidananda prabhu, 1994-95)

The tea mosquito bug, *Helopeltis antonii* is considered to be the most serious pest of cashew in India, and causes more economic loss to the crop. Bio-effeciency of neem formulations were tested against cashew tea mosquito bug, *H. antonii* and compared with chemical insecticide, endosulfan during 1995-96. It has been tested in different concentrations at flushing, panicle initation and fruit formation stages. Among the neem formulations, neem suraksha at its highest concentration (0.6%) was best as an independent treatment (Table 12). Neem formulations in combinations with the chemical insecticide also found to be effective in the management of the pest. However, the endosulfan treatment had the least infestation by the pest.

Table 12.Management of cashew tea mosquito bug using Neem insecticides

Treatment	Per cent infestation		
	Flushing	Flowering	Fruiting
Neem suraksha (0.1%)	23.70 (16.2)	26.42 (19.8)	34.60 (32.3)
Neem suraksha (0.3%)	21.18 (13.1)	30.02 (25.0)	27.46 (21.3)
Neem suraksha (0.5%)	20.78 (12.6)	23.26 (15.6)	30.54 (25.9)
Neem suraksha (0.6%)	15.72 (7.3)	19.82 (11.5)	22.76 (24.3)
NF (0.3%)	18.48 (10.1)	23.42 (15.8)	28.60 (24.3)
NF (0.6%)	16.68 (8.3)	20.94 (12.8)	27.12 (23.9)
Neem suraksha (0.3%) + Endo (0.05%)	8.64 (2.2)	17.40 (8.9)	14.48 (6.3)
NF (0.3%) + Endo (0.05%)	17.10 (8.6)	20.94 (12.8)	17.04 (8.5)
Endosulfan (0.1%)	5.72 (1.0)	14.40 (6.2)	4.48 (0.9)
Control	22.02 (14.1)	26.84 (20.4)	39.00 (39.6)

DMRT at P = 0.05

Values in the parenthesis are the original data

Studies on the reaction of cashew accessions to tea mosquito bug, *Helopeltis antonii*

Eleven local accessions, nine accessions of NRC and keeping V-4 as control were assessed for their reaction to the incidence of TMB (Table 13). Trees were scored for TMB infestation on a scale measuring from 0 to 10 with a score of one being assigned to denote 10.0 per cent damage to the shoots. Observations revealed that accessions of both the groups did not differ significantly with respect to TMB infestation. However, in case of local accessions, the lowest count of 0.68 was recorded in Ganje-2, while the maximum incidence count of 2.70 was seen in paikul-1. As regards NRC accessions, vth-92/2 registered the lowest score, while VTH-146/1 recorded the highest.

Table 13. Score for TMB damage in cashew accessions

S. No	Accessions	Mean score of shoot damage
1	Balli -1	1.48 (1.69)
2	Balli – 2	1.39 (1.43)
3	Ganje -2	1.34 (1.29)
4	Ganje -2	1.09 (0.68)
5	Bakle -1	1.72 (2.45)
6	Karapur - 1	1.15 (0.82)
7	Karapur - 1	1.43 (1.54)
8	Dhave - 1	1.37 (1.37)
9	Dhave - 2	1.58 (1.99)
10	Dhave - 3	1.76 (2.59)
11	Paikul -1	1.79 (2.70)
12	V - 4	1.39 (1.43)
CD (p= 0.05)		NS

Reaction of local cashew accessions from Goa to tea mosquito bug *Helopeltis antonii* (2000 -2001)

Eleven local accessions along with V-4 as check were scored for reaction to tea mosquito bug. The results are presented in the Table 14. The accessions differed significantly with respect to incidence of tea mosquito bug during the season of report. There was highest shoot damage in GCC- 94/6 and the lowest damage in GCC- 94/4. However, these values were 15.7 and 16.5 in V-4 and Goa -1 respectively.

Table 14. Screening of local accessions for tea mosquito bug *Helopeltis antonii* (2000 -2001)

S. No	Accessions	Mean score of shoot damage		
		2000	2001	Cumulative
1	GCC – 94/1 (Ganje - 1)	1.67 (2.30)	1.53 (1.83)	1.60 (2.01)
2	GCC – 94/2 (Ganje – 2)	1.29 (1.17)	1.56 (2.00)	1.44 (1.59)
3	GCC – 94/3 (Bakhle – 1)	1.73 (2.50)	1.34 (1.30)	1.55 (1.92)
4	GCC – 94/4 (Karapur – 1)	1.40 (1.50)	1.32 (1.25)	1.36 (1.38)
5	GCC – 94/5 (Karapur – 2)	1.44 (1.67)	1.46 (1.63)	1.45 (1.65)
6	GCC – 94/6 (Dhave – 1)	1.71 (2.50)	1.94 (3.27)	1.83 (1.83)
7	GCC – 94/7 (Dhave – 2)	1.59 (2.05)	1.66 (2.30)	1.63 (2.18)
8	GCC – 94/8 (Dhave – 3)	1.77 (2.72)	1.91 (1.17)	1.26 (1.94)
9	GCC – 94/9 (Paikul – 1)	1.80 (2.90)	1.81 (2.79)	1.81 (2.84)
10	GCC – 94/10 (Balli – 1)	1.49 (1.97)	1.37 (1.40)	1.44 (1.96)
11	Balli – 2	1.39 (1.50)	1.65 (2.23)	1.53 (1.87)
12	V - 4	1.39 (1.50)	1.57 (2.00)	1.49 (1.75)
	CD (P = 0.05)	NS	0.29	NS

Management of insect pests of Pulses

Survey, surveillance and monitoring of insect pests of pulses

(Mani Chellappan and Chidananda prabhu, 1995-96)

In order to monitor the insect pests and natural enemies on pulses, a field survey was conducted. Out of the total 14 insect species recorded on pulses, pulse pod borer (*Helicoverpa armigera*), leaf miner (*Aproaerema modicella*) and spiny pod borer (*Etiella zinkenella*) has occurred in severe to moderate intensity; *H. armigera* was particularly severe on red gram (Table 15). Apart from the insect pests, some of the hymenopteran parasitoids *viz*., *Bracon* spp, *Apanteles* spp, *Trichogramma* spp, *Tetrastichus* spp also observed and recorded.

Table 15. Survey, surveillance and monitoring of insect pests of pulses and their natural enemies

Name	Scientific name	Family
Leaf hopper	*Empoasca kerri*	Cicadellidae
Aphid	*Aphis craccivora*	Aphididae
Whitefly	*Bemiscia tabaci*	Aleyrodidae
Pod bug	*Clavigrallla gibbosa, Riptortus pedestris*	Coriedae
Thrips	*Frankliniella schultzes*	Thripidae
Sting bug	*Nezara viridula*	Pentatomidae
Leaf miner	*Aproaerema modicella*	Gelechidae
Spiny pod borer	*Etiella zinkenella*	Pyralidae
Plume moth	*Exelastis atomosa*	Pterophoridae
Blue butterfly	*Lampides boeticus*	Lycaenidae
Pod borer	*Helicoverpa armigera*	Noctuidae
Pod fly	*Melanagromyza obtuse*	Agromyzidae
Jewel beetle	*Sphenoptra parotetti*	Buprestidae
Mite	*Aceria cajani*	Eriophyidae
Natural enemies	*Bracon* sp, *Apanteles* sp,*Trichogramma* sp, *Tetrastichus* sp	

Use of eco-friendly insecticides in the management of pulse pod borer

Pulse pod borer *Helicoverpa armigera* is a major pest on red gram. A field trail was conducted using biopesticide (*Bacillus thuringiensis*) and Neem formulations for the management of *H. armigera* on red gram. Neem formulations (Neem suraksha, Neem gold and Godrej achook, all having equal concentration of Azadirachtin (0.03%) and *Bacillus thuringiensis* were used in the study. Treatments were given during flowering- pod initiation stage and 20 days thereafter and the observations were recorded on the per cent pod infestation. Results have shown that chemical insecticide, endosulfan at the recommended dose was the most effective (23.37% infestation) followed by monocrotophos and *Bacillus thuringiensis* (31.40 and 35.10% respectively) treatments. An additive effect was observed in the *Bacillus thuringiensis* + neem formulations. Among the neem formulations, neem suraksha @ 0.5% has performed well.

Table 16. Eco-friendly insecticides in the management of pulse pod borer

Treatments	Per cent pod infestation
Control	41.07 (50.6)
Neem suraksha (0.5%)	38.03 (38.0)
Neem gold (0.3%)	40.23 (41.7)
Achook (0.5%)	40.17 (41.6)
B.t (0.5%)	35.10 (34.7)
Neem suraksha + B.t (0.25%)	37.00 (36.2)
Neem gold + B.t (0.25%)	38.17 (38.2)
Achook + B.t (0.25%)	36.07 (34.7)
Endosulfan (0.1%)	23.37 (15.6)
Monocrotophos (0.1%)	31.40 (31.4)

CV = 9.79 (at P = 0.05) DMRT at P = 0.05

Studies on biologically derived materials for the management of insect pests (Mani Chellappan and Chidananda Prabhu, 1996-97)

Bio pesticides from plants are very effective against different group of insect pests. The plant product custard apple seed was extracted through different solvents using soxhlet apparatus. Ether extract of the custard apple seed when used undiluted has resulted in 100 per cent mortality of *Dysdercus cingulatus*. There was a proportional decline in the mortality of the insect as the dilution of the extract increased (Table 17). For the castor hairy caterpillar, 0.5 µl of the ether extract was found to be effective which caused 50 per cent mortality.

