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CROP PROTECTION

(ENTOMOLOGY AND PLANT PATHOLOGY)

All India Coordinated Rice Improvement Project

Indian Institute of Rice Research
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PREFACE

Under the All India Coordinated Rice Improvement Project (AICRIP) evaluation of varietal improvement, crop production and crop protection technologies across locations has been continuing to contribute towards strategies strengthening rice farmers' efforts towards sustainable rice production. About 400 scientists, belonging to ICAR - Indian Institute of Rice Research, 45 funded and more than hundred voluntary centres of State Agricultural Universities, Departments of Agriculture, ICAR Institutes and Private Undertakings work towards progress of rice research under the umbrella of AICRIP.

This volume reports the salient findings of experimental trials in Entomology and Plant Pathology during 2019. The major goal of Crop Protection programme of AICRIP is to develop a broad based, eco-friendly and cost effective IPM technology which can help in alleviating socio-economic constraints through providing gainful benefits for rice farmers. Emphasis is on ecologically conducive and cost optimizing IPM components such as host plant resistance, ecological engineering and biodiversity, utilization as well as need based application of only safe chemicals. Efforts are underway to build decision support systems for assistance in farmers' decision making.

I compliment the efforts of the entire staff of Entomology and Plant Pathology including Principal Investigators, Cooperating scientists, technical and supporting personnel for their contribution in bringing out this document containing useful and relevant information related to rice IPM.

(S.R. Voleti)

Director (Acting)

March 2020

2. ENTOMOLOGY
TRIALS
Kharif 2019

CONTENTS	**PAGE**
SUMMARY	**i-vi**
INTRODUCTION	**2.1**
2.1 HOST PLANT RESISTANCE STUDIES	
Planthopper Screening Trial **(PHS)**	**2.3**
Gall Midge Screening Trial **(GMS)**	**2.4**
Gall Midge Special Screening Trial **(GMSS)**	**2.6**
Leaf Folder Screening Trial **(LFST)**	**2.7**
Stem Borer Screening Trial **(SBST)**	**2.8**
Multiple Resistance Screening Trial **(MRST)**	**2.10**
National Screening Nurseries **(NSN)**	**2.11**
2.2 INSECT BIOTYPE STUDIES	
Gall Midge Biotype Trial **(GMBT)**	**2.16**
Gall Midge Population Monitoring Trial **(GMPM)**	**2.17**
Planthopper Special Screening Trial **(PHSS)**	**2.18**
2.3 CHEMICAL CONTROL STUDIES	
Insecticide-Botanicals Evaluation Trial **(IBET)**	**2.21**
2.4 ECOLOGICAL STUDIES	
Effect of Planting Date on Insect Pest Incidence **(EPDP)**	**2.35**
Effect of iron Seed Coating on Insect Pest incidence **(ESCP)**	**2.55**
Influence of crop Establishment Methods on Pest incidence **(IEMP)**	**2.60**
Cropping Systems Influence on Pest incidence **(CSIP)**	**2.66**
Evaluation of Pheromone Blends for Insect pests of rice **(EPBI)**	**2.68**
2.5 BIOCONTROL AND BIODIVERSITY STUDIES	
Ecological Engineering for Pest Management **(EEPM)**	**2.70**
Bio Intensive Pest Management trial **(BIPM)**	**2.78**
2.6 INTEGRATED PEST MANAGEMENT STUDIES	
Integrated Pest Management special Trial **(IPMs)**	**2.89**
2.7 ASSESSMENT OF INSECT POPULATIONS THROUGHOUT THE YEAR USING LIGHT TRAPS	**2.107**

TRIALS
Rabi 2018-19

SUMMARY

2.1 HOST PLANT RESISTANCE STUDIES

Stem Borer Screening Trial **(SBST)** **2.119**

Multiple Resistance Screening Trial **(MRST)** **2.120**

2.2 CHEMICAL CONTROL STUDIES

Botanicals and Insecticide Evaluation Trial **(BIET)** **2.121**

2.3 ECOLOGICAL STUDIES

Effect of Planting Date on Insect pest Incidence **(EPDP)** **2.125**

2.4 BIOCONTROL AND BIODIVERSITY STUDIES

Ecological engineering for pest management **(EEPM)** **2.127**

Bio intensive pest management trial **(BIPM)** **2.128**

2.5 INTEGRATED PEST MANAGEMENT STUDIES

Yield Loss Estimation Trial **(YLET)** **2.130**

Integrated Pest Management special Trial **(IPMs)** **2.131**

2 Entomology *Kharif* 2019

SUMMARY

All India Coordinated Entomology Programme was organized and conducted during *kharif* 2019 with seven major trials encompassing various aspects of rice Entomology involving 234 experiments (90.0%) that were conducted at 42 locations (IIRR, 32 funded & 9 voluntary centres) in 22 states and one Union territory. Details of scientists involved in the program at headquarters, cooperating centres and the performance of centres is provided in Appendices I and II.

2.1. Host plant resistance studies comprised of seven screening trials involving 1652 entries evaluated at 42 locations against 11 insect pests. 64 entries (3.87%) were identified as promising.

Planthopper screening trial (PHS) - Planthopper screening trial (PHS) - Evaluation of 120entries against the two planthoppers BPH and WBPH in 10 greenhouse and 8 field tests indicated 16 entries (including 7 breeding lines *viz.*,., KNM 7629, MTU 1305, MTU 1306, MTU 1308, RMS-ISM-Bph33-1, RP 221-3-5-2, RP 179-3-9-1, 4 germplasm lines from IIRR viz., IC 216735, IC 76013, IC 75975 and IC 76057, 2 germplasm lines from NRRI *viz.*, CRCPT 7 and CRCPT 8 and three checks) as promising in 7 to14 tests. Of these, 6 are in the second year of retesting.

Gall midge screening trial (GMS) - Evaluation of 40 entries in one greenhouse and 5 field tests against 6 populations of gall midge (five identified biotypes) helped in identification of one retested entry, SKL-07-8-720-63-147-182-276 as promising in 3 tests of the 6 valid tests across all the populations. Aganni was promising in 4 tests.

Gall midge special Screening trial (GMSS) - Evaluation of 85 donors against 5 gall midge biotypes in one greenhouse and 6 field tests identified 16 lines as promising in 4 to 6 tests. IIRR-ENT-2019-17 was promising in 6 tests, while 14 pyramided lines (MTU1010 with gm3+Gm4 +Gm8) along with Aganni were promising in 4 tests. Of these promising pyramided lines, six were in the second year of retesting.

Leaf folder Screening Trial (LFST) - Field evaluation of 20 entries replicated thrice in a randomised block design at 16 locations revealed that 4 entries as promising in 3-4 tests out of 9 valid field tests. Two mutant cultures of PTB, Cul M8 and Cul M9 were found promising in 4 of the 9 valid tests while another mutant culture, Cul M6-2 and a selection from landrace Kalluruli were found promising in 3 of the 9 valid field tests conducted at different locations.

Stem borer screening trial (SBST) - Evaluation of entries in 19 valid field tests identified 12 entries as promising in 4 to 6 of the 19 tests in terms of low dead hearts (≤10%), white ear damage(≤5%) and high grain yield(≥15g/hill) suggesting that recovery resistance and tolerance could be the mechanism in these entries as they have good grain yield despite damage. The mean no. of larvae in the stubbles in these entries varied from ranged from 0.13-1.68/hill. Four of these promising entries *viz.*, KAUPTB 0627-2-11, JGL 33440, BK 49-76 and JGL 33080 were in the second year of testing.

Multiple resistance screening trial (MRST) - Evaluation of 25 entries in 6 greenhouse and 43 field tests against 9 insect pests revealed three entries *viz.*, Sinnasivappu, JS5 (selection from Jaya) and SKL -07-11-177-50-65-60-267 as most promising in 4-6 tests with a PPR of 2.7 to 4.8 against 3 pests. The check lines PTB 33, Suraksha and W1263 were promising in 9, 8 and 5 tests, respectively with a PPR of 3.4 to 7.3 against 3 to 4 pests

National Screening Nurseries (NSN) comprised of 4 trials *viz.*, National Screening Nursery 1(NSN1), National Screening Nursery 2 (NSN2), National Screening Nursery – Hills (NSN hills) and National Hybrid Screening Nursery (NHSN).

NSN1: Evaluation of 367 entries at 18 locations in 5 greenhouse and 26 field tests against 7 insect pests identified three entries *viz.*, IET nos 27632, 26948 and 28793 as promising in 4 to 5 tests of the 31 valid tests against one to three pests. Aganni and PTB 33 were promising in 4 and 3 tests, respectively.

NSN2: Evaluation of 682 entries in 5 greenhouse and 18 field tests against 7 pests in 23 valid tests identified six entries along with PTB 33, RP 2068-18-3-5 and Aganni as promising in 3 to 4 tests of the 23 valid tests against one or two pests.

NHSN: Evaluation of 94 hybrids along with checks in 5 greenhouse and 17 field tests against 6 insect pests identified IET Nos 28125, JKRH-3333 (NCH-1) and CH 45 as promising in 3 tests of the 22 valid tests. Abhaya, PTB 33 and RP 2068-18-3-5 were promising in 3 to 4 tests

2.2. INSECT BIOTYPE STUDIES comprising of three trials 1) Gall midge biotype monitoring trial (**GMBT**), 2) Gall midge population monitoring (**GMPM**) and 3) Plant hopper special screening trial (**PHSS**) were conducted to monitor the virulence pattern of gall midge and brown planthopper populations.

Gall midge biotype monitoring trial (**GMBT**) - Evaluation of the gene differentials in one greenhouse and 9 field tests against 5 different biotypes identified Aganni (*Gm8*) as promising in 8 of the 10 valid tests. INRC 3021(*Gm8*), RP5925 (*Gm8*), W1263 (*Gm1*) and Kavya were promising in 5 of

the valid 10 tests. The results suggest that *Gm8* and *Gm1* hold promise across locations.

Gall midge population monitoring (GMPM) - Evaluation of the gene differentials through single female progeny testing revealed that populations at Jagtial and Warangal were less virulent on Aganni (*Gm8*) as compared to populations at Pattambi whereas there was increase in virulence on RP 2068-18-3-5 (*gm3*).This is a matter of concern as this trend has also been evident in GMBT trial in the past few years.

Planthopper special screening trial (PHSS) - Among the 16 gene differentials evaluated, two differentials *viz.*, PTB 33 (with *bph2*+*Bph3*+unknown factors) was promising at 8 locations and RP 2068-18-3-5 (with *Bph33(t)* gene) was promising in 9 out of 11 locations. T12 (with *bph7* gene) performed better at 4 centres, while Rathu Heenati (with *Bph3*+*Bph17* genes), Swarnalatha with *Bph 6* gene and Babawee with *bph 4* gene performed consistently at 3 centres, each. Three other gene differentials *viz.*, ASD 7 with *bph2,* Chinsaba with *bph 8* gene and IR 65482-7-216-1-2-B with *Bph 18* gene showed low damage at two locations only. Except for PTB 33 (DS 4.3), none of the above differentials showed promise against WBPH. RP 2068-18-3-5 showed superiority through low honeydew excretion, nymphal survival and egg hatching in tests conducted at Pantnagar.

2.3. Insecticide Botanicals Evaluation Trial (IBET) was carried out at 28 locations across the country to evaluate performance of various treatments having combinations of commercially available neem formulation, effective plant oils along with recommended insecticides against major insect pests of rice and consequent impact on natural enemies and grain yield during kharif, 2019. Based on the performance of the various treatment combinations in controlling the pest damage at various locations, all insecticides module was found to be superior in reducing stem borer damage compared to other insecticide-botanical modules and was the most effective treatment at both vegetative and reproductive phases. Lowest silver shoot damage was recorded in neem formulations and triflumezopyrim module on par with all insecticides treatment. All insecticides combination was found to be the most effective treatment against plant and leafhoppers. Against leaf folder also, insecticides module was effective in reducing leaf damage. Insecticide and botanical combination treatments were found moderately effective in reducing damage by hispa, whorl maggot and grasshopper pests. Botanical combination treatments however showed relatively higher natural enemy (mirid, spider and coccinellid) populations compared to all insecticides treatment signifying that botanicals are relatively safe to predators. Among various treatments, all insecticides treatment recorded highest yield of 4781.2 kg/ha with 32.3% increase over control followed by treatment with applications of neemazal, neem oil and triflumezopyrim showing yield of 4393.0 kg/ha (21.6% IOC).

2.4. Ecological studies consisted of trials on Effect of planting dates on insect pest incidence (**EPDP**), Effect of iron seed coating on insect pest incidence (**ESCP**), Influence of crop establishment methods on pest incidence (**IEMP**), Cropping systems influence on pest incidence (**CSIP**) and Evaluation of pheromone blends for insect pests of rice (**EPBI**)

Effect of planting dates on insect pest incidence (EPDP) trial was conducted at 22 locations. Incidence of stem borer was reported from 16 locations with maximum damage in late planting. Highest damage was observed in late planting at Titabar (43.33% DH & 54.26% WE) followed by Pusa (19.38% DH) and late planting at Nawagam (32.16% WE). Gall midge incidence was noticed at 6 locations with maximum damage in late planting at Titabar (23.85% SS) followed by Sakoli (23.29% SS). Among the foliage feeding insects, leaf folder incidence was observed at 21 locations with maximum damage in late planting at Titabar (50.44% DL) followed by Nawagam in late planting (32.47% DL) and normal planting (24.90% DL). Whorl maggot incidence was recorded at 6 locations and late planting resulted in higher incidence as compared to early and normal plantings. Hispa damage was reported from 3 locations and Malan centre recorded highest damage of 68.85% in late planting. Case worm incidence was observed at 2 locations with maximum damage (67.52%) in late planting at Titabar. Among the sap sucking insects, WBPH incidence was more as compared to BPH incidence across locations and plantings. BPH incidence was observed at 10 locations with maximum numbers at Gangavathi in late planting (79.10 hoppers/5 hills) and normal planting (60.02 hoppers/5 hills). WBPH incidence was recorded from 9 locations with maximum population in late planting at Nawagam (105.70 hoppers/5hills) followed by late planting (94.03 hoppers/5 hills) and normal planting (89.53 hoppers/5hills) at Gangavathi. GLH incidence was reported from 10 locations and was less than 10 hoppers/5 hills in different plantings at all the locations in all the three plantings, except at Ranchi (26.35 - 45.60 hoppers/5 hills). Low incidence of grasshopper was observed at Chatha and Khudwani (<10 hoppers/5 hills), that of horned caterpillar at Navasari and rice skipper at Khudwani.

Effect of iron seed coating on insect pest incidence (ESCP), initiated this year in collaboration with Agronomy revealed, low pest incidence across the locations in different treatments. Stem borer incidence was at par in different seed coated treatments (0.5 – 10.6% DH & 3.9 – 16.6% WE) and also in different sowings (0.1 – 10.8% DH & 4.1 - 16.4% WE). However, gall midge (9.2 – 13.9% SS) and BPH incidence (11-19 hoppers/hill) was low in seed coated treatments compared to normal transplanting (24.6% SS & 33/hill) and T3 treatment with uncoated seed (22.6% SS & 32 hoppers/hill).

Influence of crop establishment methods on pest incidence (IEMP) trial, initiated this year in collaboration with Agronomy, revealed that dry direct seeding recorded relatively high stem borer (12.65% WE), leaf folder (9.42% DL) and whorl maggot (9.12% DL) damage followed by normal transplanting method (10.86% WE; 9.38% LFDL). BPH numbers were found high in

normal transplanting (6.5 hoppers/hill) method as compared to dry direct seeding, puddled direct seeding and mechanised transplanting methods. Since this was the first year of this trial the findings need further years of observation, testing and validation.

Cropping systems influence on pest incidence (CSIP) was initiated this year to evaluate the influence of different rice crop establishment methods under different residue management strategies with the overall objective of realising the potential of the sequence crop to improve the overall productivity of the rice based cropping system. The trial was conducted at Karjat and Jagdalpur. At both these locations, incidence of stem borer, leaf folder, whorl maggot and GLH was too low to draw valid conclusions.

Evaluation of pheromone blends for insect pests of rice (EPBI) was a new trial initiated with an objective to evaluate pheromone blends and doses against rice leaf folder and pink stem borer. The trial was conducted at 12 locations for both pests. Rice leaf folder catches were high in RLF blend at Ludhiana (26 moths/trap) followed by Titabar (7 moths/trap). However, at other locations, catches were low in pheromone traps in spite of the presence of adult population in the field, which needs further evaluation. Multispecies blend attracted both rice leaf folder and yellow stem borer, however it needs further investigation.

2.5. BIOCONTROL AND BIODIVERSITY STUDIES These studies covered i) Ecological Engineering for Planthopper Management (**EEPM**) and ii) Bio-intensive Integrated pest management (**BIPM**).

Ecological engineering for pest management (EEPM) trial was carried out in eight locations with a combination of interventions such as organic manuring, alleyways, spacing management, water management and growing of flowering plants on bunds. The results also indicated that water management along with ecological engineering significantly reduced hopper population at Warangal (18.93 hoppers/hill) when compared to farmers practice (127.47 hoppers/hill) while increasing yields. Stem borer damage was significantly lower in ecological engineering treatments with various bund crops at New Delhi. Such interventions increased the natural enemy populations like mirids, spiders and coccinellids. Increased egg parasitisation of hoppers was observed at Gangavathi with a mean parasitisation of 15.91% with ecological engineering as compared to 4.96 % in farmer's practices. At Warangal, the benefit cost was also significantly higher with ecological engineering (1.94) compared to Farmers practice (1.29).

Bio intensive pest management trial (BIPM) was initiated to explore the feasibility of bio-intensive approaches for managing pests for organic rice cultivation. The trial was conducted in 10 locations this year. The stem borer incidence was reduced in BIPM plots at Chinsurah (5.47%), Jagdalpur (6.00%), Raipur (13.26%) and Titabar (1.38 %) as compared to farmers practice where it was 19.35%, 8.91%, 17.50% and 29.92 % respectively. In Ludhiana and Ranchi, the pest incidence was on par with that of Farmers'

practice. The results indicated an increase in natural enemy population in the organic BIPM plots.

2.6. Integrated Pest Management special (IPMs) trial was conducted at 13 locations involving 28 farmers' in a participatory mode across the Country with an objective of managing insects, diseases and weeds in a holistic way by providing a basket of options to the farmers. The insect pest incidence exceeded ETL at 8 locations and was observed high in farmer practices plots as compared to IPM plots. Stem borer damage was low in IPM plots than FP plots at 4 locations while dead heart damage was very high in FP plots at Titabar (49.8%), Pusa, Karjat and Sakoli. Gall midge incidence was low in IPM plots (<2% SS) compared to FP plots (10.2 – 36.1% SS) at Titabar while the incidence was high in both IPM and FP plots at Sakoli. Leaf folder incidence was low in IPM at Titabar (<2% LFDL) compared to FP plots (23.8 – 38.9% LFDL). Hispa incidence was low in IPM (8.81-24.8% HDL) compared to FP plots (33.3 – 96.6% HDL) throughout the crop growth period at Malan. Though the populations of planthoppers was high initially in IPM plots (177-391/ 5 hills), they got reduced later with the adoption of IPM practices (< 50/5 hills) at Gangavathi and Raipur. Yield was high in IPM plots compared to FP plots at all the locations with maximum yield at Ludhiana in IPM field (7352 kg/ ha). Similarly, BC ratio varied from 0.88 to 4.71 at various locations in both IPM and FP plots.

2.7. Assessment of insect populations throughout the year using light traps revealed that, yellow stem borer, leaf folder, and hoppers continued to be the most important pests in terms of numbers as well as spread across the locations. Gall midge continues to be an endemic pest. However, case worm, white stem borer, pink stem borer, black bug, gundhi bug, and zigzag leaf hopper showed an increase in the spread and intensity of incidence posing concern for future. Patterns in seasonal incidence and population build up on the basis of light trap data indicates that the key pests are reaching their peak levels in the months of October and November in the kharif season. Therefore, strategies are to be timed accordingly for the effective management of insect pests in rice.

ENTOMOLOGY

INTRODUCTION

Insect pests are the key constituents of biotic stresses posing hurdles for sustainable rice production. Globally, in recent times, changing climatic scenario has had a continued impact on shifting crop cultivation practices resulting in altered pest profiles in rice. Socio economic changes and concomitant ecological constraints make it particularly challenging for the farmers to battle the variety of pests infesting rice in our country. The national pests *viz.*, stem borer, gall midge, planthoppers and leaf folder consistently occur and affect rice crop growth across the diverse ecosystems. There are other pests of regional significance like hispa, caseworm, swarming caterpillar, cutworms etc. which also have the potential to cause economic losses to rice farmers under unpredictable situations.

Under All India Coordinated Rice Improvement Project (AICRIP) Entomology programme, our research focus is to develop and strengthen the all-inclusive theme of integrated rice pest management to achieve the sustainable goal of ensuring social, economic and ecological benefits for the rice farmers. Pest surveillance is the key initial step in any pest management programme. Under AICRIP, Pest Survey Reports (PSR) are generated at fortnightly interval by each cooperating centre that includes real time information on insect pest incidence in farmers' fields. In 2019, rice varieties and hybrids cultivated in Kangra district, Himachal Pradesh were severely affected by rice hispa and white stem borer, while in Sirmaur district hopper burn was seen in a few pockets. In Karnal district of Haryana, yellow stem borer, pink stem borer, BPH and WBPH were found damaging the crop. Hopper burn was reported from Balbera village on variety Pusa44 in Patiala district of Punjab. BPH and leaf folder inflicted damage at flowering stage in Navasari, Gujarat. At reproductive stage, panicle mite and gundhi bug caused considerable damage. In Maharashtra, Bhandara District, stem borer attained severe form at grain filling stage. In various parts of Pattambi, Kerala low incidence of ash weevil, mealy bugs and leaf mites were noticed, while in certain pockets BPH population attained alarming proportion. Moderate incidence of leaf mite was observed at Aduthurai, Tamil Nadu in the months of May and June. Mealy bug was also a pest of concern. At Karaikal, Puducherry, stem borer, gall midge and leaf folder were found damaging the crop. BPH was found in severe form in direct sown crop, whereas the caseworm damage was observed in transplanted paddy. In Mysore, Mandya, and Chamarajanagara districts of Karnataka, yellow stem borer, BPH, leaf folder and ear head bug were in severe form at reproductive stage. In Telangana, hispa incidence was severe in Maheshwaram mandal of Ranga Reddy district. BPH caused extensive damage in certain pockets, while in Warangal district leaf folder was observed in severe form in the *Rabi* season.

Development of multiple pest resistant varieties and strengthening all our efforts to consistently maintain a robust Host plant resistance programme is the prime activity at different centres and target pests include mainly -

planthoppers, gall midge, stem borer and leaf folder. Germplasm accessions of both indigenous and exotic origin, landraces, wild rice resources and advanced breeding lines at different stages get screened against not only insect pests but also diseases at different centres, particularly hot spots for specific pests. Promising lines with desirable resistance traits are identified for use in advanced breeding programme.

In view of the importance of all-round plant health, insecticides with their curative action and botanicals with their environment friendliness need to be integrated into pest management programmes to protect the interests of rice farmers. Hence, efforts are made not only to screen newer insecticide molecules for bio efficacy and safety but also investigate the possibility of alternating their use with botanicals possessing green chemistry and supplementary benefits as components of organic means of managing insect pests.

Investigations are also being made to study the underlying impact of climate change scenario on shift in cropping patterns and resultant alterations in pest profile dynamics. Few collaborative trials involve cooperation from agronomists at different cooperating centres.

Ecological engineering and biointensive pest management efforts aim to understand the ways of intelligently exploiting the rice ecosystem rich with natural enemy diversity for eco-friendly and economically gainful rice IPM.

Adoption of integrated pest management by farmers depends on the effectiveness of holistic solution provided to alleviate their multiple pest problems. In addition to enhanced yields farmers need to be convinced about economic gains from IPM implementation. Under AICRIP, farmer participatory multidisciplinary approach through involvement of Entomology, Plant Pathology and Agronomy researchers is being advocated to validate location specific IPM practices across the country.

Monitoring of insect pest populations through light traps at different locations helps in short- and long-term assessment of pest populations for use in pest forecasting.

The following report highlights the significant findings from the green house evaluations and field trials carried out at IIRR and its cooperating centres under AICRIP during 2019.

2.1. HOST PLANT RESISTANCE STUDIES

The prime objective of host plant resistance studies is identification and delineation of new sources of resistance to major insect pests, and multilocational evaluation of breeding lines from various National Screening Nurseries against insect pests to identify lines with tolerance/resistance. These include multi-location evaluations under both greenhouse and field conditions to evaluate the performance of germplasm accessions, breeding lines as well as characterization of insect pest populations from various hot spots. Seven trials *viz.*, i) Planthopper Screening trial (PHS), ii) Gall Midge Screening trial (GMS), iii) Gall Midge Special Screening trial (GMSS), iv) Leaf Folder Screening Trial (LFST), v) Stem Borer Screening Trial (SBST) vi) Multiple Resistance Screening Trial (MRST) and vii) National Screening Nurseries (NSN) were constituted and conducted during *Kharif* 2019. In all, 1652 entries were evaluated at 42 locations against 11 insect pests and 64entries (3.87%) were identified as promising. **The detailed pest reaction of all the entries in each trial is presented in a separate volume "Screening Nurseries: – Diseases & Insect Pests".**

i) Planthopper screening trial (PHS)

The planthopper screening trial was constituted with 120 entries comprising of 11 breeding lines developed at RRU, ANGRAU, Bapatla; 8 breeding lines developed at TNAU, Coimbatore; 10 breeding lines developed at RARS, PJTSAU, Jagtiyal; 10 breeding lines developed at Kunaram, PJTSAU; 5 breeding lines developed at APRRI, ANGRAU, Maruteru; 14 breeding lines developed at ARI, PJTSAU; Rajendranagar, 3 breeding lines developed at RARS, PJTSAU, Warangal; 5 breeding lines and 4 germplasm accessions developed at NRRI, Cuttack, 29 breeding lines, 4 germplasm accessions and improved Samba Mahshuri parent developed at IIRR, Hyderabad along with three resistant checks PTB 33, RP 2068-18-3-5 (BPH) and MO1 (WBPH) as well as one susceptible check TN1. Of these, sixteen entries were under retesting. The entries were evaluated at 14 locations in 18 tests against brown planthopper (BPH), whitebacked planthopper (WBPH) and mixed populations of planthoppers under both field and greenhouse conditions.

Evaluation of entries in 8 greenhouse and 2 field tests against brown planthopper, 2 greenhouse and 1 field test against whitebacked planthopper and 5 field tests against mixed populations of planthoppers revealed 7 breeding lines *viz.*, KNM 7629, MTU 1305, MTU 1306, MTU 1308, RMS-ISM-Bph33-1, RP 221-3-5-2, RP 179-3-9-1 as promising in 7-10 tests **(Table 2.1)**. Four germplasm accessions *viz.*, IC 216735, IC 76013, IC 75975 and IC 76057 from IIRR performed consistently better in 10 to 14 tests in the second year of retesting and two germplasm accessions *viz.,* CRCPT 7 and CRCPT 8 from NRRI performed better in 7 to 9 tests. Three breeding lines *viz.,* MTU 1305, MTU 1306 and MTU 1308 performed better in the second year of retesting. The susceptible check TN1 recorded damage score in the range of 8.2 to 9.0 in these valid tests. The universal checks - PTB 33 and MO1 performed well in 10 and 9 tests respectively. The breeding line, RP

2068-18-3-5 carrying BPH resistant Bph33t gene and gall midge resistant gm3 gene and identified as a donor check line for BPH performed better in 11 tests.

Mixed populations of brown planthopper and whitebacked planthopper were present in Gangavathi, Maruteru, Pantnagar, Sakoli and Warangal. Data on BPH and WBPH populations during the field evaluation at Gangavathi (WBPH: BPH in 1.5:1.0 ratio) revealed predominance of WBPH over BPH. In Nawagam only WBPH was present. BPH was predominant throughout the crop season at Pantnagar (BPH 5-26 times more), Maruteru (BPH 13.7 times more than WBPH) while at Warangal, BPH and WBPH were in 1:3 ratio in the beginning of the crop and there was a gradual decline in WBPH population. At Aduthurai, Jagtial and Rajendranagar, only BPH population was present.

Evaluation of the entries against the two planthoppers BPH and WBPH in 10 greenhouse and 8 field tests indicated 16 entries (including 7 breeding lines, 6 germplasm and three checks) as promising in 7 to 14 tests. Four germplasm accessions viz., IC 216735, IC 76013, IC 75975 and IC 76057 from IIRR and three breeding lines viz., MTU 1305, MTU 1306 and MTU 1308 performed better in the second year of retesting.

ii) Gall midge screening trial (GMS)

The objective of this trial was to evaluate the performance of the breeding lines developed from known sources of gall midge resistance against various populations of gall midge. The trial was constituted with 40 entries (36 breeding lines along with 3 resistant checks and one susceptible check). The nominations included material developed from 18 crosses bred at 5 locations *viz* IIRR, Jagtial, Kunaram, Pattambi and Sindewahi and were evaluated at 11 locations across the country against 5 identified biotypes of gall midge. The valid data from 6 locations for various biotypes/populations were considered for analysis and the salient findings are discussed as under:

JGL 33126, JGL 33138, SKL-07-11-177-50-65-143-89 and W1263 recorded nil damage at IIRR and CHP for GMB1. SKL-07-8-720-63-147-182-276* and Aganni had nil damage for biotype 3 at JGL. Only Aganni had nil damage at both Warangal and Sakoli. All the entries were susceptible at Pattambi.

Evaluation of 40 entries in one greenhouse and 5 field tests against 6 populations of gall midge (five identified biotypes) helped in identification of one line, SKL-07-8-720-63-147-182-276 an entry under retesting as promising in 3 tests of the 6 valid tests across all the populations (**Table 2. 2)**. Aganni was promising in 4 tests.*

Table: 2.1 Performance of the most promising entries against planthoppers, PHS, *kharif* 2019

Entry No.	Desig-nation	Cross	Brown planthopper										Whitebacked planthopper			Planthoppers					No. of Promising Tests (NPT)						TOTAL
			IIRR	ADT	CBT	CTC	LDN	MND	PNT	WGL	JGT	RNR	IIRR	CBT	NWG	MTU	GNV	PNT	SKL	WGL	BPH		WBPH		PH		
			Greenhouse reaction								110DT	78DT	GH	GH	74DT		81DT	60DT	90DT	68DT	GH (8)	FR (2)	GH (2)	FR (1)	FR (5)	18	
			Damage Score								%DT	No/10h.	DS		No/10h.	DS	No/10h.										
5	IC 216735*	Germplasm acc.	1.6	3.0	8.3	5.0	3.0	3.0	0.9	2.9	9.9	315	9	7.5	104	3	187	57	140	119	7	2	0	1	4	14
12	IC 76013*	Germplasm acc.	0.9	7.0	6.8	7.0	2.4	3.0	0.7	2.7	14.8	348	9	6.2	198	3	237	78	106	90	5	1	0	1	3	10
24	IC 75975*	Germplasm acc.	0.9	1.0	5.4	9.0	3.6	3.0	0.9	5.8	8.1	71	9	6.1	226	3	206	64	174	74	6	2	0	0	4	12
29	IC 76057*	Germplasm acc.	2.2	9.0	5.8	9.0	3.0	3.0	1.0	6.8	4.3	371	8.7	6.5	258	3	159	75	151	72	4	1	0	0	5	10
37	KNM 7629	MTU1156/ KNM118	2.5	9.0	7.0	9.0	8.1	9.0	1.0	7.8	8.9	410	8.5	8.5	190	9	178	75	184	47	2	1	0	1	3	7
49	MTU 1305*	(MTU 1075/MTU 1081)/MTU 1121	6.9	3.0	7.6	9.0	3.2	5.0	0.6	2.1	21.6	240	7.5	8.8	199	3	200	73	164	175	5	1	0	1	3	10
51	MTU 1306*	MTU 1121/MTU 1010	9.0	5.0	8.3	9.0	9.0	5.0	3.8	5.9	18.3	753	9	8.2	160	5	144	77	145	69	2	0	0	1	4	7
53	MTU 1308*	(MTU1010/ MTU1081) /MTU 1121/ JGL18047	9.0	5.0	8.3	1.0	4.7	7.0	5.6	6.3	19.3	244	9	7.5	234	3	211	80	132	71	3	1	0	0	3	7
75	RMS-ISM-Bph33-1	ISM/RP2068	6.1	9.0	6.4	9.0	3.5	3.0	5.3	6.8	19.2	85	9	9	274	5	156	75	134	195	2	1	0	0	4	7
99	CRCPT 7	CR AC 35003	6.1	9.0	7.4	3.0	9.0	9.0	6.5	8.2	6.0	187	6.3	8.2	238	5	160	73	171	59	1	2	0	0	4	7
101	CRCPT 8	CR AC 34997	7.9		8.7	5.0	9.0	9.0	2.8	4.0	3.1	194	9	8.2	239	7	168	70	158	51	3	2	0	0	4	9
108	RP 221-3-5-2	MTU1121/ Vijetha	8.7	3.0	8.3	3.0	4.6	7.0	6.3	4.5	10.2	390	9	8.2	240	3	200	75	197	124	4	0	0	0	3	7
109	RP 179-3-9-1	MTU1121/ Vijetha	6.1	3.0	7.0	3.0	3.0	7.0	5.2	5.0	7.7	525	9	8.3	311	3	194	78	181	74	4	1	0	0	3	8
117	PTB 33	R. check	0.3		7.0	1.0	2.8	1.0			0.0	129	3.5		288	9	149	89	140	59	4	2	1	0	3	10
40	RP2068-18-3-5	R. check	1.5	1.0	4.4	7.0	2.9	3.0	0.7	3.8	20.0	281	8.8	7.2	205	5	177	81	162	38	7	1	0	0	3	11
120	MO1	R. check	5.5			3.0	8.0	5.0	7.6		0.0	222	1.3		208	3	196	85	155	33	2	2	1	0	4	9
Promising level			5	5	5	5	5	5	3	5	10	350	5	5	200	5	200	75	160	75						
No. of promising entries			19	28	4	33	27	27	22	15	40	48	5	0	38	22	60	52	50	44						

*-Entries under retesting.

Table 2. 2 Reaction of promising breeding lines against gall midge populations in GMS, *kharif* 2019

Per cent plant damage

Entry No.	Designation	GMB1		NPT	GMB3	NPT	GMB4	NPT	GMB4M	NPT	GMB5	NPT	Overall NPT
		IIRR	CHP		JGT		SKL		WGL		PTB		
		GH	50DT	2	50DT	1	50DT	1	50DT	1	50DT	1	**6**
24	SKL-07-8-720-63-147-182-276*	0	20	1	0	1	10	0	0	1	93.3	0	**3**
30	Aganni	NT	0	1	0	1	0	1	0	1	100	0	**4**
Total Tested		38	39		39		39		39		40		
Average damage in the trial		56.1	34.4		73.8		69.5		71.3		90.9		
Ave. damage in TN1		100	80		100		100		90		95.2		
Promising level		0	0		0		0		0		0		
No.promising		15	7		2		1		2		0		

*- Entry under retesting. Data from Nellore and Cuttack not received. Data from JDP, MNC, RNC, RGL and MTU were not considered for analysis due to low pest pressure

iii) Gall midge special screening trial (GMSS)

This trial constituted with 85 entries (39 germplasm accessions and 40 gene pyramided lines nominated from IBT, PJTSAU along with check varieties) was carried out in 10 locations to identify new sources of resistance to gall midge biotypes/populations. Of these, 28 lines were under retesting. The valid data from seven locations which had >50% DP in TN1 were analysed and discussed biotype/population wise as under:

Evaluation of the entries for GMB1 identified Aganni,IIRR-ENT-2019-17and 13 gene pyramided lines (MTU1010 with *Gm4* and *Gm8)* (IBT GM 4, IBT GM 5, IBT GM 3, IBT GM 6,IBT GM 7, IBT GM 9, IBT GM 12, IBT GM17, and IBT GM23,IBT GM 30,IBT GM32, IBT GM36, IBT GM39) as promising with nil damage at IIRR and CHP.

Against biotype 3, IIRR-ENT-2019-17 and Aganni showed nil damage at both Jagtial and Ranchi. IIRR-ENT-2019-17, INRC 17470, RMSGM3, Aganni, 19 lines from IBT WGL series and16 from IBT GM series recorded nil damage at Sakoli for biotype 4. ARC 5906*, INRC 17470*, IIRR-ENT-2019-15, IIRR-ENT-2019-17, IBT WGL3, IBT WGL5, IBT WGL31, IBT GM 1*, IBT GM 2*, IBT GM 3* and IBT GM5, recorded nil damage against biotype 4 M at Warangal.

None of the entries recorded nil damage for biotype 5, at Pattambi.

Evaluation of 85 donors against 5 gall midge biotypes in one greenhouse and 6 field tests identified 16 lines as promising in 4 to 6 tests. IIRR-ENT-2019-17 was promising in 6 tests and 14 pyramided lines (MTU1010 with gm3+Gm4 +Gm8) along with Aganni were promising in 4 tests ***(Table 2.3)****. Of these 6 lines were promising in the second year of retesting.*

Table 2.3 Reaction of donors against gall midge populations in GMSS, *kharif* 2019

Entry No.	Designation	GMB 1	GMB 1	NPT	GMB 3	GMB 3	NPT	GMB 4	GMB4 M	GMB 5		Overall NPT
		IIRR	CHP		JGT	RCI		SKL	WGL	PTB		
		GH	50DT	2	50DT	50DT	2	50DT	53DT	50DT		7
2	IIRR-ENT-2019-17	0.00	0.00	2	0.00	0.00	2	0.0	0.0	100.0		6
66	IBT GM3*	0.0	0.0	2	0.0	35.0	1	0.0	0.0	100.0		5
68	IBT GM5	0.0	0.0	2	0.0	30.0	1	0.0	0.0	100.0		5
58	IBT WGL31	NT	0.0	1	0.0	25.0	1	0.0	0.0	100.0		4
64	IBT GM1*	0.0	30.0	1	0.0	35.0	1	0.0	0.0	100.0		4
65	IBT GM2*	0.0	20.0	1	0.0	35.0	1	0.0	0.0	100.0		4
67	IBT GM4	0.0	0.0	2	0.0	35.0	1	0.0	20.0	100.0		4
69	IBT GM6	0.0	0.0	2	0.0	30.0	1	0.0	5.0	100.0		4
70	IBT GM7*	0.0	0.0	2	0.0	25.0	1	0.0	15.0	100.0		4
72	IBT GM12*	0.0	0.0	2	0.0	30.0	1	0.0	5.0	100.0		4
74	IBT GM17*	0.0	0.0	2	0.0	25.0	1	0.0	5.0	100.0		4
77	IBT GM23	0.0	0.0	2	0.0	30.0	1	0.0	10.0	100.0		4
79	IBT GM30	0.0	0.0	2	0.0	35.0	1	0.0	5.0	100.0		4
81	IBT GM36	0.0	0.0	2	35.0	0.0	1	0.0	100.0	100.0		4
82	IBT GM39	0.0	0.0	2	30.0	0.0	1	0.0	100.0	100.0		4
40	Aganni	12.5	0.0	1	0.0	0.0	2	0.0	5.0	100.0		4
Total Tested		65.0	84.0		85.0	85.0		85.0	85.0	85.0		
Average damage in the trial		20.0	23.2		27.1	22.3		41.2	37.4	99.4		
Average damage in TN1		86.7	70.0		92.5	65.0		100.0	80.0	100.0		
Promising level		0	0		0	0		0	0	0		
No.promising		33	35		43	21		39	11	0		

*- Entry under retesting. Data from Moncompu, Ragolu and Jagdalpur was not considered due to low pest pressure.

iv) **Leaffolder screening trial (LFST)**

The main objective of Leaf folder screening trial (LFST) is to identify new sources of resistance against leaf folder, *Cnaphalocrocis medinalis* Guenee by field screening through augmented releases. The trial comprised of 20 entries with 13 nominations from Regional Agricultural Research Station, Pattambi, Kerala; two nominations from Rice & Wheat Research station, CSK HP Agricultural University, Malan, Himachal Pradesh and three nominations from Main Rice Research Station, Anand Agricultural University, Nawagam, Gujarat together with a susceptible check (TN1) and resistant check (W1263). During *Kharif* 2019, the trial was conducted at 16 locations with 20 entries replicated thrice in a randomised block design. In the first year of testing, data analysis revealed four entries as promising in 3-4 tests of 9 valid field tests **(Table 2.4).** Average damage in the trial varied from 7.7 to 78.2% while the maximum damage ranged between 14.7 and 92.8% across locations. The average damage by leaf folder in susceptible check varied from 13.8 to 82.1%. Two mutant cultures, Cul M8 and Cul M9 were found promising in 4 out of 9 valid field tests. Another mutant culture, Cul M6-2 and a selection from landrace Kalluruli were found promising in 3 of the 9 valid field tests and were found at par with resistant check, W 1263.

Table 2.4 Performance of entries against leaf folder in LFST, *Kharif* 2019

Designation	Parentage	CHT	KRK	LDN	MLN	NVS	NWG	PTB	ADT	RNR	NPT
		60DT	60DT	80DT	114DT	80DT	60DT	50DT	80DT	83DT	(9)
Cul M8*	Mutant 170 GY of PTB 21	23.7	4.4	14.1	35.4	3.2	32.3	49.3	22.8	3.9	4
Cul M9*	Mutant 220 GY of PTB 18	22.9	11.3	19.8	29.4	9.4	34.1	81.9	31.6	10.4	4
Cul M6-2*	Mutant 170 GY of PTB 18	19.7	24.4	27.3	28.5	13.4	71.5	85.2	28.4	6	3
Kalluruli*	Selection from landrace Kalluruli	25	14.6	16.5	31.7	7.9	29	74	31.8	11	3
JS 3	Pureline selection from Jaya	27.1	27.7	30.3	32.1	8	26	86	32.2	1.4	2
JS 4	Pureline selection from Jaya	22.4	22.5	31.5	42.9	9.5	26.6	85.8	31.1	7.4	2
JS 5	Pureline selection from Jaya	22.8	34	31.1	32.8	6.6	32.6	81.8	30.8	2.2	2
Cul 3	Swetha x Kuruka	25.4	33.5	27.5	36.9	13.6	24.4	84.5	27.8	7.7	2
Cul M4	Mutant of PTB 18	22.1	17.1	34.3	32.9	9.9	38.2	61.4	22	2.8	2
Matali	Local red rice from Kullu valley in HP	24.2	16.7	20.9	26.6	13.8	43.2	66.5	19.6	12.4	2
NWGR 16041	NWGR 2006/ Mahi-sugandha/47-1-1-1-1-1-1	23.4	42.3	28.8	29.6	8.5	31.4	87.1	31.4	12	2
JS 1	Pureline selection from Jaya	24	23.6	33.3	37.8	15.6	34	88	28.1	8	1
JS 6	Pureline selection from Jaya	22.8	28.8	26.3	30.8	13.3	25.3	86.1	29.3	7.7	1
Cul 7	Pureline selection from Jaya	22.2	32.5	31.7	34.9	11	41.7	89.4	22.6	3.9	1
Chohartu	Local red rice from Rohru in Shimla region	27.1	27.8	28.8	41.5	10.6	32.8	85.5	22.3	4.8	1
NWGR 9078	GR 7/NWGR 99038/1-1-1-1	24.9	36.9	23.1	30.4	19.6	50.4	82	20.8	6.6	1
NWGR 13052	Gurjari/IET17126/1-4-1-1-1-1	26	33.2	31.8	30.9	19.9	36.3	82	19.9	14.7	1
JS 7	Pureline selection from Jaya	23.5	30.3	31.9	34	18.2	29.7	92.8	31.4	11.4	0
W 1263	Resistant check	22.8	27.6	18.7	34.2	0.2	43.5	36.3	9.2	11.9	3
TN 1	Susceptible check	24	30.1	40.9	37.6	32.6	47	82.1	32.5	13.8	0
Minimum damage		19.7	4.4	14.1	26.6	0.2	24.4	36.3	9.2	1.4	
Maximum damage		27.1	42.3	34.3	42.9	36.7	71.5	92.8	32.2	14.7	
Average damage in trial		23.8	25.7	26.7	33.3	12.4	35.9	78.2	25.9	7.7	
Promising level		20	15	20	30	10	25	30	20	10	
No. Promising		1	3	4	4	9	1	0	3	12	
Total entries tested		20	20	20	20	20	20	20	20	20	

*** promising**

Data from Bapatla, Chinsurah, Gerua, Gangavathi, Jagdalpur,Karjat and Khudwani were not included in the analysis due to low pest pressure

In Leaf Folder Screening Trial (LFST), field evaluation of 20 entries replicated thrice in a randomised block design at 16 locations, during Kharif 2019, revealed that 4 entries were promising in 3-4 tests out of 9 valid field tests. Two mutant cultures of PTB, Cul M8 and Cul M9 were found promising in 4 of the 9 valid tests while another mutant culture, Cul M6-2 and a selection from landrace Kalluruli were found promising in 3 of the 9 valid field tests conducted at different locations.

v) Stem borer screening trial (SBST)

Stem borer Screening trial (SBST) initiated in 2015 was continued during *kharif* 2019 with 65 entries including nominations from IIRR, Cuttack, Jagtial, Warangal and Pattambi, which were specifically bred for stem borer tolerance. The entries were evaluated at 13 locations and at each location observations were recorded on dead heart at vegetative phase and white ear damage, grain yield in the infested plant and the larval survival in the stubbles at harvest. For effective screening two staggered sowings were

taken up in most of the locations. Two locations; Pattambi and Malan reported the damage for white stem borer, *S.fusciflua,* while in other locations yellow stem borer damage was recorded. The results of the evaluation from the valid tests are discussed below **(Table 2.5).**

Dead heart damage: The dead heart damage in the trial varied from 3.0 to 42.1% with an average damage of 19.9% DH across 5 locations in 9 valid tests. Evaluation of entries for dead heart damage at 30 and 50 DAT in two staggered sowings helped in identification of four retested entries - WGL 1083*, JGL 33440*, KAUPTB 0627-2-11*, BK 49-76* and a new entry, NND 2 as promising in 2 of the 9 tests with ≤10% DH (DS3.0).