Table 17. Effect of custard apple seed extract on *D. cingulatus* and castor hairy caterpillar

Experiment –I (*D. cingulatus*)		Experiment –II (Castor hairy caterpillar)	
Treatment	**Mortality (%)**	**Treatment**	**Mortality (%)**
Ether extract		**Topical application**	
1:0	100.0	0.5µl	50
1:1	83.3	1.0 µl	100
1:1.5	78.4	1.5 µl	100
1:3	68.0	2.0 µl	100
1:6	41.7	0.0 µl	0
0:1	10.0		
Methanol	30.0		
Acetone	25.0		

Effect of custard apple seed ether extract on haemolymph protein of treated insects

The insects treated with different concentration of custard apple ether seed extract were used for biochemical analysis. Total protein of the haemolymph was estimated using burette method. Within 24h a slight reduction in the total protein level was observed when the ether extract applied topically without dilution (Table 18). The total protein level of the haemolymph has gone down drastically due to the ether extract treatment in *D. cingulatus* and Castor hairy caterpillar

Table 18. Effect of custard apple seed ether extract on haemolymph protein of treated insects

A) *D. cingulatus*		B) Castor hairy caterpillar	
Treatment	**Protein content (g/ 100 ml)**	**Treatment**	**Protein content (g/ 100 ml)**
Control	19.81	Control	9.26
Ether extract 1:0 1:6	 17.59 19.63	Ether extract 0.5µl	6.37

Antifeedant and repellent effects of different plant extracts on *Spodoptera litura* (Mani Chellappan and H R C Prabhu, 1997-968)

Sixth instar larvae of *S. litura* were allowed to feed on castor leaf discs (soaked in plant extracts and air dried). The per cent feeding was recorded for the antifeedant and repellent actions of the extracts. Among the extracts, *Annona squamosa* seed extracts (both water and ether extracts) had the least feeding (Table 19) followed by *Adhatoda vassica*.

Table 19. Antifeedant and repellent effects of different plant extracts on *Spodoptera litura*

S. No	Treatment	Mean feeding (Cm^2)	Per cent feeding
1	*Adhatoda vassica* (EE)	1.90	12.6
2	*Adhatoda vassica* (WE)	2.20	14.0
3	*Annona squamosa* (EE)	1.56	9.9
4	*Annona squamosa* (WE)	1.80	11.9
5	*Hyptis sauveolens* (EE)	2.23	14.2
6	*Hyptis sauveolens* (WE)	3.00	19.0
7	*Eupatorium odoratum* (EE)	2.01	18.1
8	*Eupatorium odoratum* (WE)	2.10	18.9
9	Control (EE)	3.25	20.6
10	Control (EE)	3.40	21.6

Effect of topically applied plant extracts on *Spodoptera litura* food consumption and utilisation

The larvae of *S. litura* were treated topically with 2 µl of the plant extracts. The increase in the body weight was progressive for 120 hours in different degrees in various treatments (Table 20). At the end of 120 hours the larvae treated with water extracts of *H. sauveolens* and *A. vassica* had the least mean body weight (0.279 and 0.287g, respectively) compared to other treatments. Lighter pupae were formed from the treatments of *H. sauveolens, A. vassica* and *A. squamosa*.

Table 20. Food consumption and utilisation of *Spodoptera litura* on plant extracts

S. No	Treatment	Mean body weight (g)					Mean pupa weight (g)
		24h	48h	72h	96h	120h	
1	*Adhatoda vassica* (EE)	0.112	0.120	0.226	0.382	0.346	0.202
2	*Adhatoda vassica* (WE)	0.095	0.112	0.259	0.412	0.287	0.257
3	*Annona squamosa* (EE)	0.072	0.097	0.154	0.376	0.310	0.249
4	*Annona squamosa* (WE)	0.081	0.103	0.180	0.400	0.350	0.270
5	*Hyptis sauveolens* (EE)	0.099	0.108	0.211	0.421	0.333	0.231
6	*Hyptis sauveolens* (WE)	0.105	0.113	0.304	0.465	0.279	0.239
7	*Eupatorium odoratum* (EE)	0.096	0.143	0.260	0.467	0.350	0.290
8	*Eupatorium odoratum* (WE)	0.105	0.155	0.292	0.476	0.396	0.305
9	Control (EE)	0.125	0.150	0.300	0.480	0.410	0.320
10	Control (EE)	0.135	0.155	0.306	0.470	0.425	0.350

Different concentrations of *A. squamosa* seed ether extract was topically applied on *S. litura* larvae. As the concentration increased, the mean body weight gain and the cumulative faecal pellet weight degreased. At the highest concentration (2µl), there was as much as 40 per cent malformation/ mortality (Table 21). In case of *Dysdercus cingulatus* also the per cent mortality was directly proportional to the concentration and it was dose dependent.

Table 21. Effects of topically applied *Annona squamosa* ether extract on *Dysdercus cingulatus*

S.No	Treatment	Per cent malformation	Mortality (%)
1	Control	0.0	0.0
2	100%	0.0	100.0
3	75%	8.0	83.0
4	50%	10.0	78.0
5	25%	0.0	68.0
6	12.5%	0.0	42.0

Field tolerance of promising pigeon pea varieties for tur pod fly (JR Faleiro, 2002)

Tur pod fly *Melanagromyza obtusa* is a major pest of pigeon pea in Goa. Observations on damage to pod fly in 18 pigeon pea varieties were recorded at 90,120 and 130 days after sowing (DAS). The varieties exhibited significantly different damage levels to pod fly (Table 22). The variety BSMR-736 recorded the least pod damage of 0.50 per cent.

Table 22. Tolerance of pigeon pea varieties against tur pod fly

Variety	Per cent pod damage			
	90 DAS	120 DAS	130 DAS	Cumulative
ICPL – 98002	4.58 (23.35)	3.85 (15.52)	4.03 (15.80)	4.23 (18.2)
ICPL – 98005	4.81 (25.62)	5.60 (31.31)	4.70 (22.67)	5.06 (26.53)
ICPL – 98008	3.86 (14.41)	5.39 (30.07)	3.75 (13.75)	5.56 (19.41)
ICPL – 98010	3.10 (09.88)	5.24 (29.50)	3.73 (14.31)	4.20 (17.89)
ICPL – 98013	3.54 (12.92)	5.55 (31.17)	3.13 (9.83)	5.08 (17.97)
ICPL – 98014	3.59 (12.77)	5.01 (26.89)	3.46 (13.39)	4.25 (17.68)
DSLR – 120	3.07 (11.85)	3.32 (14.06)	3.14 (09.79)	3.26 (11.90)
DSLR – 132	3.44 (15.33)	4.11 (17.10)	3.02 (09.54)	3.78 (14.00)
PH – 4693	2.46 (07.65)	5.17 (26.23)	3.69 (13.28)	4.02 (15.72)
AL – 1439-1	3.83 (19.07)	4.17 (22.56)	3.44 (11.85)	4.24 (17.82)
P-9-140-53	2.58 (08.30)	3.67 (17.25)	4.70 (21.80)	3.95 (15.78)
AL-1433-2	5.17 (28.32)	4.38 (19.30)	3.96 (15.31)	4.61 (20.97)
Manak	3.46 (12.04)	4.66 (21.51)	2.64 (06.68)	3.73 (13.41)
UPAS-120	4.55 (20.20)	4.57 (20.89)	3.66 (13.01)	4.29 (18.03)
ICPL- 87	3.50 (16.54)	3.12 (12.50)	3.54 (13.22)	3.68 (14.08)
TS- 3	2.41 (11.10)	0.17 (00.00)	1.99 (03.76)	2.03 (04.95)
BSMR – 736	-	-	1.27 (01.74)	0.97 (00.50)
Local	1.53 (3.17)	2.30 (9.80)	3.02 (09.21)	2.69 (07.39)
CD (P = 0.05)	NS	1.90	1.09	1.33

Figures in parenthesis are original values. NS = Non significant

Management of Tur pod fly *Melanagromyza obtuse*

(JR Faleiro *et al*., 2003-2004)

This pest Tur pod fly *Melanagromyza obtuse* is predominant during kharif. An exposure-protection insecticidal schedule (Table 23) was devised with 0.05 per cent Monocrotophos 36 SL, beginning at flowering and subsequently at 15 and 30 days after flowering (DAF). In all, there were seven treatments including control. Least pod infestation of 7.67 per cent was recorded when the crop was protected at flowering and 15 DAF, indicating that two sprays of 0.05 per cent Monocrotophos 36 SL at 15 days interval commencing from flowering are essential to protect the crop from pod fly.

Table 23. Management of Tur pod fly *Melanagromyza obtuse*

S. No	Treatments			Per cent pod damage
	F	15DAF	30 DAF	
1	S	-	-	2.91 (8.33)
2	S	S	-	2.83 (7.67)
3	S	S	S	3.38 (11.00)
4	-	S	-	3.53 (12.00)
5	-	S	S	3.81 (14.00)
6	-	-	S	3.37 (7.67)
7	Control			3.62 (12.00)
C.D (P = 0.05)				NS

S = Spray of 0.05 % monocrotophos 36 SL

Ground nut insect pests management

Bio-efficacy of insecticides for the management of groundnut pod borer, *Anisolobes stallii*

(Mani chellappan and H R C Prabhu, 1997-98)

Groundnut pod borer, *Anisolobes stallii* is a major pest in this region. To manage this pest different treatment were given when the crop started pegging. The per cent infestation was recorded at the time of harvest (Table 24). In the untreated control, the infestation was as high as 81 per cent. Among the insecticide treatment, carbofuron treatment gave a fairly good control (29.1 %) followed by thimmet (39.5 %). The karanji oil cake had some insecticidal effect recording 63.1 per cent infestation as against the neem cake (71.9%).

Table 24. Bio-efficacy of insecticides for the management of groundnut pod borer, *Anisolobes stallii*

S. No	Treatment	Per cent infestation
1	Control	81.3
2	Endosulfan	61.3
3	Malathion	49.5
4	Lindane	44.5
5	Sevin	53.5
6	Neem cake	71.9
7	Karanji oil cake	63.1
8	Carbofuran	29.1
9	Thimmet	39.5

Screening groundnut varieties for field tolerance to groundnut pod borer (Earwig) (Faleiro *et al*., 2003)

The incidence of damage to pods due to earwig / wireworm was recorded in three groups of groundnut varieties viz. ICRISAT short duration, ICRISAT confectionary and UAS, Dharwad short duration varieties (Table 25). It reveals that damage levels in pods of groundnut due to earwig infestation were high

(8.13 to 16.1%) and significantly different in the ICRISAT confectionary group of varieties. In the short duration group damage levels in both ICRISAT and Dharwad varieties was less than 10 per cent and statistically non significant. Highest damage incidence (6.77 %) was recorded in the confectionary group of varieties during 2003.

Table 25. Field tolerance of groundnut varieties against pod borer (Earwig) ICRISAT- Short duration, ICRISAT- Confectionary, UAS, Dharwad-Short duration

Variety	Per cent pod damage	Variety	Per cent pod damage	Variety	Per cent pod damage
ICGV-93429	1.75 (2.55)	ICGV-97040	1.99 (3.47)	TAG – 24	1.44 (1.57)
ICGV-96333	1.36 (1.36)	ICGV-97045	2.15 (4.11)	Dh - 22	1.62 (2.13)
ICGV-96342	1.50 (1.75)	ICGV-97047	1.94 (3.27)	Dh - 86	1.61 (2.10)
ICGV-96346	1.85 (2.91)	ICGV-97049	1.94 (3.28)	Dh -3-30	1.54 (1.89)
ICGV-96352	1.50 (1.78)	ICGV-97051	1.36 (2.61)	Dh -40	1.20 (0.64)
ICGV-96390	1.54 (1.87)	ICGV-97058	1.96 (3.37)	K- 134	1.57 (1.97)
ICGV-96395	1.69 (2.35)	ICGV-97061	2.45 (5.53)	JL-24	1.79 (2.70)
ICGV-96399	1.58 (1.99)	ICGV-98396	1.87 (2.99)	GB- BD	1.74 (2.45)
ICGV-96442	1.31 (1.23)	ICGV-98397	2.25 (4.55)	ICGV-92242	1.71 (2.42)
ICGV-97243	1.23 (1.03)	ICGV-98402	1.87 (3.00)	ICGS - 76	2.73 (2.23)
ICGV-97245	1.76 (2.61)	ICGV-98404	2.10 (3.89)		
ICGV-97257	1.34 (1.30)	ICGV-98412	2.73 (2.49)		
ICGV-97261	1.55 (1.89)	ICGV-98426	1.47 (1.67)		
ICGV-97262	2.02 (3.57)	ICGV-98432	2.70 (6.70)		
Chico	1.57 (1.96)	ICGV-98439	1.99 (3.46)		
LocalTAG24	1.35 (1.32)	LocalTAG24	1.84 (2.81)		
C.D (P=0.05)	NS	C.D (P=0.05)	NS	C.D (P=0.05)	NS

Influence of sowing dates on the incidence of pod borer in groundnut

Damage levels of earwig/ wireworm in groundnut sown at four different sowing dates *viz*. 16th, 23rd, 30th December and 6th January, 2003 indicated that the crop could not withstand drought and had to be irrigated (Table 26). Least damage to pods cultivated under protective irrigation was recorded in the crop sown on 6/1/2003.

Table 26. Influence of sowing dates pod damage due to earwig and marketable yield in groundnut

Date of sowing	Per cent pod damage	Marketable yield (t/ ha)
16-12-02	5.34 (29.75)	1.12
23-12-02	5.09 (27.13)	0.76
30-12-02	3.93 (16.36)	1.35
6-1-03	2.81 (8.63)	1.35
C.D. (P = 0.05)	1.39	0.29

Testing an irrigation and chemical control schedule for the management of pod borer in groundnut (Faleiro *et al*., 2003-2004)

Earwig/ wireworm infestation is a production constraint of rabi groundnut grown on residual soil moisture in the state. To manage these pest two levels of irrigation and eight insecticide treatments were undertaken.

I. Irrigation

Protective irrigation at sowing and pegging (II)

II. No irrigation

Insecticide (drenching soil with 0.04% chlorphyriphos 20 EC @ 100 ml/ running meter)

at Sowing (S) Pegging (P)

P + 15 Days after pegging (DAP)

P + 15 + 30 DAP

\- + 15 + 30 DAP

\- + 15 DAP + -

\- + - + 30 DAP

Control (No insecticide)

Results of the above trail indicated that insecticides did not have a significant influence on the infestation level (Table 27). However, the crop that received protective irrigation registered significantly superior plant population and higher levels of yield.

Table 27. Influence of irrigation and insecticide on plant population, yield and damage due to earwig in groundnut

Treatments	Pod damage (%)	Plant population	Marketable yield (t/ ha)	Gross income (Rs./ ha)
I_1S	6.92 (48.45)	21.55	0.99	7920
I_1P	7.70 (42.63)	20.11	1.08	8640
I_1P + 15	5.50 (32.04)	16.66	1.20	9600
I_1P + 15 + 30	6.56 (46.78)	19.66	1.10	8800
$I_1$15 + 30	7.66 (59.40)	20.66	0.81	6533
I_1 15	7.33 (53.64)	14.00	0.75	6027
$I_1$30	7.05 (49.93)	16.55	0.87	7013
I_1	6.35 (40.92)	20.33	0.95	7600
I_2S	7.62 (59.10)	13.77	0.57	4613
I_2P	4.19 (23.33)	04.77	0.31	2533
I_2P+15	7.27 (52.34)	12.11	0.85	6800
I_2P+ 15 + 30	4.12 (19.62)	09.33	0.58	4667
$I_2$15+ 30	5.19 (36.73)	08.22	0.55	4427
$I_2$15	7.16 (51.49)	10.44	0.44	3573
$I_2$30	7.38 (54.04)	10.22	0.50	4053
I_2	6.52 (43.54)	09.00	0.48	3893
C.D. (P = 0.05)				
Irrigation	NS	02.17	0.20	-
Insecticide	NS	NS	NS	-
Interaction	NS	06.13	NS	-

In 2004, also same treatments schedule were undertaken to manage the wireworm in groundnut. The least infestation of 12.34 per cent was recorded when the plots were irrigated and drenched with chlorphriphos at pegging. This was statistically at par with plots that received no irrigation and were treated with insecticide at sowing.

Fruit fly biodiversity and their management

Seasonal incidence and abundance of fruit fly diversity in Goa (JR Faleiro and Ramesh, 2006-2007)

The abundance and diversity of fruit fly species of western ghats of Goa, was studied with weekly observations of fruit fly captures in methyl eugenol (orchard fly) and cue- lure (melon fly) baited plastic bottle traps. It was set in three distinct ecological habitat of the state *viz*. i) coastal plains, ii) undulating mid lands and iii) mountainous uplands. From the studies, it was evident that in methyl eugenol baited traps *B. dorsalis* was the most abundant species followed by *B. caryeae, B. zonata, B. affinis, B. correcta* and *B. verbicifolia*. It was also seen that *B. cucurbitae* was the most dominant species where cue lure baited traps were set followed by *B. tau, B. gavisa, B. caudate*, and *B. nigrotibialis*. The highest (312.17 flies/ trap) activity of orchard fly, *B. dorsalis* was recorded in the month of June, 2006 while it was least active (15.37 flies/ trap) during December, 2006. Further, the melon fly *B. cucurbitae* was most active (157.75 flies/ trap) during the month of September, 2006 while, the least (16.79 flies/ trap) activity of *B. cucurbitae* recorded in the month of June and December, 2006.