White ear damage: The white ear damage across 5 locations in 6 valid tests varied from 0.0 to 78.8% with a mean of 21.1%WE. Evaluation of entries identified, CRCPT 7, JGL 32994, JGL 33440, KMR3, WGL 1062, IET28068*, NND2 and NND5 as promising in 2 tests of the 6 valid tests with ≤5% WE (DS1.0). The larval survival per entry across 9 locations in 12 tests varied from 0 to12 larvae/hill in the stubbles with a mean of one larvae/hill. At Rajendranagar, traces of pink stem borer larvae were observed in very few entries.

Grain yield: JGL 33145*, KAUPTB 0627-2-11, RP 5587-B-B-B-273-1* and TKM 6 were promising in 3 of the 4 tests with ≥15g/hill in 3 of the 4 valid tests for grain yield /hill despite stem borer damage in the valid tests. However, JGL 33440*, NND 2, JGL 34452*, JGL 32994*, KMR3*, CRCPT 7, JGL 33080*, BK 49-76*, RP bio 4919-385 and IET 27049* which were promising 2-3 tests for stem borer damage were also promising in one to two tests for grain yield of the 4 valid tests.

.Table 2.5 Reaction of cultures to stem borer in SBST, kharif 2019.

S.No.	Designation	No. of promising tests (NPT)					
		SBDH	SBWE	SBDH+SBWE	GY/hill (g)	Overall	Larvae/per hill
		9	6	15	4	19	12
32	KAUPTB 0627-2-11*	2	1	3	3	6	0.61
17	JGL 34452	2	1	3	2	5	1.18
31	JGL 33440*	2	2	4	1	5	0.91
61	NND 2	2	2	4	1	5	0.84
9	JGL 32994	1	2	3	1	4	0.71
29	JGL 33080*	1	1	2	2	4	1.1
52	BK 49-76*	2	0	2	2	4	0.93
54	RP bio 4919-385	1	1	2	2	4	1.31
55	KMR3	1	2	3	1	4	1.68
58	IET 27049	1	1	2	2	4	0.88
5	CRCPT 7	1	2	3	1	4	0.66
30	TKM 6	0	1	1	3	4	0.9

- Data not received from NRTI, CTC.Data from CBT,PTB,GGT,CHN,MLN,RNR for DH;CBT,PTB,GGT, CHN,MLN, RNR,NVS , for WE; was not considered due to insufficient pest pressure for screening.

Evaluation of entries in 19 valid field tests identified 12 entries as promising in 4 to 6 of the 19 tests in terms of low dead hearts, white ear damage and high grain

yield suggesting that recovery resistance and tolerance could be the mechanism in these entries as they have good grain yield despite damage The mean no. of larvae in the stubbles in these entries varied from ranged from 0.13-1.68/hill. Four of these entries viz., KAUPTB 0627-2-11, JGL 33440, BK 49-76 and JGL 33080 are promising in the second year of testing

vi) Multiple resistance screening trial (MRST)

This trial was constituted with a view to identify the reaction of entries found promising in pest specific trials to other pests and to evaluate the reaction of advanced breeding lines to insect pests. The trial included evaluation of 25 entries consisting of three each of the promising entries from PHS and GMS trials, 5 from SBST trial, 3 nominations from Kerala and 6 nominations from Cuttack along with four resistant checks and one susceptible check, against 9 insect pests, at 28 locations. **The details of the reaction of entries is available in Screening Nurseries-Diseases and Insect pests Vol II. The valid data from various locations are discussed pest wise (Table 2. 6).**

BPH: IR 73382-80-9-3-13-2-2-1-3-B (HWR-16) and RP 5995 Bphk17-5 were promising in 2 of the 4 valid greenhouse tests with a DS ≤3.0. PTB 33 was promising in 3 tests.
WBPH: None of the entries was found promising.
Mixed population of planthoppers: Cul M9 (Mutant 220 Gy of PTB 18) and PTB33 exhibited field tolerance with a DS ≤3.0in 2 valid tests at GGV and MTU for mixed population of planthoppers though BPH was predominant at MTU and WBPH at GGV.

Gall midge: Sinnasivappu and W1263 had nil damage in 4 and 2 tests, respectively of the 6 valid tests for gall midge.

Stem borer: Evaluation of entries against stem borer at vegetative phase for dead heart damage in 7 valid tests identified JS1 (a pure line selection from Jaya) with nil damage. Cul 7, Cul M9, JS 3, RP 5690-20-6-3-2-1, RP 5587-B-B-B-262, BK 39-179, PTB33 and Suraksha were identified as promising in 2 of the 14 valid tests at reproductive phase for white ear damage.

Foliage feeders: Incidence of leaf folder, whorl maggot, case worm and rice hispa were observed at various locations. RP 5995, Bphk17-5 and Suraksha were promising for leaf folder damage in 2 of the 8 valid tests. Suraksha was the only entry promising against whorl maggot in 2 of the 5 valid tests with ≤5.0% DL. None of the entries were found promising for rice hispa (net house screening at Malan for adult damage) and case worm, in one test each.

Evaluation of 25 entries in 6 greenhouse and 43 field tests against 9 insect pests revealed three entries viz., Sinnasivappu, JS5 (selection from Jaya) and SKL -07-11-177-50-65-60- and Cul7, as most promising in 4-6 tests with a PPR of 2.7 to 4.8 against 3 pests. The check lines PTB 33, Suraksha and W1263 were promising in 9, 8 and 5 tests, respectively with a PPR of 3.4 to 7.3 against 3 to 4 pests

Table 2.6 Performance of the most promising cultures against insect pests in MRST, *kharif* 2019

Sl. No.	Designation	No.of promising tests (NPT)											No of promising		MRI	PPR
		BPH	WBPH	PH	GMB	SBDH	SBWE	LF	WM	RH	CW	PM	Tests (T)	Pests (P)	P X T	441
		4	1	2	5	7	14	8	5	1	1	1	49	9	441	
25	Sinna sivappu	0	0	1	3	0	0	1	1	0	0	0	6	3	18	4. 8
9	JS 5	0	0	1	0	1	1	1	0	0	0	0	4	3	12	2.7
16	SKL -07-11-177-50- 65-60-267	0	0	1	0	1	1	0	1	0	0	0	4	3	12	2.7
	Checks															
10	PTB33	3	0	2	0	1	2	0	0	0	0	1	9	3	27	6.1
20	Suraksha	0	0	1	0	1	2	2	2	0	0	0	8	4	32	7.3
15	W1263	0	0	1	2	0	0	1	1	0	0	0	5	3	15	3.4

PPR-Percent Promising reaction:MRI of test entryX100/total MRI, Data from IIRR for BPH and WBPH and NRRI were not received. FR from PNT, WGL, CBT, for planthoppers; JDP,RGL, MTU for GM RGL,RNR,RPR, LDN,CHP,GNV for SBDH; CHP, RGL, GNV for SBWE;JDP, MTU, GNV for LF; RPR for CW not considered for analysis.

Vii. National Screening Nurseries

National Screening Nurseries (NSN) comprised of 4 trials, National Screening Nursery 1(NSN1), National Screening Nursery 2(NSN2), National Screening Nursery–Hills (NSN hills) and National Hybrid Screening Nursery (NHSN). NSN1was constituted with 367 entries (339AVT entries along with 10 insect checks and 14 disease checks) was evaluated at 18 locations. NSN 2 trial comprised of 682 entries (658 entries from IVT trials, 10 insect and 14 disease checks) was evaluated at 14 locations against 7 insect pests. NSN-Hills trial consisting of 130 entries (106 hill entries + 10 insect check lines and 14 disease checks) was evaluated at 8 locations in 13 valid tests (4 greenhouse and 9 field tests) against 9 insect pests. NHSN trial constituted with 118 entries (94 hybrids + 10 insect checks+14 disease checks) was evaluated at 14 locations against 7 insect pests. The valid data in each trial are discussed pest wise:

Brown planthopper:
NSN1: PTB 33 was resistant in 2of the 3 tests, while 14 more entries recorded a DS of ≤3.0 in one of the tests.

NSN2: Though evaluation was carried out at 3 locations in green house tests these was no consistency in the reaction of test entries at any two locations except for PTB33 and RP 2068-18-3-5.

NSN hills: IET Nos.26565 and 28194 recorded < DS 4.0 at both IIRR and LDN for BPH.

NHSN: IET Nos 28121, 28123, Gontra Bidhan-3, 28132, 28158 and 28160 were promising in one of the 3 greenhouse tests with a DS≤ 3.0. PTB 33 and RP 2068-18-3-5 also showed similar trend.

Whitebacked planthopper:
NSN1: None of the test entries were observed to be promising for WBPH except MO1.

NSN2: All the entries were susceptible to WBPH.

NSN hills: All the entries were found susceptible.

NHSN: All the entries were susceptible, while MO1 was promising in greenhouse test at IIRR with a DS of ≤3.0.

Planthoppers (Mixed population):
NSN1: Field tolerance for mixed populations of planthoppers was exhibited by IET Nos 27117, 27583, 27360, 26744, 28790, 27939, 27927, 27880, 26763 (R), NSN1-159 and PTB33 at Maruteru with a DS ≤ 3.0. The ratio of BPH to WBPH was 19:1 at Maruteru, while WBPH was predominant at Gangavathi.

NSN2: Twelve entries *viz.*, IET Nos 28344,28346, 28676, 28511, 28512, 28520, 28263, 28264, 28287, 28071, 27641, 28075 showed field tolerance at Maruteru with a DS of 3.0 (visual score). IET 28071 was promising for BPH at one location in GR test and in field reaction at MTU also.

NSN hills: All the entries were susceptible. PTB33, RP 2068-18-3-5 and Suraksha had DS3.0.

NHSN: None of the entries were found promising.

Gall midge:
NSN1: IET Nos 27632 recorded nil damage against gall midge in 2 of the 4 tests. W1263 and Aganni were promising in 2 and 3 tests, respectively.

NSN2: IET 28334 had nil damage at IIRR and CHP for GMB 1 but it recorded 10.3% SS at Moncompu.

NSN hills: Eighteen entries , *viz.*, IET Nos 27491,27496, 28210, 28215, , 27501, 27498, HR-12, Nidhi, Co-39, RP-Bio-226, Abhaya entries along with NC (Vivekdhan 62,Sukaradhan -1) recorded nil damage against GMB1 apart from Aganni, Kavya, RP 2068-18-3-5, Suraksha and W-1263.

NHSN: IET Nos 28115, 28118, 28125, 28157 and 28178 recorded nil damage for gall midge in green house reaction at IIRR apart from Aganni, RP2068-18-3-5, W1263, and Suraksha. This year the field incidence of gall midge was very high. At Pattambi, the incidence was as high as 195.8 % SS with an average damage in the trial of 73.1% SS but IET Nos 28182, 28183, JKRH-3333 (NCH-1) and Benibhog recorded nil damage.

Stem borer:
NSN1: IET nos. 27512 and 27353 recorded nil damage in 2 (MNC and CHP) of the 6 tests at vegetative phase for dead heart damage. IET Nos 26927 and 26948 recorded nil white ears in 3 of the 9 tests at reproductive phase. The low damage could be due to escape in the critical stages.

NSN2: IET No 28512 had nil damage for dead heart at MNC of the 4 locations tested and for white ear damage at MNC and CHP.

NSN hills: Vivek dhan 62 (NC) at dead heart stage and IET 28227 and Vivek Dhan 154 had 5 % WE.

NHSN: US-314 (NCH) 28125, 28137, 28141,28169,28174,28181, JKRH-3333 (NCH-1), ADT-49 (RCV), 28187 and CH 45 recorded nil white ear damage in two of the eight locations tested.

However, these lines need to be further tested under greenhouse conditions for validation of the reactions and to rule out any damage escape.

Leaf folder:
NSN1: IET No28793 was the only entry with nil damage in one of the 3 valid tests.

NSN2: Eight entries *viz.,*IET Nos 28332, 28365, 28736, 28754, 28288, 28602, 28070 and 28074 had nil damage in one of the 3 valid tests.

NSN hills: All the entries were susceptible at Chatha.

NHSN: IET 28112 had nil damage at 58 DAT at RNR of the 4 locations tested.

Whorl maggot:
NSN2: IET Nos 28406, 28752, 28532, 28550, 28696, 28074 had nil damage at Jagdalpur (77 DAT) of the 3 valid tests.

NSN hills: All the test entries were susceptible at Malan.

NHSN: None of the entries were promising.

Rice hispa:
At Malan, standard facility with technique has been developed for screening against hispa.

NSN 2: None of the entries were promising

NSN Hills: All the entries were found susceptible.

Other pests
Gundhi bug and Grasshopper
NSN Hills: The mean grain damage by gundhi bug at Chatha was 26.4% and the leaf damage by grasshoppers at Khudwani was 11.9% DL. None of the entries were promising at a level of 10% DG and 5 % DL, respectively.

Case worm and whorl maggotNSN1: All the entries were susceptible to case worm at TTB and WM at JDP.

Overall reaction
NSN1: Evaluation of 367 entries at 18 locations in 5 greenhouse and 26 field tests against 7 insect pests identified three entries *viz.*, IET nos 27632, 26948 and 28793 as promising in 4 to 5 tests of the 31 valid tests against

one to three pests. Aganni and PTB 33 were promising in 4 and 3 tests, respectively **(Table 2.7)**.

NSN2: Evaluation of 682 entries in 5 greenhouse and 18 field tests against 7 pests in 23 valid tests identified six entries along with PTB-33, RP 2068-18-3-5 and Aganni as promising in 3 to 4 tests of the 23 valid tests against one or two pests **(Table 2.8)**.

NHSN: Evaluation of 94 hybrids along with checks in 5 greenhouse and 17 field tests against 6 insect pests identified IET Nos 28125, JKRH-3333 (NCH-1) and CH 45 as promising in 3 tests of the 22 valid tests. Abhaya, PTB33 and RP 2068-18-3-5 were promising in 3 to4 tests **(Table 2.9)**.

It is pertinent to note that since the breeding lines in these nurseries were not specifically bred for insect resistance, the number of promising tests is very low in all the identified promising entries in the nurseries. So, these entries need to be further tested, verified and validated under suitable pest pressure situations for use in pest resistance breeding programme.

Table 2.7 Performance of the most promising cultures against insect pests in NSN1, *kharif* 2019

Entry No	IET No.	Cross combination	No. of promising tests (NPT)									Overall NPT
			BPH	WBPH	PH	GM	SBDH	SBWE	LF	CW	WM	
			3	1	2	4	6	9	4	1	1	**31**
232	27632	MTU 1297(MTU 2036-1-1-1-1)	0	0	0	2	0	2	0	0	0	**4**
246	26948	PRNP-48	0	0	0	0	1	3	0	0	0	**4**
250	28793	120-11-RM-Sub-1	0	0	0	1	1	1	2	0	0	**5**
355	AGANNI		0	0	0	3	1	0	0	0	0	**4**
358	PTB 33		2	0	1	0	0	0	0	0	0	**3**

Data from JDP, WGL, PNT,GGV,CBT for BPH; PNT, CBT,WGL for WBPH; MNC,JDP,RGL,CBT for GM; WGL,CBT ,RGL, RNR, JDP, RPR,SKL,GNV, MSD, LDN ,NWG for SBDH; CHP,GNV,RNR, SKL, WGL, for SBWE; CBT,WGL , RPR,GNV, MSD, JDP, RGL for LF; JDP for GLH; CBT for WM; RPR for CW - not considered for analysis due to low pest pressure.

Table 2.8 Performance of most promising cultures against insect pests in NSN2, *kharif* 2019

Entry No.	IET No.	No. of promising tests (NPT)									Overall NPT
		BPH	WBPH	PH	GM	SBDH	SBWE	LF	WM	RH	
		3	1	1	2	4	5	3	3	1	**23**
351	28512	0	0	1	0	1	2	0	0	0	**4**
604	28071	1	0	1	0	0	2	0	0	0	**4**
10	28331	1	0	0	0	1	1	0	0	0	**3**
13	28334	0	0	0	2	0	1	0	0	0	**3**
350	28511	0	0	1	0	1	1	0	0	0	**3**
357	28517	0	0	0	1	0	2	0	0	0	**3**
	Checks										
674	AGANNI	0	0	0	2	1	0	0	0	0	**3**
677	PTB 33	2	0	0	0	1	1	0	0	0	**4**
679	RP 2068-18-3-5	2	0	0	1	0	0	0	0	0	**3**

Data from JDP, PNT, CBT for BPH; JDP for GLH;CBT,PNT for WBPH; CBT,JDP,MNC for GM; CBT,JDP,NVS,GGT,GNV, for SBDH;CBT, GGT for SBWE;CBT,NVS for LF; CBT for WM not considered for analysis due to insufficient pest pressure.

Table 2.9 Performance of the most promising hybrids against insect pests in NHSN, *Kharif* 2019

Entry No	IET No.	No.of promising tests								Overall NPT
		BPH	WBPH	PH@	GM NPT	SBDH	SBWE	LF	WM	
		3	1	1	2	2	8	4	1	**22**
19	28125	0	0	0	1	0	2	0	0	**3**
88	JKRH-3333 (NCH-1)	0	0	0	1	0	2	0	0	**3**
100	CH 45	0	0	0	0	0	2	0	1	**3**
109	Abhaya	0	0	0	1	0	2	0	0	**3**
113	PTB 33	1	0	0	0	0	2	0	0	**3**
115	RP 2068-18-3-5	1	0	1	1	0	1	0	0	**4**

@-Mixed population of planthoppers

Data from PNT for BPH& WBPH; CBT for GM; GGT, LDN, NWG, RNR, RPR for SBDH; CHN for SBWE; RPR,GGT for LF; PTB and RNR for WM;RPR for CW; not considered for analysis due to low pest pressure

2.2. INSECT BIOTYPE STUDIES

Variation in the response of host plant/ gene differentials to different pest populations in endemic areas are monitored for two major pests viz., planthoppers and gall midge through Insect biotype studies comprising of three trials 1) Gall midge biotype monitoring trial (GMBT), 2) Gall midge population monitoring (GMPM) trial and 3) Planthopper screening trial (PHSS). The results of the observed virulence pattern of gall midge populations during *kharif* 2019 are discussed below:

a) Gall midge biotype monitoring trial (GMBT)

Gall midge biotype trial was constituted with a set of 15 gene differentials categorized into 5 groups and two gene pyramided lines and carried out at 13 locations. The results of the evaluation from the valid data of 9 locations in 10 tests are summarized in **(Table 2.10)** and discussed as under.

Biotype 1: This biotype is characterized by the reaction pattern R-R-R-R-S. The populations at IIRR, Chiplima and Ambikapur (near Raipur) were grouped under this category. All differentials showed susceptibility except Kavya, W1263 (*Gm1*); Aganni, INRC 15888, and RP5925 (*Gm8*) which had <10 % plant damage at all the three locations tested. Variation in the reaction of the other donors was observed

Biotype 3: The reaction of the gall midge populations at Ranchi conformed to the typical pattern of R-S-R-R-S for biotype 3 except for susceptibility of RP 2068-18-3-5 and Phalguna, ARC 5984. At Jagtial, only differentials with *Gm8* gene (Aganni, INRC 3021 and RP5925) were promising.

Biotype 4: Gall midge populations from Sakoli were designated as biotype 4 from earlier studies. But this year only Aganni and INRC 3021 (both with *Gm8*) showed promise, while Kavya, W1263 and RP5925 recorded 0-5 % DP at this location.

Biotype 4M: Aganni (with *Gm8*) and INRC 3021(with *Gm8*) exhibited nil damage whereas RP5925 had 15% DP when evaluated at Warangal. But in farmer's field 30 km from research farm, Aganni recorded 5 % DP, while INRC 3021 showed no damage.

Biotype5: At Pattambi, this year the infestation level was so high that all the donors exhibited susceptibility, though W1263 (with*Gm1*) recorded lowest damage of 23.8 % DP. At Moncompu, both Kavya and W1263 with *Gm1* gene had nil damage.

Evaluation of the gene differentials in one greenhouse and 9 field tests against 5 different biotypes identified Aganni (Gm8) as promising in 8 of the 10 valid tests. INRC 3021(Gm8), RP5925 (Gm8), W1263 (Gm1) and Kavya were promising in 5 of the valid 10 tests. The results suggest that Gm8 and Gm1 hold promise across locations.

Table 2.10 Reaction of gene differentials to gall midge populations in GMBT, *kharif* 2019

Group	Entry No.	Differential	Gene	GMB1			GMB3		GMB 4	GMB 4M	GMB 4M $	GMB 5		Overall NPT
				IIRR	CHP	ABP (RPR)	JGT	RCI	SKL	WGL1	WGL2	PTB	MNC	
				GH	50DT	60DT	50DT	50DT	50DT	54DT	59DT	50DT	50DT	
				%DP	%DP	%DP	%DP	%DP	%DP	%DP	%DP	%DP	%DP	10
I	1	KAVYA	*Gm 1*	0	10	0	35	0	0	65	85	47.6	0	5
	2	W 1263	*Gm 1*	0	0	0	20	0	5	65	100	23.8	0	5
	3	ARC 6605	*(?)*	0	60	60	95	0	95	80	75	100	20	2
II	4	PHALGUNA	*Gm 2*	5.9	80	50	100	30	100	85	89.5	100	26.7	0
	5	ARC 5984	*Gm 5*	15.4	50	60	75	40	100	75	95	100	26.7	0
	6	DUKONG 1	*Gm 6*	0	50	50	95	0	100	85	95	100	33.3	2
	7	RP 2333-156-8	*Gm 7*	0	50	70	70	40	95	70	95	100	26.7	1
	8	MADHURI L 9	*Gm 9*	0	20	30	30	0	63.2	95	80	90.5	26.7	2
	9	BG 380-2	*Gm10*	27.3	50	100	90	0	100	90	95	100	33.3	1
III	10	MR 1523	*Gm11*	0	60	0	10	0	95	55	77.8	100	33.3	3
IV	11	RP 2068-18-3-5	*gm 3*	0	40	20	45	30	45	30	47.4	100	6.7	1
	12	ABHAYA	*Gm 4*	0	50	30	35	0	85	45	80	100	40	2
	13	INRC 3021	*Gm 8*	16.7	20	20	0	0	0	0	5	100	20	5
	14	AGANNI	*Gm 8*	0	0	5	0	0	0	0	0	100	26.7	8
	15	INRC 15888	*Gm 8*	0	10	10	30	20	30	60	100	100	13.3	3
	16	B 95-1	*none*	100	40	80	100	35	100	95	100	100	46.7	0
V	17	TN1	*none*	100	70	100	95	60	100	90	100	100	33.3	0
	18	RP 5925	*Gm 8*	0	0	0	0	30	5	15	30	100	26.7	5
	19	RP 5921	*Gm 1*	P.D.I	0	50	70	35	75	NP	100	100	20	1
	20	S. Check	*none*	100	40	90	100	50	100	95	100	100	26.7	0
Total Tested				20	20	20	20	20	20	20	20	20	20	
Ave.damage in the trial				19.2	35	41.3	54.8	18.5	64.7	62.9	77.5	93.1	24.3	
Average damage in S. checks				100	50	90	98.3	48.3	100	93.3	100	100	35.6	
Promising level				0	10	10	0	0	10	0	10	0	0	
No. promising				12	6	6	3	10	5	2	2	0	2	

* NP-no plants, $- farmers field Pest incidence was low at JDP, MND,MTU and RGL. Data not received from Cuttack and Nellore

b) Gall midge population monitoring (GMPM)

The virulence pattern of the gall midge populations is monitored through progeny testing of a single gall midge female in GMPM trial. This year the trial was conducted on three differentials, W1263 (*Gm1*), RP2068-18-3-5 (*gm3*) and Aganni (*Gm8*) along with Purple variety at Warangal, Pattambi and Jagtial. The differentials were grown in a single pot with 5-10 seedlings each and labeled appropriately. Each pot was infested with a single mated female collected from light source and covered by a plastic bag placed tightly over the pot. The pots were observed for the gall development and emergence of insects from the gall. Number and sex of the emerging adults was also recorded from each pot. Based on these observations, virulence status was assigned to the parent insect. The results of this year's trial are summarized in **(Table 2. 11)** and discussed below.

Pattambi: Of the 128 females tested,91 females were virulent. Of these, 68% were virulent on purple, 39.1% % on W1263, 17.97% on RP 2068-18-3-5 and 71.1% on Aganni but the damage was low (only12.9%SS) on W1263.The sex ratio was highly favourable on all the lines and 1M:1.1F on W 1263. This corroborates with the low damage observed in W1263 *(Gm1)* in the other gall midge trials at this location

Warangal: At this location, 250 females were tested, however, the number of infested pots as well as galls were low. Aganni showed the lowest incidence followed by RP 2068-18-3-5 and sex ratio was also in favour of males in Aganni.

Jagtial: Hundred females were tested and Aganni showed nil virulence and damage. The percent virulence was 36% was on purple variety, 20% on W1263 and28% on RP 2068-18-3-5, while. the percent male progeny varied from 30.0 to38.9 %.

Evaluation of the gene differentials through single female progeny testing revealed that populations at Jagtial and Warangal were less virulent on Aganni (Gm8) as compared to populations at Pattambi whereas there was increase in virulence on RP 2068-18-3-5 (gm3).This is a matter of concern as this trend has also been evident in GMBT trial in the past few years.

Table 2.11 Virulence composition of gall midge populations in GMPM, *kharif* 2019

	Locations											
Parameters	Pattambi				Warangal				Jagtial			
No of females tested	128				250				100			
	AGA-NNI	RP 2068-18-3-5	W 1263	PUR-PLE	AGA-NNI	RP 2068-18-3-5	W 1263	PUR-PLE	AGA-NNI	RP 2068-18-3-5	W 1263	PUR-PLE
Pots with Infes-ted plants	91	50	33	87	1	5	14	24	0	28	20	36
% of virulent females	71.1	39.1	17.97	68	0.4	2	5.6	9.6	0	28	20	36
No of plants damaged	287	259	51	337	6	25	50	89	0	188	154	170
% DP	84.4	73.6	17.8	99.4	0.4	2.13	6	8.23	0	27.4	13	21.2
SS(%)	60	63.1	12.9	56.6	0.17	28	36	35.96	0	14.9	13	21.2
Sex rtaio (M:F)	1:4.1	1:3.4	1:1.1	1:1.25	1:0	1:1.5	1:5	1:0.78	0	1:1.8	1:2.33	1:1.6
% male progeny	19.7	15.9	47.4	28.3	100	40	16.7	56.3	0	35.7	30	38.9

No data was received from Ragolu,Sakoli and Moncompu

C. Planthopper Special Screening Trial (PHSS)

A set of 16 primary sources of BPH resistance with some sources having known resistance gene(s) was evaluated at eleven locations viz., IIRR, Aduthurai, Coimbatore, Gangavathi, Ludhiana, Mandya, Maruteru, New Delhi, Pantnagar, Rajendranagar and Warangal in the greenhouse in standard seedbox screening test (SSST) with 2 to 3 replications. The special screening tests such as days to wilt to know the tolerance mechanism,

feeding preference test by measuring honeydew excretion, nymphal survival and egg hatching tests were conducted at Pantnagar.

Based on SSST results presented in **(Table 2.12)** showed that two gene differentials *viz.*, PTB 33 (with *bph2+Bph3*+unknown factors) was promising at 8 locations and RP 2068-18-3-5 (with *Bph33(t)* gene) was promising in 9 out of 11 locations. T12 (with *bph7* gene) performed better at 4 centres, while Rathu Heenati (with *Bph3+Bph17* genes), Swarnalatha with *Bph 6* gene and Babawee with *bph 4* gene performed consistently at 3 centres, each. Three other gene differentials *viz.*, ASD 7 with *bph2,* Chinsaba with *bph 8* gene and IR 65482-7-216-1-2-B with *Bph 18* gene showed low damage at two locations only. Four differentials *viz.*, IR 64 (with Bph1 gene +), IR 36 with (bph2 gene) at, MUT NS 1 with unknown genetics and Pokkali with bph9 gene, performed better at one location. Three gene differentials *viz.*, IR71033-121-15 with Bph 20/21 gene, Milyang 63 and OM 4498 with unknown genetics showed susceptible reaction at all the test locations.

Except for PTB 33 (DS 4.3), none of the above differentials showed promise against WBPH when evaluated at CBT.

At Pantnagar, lowest nymphal survival was observed in RP 2068-18-3-5 followed by Babawee and highest nymphal survival was *observed* in IR 36. RP 2068-18-3-5 did not wilt. Honeydew excretion was lowest in RP 2068-18-3-5 followed by Rathu Heenati and Babawee. RP 2068-18-3-5 showed superiority in all the three tests compared to other donors.

Among the 16 gene differentials evaluated, two differentials viz., PTB 33 (with bph2+Bph3+unknown factors) was promising at 8 locations and RP 2068-18-3-5 (with Bph33(t) gene) was promising in 9 out of 11 locations. T12 (with bph7 gene) performed better at 4 centres, while Rathu Heenati (with Bph3+Bph17 genes), Swarnalatha with Bph 6 gene and Babawee with bph 4 gene performed consistently at 3 centres, each. Three other gene differentials viz., ASD 7 with bph2, Chinsaba with bph 8 gene and IR 65482-7-216-1-2-B with Bph 18 gene showed low damage at two locations only. Except for PTB 33 (DS 4.3), none of the above differentials showed promise against WBPH. RP 2068-18-3-5 showed superiority through low honeydew excretion, nymphal survival and egg hatching in tests conducted at Pantnagar.

Table: 2.12 Reaction of most promising gene differentials against BPH in PHSS, kharif 2019

Entry No.	Designation	Gene	Reaction of Differentials (DS)											
			IIRR	ADT	CBT BPH	GNV	LDN	MND	MTU	NDL	PNT	RNR	WGL	NPT (11)
1	ASD 7 (ACC 6303)	*bph2*	9.0	8.6	6.5	3.0	6.9	9.0	1.0	7.3	8.4	9.0	8.8	2
2	Babawee (ACC 8978)	*bph4*	9.0	8.4	7.3	1.0	6.2	7.0	3.0	6.8	2.1	9.0	6.2	3
3	Chinsaba (ACC 33016)	*bph8*	9.0	8.6	6.4	3.0	6.7	9.0	3.0	7.3	9.0	7.3	8.1	2
7	IR 65482-7-216-1-2-B	*Bph18*	7.3	8.8	7.1	1.0	5.8	7.0	7.0	7.0	3.5	5.7	8.2	2
14	Ptb33	*bph2*+ *Bph3*+	1.4	???	4.3	3.0	2.0	NG	9.0	5.0	NG	3.3	3.3	8
16	Rathu Heenati (ACC 11730)	*Bph3*+ *Bph17*	8.4	7.7	7.6	3.0	4.9	5.0	7.0	6.6	5.1	6.8	8.2	3
17	RP 2068-18-3-5	*Bpt33*	1.1	1.0	7.8	3.0	2.1	3.0	1.0	4.0	1.2	5.9	1.9	9
18	Swarnalatha (ACC 33964)	*Bph6*	8.5	3.0	7.1	9.0	5.5	7.0	3.0	7.7	5.6	4.7	6.0	3
19	T 12 (ACC 56989)	*bph7*	8.5	3.5	7.5	9.0	4.4	7.0	1.0	4.8	8.8	8.1	5.3	4

2.2. CHEMICAL CONTROL STUDIES

Insecticide-Botanicals Evaluation Trial (IBET)

Use of plant extracts or botanicals is one of the earliest and traditional practices in control of insect pests of crops. Botanicals can play a key role in management of rice pests as they are environment-friendly, safe to non-target organisms, renewable and cost effective. Integration of botanicals in rice IPM will reduce pesticide load in environment, prevent insecticide resistance and help in conserving natural enemy populations. Earlier efforts under AICRIP were mainly focussed on evaluation of efficacy of various commercial botanical formulations *vis–a–vis* insecticides against insect pests. Hence, it was felt necessary to test combination of insecticide and botanical modules against major pests of rice in order to identify the effective combination and strategically integrate use of botanicals for ideal rice IPM. So, a trial consisting of various treatments having combinations of effective and commercially available oils with recommended insecticides was initiated last year during *kharif* 2019 to evaluate their performance against major insect pests at 28 locations.

Sl. No.	Location	Date of sowing	Date of planting	Date of harvesting	No of applications	Times of application (DAT)
1	Arundhutinagar	-	-	-	1	45
2	Bapatla	13-08-2019	04-09-2019	04-01-2020	3	60, 70 & 91
3	Coimbatore	03-06-2019	24-06-2019	17-10-2019	3	32, 51 & 67
4	Chiplima	28-06-2019	24-07-2019	23-11-2019	3	25, 50 & 65
5	Chinsurah	26-06-2019	17-07-2019	05-11-2019	3	15, 30 & 50
6.	Cuttack	04-07-2019	04-08-2019	30-11-2019	3	25, 50 & 65
7.	Gangavathi	26-07-2019	12-09.2019	16-01-2020	3	24, 48 & 61
8	Jagdalpur	26-06.2019	06-08-2019	10-12-2019	3	33, 53 & 73
9	Khudwani	16-05-2019	13-06-2019	11-10-2019	3	30, 50 & 65
10	Karjat	13-06-2019	07-07-2019	11-11-2019	2	31 & 51
11	Karaikal	08-08-2019	04-09-2019	17-12-2019	3	36, 51 & 70
12	Ludhiana	24-05-2019	24-06-2019	30-10-2019	3	42, 57 & 78
13	Malan	23-06-2019	19-07-2019	07-11-2019	3	36, 42 & 57
14	Mandya	14-08-2019	11-09-2019	06-01-2020	3	31, 50 & 65
15	Masodha	12-06-2019	10-07-2019	15-10-2019	2	29, 46 & 64
16	Maruteru	06-07-2019	06-08-2019	23-11-2019	3	32, 52 & 69
17	Navsari	03-07-2019	05-08-2019	02-12-2019	4	20, 30, 50 & 60
18	Nawagam	18-07-2019	16-08-2019	25-11-2019	3	26, 40 & 60
19	New Delhi	27-06-2019	22-07-2019	18-11-2019	5	35, 57, 66, 71 & 78
20	Pattambi	07-07-2019	26-07-2019	18-11-2019	3	15,45 & 75
21	Pusa	23.06.2019	18-07-2019	22-11-2019	3	24, 44 & 59
22	Raipur	10-07-2019	16-08-2019	02-12-2019	3	45, 59 & 81
23	Ragolu	30-07-2019	30-08-2019	11-12-2019	2	28 & 51
24	Rajendranagar	05-07-2019	04-08-2019	28-11-2019	4	27, 34, 53 & 70
25	Ranchi	09-07-2019	30-07-2019	04-11-2019	3	30, 50 & 65
26	Sakoli	27-06-2019	24-07-2019	20-11-2019	3	17,35 & 58
27	Warangal	20-06-2019	18-07-2019	01-12-2019	2	33. 60 & 74
28	Titabar	09-07-2019	10-08-2019	10-12-2019	1	21

Treatments:

Four combination modules/treatments consisting of three insecticides- Chlorantraniliprole 20% SC, Cartap hydrochloride 50% SC and Triflumezopyrim 10% SC, one commercial neem formulation - Neemazal and two oils - Neem and Eucalyptus oil procured from local market, Hyderabad (Telangana) were compared along with untreated control (only water spray). There were five treatments **(Table 2.13)** replicated four times and laid out in Randomized Complete Block Design (RCBD). Spray applications of the treatments were done based on pest incidence exceeding the economic threshold level guidelines at 10-15 days interval. All the treatments were applied as high-volume sprays @ 500 litres of spray fluid/ha.

Standard observation procedures were followed to record insect pest incidence at regular intervals throughout the crop growth period. To assess stem borer and gall midge damage, observations were recorded on total tillers (TT), dead hearts (DH) and silver shoots (SS) at 30 and 50 DAT, while stem borer damage at heading stage was expressed as per cent white ears based on counts of panicle bearing tillers (PBT) and white ear heads (WE). In case of sucking pests such as brown planthopper (BPH), white backed planthopper (WBPH), green leafhopper (GLH) and natural enemies, number of insects were recorded on 10 randomly selected hills. The damage due to foliage feeders such as leaf folder, whorl maggot, hispa, blue beetle etc., was assessed based on counts of damaged leaves/10 hills. At the time of harvest, the grain yield from net plot leaving 2 border rows on all sides was collected and expressed as kg/ha.

ANOVA test for Random Complete Block Design (RCBD) was applied to analyse data collected for each date of application at each location as well as for yield at harvest to assess the performance of the different treatments. The comparative efficacy of the treatments was worked out based on efficacy at each DAT and pooled means of the pest damages across observations and over locations. Pooled yield data analysis was carried out to assess the impact of each treatment on yield.

Results

Pest Infestation (Table 2.13)

Stem borer infestation was observed in 20 locations and damage during vegetative stage ranged from 0.8 to 13.0% dead hearts (DH) in all insecticide treatments and 1.1 to19.5% in other combination treatments compared to 1.5 to 32.8% in untreated control, during 30 to 77 DAT. There were significant differences in dead heart damage among the treatments at 12 locations. All insecticides treatment module recorded the lowest mean damage of 3.7% when compared to 10.5% in untreated control. Among other treatments, neemazal, eucalyptus oil and cartap hydrochloride combination showed lowest mean infestation of 5.4% DH. White ears (WE) damage at heading stage in various treatments ranged from 0.5 to 59.3% compared to 1.3 to 79.4% in control across 23 centres. There were significant differences among treatments in white ear damage at 14 locations. Highest white ear damage was reported from Arundhatinagar which ranged from 34.1 to

59.3% while Ragolu reported the lowest (0.7-1.5%) in treatments compared to a maximum of 79.4% in untreated control. Mean WE infestation ranged from 5.9 to10.6% in treatments as compared to 17.0% in control. Among modules, all insecticides module was found to be the best with 5.9% mean white ear damage followed by neemazal, eucalyptus oil and cartap hydrochloride module with 7.6% WE.

Overall, all insecticides module was found to be superior in reducing stem borer damage compared to other insecticide-botanical modules and was the most effective treatment at both vegetative and reproductive phases.

Gall midge occurrence was reported from 7 centres of which Chiplima recorded highest damage ranging from 8.1to 16.7% SS across treatments and 22.4 to 23.9% SS in control at 56 and 75 DAT. At other locations, the SS damage varied from 0.8 to 14.2% in treatments and 1.1 to 19.7% in control. There were significant differences in the efficacy among the treatments at Chiplima, Ranchi and Titabar. Lowest mean infestation was recorded in Neem formulations and triflumezopyrim combination (5.8%) on par with all insecticides treatment (6.2%) and significantly superior to control 12.0%).

Brown planthopper incidence was very high at Maruteru (129.5-232.8 hoppers/10hills) at 50 DAT followed by New Delhi with population of 30.0 to 129.3 hoppers/10 hills at 90 DAT. Across 11 locations, all insecticides treatment was found to be the most effective one (31.2 hoppers/10 hills) followed by insecticide-botanical treatments in reducing BPH populations (31.4-38.8 hoppers/10 hills) and they were significantly superior to control (48.2 hoppers/10 hills).

White backed planthopper populations were observed at 11 locations and Gangavathi recorded the highest populations ranging from 163.3 to 194.3 hoppers/10 hills across the treatments at 55 DAT followed by Nawagam centre (57.5-173.5 hoppers/10 hills). Treatment consisting of all insecticides was the most effective in reducing WBPH populations (27.5 hoppers/10 hills). Botanical-insecticide combination treatments also showed significant efficacy against the hoppers (34.0 to 35.4 hoppers/10 hills) compared to that of control (49.6 hoppers/10 hills).

Green leafhopper incidence was high at Masodha (23.8-248.5 hoppers/10 hills) among the 10 centres. All insecticides combination was the most effective treatment showing population of 13.5 hoppers/10 hills and superior to control (33.9 hoppers/10 hills).There were significant differences in hopper populations among the treatments at 6locations as well as in populations recorded at 92 and 98 DAT at Bapatla, 30 and 50 DAT at Jagdalpur, 63 and 83 DAT at Navsari and 50 DAT at Ragolu. All the treatments showed significant efficacy (13.5-22.8 hoppers/10hills) when compared to control (33.9).

Leaf folder damage was recorded from 19 locations and highest leaf damage was recorded in Ranchi centre (17.0-59.3%) during 63 to 67 DAT followed by

Malan with 25.6 to 56.5% at 79 DAT. There were significant differences in leaf damage among the treatments at 13 locations. All insecticides module was the most effective treatment showing mean leaf damage of 4.9% DL followed by treatment with neem formulations and triflumezopyrim (6.6% DL) when compared to other treatments and untreated control (11.4% DL). All botanicals combination treatment also significantly reduced leaf folder damage (7.6% DL) when compared to control.

Whorl maggot infestation was recorded at 8 centres and higher foliage damage was noticed in New Delhi ranging from 11.6-17.5% in treatments followed by Jagdalpur (12.1-14.8%) compared to highest damage in control (24.4%) observed at Titabar . The lowest mean damage was recorded in insecticides treatment (5.1% DL). A damage range of 5.6-7.4% DL was recorded in botanical treatments compared to control (9.0% DL).

Hispa damage was recorded at 4 centres *viz.*, Malan, Maruteru, Ranchi and Ragolu. Highest damage of 47.8 to 92.1% DL was observed in Malan at 77 DAT followed by Ranchi (14.5-65.3% DL at 25 and 33 DAT). Treatment consisting of all insecticides was the most effective one with 26.1% mean leaf damage. Other treatments were also found effective showing 29.2 to 30.7% leaf damage compared to 44.6% in control.

Grasshopper infestation was reported only from Khudwani centre during 30 to 77 DAT with damage range of 0.2 to 8.2% in treatments and 2.0 to 9.9% DL in control. All insecticides module recorded the lowest mean damage of 3.2% compared to 4.9% DL in control.

Natural enemies: The populations of **mirid bug**, an important natural enemy of BPH, were recorded in 7 centres. High populations of 6.8 to 45.0 mirid bugs/10 hills were observed in Gangavathi, followed by Maruteru with 17.8 to 38.0 bugs/10 hills in treatments as against 25.5 to 49.0 bugs/10 hills in control. There were no significant differences in mirid populations among treatments at Bapatla (except at 92 DAT) and Sakoli . Low mean population of mirid bugs was recorded in all insecticides treatment (12.9/10 hills) indicating that the adverse effect of insecticide on predators. Botanical combination treatments showed relatively higher mirid populations (17.8/10 hills) at par with control (19.7 bugs/10 hills) signifying that botanicals are relatively safe to mirid bug. **Spider** populations were recorded in 8 locations, of which Gangavathi reported more spider numbers (14.0-37.3/10hills) during 40 to 100 DAT followed by New Delhi (27.0-31.8/10 hills at 100 DAT) and Maruteru (20.8-28.8/10 hills at 50 DAT). Mean spider population in botanical treatments ranged from 13.2 to15.1/10 hills as compared to 16.3 in control indicating the relative safety of these treatments to spiders. Comparatively lower spider numbers were recorded in all insecticide treatment (12.1/10 hills). **Coccinellid** populations were reported from 3 centres-Bapatla, Sakoli and Warangal. There were no significant differences in populations among the treatments and control across centres. However, the lowest mean numbers 3.58 per10 hills were recorded in botanicals and cartap hydrochloride treatment compared to 4.54 per 10 hills in control.

Grain Yield (Table 2.14):
There were significant differences in grain yield among the treatments including control at all locations except Bapatla, Chatha, Gangavati, Karaikal and New Delhi. Based on mean yield of these locations, all insecticides- Chlorantraniliprole, Cartap hydrochloride, Triflumezopyrim treatment recorded the highest grain yield of 4781.2 kg/ha with 32.3% increase over control (IOC) followed by neemazal, neem oil and triflumezopyrim with 4393.0 kg/ha (21.6% IOC). All the treatments were significantly superior to control plot which showed an yield of 3613.0 kg/ha.

Insecticide Botanicals Evaluation Trial (IBET) was carried out at 28 locations across the country to evaluate performance of various treatments having combinations of commercially available neem formulation, effective plant oils along with recommended insecticides against major insect pests of rice and consequent impact on natural enemies and grain yield during kharif, 2019. Based on the performance of the various treatment combinations in controlling the pest damage at various locations, all insecticides module was found to be superior in reducing stem borer damage compared to other insecticide-botanical modules and was the most effective treatment at both vegetative and reproductive phases. Lowest silver shoot damage was recorded in neem formulations and triflumezopyrim module on par with all insecticides treatment. All insecticides combination was found to be the most effective treatment against plant and leafhoppers. Against leaf folder also insecticides module was effective in reducing leaf damage. Insecticide and botanical combination treatments were found moderately effective in reducing damage by hispa, whorl maggot and grasshopper pests. Botanical combination treatments however showed relatively higher natural enemy (mirid, spider and coccinellid) populations compared to all insecticides treatment signifying that botanicals are relatively safe to predators. Among various treatments, all insecticides treatment recorded highest yield of 4781.2 kg/ha with 32.3% increase over control followed by treatment with applications of neemazal, neem oil and triflumezopyrim showing yield of 4393.0 kg/ha (21.6% IOC). All the treatments were superior to untreated control.

Table: 2. 13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

Sl. No.	Treatment details	Stem borer damage (% Dead Hearts)															
		ARD		CBT		CHN		CHP		CTC		GNV	JDP				
		30DT	50DT	30DT	50DT	30DT	50DT	56DT	75DT	30DT	60DT	50DT	30DT	30DT	50DT	50DT	70DT	70DT
1	Botanical-Insecticide 1	1.7b	5.2b	9.0a	4.4a	10.2b	7.6c	2.3c	2.0c	4.0bc	3.2c	3.0a	5.1a	2.7bc	2.8a	1.5b	1.8ab	1.5b
2	Botanical-Insecticide 2	1.4b	4.8b	9.2a	4.2a	11.5b	9.3bc	3.5b	3.2b	4.3b	3.8c	2.0b	3.2a	2.2bc	5.0a	1.8ab	1.2b	1.2b
3	All Botanical	2.2ab	5.9ab	10.9a	4.9a	11.8b	10.7b	3.0bc	3.5b	6.4a	5.9b	3.4a	3.7a	5.3ab	2.3a	1.5b	1.5ab	1.5b
4	All Insecticide	2.3ab	7.0ab	8.9a	3.2a	5.5c	3.7d	1.9c	1.5c	3.2c	2.2d	1.5b	1.6a	1.6c	2.0a	1.1b	1.0b	1.0b
5	Control (Water Spray)	3.0a	9.1a	12.0a	6.6a	18.5a	16.6a	5.7a	7.0a	7.4a	8.1a	3.7a	6.1a	6.9a	4.1a	3.4a	2.2a	3.7a

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

Sl. No.	Treatment details	Stem borer Damage (%Dead Hearts)															
		KJT		KRK		LDN							MND		MSD		NVS	
		30DT	50DT	30DT	50DT	41DT	45DT	50DT	56DT	61DT	66DT	71DT	30DT	50DT	30DT	50DT	30DT	50DT
1	Botanical-Insecticide 1	19.5a	12.3a	7.3a	1.9a	4.2a	2.9b	2.9b	3.0b	2.8b	1.9bc	2.0c	3.8b	6.4bc	8.9c	8.5c	9.4c	12.5c
2	Botanical-Insecticide 2	15.6a	9.4ab	7.2a	1.4a	4.2a	2.9b	2.9b	2.9b	2.8b	2.8b	3.0b	3.6b	9.2ab	3.9d	3.6d	11.1bc	14.5b
3	All Botanical	17.5a	7.9d	10.3a	2.7a	4.2a	2.8b	2.9b	3.1b	2.9b	2.7b	3.0b	2.2b	5.0bc	16.6b	13.9b	13.1b	15.0b
4	All Insecticide	13.0a	7.7b	9.4a	1.9a	4.1a	1.5c	1.6b	1.5c	1.5c	1.8c	1.9c	1.3b	1.7c	1.7d	0.8d	8.7c	10.8c
5	Control (Water Spray)	11.8a	12.8a	6.4a	3.3a	4.2a	4.6a	5.6a	6.1a	7.1a	7.9a	7.9a	9.1a	12.7a	29.4a	26.3a	20.8a	22.5a

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

S. No.	Treatment details	Stem borer Damage (% Dead hearts)														Mean
		NWG		PUS		RCI		RPR		SKL		TTB		WGL		
		30DT	50DT	30DT	50DT	30DT	50DT	30DT	50DT	65DT	80DT	30DT	50DT	75DT	77DT	
1	Botanical-Insecticide 1	2.6a	5.2c	10.1b	12.2bc	6.7b	5.0b	14.0b	12.3b	2.3a	1.8c	4.7d	5.5d	1.1a	1.4a	**5.4**
2	Botanical-Insecticide 2	2.1a	8.4b	10.0b	10.5c	7.4b	3.8c	14.3b	12.3b	2.0a	2.7bc	7.4c	8.5c	1.2a	1.7a	**5.5**
3	All Botanical	2.1a	10.2b	11.2b	13.2d	6.6b	5.1b	13.9b	12.4b	2.0a	4.4ab	17.7b	15.6b	1.2a	2.3a	**6.8**
4	All Insecticide	2.1a	2.8d	5.8c	3.9d	4.5c	2.0d	12.1b	12.0b	2.4a	3.3abc	3.1d	2.6e	1.1a	1.1a	**3.7**
5	Control (Water Spray)	2.8a	13.2a	16.1a	18.3a	11.7a	13.6a	18.4a	17.4a	2.0a	5.1a	32.8a	27.9a	1.5a	2.8a	**10.5**

Botanical-Insecticide 1:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT), Cartap hydrochloride 50% SC 2g/l (60-65 DAT)
Botanical-Insecticide 2:	Neemazal 1% EC 2ml/l (25-30 DAT), Neemoil 10 ml/l (45-50 DAT), Triflumezopyrim 10% SC 0.48ml/l (60-60 DAT)
All Botanical:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT) , Neem oil 10ml/l (60-65 DAT)
All Insecticide:	Chlorantraniliprole 20% SC 0.2ml/l (25-30 DAT), Cartap hydrochloride 50% SC 2g/l (50-55 DAT),Triflumezopyrim 10% SC 0.48ml/l (65-70 DAT)

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

Sl. No.	Treatment details	Stem borer Damage (% White Ears)											
		ARD	CBT	CHN	CHP	CTC	GVT	KJT	KRK	LDN	MND	MSD	MTU
		Pre-harvest											
1	Botanical-Insecticide 1	34.1c	17.8a	7.3c	3.2c	4.4d	2.8b	4.4b	1.1a	2.5c	2.8d	6.1c	9.0a
2	Botanical-Insecticide 2	59.3ab	17.3a	13.2b	5.2b	7.0c	2.3bc	1.9cd	1.8a	3.5b	6.5c	3.0d	7.9ab
3	All Botanical	47.2bc	17.7a	9.6bc	5.0b	10.9b	3.1ab	4.0bc	1.6a	3.5b	9.6b	9.8b	8.4a
4	All Insecticide	44.4bc	16.0a	7.5c	2.2c	2.6d	1.6c	1.5d	1.8a	2.1c	2.0d	1.0d	4.6b
5	Control (Water Spray)	79.4a	18.9a	9.6a	7.8a	13.7a	4.2a	15.0a	1.3a	8.7a	15.2a	29.6a	6.8ab

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

Sl. No.	Treatment details	Stem borer Damage (% White Ears)											Mean
		NDL	NVS	NWG	PUS	RCI	RGL	RNR	RPR	SKL	TTB	WGL	
		Pre-harvest											
1	Botanical-Insecticide 1	1.6b	7.0cd	23.1d	10.4c	4.0c	0.8b	0.9c	18.7bc	6.5a	3.9d	1.1a	7.6
2	Botanical-Insecticide 2	2.9a	9.2bc	32.3c	8.3d	5.0c	1.1b	2.4b	19.6b	6.5a	6.2c	2.3a	9.8
3	All Botanical	2.9a	10.6ab	41.2d	14.0b	7.1b	1.5b	1.4bc	17.7bc	7.9a	13.2b	2.4a	10.9
4	All Insecticide	1.6b	4.8d	5.6e	3.1e	2.7d	0.7b	05c	16.5c	7.4a	4.0d	1.4a	5.9
5	Control (Water Spray)	2.8a	13.2a	51.6a	23.1a	10.4a	5.0a	6.2a	27.1a	9.1a	20.9a	2.4a	17.0

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

Sl. No.	Treatment details	Gall midge Damage (% Silver Shoots)											Mean
		CHP 56 DT	CHP 75 DT	KRK 50 DT	MTU 50 DT	RCI 30 DT	SKL 45 DT	SKL 65 DT	TTB 50 DT	WGL 70 DT	WGL 77 DT	WGL 93 DT	
1	Botanical-Insecticide1	15.6bc	14.2b	1.3a	1.3a	6.3b	9.7a	18.1a	5.5cd	1.6a	1.3a	0.9a	**6.9**
2	Botanical Insecticide 2	9.1d	8.1c	1.3a	2.6a	7.0b	8.4a	14.5a	8.6c	1.5a	1.8a	1.3a	**5.8**
3	All Botanical	13.7c	13.3b	0.8a	2.2a	6.7b	8.2a	15.2a	15.2b	1.0a	2.1a	1.1a	**7.2**
4	All Insecticide	16.7b	14.7b	1.8a	1.6a	3.1c	10.6a	14.2a	2.0d	1.0a	2.4a	1.0a	**6.2**
5	Control (Water Spray)	23.9a	22.4a	1.8a	1.6a	13.1a	12.6a	19.7a	31.2a	1.4a	2.7a	1.1a	**12.0**

Botanical-Insecticide 1:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT), Cartap hydrochloride 50% SC 2g/l (60-65 DAT)
Botanical-Insecticide 2:	Neemazal 1% EC 2ml/l (25-30 DAT), Neemoil 10 ml/l (45-50 DAT), Triflumezopyrim 10% SC 0.48ml/l (60-60 DAT)
All Botanical:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT) , Neem oil 10ml/l (60-65 DAT)
All Insecticide:	Chlorantraniliprole 20% SC 0.2ml/l (25-30 DAT), Cartap hydrochloride 50% SC 2g/l (50-55 DAT),Triflumezopyrim 10% SC 0.48ml/l (65-70 DAT)

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

Sl. No.	Treatment details	Brown Planthopper(No./10 hills)													
		BPT						GNV				LDN			MND
		55DT	63DT	92DT	98DT	115DT	122DT	40DT	60DT	80DT	100DT	60DT	70DT	75DT	65DT
1	Botanical-Insecticide 1	79.3a	43.8bc	16.8a	10.0a	7.0a	2.8cd	40.0b	39.5b	33.0c	28.0cd	1.8b	2.5bc	5.5c	10.8a
2	Botanical-Insecticide 2	87.0a	42.5c	20.3a	9.3a	7.3a	2.5d	40.5b	41.0b	37.0bc	30.5c	2.0b	2.0bc	2.3d	9.5a
3	All Botanical	87.7a	58.3bc	18.8a	9.3a	6.3a	3.5ab	42.5b	41.0b	41.3b	39.0b	2.0b	3.0b	7.0b	12.3a
4	All Insecticide	105.3a	61.5b	21.0a	7.8a	6.0a	3.3bc	37.0b	30.8c	25.0d	20.5d	1.5b	1.3c	1.5d	14.0a
5	Control (Water Spray)	105.3a	125.3a	19.8a	10.8a	7.3a	4.0a	49.0a	61.8a	70.3a	76.5a	4.0a	8.8a	12.8a	11.0a

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

Sl. No.	Treatment details	Brown Planthopper(No./10 hills)													
		MTU		NDL						NVS				RGL		
		30DT	50DT	50DT	60DT	70DT	80DT	90DT	100DT	60DT	63DT	80DT	83DT	30DT	50DT	75DT
1	Botanical-Insecticide 1	33.0a	232.8a	3.3a	12.0a	55.3ab	30.3bc	96.3a	77.8a	7.3a	6.5b	11.3a	9.0b	40.8b	55.5c	41.0b
2	Botanical-Insecticide 2	29.7a	131.5a	4.3a	17.0a	38.3b	11.8c	30.0b	62.0a	7.0a	4.5c	11.0a	6.3d	37.5b	59.3bc	42.5ab
3	All Botanical	37.5a	173.0a	6.5a	15.3a	87.0a	49.0ab	124.3a	90.8a	7.3a	4.8c	11.8a	7.5c	39.0b	62.3b	45.0ab
4	All Insecticide	34.3a	129.5a	4.0a	18.5a	74.3ab	21.5bc	35.8b	70.8a	7.0a	2.3d	11.5a	4.5e	32.5c	40.3d	40.8b
5	Control (Water Spray)	33.3a	224.8a	4.3a	17.3a	68.0ab	72.8a	129.3a	89.0a	7.0a	8.8a	11.5a	14.0a	48.3a	70.5a	49.3a

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

Sl. No.	Treatment details	Brown Planthopper (No./10hills)											Mean
		RPR			SKL				WGL				
		60DT	80DT	100DT	49DT	53DT	64DT	68DT	61DT	70DT	75DT	77DT	81DT	
1	Botanical-Insecticide 1	6.3b	48.3bc	23.8b	62.3a	31.0b	54.5a	39.8b	25.8ab	40.5ab	69.5a	29.8a	26.5ab	**36.34**
2	Botanical-Insecticide 2	5.0bc	47.8bc	23.3b	66.0a	26.8b	55.5a	42.8b	24.3ab	46.3a	81.0a	20.3a	24.5bc	**31.45**
3	All Botanical	5.0bc	50.5b	23.0b	60.8a	25.3b	62.5a	39.3b	24.5ab	41.3ab	65.0a	25.3a	33.3a	**38.76**
4	All Insecticide	4.3c	42.8c	22.5b	63.3a	25.0b	61.0a	43.8ab	21.3b	34.8b	61.3a	17.5a	17.8c	**31.18**
5	Control (Water Spray)	10.0a	70.3a	37.8a	67.3a	43.3a	62.0a	50.3a	29.8a	43.3a	80.5a	38.8a	29.8ab	**48.21**

Botanical-Insecticide 1:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT), Cartap hydrochloride 50% SC 2g/l (60-65 DAT)
Botanical-Insecticide 2:	Neemazal 1% EC 2ml/l (25-30 DAT), Neemoil 10 ml/l (45-50 DAT), Triflumezopyrim 10% SC 0.48ml/l (60-60 DAT)
All Botanical:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT) , Neem oil 10ml/l (60-65 DAT)
All Insecticide:	Chlorantraniliprole 20% SC 0.2ml/l (25-30 DAT), Cartap hydrochloride 50% SC 2g/l (50-55 DAT),Triflumezopyrim 10% SC 0.48ml/l (65-70 DAT)

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

S. No.	Treatment Details	Whitebacked Planthopper (No./10 hills)																
		BPT						GNV				LDN						
		55DT	63DT	92DT	98DT	115DT	122DT	40DT	60DT	80DT	100DT	50DT	55DT	60DT	70DT	75DT	85DT	90DT
1	Botanical-Insecticide 1	163.3a	67.5bc	29.5a	13.5a	4.3a	2.8a	142.3b	125.0b	104.0c	86.5c	17.5a	12.0b	12.3b	11.3b	12.0b	9.3b	10.0b
2	Botanical-Insecticide 2	171.8a	83.3b	20.3a	12.5a	4.5a	2.8a	142.5b	117.8b	77.0d	63.5d	18.3a	11.3b	11.5b	11.0b	12.5b	3.3c	4.5c
3	All Botanical	194.3a	64.8c	30.8a	14.3a	4.8a	2.5a	141.3b	135.3b	131.8b	107.0b	18.0a	12.0b	12.0b	11.0b	12.3b	10.3b	11.0b
4	All Insecticide	176.5a	67.8bc	20.5a	13.3a	5.5a	2.5a	120.0b	93.3c	47.0e	40.0e	17.8a	9.8b	10.8b	9.5b	9.8b	3.0c	3.8c
5	Control (Water Spray)	178.8a	136.8a	16.8a	14.8a	5.0a	2.0a	165.8a	168.3a	154.5a	138.0a	18.0a	23.0a	26.8a	34.3a	45.0a	51.0a	35.0a

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

S. No.	Treatment Details	Whitebacked Planthopper (No./10 hills)											
		MND	MTU	NDL				NVS			NWG		
		65DT	50DT	30DT	40DT	50DT	60DT	60DT	80DT	83DT	50DT	65DT	75DT
1	Botanical-Insecticide 1	9.3a	32.8a	3.8ab	15.5a	13.8b	13.3a	6.0a	10.8a	8.0b	101.5b	113.0b	21.0b
2	Botanical-Insecticide 2	7.8a	21.8a	2.5b	18.5a	18.0ab	16.3a	6.0a	10.8a	4.0d	117.0b	107.0b	15.0bc
3	All Botanical	11.5a	21.3a	3.0b	18.8a	15.0b	13.0a	6.3a	10.8a	6.5c	120.0b	96.0b	34.0a
4	All Insecticide	8.3a	17.5a	5.5ab	16.0a	27.8a	11.5a	6.0a	11.0a	2.5e	55.8c	57.5c	10.0c
5	Control (Water Spray)	10.0a	30.5a	8.5a	19.3a	18.3ab	13.5a	6.5a	11.3a	13.5a	151.0a	173.5a	42.0a

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

S. No.	Treatment Details	Whitebacked Planthopper (No./10 hills)													Mean
		RGL			SKL				WGL						
		30DT	50DT	75DT	49DT	53DT	64DT	68DT	40DT	61DT	70DT	75DT	77DT	81DT	93DT	
1	Botanical-Insecticide 1	34.5abc	60.3bc	50.0ab	17.0a	13.5b	21.0a	14.5b	5.5a	15.3a	22.5ab	45.8a	14.5ab	18.8a	6.8ab	**35.4**
2	Botanical-Insecticide 2	31.0bc	63.0bc	63.3ab	16.0a	13.5b	19.5a	14.3b	8.5a	15.3a	28.3a	49.5a	10.3b	14.5ab	3.3d	**34.0**
3	All Botanical	37.3ab	70.5b	66.0ab	16.0a	14.8ab	19.0a	13.5b	7.3a	16.8a	25.5ab	40.3a	14.0ab	20.8a	10.3a	**38.2**
4	All Insecticide	28.8c	51.3c	56.5b	16.5a	14.0b	21.3a	13.0b	5.8a	13.8a	21.0b	38.5a	11.0b	8.8b	2.5b	**27.5**
5	Control (Water Spray)	41.0a	90.3a	68.5a	17.0a	19.3a	22.0a	18.3a	9.0a	16.0a	22.8ab	45.0a	18.5a	18.3a	5.5ab	**49.6**

Botanical-Insecticide 1:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT), Cartap hydrochloride 50% SC 2g/l (60-65 DAT)
Botanical-Insecticide 2:	Neemazal 1% EC 2ml/l (25-30 DAT), Neemoil 10 ml/l (45-50 DAT), Triflumezopyrim 10% SC 0.48ml/l (60-60 DAT)
All Botanical:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT) , Neem oil 10ml/l (60-65 DAT)
All Insecticide:	Chlorantraniliprole 20% SC 0.2ml/l (25-30 DAT), Cartap hydrochloride 50% SC 2g/l (50-55 DAT),Triflumezopyrim 10% SC 0.48ml/l (65-70 DAT)

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

Sl. No.	Treatment details	Leaf folder Damage (% Damaged Leaves)																	
		ARD	BPT					CHN		GNV		JDP						KRK	
		45DT	58DT	65DT	93DT	100DT	117DT	15DT	30DT	60DT	90DT	30DT	30DT	50DT	50DT	70DT	70DT	30DT	50DT
1	Botanical-Insecticide 1	2.4b	6.7b	4.2b	2.0ab	3.1a	1.3a	1.7c	0.6bc	3.3b	3.3b	11.1a	8.2a	6.1a	2.7b	5.0bc	3.3c	9.2	5.5b
2	Botanical-Insecticide 2	3.0ab	10.8a	4.0b	1.4b	2.6a	1.0b	2.8b	1.1b	2.9b	2.6b	6.4b	6.9ab	6.4a	3.6b	7.3a	4.4ab	8.8	6.9b
3	All Botanical	3.4ab	9.0ab	3.4b	3.5a	3.2a	1.3ab	1.3c	0.8bc	5.4a	4.6a	8.6ab	6.7ab	7.1a	3.8b	6.3ab	3.6bc	6.3	7.2b
4	All Insecticide	2.7b	8.5ab	2.9b	1.3b	2.7a	1.1ab	1.2c	0.4c	1.9c	1.5c	7.9b	3.8b	8.2a	2.5b	3.6c	1.5d	7.7	8.2b
5	Control (Water Spray)	4.3a	7.9ab	7.0a	2.5ab	2.8a	1.0b	3.5a	2.8a	5.8a	5.2a	8.9ab	8.8a	5.9a	7.7a	5.9ab	4.9a	10.9	11.8a

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

Sl. No.	Treatment details	Leaf folder Damage (% Damaged Leaves)																
		LDN							MLN	MND	MSD		NDL			NVS		
		41DT	46DT	55DT	61DT	66DT	75DT	80DT	79DT	50DT	DAT	DAT	50DT	60DT	90DT	30DT	50DT	80DT
1	Botanical-Insecticide 1	6.2a	4.3b	4.3b	4.5b	4.8b	2.5c	2.5c	27.5b	3.7cd	10.7c	4.6b	1.1a	1.9a	1.7a	5.8d	7.1d	7.0d
2	Botanical-Insecticide 2	6.1a	4.1b	4.4b	4.2b	4.4b	4.0b	4.1b	25.6b	5.2c	7.4d	2.2c	0.9a	1.6a	2.1a	7.6c	9.0c	7.9c
3	All Botanical	6.4a	4.3b	4.4b	4.5b	4.5b	4.0b	4.1b	26.7b	7.6b	14.9b	5.8b	1.1a	1.3ab	1.8a	9.2b	10.0b	9.1b
4	All Insecticide	6.5a	3.0c	2.4c	2.0c	2.1c	1.8c	2.0c	27.8b	2.3b	3.6e	0.9c	0.7a	.06b	1.9a	4.7d	6.0e	6.1e
5	Control (Water Spray)	6.2a	7.4a	7.7a	8.8a	9.2a	10.6a	13.1a	56.5a	15.9a	21.8a	10.3a	1.3a	1.6a	2.2a	13.5a	14.1a	13.3a

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

Sl. No.	Treatment details	Leaf folder Damage (% Damaged Leaves)																Mean
		NWG			PSA		RCI		RGL		RPR		SKL				TTB		
		30DT	45DT	60DT	30DT	50DT	63DT	67DT	30DT	50DT	40DT	60DT	49DT	57DT	64DT	72DT	30DT	50DT	
1	Botanical-Insecticide 1	6.0b	10.4b	12.2c	10.1bc	13.4b	55.8a	15.5cd	1.6b	2.4ab	3.1ab	2.1b	1.1a	1.2ab	2.3ab	2.4ab	3.4d	4.5c	**6.5**
2	Botanical-Insecticide 2	5.5b	11.7b	19.5b	9.1bc	11.3b	54.8a	17.0c	2.2ab	2.8ab	2.7b	2.3b	1.4a	1.2ab	2.1ab	2.7ab	5.7c	5.6c	**6.6**
3	All Botanical	6.2b	13.2b	22.8b	10.8d	11.9b	53.0a	33.3b	2.4a	3.8ab	2.4b	2.3b	1.4a	1.5ab	2.1ab	3.0ab	10.7b	8.6d	**7.6**
4	All Insecticide	3.4c	6.2c	6.4d	8.1c	4.2c	52.5a	11.8d	1.6b	1.4b	2.7b	1.8b	1.4a	0.9b	1.8b	2.2b	2.5d	2.6d	**4.9**
5	Control (Water Spray)	7.3a	19.4a	34.6a	15.7a	16.5a	56.8a	59.3a	2.8a	4.2a	4.2a	3.4a	1.0a	1.8a	2.3a	3.4a	23.9a	15.3a	**11.4**

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

S. No.	Treatment details	Green Leafhopper (No./10 hills)																	
		BPT						GNV				JDP						MSD	
		55DT	63DT	92DT	98DT	115DT	122DT	40DT	60DT	80DT	100DT	30DT	30DT	50DT	50DT	70DT	70DT	DT	DT
1	Botanical-Insecticide 1	5.8a	4.5a	10.0b	15.8b	20.0a	10.8b	21.8b	21.0b	19.5b	17.8b	7.5a	5.5a	18.0a	9.5b	15.5b	4.5b	115.5c	117.8c
2	Botanical-Insecticide 2	5.5a	6.0a	16.0a	26.0a	25.3a	14.3a	22.5ab	18.8b	16.0bc	12.8bc	8.0a	7.3a	15.0a	5.0b	16.8b	10.0b	62.5d	48.5d
3	All Botanical	5.3a	4.8a	12.5ab	24.3a	22.5a	12.8ab	21.8b	20.5b	18.3bc	14.5bc	6.0a	9.5a	19.3a	6.3b	19.3ab	10.0b	137.5b	132.b
4	All Insecticide	4.8a	7.0a	15.0ab	26.8a	25.5a	12.0ab	18.5b	16.0b	13.3c	10.3c	11.0a	5.0a	17.3a	6.0b	16.0b	6.5b	28.5e	23.8e
5	Control (Water Spray)	6.0a	4.5a	12.5ab	21.5ab	20.8a	12.3ab	27.0a	29.5a	29.3a	29.0a	5.5a	8.5a	14.0a	22.3a	25.3a	18.0a	240.0a	248.5a

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

S. No.	Treatment details	Green Leafhopper (No./10 hills)																Mean
		NVS				RCI		RGL		RPR		SKL				TTB		
		60DT	63DT	80DT	83DT	63DT	67DT	30DT	50DT	40DT	60DT	49DT	53DT	64DT	68DT	30DT	50DT	
1	Botanical-Insecticide 1	4.5a	4.5b	9.0a	7.0b	62.8b	13.5c	4.5a	36.0ab	4.8b	4.0ab	10.8b	6.3b	15.8b	13.8b	4.5d	3.5d	**19.0**
2	Botanical-Insecticide 2	4.3a	2.5cd	8.8a	3.3d	66.5ab	17.8c	4.3a	41.3a	4.3b	3.3bc	12.3ab	8.3b	15.0b	13.8b	17.5c	18.8c	**17.0**
3	All Botanical	4.5a	3.5bc	8.8a	4.5c	62.8b	25.3b	3.8a	44.0a	4.3b	3.8b	13.0ab	7.3b	15.8ab	12.3b	31.0b	34.8d	**22.8**
4	All Insecticide	4.8a	1.5d	9.0a	2.5e	69.5a	9.0d	3.5a	29.3b	3.0b	2.0c	13.8a	8.5b	19.5a	14.0b	3.3d	2.8d	**13.5**
5	Control (Water Spray)	4.5a	6.3a	9.0a	13.0a	64.0ab	66.0a	5.5a	46.a	7.8a	5.5a	12.5ab	12.3a	16.8ab	18.3a	42.3a	48.8a	**33.9**

Botanical-Insecticide 1:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT), Cartap hydrochloride 50% SC 2g/l (60-65 DAT)
Botanical-Insecticide 2:	Neemazal 1% EC 2ml/l (25-30 DAT), Neemoil 10 ml/l (45-50 DAT), Triflumezopyrim 10% SC 0.48ml/l (60-60 DAT)
All Botanical:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT) , Neem oil 10ml/l (60-65 DAT)
All Insecticide:	Chlorantraniliprole 20% SC 0.2ml/l (25-30 DAT), Cartap hydrochloride 50% SC 2g/l (50-55 DAT),Triflumezopyrim 10% SC 0.48ml/l (65-70 DAT)

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

S. No.	Treatment details	Hispa (% Damaged Leaves)					Mean
		MLN	MTU	RCI		RGL	
		77DT	30DT	29DT	35DT	30DT	
1	Botanical-Insecticide 1	47.8b	3.40a	59.8a	34.8b	0.3ab	**29.2**
2	Botanical-Insecticide 2	50.0b	4.1a	62.0a	36.8b	0.3ab	**30.7**
3	All Botanical	50.8b	3.2a	62.3a	35.8b	0.2ab	**30.5**
4	All Insecticide	53.1b	2.9a	59.8a	14.5c	0.1b	**26.1**
5	Control (Water Spray)	92.1a	3.2a	61.3a	65.3a	0.4a	**44.6**

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

S. No.	Treatment details	Whorl Maggot (% Damage Leaves)									
		CHN		JDP						MTU	NDL	
		15DT	30DT	30DT	30DT	50DT	50DT	70DT	70DT	30DT	30DT	40DT
1	Botanical-Insecticide 1	2.3d	0.9d	14.8a	7.3b	10.0a	5.5bc	7.0b	4.1b	1.5a	11.6b	8.7b
2	Botanical-Insecticide 2	3.2c	1.4c	12.1a	7.6b	11.8a	6.7b	7.6ab	4.2b	1.6a	16.7ab	11.3a
3	All Botanical	3.8b	2.0b	14.1a	9.0ab	11.6a	7.2b	9.8a	4.2b	1.1a	15.4ab	11.4a
4	All Insecticide	1.6e	0.5d	13.4a	4.0c	10.5a	3.6c	6.8b	2.6c	1.1a	17.5a	10.3ab
5	Control (Water Spray)	4.8a	2.7a	13.9a	9.9a	14.9a	9.6a	9.0ab	5.5a	1.7a	15.5ab	9.7ab

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

S. No.	Treatment details	Whorl Maggot (% Damage Leaves)								Mean
		NDL			KRK	RGL	RNR	TTB		
		50DT	60DT	70DT	DAT	30DT	DAT	30DT	50DT	
1	Botanical-Insecticide 1	10.6a	6.2ab	3.1a	1.3ab	1.8b	2.5a	2.7d	3.7d	5.6
2	Botanical-Insecticide 2	11.4a	8.0a	2.8a	1.5a	1.8b	3.5a	6.6c	6.2c	6.6
3	All Botanical	12.7a	8.0a	2.5a	1.0abc	1.6b	2.1a	11.6b	11.4b	7.4
4	All Insecticide	10.8a	4.1b	2.4a	0.5c	1.1c	2.5a	2.0d	1.4e	5.1
5	Control (Water Spray)	12.8a	7.9a	3.8a	0.8bc	2.1a	3.8a	24.4a	18.0a	9.0

Table: 2.13 Insect pests incidence in different treatments, IBET, *Kharif* 2019

S. No.	Treatment details	Grasshopper Damage (% Leaf Damages)						Mean
		KHD						
		30DT	37DT	50DT	57DT	65DT	72DT	
1	Botanical-Insecticide 1	6.2ab	1.0b	6.7ab	0.9b	7.9b	0.7c	**3.9**
2	Botanical-Insecticide 2	6.6a	0.9bc	7.2ab	0.7c	8.2b	1.0bc	**4.1**
3	All Botanical	5.3b	0.9bc	6.0bc	0.9bc	7.7b	1.2b	**3.7**
4	All Insecticide	6.1ab	0.5c	5.4c	0.4d	6.1c	0.2d	**3.2**
5	Control (Water Spray)	5.5b	2.0a	7.8a	2.2a	9.9a	2.1a	**4.9**

Botanical-Insecticide 1:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT), Cartap hydrochloride 50% SC 2g/l (60-65 DAT)
Botanical-Insecticide 2:	Neemazal 1% EC 2ml/l (25-30 DAT), Neem oil 10 ml/l (45-50 DAT), Triflumezopyrim 10% SC 0.48ml/l (60-60 DAT)
All Botanical:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT) , Neem oil 10ml/l (60-65 DAT)
All Insecticide:	Chlorantraniliprole 20% SC 0.2ml/l (25-30 DAT), Cartap hydrochloride 50% SC 2g/l (50-55 DAT),Triflumezopyrim 10% SC 0.48ml/l (65-70 DAT)

Table: 2.13 Incidence of Natural enemies in different treatments, IBET, *Kharif* 2019

S. No.	Treatment details	Mirid bugs (No./10 hills)									
		BPT						GNV			
		55DT	63DT	92DT	98DT	115DT	122DT	40DT	60DT	80DT	100DT
1	Botanical-Insecticide 1	9.3a	12.0a	9.0ab	11.0a	15.8a	6.3a	26.0a	28.3ab	17.8c	10.3b
2	Botanical-Insecticide 2	11.0a	15.0a	9.0ab	8.5a	15.8a	7.3a	28.5a	28.0ab	16.3c	9.5b
3	All Botanical	11.0a	14.0a	6.5b	10.8a	15.3a	6.5a	23.8a	34.0a	40.0b	45.0a
4	All Insecticide	10.3a	13.8a	9.0ab	10.3a	11.8a	7.8a	28.0a	20.3b	14.3c	6.8b
5	Control (Water Spray)	11.3a	13.0a	11.0a	11.8a	13.8a	7.0a	25.5a	35.3a	49.0a	45.5a

Table: 2.13 Incidence of Natural enemies in different treatments, IBET, *Kharif* 2019

S. No.	Treatment details	Mirid bugs (No./10 hills)													Mean
		LDN			MTU	NVS	SKL				WGL				
		60DT	70DT	75DT	50DT	DT	60DT	75DT	60DT	75DT	70DT	75DT	77DT	81DT	
1	Botanical-Insecticide 1	6.3bc	7.5b	7.8b	38.0a	12.0c	14.0a	26.3a	17.3a	31.0a	4.8ab	18.8a	2.8b	6.8a	**14.7**
2	Botanical-Insecticide 2	6.0c	7.0b	7.3b	23.0a	9.0d	14.3a	26.5a	16.8a	34.0a	3.3b	18.3a	6.3ab	8.3a	**14.3**
3	All Botanical	7.3b	6.5b	7.0bc	32.8a	16.0b	14.5a	25.8a	19.3a	34.0a	3.0b	18.3a	11.0a	8.5a	**17.8**
4	All Insecticide	5.8c	6.3b	6.0c	17.8a	6.8e	16.5a	24.5a	18.8a	33.3a	2.5b	16.8a	3.5b	7.0a	**12.9**
5	Control (Water Spray)	9.0a	10.3a	10.5a	39.5a	19.0a	16.5a	27.8a	20.8a	34.5a	7.3a	22.3a	4.8b	8.8a	**19.7**

Table: 2.13 Incidence of Natural enemies in different treatments, IBET, *Kharif* 2019

S. No.	Treatment details	Spiders/(No .10 hills)											
		BPT						CHP		GNV			
		55DT	63DT	92DT	98DT	115DT	122DT	56DT	76DT	40DT	60DT	80DT	100DT
1	Botanical-Insecticide 1	12.8a	5.3a	9.8a	6.0ab	8.5a	5.8a	9.0b	10.8c	27.8a	28.3a	21.0b	15.0b
2	Botanical-Insecticide 2	13.3a	6.0a	10.8a	7.3a	8.3a	5.0a	9.0b	7.3d	30.8a	29.3a	20.8b	16.0b
3	All Botanical	13.5a	5.0a	10.3a	5.3b	8.3a	5.0a	11.0ab	13.0b	32.5a	31.3a	32.8a	33.3a
4	All Insecticide	12.0a	4.8a	8.5a	6.8ab	7.0a	4.8a	6.5c	5.0e	27.5a	20.3b	14.0b	7.8c
5	Control (Water Spray)	15.0a	5.5a	9.5a	7.0ab	7.5a	4.8a	12.5a	15.5a	29.5a	32.5a	37.3a	37.3a

Botanical-Insecticide 1:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT), Cartap hydrochloride 50% SC 2g/l (60-65 DAT)
Botanical-Insecticide 2:	Neemazal 1% EC 2ml/l (25-30 DAT), Neem oil 10 ml/l (45-50 DAT), Triflumezopyrim 10% SC 0.48ml/l (60-60 DAT)
All Botanical:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT) , Neem oil 10ml/l (60-65 DAT)
All Insecticide:	Chlorantraniliprole 20% SC 0.2ml/l (25-30 DAT), Cartap hydrochloride 50% SC 2g/l (50-55 DAT),Triflumezopyrim 10% SC 0.48ml/l (65-70 DAT)

Table: 2.13 Incidence of Natural enemies in different treatments, IBET, *Kharif* 2019

S. No.	Treatment details	Spiders (No. /10 hills)									
		MTU		NDL							
		30DT	50DT	30DT	40DT	50DT	60DT	70DT	80DT	90DT	100DT
1	Botanical-Insecticide 1	13.8a	27.3a	8.3a	7.0b	12.8ab	13.0a	17.0a	21.5ab	18.0ab	27.0a
2	Botanical-Insecticide 2	14.0a	20.8a	10.5a	9.3ab	9.8b	16.3a	15.3ab	20.3b	14.3b	31.5a
3	All Botanical	16.0a	25.a	8.8a	8.5ab	11.3ab	13.0a	15.0ab	21.0ab	20.0a	38.8a
4	All Insecticide	16.3a	26.3a	8.5a	11.0a	10.0b	17.5a	13.0b	21.0ab	17.3ab	29.0a
5	Control (Water Spray)	17.3a	28.8a	9.3a	7.0b	14.0a	13.8a	14.8ab	28.8a	17.5ab	31.8a

Table: 2.13 Incidence of Natural enemies in different treatments, IBET, *Kharif* 2019

S. No.	Treatment details	Spiders (No. /10 hills)											Mean
		NVS	SKL			WGL							
		80DT	40DT	60DT	75DT	32DT	61DT	70DT	75DT	77DT	81DT	93DT	
1	Botanical-Insecticide 1	17.0c	4.3a	5.0a	2.8a	3.3b	5.3a	11.5a	22.0a	14.0a	19.8a	14.3a	**13.5**
2	Botanical-Insecticide 2	15.3d	3.8a	4.5a	2.5a	3.3b	6.3a	11.5a	20.0a	11.0a	17.0a	15.8a	**13.2**
3	All Botanical	23.5b	4.5a	4.0a	2.5a	5.3a	6.3a	13.5a	21.8a	3.0b	20.0a	17.3a	**15.1**
4	All Insecticide	4.5e	3.8a	5.0a	2.5a	5.0a	4.8a	13.0a	20.3a	12.8a	15.8a	16.8a	**12.1**
5	Control (Water Spray)	35.5a	4.0a	5.0a	2.8a	5.5a	4.8a	13.8a	22.8a	14.3a	17.8a	17.0a	**16.3**

Table: 2.13 Incidence of Natural enemies in different treatments, IBET, *Kharif* 2019

S. No.	Treatment details	Coccinellids (No./10hills)												Mean
		BPT				SKL			WGL						
		92 DT	98 DT	115 DT	122 DT	40 DT	60 DT	75 DT	40 DT	61 DT	70 DT	77 DT	81 DT	93 DT	
1	Botanical-Insecticide 1	2.8 ab	4.8 a	2.8 a	2.8 a	3.0 a	2.8 b	2.3 a	3.5 a	2.8 ab	2.3 b	4.5 ab	8.5 a	4.0 b	**3.58**
2	Botanical-Insecticide 2	2.3 b	4.3 a	3.3 ab	3.5 a	3.0 a	3.0 ab	2.3 a	4.8 a	2.0 b	3.3 ab	3.5 b	10.8 a	6.5 ab	**4.02**
3	All Botanical	3.8 a	4.5 a	4.3a	3.5 a	2.8 a	4.3 a	1.8 a	3.0 a	2.0 b	5.5 a	8.3 a	10.0 a	9.5a	**4.85**
4	All Insecticide	2.3 b	4.5 a	3.5 ab	2.8 a	2.8 a	4.0 ab	1.8 a	5.3 a	2.5 ab	3.8 ab	4.0 ab	7.3 a	5.0 b	**3.79**
5	Control (Water spray)	3.3a	5.0 a	3.5a b	3.5 a	2.8 a	3.8 ab	2.8 a	3.5 a	3.5 a	5.0 ab	5.8 ab	11.8 a	5.5 b	**4.54**

Botanical-Insecticide 1:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT), Cartap hydrochloride 50% SC 2g/l (60-65 DAT)
Botanical-Insecticide 2:	Neemazal 1% EC 2ml/l (25-30 DAT), Neem oil 10 ml/l (45-50 DAT), Triflumezopyrim 10% SC 0.48ml/l (60-60 DAT)
All Botanical:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT) , Neem oil 10ml/l (60-65 DAT)
All Insecticide:	Chlorantraniliprole 20% SC 0.2ml/l (25-30 DAT), Cartap hydrochloride 50% SC 2g/l (50-55 DAT),Triflumezopyrim 10% SC 0.48ml/l (65-70 DAT)

Table: 2.14 Grain Yield in different treatments, IBET, *Kharif* 2019

S. No.	Treatment details	Grain Yield (Kg/ha)													MND
		ARD	CBT	CHN	CHP	CHT	CTC	GVT	JDP	KHD	KJT	KRK	LDN	MLN	
1	Botanical-Insecticide 1	6716.7a	2941.1a	4787.5d	4450.7b	1550.0a	4100.0b	7634.0a	3862.5b	5308.3a	2330.0c	2237.5a	7160.5b	2013.9a	4052.0ab
2	Botanical-Insecticide 2	5416.7ab	2907.6a	5812.5c	4318.5bc	1475.0a	3800.0c	7938.0a	4050.0ab	5216.7a	3010.0a	2393.8a	7111.1b	1898.1a	3894.6ab
3	All Botanical	5416.7ab	2643.5a	6487.5b	4200.9c	1962.5a	3366.7d	7488.0a	4000.0b	5079.2ab	2500.0b	2068.8a	7000.0b	1805.6a	3670.0b
4	All Insecticide	6316.7a	3384.8a	6825.0b	4920.7a	1787.5a	4300.0a	8168.0a	4375.0a	5358.3a	3140.0a	2137.5a	7543.2a	1805.6a	4645.0a
5	Control (Water Spray)	4733.3b	2587.0a	7275.0a	3451.8d	1900.0a	2650.0e	6668.0b	3137.5c	4640.0b	1710.0d	2106.3a	6395.1c	715.3b	2680.0c

Table: 2.14 Grain Yield in different treatments, IBET, *Kharif* 2019

S. No.	Treatment details	Grain Yield (Kg/ha)												Mean	IOC (%)
		MTU	MSD	NDL	NVS	NWG	PUS	RCI	RGL	RNR	RPR	TTB	WGL		
1	Botanical-Insecticide 1	1833.6d	2706.3c	3675.0a	4171.3b	4184.8bc	5497.9b	4302.6b	5520.0ab	6213.5a	5981.3a	3977.0b	4269.3c	**4286.5**	**18.6**
2	Botanical-Insecticide 2	3699.5a	3176.3b	4037.5a	4071.7c	4784.6b	5165.6bc	4190.3b	5194.0bc	6272.6a	5706.3a	3832.0c	4846.0b	**4393.0**	**21.6**
3	All Botanical	2708.5bc	2265.0d	4012.5a	3869.5d	3136.1cd	4960.9c	3654.8c	5028.0c	5980.9ab	6053.1a	3389.0d	3670.6d	**4089.2**	**13.2**
4	All Insecticide	3429.4ab	3306.3a	4450.0a	4246.3a	6115.1a	6170.8a	4789.8a	5684.0a	6334.2a	5712.5a	4110.0a	5554.7a	**4781.2**	**32.3**
5	Control (Water Spray)	2174.4cd	1475.0e	4225.0a	3630.5e	2773.8d	4174.9d	3149.1d	4864.0c	5335.9b	4975.0b	2964.0e	3548.4d	**3613.0**	

Botanical-Insecticide 1:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT), Cartap hydrochloride 50% SC 2g/l (60-65 DAT)
Botanical-Insecticide 2:	Neemazal 1% EC 2ml/l (25-30 DAT), Neem oil 10 ml/l (45-50 DAT), Triflumezopyrim 10% SC 0.48ml/l (60-60 DAT)
All Botanical:	Neemazal 1% EC 2ml/l (25-30 DAT), Eucalyptus oil 2ml/l (45-50 DAT) , Neem oil 10ml/l (60-65 DAT)
All Insecticide:	Chlorantraniliprole 20% SC 0.2ml/l (25-30 DAT), Cartap hydrochloride 50% SC 2g/l (50-55 DAT),Triflumezopyrim 10% SC 0.48ml/l (65-70 DAT)

2.4. ECOLOGICAL STUDIES

Field incidence of insect pests is highly dependent on crop stage and prevailing abiotic as well as biotic factors that affect their multiplication and growth. Climate change effects have become visible in India affecting the temperature and rainfall patterns. As cropping systems are highly dependent on monsoon rains in the country, a shift in sowing or planting dates have been observed as a strategy to cope up with the climate change impacts. Keeping this in view, to generate knowledge on impact of these changes on pest incidence, the trial on Effect of planting dates on insect pest incidence **(EPDP)** was continued and efforts were made to relate pest dynamics with the abiotic factors of various locations.