Cue lure trap

Methyl eugenol trap

The activity of *B. dorsalis* was high during the maturity of the mango in the field between April to June. With regards to *B. cucurbitae* maximum fly activity was noticed after the kharif during September- October and again during February. In spite of low *B. cucurbitae* activity during the cropping season between June to August the pest causes substantial damage (more than 20 %) to hill cucumber in Goa. Further, both orchard and melon fly populations were highest in the coastal region which declined in the midlands and was least in the mountainous uplands of the western region.

Host range preference of fruit fly

Choice test studies revealed that cucumber was most preferred for egg laying and was statistically at par with red pumpkin. The flies showed medium preference to the local cucumber cultivar, bottle gourd, snake gourd and ridge gourd, while no egg laying occurred in little gourd, musk melon and bitter gourd.

Effect of indigeneous food baits and bio-control agents against fruit flies

The efficacy of different food baits to attract *B. cucurbitae* was evaluated in a single killing point trail. The results revealed that among the baits (14 treatments) evaluated, banana/ jaggery (10% weight:volume) were equally effective as compared to commercial protein hydrolysate (PH) (3% volume:volume) and could serve as a low cost indigenous bait for use in the field replacing the costly PH.

Wide area management of *B. cucurbitae*

The trail was taken up in a farmer participatory programme with an aim to educate the farmers on bait application technique (BAT). The treatments involve imported protein hydrolysate (PH) and locally available baits (banana, banana+ jaggery) vis-a- vis plots treated with insecticide (malathion 50 EC) and plots receiving no treatment (control). Results indicate that melon fly, *B. cucurbitae* caused substantial (21%) damage to cucumbers in untreated control where no baits/insecticides treatments were made. Least fruit infestation of 1.32 per cent was recorded in the farm treated with insecticide. Among the baits tested, banana recorded the least infestation

Squirting of the baits

(5.38%). The encouraging results obtained in this study with baits prepared from locally available material will discourage the farmers from using insecticides for the management of *B. cucurbitae* on cucumber.

Hot water treatment of mango to control *Bactrocera* spp

(JR Faleiro, 2006-2007)

Nine treatments were conducted involving treatment of freshly harvested mangoes in hot water at 48^0 C for 1 hr and 1.5 hours. Hot water treatment (HWT) of fruits at these temperatures effectively controlled fruit fly in all the nine experiments, suggesting that treating fruits at 48^0 C for 1 hr is adequate to control the pest. Infestation in the control treatment ranged from 3.33 to 30.00 per cent with either *B. dorsalis* or *B. caryeae* emerging from the infested fruits in the control treatment. Organoleptic analyses revealed that the total soluble solids (TSS) and pH of hot water treated and untreated fruits did not vary. An overall organoleptic evaluation through 90 respondent revealed that aroma and sweetness improved in treated fruits as compared to fruits in untreated control while, the colour was also not adversely affected due to HWT. In general, fruit quality was not affected by hot water treatment. In fact, aroma and sweetness improved in fruits that were subjected to HWT.

Hot water treatment of mango

Protection exposure schedule for the management of *B. cucurbitae*

Spraying of 0.1% malathion 50EC at 15 days interval commencing from 15 days after sowing (DAS) to 60 DAS was undertaken against *B. cucurbitae*. Least infestation due to *B. cucurbitae* was obtained by protecting the crop with the above spray schedule at 30+45+60 DAS. Further, pooled analysis of data indicated that the least infestation (11.67 %) due to melon fly in cucumber was recorded in plots receiving complete protection from the pest with cover sprays of 0.1% malathion 50EC at 15, 30, 45 and 60 DAS. This was followed by plots that were protected from the pest at 15+ 30+ 45 DAS which recorded pooled mean infestation of 16.09 per cent which was statistically at par (16.96%) with plots receiving protection from the pest at 15+ 30 DAS. The infestation level in untreated control was 24.14 per cent.

Impact of weather factors on fruit flies

Melon fly and orchard fly was correlated with weather parameters. As regards the major orchard fly species *viz*. *B. caryeae* and *B. dorsalis* relative humidity was significantly and positively correlated to both *B. caryeae* and *B. dorsalis* in the upland while, wind speed has a significant positive impact on the activity of both these fly species in midland. Further, rainfall was significantly and positively correlated to *B. dorsalis* in the upland while, availability of food had a significant and positive impact on the activity of both *B. caryeae* and *B. dorsalis* in the coastal zone. With regards to the melon flies, maximum temperature, minimum temperature and relative humidity had a significant and positive correlation with the captures of *B. cucurbitae* in the upland, midland and coastal zones, respectively.

Incidence (%) of fruit flies at three geographical zones of Goa

The geographical distribution of *Bactrocera* fruit flies in Goa was studied through methyl eugenol and cue lure traps set in three different ecological habitats of goa *viz*., coastal, undulating mid lands and mountainous upland (Table 28). Both the orchard and melon flies were most abundant in the coastal region, followed by the midland and uplands. However, *B. caryeae* was most active in the midland, unlike *B. dorsalis* which was most active in the coastal region.

Table 28. Incidence (%) of fruit flies at three geographical zones of Goa

Species		Per cent incidence			Anova	
		Upland	Midland	Coastal	F	P
Orchard flies	*B. caryeae*	95.25	98.11	81.13	8.235	0.001
	B. dorsalis	100	98.12	100	11.248	0.001
	B. zonata	59.43	39.62	48.11	2.911	0.056
	B. correcta	41.50	40.56	51.88	2.179	0.115
	B. affinis	10.37	2.80	3.77	2.040	0.132
Melon flies	*B. cucurbitae*	98.11	100	100	23.507	0.0001
	B. tau	53.78	76.41	59.43	6.643	0.001
	B. gavisa	19.81	17.92	29.24	4.203	0.016
	B. caudate	0.04	3.77	19.81	13.3256	0.0001
	B. nigrotibialis	16.03	14.15	2.83	5.565	0.004

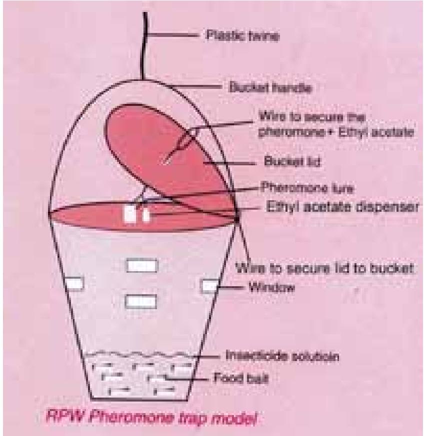
Pheromone technology for Red palm weevil *Rhynchophorus ferrugineus*

Integrated management of Red palm weevil *Rhynchophorus ferrugineus* in coconut

Red palm weevil *Rhynchophorus ferrugineus* also known as the Asian palm weevil is one of the most destructive pests of coconut. In India, about 12 per cent of young coconut palms falling in the susceptible age group of 5 to 20 years are attacked by RPW. In Goa the practice by the coconut climber/ farmer to make steps by cutting the trunk at about 1m interval for facilitating climbing of palm opens wounds on the trunk in which RPW lays eggs and then completely eaten away the stem portion, leads to the death of trees.

Designing of pheromone trap (JR Faleiro, 2005)

Five litre capacity polythene buckets with four windows (1.5× 5 cm^2) cut equidistantly below the upper rim of the bucket were used to fabricate the pheromone traps. Jute sack pieces were stuck with adhesive to the outer surface of the trap to provide grip to the attracted weevils and facilitate their entry in to the trap. The pheromone sachet (ferrolure+), hung to the bucket lid from inside with a piece of wire. Keep 250 to 300g coconut petiole bits, of the kairomone releasing food bait mixed in one litre of insecticidal solution. The insecticide solution killed trapped weevils. Traps should be placed under the shade of palm canopy at a height of one meter from the ground level.



RPW Pheromone trap model

Integrated pest management stratagies for red palm weevil

(Mani chellappan and JR Faleiro 1998-99)

Two field trails were conducted to evaluate the trapping potential of new ferrugineol based pheromone lures; using food (sugarcane bits) baited bucket traps (5L) traps having four windows. Besides the pheromone lure and food bait the trap also contained 0.1 per cent carbaryl solution. Results revealed that ferrolure improved recorded the best weevil catches and was statistically at par with RF 078A210. Both F and F+ were equally effective in trapping the pest (Table 29). It is essential to use ferruginol based pheromone lures along with a food to attain higher weevil captures. Pheromone trap captures were female dominated.

Table 29. Attraction of red palm weevil to different ferruginol based lures

Treatment	Average number of weevils trapped		
	Old Goa	Valpoi	Cumulative average
Ferrolure + (F+)	2.02 (4.09)	2.93 (8.57)	3.65 (13.30)
Ferrolure improved	3.25 (10.56)	3.62 (13.08)	4.84 (23.46)
Ferrolure (F)	2.00 (4.00)	2.47 (6.10)	3.10 (9.61)
RF078A210	2.73 (7.43)	2.91 (8.49)	3.95 (15.58)
RF078B210	2.26 (5.11)	2.83 (7.99)	3.54 (12.56)
Pheromone only	1.34 (1.80)	1.10 (1.20)	1.64 (2.69)
Food only	1.27 (1.60)	0.88 (0.77)	1.35 (1.82)
CD : P= 0.05	1.03	0.96	1.12
Male: female ratio	1:1.6	1:2.0	1:1.81

Monthly weevil captures in Goa

(JR Faleiro and HRC Prabhu, 1999-2001)

To ascertain the population levels of the pest in the state, 40 food baited pheromone traps were set through out Goa in July, 1999 and the activity of the pest was monitored up to December, 2001. All the 40 traps were serviced once a fortnight when the insecticide solution and the food bait were replaced and also the trapped weevils captured for each of the 11 Talukas of Goa. The mean monthly catch per trap for the period between August, 1999 and December, 2001 was 30.06, suggesting that the weevil activity was high through out the state.