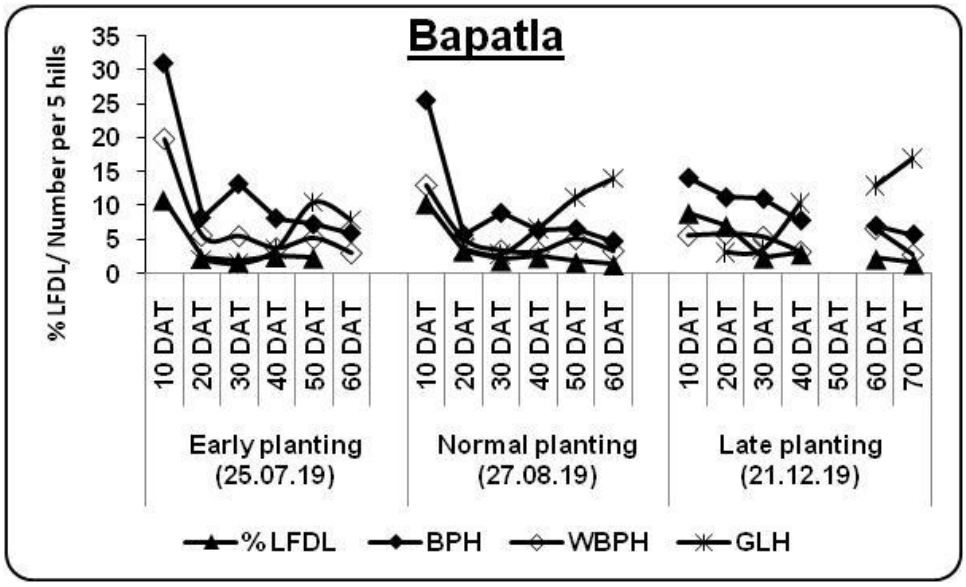
In India, rice is grown traditionally by manual transplanting method which requires more water and labour leading to high crop production costs. To overcome these constraints, farmers are gradually shifting to alternative methods of rice cultivation, weed management tactics and crop residue management strategies to improve the productivity of rice-based cropping systems. In view of these changes in agronomic practices in rice cultivation, three trials on - Effect of iron seed coating on insect pest incidence **(ESCP),** Influence of crop establishment methods on pest incidence **(IEMP)** and Cropping systems influence on pest incidence **(CSIP)** were planned in collaboration with Agronomy to know the effect of these changes on insect pest incidence.

i) Effect of Planting Dates on Insect Pest Incidence (EPDP)

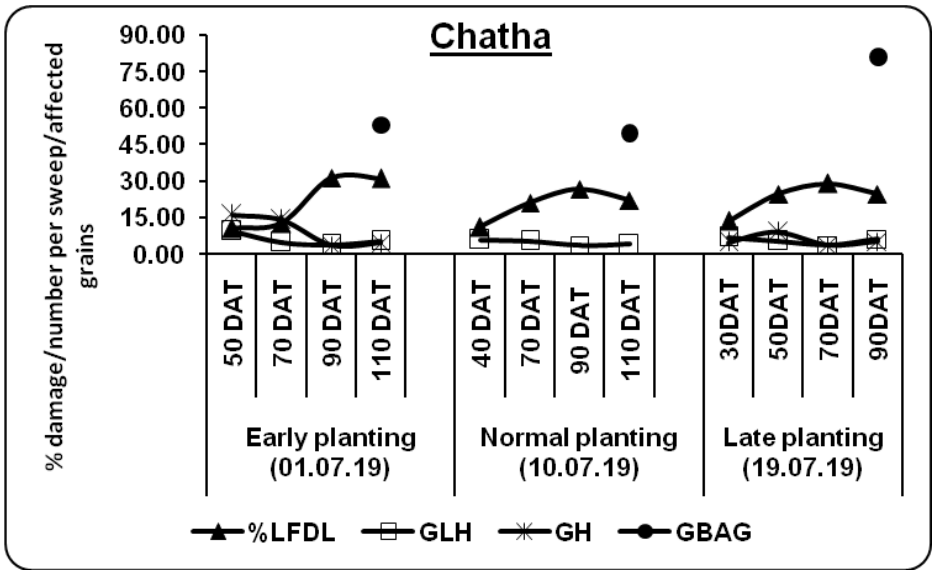
During *Kharif* 2019, effect of planting dates on insect pest incidence trial was conducted at 22 locations. At each location, most popular variety of that region was planted at three dates *viz.*, normal planting as per the recommended package of practices of that region, 20 days earlier to normal planting, designated as 'early planting' and 20 days later than the normal planting, designated as 'late planting'. Each time, sowing of the nursery and planting was done separately in 500 sq. m area. Observations on insect pest incidence were recorded on ten randomly selected hills at 10-day interval starting from the first appearance of the pest. Location wise pest incidence at different dates of planting is discussed here.

1) Bapatla (15° 90'N & 80°47'E), Andhra Pradesh: Incidence of leaf folder, BPH, WBPH and GLH was observed in different plantings in BPT 5204.

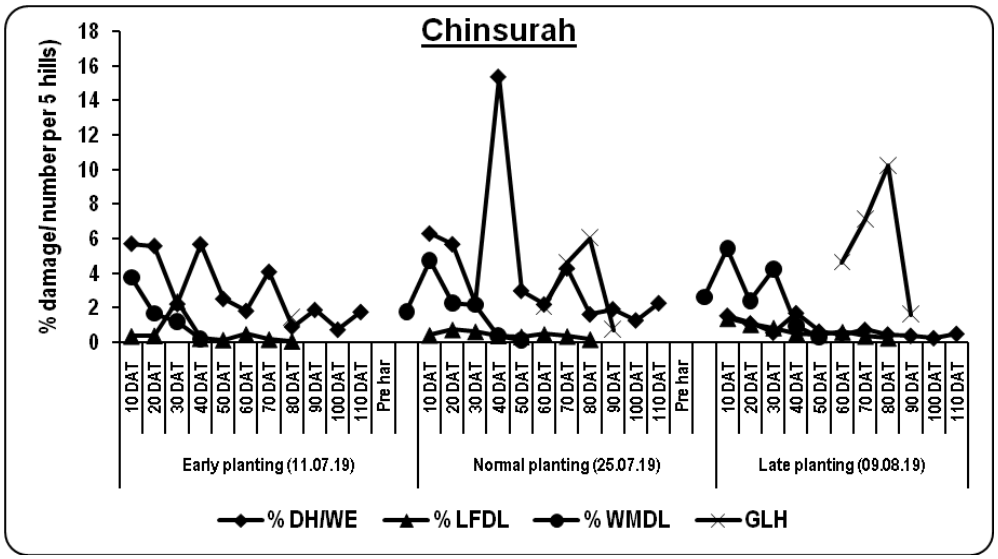
In general, the pest incidence was low, below ETL across the plantings. However, the incidence was high and crossed ETL at 10 DAT but declined in later stages. Grain yields of 4320, 3880 and 3532 kg/ha were recorded in early, normal and late plantings, respectively.



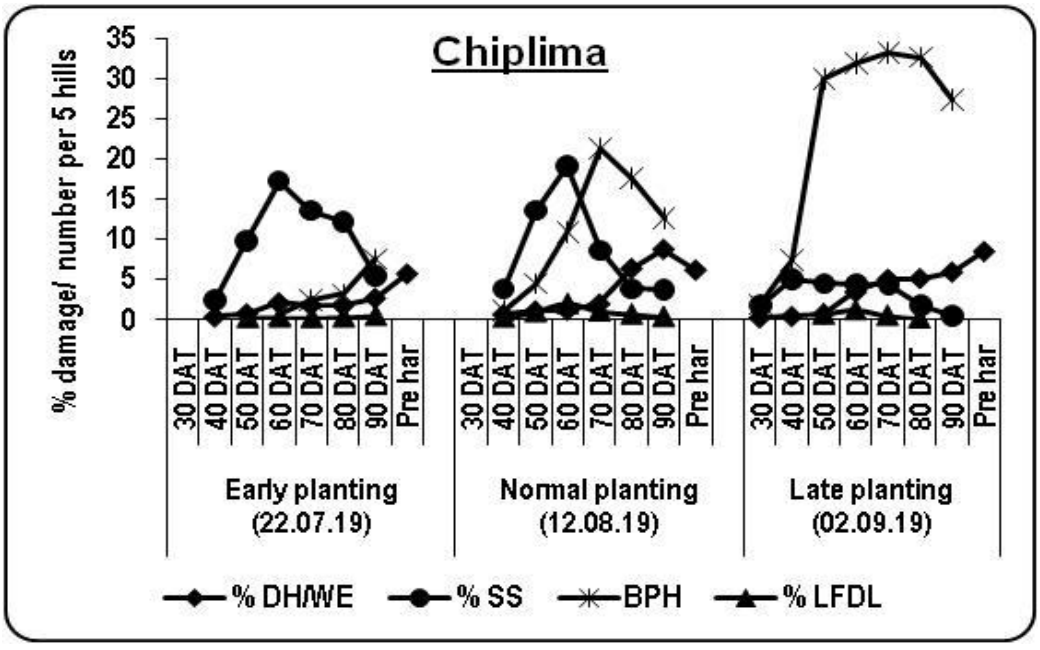
2) Chatha (32° 69'N & 74° 85'E), Jammu & Kashmir: Incidence of leaf folder was high in all the three plantings (21.37%, 20.23% and 22.91%) in Basmati 370 variety grown in this trial. Grasshopper population was also high in early planting at 50 DAT (16.11/sweep) and 70 DAT (14.00/sweep). Gundhi bug damage was observed up to 53.22% in early planting, 49.67% in normal planting and 81.11% in late planting. Grain yield ranged from 3404 to 4728 kg/ ha in different plantings.



3) Chinsurah (22° 88'N & 88° 39'E) West Bengal: Very low incidence of leaf folder (<3%), whorl maggot (<5%) and GLH (<3/hill) was observed. Incidence of stem borer (<5%) was also low except at 50 DAT in normal planting (15.37%). Grain yield ranged between 3960 and 4900 kg/ ha in all the three plantings.

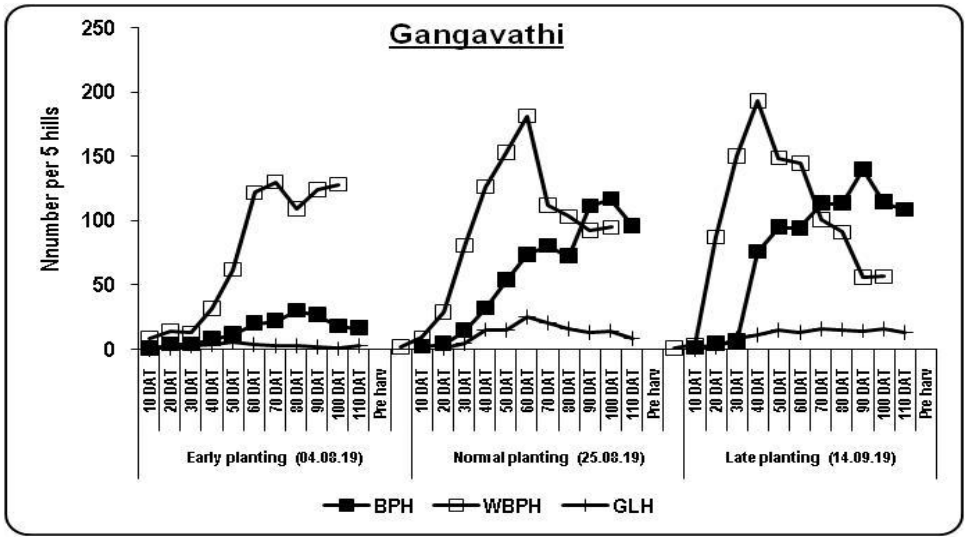


4) Chiplima (**21° 46'N & 83° 98'E), Orissa:** Gall midge incidence recorded on swarna variety was high and exceeded ETL in early planting starting from 60 DAT (17.28% SS) till 80 DAT (12.16% SS) and in normal planting at 50 DAT (13.59% SS) and 60 DAT (19.20% SS). Incidence of stem borer, leaf folder and BPH was low in all the three plantings. Grain yield of 3800, 3560 and 2600 kg/ ha was recorded in early, normal and late plantings, respectively.



5) Gangavathi (15° 43' N & 76° 53' E), Karnataka: WBPH population (0.4 – 193.2 hoppers/5 hills) was higher than that of BPH (0.6 -140.5 hoppers/5 hills) in all the three plantings on RP Bio 226 grown in this trial. WBPH numbers crossed ETL at 60 – 110 DAT in early planting (62.2 – 128.3 hoppers/ 5 hills), at 40 – 110 DAT in normal planting (80.8 – 181.4 hoppers/ 5 hills) and at 30 - 90 DAT in late planting (87.5 – 193.2 hoppers/ 5 hills). Similarly, BPH population crossed ETL in normal planting between

50 DAT – 110 DAT (53.9 – 117.3 hoppers/ 5 hills) and at 40-110 DAT in late planting (76.2 – 140.5 hoppers/ 5 hills). Stem borer (< 2% DH & <6% WE), leaf folder (<3% DL) and GLH (<5 hoppers/hill) damage was low. Grain yields of 7190, 6264 and 5068 kg/ ha were recorded in early, normal and late plantings, respectively.



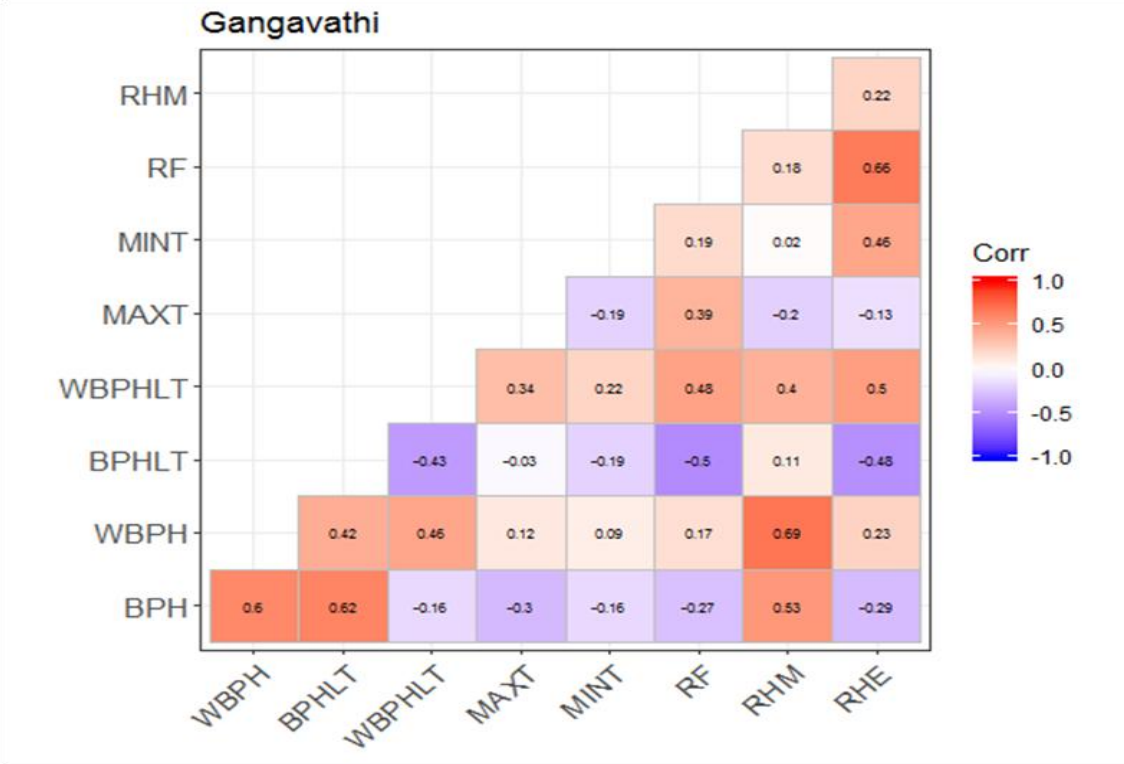
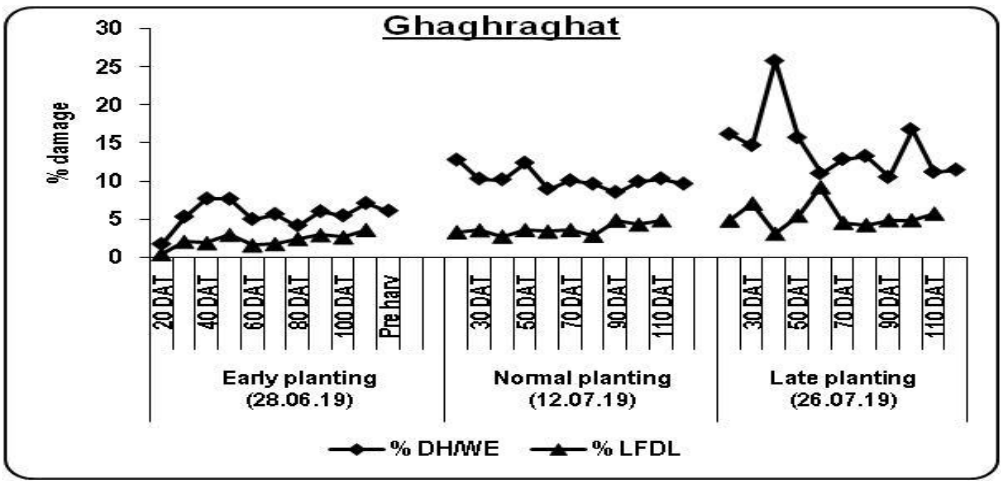


Fig 2.1 Correlation matrix between field incidence, light trap catches and weather parameters at Gangavathi, *Kharif* 2019

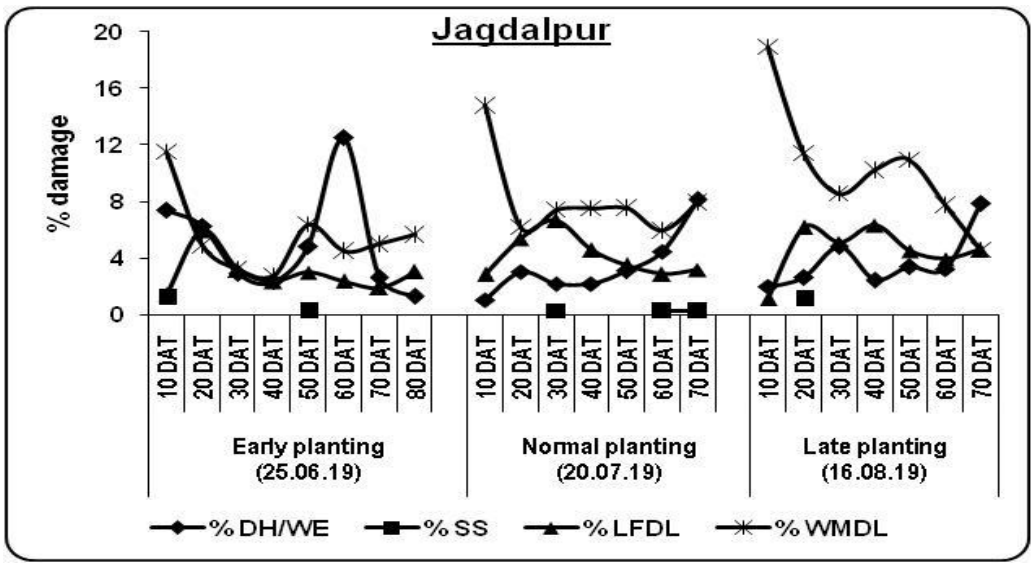
The relation between the pest incidence, light trap catches and ten days preceding weather parameters, *i.e.,* maximum temperature, minimum temperature, relative humidity morning, relative humidity evening and rainfall was estimated using Pearson correlation coefficients **(Fig 2.1)**.

There was significant positive correlation between BPH and WBPH incidence in the field (0.60) and light trap catches (0.62). Similarly, relative humidity morning had significant positive impact on the field incidence of both BPH (0.53) and WBPH (0.69).

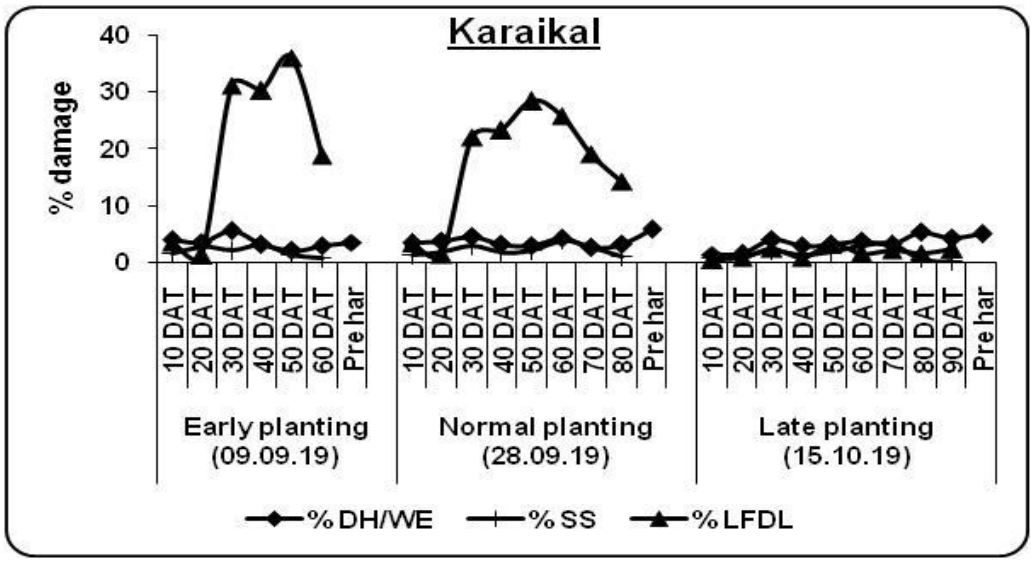
6) Ghaghraghat (23° 27' N & 84° 45' E), Uttar Pradesh: High incidence of stem borer was observed during vegetative stage from 20 DAT onwards in normal planting (12.8 – 10.34% DH) and late planting (16.2–16.8% DH) with highest damage at 40 DAT (25.83% DH) in late planting. However, white ear damage was low in early and normal plantings compared to 11.49% in late planting. Leaf folder damage was low in all the three plantings (2.25–5.43%). Early, normal and late plantings recorded grain yield of 4040, 3248 and 2660 kg/ ha, respectively.



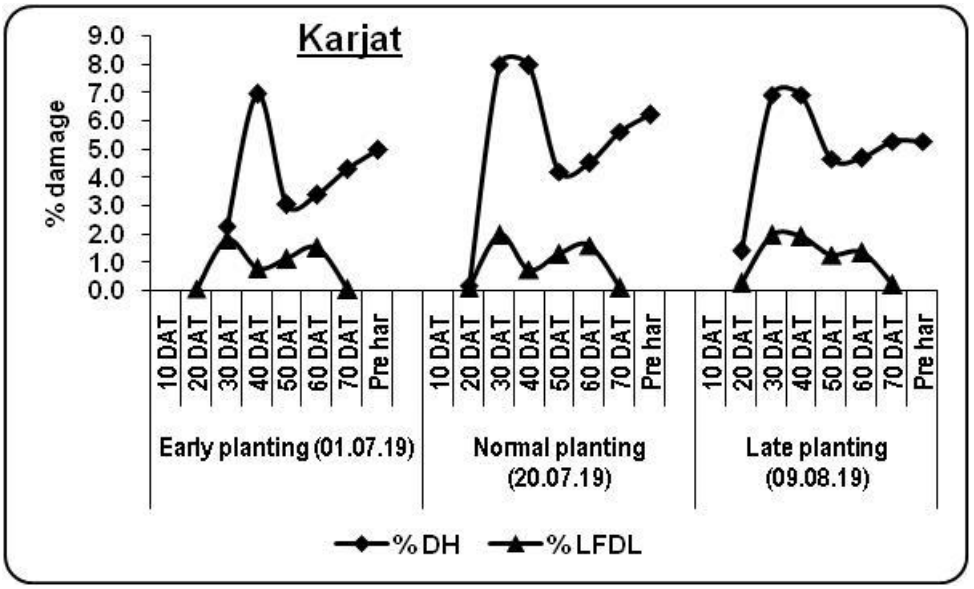
7) Jagdalpur (19° 4' N & 82° 0' E), Chattisgarh: Low incidence of stem borer (1.06-12.48% DH), gall midge (0.27-1.25% SS) leaf folder (1.12-6.67% DL), BPH (0.1-0.7 hoppers/5 hills), WBPH (0.1-0.4 hoppers/5 hills) and GLH (0.9-8.2 hoppers/5 hills) was observed in Swarna variety in all the three plantings. Only, incidence of whorl maggot crossed ETL in all the three plantings with highest damage in late planting at 10 DAT (18.91%). Grain yield varied from 3727 to 4840 kg/ ha in all the three plantings.



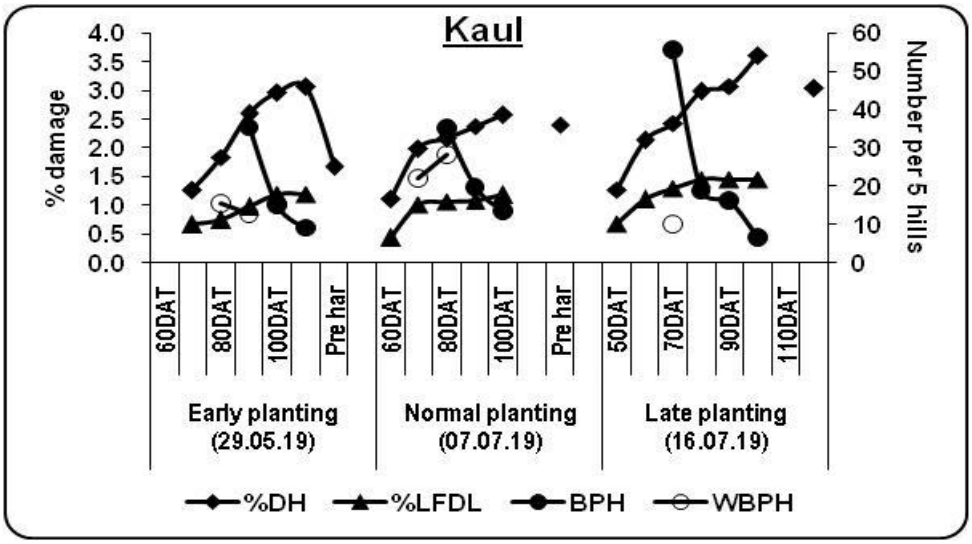
8) Karaikal (10° 92' N & 79° 84' E), Puducherry: High incidence of leaf folder was observed starting from 30 DAT to 60 DAT (31.13 – 35.99%) in early planting and 30 DAT to 80 DAT (14.24 – 28.34%) in normal planting while it was low (<5%) in late planting. Low incidence of stem borer (1.34 – 5.79%) and gall midge (0.19 – 3.77%) was observed in all the three planting and grain yield ranged between 2080 and 2880 kg/ha.



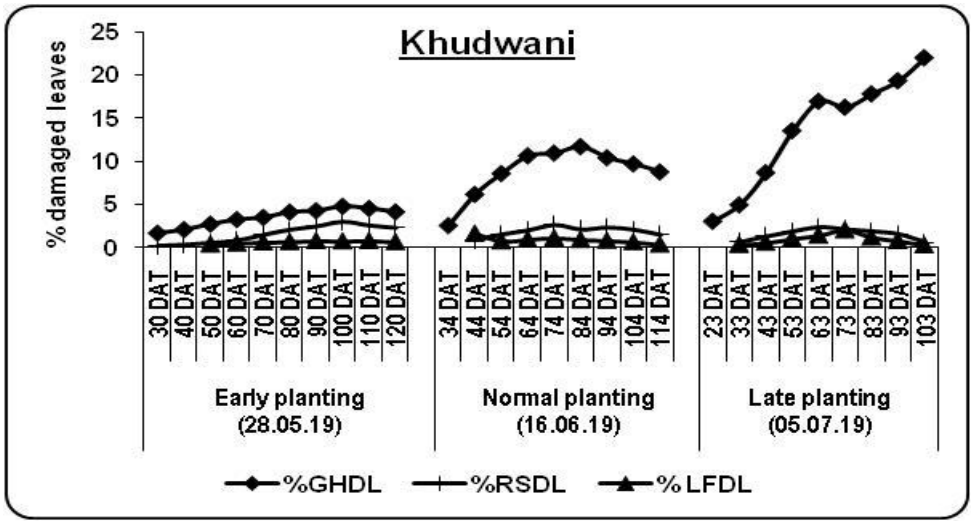
9) Karjat (18° 92' N & 73° 33' E), Maharashtra: Very low incidence of stem borer (0.2 – 8.0%) and leaf folder (<2% DL) was reported from all the three plantings in Karjat 10 variety grown in this trial. Yield of 3560 – 3680 kg/ ha was recorded in various plantings.



10) Kaul (29° 85' N & 76° 66' E), Haryana: Low incidence of stem borer (1.1 – 3.6%), leaf folder (0.44 – 1.46%), BPH (6.7 – 55.7 hoppers/5 hills) and WBPH (10.0 – 28.2 hoppers/5 hills) was registered in all the three plantings in HKR 127 variety grown in this trial. Grain yield varied from 3120 to 3720 kg/ ha in three plantings.

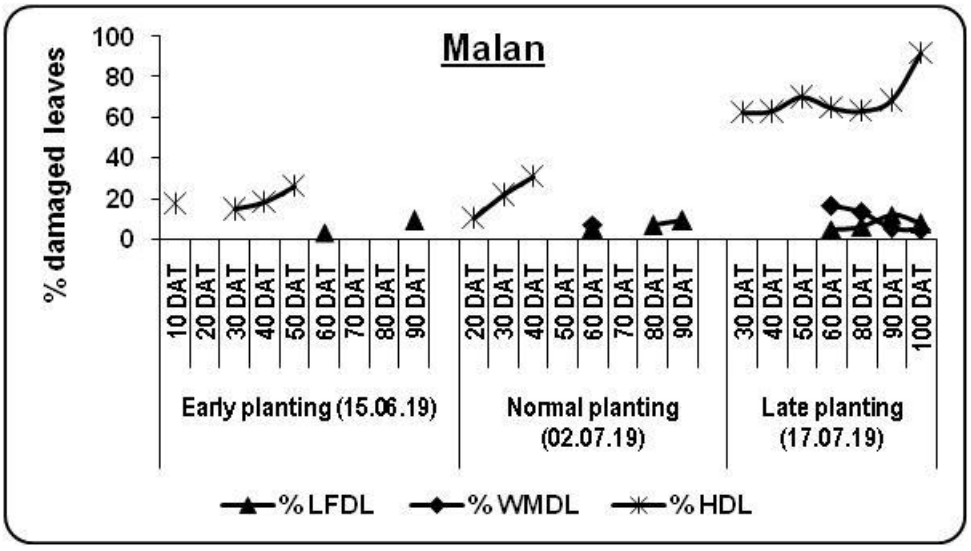


11) Khudwani (33° 71' N & 75° 10' E), Jammu & Kashmir: Incidence of grasshopper was high on Shalimar rice- 4 variety in late planting from 53 to 103 DAT (13.55 – 21.98 % DL) and from 64 DAT to 94 DAT (10.43 – 11.71% DL) in normal planting while it was low in early planting. Very low incidence of leaf folder (<3% DL) and rice skipper (<3% DL) was reported in all the three plantings.

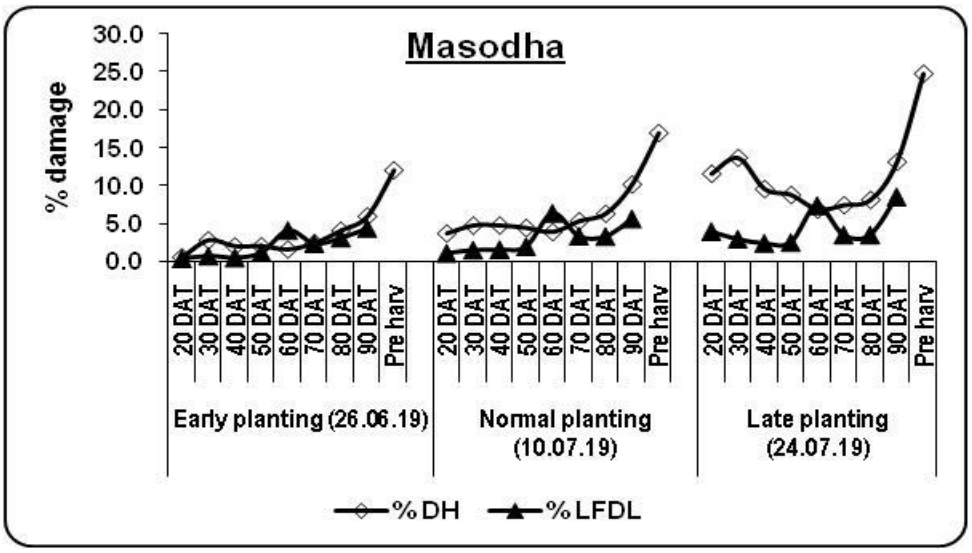


12) Malan (32° 11' N & 76° 25' E), Himachal Pradesh: Very high incidence of hispa was reported in late planting (62.08 – 91.52% HDL) as compared to normal planting (10.04 – 30.91% DL) and early planting (14.40 – 25.75% DL) in Kasturi variety. Whorl maggot incidence was high in late planting (4.44 – 16.21% DL) and only at 60 DAT (7.14%DL) in normal

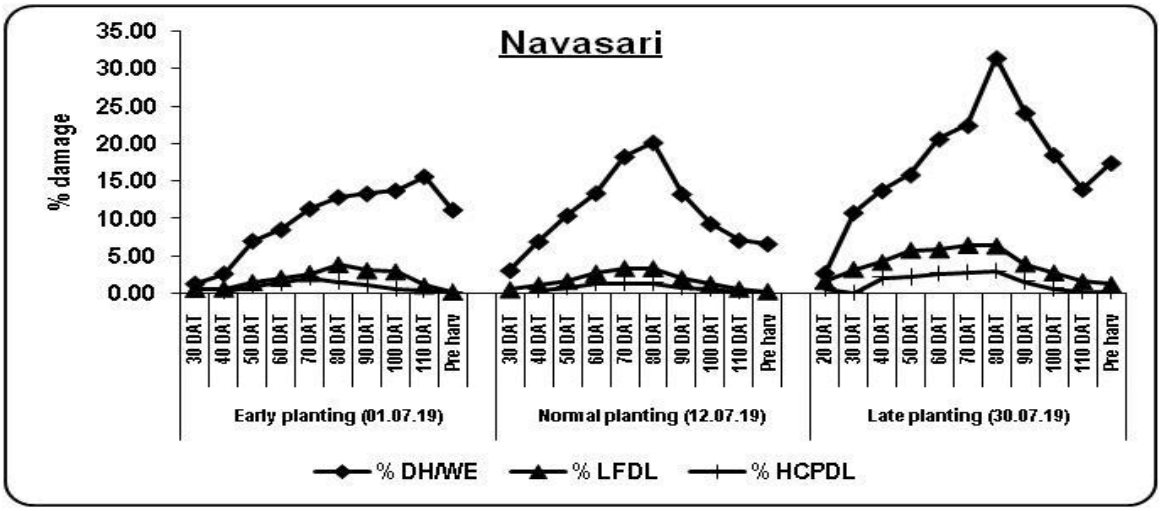
planting. Low incidence of leaf folder was recorded in all the three plantings except at 90 DAT in late planting (11.9% DL).



13) Masodha (26°77' N & 82° 14'E), Uttar Pradesh: Stem borer and leaf folder incidence was observed in Pusa Basmati 1 variety grown in this trial. Stem borer damage was observed in all the three plantings at both vegetative and flowering stages. However, dead heart damage crossed ETL only in late planting at 20 to 30 DAT (11.59 – 13.68% DH) while white ears were observed above ETL in all the three plantings (12.05 – 24.74% WE). Low incidence of leaf folder was reported in all the three plantings (0.41 – 8.48% DL). Yield ranged from 2510 to 3600 kg/ ha in all the three plantings.



14) Navasari (20° 94' N & 72° 95' E), Gujarat: Stem borer incidence was high in all the three plantings in GR 11 variety. Stem borer damage crossed ETL at 70 DAT onwards up to pre harvest in early planting (11.28 – 15.59% DH & 11.12% WE), at 50-90 DAT in normal planting (10.37 – 20.13% DH) and at 30 DAT to pre harvest in late planting (10.74 – 31.42% DH & 17.39% WE) with highest damage in late planting. Low incidence of leaf folder (0.16 – 6.37% DL), horned caterpillar (0.01 – 2.95% DL), BPH, WBPH and GLH with less than 2 hoppers / hill was reported. Grain yield of 3830 to 4561 kg/ ha was recorded in all the three plantings.



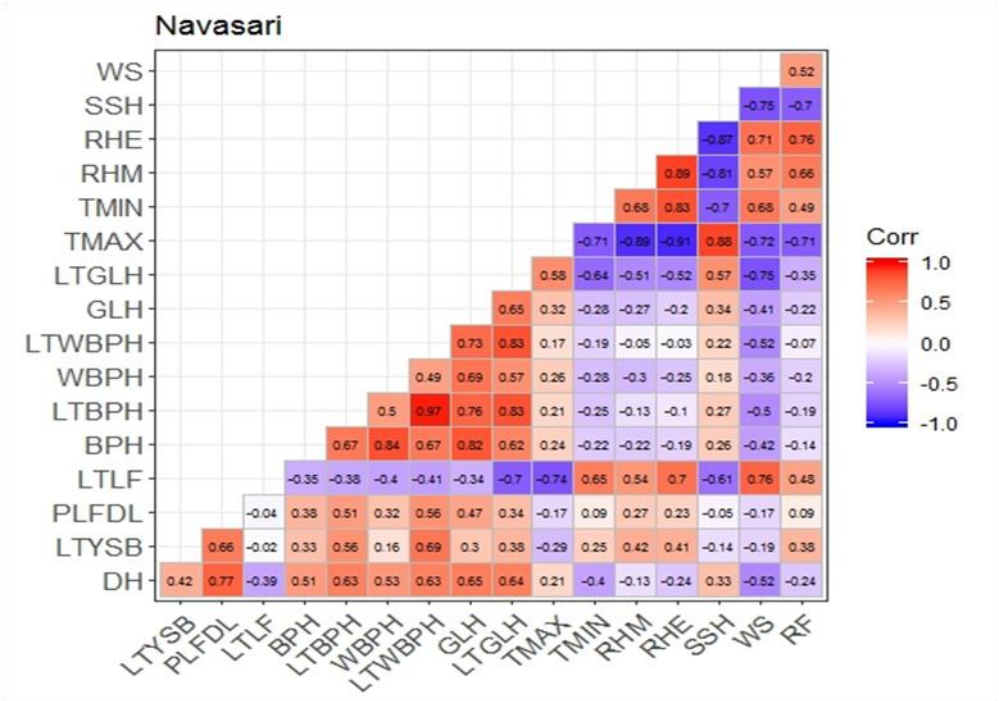
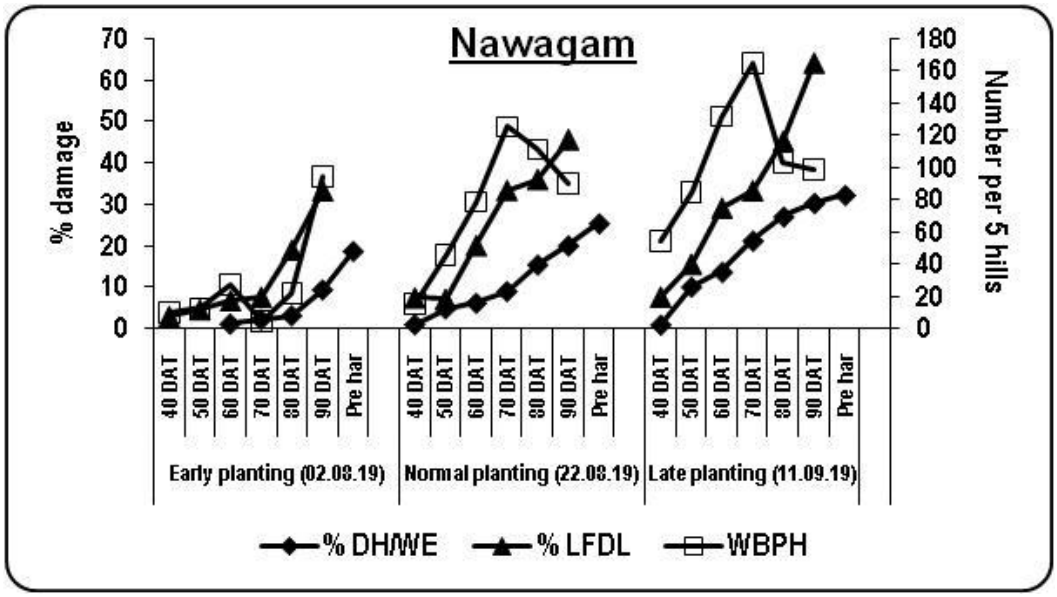


Fig 2.2 Correlation matrix between field incidence, light trap catches and weather parameters at Navasari, *Kharif* 2019

Correlation between field incidence, light trap catches and preceding ten days weather parameters revealed a significant positive relationship between light trap catches of YSB with relative humidity morning (0.42) and relative humidity evening (0.41). A negative non-significant relationship was observed between YSB light trap catches and maximum temperature **(Fig 2.2)**. However, dead heart incidence in the field showed a significant negative relation with wind speed (-0.52) and minimum temperature (-0.40). Similarly, a significant negative correlation was observed between leaf folder light trap catches and maximum temperature (-0.74) and sunshine hours (-0.61) while it was positively significant with minimum temperature (0.65), morning RH (0.54), evening RH (0.70) and wind speed (0.76). However the relation between field incidence of dead hearts or white ears and leaf folder damage with weather parameters was not significant.