Table 30.Monthly RPW captures in Goa

Months	Male	Female	Total	Weevil catch/ trap	Sex ratio
August 1999	518	1006	1524	38.10	1:1.94
September	632	1237	1869	46.73	1:1.96
October	784	1603	2387	59.68	1:2.04
November	824	1710	2534	63.35	1:2.08
December	449	887	1336	33.40	1:1.98
January 2000	501	852	1353	33.82	1:1.70
February	432	801	1233	30.82	1:1.85
March	323	695	1018	25.45	1:2.15
April	328	806	1134	28.35	1:2.45
May	180	431	611	15.27	1:2.39
June	58	120	178	4.45	1:2.06
July	320	556	876	21.90	1:1.73
August	345	637	982	24.55	1:1.84
September	421	911	1332	33.30	1:2.16
October	519	1141	1660	41.50	1:2.20
November	439	887	1326	33.15	1:2.02
December	454	795	1249	31.23	1:1.75
January 2001	360	766	1126	28.15	1:2.13
February	384	630	1014	25.35	1:1.64
March	363	640	1003	25.08	1:1.76
April	375	664	1039	25.98	1:1.77
May	465	794	1259	31.48	1:1.71
June	217	428	645	16.13	1:1.97
July	225	445	670	16.75	1:1.98
August	308	667	975	24.38	1:2.17
September	341	662	1003	25.45	1:1.94
October	378	888	1266	31.65	1:2.34
November	373	927	1300	32.50	1:2.48
December	311	638	949	23.73	1:2.05
Total	11,627	23,224	34,851	30.06	1:2.00

Management of red palm weevil using food baited pheromone traps (JR Faleiro and HRC Prabhu, 1999-2000)

Forty food baited pheromone traps were set in all the Talukas of Goa. One pheromone traps was set to monitor an area of approximately 600 ha. These traps were serviced once a fortnight, when the foods bait (500g of coconut petiole) and insecticide solution (1 litre) containing carbofuran granules were replaced. Data on weevil captures between August 99 to March 2000, in Table 31 revealed that the counts on trapped weevils were female dominated.

Table 31. Sex ratio of pheromone trap captured weevils

Months	Male (M)	Female (F)
August' 99	518	1006
September ' 99	632	1237
October ' 99	784	1603
November ' 99	824	1710
December ' 99	449	887
January ' 2000	501	852
February ' 2000	432	801
March ' 2000	323	695
Total	4403	8791
M:F Ratio	1:2.00	

Weevil captures during the above period also showed that the pest was active throughout Goa. An average trap catch of 41.40 weevils per trap indicates a high incidence of the pest in the state. Weevil captures were at par in North and South Goa. However, the lowest weevil activity was recorded in pernem, while the highest trap captures were from bardez. Weevil captures gradually increased from August 99, reaching a peak during Nov' 99. Subsequently, weevil captures reduced, reaching a low during March 2000.

Status of pheromone trap captured female weevils

Pheromone trap captured red palm weevil adults were collected from traps and reared in the laboratory on coconut petiole for a period of ten weeks. It has been divided in to two sets *viz*., i) a single female was caged individually and confined to a celibate life and a female was caged together with a male partner. Reproductive status of pheromone trap captured female weevils showed that (Table 32) pheromone traps for RPW besides acting as monitors also play a significant role in suppressing the population build up of this dreaded pest in the field. Maximum egg lay was during the first five weeks. Also, female caged with a male partner laid more eggs as compared to females reared individually without a male partner. The per cent hatch was superior when trap captured females were reared with males. Female weevils reared without a male partner also laid fertile eggs indicating that female weevils had entered the trap after mating, probably to find a suitable host for egg laying.

Table 32. Biological parameters of pheromone trap captured red palm weevils

Parameters	Female only	Female + male
Avg. Life span (days)	95 (81-105)	70 (61-83)
Avg. No of eggs laid	218.6 (130-309)	338.40 (201- 461)
% hatch	33.08 (0.0-61.30)	68.48 (56.93- 77.35)
Avg. Post ovipositional period (days)	14 (5-35)	2.6 (1-4)

Seasonal activity of RPW (JR Faleiro 2002-2003)

Month wise weevil captures between August, 1999 and December, 2001 showed that weevil activity was high after the south west monsoon between October and November, while low activity of the pest was noticed during the monsoon between June and July. The weevil captures were female dominated and for every male weevil trapped two female weevils were captured. It is evident that maximum temperature and rainfall had a significant impact on the weevil activity (Table 33). While, the maximum temperature was positively correlated (r =0.5) with weevil captures, rainfall was negatively correlated (r =-0.61) with the weevil catch.

Table 33. Correlation between monthly weevils captures and weather parameter

S. No	Weather parameter	Pearson correlation coefficient (r)
1	Maximum temperature (^{o}C)	0.51
2	Minimum temperature (^{o}C)	-0.32
3	Rainfall (mm)	-0.61
4	Relative humidity (%)	-0.20
5	Daily sunshine hours	0.26

Diurnal activity of Red palm weevil

The diurnal activity of RPW was studied by recording data on the weevil captures in four food baited traps (Table 34). Six hourly observations on the number of weevils trapped were recorded on a daily basis at 6 am, 12 pm, 6 pm and 12 am. The results showed that the maximum number of weevils trapped were at 6 am. This indicates that RPW was most active between 12 am (mid night) to 6 am. Highest mean cumulative catch per trap was between 12 am and 6 am while, the least cumulative catch per trap was recorded between 6 pm to 12 am. The results clearly indicate that RPW adults prefer to fly in the coconut plantations of Goa between 12 at mid night and 6 in the morning.

Table 34. Red palm weevil captures in pheromone traps at different times of the day

Time	May 2002	November 2002	Total	Catch per trap
6 AM – 12 PM	5	30	35	5.0
12 PM – 6 PM	5	33	38	5.4
6 PM- 12 AM	0	22	22	3.1
12 AM- 6 AM	16	51	67	9.6

Spatial distribution pattern of RPW in coconut plantations

(JR Faleiro and HRC Prabhu, 2000- 2001)

Spatial distribution studies of pest population serves as a basis for decision making to implement the management tactics. Results pertaining to different dispersion parameters and also dispersion indices are presented in Table 35. The variance was always greater than mean, suggesting aggregative nature of distribution of RPW population in the field. Further, the dispersion parameter K and accurate K were less than eight, indicating that RPW population followed the negative binomial series. The statistic T in this study was found to be less than all the corresponding monthly standard errors of T, signifying aggregation or clumping of the population. The observed Cole's index values for all the months were greater than the values of maximum regularity and randomness suggesting aggregation. David Moore's Index values were also found to be greater than maximum regularity (-1) and randomness (0), confirming the contagious nature of RPW. The results from the study clearly indicate that RPW population in coconut plantations of Goa is aggregated and follows the negative binomial distribution pattern.

Table 35. Clumping parameter K and third moment test for red palm weevil

Month	Dispersion parameters (K)	K from Trail and error method	Statistic T	SE (T)
1999				
August	3.58	0.197	-4627.28	2477137.09
September	2.89	0.188	-10069.74	5097345.25
October	6.12	0.174	665.71	12774213.59
November	6.53	0.172	-15310.29	15706157.26
December	1.84	0.200	-4612.94	1578847.72
2000				
January	3.41	0.196	-5219.85	1761152.89
February	3.15	0.210	187.10	1129322.73
March	2.78	0.215	-2710.73	604364.96
April	1.99	0.209	-5553.82	891486.72
May	1.09	0.246	784.66	96665.47
June	0.74	0.420	-10.66	772.27
July	1.55	0.224	-3145.46	310946.97

Ovipositional preference of RPW to different coconut cultivars

(JR Faleiro and HRC Prabhu, 1999-2000)

Fresh wounds and injury on the palm surface is known to attract RPW females for oviposition. Six coconut cultivars *viz*. Benaulim, Calangute, D×T, Chowghat Orange Dwarf (COD), Malayalam Yellow Dwarf (MYD) and Chowghat Green Dwarf (CGD), were screened in the laboratory to ascertain the ovipositional preference of RPW. Three pairs pheromone trap captured weevils were caged separately and offered freshly cut coconut petiole bits (1×1×10 cms) of the above six cultivars every day. The number of eggs laid by the female weevil in the petiole bits was noticed. Also, the per cent egg hatch was recorded. The lowest average number of eggs laid (20.77) was in MYD and the difference in egg lay was statistically significant from CDG, which recorded the highest average egg lay (47.22).

Standardisation of trap colour

Seven different trap colours *viz*., green, light blue, dark blue, white (transparent), pink, orange and yellow were tested in the field for eight weeks. The results indicate that the catches ranged from 8.66 to 3.33 weevils per trap in pink and yellow coloured traps, respectively and were statistically at par, proving that trap colour did not significantly enhance weevil captures.

b) Trap surface

Trap surface plays important role for adult weevil to enter in to bucket. In order to facilitate entry of attracted weevils into the trap, the surface of the standard bucket trap was covered with jute sack. The trapping efficiency of such traps was evaluated against traps without jute sack. Results indicated that the traps covered with jute sack enhanced weevil captures (18 .50 weevils/trap) as compared to traps that were not covered with jute sack (16.50 weevils/trap).

Influence of food baits on weevil captures in pheromone traps (JR Faleiro, 2002-2003)

Kairomone releasing food baits like sugarcane, toddy, dates and coconut play an important role in enhancing the trapping efficiency. The food bait and the chemical lure act synergistically to attract RPW adults. Field trails were conducted to ascertain the quantity of fresh coconut petiole to be used in RPW pheromone traps (Table 36). Quantities ranging from zero to 500 g per trap were tested. Results showed that coconut petiole at 200g per trap were sufficient to maintain the trapping efficiency. Results also revealed that weevil captures were not affected even when the food bait was not replaced for one month. However, water in the trap had to be replenished if traps were not serviced beyond 15 days.

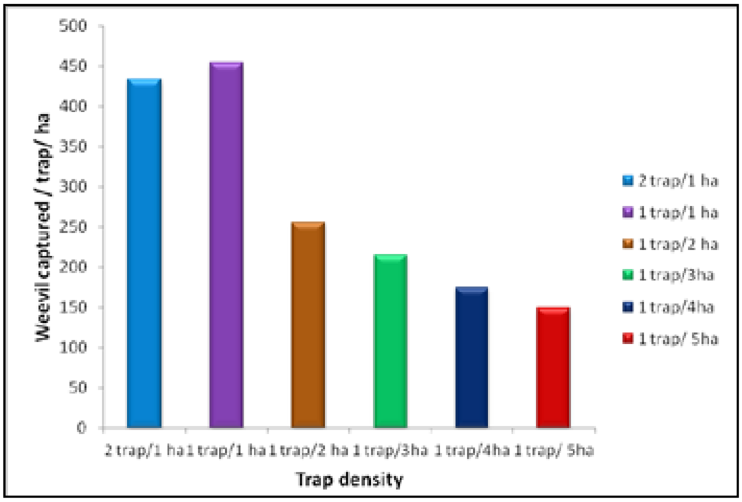
Table 36. Weevil captures in relation to quantity of food bait in pheromone traps

S. No	Quantity of food bait per trap (g)	Mean cumulative weevil captures/ trap
1	Zero	2.78 (7.5)
2	50	2.34 (5.5)
3	100	3.8 (15.0)
4	200	4.35 (20.5)
5	500	4.52 (20.0)
CD (P=0.05)		1.20

Standardisation of trapping density

(JR Faleiro and HRC Prabhu 2000-2001)

It is essential to have an optimum density of traps in the field, so as to obtain a good catch of the pest. For mass trapping programmes of RPW, involving food baited pheromone (ferrolure +) traps, a trap density of 1 traps/ ha is recommended. A trail was laid out in Sanguem involving six treatments, wherein trap densities ranging from 2 traps/ ha to 1 trap/ 5 ha were evaluated. Results indicate that a possibility of lowering the recommended trapping density of 1 trap/ ha to 1 trap/ 3 ha thereby economizing on the use of the costly pheromone lure.



Red palm weevil captures at different densities

Height for the trap locations on the palm

In order to determine the optimum height for setting traps in the field, the evaluation of traps were undertaken at five levels of height, wherein traps were set at ground level and at 0.5, 1.0, 1.5 and 2.0 m above the ground, along the trunk of the palm. Highest weevil captures of 30.4 weevils per trap was recorded when traps were set at 1.0 m height.

Effect of food bait, trap servicing and their interaction on weevil captures (JR Faleiro 2000-2001)

A field trail was conducted to find out the effect of food bait and trap servicing on weevil captures. Six food baits (250 gm each) evaluated in this trais were (i) coconut petiole + yeast (5 gm) + acetic acid (5 ml) + toddy, ii) sugarcane, iii) pineapple, iv) coconut petiole + yeast, v) toddy and vi) coconut petiole. Results in the Table 37 revealed that irrespective of food bait used, servicing of the pheromone trap i.e. periodic replacement of the kairomone releasing bait at least once in ten days is essential to maintain the efficiency of the pheromone trapping programme. However, interaction effect between the bait and servicing duration was non significant.

Table 37. Effect of food bait, trap servicing and their interaction on weevil captures in red palm weevil pheromone traps

S. No	Treatments	Mean weevil captures/trap
A	Food baits	
1	Coconut petiole + Yeast + Acetic acid + Toddy	2.33 (06.11)
2	sugarcane	2.60 (07.77)
3	pineapple	3.05 (12.22)
4	coconut petiole + yeast	1.90 (03.55)
5	toddy	1.83 (03.22)
6	coconut petiole	1.92 (03.55)
	CD (P= 0.05)	0.65
B	Trap servicing	
1	Trap serviced after 10 days	2.88 (09.77)
2	Trap serviced after 20 days	2.27 (05.77)
3	Trap serviced after 30 days	1.66 (02.61)
	CD (P= 0.05)	0.46
C	Interaction	NS

Influence of different insecticides on weevil captures in red palm weevil pheromone traps (JR Faleiro 2000-2001)

Eight commonly available insecticides were evaluated for their use in food baited RPW pheromone traps. Besides these insecticidal treatments a control without any insecticide was also maintained. Results revealed that there was significant difference among the treatments during the second and fourth week (Table 38). Also, significant difference among weevil captures were observed when the data was pooled and analysed on a cumulative basis when carbofuran 3G registered the best weevil captures of 25.00 weevils per trap. Insecticides with offensive odour should not be used in RPW pheromone traps as these chemicals repel the weevil and reduce the trapping efficiency.

Table 38. Mean weevil captures in red palm weevil pheromone traps with different insecticides

Treat No	Insecticides used	Average weekly weevil captures					cumulative
		Week 1	Week 2	Week 3	Week 4	Week 5	
1	Carbofuran 0.05%	2.08 (4.33)	3.07 (9.33)	2.60 (6.66)	1.87 (3.00)	1.35 (1.66)	4.97 (25.00)
2	Chlorphyriphos 0.05%	1.44 (1.66)	1.35 (1.66)	1.09 (1.00)	1.09 (1.00)	1.05 (0.66)	2.53 (9.00)
3	Nimbicide 0.5%	1.42 (2.00)	1.93 (4.00)	0.71 (0.00)	1.05 (0.66)	1.35 (1.66)	2.52 (7.00)
4	Monocrotophos 0.1%	1.05 (0.66)	1.44 (1.66)	1.74 (2.66)	2.18 (4.33)	1.29 (1.33)	3.27 (10.6)
5	Phorate 0.03%	1.17 (1.00)	1.48 (2.00)	1.74 (2.66)	0.88 (0.33)	1.34 (1.33)	2.77 (7.33)
6	Carbaryl 0.1%	1.00 (0.66)	1.8 (3.66)	2.29 (5.66)	1.26 (1.33)	1.49 (2.33)	3.37 (13.66)
7	Endosulfan 0.1%	1.42 (2.00)	1.46 (1.66)	1.17 (1.00)	1.47 (2.00)	1.55 (2.66)	3.07 (9.33)
8	Deltamethrin 0.00028%	1.61 (2.66)	1.34 (1.33)	2.08 (4.00)	1.34 (1.33)	1.79 (3.33)	3.62 (12.6)
9	Control	1.44 (1.66)	0.88 (0.33)	1.17 (1.00)	1.95 (3.33)	1.09 (1.00)	2.77 (7.33)
CD (P=0.05)		NS	0.68	NS	0.31	NS	1.17

Evaluation of different food attractants to use as food baits in pheromone traps (JR Faleiro and HRC Prabhu, 2000- 2001)

Potential of different food baits were tested when used along with ferrugineol based pheromone lures. In each trap a quantity of 250g of food bait (coconut petiole, oil palm petiole, oil palm fruit, dates, cashew *etc*) was used along with 10 g of carbofuran 3G dissolved in 1L of water. In traps containing toddy, 250 ml of the same was used to which was added 750ml water. In some treatments 5g of yeast and or 5ml of acetic acid were also used. Traps were serviced fortnightly when the food bait and insecticide solution was replaced. Results revealed that dates recorded the highest average weevil catch of 62.00 weevils per trap which was statistically superior to all the other food baits evaluated and was followed by sugarcane (49.33). Although, coconut petiole ranked fourth (32.66 weevils) it was the best food bait, considering its cost and availability. Oil palm fruit had negative effect on the weevil captures as the fruit in the trap containing insecticide solution got putrefied and repelled the attracted weevils (Table 39).