15) Nawagam (23° 26' N & 71°95' E), Gujarat: Dead heart damage due to yellow stem borer was high in late planting starting from 60 - 90 DAT (13.54 – 30.22%) and at 90 DAT (19.96%) in normal planting in GR 11 variety. White ears incidence was very high in late planting (32.16%) followed by normal planting (25.29%) and early planting (18.59%).Leaf folder incidence was also very high in late planting starting from 50 – 90 DAT (15.49 – 64.09%) followed by normal planting from 60 – 90 DAT (20.02 – 45.62%) and early planting at 80 – 90 DAT (18.91 – 33.27%). WBPH incidence crossed ETL from 50 – 90 DAT (84.4 – 164.3 hoppers/ 5 hills) in late planting, during 60 – 90 DAT in normal planting (78.1 – 124.8 hoppers/5 hills) and at 90 DAT in early planting (93.7 hoppers/5hills). Very low yield of 2320 kg/ ha was recorded in late planting followed by 2530 kg/ ha in normal planting and 4240 kg/ ha in early planting.



A significant positive correlation was found between light trap catches and preceding ten days maximum temperature (LT YSB = 0.85; LTLF = 0.67 & LTWBPH= 0.81). Field incidence of all the three pests was negatively

correlated with minimum temperature and morning, evening relative humidity **(Fig 2.3)**.

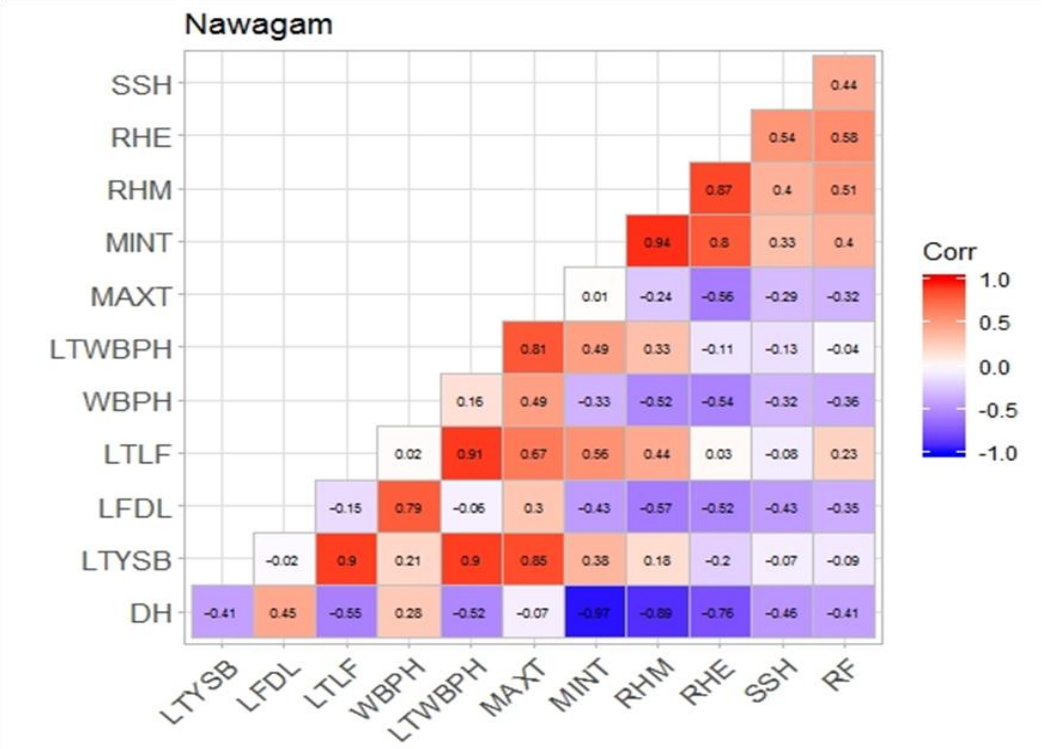
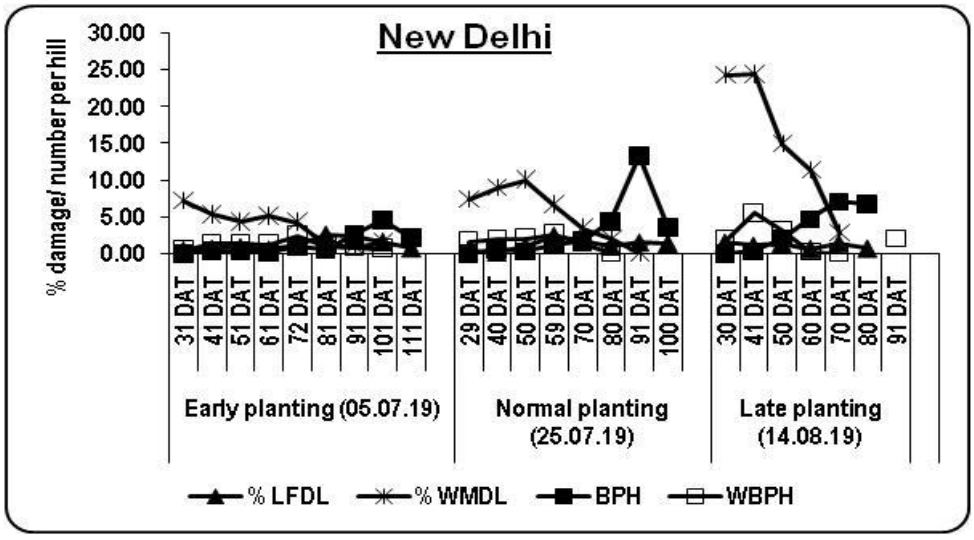
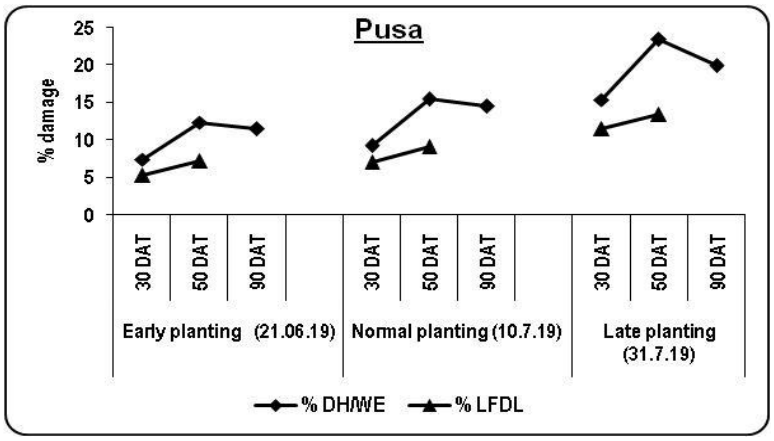


Fig 2.3 Correlation matrix between field incidence, light trap catches and weather parameters at Nawagam, *Kharif* 2019

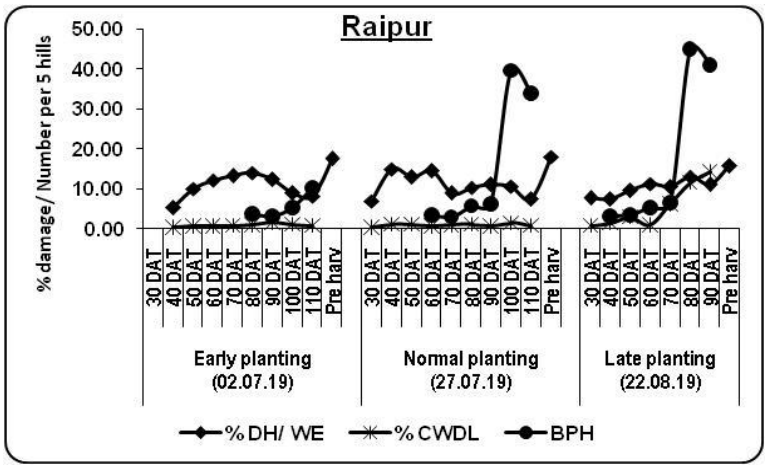
16) New Delhi (28° 61' N & 77° 20' E): High incidence of whorl maggot was observed in late planting starting from 30 DAT till 60 DAT (11.32 – 24.29%DL) as compared to normal and early plantings (<10%) in Pusa 1121 grown in this trial. Very low incidence of leaf folder (<3%), BPH (<8 hoppers/hill) except in normal planting at 91 DAT (13 hoppers/hill) and WBPH (<6 hoppers/hill). Spiders (<0.3 – 2.8/hill) and rove beetles (<0.02 – 2.42/hill) were also recorded in all the three plantings.

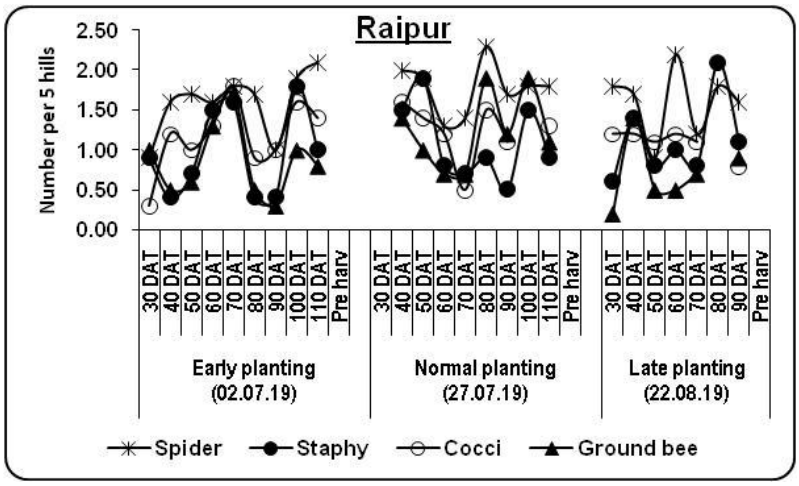


17) Pusa (25°98'N & 85°64' E), Bihar: Stem borer incidence was reported high in late planting resulting in 19.38% dead hearts and 19.92% white ears in Rajendra mansuri variety grown in this trial. Low incidence of leaf folder was observed in all the three plantings (5.3 – 13.38%). Grain yield of 3970 to 5090 kg/ ha was recorded in three plantings.

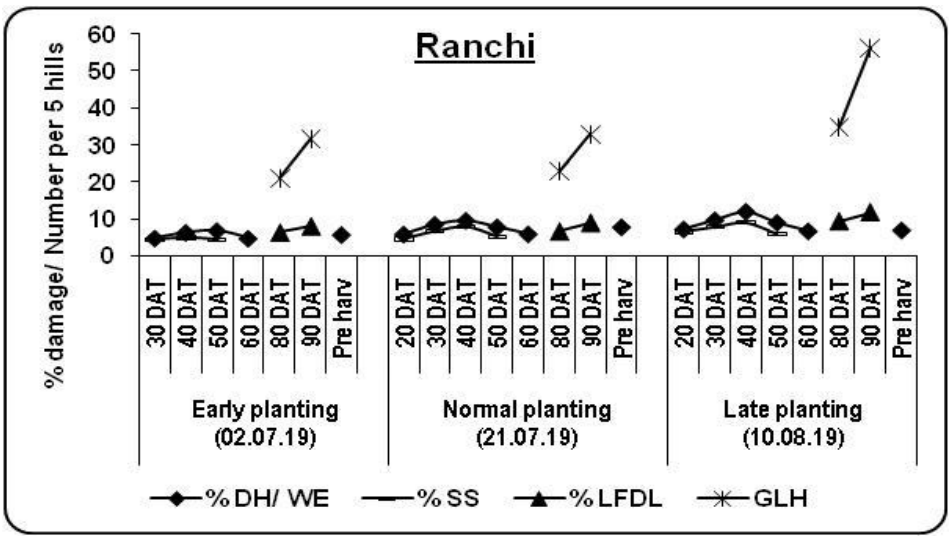


18) Raipur (21° 25'N & 81°63'E), Chhattisgarh: High incidence of stem borer was observed from 50 to 90 DAT (10.07 – 14.00% DH) in early planting, 40 to 60 DAT (12.89 – 14.99% DH) in normal planting and 60 to 90 DAT (10.59 – 11.25% DH) in late planting in Swarna variety grown in this trial. White ear damage of 17.66%, 18.03% and 15.77% was recorded in early, normal and late plantings, respectively. Incidence of leaf folder (<2%), whorl maggot (<2%), hispa (<2%), BPH (0 - 9/hill), WBPH (<1/hill), GLH (<2/hill) was very low. High caseworm incidence was recorded in late planting at 80 – 90 DAT (11.62 – 14.39%DL). Grain yield ranged between 4640 and 6120 kg/ ha in different plantings. Incidence of spiders (0.9-2.30/5 hills), staphylinid beetles (0.40 – 2.10/5hills), ground beetles (0.20 – 1.90/ 5 hills) and coccinellids (0.30 – 1.80/ 5 hills) was also recorded in all the three plantings.

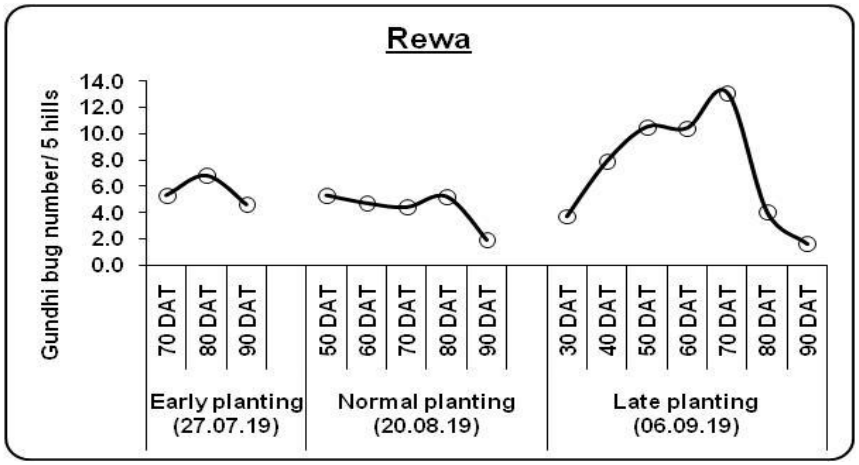




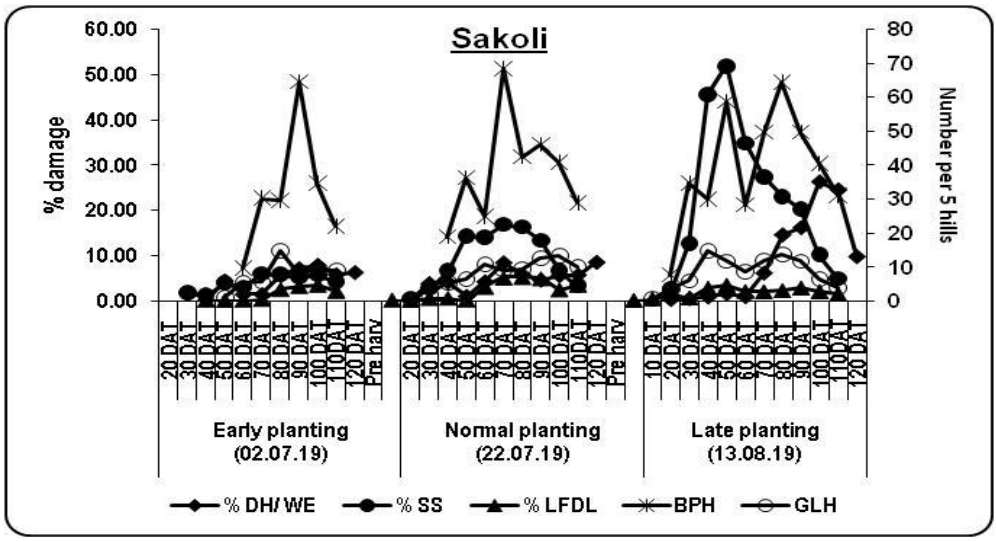
19) Ranchi (23° 34'N & 85°31'E), Jharkhand: Low incidence of stem borer (4.72 – 12.08% DH), gall midge (4.36 – 9.06% SS), leaf folder (6.37 – 11.78% DL), hispa (3.88 – 8.27% DL) and GLH (4.20 – 11.26/hill) was noticed in all the three plantings on Birsa Vikas Sugandha 1 variety grown in this trial. Grain yield varied from 3413 to 4408 kg/ ha in three plantings.



20) Rewa (24° 54'N & 81° 30'E), Madhya Pradesh: Very low incidence on only gundhi bug was recorded in all the three plantings in PS3 variety grown in this trial.



21) Sakoli (21° 08'N & 79° 99'E), Maharashtra: Gall midge incidence was very high in late planting starting from 40 to 110 DAT (10.10 – 51.91% SS) followed by normal planting at 60 – 100 DAT (13.27 – 16.87% SS) while incidence was low in early planting (<6% SS). Stem borer damage was high in late planting between 90 and 120 DAT (14.59 – 26.28%) compared to normal (<9%) and early plantings (<8%). Incidence of leaf folder (<6%), BPH (<16/hill), WBPH (<4/hill) and GLH (<3/hill) was very low. Grain yield of 4720, 4108 and 1960 kg/ ha was recorded in early, normal and late plantings, respectively.



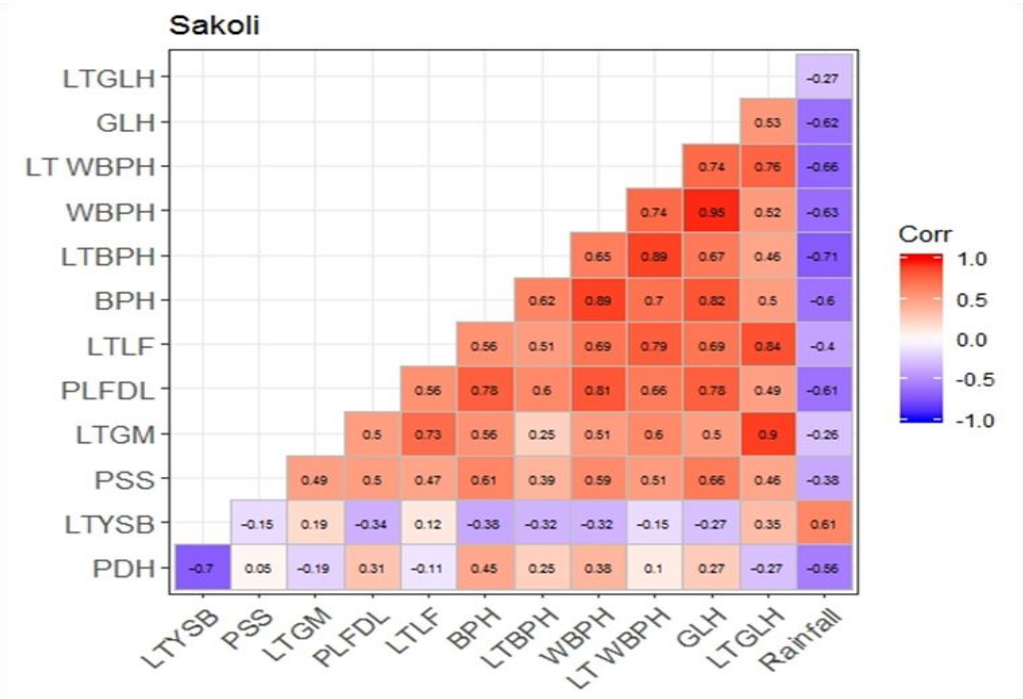
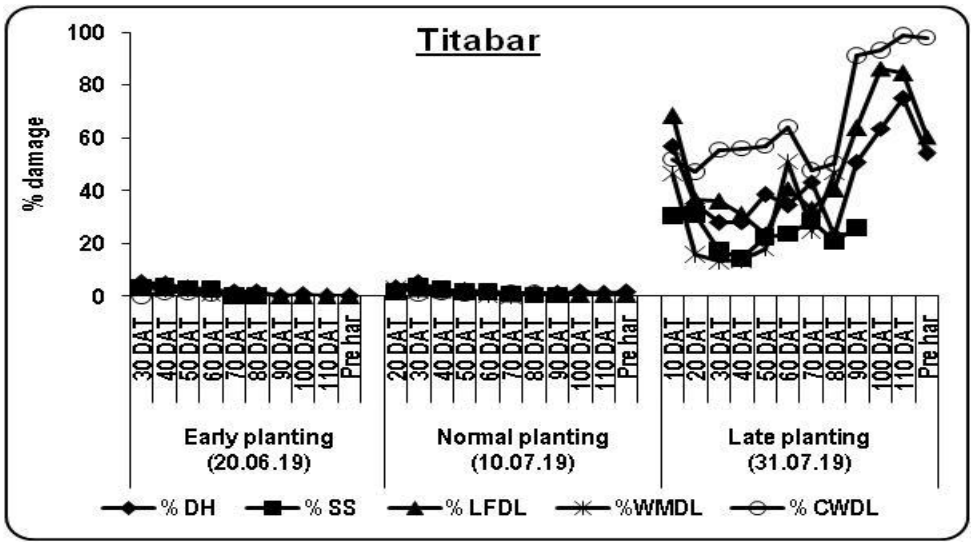


Fig 2.4 Correlation matrix between field incidence, light trap catches and weather parameters at Sakoli, *Kharif* 2019

A significant negative correlation was observed between preceding rainfall and field incidence of various pests **(Fig 2.4)**. Light trap catches of planthoppers were found significantly positively correlated with field incidence whereas it was significantly negative with respect to stem borer.

22) Titabar (26° 58'N & 94° 19'E): Incidence of stem borer, gall midge, leaf folder, whorl maggot and caseworm was very high in late planting in Ranjit variety as compared to early and late plantings. Stem borer damage was very high in late planting and crossed ETL starting from 10 DAT onwards till harvest (22.82 – 75.07% DH & 54.26%% WE). Similarly, gall midge incidence also crossed ETL from 10 – 90 DAT (14.22 – 31.01%) in late planting. Highest Leaf folder damage exceeded ETL from 10 DAT to harvest stage (23.65-86.29%) and highest damage was observed at 100 DAT, while whorl maggot incidence ranged from 13.28 to 50.91% DL from 10 – 80 DAT, in late planting. Caseworm damage was also high in late planting from 10 DAT till harvest (47.23 – 98.58%). Very low incidence of GLH, thrips and WBPH was reported in all the three plantings. Grain yield varied from 4880 to 5500 kg/ ha in all the three plantings.



The relation between light trap catches, field incidence of pests and preceding weather parameters was assessed using Pearson correlation coefficients **(Fig 2.5)**. Data analysis revealed a significant negative correlation between preceding minimum temperature and field incidence of per cent dead hearts (-0.61), per cent leaf folder damaged leaves (-0.66). A significant positive correlation was found between rainfall and light trap catches of YSB (0.72) and leaf folder (0.76). Relative humidity evening was significantly positively correlated with gall midge catches in light trap (0.54) while sunshine hours were significantly negatively correlated (-0.42).

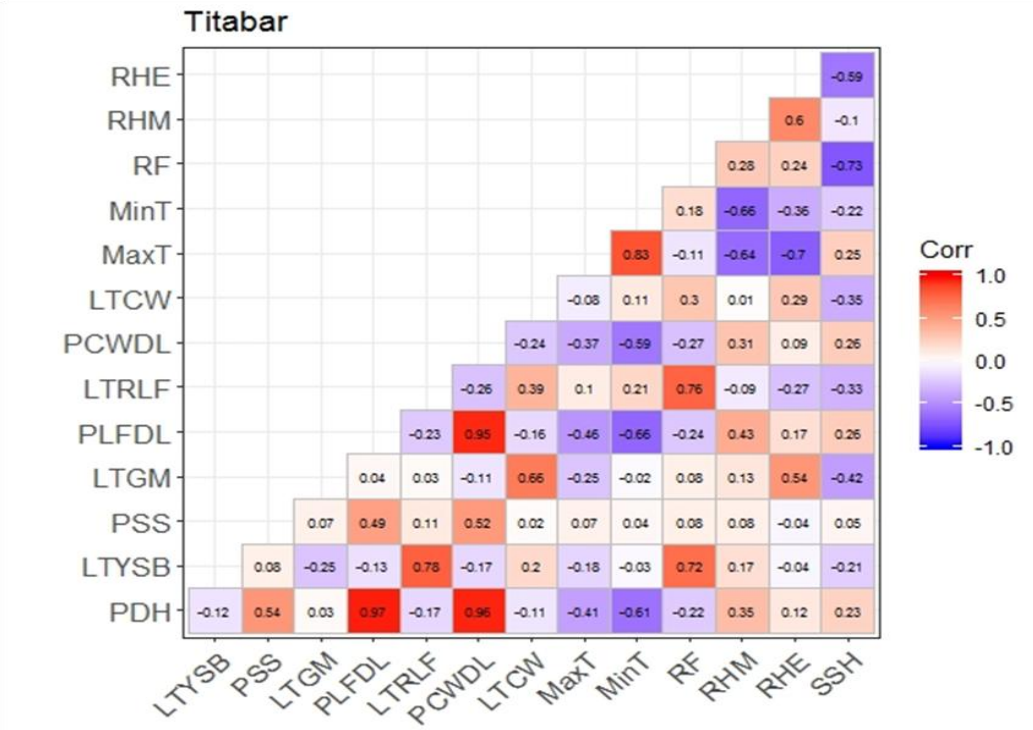


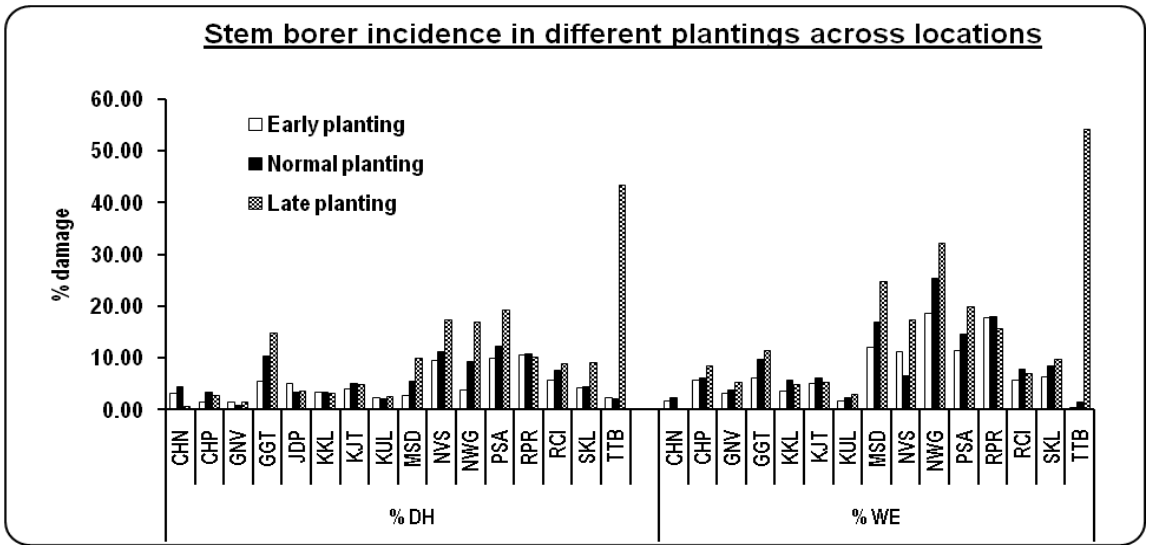
Fig 2.5 Correlation matrix between field incidence, light trap catches and weather parameters at Titabar, *Kharif* 2019

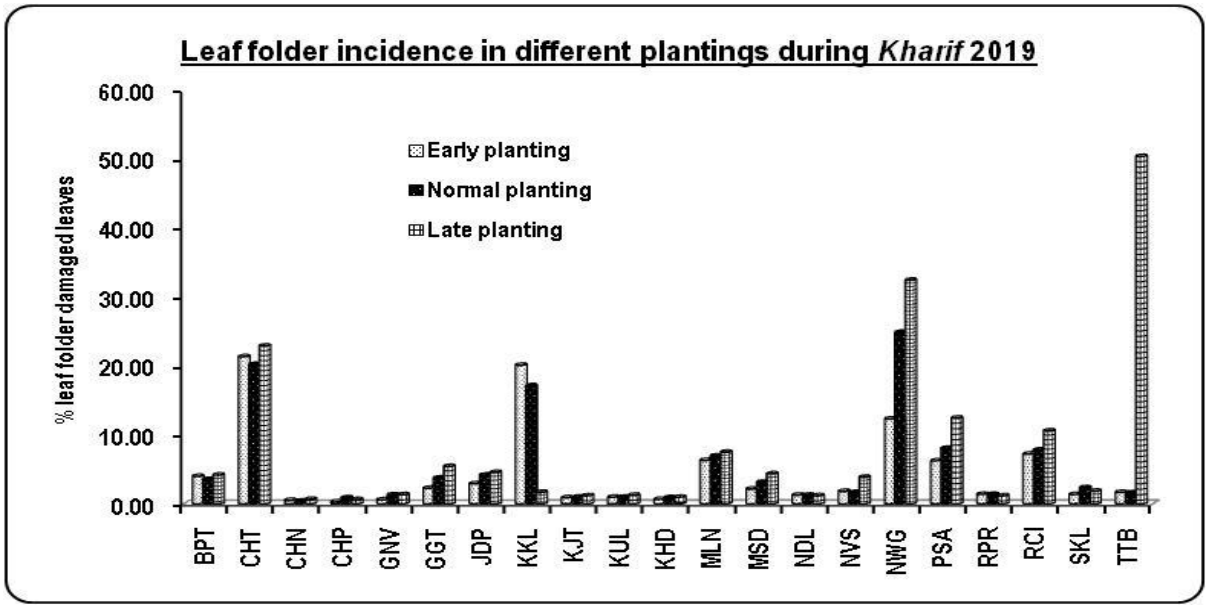
Insect Pest incidence across locations in EPDP

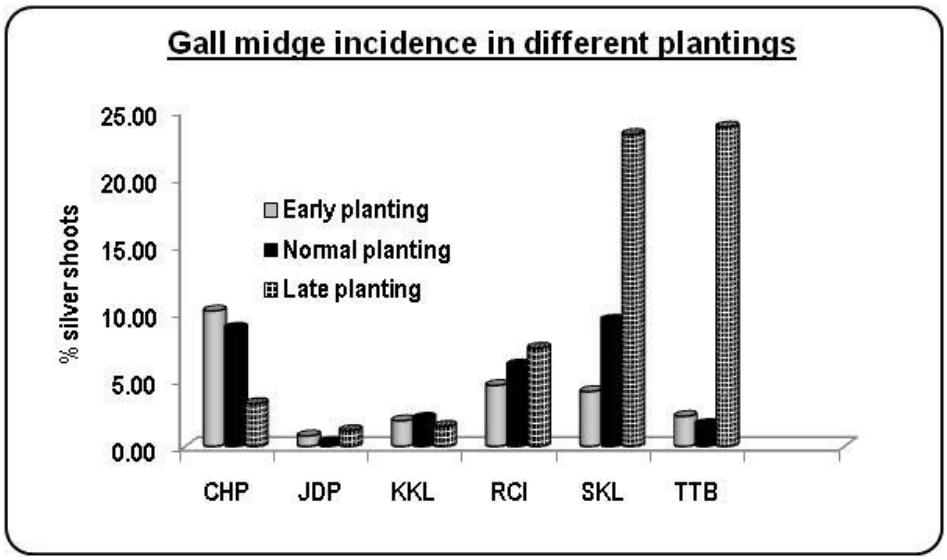
In general, insect pest incidence was low to moderate in EPDP trial across locations during *Kharif* 2019. Incidence of stem borer was reported from 16 locations with maximum damage in late planting. Highest dead heart damage was observed in late planting at Titabar (43.33%) followed by Pusa (19.38%) and Navasari (17.38%). Similarly, maximum white ear damage was also observed in late planting at Titabar (54.26%) followed by late planting at Nawagam (32.16%) and normal planting at Nawagam (25.29%). Gall midge incidence was also the highest (23.85% SS) in late planting at Titabar among 6 locations, followed by Sakoli (23.29). However, the damage was low at other locations and in other two plantings.

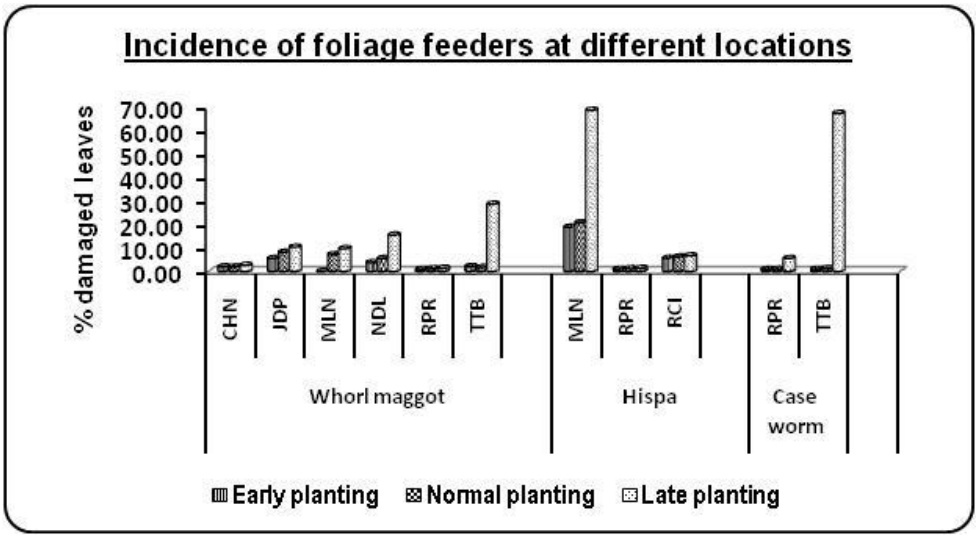
Among the foliage feeding insects, leaf folder incidence was observed at 21 locations with maximum damage in late planting at Titabar (50.44% DL) followed by Nawagam (32.47% DL in late planting and 24.90% DL in normal planting). However, at Chatha, more than 20% damage was observed in all the three plantings while it varied from 17.15 (normal planting) to 20.12% (late planting) at Karaikal. Whorl maggot incidence was recorded at 6 locations and late planting had higher incidence compared to early and normal plantings at all the locations. Hispa damage was reported from 3 locations and Malan centre recorded highest damage of 68.85% in late planting, 20.81% in normal planting and 18.89% in early planting. Case worm incidence was observed at two locations with maximum damage (67.52%) in late planting at Titabar.

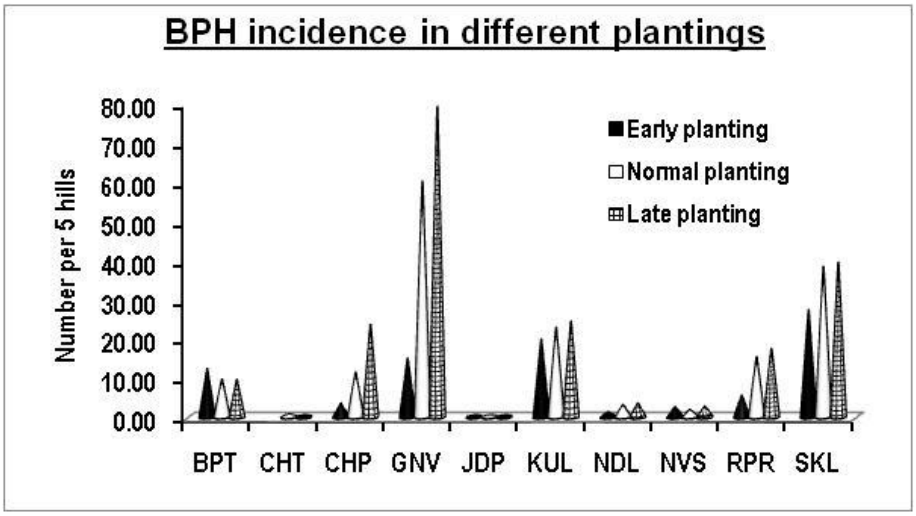
Among the sap sucking insects, WBPH incidence was more as compared to BPH incidence across locations and plantings. BPH incidence was observed at 10 locations with maximum numbers at Gangavathi in late planting (79.10/5 hills) and normal planting (60.02/5 hills). WBPH incidence was recorded from 9 locations with maximum population in late planting at Nawagam (105.70/5hills) followed by late planting (94.03/5 hills) and normal planting (89.53/5hills) at Gangavathi. GLH incidence was reported from 10 locations. The incidence was less than 10% in different plantings at all the locations except Ranchi, which recorded higher population (26.35 - 45.60/5 hills) in all the three plantings.

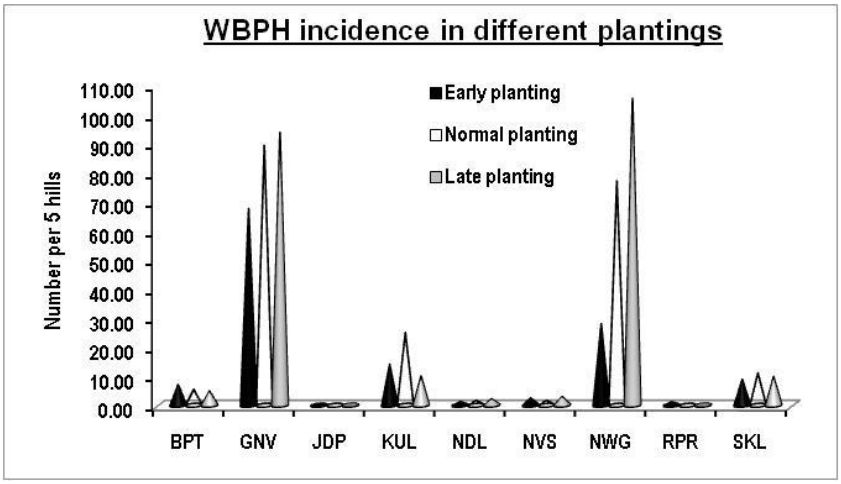





Gall midge incidence in different plantings
% silver shoots
25.00
20.00
15.00
10.00
5.00
0.00
Early planting
Normal planting
Late planting
CHP
JDP
KKL
RCI
SKL
TTB


Incidence of foliage feeders at different locations
% damaged leaves
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
CHN
JDP
MLN
NDL
RPR
TTB
MLN
RPR
RCI
RPR
TTB
Whorl maggot
Hispa
Case worm
Early planting
Normal planting
Late planting


BPH incidence in different plantings
Number per 5 hills
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Early planting
Normal planting
Late planting
BPT
CHT
CHP
GNV
JDP
KUL
NDL
NVS
RPR
SKL



During *Kharif* 2019, the insect pest incidence was low to moderate in different dates of planting across 22 locations. Incidence of stem borer, gall midge, leaf folder, whorl maggot, hispa, caseworm, BPH, WBPH and GLH was found high in late planting as compared to early and normal plantings **(Fig 2.6)**. At Titabar, pest incidence of stem borer, leaf folder and gall midge was significantly high compared to other locations. Low incidence of grasshopper was observed at Chatha and Khudwani, horned caterpillar at Navasari and rice skipper at Khudwani.

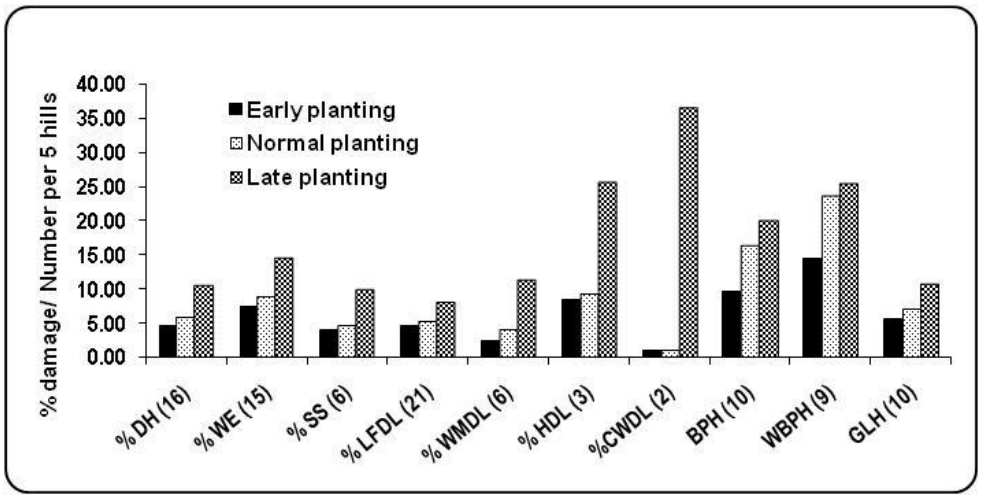


Fig 2.6 Insect pest incidence in different dates of planting during *Kharif* 2019

Effect of planting dates on insect pest incidence (EPDP) trial was conducted at 22 locations during Kharif 2019. Incidence of stem borer was reported from 16 locations with maximum damage in late planting. Highest dead heart damage was observed in late planting at Titabar (43.33% DH & 54.26% WE) followed by Pusa (19.38% DH) and late planting at Nawagam (32.16% WE). Gall midge incidence was noticed at 6 locations with maximum damage in late planting at Titabar (23.85% SS) followed by Sakoli (23.29% SS). Among the foliage feeding insects, leaf folder incidence was observed at 21 locations with maximum damage in late planting at Titabar (50.44% DL) followed by Nawagam in late planting (32.47% DL) and normal planting (24.90% DL).

Whorl maggot incidence was recorded at 6 locations and late planting resulted in higher incidence as compared to early and normal plantings. Hispa damage was reported from 3 locations and Malan centre recorded highest damage of 68.85% in late planting. Case worm incidence was observed at 2 locations with maximum damage (67.52%) in late planting at Titabar. Among the sap sucking insects, WBPH incidence was more as compared to BPH incidence across locations and plantings. BPH incidence was observed at 10 locations with maximum numbers at Gangavathi in late planting (79.10/5 hills) and normal planting (60.02/5 hills). WBPH incidence was recorded from 9 locations with maximum population in late planting at Nawagam (105.70/5hills) followed by late planting (94.03/5 hills) and normal planting (89.53/5hills) at Gangavathi. Low incidence of grasshopper at Chatha and Khudwani (<10%), horned caterpillar at Navasari and rice skipper at Khudwani was observed.

ii) Effect of Iron seed coating on insect pest incidence (ESCP)

Seed priming and seed coating treatments which help to increase the germination rate and improve the anchorage are essential in direct seeding in puddle soils. The high-density Fe coated seeds have also been reported to be resistant to bird damage and seed borne diseases. Keeping this in view, a collaborative trial with Agronomy (YET 4 – Enhancing the productivity of direct seeded rice with iron coating under different rice ecologies) was initiated with an objective to assess and generate useful information on the impact of iron seed coating on insect pest incidence.

During *Kharif* 2019, observations on insect pest incidence were recorded at 3 locations, *viz.,* Raipur, Karjat and Chiplima. The field trial was laid out , in split plot design with 4 dates of sowings at one week interval as main plots and 5 establishment methods (T1- Iron coated seed, seed rate 25 kg/ha, broadcasting in 1-2 mm water level condition (Direct sowing) T2- Iron coated seed, seed rate 25 kg/ha, broadcasting in wet Condition (Direct sowing) T3 – Un-coated seed, seed rate 25 kg/ha, broadcasting in 1-2 mm water level condition (Direct sowing) T4 – Uncoated seed, seed rate 25 kg/ha, broadcasting in wet condition (Direct sowing) T5 – Normal transplanting 21-25 days after sowing as subplots in 3 replications. Standard procedures were followed to record observations on insect pest incidence in all treatments. The results are summarized below.

At **Raipur**, there was low to moderate incidence of stem borer (5.2-16.7% DH & 8.4-3.3% WE) and low incidence of leaf folder (0.5–3.7% LFDL), whorl maggot (0.5-3.0% WMDL), case worm (0.0-4.0% CWDL), hispa (0.4–3.9% HDL), brown planthopper (3 – 9 hoppers/hill) and green leaf hopper (0 – 5 hoppers/hill) in Swarna variety grown in this trial. Dead heart and white ear damage by stem borer was at par in different dates of sowings whereas sub plot T1 (Iron coated seed, seed rate 25 kg/ha, broadcasting in 1-2 mm water level condition -Direct sowing) recorded significantly lowest dead heart damage (7.7% DH) compared to other sub plots **(Table 2.15)**. White ear damage was at par in all the sub plots. Interaction effects are almost at par

with each other in different treatments. Observations on natural enemies were also recorded to know the impact of seed coating. Data revealed that Spiders (0-4/hill) and Coccinellids (0-4/hill) were relatively higher than Staphylinid and Rove beetles (0-3/hill).

Table 2.15 Effect of Iron Seed Coating on Pest Incidence (ESCP) at Raipur, *Kharif* 2019

Main plots		**%DH**	**%WE**	**%LFDL**	**%WMDL**	**BPH (No./hill)**
1st sowing (19.07.2019)		8.7(3.0)a	14.5(3.9)a	1.3(1.3)b	1.5(1.4)b	5(2)ab
2nd sowing (26.07.2019)		8.7(3.0)a	14.4(3.8)a	1.9(1.5)a	1.5(1.4)b	6(2)a
3rd sowing (02.08.2019)		9.8(3.2)a	16.4(4.1)a	1.8(1.5)ab	1.8(1.5)a	5(2)b
4th sowing (09.08.2019)		10.8 (3.3)a	15.4(3.9)a	1.9(1.5)a	1.7(1.5)ab	6(2)a
LSD (0.05)	**Main plots**	**0.32**	**0.38**	**0.17**	**0.07**	**0.63**
CV(%)		**11.39**	**10.9**	**13.01**	**5.28**	**6.13**
Sub plots						
T1 = Broadcasting of Iron coated seed in 1-2 mm water level		7.7(2.8)b	15.0(3.9)a	1.6(1.4)a	1.3(1.3)b	5(2)ab
T2 = Broadcasting of Iron coated seed in wet soil condition		10.6(3.3)a	14.6(3.9)a	1.5(1.4)a	1.6(1.4)ab	5(2)ab
T3 = Broadcasting of un coated seed in 1-2 mm water level		9.5(3.1)ab	16.6(4.1)a	1.6(1.4)a	1.8(1.5)a	6(3)a
T4 = Broadcasting of un coated seed in wet soil condition		10.1(3.2)a	14.4(3.9)a	2.0(1.6)a	1.5(1.4)ab	5(2)b
T5 = Normal transplanting		9.6(3.1)ab	15.3(4.0)a	2.0(1.6)a	1.9(1.5)a	6(3)a
LSD (0.05)	**Sub plots**	**0.33**	**0.29**	**0.21**	**0.16**	**1.14**
CV(%)		**12.64**	**8.79**	**17.56**	**13.5**	**11.83**
1st sowing (19.07.2019)	T1	6.1(2.6)d	14.4(3.8)abc	1.1(1.2)de	1.2(1.3)b	5(2)abc
	T2	11.2(3.4)abc	14.1(3.8)abc	1.5(1.4)abcde	1.8(1.5)a	5(2)bc
	T3	8.9(3.0)abcd	14.7(3.9)abc	0.6(1.1)e	1.6(1.4)a	6(3)abc
	T4	7.9(2.9)bcd	15.5(4.0)abc	1.3(1.4)abcde	1.2(1.3)b	4(2)c
	T5	9.5(3.2)abcd	13.8(3.8)abc	2.1(1.6)abcd	1.9(1.5)a	6(2)abc
2nd sowing (26.07.2019)	T1	8.3(2.9)abcd	14.8(3.9)abc	1.1(1.3)cde	1.6(1.5)a	5(2)abc
	T2	9.5(3.2)abcd	15.6(4.0)abc	1.6(1.4)abcde	1.6(1.4)a	7(3)ab
	T3	8.9(3.0)abcd	15.6(4.0)abc	1.8(1.5)abcde	2.0(1.6)a	6(3)abc
	T4	7.8(2.9)bcd	13.7(3.8)abc	2.3(1.7)abc	1.0(1.2)b	4(2)c
	T5	9.0(3.1)abcd	12.5(3.6)bc	2.6(1.8)a	1.5(1.4)a	7(3)a
3rd sowing (02.08.2019)	T1	7.4(2.8)cd	15.7(4.0)abc	1.7(1.4)abcde	1.5(1.4)a	5(2)bc
	T2	10.3(3.3)abc	15.9(4.0)abc	1.6(1.4)abcde	1.6(1.4)a	5(2)abc
	T3	9.6(3.2)abcd	18.5(4.4)a	2.2(1.6)abcd	1.6(1.5)a	5(2)abc
	T4	12.1(3.5)ab	15.3(4.0)abc	2.1(1.6)abcd	1.8(1.5)a	5(2)bc
	T5	9.5(3.2)abcd	16.7(4.1)abc	1.5(1.4)abcde	2.2(1.6)a	5(2)abc
4th sowing (09.08.2019)	T1	9.0(3.1)abcd	14.9(3.9)abc	2.4(1.7)ab	1.0(1.2)b	6(2)abc
	T2	11.3(3.4)abc	13.0(3.6)c	1.2(1.3)bcde	1.4(1.3)b	5(2)abc
	T3	10.7(3.3)abc	17.7(4.3)ab	1.7(1.5)abcde	2.0(1.5)a	7(3)ab
	T4	12.5(3.6)a	13.3(3.7)bc	2.4(1.7)abcd	2.2(1.6)a	5(2)abc
	T5	10.3(3.3)abc	17.8(4.3)ab	1.8(1.5)abcd	1.9(1.5)a	5(2)abc
LSD (0.05)	**M in S**	**0.66**	**0.58**	**0.43**	**0.32**	**0.47**
	S in M	**0.67**	**0.64**	**0.42**	**0.3**	**0.44**

Table 2.16 Effect of Iron seed coating on pest incidence (ESCP) at Karjat, *Kharif* 2019

Main plots		% DH			% WE
		15 DAT	30 DAT	45 DAT	Pre har
1st sowing (03.07.2019)		6.4(2.5)a	2.0(1.4)a	2.1(1.5)a	7.1(2.7)a
2nd sowing (10.07.2019)		4.2(2.1)a	0.11(0.7)b	0.7(1.0)b	6.9(2.6)a
3rd sowing (17.07.2019)		4.9(2.1)a	1.7(1.4)a	1.3(1.3)ab	4.8(2.3)b
4th sowing (24.07.2019)		0.8(1.0)b	0.2(0.8)b	0.7(1.0)b	4.1(2.1)b
LSD (0.05)		**0.92**	**0.53**	**0.32**	**0.23**
CV(%)		**13.39**	**14.75**	**29.88**	**10.85**
Sub plots					
T1 = Broadcasting of Iron coated seed in 1-2 mm water level		4.8(2.1)a	1.4(1.2)a	1.9(1.5)a	6.0(2.5)ab
T2 = Broadcasting of Iron coated seed in wet soil		4.3(2.0)a	1.6(1.3)a	0.8(1.1)b	4.8(2.2)b
T3 = Broadcasting of un coated seed in 1-2 mm water level		3.7(1.7)a	0.5(0.9)a	0.7(1.1)b	7.1(2.7)a
T4 = Broadcasting of un coated seed in wet soil		3.2(1.8)a	0.9(1.1)a	1.5(1.3)ab	4.7(2.2)b
T5 = Normal transplanting		4.4(2.0)a	0.5(0.9)a	1.0(1.1)b	6.0(2.5)ab
LSD (0.05)		**0.57**	**0.36**	**0.30**	**0.42**
CV(%)		**15.36**	**10.15**	**30.53**	**20.74**
Interactions					
1st sowing (03.07.2019)	T1	4.6(2.2)abc	3.4(1.8)ab	3.1(1.9)a	6.2(2.6)abcd
	T2	5.3(2.4)abc	4.3(1.9)a	1.8(1.4)abc	4.6(2.2)bcd
	T3	10.3(3.2)a	0.8(1.0)cd	2.1(1.6)ab	9.6(3.1)a
	T4	4.9(2.2)abc	1.3(1.3)abcd	1.7(1.5)abc	6.4(2.6)abcd
	T5	6.6(2.5)abc	0.0(0.7)d	1.7(1.4)abc	8.3(2.9)ab
2nd sowing (10.07.2019)	T1	5.2(2.4)abc	0.0(0.7)d	1.0(1.2)bcd	6.5(2.6)abcd
	T2	4.6(2.2)abc	0.0(0.7)d	1.0(1.2)bcd	8.0(2.9)abc
	T3	3.1(1.9)abcd	0.0(0.7)d	0.0(0.7)d	8.8(3.0)ab
	T4	3.5(1.8)abcd	0.6(1.0)cd	0.5(1.0)cd	4.9(2.3)bcd
	T5	4.8(2.3)abc	0.0(0.7)d	1.1(1.2)bcd	6.2(2.5)abcd
3rd sowing (17.07.2019)	T1	8.4(2.8)a	2.2(1.6)abc	1.7(1.5)abc	6.0(2.5)abcd
	T2	5.5(2.2)abc	1.3(1.3)abcd	0.5(0.9)cd	3.3(1.9)d
	T3	1.2(1.1)cd	1.1(1.2)abcd	1.0(1.2)bcd	6.6(2.7)abcd
	T4	3.2(1.9)abcd	1.8(1.5)abc	2.6(1.7)ab	3.5(2.0)cd
	T5	6.1(2.5)ab	2.1(1.5)abcd	0.5(1.0)cd	4.7(2.3)bcd
4th sowing (24.07.2019)	T1	1.0(1.1)cd	0.0(0.7)d	2.0(1.6)abc	5.3(2.4)abcd
	T2	1.8(1.3)bcd	0.9(1.1)bcd	0.0(0.7)d	3.3(1.9)d
	T3	0.0(0.7)d	0.0(0.7)d	0.0(0.7)d	3.4(2.0)d
	T4	1.1(1.1)cd	0.0(0.7)d	1.0(1.2)bcd	3.8(2.1)cd
	T5	0.0(0.7)d	0.0(0.7)d	0.6(0.9)cd	4.8(2.3)bcd
LSD (0.05)	**M in S**	**1.14**	**0.72**	**0.62**	**0.84**
	S in M	**1.37**	**0.83**	**0.64**	**0.38**

At **Karjat,** only stem borer incidence was observed in different sowings and treatments in Swarna variety **(Table 2.16)**. Though the dead heart incidence was significantly high in first sowing starting from 15 DAT to 45 DAT (2.0-6.4%

DH) and 7.1% WE at pre-harvest compared to other sowings, the stem borer damage did not reach ETL. Similarly, dead heart damage was at par in different sub-plot treatments while white ears were relatively high (7.1% WE) in T3 subplot (Broadcasting of uncoated seed in 1-2 mm water).

At **Chiplima**, stem borer, gall midge and brown planthopper incidence was observed in first sowing in different treatments in Swarna variety grown in this trial **(Table 2.17)**. Gall midge incidence was very high in normal transplanting (18.9-30.3% SS) and was at par with T3 (hydro primed flooded treatment – 20.3-24.8% SS) compared to other treatments during 55 to 75 DAT. Similarly, BPH incidence was significantly high in normal transplanting (26-39 hoppers/hill) which was at par with T3 (25-39 hoppers/hill). Stem borer incidence was low both at vegetative and reproductive stages in all the treatments.

Pest incidence data from only Karjat and Raipur were included for analysis of impact of sowing on pest occurrence **(Fig 2.7)**. The stem borer damage across the sowings was not significant with dead heart damage of 0.1 to 10.8% and 4.1 to16.4% white ears across the treatments. Data from all three locations were considered for analysis of effect of iron coating on pest incidence. The different iron coated seed treatments across locations revealed no significant differences in dead heart damage of 0.5 to 10.6% and white ear damage of 3.9 to 16.6% across all the locations **(Fig 2.8)**. Gall midge incidence recorded only at Chiplima, was lowest in T2 treatment (9.2% SS) and significantly superior to remaining treatments. It was high in T5- normal transplanting (24.6% SS) on par with T3 treatment with uncoated seed (22.6% SS). Similalrly BPH population was lowest in T2 treatment (11 hoppers/hill) followed by other Iron seed coated treatments (19 hoppers/hill) compared to normal (33 hoppers/hill) transplanting and uncoated seed treatments (32 hoppers/hill). Incidence of other pests like leaf folder, whorl maggot, case worm and hispa was very low (<5%) to draw valid conclusions.

Table 2.17 Effect of Iron seed coating on insect pest incidence (ESCP) at Chiplima, *Kharif* 2019

Treatments	% DH		% WE	% SS		BPH	
	55 DAT	75 DAT	Pre har	55 DAT	75 DAT	55 DAT	75 DAT
T1: Fe coated flooded	3.0(1.9)b	5.5(2.4)b	6.2(2.6)a	16.0(4.0)b	11.8(3.5)b	17(4)bc	21(5)b
T2: Fe coated dry	2.4(1.7)b	1.6(1.4)c	3.9(2.1)b	11.0(3.4)c	7.4(2.8)c	9(3)d	12(3)c
T3: Hydro primed flooded	5.6(2.5)a	7.6(2.9)a	7.6(2.9)a	24.8(5.0)a	20.3(4.6)a	25(5)ab	39(6)a
T4: Hydro primed dry	2.6(1.7)b	5.0(2.3)b	7.8(2.9)a	14.8(3.9)b	10.5(3.3)b	16(4)cd	22(5)b
T5: Normal transplanting	7.4(2.8)a	5.5(2.4)b	6.3(2.6)a	30.3(5.5)a	18.9(4.4)a	26(5)a	39(6)a
LSD (0.05)	**0.56**	**0.47**	**0.38**	**0.54**	**0.46**	**0.84**	**1.03**
CV(%)	**14.01**	**10.83**	**7.84**	**6.6**	**6.63**	**10.16**	**10.81**

Across the locations, there were no significant differences with respect to stem borer damage (0.5 – 10.6% DH & 3.9 – 16.6% WE). However, at Chiplima, T2 treatment (Fe coated seed in dry condition) showed significantly lower incidence of gall midge (9.2 – 13.9% SS) and BPH (11 – 19 hoppers/ hill).

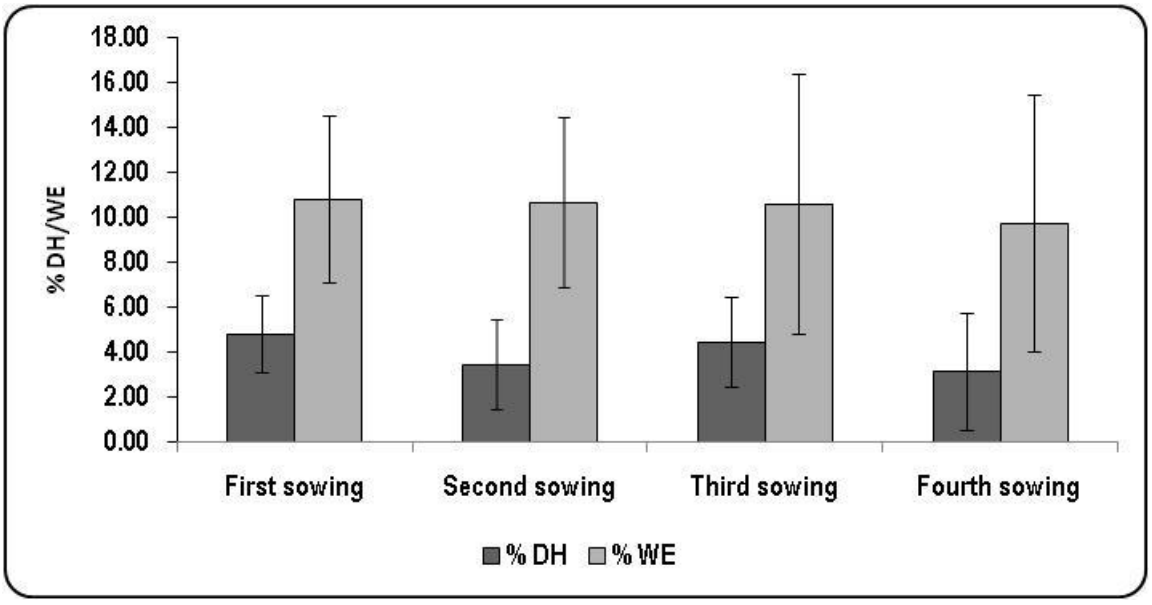


Fig. 2.7 Effect of seed coating on pest incidence in different sowings across locations, *Kharif* 2019

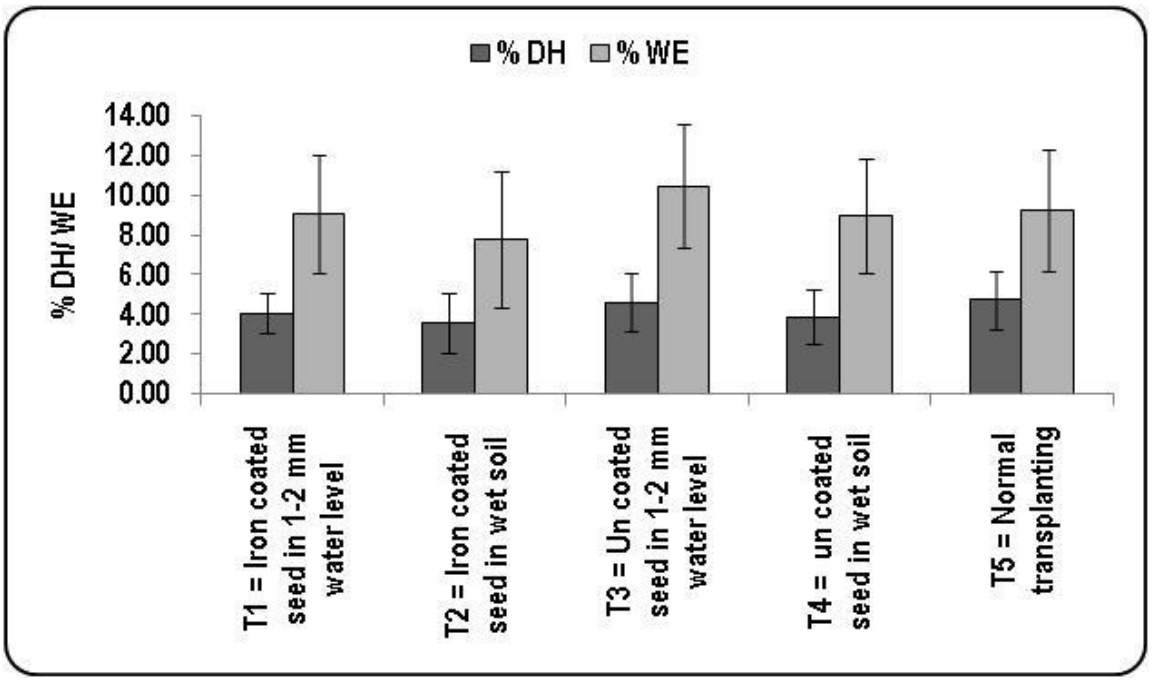


Fig 2.8.Effect of seed coating on pest incidence across locations, *kharif* 2019

Effect of iron seed coating on insect pest incidence (ESCP), initiated this year in collaboration with agronomy revealed, low pest incidence across the locations in different treatments. Stem borer incidence was at par in different seed coated treatments (0.5 – 10.6% DH & 3.9 – 16.6% WE) and also in different sowings (0.1 – 10.8% DH & 4.1 - 16.4% WE). However, gall midge (9.2 – 13.9% SS) and BPH incidence (11-19/hoppers hill) was found low in seed coated treatments compared to normal transplanting (24.6% SS & 33/hill) and T3 treatment with uncoated seed (22.6%SS & 32/hill).

iii) Influence of Establishment Methods on Pest Incidence (IEMP)

In India, rice is grown traditionally by manual transplanting method which requires more water and labour leading to high crop production costs. To overcome these constraints, the, farmers are gradually shifting to alternative methods of rice cultivation like direct seeding, aerobic rice, mechanical transplanting etc. Hence, a collaborative trial with Agronomy section was initiated In order to assess the influence of crop establishment methods and weed management strategies on pest incidence.

The field trial was laid out in split plot design with three replications. Main plot treatments comprised of three different crop establishment methods (M1: Mechanised transplanting, M2: Puddled direct seeding and M3: Unpuddled dry direct seeding. The sub plot treatments comprised of four weed management treatments (S1 = Weed free; S2 = Weedy check; S3 = Mechanical weeding using weeder; S4 = Chemical weed control (pre and post emergence herbicide application)

During *Kharif* 2019, the trial was conducted at eight locations, *viz,* Aduthurai, Chiplima, Jagdalpur, Ludhiana, Malan, Mandya, Moncompu and Rajendranagar. Standard procedures were adopted to record insect pest incidence in different main and sub plot treatments. The results are summarized below.

At **Aduthurai**, the three main plots included mechanical transplanting, puddled direct seeding and unpuddled direct seeding methods of crop establishment, while the four sub plots consisted of weed free, weedy check, mechanical weeding and chemical weed control treatments. Incidence of stem borer, hispa, whorl maggot and BPH was observed **(Table 2.18)**. Dead heart incidence was low in different crop establishment methods and sub-plots with weed management treatments except in weedy check which recorded 10.70% DH exceeding ETL **(Table 2.18)**. However, white ear damage was high in all the main plots (15.74-27.54%) and sub plots (17.44 to 24.24%). Lowest white ear damage was recorded in Mechanised transplanting (15.74% WE) followed by puddled direct seeding (19.73% WE), while maximum white ear damage was observed in unpuddled direct seeding (27.54% WE). There were significant differences among the treatments. Among the sub-plots, weed free plot exhibited least white ear incidence (17.44%) significantly superior to mechanical weeding (20.30% WE), chemical weed treatment (22.02% WE), while weedy check treatment recorded highest incidence (24.24%). Interactive effects revealed that mechanised transplanting with weed free subplot showed the least white ear incidence (10.50%) followed by mechanical weeding subplot (15.50% WE) which was at par with puddled direct sowing with weed free sub plot (16.33% WE). These three treatments were significantly superior to rest of the treatments. Similarly, hispa damage was also significantly low in

mechanised transplanting main plot (8.47% DL) and weed free sub plot (10.23% DL) while highest damage was recorded in unpuddled direct sowing (27.54% DL) and weedy check sub plot (24.24% DL). Whorl maggot (maximum of 8.23% DL and BPH (2.16 hoppers/hill) incidence was very low across main and sub plots. Though there were significant differences, no trends were discernible on the effect of the treatments on these two pests.

Table 2.18 Influence of Crop Establishment Methods on Pest Incidence at Aduthurai, *Kharif* 2019

Treatments		% DH	% WE	% HDL	% WMDL	BPH/hill
Mechanised transplanting	Weed free	6.73g	10.50i	3.67j	2.67h	0.60g
	Weedy check	9.43cd	19.43f	13.57f	6.17e	1.53de
	Mechanical weeding	7.07g	15.50h	17.03i	2.27g	0.97f
	Chemical weed control	7.93f	17.53g	9.60h	4.27f	1.10f
Puddled direct seeding	Weed free	7.23g	16.33h	11.97g	5.47e	1.30ef
	Weedy check	10.73b	23.67d	17.07c	8.43ab	2.17b
	Mechanical weeding	8.70e	18.20g	14.47e	7.17d	1.60de
	Chemical weed control	8.97de	20.70e	15.50d	7.57cd	1.83cd
Unpuddled direct seeding	Weed free	8.60e	25.50c	15.07de	7.37d	1.57de
	Weedy check	11.93a	29.63a	18.83a	8.83a	2.80a
	Mechanical weeding	9.33cd	27.20b	16.60c	8.13bc	2.00bc
	Chemical weed control	9.97c	27.83b	17.83b	8.60ab	2.27b
LSD (0.05)	**M in S**	**0.67**	**0.66**	**0.63**	**0.48**	**0.32**
	S in M	**0.62**	**0.84**	**0.71**	**0.84**	**0.34**
Main plots						
M1 = Mechanised transplanting		7.79c	15.74c	8.47c	4.09c	1.05c
M2 = Puddled direct seeding		8.91b	19.73b	14.75b	7.16b	1.73b
M3 = Unpuddled direct seeding		9.96a	27.54a	17.08a	8.23a	2.16a
LSD (0.05)		**0.23**	**0.63**	**0.47**	**0.74**	**0.20**
CV (%)		**2.27**	**2.64**	**3.06**	**10.08**	**10.87**
Sub plots						
S1 = Weed free		7.52d	17.44d	10.23d	5.17d	1.15d
S2 = Weedy check		10.70a	24.24a	16.49a	7.81a	2.17a
S3 = Mechanical weeding		8.37c	20.30c	12.70c	6.19c	1.52c
S4 = Chemical weed control		8.96b	22.02b	14.31b	6.81b	1.73b
LSD (0.05)		**0.39**	**0.38**	**0.37**	**0.28**	**0.19**
CV (%)		**4.39**	**1.83**	**2.74**	**4.35**	**11.45**

At **Chiplima**, five crop establishment methods, viz., normal transplanting, sowing behind the plough, mechanical line sowing, manual line sowing and broadcasting were evaluated with MTU 1156 variety. Low incidence of stem borer (2.07 to 6.62 DH% during 55 to 75 DAT & up to 6.91% WE), gall midge (3.09 to 7.33 SS% during 55 to 75 DAT) and BPH (29-33 to 38.00 hoppers/5 hills) was observed in all the establishment methods **(Table 2.19)**. Broadcasting method showed pest damage at par with normal

transplanting method, however there were no discernible trends among the treatments.

Table 2.19 Influence of Crop Establishment Methods on Pest Incidence at Chiplima, *Kharif* 2019

Treatments	% DH		% WE	% SS		BPH/ 5 hills
	55 DAT	75 DAT	Pre har	55 DAT	75 DAT	75 DAT
T1 = Normal transplanting	5.00 (2.11)a	4.47 (2.09)ab	2.97 (1.69)b	7.33 (2.71)a	5.95 (2.42)ab	31.00 (5.56)b
T2 = Sowing behind the plough	4.33 (2.07)a	4.71 (2.15)ab	5.88 (2.39)ab	7.39 (2.71)a	8.34 (2.89)a	34.67 (5.88)ab
T3 = Mechanical line sowing	2.23 (1.47)b	4.53 (2.12)ab	6.91 (2.61)a	3.09 (1.75)c	4.94 (2.21)b	29.33 (5.41)b
T4 = Manual line sowing	2.07 (1.42)b	3.71 (1.92)b	3.89 (1.97)ab	5.22 (2.28)b	6.04 (2.46)ab	30.67 (5.53)b
T5 = Broadcasting	5.47 (2.32)a	6.62 (2.55)a	5.91 (2.43)a	5.91 (2.43)ab	6.63 (2.55)ab	38.00 (6.16)a
LSD 0.05	***0.53***	***0.61***	***0.73***	***0.37***	***0.54***	***0.58***
CV (%)	***14.91***	***14.79***	***17.40***	***8.32***	***11.43***	***5.40***

At **Jagdalpur**, the trial was carried out with Durgeshwary variety and included three main plots with mechanical transplanting, puddled direct seeding and unpuddled dry direct seeding methods of crop establishment and four sub plots with weed free, weedy check, mechanical weeding and chemical weed control treatments. Observations were recorded on incidence of stem borer, leaf folder, whorl maggot and GLH. Low incidence of stem borer was recorded in all the treatments (0.7 to 9.7% DH) except in weedy check sub plot of unpuddled dry direct seeding which showed 17.9% dead heart damage at 70 DAT **(Table 2.20)**. Leaf folder (up to 8.7 % DL), whorl maggot (maximum of 10.7% DL) and GLH (highest of 12.7 hoppers/10 hills) incidence was also low and there were no significant trends in the impact of treatments on pest incidence.

At **Ludhiana**, three establishment methods, viz., ridge planting, flat planting and bed planting were practiced at three plant densities of 33 plants, 25 plants and 20 plants per square meter with PR 121 variety. Very low incidence of stem borer, leaf folder and planthoppers was observed in all the treatments **(Table 2.21)**.

At **Malan**, Direct seeding, normal transplanting and semi dry rice methods were evaluated in this trial. Incidence of leaf folder was observed ranging from 13.89 to 23.24% DL during 45 to 90 DAT in different crop establishment methods with maximum damage in normal transplanting method (17.68 – 23.24% LFDL) followed by semi dry rice and direct seeding **(Table 2.22)**.

Table 2.20 Influence of Crop Establishment Methods on Pest Incidence at Jagdalpur, *Kharif* 2019

Treatments		% DH		%LFDL	% WMDL	GLH/10 hills
		50 DAT	70 DAT	70 DAT	70 DAT	70 DAT
Mechanised transplanting	Weed free	0.8(1.0)b	2.5(1.6)b	8.2(3.0)a	9.4(3.1)ab	9.3(3.1)a
	Weedy check	0.7(1.0)b	6.7(2.6)ab	6.1(2.5)a	13.7(3.8)a	7.0(2.7)a
	Mechanical weeding	0.8(1.0)b	2.7(1.7)b	8.1(2.7)a	9.8(3.2)ab	10.7(3.3)a
	Chemical weed control	5.5(2.3)a	3.8(1.6)b	5.0(2.3)a	10.0(3.2)ab	8.3(2.8)a
Puddled direct seeding	Weed free	0.0(0.7)b	1.7(1.4)b	7.3(2.8)a	8.3(2.9)ab	5.0(2.3)b
	Weedy check	1.0(1.1)b	4.5(2.0)ab	8.7(3.0)a	7.7(2.8)ab	8.7(3.0)a
	Mechanical weeding	1.8(1.3)ab	5.8(2.4)ab	6.0(2.5)a	5.5(2.4)b	8.0(2.8)a
	Chemical weed control	0.0(0.7)b	0.9(1.1)b	7.8(2.9)a	9.2(3.1)ab	2.3(1.7)b
Unpuddled dry direct seeding	Weed free	2.3(1.4)ab	3.5(2.0)ab	7.7(2.8)a	10.5(3.3)ab	3.7(1.9)b
	Weedy check	0.0(0.7)b	17.9(4.0)a	5.9(2.5)a	9.7(3.2)ab	6.7(2.6)a
	Mechanical weeding	0.0(0.7)b	5.0(2.0)ab	8.6(3.0)a	9.7(3.2)ab	12.7(3.5)a
	Chemical weed control	1.3(1.3)ab	0.9(1.1)b	6.0(2.5)a	10.5(3.2)ab	8.0(2.7)a
LSD (0.05)	**M in S**	**0.93**	**2.05**	**1.13**	**0.97**	**1.14**
	S in M	**1.1**	**2.04**	**1.14**	**1.23**	**1.55**
Main plots						
M1 = Mechanised transplanting		2.0(1.4)a	3.9(1.9)a	6.9(2.6)a	10.7(3.3)a	8.8(3.0)a
M2 = Puddled direct seeding		0.7(0.9)a	3.2(1.7)a	7.5(2.8)a	7.7(2.8)a	6.0(2.5)a
M3 = Unpuddled direct seeding		0.9(1.0)a	6.8(2.3)a	7.0(2.7)a	10.0(3.2)a	7.8(2.7)a
LSD (0.05)		**0.82**	**1.02**	**0.59**	**0.91**	**1.22**
CV (%)		**15.92**	**16.25**	**19.10**	**25.73**	**39.76**
Sub plots						
S1 = Weed free		1.0(1.0)a	2.6(1.7)b	7.7(2.9)a	9.4(3.1)a	6.0(2.4)b
S2 = Weedy check		0.6(0.9)a	9.7(2.8)a	6.9(2.7)a	10.3(3.3)a	7.4(2.8)ab
S3 = Mechanical weeding		0.8(1.0)a	4.5(2.0)ab	7.6(2.7)a	8.3(2.9)a	10.4(3.2)a
S4 = Chemical weed control		2.3(1.4)a	1.8(1.3)b	6.3(2.6)a	9.9(3.2)a	6.2(2.4)a
LSD (0.05)		**0.54**	**1.18**	**0.66**	**0.56**	**0.66**
CV (%)		**19.20**	**21.42**	**24.52**	**18.14**	**24.55**

At **Mandya**, three crop establishment methods, *viz.*, mechanical transplanting, direct seeding and normal transplanting were assessed. Low incidence of stem borer (3.31-5.75% DH & 5.29 to 9.54% WE), leaf folder and case worm (<5.00% DL) as well as BPH (up to 9.00 hoppers/5 hills) was observed in all the methods in KMP 175 variety **(Table 2.23)**.

Table 2.21 Influence of Crop Establishment Methods on Pest Incidence at Ludhiana, *Kharif* 2019

Establishment methods	Plants/m² (Spacing)	% DH	% LFDL	PH/hill
		40 DAT	40 DAT	40 DAT
Ridge planting	33 plants (30 x 10 cm)	1.9 ± 0.2	2.3 ± 0.5	2.4 ± 0.5
	25 plants (30 x 13 cm)	1.6 ± 0.3	2.0 ± 0.5	2.0 ± 0.4
	20 plants (30 x 16 cm)	1.5 ± 0.3	1.6 ± 0.4	1.9 ± 0.5
Flat planting	33 plants (15 x 20 cm)	2.1 ± 0.4	2.4 ± 0.6	1.3 ± 0.3
	25 plants (20 x 20 cm)	2.1 ± 0.3	1.7 ± 0.3	1.3 ± 0.3
	20 plants (25 x 20 cm)	1.3 ± 0.4	1.5 ± 0.3	1.2 ± 0.3
Bed planting	33 plants (33.75 x 9 cm)	3.2 ± 0.5	4.1 ± 0.8	1.1 ± 0.3
	25 plants (33.75 x 12 cm)	3.2 ± 0.5	3.1 ± 0.6	1.0 ± 0.2
	20 plants (33.75 x 15 cm)	2.3 ± 0.3	2.3 ± 0.5	0.9 ± 0.2

Table 2.22 Influence of Crop Establishment Methods on Pest Incidence at Malan, Kharif 2019

Establishment methods	% Leaf folder damaged leaves			
	45 DAT	60 DAT	75 DAT	90 DAT
Direct seeding	13.89 (3.71)a	14.44 (3.78)b	14.72 (3.82)a	17.85 (4.21)ab
Normal transplanting	17.68 (4.20)a	19.55 (4.42)a	17.00 (4.11)a	23.24 (4.81)a
Semi dry rice	15.65 (3.94)a	15.74 (3.94)ab	15.19 (3.89)a	16.32 (4.01)b
LSD 0.05	*0.56*	*0.62*	*0.59*	*0.61*
CV (%)	*9.68*	*10.47*	*10.27*	*9.69*

Table2.23 Influence of Crop Establishment Methods on Pest Incidence at Mandya, *Kharif* 2019

Establishment methods	% Dead hearts					% WE
	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	Pre har
Mechanical transplanting	3.31 ±1.97	6.15 ±1.64	3.33 ± 0.76	2.50 ± 0.91	1.24 ± 0.32	5.29 ±1.44
Direct seeding	3.58 ±1.44	4.22 ±1.02	4.92 ±1.15	3.50 ± 1.03	1.83 ± 0.27	9.29 ±2.31
Normal transplanting	5.74 ± 2.26	5.24 ±1.00	5.75 ± 0.78	4.44 ± 1.22	3.65 ± 0.80	9.54 ±1.97
Establishment methods	**% Leaffolder damaged leaves**					
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90DAT
Mechanical transplanting	0.54 ± 0.22	1.55 ± 0.49	4.19 ± 0.57	2.02 ± 0.69	1.02 ± 0.32	
Direct seeding		1.76 ± 0.35	3.40 ± 0.72	2.91 ± 0.69	1.92 ± 0.56	0.67 ± 0.30
Normal transplanting	0.61 ± 0.28	2.35 ± 0.76	4.61 ± 0.73	3.36 ± 0.57	2.15 ± 0.69	0.52 ± 0.13
Establishment methods	**% Case worm damaged leaves**					
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
Mechanical transplanting	0.36 ± 0.22	0.62 ± 0.20	0.92 ± 0.19	1.58 ± 0.38	1.26 ± 0.36	0.40 ± 0.16
Direct seeding		0.37 ± 0.15	1.08 ± 0.40	1.44 ± 0.29	0.58 ± 0.18	
Normal transplanting	0.32 ± 0.20	0.82 ± 0.14	1.32 ± 0.32	1.97 ± .41	1.52 ± 0.33	1.15 ± 0.24
Establishment methods	**BPH numbers per 5 hills**					
	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	
Mechanical transplanting	0.40 ± 0.24	2.80 ± 0.86	5.60 ±1.29	4.60 ±0.93	2.40 ± 0.51	
Direct seeding	0.80 ± 0.37	2.20 ± 0.80	5.00 ±1.30	5.60 ±1.50	1.80 ± 0.58	
Normal transplanting	2.60 ± 1.21	4.00 ± 1.30	9.00 ±1.73	8.20 ±1.66	3.20 ± 0.86	

At **Moncompu**, drum seeding and normal transplanting methods were practiced with cono weeding and chemical weed control by spraying pre and post emergence herbicides. Uma variety was grown in this trial. Low incidence of stem borer (<9.0% DH & <5% WE), leaf folder (<1% LFDL), BPH (<8/hill), WBPH (<4/hill) and GLH (<2/hill) was observed in both the crop

establishment methods and weed management sub plots **(Table 2.24)**. Incidence of gall midge was also observed but only in chemical weed control sub plot of normal transplanting method (<2% SS).

Table 2.24 Influence of Crop Establishment Methods on Pest Incidence at Moncompu, *Kharif* 2019

Main plots	Sub plots	% DH		% WE	% SS	% LFDL	BPH/hill
		30 DAT	90 DAT	Pre har	60 DAT	60 DAT	90 DAT
Drum seeding	Cono weeding		1.42 ± 0.6	4.33 ± 0.5		0.25 ± 0.1	6.80 ± 3.0
	Chemical weed control		1.58 ± 0.8	3.08 ± 0.9		0.14 ± 0.1	5.80 ± 2.5
Normal Transplanting	Cono weeding	1.55 ± 1.0	8.06 ± 3.5	2.82 ± 1.2		0.30 ± 0.2	7.00 ± 1.2
	Chemical weed control	1.47 ± 0.9	3.58 ± 1.0	4.36 ± 0.8	1.79 ± 0.9	0.16 ± 0.2	6.00 ± 2.9

At **Rajendranagar**, the three establishment methods included normal transplanting, wet seeding (line sowing under puddle condition) and dry sowing converted to wet method. RNR 15048 (Telangana sona) variety was grown in this trial in all the methods. Very low incidence of stem borer was observed in all the three methods **(Table 2.25)**.

Table 2.25 Influence of Crop Establishment Methods on Pest Incidence at Rajendranagar, *Kharif* 2019

Establishment methods	% DH	% WE
	55 DAT	97 DAT
Normal transplanting	3.75 ± 0.11	5.49 ± 1.86
Wet seeding (Line sowing under puddle condition)	3.27 ± 0.13	1.99 ± 1.08
Dry sowing converted to wet	1.11 ± 0.05	1.12 ± 0.22

Among the crop establishment methods, across the locations, the pest incidence was found relatively high in dry direct seeding followed by normal transplanting method **(Fig 2.9)**. White ears caused by stem borer were found high in dry direct seeding followed by puddled direct seeding which might be due to very high incidence at Aduthurai, resulting in skewness. BPH population was observed high in normal transplanting method compared to other methods.

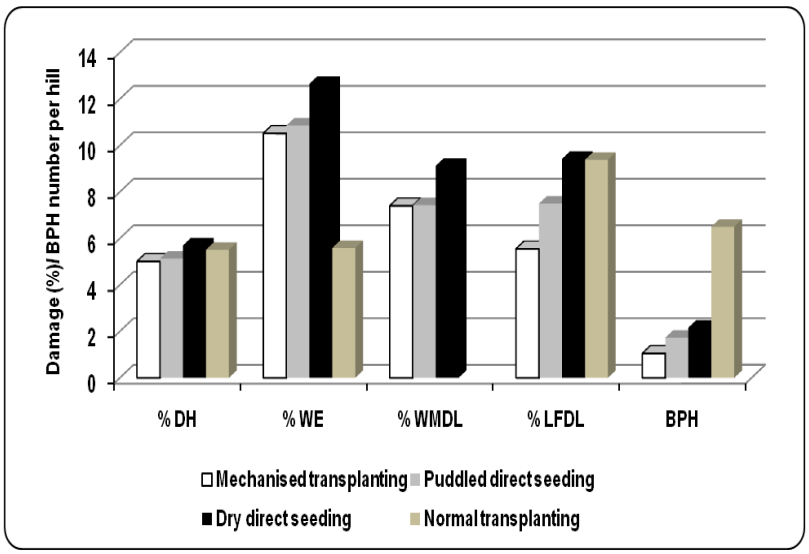


Fig 2.9. Influence of crop establishment methods on pest incidence (IEMP) across locations, *Kharif* 2019

Influence of crop establishment methods on pest incidence (IEMP) trial, initiated this year in collaboration with Agronomy, revealed that dry direct seeding recorded relatively high stem borer (12.65% WE), leaf folder (9.42% LFDL) and whorl maggot (9.12% WMDL) damage followed by normal transplanting method (10.86% WE; 9.38% LFDL). BPH numbers were found high in normal transplanting (6.5/hill) method as compared to dry direct seeding, puddle direct seeding and mechanised transplanting methods. Since this was the first year of this trial the findings need further years of observation, testing and validation.

iv) Cropping Systems Influence on Pest Incidence (CSIP)

Rice based cropping system is the major crop production system being practiced by Indian farmers involving rotation with crops like other cereals, pulses, cotton and vegetables. Generally, normal transplanting method is followed in raising the rice crop. However, due to the constraints in water and labour availability, farmers have been forced to look into the alternative methods like direct seeding in wet and dry conditions, aerobic rice etc. Similarly, incorporation of crop residues is known to help *Rabi* crops in rice based cropping systems. As rice straw contains about 1-2% of Potassium, incorporation of rice straw acts as a good source of nutrients for crops grown after rice. Keeping these in view, a trial on cropping systems influence on pest incidence (CSIP) was initiated in collaboration with Agronomy section (CA/SM 1- Conservation Agriculture/ System based management practices in rice and rice based cropping systems to utilise resources and enhance the productivity and profitability) to evaluate the influence of different rice crop establishment methods under different residue management strategies with the main aim of realising the potential of the sequence crop to improve the overall productivity of the rice based cropping system.

The field trial was laid out in split plot design with three replications. Main plot treatments comprised of three different crop establishment methods (M1: Transplanting, M2: Wet seeding (line sowing under puddled conditions) and M3: Aerobic rice – Dry rice cultivation). The sub plot treatments comprised of three different Residue/straw management techniques (S1: No residue, S2: Incorporation of 15 cm height of rice straw from ground, S3: Incorporation of 30 cm height of rice straw from ground) to be superimposed for *Rabi* crops. During *Kharif* 2019, the trial was conducted at two locations, *viz*, Karjat, and Jagdalpur. Standard procedures were followed to record observations on insect pest incidence in all treatments The results are summarized below.

At **Karjat**, only stem borer was observed and incidence was low in all the three methods of crop establishment and residue management strategies. However, the incidence crossed ETL in M3 - aerobic rice (10.2% DH) and S1- No residue sub-plot (10.9% DH), at 60 DAT. The white ear incidence ranged from 8.1 to 10.8 across main plot and sub plot treatments. There were no

significant differences among the treatments in pest incidence at both vegetative and reproductive stages **(Table 2.26)**.

At **Jagdalpur**, incidence of stem borer, leaf folder, whorl maggot and GLH was observed. Stem borer incidence at vegetative stage did not exceed 7.0% DH across the treatments, while leaf folder damage was also low ranging between 4.5 and 7.3% DL. Whorl maggot incidence was observed up to a maximum of 11.1% and GLH populations were recorded up to 12.7 hoppers/5 hills. Due to low pest incidence all the treatments were on par and no trends were discernible **(Table 2.27)**.

A collaborative trial on cropping systems influence on pest incidence (CSIP) was initiated this year to evaluate the influence of different rice crop establishment methods under different residue management strategies with the overall objective of realising the potential of the sequence crop to improve the overall productivity of the rice based cropping system. During Kharif 2019, the trial was conducted at, Karjat and Jagdalpur. At both these locations, incidence of stem borer, leaf folder, whorl maggot and GLH was too low to draw valid conclusions.