Kairomone producing food baits

Table 39. Red palm weevil, *Rhynchophorus ferrugineus* captures in pheromone (ferrolure+) traps containing different food baits

S. No	Treatments	Average catch per trap
1	Coconut petiole	32.66
2	Toddy (250 ml- made to 1L with water)	24.66
3	Sugarcane pieces	49.33
4	Oil palm petiole	17.33
5	Oil palm fruit	7.33
6	Pineapple pieces	27.00
7	Dates	62.00
8	Plantain	31.66
9	Toddy + yeast (5g) + acetic acid (5ml) + Coconut petiole	37.66
10	Yeast (5g) + Coconut petiole	26.00
11	Cashew apple	19.00
12	Control	10.00
	CD (P=0.05)	13.73

Liquid food baits

Locally available alcoholic beverages as food bait in RPW pheromone traps was studied during 2002. Cashew feni, coconut feni and ethyl alcohol @ 10ml/ litre of water were tested separately in a replicated field trail. The traditionally used and recommended food bait (coconut petiole) was also incorporated as one of the treatments in the trail. Results revealed that a mean weevil catch of 1.35, 1.00, 0.75 and 2.25 weevils / trap were captured by traps containing cashew feni, coconut feni ethyl alcohol and coconut petiole respectively. Wherever, solid food bait is not available, the farmer could conveniently add the liquid alcoholic beverage in to the trap.

Studies on longevity of pheromone lure ferrolure +

(JR Faleiro and HRC Prabhu, 2000- 2001)

In order to measure the amount of pheromone in a given lure at different intervals, the quantity of pheromone intact in a sachet was assessed by visual observation using the following grade index. For the quantity of lure remaining intact between two score values, then a score value in decimal was assigned to that sachet.

Table 40. Longevity of ferrolure + in coconut plantations of Goa

Month	Lure intact (%)	Lure released (%)	Amount released (%)	Average daily release (mg / day)	Average monthly weevil catch/ trap
January 2000*	94.55	5.55	38.85	1.30	33.82
February	90.95	3.50	24.50	0.82	30.82
March	87.22	3.73	26.11	0.87	25.45
April	52.38	34.84	243.88	8.13	30.88
May	32.20	20.18	141.26	4.71	17.17
June	7.65	24.55	171.85	5.73	4.35
July **	97.94	2.06	16.48	0.55	21.90
August	96.20	1.74	13.92	0.46	24.55
September	95.21	0.99	7.92	0.26	40.05
October	88.05	7.16	57.28	1.91	41.50
November	77.33	10.72	85.76	2.86	33.15
December	51.48	25.85	206.80	6.89	31.23
January 2001	30.70	20.78	166.24	5.54	28.15
February ***	99.50	0.50	4.00	0.13	25.35
March	96.74	2.76	22.08	0.74	25.08

New Lure (ferrolure + 700) ** New Lure (ferrolure + 800) * New Lure (ferrolure + 700)*

Different dispensers for ferrugineol based lures

The lures (ferrolure + 700mg) set at the end of December, 1999 were active for six months and were replaced only in June, 2000 when 7.65 per cent of the pheromone was intact. Subsequently, (ferrolure + 800mg) set in the field at the end of June, 2000 remained active for seven long months and were replaced at the end of January, 2001. Even at very low average daily release of 0.13mg/day, during February, 2001 a medium weevil catch of 25.35 weevils was obtained. Similarly, with a high release of 5.73mg per day during June 2000 a monthly catch of only 4.35 weevils was obtained. This indicates that the lure is capable of maintaining the trapping efficiency at very low release rates (Table 40).

Efficacy of ferrugineol based pheromone lures

(JR Faleiro, 2002-2003)

The aggregation pheromone (4methyl-5-nonanol) is extensively used to manage RPW. Currently ferrolure + manufactured by Chem Tica International, Costa Rica is the most popular commercially available ferrugineol based lure. Three different trails (A, B and C) were conducted to access the efficacy of ferrugineol based formulations from different manufacturers (Table 41). In order to evaluate the need of using the chemical lure along with a food bait in a single trap two treatments were devised in the above trails, where in one had only the pheromone without the food bait and other had only the food bait without the pheromone.

Table 41. Efficacy of ferrugineol based pheromone lures

Trail A	Trail B	Trail C
Ferrolure + (F+)	Ferrolure + (F+)	Pherobank 400mg
Ferrolure improved	CPCRI lure	Pherobank 700mg
Ferrolure (F)	ISCA Technologies lure	Pherobank 1000mg
RF078A210	Pheromone only	Ferrolure + (F+)
RF078B210	Food bait only	ISCA Technologies lure
Pheromone only		CPCRI lure
Food bait only		Pheromone only
		Food bait only

In trail A, ferrolure improved recorded the best weevil catches and was statistically at par with RF078A210. Also, ferrolure and ferrolure+ were equally effective in trapping the pest. In trail B ferrolure+ registered the best weevil captures. The lure from CPCRI Kasargod and ISCA Technologies, USA were statistically at par. In trail C, the pherobank 400mg lure was the best, recording significantly superior mean weevil captures. In all the trails (A, B and C) superior weevil catches were obtained when the pheromone lure was used along with food bait.

Salient Research Findings

Rice insect pests management

- The highest incidence of case worm, *Nymphula depunctalis* and the leaf folder, *Cnaphalocrosis medinalis* was recorded at 14, 21 and 56 days after transplanting (DAT) respectively with variety Co-44. High incidence of gall midge, *Orseolia oryzae*, was observed at 35 and 42 DAT, with the variety MO-5.

- The short duration variety Neela was found to be most tolerant to whorl maggot and leaf folder attack. Among the medium duration varieties, Vibhava was most tolerant to case worm and whorl maggot.

- The lowest cumulative damage due to leaf folder attack was 4.33% leaves/hill observed in the crop receiving Neemrich-1 and Monocrotophos as alternate sprays. The lowest cumulative damage (0.44%) due to gall midge *Orseolia oryzae* was observed with Monocrotophos treated field.

- Neem based compounds *viz*., Limnool, Neem rich-II, Nimbecidine and Achook are equally effective and their yields are similar to that of Monocrotophos treatment.

Sweet Potato weevil management

- The Sweet potato weevil infestation could be effectively managed by dipping plant cuttings in Monocrotophos 36 SL (0.05%) for 30 minutes before planting together with a spray and soil drench (200 ml/plant) of Endosulfan 35 EC (0.07%) at 30 and 50 DAP, respectively.

- More marketable tubers (72.04%) are obtained when the plots receiving vines treated with Nimbecidine (0.5%) + Pheromone combination followed by monocrotophos (0.05%) + pheromone (70.27%).

Cashew Entomology Research

- Treating the cashew plantations with Neem formulations Neem suraksha at flushing, panicle initation and fruit formation stages gives better protection against tea mosquito bug. However, the endosulfan treatment had the least infestation by the pest.

- The local accessions cashew variety Ganje-2 has recorded the lowest infestation against tea mosquito bug *H. antonii*.

Pulses insect pests management

- Pulse pod borer *Helicoverpa armigera* could be effectively managed with spraying of Neem formulations (Neem suraksha, Neem gold and Godrej achook), containing Azadirachtin concentration (0.03%) along with *Bacillus thuringiensis*. An additive effect was observed in the *Bacillus thuringiensis* + neem formulations.

- Ether extract of the custard apple *Annona squamosa* seed when used undiluted has resulted in 100 per cent mortality against cotton stainer *Dysdercus cingulatus*. Different plant extracts has been tested against *Spodoptera litura* for their insecticidal properties. Among the extracts, *A. squamosa* seed extracts (both water and ether extracts) had the least feeding followed by *Adhatoda vassica*.

- Tur pod fly *Melanagromyza obtuse* could be effectively managed with two sprays of 0.05 per cent Monocrotophos 36 SL at 15 days interval commencing from flowering.

- The pigeon pea variety BSMR-736 recorded the least pod damage of 0.50 per cent against pod fly *Melanagromyza obtuse*

Ground Nut insect pests management

- Ground nut field treated with carbofuran gave a fairly good control against pod borer, *Anisolobes stallii* followed by thimet.

- Irrigation and chemical control schedule has been developed for the management of pod borer in groundnut. The least infestation was recorded when the plots were irrigated and drenched with chlorphriphos at pegging stage.

Fruit fly Research

- The orchard fly *B. dorsalis* was the most abundant species followed by *B. caryeae, B. zonata, B. affinis, B. correcta* and *B. verbicifolia* in the methyl eugenol baited traps. The melon fly *B. cucurbitae* was the most dominant species in the cue lure baited traps followed by *B. tau, B. gavisa, B. caudate*, and *B. nigrotibialis*.

- Bait application technique (BAT) has been developed for fruit fly. Among the baits (14 treatments) evaluated, banana/ jaggery (10% weight:volume) were equally effective as compared to commercial protein hydrolysate (PH) (3% volume:volume) and could serve as a low cost indigenous bait for use in the field replacing the costly PH.

- Freshly harvested mangoes treated in hot water at 48^0 C for 1 hr and 1.5 hours. Hot water treatment (HWT) of fruits at these temperatures effectively controlled fruit fly

- Spraying of 0.1% malathion 50EC at 15 days interval commencing from 15 days after sowing (DAS) to 60 DAS is very effective in managing the *B. cucurbitae* on cucurbits.

- Both the orchard and melon flies are most abundant in the coastal region, followed by the midland and uplands region.