Table 2.26 Influence of cropping systems on pest incidence at Karjat, *Kharif* 2019

Treatments		% DH				% WE
		15 DAT	30 DAT	45 DAT	60 DAT	90 DAT
M1= Transplanting	S1	8.0(2.8)a	8.3(2.8)a	10.3(3.2)a	14.2(3.8)a	14.1(3.7)a
	S2	6.2(2.5)a	6.4(2.5)a	7.7(2.7)a	7.8(2.8)a	8.0(2.8)b
	S3	4.5(2.1)a	5.3(2.2)a	6.8(2.6)a	7.3(2.7)a	7.0(2.7)b
M2 = Wet seeding	S1	5.9(2.4)a	6.1(2.4)a	6.8(2.6)a	8.6(2.9)a	8.7(2.9)ab
	S2	5.6(2.3)a	5.9(2.3)a	6.5(2.5)a	8.7(2.9)a	8.6(2.9)ab
	S3	2.4(1.5)a	4.5(2.1)a	5.2(2.3)a	7.6(2.8)a	7.3(2.7)b
M3 = Aerobic rice	S1	5.4(2.3)a	4.4(2.1)a	5.8(2.4)a	9.9(3.1)a	9.6(3.1)ab
	S2	5.8(2.4)a	5.6(2.3)a	6.1(2.5)a	10.1(3.2)a	10.5(3.2)ab
	S3	5.4(2.3)a	4.2(2.0)a	6.7(2.6)a	10.5(3.2)a	10.1(3.2)ab
LSD (0.05)	**M in S**	**1.23**	**1.58**	**1.00**	**1.00**	**0.87**
	S in M	**1.27**	**1.84**	**1.42**	**1.13**	**0.97**
Main plots						
M1= Transplanting		6.2(2.5)a	6.6(2.5)a	8.3(2.8)a	9.8(3.1)a	9.7(3.1)a
M2 = Wet seeding		4.6(2.1)a	5.5(2.3)a	6.2(2.5)a	8.3(2.9)a	8.2(2.8)a
M3 = Aerobic rice		5.5(2.3)a	4.7(2.1)a	6.2(2.5)a	10.2(3.2)a	10.1(3.2)a
LSD (0.05)		**0.54**	**0.90**	**0.79**	**0.54**	**0.46**
CV (%)		**13.97**	**23.14**	**18.15**	**10.56**	**8.96**
Sub plots						
S1 = No residue		6.4(2.5)a	6.2(2.4)a	7.6(2.7)a	10.9(3.3)a	10.8(3.2)a
S2 = 15 cm ht. of rice straw		5.9(2.4)a	5.9(2.4)a	6.8(2.6)a	8.9(2.9)a	9.0(3.0)a
S3 = 30 cm ht of rice straw		4.1(2.0)a	4.6(2.1)a	6.2(2.5)a	8.5(2.9)a	8.1(2.8)a
LSD (0.05)		**0.51**	**0.66**	**0.42**	**0.41**	**0.36**
CV (%)		**17.67**	**22.53**	**12.72**	**10.81**	**9.44**

Table 2.27 Influence of cropping systems on pest incidence at Jagdalpur, *Kharif* 2019

Treatments		% DH	% LFDL		% WMDL		GLH (N0./10 hills)
		70 DAT	50 DAT	70 DAT	50 DAT	70 DAT	70 DAT
M1= Transplanting	S1	4.5(2.2)a	7.1(2.7)a	5.9(2.5)a	6.7(2.7)b	4.5(2.2)a	7.0(2.3)ab
	S2	4.5(2.1)a	7.0(2.7)a	2.6(1.7)b	6.6(2.6)b	4.6(2.2)a	10.3(3.0)a
	S3	1.5(1.1)a	7.2(2.8)a	5.1(2.4)a	7.3(2.7)b	6.0(2.5)a	12.7(3.7)a
M2 = Puddled direct seeding	S1	3.6(1.8)a	5.6(2.4)a	4.6(2.2)ab	9.8(3.2)a	6.5(2.5)a	7.7(2.7)ab
	S2	7.6(2.5)a	5.3(2.4)a	7.2(2.8)a	8.3(3.0)a	8.6(3.0)a	7.3(2.7)ab
	S3	2.0(1.3)a	9.0(3.1)a	6.3(2.6)a	10.4(3.3)a	5.8(2.5)a	5.7(2.3)ab
M3 = Unpuddled dry direct seeding	S1	5.1(1.8)a	4.1(2.1)a	5.0(2.3)ab	11.2(3.4)a	5.1(2.4)a	1.7(1.3)b
	S2	8.9(2.9)a	7.5(2.8)a	5.6(2.5)a	9.9(3.2)a	8.5(2.9)a	9.3(3.0)ab
	S3	2.7(1.8)a	5.6(2.4)a	5.6(2.5)a	12.2(3.6)a	8.4(2.9)a	7.3(2.7)ab
LSD (0.05)	**M in S**	**1.95**	**1.01**	**0.64**	**0.34**	**1.25**	**1.76**
	S in M	**1.93**	**1.02**	**0.65**	**0.59**	**1.13**	**1.64**
Main plots							
M1= Transplanting		3.5(1.9)a	7.1(2.7)a	4.5(2.2)a	6.9(2.7)b	5.1(2.3)a	10.0(3.0)a
M2 = Puddled direct seeding		4.4(1.9)a	6.6(2.6)a	6.0(2.5)a	9.5(3.2)ab	6.9(2.6)a	6.9(2.6)a
M3 = Unpuddled dry direct seeding		5.6(2.2)a	5.8(2.4)a	5.4(2.4)a	11.1(3.4)a	7.3(2.7)a	6.1(2.3)a
LSD (0.05)		**1.12**	**0.61**	**0.38**	**0.52**	**0.50**	**0.80**
CV (%)		**23.25**	**18.00**	**12.25**	**12.93**	**14.73**	**23.14**
Sub plots							
S1 = No residue		4.4(1.9)a	5.6(2.4)a	5.2(2.3)a	9.3(3.1)ab	5.4(2.4)a	5.4(2.1)a
S2 = 15 cm ht. of rice straw		7.0(2.5)a	6.6(2.6)a	5.2(2.3)a	8.3(2.9)b	7.2(2.7)a	9.0(2.9)a
S3 = 30 cm ht of rice straw		2.1(1.4)a	7.3(2.8)a	5.7(2.5)a	10.0(3.2)a	6.7(2.6)a	8.6(2.9)a
LSD (0.05)		**1.12**	**0.58**	**0.37**	**0.19**	**0.72**	**1.02**
CV (%)		**25.40**	**21.87**	**15.25**	**6.13**	**27.32**	**37.67**

v) Evaluation of Pheromone Blends for Insect pests of Rice (EPBI)

Pheromones serve as a tool for monitoring pest populations and help in controlling insect pests. They are highly specific to the target pest and safe to other non-target pests and natural enemies in the ecosystem. Pheromones are being successfully used in monitoring and management of insect pests in most of the agricultural crops. In rice, yellow stem borer pheromones are being used widely by farmers for monitoring and mass trapping as an eco friendly IPM strategy. Keeping this success in view, preliminary studies have been carried out in the last few years to develop pheromone technology for other key pests, pink stem borer and leaf folder. Some of the blends at specified doses have been found effective in laboratory and field assays. Hence, a new trial was initiated during *Kharif* 2019 with an objective to evaluate these blends and doses of pheromone compounds for monitoring rice leaf folder and pink stem borer. The trial was conducted at 8 locations, *viz.*, Aduthurai, Coimbatore, Jagdalpur, Ludhiana, Navasari, Pattambi, Raipur and Titabar for rice leaf folder and four locations, Ludhiana, Pattambi, Raipur and Warangal for pink stem borer.

The trial was constituted with three blends for rice leaf folder comprising of one RLF blend which was found effective at IIRR and other AICRIP locations

previously, one multispecies blend with both RLF and YSB pheromone compounds and one control blend treated with hexane, replicated thrice. Similarly, pink stem borer blend and control blend were evaluated with three replications. These traps were placed randomly in the field and at each observation, adults caught in each trap was recorded along with observations on field population counts through disturb and count method (DCM), sweep net catches and light trap catches. The results of these evaluations were summarised below.

Rice leaf folder catches were high in RLF blend at Ludhiana followed by Titabar **(Table 2.28)**. However, at other locations, the catches were low in RLF blend despite the presence of adult population in the field indicating the need for further retesting and confirmation. Multispecies blend was found to attract both RLF and YSB at Ludhiana alone and needs further assessment.

Table 2.28 Evaluation of pheromone blends for rice leaf folder, *Kharif* 2019

Pheromone blends	Trap catches							
	LDN	CBT	JDP	NVS	PTB	RPR	ADT	TTB
RLF blend	26	3	4	3	0	2	0	7
Multispecies blend (RLF + YSB)	6 + 3				0	2	0	
Control blend	4	1	2	0	0	1	0	1
Disturb & Count method (DCM)		3		10	11			2
Sweep net catches	22	0		3	10		6	8
Light trap catches	40	0		8	1		10	34

All values are mean of three pheromone traps/ catches

In general, pink stem borer population was low at all the tested locations as evident by sweep net and light trap catches. Pheromone trap catches of adult male moths were also low at all the locations indicating the need for further testing **(Table 2.29)**.

Table 2.29 Evaluation of pheromone blends for Pink stem borer, *Kharif* 2019

Pheromone blends	Trap catches			
	LDN	PTB	RPR	WGL
PSB blend	4	2	5	0
Control blend	0	2	0	0
Sweep net catches	0	2		0
Light trap catches	2	1		0

All values are mean of three pheromone traps/catches

Evaluation of pheromone blends for insect pests of rice (EPBI) was a new trial initiated with an objective to evaluate pheromone blends and doses against rice leaf folder and pink stem borer. During Kharif 2019, the trial was conducted at 12 locations for both pests. Rice leaf folder catches were high in RLF blend at Ludhiana (26/trap) followed by Titabar (7/trap). However, at other locations, catches were low in pheromone traps in spite of the presence of adult population in the field, which needs further evaluation. Multispecies blend attracted both rice leaf folder and yellow stem borer, however it needs further investigation.

2.4. BIOCONTROL AND BIODIVERSITY STUDIES

These studies covered i) Ecological Engineering for Planthopper Management (EEPM) ii) Bio-intensive Integrated pest management (BIPM) and iii) Monitoring of pest species and their natural enemies (MPNE).

i) Ecological Engineering for Planthopper Management (EEPM)

This trial has the objective of habitat management through cultural and non-pesticidal methods along with floral diversity to increase natural biological control and augment egg predators of hoppers for managing planthoppers by enhancing natural enemy fitness. Data were recorded on insect pests mainly hoppers and their natural enemies and analyses were done using the independent't' test or ANOVA. The trial was conducted at eight locations during kharif 2019 *viz.*, Bapatla, Gangavathi, Moncompu, Mandya, New Delhi, Malan, Rajendranagar and Warangal.

1. *Bapatla*

The intervention adopted in the ecological engineering plots were organic manuring, alleyways, border planting of marigold and application of need based neem oil formulation. The population of hoppers were on par **(Table 2.30)** and among their natural enemies, spiders were significantly higher in ecological engineering plots (10.1/10 hills as compared to 7.7/10 hills in farmer's practice.

Table 2.30 Effect of ecological engineering on populations of hoppers and their natural enemies at Bapatla, EEPM, *kharif* 2019

Parameters	Population of hoppers (No./ hill)				Population of natural enemies (No./10 hills)					
	BPH		WBPH		Green mirids		Spiders		Coccinellids	
	EE	FP	EE	FP	EE	FP	EE	FP	EE	FP
Mean	4.15	5.85	6.60	6.73	13.9	11.2	10.1	7.7	0.39	0.31
t value	0.17 NS		7.07 NS		1.81 NS		2.17*		1.14 NS	
df	198		198		198		198		198	
P - value	0.86		0.71		0.07		0.03		0.26	

2. Gangavathi

Two interventions *viz.*, alleyways and growing border crop of cowpea were undertaken in the ecological engineering (EE) plots. Four observations were recorded on planthoppers and their natural enemies throughout the crop period. In the ecological engineering plots the hopper population was higher ranging from 13.20/hill at 40 DAT to a maximum of 158.00/hill at 80 DAT, thereafter decreasing to 33.00 at 100 DAT **(Fig.2.10)** which was significantly higher than that of the population in Farmers Practice plots with chemical interventions, where the highest was observed at 80 DAT (40.00/hill).

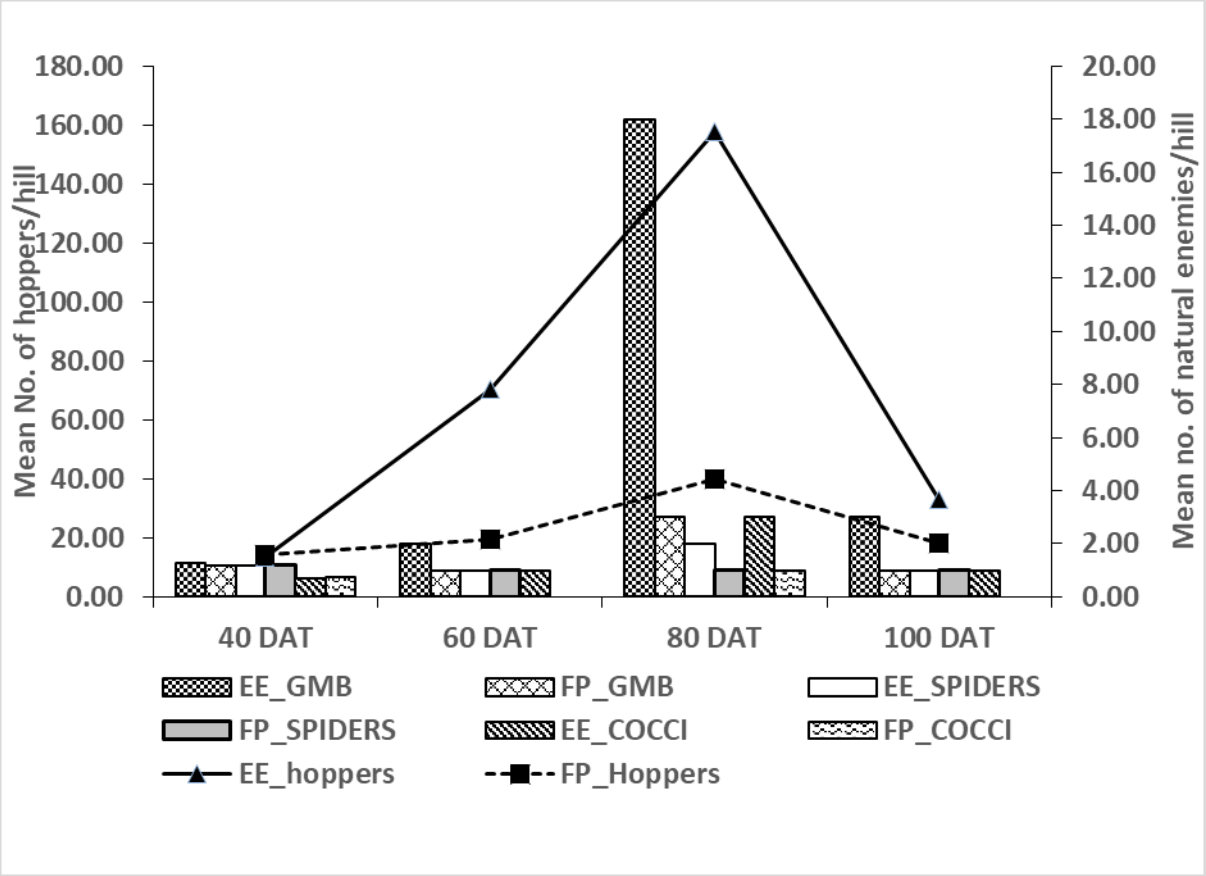


Fig.2.10 Abundance of hoppers and its natural enemies at Gangavathi, EEPM, *kharif* 2019

The mean hopper numbers over the crop period were significantly higher in EE plots (68.65/hill) in comparison to farmers' practices (FP) (22.98/hill, **(Table 2.31)**. But, the population of green mirids, spiders and coccinellids were significantly higher in EE plots indicating a positive trend for these practices in conservation of natural enemies. The green mirid number in the ecological engineering plots (60.75/10 hills) was 5 times higher than that of the farmers practice (15.40/10hills). Similarly the coccinellid population in EE treatment was three times higher (14.2/10 hills) as compared to the population in FP treatment (4.30/ 10hills). Mean parasitisation by three species of parasitoids in the EE plots was significantly higher (31.15%; t= 7.01; P= <0.01) compared to 12.53 % under farmers practice. The egg parasitisation was assessed by two methods – egg bating and by destructive sampling. The parasitisation per cent was significantly higher in the ecological engineering plots in both methods of assessment and on all dates of sampling (Table). The per cent parasitisation ranged from 14- 17 per cent in the EE treatment while it ranged from 4 -7 per cent in the FP treatment. Three species of parasitoids were observed in both treatments. While the parasitisation by *Oligosita sp* in EE plots was up to 35.87 per cent *Anagrus* sp was dominant in FP treatments accounting for 37.21 % **(Fig 2.11)**. There is no mention of yield and BC at this centre.

Table: 2.31 Effect of ecological engineering on populations of hoppers and their natural enemies at Gangavathi, EEPM, *kharif* 2019

A. Hoppers and its predators

Parameters	Hoppers (No./ hills)		Population of natural enemies (No./ 10 hills)					
			Green mirids		Spiders		Coccinellids	
	EE	FP	EE	FP	EE	FP	EE	FP
Mean	67.88	19.66	50.75	8.10	20.30	8.35	17.50	4.85
t value	10.49 **		10.72**		9.19**		10.14**	
df	398		398		398		398	
P - value	<0.01		<0.01		<0.01		<0.01	

B. Parasitoids

Parameters	% parasitisation by egg baiting		*Egg Parasitisation % at						Mean parasitisation %	
			40 DAT		60 DAT		75 DAT			
	EE	FP	EE	FP	EE	FP	EE	FP	EE	FP
Mean	17.67	7.25	15.78	3.91	15.90	4.27	14.28	4.41	15.91	4.96
t value	2.28*		4.89**		6.67**		1.59**		8.14**	
df	48		48		48		48		198	
P - value	<0.01		<0.01		<0.01		<0.01		<0.01	

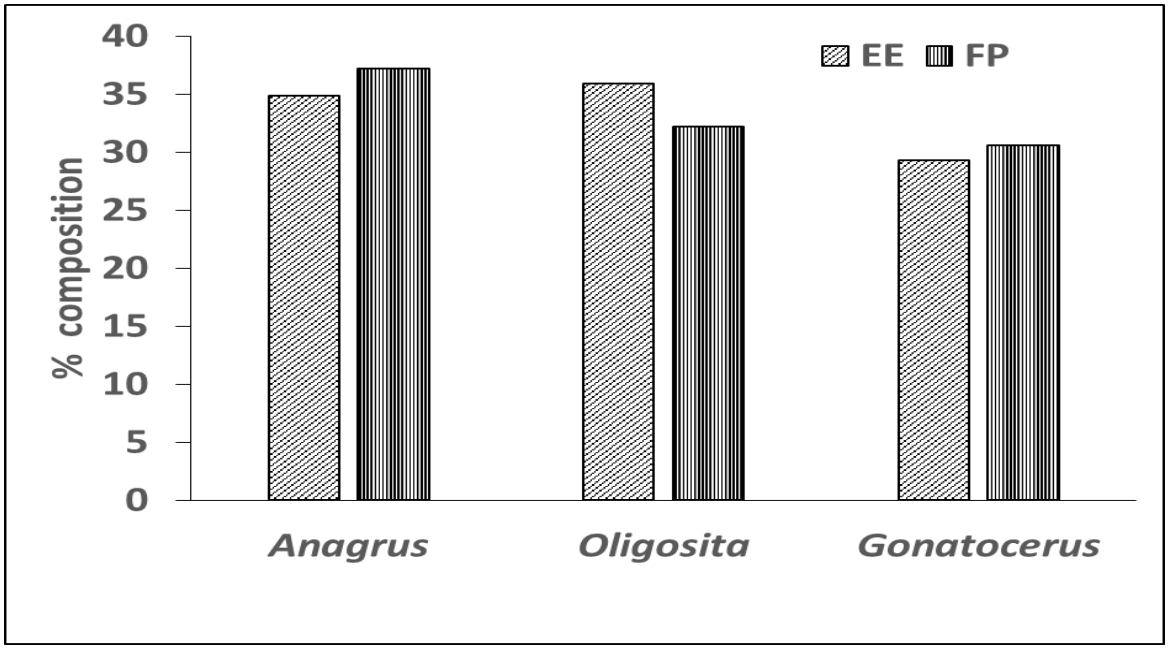


Fig.2.11 Per cent composition of egg parasitoids of hoppers at Gangavathi, EEPM, *kharif* 2019

3. Malan

At Malan three treatments were tested in natural farming systems *viz.*, (i) with bund flora of French marigold along with recommended fertilizers (ii) with bund flora of French marigold with Azolla application and without fertilizers (iii) only natural farming. The key pest observed was the leaffolder and the percent damaged leaves varied significantly among the treatments on all four observation dates. The mean maximum leaf damage (24.37 %) was found in the treatment with fertilizer application **(Table 2.32)** which was on par with the natural farming with no bund crop. The most effective treatment for reduction in leaffolder damage was bund cropping along with azolla application (12.26%). On the other hand the mirid bug population was on par in bund cropping treatment with and fertilizers and significantly higher than the plots without bund crop (5.0 - 6.48/ hill) **(Table 2.33)**.

Table 2.32 Effect of ecological engineering on leaffolder incidence at Malan, EEPM, *kharif* 2019

Treatment	% leaves damaged by Leaffolder				
	I observation	II observation	III observation	IV observation	Mean
With bund flora (Marigold) and RFD	23.29 (28.85)	27.70 (31.59)	23.02 (28.66)	23.46 (28.97)	**24.37**
With bund flora (Marigold)+ Azolla application	11.88 (20.14)	11.72 (20.00)	11.79 (20.07)	13.65 (21.36)	**12.26**
Natural Farming with no bund flora	20.19 (26.61)	15.72 (23.34)	14.23 (22.16)	13.85 (21.85)	**16.00**
CD (p=0.05%)	2.30	4.36	1.15	3.99	

Table 2.33 Effect of ecological engineering on abundance of mirid bugs at Malan, EEPM, *kharif* 2019

Treatment	Mirid bugs (No./ hill)			
	I observation	II observation	III observation	IV observation
With bund flora (Marigold) and RFD	9.21	10.12	9.76	9.38
With bund flora (Marigold)+ Azolla application	9.38	9.14	9.52	9.92
Natural Farming with no bund flora	5.00	6.48	5.00	5.46
CD (p=0.05%)	1.12	NS	1.46	0.83

4. **Moncompu**

Bund planting of marigold was taken up in EE plots. The pooled analysis revealed that number of hoppers was significantly higher in FP plots **(Table 2.34)** on 60 and 90 DAT with a mean population of 8.21/ hill as compared to 2.8/hill in EE plots. The population of pest were however low due to submergence by floods. Among the natural enemies recorded coccinellids (5.85/10 hills) was significantly higher in EE treatment as compared to 4.13/10 hills in FP treatment.

Table 2.34 Effect of ecological engineering on hoppers and their natural enemies at Moncompu, EEPM, *kharif* 2019

Parameters	Hoppers (No./hill)		Green mirids (No./10 hills)		Spiders (No./10 hills)		Coccinellids (No./10 hills)	
	EE	FP	EE	FP	EE	FP	EE	FP
Mean	2.80	8.21	3.10	2.60	2.17	2.00	5.85	4.13
t value	4.88		0.49		0.45		2.77*	
df	198		398		398		398	
P - value	<0.01		NS		NS		0.02	

5. Mandya

Floral diversity was increased in EE plots by growing cowpea and *sun hemp* on the bunds, alleyways and application of vermicompost. The mean population of hoppers in EE plots (12.36/ hill) was significantly higher compared to that of FP plots (8.66/hill) **(Table 2.35)**. However a reverse trend was observed in case of natural enemies and was significantly higher in the ecological engineering plots. Coccinellids, spiders and mirids were observed at 28.10, 37.10 and 10.80 per ten hills in the EE treatment as compared to 12.51, 21.51 and 3.47 in the FP treatment.

Table 2.35 Effect of ecological engineering on hoppers and their natural enemies at Mandya, EEPM, *kharif* 2019

Parameters	Hoppers (No./hill)		Green mirids (No./10 hills)		Spiders (No./10 hills)		Coccinellids (No./10 hills)	
	EE	FP	EE	FP	EE	FP	EE	FP
Mean	12.36	8.66	10.80	3.47	37.10	21.51	28.10	12.51
t value	5.70**		8.61**		8.26**		8.45**	
df	98		398		398		398	
P - value	<0.01		<0.01		<0.01		<0.01	

6. **New Delhi**

Five treatments were tested. Four of these had bund plantings of (i) crops - Sesamum, Soybean, Sunflower, (ii) flower crops- Marigold, Balsam and Gaillardia (iii) combination of crops and flowering crops (iv) natural weeds

(V) control with no border crop. Observations were recorded on damage by stemborer, leaffolder, whorl maggot and population of hoppers and their natural enemies over the crop period. A mixed population of brown planthopper and white backed planthoppers were observed. The BPH population peaked from 84-94 DAT and mean ranged from 10.9 -27.8 / hill among the various treatments which were on par. The incidence of stem borers assessed by white ear damage was significantly different among the treatments with the lowest damage observed in plot with a border of crops- Sesamum, Soybean, Sunflower (0.95 %) while the highest was observed in plots without a border crop (1.74%) **(Table 2. 36)**. The population of natural enemies such as spiders and mirids were also highest in the crop associated these crops (34.75 and 125.25/ 10 hills respectively).

Table 2.36 Effect of ecological engineering on abundance of pests and natural enemies at New Delhi, EEPM, *kharif* 2019

Treatment	%WE	Spiders (No./10 hills)	Mirids (No./10 hills)	Plot Yield (Kg)
Crops (Sesamum, Soybean, Sunflower)	0.95 (5.60)	34.75	125.25	4530
Flowers - (Marigold, Balsam, Galardia)	1.19 (6.20)	27.00	120.75	4805
Natural Weeds	1.55 (7.10)	17.50	58.00	4125
Crops + Flowers	1.07 (5.91)	34.25	108.50	5610
CONTROL	1.74 (7.52)	20.25	49.25	4000
CD (p=0.05%)	1.15	8.06	40.74	1020

7. **Rajendranagar**

Three treatments- Farmers practice plots with chemical interventions (FP), Ecological engineering plots with and without alternate wetting and drying (EEP 1 and EEP 2 respectively) were tested. Practices followed in EE plots were, alleyways, alternate wetting and draining of water, increase in floral diversity on bunds by planting yellow marigold in addition to no chemical plant protection measures. The mean population of hoppers ranged from 15-22 among the treatments and did not differ significantly. But the yield was found to be significantly higher in the ecological engineering treatment with alternate wetting and drying (4410kg/ha) **(Table 2.37)**

Table 2.37 Effect of ecological engineering on hoppers and their natural enemies at Rajendranagar, EEPM, *kharif* 2019

Treatment	Hoppers (No./ hill)	Spiders No./ 10 hills)	Yield (kg/ha)
EEP-I	22.3	5.1	4410
EEP-II	18.33	4.7	4000
FP	15.34	4.9	3530
CD(0.05)	NS	NS	388.50
SEM	-	-	133.17

8. Warangal

Three treatments- Farmers practice plots with chemical interventions (FP), Ecological engineering plots with and without alternate wetting and drying (EEP 1 and EEP 2 respectively) were tested. Practices followed in EE plots were, alleyways, alternate wetting and draining of water, increase in floral diversity on bunds by planting marigold in addition to no chemical plant protection measures. Five observations were recorded on the two planthoppers and their natural enemies through the crop period. A mixed population of BPH and WBPH was observed. The population of brown planthopper reached a peak at 100 DAT and was highest in the FP treatment 127.47/hill and lowest (28.87/ hill) in ecological engineering treatment with alternate wetting and drying **(Table 2.38)**. The hopper numbers were consistently lowest in the EEP-I treatment plots indicating that alternate wetting and drying along with ecological engineering can reduce hopper population. The populations of spiders and coccinellids were significantly different at 111 DAT in the three treatments. The number of spiders were higher in ecological engineering plots without alternate wetting and drying (24.80/10 hills). The number of coccinellids at 111 DAT was also significantly higher in EEP II plots (11.87/ 10 hills). Mirid bugs were on par in all treatments.

The EE plots yielded higher **(Table 2.39)** with the highest being in EEP-I (4455 kg /ha) while the FP plots yielded an average of 3238 kg/ha. The B: C ratio was also higher in the ecological engineering plots than FP plots and the highest BCR of 1.94 was observed in EEP-I plots with alternate wetting and drying. FP plots showed lowest B: C ratio of 1.29.

Table 2.38 Effect of ecological engineering on populations of hoppers and their natural enemies at Warangal, EEPM, *kharif* 2019

A. Hoppers

	BPH (No./ 10 hills)			WBPH (No. /10 hills)		
	74DAT	**100 DAT**	**111DAT**	**74DAT**	**100 DAT**	**111DAT**
EEP-I	80.40	28.87	18.93	60.67	10.40	10.60
EEP-II	98.27	105.73	58.67	68.47	33.47	31.87
FP	84.20	127.47	62.80	61.00	42.13	34.00
CD(0.05)	11.88	47.21	20.56	NS	17.32	10.28
SEM	2.80	14.83	6.16	-	4.68	3.29

B. Natural enemies of hoppers

Treatments	**Spiders No. /10 hills**	**Coccinellids No. /10 hills**	**Mirids No. /10 hills**
	111 DAT	**111 DAT**	**Mean**
EEP-I	20.33	8.60	22.67
EEP-II	24.80	11.87	18.67
FP	23.20	9.47	17.67
CD(0.05)	2.25	1.78	NS
SEM	0.58	0.47	-

Table 2.39 Grain Yield and Benefit cost ratio of Ecological engineering at Warangal, EEPM, *kharif* 2019

Treatment	Grain yield (Kg/ha)	B:C ratio
EEP-I	4454.72	1.94
EEP-II	3958.86	1.73
FP	3238.07	1.29
CD(0.05)	357.46	0.16
SED	151.40	0.08

Table 2.40 Natural enemy population on marigold planted on bunds in EEP plots* *kharif* 2019

Treatments	Mirids		Coccinellids		Spiders	
	80 DAT	100 DAT	80 DAT	100 DAT	78 DAT	95 DAT
EEP-I	0.16	0.06	0.20	0.46	1.04	1.38
EEP-II	0.22	0.04	0.20	0.40	1.04	1.16

*Mean of 50 marigold plants

Low populations of mirids, coccinellids and spiders were also observed on the marigold plants grown on the bunds indicating a sharing of natural enemies **(Table 2.40)**.

Ecological engineering for pest management was taken up in eight locations with a combination of interventions such as organic manuring, alleyways, spacing management, water management and growing of flowering plants on bunds. The results also indicated that water management along with ecological engineering significantly reduced hopper population at Warangal (18.93/hill) when compared to farmers practice (127.47/hill) while increasing yields. Stem borer damage was significantly lower in ecological engineering treatments with various bund crops at New Delhi. Such interventions increased the natural enemy populations like mirids, spiders and coccinellids. Increased egg parasitisation of hoppers was observed at Gangavathi with a mean parasitsation of 15.91 with ecological engineering as compared to 4.96 % in farmer's practices. At Warangal, the benefit cost was also significantly higher with ecological engineering (1.94) when compared to Farmers practice (1.29).

ii) Bio-intensive pest management trial (BIPM)

This trial was initiated, to generate comprehensive plant protection and soil health data to validate adoption of pest management practices for use as an integral component of organic rice cultivation. The trial was taken up at ten centres *viz.*, Bapatla, Chinsurah, Jagdalpur, Karjat, Moncompu, Ludhiana, Pattambi, Ranchi, Raipur and Titabar.

The trial involved mainly two treatment blocks *viz.*, i) Bio-intensive pest management (BIPM) which was again split into - one sub block receiving seed treatment and application of *Trichoderma* and - another sub block with pseudomonas and ii) Input intensive pest management or Farmers Practice block (FP) spread over an area of a minimum of half acre for each block planted with a local popular variety of the region. The results of the trials at various locations are given below.

1. Bapatla

The practices under BIPM treatment were seed treatment with *Psuedomonas*, installation of pheromone traps and application of neem oil

twice during the season. Observations were recorded on incidence of leaffolders and hoppers and their natural enemies. The FP plots recorded significantly higher leaffolder damage throughout the crop season **(Fig 2.12)** ranging from 2.58 to 12.58% as compared to 1.59 to 4.60 in the BIPM plots. The mean per cent leaves damaged by leaffolder was significantly higher in FP plots (10.42%) as compared to BIPM (2.84%)**(Table 2.41)**. The hopper population was very low ranging from 1.09 to 2.23 per hill and there was no difference between the treatments.

Table 2.41 Pest incidence under Bio-intensive pest management trial at Bapatla, *kharif* 2019

Parameters	LF		WBPH		BPH	
	(% damage)		(No./ hill)		(No./ hill)	
	BIPM	FP	BIPM	FP	BIPM	FP
Mean	2.84	10.42	1.09	1.20	1.79	2.23
t value	7.85**		0.58^{NS}		1.98^{NS}	
df	78		100		100	
P - value	<0.01		NS		NS	

* LF- leaffolder; WBPH – white-backed planthopper; BPH – brown planthopper

The population of beneficial insects were on par in both treatments **(Table 2.42)**. The yield, however was significantly higher in FP treatment (5665 kg/ha) **(Table 2.42)**.

Table 2.42 Population of natural enemies and yield under Bio-intensive pest management trial at Bapatla, *kharif* 2019

Parameters	Spiders (No./10 hills)		Coccinellids (No./10 hills)		Mirids (No./10 hills)		Yield* (kg/ha)	
	BIPM	FP	BIPM	FP	BIPM	FP		
Mean	7.1	7.6	3.50	3.25	8.40	10.30	3910	5665
t value	0.51^{NS}		0.32^{NS}		1.37 ^{NS}		8.63**	
df	100		100		100		10	
P - value	0.61		0.75		0.17		<0.01	

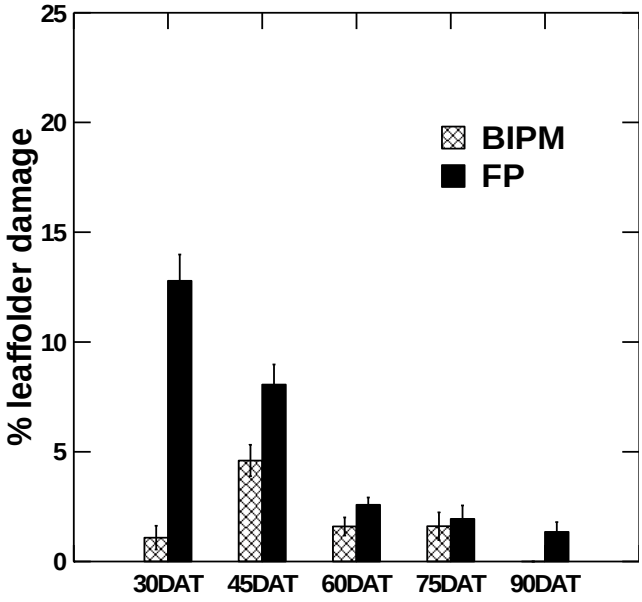


Fig 2.12 Leaffolder damage under Bio-intensive pest management trial at Bapatla, *kharif* 2019

2. Chinsurah

Observations were recorded on the damage by whorl maggot, stem borer, leaffolder and natural enemies like spiders, coccinellids and staphylinids. Whorl maggot incidence observed in the early crop growth ranged from 3.94 to 4.09 % DL and was on par in the two treatments (Table 2.xxx). The dead heart damage by stem borer was significantly higher in FP plots (13.93%) than that of BIPM plots (7.69%). A similar trend was observed with white ear damage in the reproductive phase with 5.47 % damage recorded in BIPM plots as compared to 19.35% in FP plots **(Table 2.43)**. The populations of other pests were low.

Table 2.43 Pest incidence under Bio-intensive pest management trial at Chinsurah, *kharif* 2019

Parameters	WM		DH		WE	
	(% damage)		(% damage)		(% damage)	
	BIPM	FP	BIPM	FP	BIPM	FP
Mean	4.09	3.94	7.69	13.93	5.47	19.35
t value	0.01NS		4.86**		8.67**	
df	58		58		22	
P - value	0.10		<0.01		<0.01	

*WM- whorl maggot; DH – Dead heart; WE- white ears

The natural enemy population was relatively higher in the BIPM plots. But only the number of spiders (2.83/ 10 hills) was significantly higher than that of FP plots (1.50/10 hills). However there were no significant differences in populations of coccinellids between the treatments. Due to the lower stem

borer damage in the vegetative and reproductive phase the yield was significantly higher in BIPM plots (7297 kg/ha) than that of FP plots (5433 kg/ha)**(Table 2.44)**.

Table 2.44 Population of natural enemies and yield under Bio-intensive pest management trial at Chinsurah, *kharif* 2019

Parameters	Spiders (No./10 hills)		Coccinellids (No./10 hills)		Yield* (kg/ha)	
	BIPM	FP	BIPM	FP		
Mean	1.67	0.33	2.67	1.36	7297	5433
t value	2.25*		1.56NS		12.63**	
df	34		34		10	
P - value	0.02		0.12		<0.01	

*projected yield

3. Jagdalpur

Incidence of whorl maggot, thrips, leaffolder, stem borer, BPH and GLH were observed. The pest incidence was low for all pests. The per cent leaves damaged by whorl maggot leaffolder and thrips were lower in BIPM plots compared to farmer's practice plots but statistically on par. However damage by stem borer was significantly lower in BIPM plots (6.00% DH or WE?) as compared to farmers' practice (8.91%) **(Table 2.45)**. BIPM plots yielded significantly higher (4162 kg/ha) than that of FP plots (3573 kg/ha).

Table 2.45 Pest incidence under Bio-intensive pest management trial at Jagdalpur, *kharif* 2019

Para-meters	Per cent damage by								Yield Kg/ha	
	WM		Thrips		LF		SB			
	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP
Mean	5.95	6.85	1.25	1.57	3.89	5.13	6.00	8.91	4162	3573
t value	1.74^{NS}		0. 68^{NS}		1.46^{NS}		0.47 *		2.88*	
df	40		22		40		10		10	
P - value	0.32		0.14		0.20		0.02		0.02	

*WM- whorl maggot; LF- leaffolder; SB- stemborer

4. Karjat

At this location, three modules were tested. The BIPM 1 and 2 differed in spraying with two organisms, *Trichoderma* and *Pseudomonas* respectively and were similar in all other bio intensive interventions. Observations were recorded on the pest incidence, mainly stem borer. Though the dead hearts caused by stem borer was significantly lower in FP treatment at 30 DAT they increased consistently until 90 DAT, while the incidence declined in the BIPM treatments **(Fig 2.13)**. However, there were no significant differences in mean dead heart incidence among the treatments **(Table 2.46)**. The white ear damage was significantly higher in FP (10.86%) as compared to 1.87 and 3.17 % in BIPM plots. The yield was on par in the BIPM plots

(3500 and 3466 kg/ha) and significantly higher compared to FP plots (2626.67 kg/ha).

Table 2.46 Pest incidence under Bio-intensive pest management trial at Karjat, *kharif* 2019

Parameters	Mean DH/WE (% damage)	Mean white ears (% damage)	Yield (kg/ha)
BIPM1	10.05	1.87	3500.00
BIPM2	11.36	3.17	3466.67
FP	12.87	10.86	2626.67
CD (p=0.05%)	NS	2.21*	209.58*

* DH-Dead Heart; WE- white ears

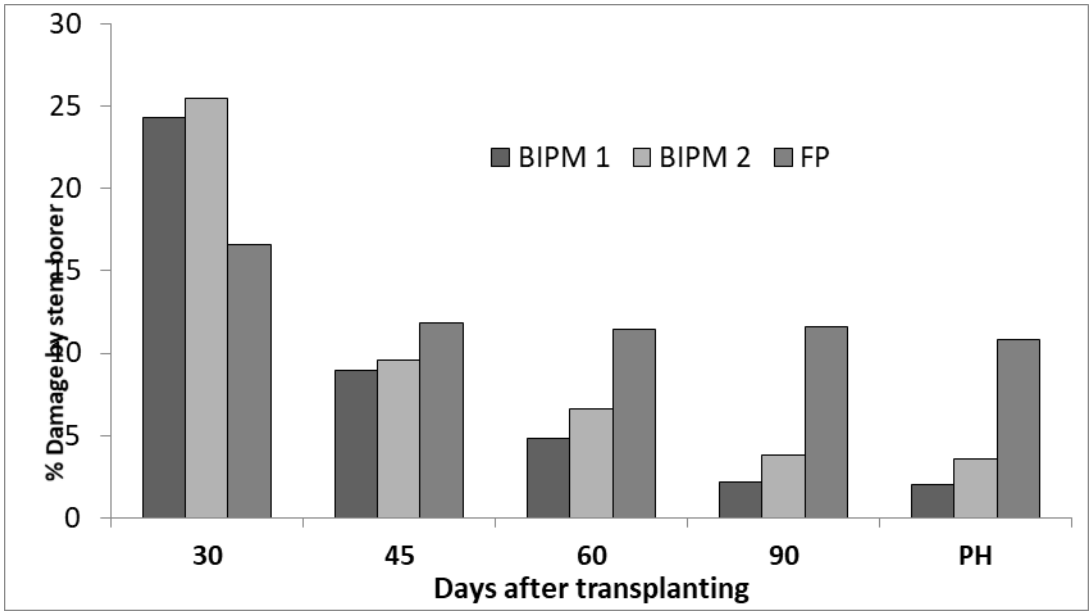


Fig 2.13 Stem borer damage under Bio-intensive pest management trial at Karjat, *kharif* 2019

5. Ludhiana

The trial involved treatments planted with variety PR 121, in six replications. The practices followed in BIPM plots were application of vermicompost @ 500 g/ m^2 and rice husk ash @ 100 g/ m^2 of nursery bed, seed dressing with phosphorus solubilizing microorganisms (PSM) (@ 10 g/ kg seed and *Pseudomonas subtilis and P. argentinensis* (@ 10 g / kg seed at the time of sowing; root dipping with PSM and *Pseudomonas spp* before transplanting; Field ploughing thoroughly to incorporate weed and straw into soil; 2.5 tonnes/ ha of vermicompost as basal + 400 kg neem cake/ ha half as basal and half as top dressing at active tillering stage; Clipping of leaf tips before field transplanting; Pheromone traps for mass trapping of stem borers @ 20/ha; Flower plants of marigold, soybean, cosmos, sesame on bunds for natural enemies; need based application of nimbecidine @ 5 ml/L; proper plant spacing and water management for planthoppers. The practices followed in the FP treatment included application of urea 50 kg/ acre,

Table 2.47 Pest incidence under Bio-intensive pest management trial at Ludhiana, *kharif* 2019

Para-meters	LF % damage		WM % damage		Spiders (No./hill)		Coccinellids (No./hill)		Ichneumonid (No./10 sweeps)		Braconid (No./10 sweeps)	
	BIPM	**FP**	**BIPM**	**FP**	**BIPM**	**FP**	**BIPM**	**FP**	**BIPM**	**FP**	**BIPM**	**FP**
Mean	5.58	5.73	1.55	2.41	46.00	34.00	14.57	9.29	63.00	50.14	55.86	41.43
t value	0.08^{NS}		1.38 ^{NS}		1.10^{NS}		1.29 ^{NS}		1.23^{NS}		2.04*	
df	12		8		12		12		12		12	
P - value	0.94		0.20		0.30		0.23		0.24		0.05	

*WM- whorl maggot; DH – Dead heart; LF- leaffolder; BPH –brown planthopper; WBPH – white backed planthopper

spraying chlorpyriphos @ 1.0 l/ acre at 60 DAT and imidacloprid (Confidor 17.8 SL) @ 40 ml / acre at 70 DAT.

Incidence of whorl maggot, stem borer, leaffolder, BPH, WBPH and natural enemies including predators like spiders, coccinellids and the parasitoids like ichneumonids and braconids were observed. Pest incidence was low and whorl maggot and leafolder damage did not exceed 5.5%. The two treatments were on par for all pest incidences **(Table 2.47)**. The beneficials such as spiders and coccinellids recorded in BIPM plots though higher in numbers in BIPM plots were on par with FP plots. The Braconid numbers per ten sweeps was significantly higher in the BIPM plots (55.86/10 hills) compared to that of Farmers' practice plots (41.43/10 hills). The yields were on par in both FP (7601kg/ha) and BIPM plots (7634 kg/ha) (Table 2. xxx)

6. Moncompu

Incidence of stem borer and natural enemies were observed in BIPM and Farmers' practice plots. The incidence of dead hearts in BIPM (9.03%) was on par with that of farmer's practice plots (11.58%) **(Table 2.48)**. On the other hand white ear damage was significantly higher in FP (14.38%) as compared to BIPM treatment (10.75%). The number of coccinellid per 10 hills (3.40) was higher in BIPM than that observed in FP (2.62) **(Table 2.49)**. The yield was on par in both treatments (Table 2.xxx) while straw yield was significantly higher in Farmers practice (7318 kg/ha) as compared to 5914 kg/ha in BIPM plot.