Pheromone Based Technology for the Management of Coconut Red Palm Weevil

- Pheromone trap model has been developed for the management of coconut red palm weevil. The weevil activity was high through out the state.

- Weevil activity was high after the south west monsoon between October and November, while low activity of the pest was noticed during the monsoon between June and July. For every male weevil trapped two female weevils were captured.

- RPW was most active between 12 am (mid night) to 6 am. The traps covered with jute sack enhanced weevil captures (18 .50 weevils/trap) as compared to traps that were not covered with jute sack (16.50 weevils/trap).

- Density of 1 trap/ ha and set up to 1.0 m height from the ground level is sufficient to attract the adult populations.

- Kairomone releasing food baits *viz*. (i) coconut petiole + yeast (5 gm) + acetic acid (5 ml) + toddy, ii) sugarcane, iii) pineapple, iv) coconut petiole + yeast, v) toddy and vi) coconut petiole could enhance the weevil attractions. The quantity 200g per trap was sufficient to maintain the trapping efficiency. Periodic replacement of the kairomone releasing bait at least once in ten days is essential to maintain the efficiency of the pheromone trapping programme.

- Among the insecticides treatment carbofuran 3G registered the best weevil captures of 25.00 weevils per trap.

Thrust areas for future research

- Investigate the predatory potential of weaver ant *Oecophylla smaragdina* against tea mosquito bug and fruit flies.
- Development of Integrated pest management strategies for cashew insect pests.
- Evaluation of entomopathogenic fungi and nematodes against red palm weevil on coconut.
- Identification and documentation of natural enemies in different agricultural and horticultural ecosystem
- Bio-ecology and management of emerging insect pests in relation to increasing climate change.
- Use of predators and parasitoids for the management of mealy bugs on different crops.
- Exploitation of antifeedant and repellent properties of locally available plants against managing the major insect pests.

Transfer of technology to the farmer's field

Management of the orchard fruit fly *Bactrocera dorsalis* using Methyl eugenol traps and Hot water treatment

Introduction

Fruit flies are an important group of insects that occur across India. This Tephritidae family consists of over 4500 species of the fruit flies in the world of which 200 species are of economic importance. Studies on the abundance of fruit fly diversity in Goa revealed that among the orchard flies *B. dorsalis* was the most abundant species followed by *B. caryeae*, *B. zonata*, *B. affinis*, and *B. correct*a. In India, the loss in fruit yield ranges from 1 to 31% with a mean of 16% (Verghese *et al.*, 2002). The Orient fruit fly not only causes economic loss but is also of quarantine importance.

Symptoms of damage

- Maggot bore into semi-ripen fruits with decayed spots and dropping of fruits.
- Oozing of fluid
- Brownish rotten patches on fruits

Technology intervention

Pheromone based trapping technology and hot water treatment was standardized to minimize the infestation levels.

Fabrication of Bottle Trap

Fabricated using disposable plastic water bottles (capacity: 1L). Each trap had four windows of 1square inch, cut open just below the shoulder of the bottle. For facilitating the retaining of flies captured, the bottom of the bottle trap was cut and reversed into the open lower end of the bottle.

The trap was loaded separately with Methyl Eugenol (ME). ME blocks were prepared using plywood pieces of 5 X 5 X 1.2 cm which were soaked overnight in a mixture of ethanol solvent, ME and0.1 % malathion 50 EC in a ratio of 6:4:1 by volume. Each trap was fastened with the help of small nylon ropes to the twigs of the trees at 2m height. The lures were replaced at bimonthly intervals in order to sustain the trapping efficiency.

Hot water treatment of mango to control *Bactrocera* spp

Freshly harvested mangoes were exposed to hot water at 48^0 C for 1 hr and 1.5 hrs, effectively controlled fruit fly infestation. Infestation in the control treatment ranged from 3.33 to 30.00 per cent with either *B. dorsalis* or *B. caryeae* emerging from the infested fruits in the control treatment.

Hot water treated mangoes (48^0Cfor 1 hr/48^0C for 1.5 hr/untreated control)

2) Management of the melon fly using food baits in hill cucurbits of Goa

Hill cucurbits *viz*., cucurbits, ridge, gourd, bitter gourd and snake gourd are cultivated by a specialized group of farmers in Goa called *mollekars*. These cucurbits are cultivated during *kharif* at the foot hills of Western ghats in the

Goa region. A patch of 5 to 10 ha is cultivated together by a group of about 10 families who toil on the land collectively by sharing each others work while distinctly maintaining their identity on the piece of land cultivated by an individual family.

Squirting of the baits

There are no reports on the area under these crops in Goa, however, the cultivation of these cucurbits has steadily increased in the state over the years and can be roughly estimated to be around 500 hactares of which cucumber occupies 50 per cent of the area followed by ridge gourd while (30%), bitter gourd (10%) and snake gourd (10 %). The melon fly, *Bactrocera cucurbitae* (Diptera: Tephritidae) is distributed widely through out the world damaging 81 host plants. B. cucurbitae attacks hill cucurbits of Goa with over 20 per cent infestation being recorded in cucumber. This pest can be successfully managed by application of food baits.

Data available with the ICAR, Old Goa suggests that damage due to *B. cucurbitae* in the above cucurbits cultivated in Goa during Kharif ranges from about 5 to 20 per cent with cucumber being most susceptible. Often farmers resort to use of harmful insecticides to control this pest which are mostly sourced through pesticide dealers resulting in several drawbacks including accumulation of pesticide residue in the fruit and damage to the fragile environment.

Technological intervention

Prepare bait using banana (velchi) or jaggery make as 10 g banana / jaggery mashed up and liquidized in 1 L of water (10 % weight: volume). Add 2 ml malathion 50 EC to the above bait solution. Apply this bait by squirting (splashing) 8 L /ha @ 200 splashes / ha (each splash of approximately 40 ml) roughly equivalent to one splash every 7m in a square grid i. e. after every 10 steps in a square grid. Applications are to be made at weekly intervals, commencing from 30 days after planting up to the end of the commercial fruit production. In all, 8-10 application (squirting) of baits may be required per cropping season.

Estimated cost of the technology

Cost of the material and labour cost: Rs. 5000/ha

All the materials are available in local shops and insecticide shops.

Benefits envisaged

Benefit of Rs. 70000.00 per ha over a period of 3-4 months.

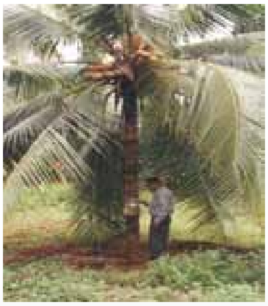
This ensures substantial (90 %) reduction in the insecticide load when compared to chemical control, while achieving control comparable with insecticide schedule i.e. < 5% damage. Bait application technique for melon fly management ensures insecticide reside-free crop, besides saving a substantial loss due to attach by *B. cucurbitae*. In the long run this can augur well for organic production of hill cucurbits to further enhance the economy.

3) Management of the red palm weevil using pheromone technology

Coconut is a major plantation crop in India with more than 10 million people depending upon for their livelihood. India ranks first in production among the 90 coconut growing countries in the world. Red palm weevil (RPW) is one of the most destructive pests of coconut in South and Southeast Asia. In India, about 12 per cent of young coconut palms falling in the susceptible age group of 5 to 20 years are attacked by RPW. Considering the value of the crop, the reported damage level is high, specially due to the fact that attack by RPW often results in the death of the palm. Being an internal tissue borer, RPW is difficult to detect in the palms in the early stage of attack. Repeated infestation of RPW is known to occur in and around heavily infested gardens, especially where severely infested palms are eradicated. This has been attributed to the highly aggregated spatial distribution pattern of the pest.

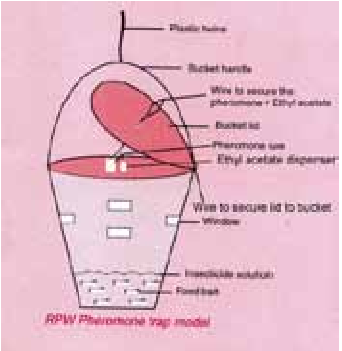
The existing management strategy for RPW mostly relies on the use of hazardous chemicals, both for the prophylactic and curative treatments.

Technological intervention



Pheromone based trapping technology was standardized to minimize the infestation levels. Trap colour, trap surface, type of food bait, quantity of food bait, trap height, frequency of trap servicing, insecticide for the use in traps, attractiveness of food bait, longevity of pheromone lure and pheromone trapping density were standardized.

Method of trapping: Place one to two trap/ha with Ferrulure+ for trapping the RPW in the mass trapping programmes. Trap should be placed under tree shade at a height of one meter from ground level and needs to be serviced once in 10 days. Carbofuran 3G (0.05%) should be added inside the trap to kill the attracted weevils. Each lure will serve for six months.



Estimated cost of the technology

Cost of lure, pheromone trap and labour charges for servicing: Rs. 2000/ha All the materials are available in local shops and insecticide shops.

Benefits envisaged

Mass trapping reduced the incidence of RPW to less than one per cent compared to 10 per cent infestation in the un-trapped gardens thereby saving 15 trees per year.

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