Table 2.48 Pest incidence under Bio-intensive pest management trial at Moncompu, *kharif* 2019

Parameters	DH (% damage)		WE (% damage)	
	BIPM	FP	BIPM	FP
Mean	9.03	11.58	10.75	14.38
t value	1.30NS		1.96*	
df	82		22	
P - value	0.19		0.05	

* DH-Dead Heart; WE- white ears

Table 2.49 Yield parameters under Bio-intensive pest management trial at Moncompu, *kharif* 2019

Parameters	Coccinellids (No./ 10 hills)		Spiders (No./ 10 hills)		Grain Yield (kg/ha)		Straw Yield (kg/ha)	
	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP
Mean	3.40	2.62	1.48	1.24	4796	4986	5914	7318
t value	2.20*		0.96NS		0.44NS		2.20*	
df	82		82		8		8	
P - value	0.02		0.34		0.67		0.05	

Table 2.50 Pest incidence under Bio-intensive pest management trial at Pattambi, *kharif* 2019

Para-meters	Leaffolder (% damage)						Gall midge (% silver shoots)								Stem borer (% White ears)	
	60 DAT		75 DAT		Mean		30 DAT		45 DAT		60 DAT		Mean		Mean	
	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP
Mean	53.99	39.44	20.89	28.99	21.41	17.46	32.31	22.15	52.06	35.73	33.95	18.76	44.61	34.94	6.40	19.21
t value	2.34*		2.42*		0.85^{NS}		2.55*		2.31*		2.98*		1.92^{NS}		2.14*	
df	10		10		58		10		10		10		46		10	
P - value	0.04		0.04		0.40		0.03		0.04		0.02		0.25		0.04	

Table 2.54. Pest incidence under Bio-intensive pest management trial at Ranchi, *kharif* 2019

Para-meters	Hispa % damage		LF % damage		DH % damage		SS (No./10 hills)		WE % damage		Yield Kg/ha	
	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP
Mean	4.52	3.79	4.06	3.08	5.04	2.78	4.42	3.38	4.77	4.01	3433	4011
t value	1.71^{NS}		3.63^{NS}		4.94 ^{NS}		3.34^{NS}		1.74^{NS}		1.95NS	
df	38		58		58		58		18		10	
P - value	0.98		0.10		0.06		0.08		0.10		0.08	

* DH – Dead heart; LF- leaffolder; SS –silver shoots; WE – white ears

7. Pattambi

The practices followed in BIPM plots were application of Neem cake + Vermicompost as per recommended; growing marigold, cowpea on bunds and application of Azadirachtin 0.003% at 15, 30, 45, 60 and 75 DAT. Incidence of whorl maggot, gall midge , leaffolder, caseworm, stem borer and predators like spiders, coccinellids and mirids was recorded. The mean per cent leaves damaged by leaffolder were significantly higher in BIPM plots reaching a maximum of 53.99 % **(Table 2.50)** compared to farmer's practice plots (39.44 %). Damage by gall midge was also significantly higher in BIPM plots (mean of 44.61%) as compared to farmers' practice (34.94%). On the other hand, white ear damage due to stemborer was significantly lower in BIPM treatment (6.40%) as against 19.21% in FP plots.

The spider population (13.75/10 hills) and coccinellids (10.83) was significantly higher in the BIPM plots compared to that of Farmers' practice plots (7.58 and 5.75 respectively) **(Table 2.51)**. However, yields were low in both treatments though BIPM plots (2239 kg/ha) yielded higher than that of FP plots (1562 kg/ha).

Table 2.51 Population of natural enemies and yield under Bio-intensive pest management trial at Pattambi, *kharif* 2019

Parameters	Spiders (No./10 hills)		Coccinellids (No./10 hills)		Mirid (No./10 hills)		Yield* (kg/ha)	
	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP
Mean	13.75	7.58	10.83	8.00	8.33	5.75	2239	1562
t value	4.14**		4.33**		4.08 **		3.55**	
df	22		22		22		38	
P - value	<0.01		<0.01		<0.01		<0.01	

*projected yield

8. Raipur

Four modules were tested at this location. Two BIPM modules with variations of *Pseudomonas* (BIPM1) and *Trichoderma* (BIPM2) treatments and two farmers' practices- one with inorganic fertilization and no crop protection (FP1) and another with crop protection (FP2) were tested. Incidence of stem borer, leaffolder, whorl maggot and predators like spiders, coccinellids were recorded throughout the crop growth period. The per cent leaves damaged by whorl maggot and leaffolder were low in both treatments. The mean per cent dead hearts were on par in BIPM 1, 2 and FP2 (13.26, 13.71 and 13.54 respectively) as compared to 17.50 % in FP 2 treatment **(Table 2.52)**. There were no significant differences in the incidence of white ears among the treatments. Population of BPH was higher in the FP treatments (26.19 and 27.15 per 10 hills) as compared to the BIPM treatments(20.38 and 22.31/10 hills). Among the natural enemies, only ground beetle population was significantly higher in the two BIPM treatments (2.86 and 2.38 respectively) (**Table 2.53**).

The egg parasitisation of stem borers was was observed to be 15.80 % in BIPM 1 compared to 4.87 % in FP 2. The egg parasitoids *Telenomus* and

Trichogramma we accounted for 40 and 60 per cent of the parasitoid composition, respectively. The yield was highest in FP2 (5805.92 k/ha).

Table 2.52 Pest incidence and yield under Bio-intensive pest management trial at Raipur, *kharif* 2019

Treatments	Stem borer		BPH	Yield
	% Dead hearts	% White ears	(No./ 10 hills)	(Kg/ha)
BIPM1	13.26 (21.27)	20.84 (27.14)	20.38	4797.56
BIPM 2	13.71 (21.72)	19.39 (26.10)	22.81	4601.85
FP 1	17.50 (24.68)	20.43 (26.83)	26.19	4526.85
FP 2	13.54 (21.58)	17.52 (24.69)	27.15	5805.92
CD (p=0.05%)	1.67	NS	1.79	

* DH – Dead heart; BPH –brown planthopper; WE- white ear

Table 2.53 Population of natural enemies under Bio-intensive pest management trial at Raipur, *kharif* 2019

Treatments	Spiders (No./10 hills)	Coccinellids (No./10hills)	Ground beetle (No./10hills)	Staphylinid (No./10hills)
IPM1	3.12	2.50	2.86	2.38
BIPM 2	3.31	2.57	2.38	1.86
FP 1	3.00	2.38	1.95	1.57
FP 2	2.81	2.19	1.93	2.00
CD (p=0.05%)	NS	NS	0.71	NS

9. Ranchi

Incidence of hispa, stem borer, leaffolder and gall midge were recorded throughout the crop growth period. There were no significant differences in pest incidence between the two treatments. **(Table 2.54)**. FP plots yielded higher (4011kg/ha) than that of BIPM plots (3433 kg/ha) though statistically at par.

10. Titabar

The treatments were planted with Keteki Joha variety, in six replications of plot size 100 m^2. The practices followed in BIPM plots were wet seed treatment with *Pseudomonas florescens* prepared @10g/litre of water per kg of seed, seedling root dip treatment with Azospirillum and Phosphorous solubilizing bacteria (PSB) @ 600g culture for 1 ha, application of vermicompost @ 500g/ sq m and rice husk ash @100g/ sqm of the nursery bed; application of vermicompost @ 2.5ton/ ha + green manure crop @ 2.5t/ ha half as basal and half at active tillering stage, clipping of rice seedlings before transplanting, mass trapping of stem borer with pheromone trap @ 20 traps/ha, (2 in 600 sqm); *Trichogramma joponicum* for stem borer and *T. chilonis* for leaf folder @ 5cc egg/ ha. Neem oil @ 5 ml/liter of water was applied when the insect pest incidence was observed. Pigeonpea and marigold were grown on the border of the plot. The practices followed in the FP treatment were no seed treatment; no fertilizer in nursery, application of N- 60kg, P_2O_5 -20kg and K2O -40 kg/ha and no application of insecticides.

. The damage by leaffolder (0.88%), whorl maggot (0.78%) and caseworm (0.714 %) were significantly lower **(Table 2.55)** in BIPM plots as compared to FP plots (19.35, 9.06 and 16.62% respectively). Similar trend was observed

for dead hearts caused by stem borer in BIPM treatment (1.38 %) compared to the significantly higher damage of 29.92 % in FP plots. The abundance of natural enemies was also found to be higher in BIPM treatment. The spider and coccinellid numbers per ten hill was significantly higher in BIPM plots (3.89 and 4.67 respectively) as compared to less than one in FP treatment (Table 2.xx). The yield on the other hand was highest in FP2 (5805.92 k/ha), however BIPM plots yielded significantly higher (5321kg/ha) than FP plots (3020 kg/ha) **(Table 2.56)**.

The egg parasitisation of stem borers was assessed and a mean of 55.75 % was observed in BIPM compared to 11.64 % in FP treatment. Three egg parasitoids - *Tetrastichus*, *Telenomus* and *Trichogramma* were observed accounting for 28.57, 20.23 and 51.19 per cent of the parasitisation respectively.

Table 2.55 Pest incidence and yield under Bio-intensive pest management trial at Titabar, *kharif* 2019

Para-meters	LF		WM		DH		CW		Yield	
	(% damage)		(% damage)		(% damage)		(% damage)		(kg/ha)	
	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP
Mean	0.88	19.37	0.78	9.06	1.38	29.92	0.71	16.62	5321	3020
t value	17.50**		17.22**		36.30**		18.13**		37.14**	
df	58		58		58		58		10	
P - value	<0.01		<0.01		<0.01		<0.01		<0.01	

WM- whorl maggot; DH– Dead heart; CW- caseworm; LF- leaffolder; *projected yield

Table 2.56 Population of natural enemies under Bio-intensive pest management trial at TITABAR, *kharif* 2019

Parameters	Spiders (No./10 hills)		Coccinellids (No./10 hills)		Mirid (No./10 hills)		% egg parasitisation	
	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP
Mean	3.89	0.71	4.67	0.72	0.78	0.64	55.75	11.64
t value	17.25**		19.13**		2.85		10.13**	
df	58		58		58		48	
P - value	<0.01		<0.01		NS		<0.01	

Bio intensive pest management trial was initiated to explore the feasibility of bio-intensive approaches for managing pests for organic rice cultivation. The trial was conducted in 10 locations this year. The stem borer incidence was reduced in BIPM plots as in Chinsurah (5.47 %), Jagdalpur (6.0%), Raipur (13.26%) and Titabar (1.38 %) as compared to farmers practice where it was 19.35, 8.91, 17.50 and 29.92 % respectively. In Ludhiana and Ranchi, the pest incidence was on par with that of Farmers' practice. The natural enemies were higher in BIPM plots in all locations. The results also indicated an increase in natural enemy population in the organic BIPM plots.

2.5. INTEGRATED PEST MANAGEMENT

i) Integrated pest management special trial (IPMs)

Rice crop is affected by a number of biotic factors including insects, diseases and weeds which act as major constraints at various stages of crop growth. Holistic management of these pests in an effective way needs farmers to be empowered with knowledge and skills to take appropriate decisions at farm level. Keeping this in view, IPMs trial was continued in association with agronomists and plant pathologists in farmers' fields. The major aim of this trial is to validate IPM practices from a basket of options available and demonstrate to farmers the management of pests in a sustainable way.

IPMs trial was conducted at 13 locations during *Kharif* 2019. At 7 locations *viz.*, Karjat, Mandya, Pantnagar, Pusa, Rajendranagar, Raipur and Sakoli, the trial was carried out in three farmers' fields. At Jagdalpur, the trial was conducted in two farmers' fields while in the rest of 5 locations, i.e., Chinsurah, Gangavathi, Ludhiana, Malan and Titabar, the trial was carried out in one farmer field. Location wise details of farmers, villages, pest incidence and management practices followed were discussed below:

Chinsurah: IPM trial was conducted in Sri Narayan Chandra Mondal's field at Bele Village, Radhanagar post, Pandua block in Hooghly district, West Bengal. Practices followed in IPM and FP plots are given below:

Practices followed in IPMs trial at Chinsurah, *Kharif* 2019

	IPM practices	Farmers practices
Area/ variety	1 acre; Swarna	1 acre; Swarna
Nursery	• Application of 8 kg of 10:26:28 complex	
Main field	• Field preparation with power tiller, cutting of bunds and leveling the field • Application of 105:100:27 kg urea, SSP & MOP • Application of Butachlor + hand weeding • Application of Ferterra @ 4 kg/ acre • Application of Coragen @ 60 ml/ acre • Application of carbendazim • Installation of pheromone traps @ 6/acre for stem borer mass trapping	• Field preparation with power tiller, cutting of bunds and leveling the field • Application of 80 kg10-26-26; Urea 40 KG • Hand weeding two times • Application of Phorate 10 G @ 4.5 kg/ acre • Triazophos @ 750 ml/ acre two times • Application of Carbendazim

Very low incidence of stem borer, leaf folder, whorl maggot, hispa, BPH, WBPH and GLH was observed in Swarna variety grown at this location in both IPM and farmer practices plots **(Table 2.57)**. The data on weed population and biomass showed significant decrease in IPM by 42.58 and 32.57%; 52.85 and 33.33% respectively than in farmers practice. Higher BC ratio (1.59) was obtained in IPM plot compared to FP plot (1.45) mainly due to higher grain yield that resulted in increased returns (**Table 2.58)**.

Table 2.57 Insect pest incidence in IPMs trial at Chinsurah, *Kharif* 2019

Treatments	% DH	% WE	% LFDL	% WMDL	% HDL	BPH	WBPH	GLH
	85 DAT	Pre har	36 DAT	29 DAT	64 DAT	50 DAT	64 DAT	78 DAT
IPM	0.25 ± 0.20	0.74 ± 0.33	0.05 ± 0.05	0.94 ± 0.27	0.00 ± 0.00	0.00 ± 0.00	0.80 ± 0.80	38.80 ± 5.33
FP	7.81 ± 0.35	8.74 ± 0.64	0.70 ± 0.07	2.53 ± 0.59	0.74 ± 0.18	13.60 ± 1.31	3.20 ± 0.97	48.4 ± 7.61

Table 2.58 Returns and BC ratio in IPMs trial at Chinsurah, *Kharif* 2019

Treatments	Yield (q/ha)	Gross Returns (Rs.)	Cost of Cultivation (Rs)	Net Returns (Rs.)	BC Ratio
IPM	45.34	82972	52245	30727	1.59
FP	39.81	72852	50403	22449	1.45

Price of paddy = 1830 Rs/ q

Gangavathi: IPMs trial was conducted in Sri Suryarao's field at Vidyanagar village, Koppal district of Karnataka state. BPT 5204 was grown in both IPM and FP plots. Practices followed in both IPM and FP plots were given below:

Practices followed in IPMs trial at Gangavathi, *Kharif* 2019

IPM practices	Farmers Practices
Variety – BPT 5204	Variety – BPT 5204
• Seed treatment with Carbandezim @ 2g / kg seed • Fertilizer application @ 60:30:30 kg NPK /ha • Forming alleyways of 30 cm • Grown marigold on bunds • Installation of pheromone traps @ 8 traps/ ha • Sprayed Chlorpyriphos 20 EC @ 2ml / liter at 45 DAT • Followed alternate wetting and dring • Sprayed Tilt (Propiconazole) @ 1ml / liter water • Sprayed Metarhizium @ 2 g/ liter water at 60 DAT	• Fertilizer application @ 120:60:60 kg NPK /ha • Application of weedicide, Butachlor @ 400 ml/ac • Application of Ferterra @ 4 kg at 25 DAT • Sprayed Chlorpyriphos 20 EC @ 2ml / liter at 50 DAT • Application of Triflumezopyrim @ 94 ml / acre at 60 DAT • Sprayed Merger (Tricyclazole + Mancozeb) @ 2 g / liter water at 45 DAT • Sprayed Tilt (Propiconazole) @ 1ml / liter water at 65 DAT • Sprayed Nativo (Trifloxystrobin + Tebiconazole) at 85 – 90 DAT

Very low incidence of stem borer and leaf folder (<2%) was observed in both the treatments (Table…). Planthopper incidence was high in both IPM and FP plots up to 57 DAT and WBPH population was higher than BPH population. Incidence of BPH and WBPH started at 15 DAT in both IPM and FP plots with highest populations in IPM plots initially **(Fig 2.14)**. Highest

population of WBPH was found in IPM plot from 22 DAT to 57 DAT (177 - 391/5hills) while it ranged between 150 and 355 in FP plots. Though, initially, WBPH population was high in IPM plots but from 64 DAT onwards, it declined due to appropriate IPM interventions whereas the population remained high in FP plots. On the other hand, BPH population was high in FP plot initially and later got reduced **(Fig 2.14)**.

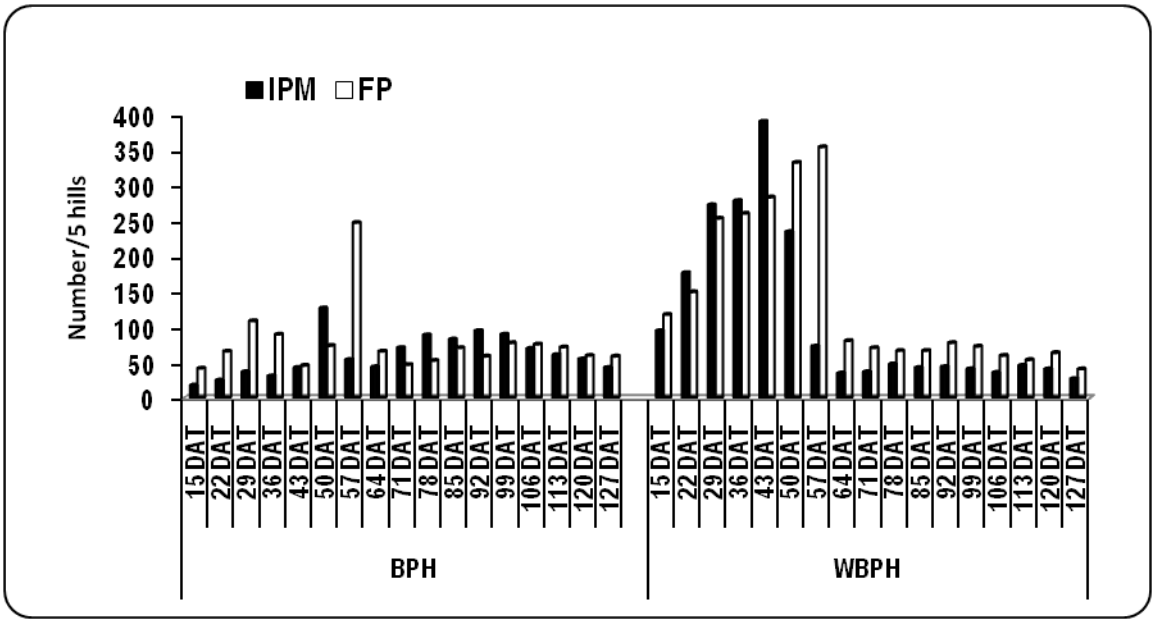


Fig 2.14 Planthopper population in IPM and FP plots in IPMs trial at Gangavathi, *Kharif* 2019

Table 2.59 Pest incidence and BC ratio in IPMs trial at Gangavathi, *kharif* 2019

Treatments	% DH 71 DAT	% LFDL 78 DAT	GLH 57 DAT	Yield (q/ha)	Gross Returns (Rs.)	Cost of Cultivation (Rs.)	Net Returns (Rs.)	BC ratio
IPM	1.56 ± 0.30	0.79 ± 0.16	2.0 ± 0.3	67.88	139154	62473	76681	2.23
FP	2.05 ± 0.18	0.92 ± 0.07	13.4 ± 1.6	63.66	130503	70610	59893	1.85

Price of paddy = 2050 Rs/ q

IPM adopted fields showed significantly low weed intensity 63.48 &50% in weed population and 40.51% in weed biomass. Grain yield of 67.88 q/ ha was recorded in IPM plot compared to FP plot (63.66 q/ ha) resulting in higher gross returns **(Table 2.59)**. High gross returns due to high price of paddy and low cost of cultivation in IPM plot resulted in high BC ratio (2.23) compared to FP plot (1.85).

Jagdalpur: IPMs trial was conducted in two farmer's field's *viz.*, Sri Pooran Bagel and Smt Santi Bai of Chokar village, Bastar district of Chattisgarh.

Low incidence of stem borer, leaf folder, gall midge, whorl maggot, hispa, BPH, WBPH and GLH was observed in both IPM and FP plots. Caseworm and thrips incidence was also noticed in both IPM and FP plots. Practices followed in IPM and FP plots were given below:

Practices followed in IPMs trial at Jagdalpur, *Kharif* 2019		
	IPM Practices	**Farmers Practices**
Area	1 acre	1 acre
Variety	Dhaniya	Dhaniya
Nursery	• Application of 3.2 kg N, 2 kg P, 1.2 kg K / 400m^{2}nursery	• Application of 2 kg N, 1 kg P, 1 kg K / 400m^2 nursery
Main field	• Application of 80:50:30 kg NPK per hectare • Seedlings transplanted at spacing of 20/15 cm; Left alleyways of 30 cm after 10 rows. • Applied Butachlor 1.5 kg ai/ha at 4 DAT+ 1 hand weeding • Nitrogen top dressing at 45 DAT • Applied chlorpyriphos + Cypermethrin @ 1 lit/acre at 35 DAT • Sprayed Tricyclazole @ 125 g/ acre against blast	• Application of 80 kg N, 50 kg P & 30 Kg K/ acre • Applied phorate 10 G @ 5kg/ha • Hand weeding twice • Sprayed Carbendazim @ 200 g/ha against blast

Grain yields were higher in IPM plots (40.16 Q/ ha) than FP plots (34.28 Q/ ha). BC ratio was also higher in IPM plots (3.83) compared to FP plots (3.03) mainly due to high gross returns and low cost of cultivation **(Table2.60)**.

Table 2.60 Insect pest incidence, returns and BC ratio in IPMs trial at Jagdalpur, Kharif 2019

Farmer's Name	Treatments	% DH	% WE	% LFDL	% WMDL	Yield	Gross Returns (Rs.)	Cost of cultivation (Rs.)	Net Returns (Rs.)	BC ratio
		60 DAT	Pre har	45 DAT	45 DAT	Q/ ha				
F1 = Sri Pooran Bagel	IPM	3.01 ± 0.76	5.97 ± 1.84	8.53 ± 1.96	6.02 ± 1.73	40.48	85008	22000	63008	3.86
	FP	0.00 ± 0.00	0.00 ± 0.00	9.27 ± 0.82	5.10 ± 1.28	34.64	72744	23750	48994	3.06
F2 = Smt Santi Bai	IPM	2.60 ± 1.17	4.95 ± 0.72	1.95 ± 0.64	17.46 ± 0.93	39.84	83664	22000	61664	3.80
	FP	2.25 ± 1.49	3.44 ± 1.02	4.91 ± 1.22	9.03 ± 1.85	33.92	71232	23750	47482	3.00
IPM		2.81	5.46	5.24	11.74	40.16	84336	22000	62336	3.83
FP		1.13	1.72	7.09	7.02	34.28	71988	23750	48238	3.03

Price of paddy = 2100 Rs./q

Karjat: IPMs trial was conducted in three farmers' fields' *viz.*, Sri Datta Lakshman Modak of Arwand village, Sri Ragho Damu Mune of Barane village and Sri Ravindra Pandurang Kadam of Salokh village in Karjat taluq of Raigad district, Maharashtra State. Practices followed in both IPM and FP plots were given below:

Practices followed in IPMs trial at Karjat, *Kharif* 2019

Practices adopted	IPM practices	Farmers practices
Area	1 acre	1 acre
Varieties	1) Sri Datta Lakshman Modak, Arwand village - Karjat-3 2) Sri Ragho Damu Mune, Barane village - Karjat 3 3) Sri Ravindra Pandurang Kadam, Salokh village – Karjat 7	Karjat 3 Karjat 3 Karjat 7
Nursery	Seed treatment with carbendazim @ 10 g/ 10 kg seed Raised bed 3x1m treated with rice husk (hull) ash @3kg/bed	Land burned with waste materials Application of Phorate1 kg
Main field	• Deep ploughing • Application of FYM 4 T, Suphala 215 Kg, Urea 87 Kg • 2-3 seedlings transplanted at a spacing 20 x15 cm. • Alleyways of 40cm left after every 10 rows • Bispyribasodium 250ml/ha (Nomini gold). • Pheromone traps @ 8 / acre • Use of bird perches in the field • Use Vaibhav sickle for harvesting • Application of Cartap hydrochloride 18 kg/ha (one application)	• Deep ploughing • Application of FYM 2 T,Urea 145 kg, Suphala 75 kg • 4-5 seedlings transplanted randomly • Hand weeding once • Phorate 10 kg/ha (two applications)

Table 2.61 Insect pest incidence and weed parameters in IPMs trial at Karjat, *kharif* 2019

Treatments		% DH 36 DAT	% DH 43 DAT	% DH 50 DAT	Weed Popl No./m²	Weed biomass g/m²	Yield Kg/ha
IPM		6.2(2.3)b	9.4(2.9)b	12.7(3.6)a	3.4(1.9)a	1.6(1.2)b	2965a
FP		10.6(2.9)a	15.1(3.9)a	17.3(4.2)a	2.6(1.7)a	2.5(1.7)a	2405b
LSD (0.05)		**0.39**	**0.47**	**0.61**	**0.43**	**0.32**	**65**
F1- Sri. Datta Lakshman Modak		11.7(3.5)a	11.3(3.4)b	8.8(3.0)c	2.8(1.8)a	1.5(1.3)b	2687ab
F2 - Sri Ragho Damu Mune		0.0(0.7)b	7.0(2.6)c	16.4(4.1)b	3.5(1.9)a	3.4(1.9)a	2596b
F3- Sri Ravindra Pandurang Kadam		13.5(3.7)a	18.4(4.3)a	19.9(4.5)a	2.791.8)a	1.4(1.2)b	2772a
LSD (0.05)		**0.32**	**0.53**	**0.38**	**0.3**	**0.2**	**102**
F1- Sri. Datta Lakshman Modak	IPM	8.9(3.1)b	8.3(2.9)d	7.8(2.9)d	2.6(1.7)b	0.0(0.70d	2950b
	FP	14.5(3.9)a	14.3(3.8)bc	9.7(3.2)cd	3.0(1.9)ab	2.991.8)b	2424c
F2 - Sri Ragho Damu Mune	IPM	0.0(0.7)c	4.2(2.0)d	13.9(3.8)bc	5.0(2.3)a	4.9(2.3)a	2848b
	FP	0.0(0.7)c	9.8(3.2)cd	18.9(4.4)ab	2.0(1.5)b	1.9(1.5)c	2344c
F3 -Sri Ravindra Pandurang Kadam	IPM	9.8(3.2)b	15.7(4.0)ab	16.4(4.1)b	2.6(1.7)b	0.0(0.7)d	3096a
	FP	17.3(4.2)a	21.1(4.6)a	23.4(4.9)a	2.8(1.8)b	2.7(1.8)bc	2448c
LSD (0.05)		**0.45**	**0.74**	**0.53**	**0.4**	**0.29**	**145**

Higher incidence of dead hearts was observed in IPM plots (6.2 to 12.7% DH) compared to Farmers Practice plots (10.6 to 17.3%) **(Table 2.61)**. Grain yield was higher in IPM plots (2965 kg/ha) than FP plots (2405 kg/ha) resulting in higher gross returns and BC ratio **(Table 2.62)**.

Table 2.62 Returns and BC ratio in IPMs trial at Karjat, *Kharif* 2019

Farmers	Treatments	Yield (q/ ha)	Gross returns (Rs.)	Cost of cultivation (Rs.)	Net returns (Rs.)	BC ratio
F1- Sri. Datta Lakshman Modak, Arwand village	IPM	29.5	59625	42183	17442	1.41
	FP	24.2	46950	42650	4300	1.10
F2 - Sri Ragho Damu Mune, barane village	IPM	28.5	57375	42183	15192	1.36
	FP	23.4	45875	42800	3075	1.07
F3 -Sri Ravindra Pandurang Kadam, Salokh village	IPM	31.0	62075	42183	19892	1.47
	FP	24.5	50125	43915	6210	1.14

Ludhiana: PR 121 variety was grown in IPMs trial conducted at Sri Inderjit Singh's field of Sudhar village, Ludhiana district, Punjab State. Very low incidence of stem borer, leaf folder, whorl maggot, BPH and WBPH was observed in both the treatments **(Table 2.63**). Observations on natural enemies like spiders, coccinellids, ichneumonids and braconids were also taken in both IPM and FP plots. Sheath blight and false smut diseases recorded at Ludhiana revealed that the disease severity is too low to draw valid conclusions. Grain yield was relatively high in IPM (73.52 q/ ha) as compared to FP plot (72.48 q/ ha) resulting in higher BC ratio (3.26) due to high gross returns and low cost of cultivation.

Practices followed in IPMs trial at Ludhiana, *Kharif* 2019

	IPM Practices	Farmers Practices
Variety	PR 121	PR 121
Nursery	• Seed treatment with 20 g Bavistin 50 WP and 1 g Streptocycline • Application of urea @ 1.0 kg and Zinc sulphate @ 1 kg/ acre nursery	• Application of urea @ 1.0 kg/ acre nursery and Zinc sulphate @ 1 kg/ acre nursery
Main field	• Alley ways of 30 cm after every 2 m • Application of Butachlor @ 1.2 L/ acre • Sprayed Fame 480 SC @ 20 ml/acre • Sprayed Chess @ 120 g/ acre & Tilt @ 200ml/ acre • Recommended dose of neem coated urea-90 kg/ acre • Growing flowering plants like green gram, black gram, soybean, cowpea, sesamum, Marigold. • Water management for planthoppers	• Applied urea 120 kg and zinc sulphate 25 kg/ acre • Application of Butachlor @ 1.2 L/ acre • Application of Mortar @ 170 g/ acre • Sprayed Chess @ 120g/acre • Sprayed Tilt @ 200ml/ acre

Table 2.63 Insect pests and disease incidence in IPMs trial at Ludhiana, *kharif* 2019

Treatments	% DH	% WE	% LFDL	% WMDL	BPH	WBPH	Yield	Gross Returns (Rs.)	Cost of cultivation (Rs.)	Net Returns (Rs.)	BC ratio
	66 DAT	Pre har	87 DAT	52 DAT	80 DAT	73 DAT	Q/ ha				
IPM	4.45 ± 0.3	3.56 ± 0.5	5.06 ± 0.6	4.24 ± 0.5	19 ± 2.1	21 ± 2.0	73.52	133439	40970	92469	3.26
FP	5.86 ± 1.5	5.28 ± 0.7	7.98 ± 0.3	5.63 ± 0.7	13 ± 1.0	30 ± 1.9	72.48	131551	44960	86591	2.93

Price of paddy = Rs.1815

Malan: The trial was conducted in Sri Krishan Kumar's field of Jia Haar village, Kangra district, Himachal Pradesh. HPR 2880 was grown in IPM field and Jheni, a local variety was grown in FP plot. Incidence of black beetle and hispa was observed starting from 15 DAT onwards. Very high incidence of hispa was observed from 15 DAT onwards and the damage increased with increase in crop growth however, got reduced after 57 DAT. Hispa damage was severe in FP plot as compared to IPM plot with damage ranging from 33.3 to 94.7% **(Table 2.64)**. Dead heart damage caused by black beetle was also higher in FP plot (38.8 – 60.3%) than IPM plot (13.0 – 22.3%) during 15 to 50 DAT. The weed population was 50% lower in IPM adopted field compared to FP plot. Hence, weed biomass was also found low in IPM plot at 57 DAT **(Table 2.65)**. IPM plot showed higher yield (34.88 q/ha) than FP plot (16.88 q/ ha). Net returns were negative in FP plot (0.88) due to low grain yield and high cost of cultivation while IPM plot showed high BC ratio (1.37).

Practices followed in IPMs trial at Malan, *Kharif* 2019

	IPM Practices	Farmers Practices
Variety	HPR 2880	Jheni local variety
Nursery	• Line sowing • Application of FYM	• Broadcast nursery • Application of urea @ 30 kg
Main field	• Application of 90 kg N, 40 kg P and 40 kg K. • Application of herbicide – Bispyribac sodium salt • Sprayed Chlorpyriphos • Application of Bavistin	• Applied of 30 kg urea

Table 2.64 Pest incidence in IPMs trial at Malan, *kharif* 2019

Treatments	% DH due to black beetle				% HDL				
	15 DAT	29 DAT	36 DAT	50 DAT	15 DAT	36 DAT	50 DAT	57 DAT	85 DAT
IPM	19.42 ± 0.8	22.28 ± 3.8	16.9 ± 5.9	12.96 ± 2.4	14.9 ± 0.5	20.2 ± 1.9	17.2 ± 2.9	24.8 ± 3.1	8.81 ± 0.3
FP	60.3 ± 8.0	51.0 ± 8.6	40.4 ± 7.8	38.8 ± 4.2	33.3 ± 4.7	41.1 ± 3.4	58.1 ± 0.7	94.7 ± 2.3	96.6 ± 3.5

Table 2.65 Weed dynamics, returns and BC ratio in IPMs trial at Malan, *Kharif* 2019

Treatments	Weed Population (No./m²)		Weed biomass (g/m²)		Yield (q/ ha)	Gross returns (Rs.)	Cost of cultivation (Rs.)	Net returns (Rs.)	BC ratio
	29DAT	57 DAT	29DAT	57 DAT					
IPM	16.90 ± 1.4	15.76 ± 1.7	19.42 ± 2.0	19.46 ± 2.1	34.88	62784	45861	16923	1.37
FP	29.60 ± 2.6	45.60 ± 3.5	18.20 ± 0.9	38.28 ± 4.4	16.88	30384	34686	-4302	0.88

Price of Paddy = RS. 1800/Q

Mandya: IPMs trial was conducted in three farmers' fields i.e., in the fields of Sri Mahadevu, Sri Jayaramu and Sri Shivalinga at Ganadalu village of Mandya district in Karnataka State. Practices followed in IPM and FP plots are given in table below:

Practices followed in IPMs trial at Mandya, *Kharif* 2019

Practices adopted	IPM practices	Farmers practices		
		Sri Mahadevu	**Sri Jayaramu**	**Sri Shivalinga**
Area	1 acre	1 acre	1acre	1acre
Variety	MTU 1001 /MTU 1001/ BR 2655	MTU 1001	MTU 1001	BR 2655
Fertilizers applied	Urea 45 kg/ acre, SSP 125 kg/ acre, MOP 35 kg/ acre, Top dressing 45 kg urea	Urea 50 kg/ acre, 10:26:26 complex fertilizer 100 kg/ acre, MOP 25 kg/ acre	100 kg - 10:26:26 complex fertilizer; 100 Kg Urea	100Kg - 10:26:26 complex fertilizer; 50 Kg Urea/ acre
Nursery	Seed treatment with Carbendezim @ 4 g/kg of seed			
Main field	• Transplanting with 20 x 15cm spacing	• Randomly transplanted	• Randomly transplanted	• Randomly transplanted
	• Alley ways of 30cm after every 2m	• Pretilachlor @ 400 ml/ acre + two hand weedings	• Butachlor @ 400 ml/ acre + two hand weedings	• Butachlor @ 1.2 lit/ acre + two hand weedings
	• Londax power @ 4kg/ac - herbicide at 3 DAT + one hand weeding	• Carbofuran 4G application @ 8 kg/ acre	• Carbofuran 4G application @ 8 kg/ acre	• Carbofuran 4G application @ 8 kg/ acre
	• Installation of pheromone traps for monitoring stem borer @ 8 traps / ha	• Chlorantrinili prole (Coragen) @ 60 ml/ acre	• Fluben diamide 48 SC @ 0.1 ml/ liter	• one spray of Chloropyriphos 20EC @ 2ml/lit
	• Application of Fipronil 5 SC @ 1.5 ml/l	• Tebuconazole (Nativo) @ 0.4 g/l	• Imidacloprid 17.8 SL @ 0.3 ml/l	• Hexaconazole 5 EC @ 2ml/liter
	• Zinc sulphate @ 8 kg/ acre	• Dinotefuron 20 SG @ 250 g/ ha at 70 DAT	• Propicona zole 25 EC @ 1 ml/l	• Buprofezin 25 EC (Applaud) @ 1.4 ml/liter
	• Tricyclazole 75WP @ 0.6g/lit			

Table 2.66 Insect pest and disease incidence in IPMs trial at Mandya, *Kharif* 2019

Farmer Name	Treat ments	% DH	% WE	% LFDL	% CWDL	BPH	Leaf blast % severity
		50 DAT	Pre har	36 DAT	57 DAT	85 DAT	43 DAT
F1- Sri Mahadevu	IPM	3.4 ± 0.8	4.0 ± 1.2	1.3 ± 0.2	0.6 ± 0.1	5.8 ± 0.8	4.5 ± 0.6
	FP	6.2. ±1. 0	6.2 ± 1.9	4.7 ± 0.5	2.0 ± 0.4	14.8 ± 1.2	9.2 ± 1.3
F2 - Sri Jayaramu	IPM	4.3 ± 1. 0	3.2 ± 1.0	1.5 ± 0.3	0.9 ± 0.2	7.4 ± 0.9	3.6 ± 0.5
	FP	6.0 ± 1.1	7.8 ± 2.6	4.9 ± 0.9	2.2 ± 0.5	13.2 ± 2.1	7.9 ± 0.9
F3- Sri Shivalinga	IPM	3.3 ± 1.1	5.0 ± 1.6	1.5 ± 0.3	1.5 ± 0.5	5.8 ± 0.9	2.7 ± 0.3
	FP	5.6± 1.5	3.9 ± 0.8	3.7 ± 0.6	2.5 ± 0.8	10.8 ± 1.6	4.6 ± 1.0
IPM		3.67	4.07	1.43	1.00	6.00	3.60
FP		5.93	5.97	4.43	2.23	13.00	7.23

Incidence of stem borer, leaf folder, caseworm and BPH was observed in both IPM and FP plots in all the three farmers' fields. In general, pest

damage was very low across the farmers' fields **(Table 2.66)**. Leaf blast incidence was recorded in both IPM and FP plots in all the three farmers' fields at Mandya. Leaf blast severity was low in IPM plots as compared to FP plots due to the adoption of IPM practices. Weed population and weed biomass was low in both IPM and FP plots in all the three farmers' fields **(Table 2.67)**.

Table 2.67 Weed population and weed biomass in IPMs trial at Mandya, *Kharif* 2019

Farmer name	Treatments	Weed population (No./m²)		Weed biomass (g/m²)	
		29 DAT	57 DAT	29 DAT	57 DAT
F1- Sri Mahadevu	IPM	1.60 ± 0.75	2.60 ± 1.17	0.20 ± 0.10	1.00 ± 0.48
	FP	2.20 ± 0.66	3.80 ± 1.07	0.51 ± 0.26	1.52 ± 0.46
F2 - Sri Jayaramu	IPM	1.80 ± 0.58	4.00 ± 0.84	0.27 ± 0.09	1.55 ± 0.34
	FP	4.00 ± 0.71	4.40 ± 0.51	1.20 ± 0.25	1.98 ± 0.28
F3- Sri Shivalinga	IPM	1.80 ± 0.80	2.60 ± 0.98	0.43 ± 0.21	0.86 ± 0.41
	FP	2.80 ± 0.86	2.68 ± 0.87	0.86 ± 0.28	0.60 ± 0.25
IPM		1.73	3.07	0.30	1.14
FP		3.00	3.63	0.86	1.37

High grain yield was recorded in IPM plots with 58.3 q/ ha in IPM plot of Sri Jayaramu's field followed by IPM plot of Sri Mahadevu's field (54.3 q/ ha). High BC ratios were obtained in IPM plots (1.73) compared to FP plots (1.33) **(Table 2.68)**.

Table 2.68 Grain yield , Gross returns and BC ratio in IPMs trial at Mandya, *Kharif* 2019

Farmer name	Treatments	Yield q/ha	Gross Returns (Rs.)	Cost of cultivation (Rs.)	Net Returns (Rs.)	BC ratio
F1- Sri Mahadevu	IPM	54.3	86880	48425	38455	1.79
	FP	47.8	76480	54250	22230	1.41
F2 - Sri Jayaramu	IPM	58.3	93280	48050	45230	1.94
	FP	51.6	82560	56500	26060	1.46
F3- Sri Shivalinga	IPM	45.6	70680	48300	22380	1.46
	FP	39.1	60605	54775	5830	1.11
IPM		52.73	83613	48258	35355	1.73
FP		46.17	73215	55175	18040	1.33

Price of paddy = Rs.1600/q (F1 & F2); Rs.1550/q (F3)

Pantnagar: IPM trial was conducted in two villages in three farmers' fields' *viz.*, Sri Nand Gopal's field in Dineshpur village, Ward No.2, Sri Prakash Sarkar's field and Sri Sachin Mandal's field in Panchananpur village, Dineshpur, Udham Singh Nagar mandal of Uttarakhand State. Varieties grown and practices followed in IPM and FP plots are given below:

Practices followed in IPMs trial at Pantnagar, *Kharif* 2019

Sri Nand Gopal, Dineshpur village, Ward No.2, Udham Singh Nagar, Uttarakhand		
	IPM	**FP**
Area	2500 sq.m	2500 sq.m
Variety	PR 126	PR 126
Main Field	• Application of NPK @ 100 kg/ ha, Zinc @ 25 kg/ ha, urea @ 120 kg/ ha	• Application of NPK @ 120 kg/ acre, Chelated Zinc @ 6 kg/ha and urea 120 kg/ ha.
	• Application of Pretilachlor @ 1.5 L/ ha	• Application of Pretilachlor 50 EC @ 1.5 liter/ ha, Nominee Gold @ 200 ml/ ha
	• Sprayed Cartap hydrocloride 50% SP@ 600g/ha- two times	• Application of Cartap hydrochloride 4G @ 19 kg/ ha, Monocrotophos 36 SL @ 1500ml/ha,Buprofezin 25 SP @1000 ml /ha
	• Applied streptocycline @15 g/ha + copper oxycloride @ 500 g/ha	• Applied Streptocycline @ 15g/ha + Copper oxycloride @ 500g/ha, Hexaconazole 5% EC @ 2000 ml/ha
	• Installed pheromone traps for YSB @ 8/ ha	
Sri Prabhash Sarkar & Sri Sachin Mandal, Panchananpur, Dineshpur, Udham Singh Nagar, Uttarakhand		
Area	2500 sq.m	2500 sq.m
Variety	HKR 47	HKR 47
Main Field	• Application of NPK 100 kg/ ha, Zinc 25 kg and Urea 120 kg	• Application of NPK 120 kg/ ha, Chelated Zinc @ 6 kg/ ha and Urea 120 kg/ha
	• Application of Pretilachlor @ 1.5 L/ ha	• Applied Pretilachlor 50 EC @ 1.5 liter/ ha , Nominee Gold @ 200 ml/ ha
	• Sprayed Cartap hydrocloride @ 600g/ha- two times	• Application of Cartap hydrocloride 4.0G @ 19 kg/ ha, Chlorantraniliprole 18.5 % SC (Coragen) @150 ml/ha, Acephate75 SP @1250 g/ha
	• Applied streptocycline @15 g/ha + copper oxicloride @ 500g/ha	• Applied Streptocycline @ 15g/ha + Copper oxycloride @ 500g/ha, Cocide 2000 @ 500 g/ha
	• Installed pheromone traps for YSB @ 8/ ha	

Table 2.68 Pest incidence in IPMs trial at Pantnagar, *kharif* 2019

Farmer's name	**Treat ments**	**% DH**			**% LFDL**	**% WMDL**	**% HDL**	**BPH**	**Yield**
		43 DAT	**50 DAT**	**57 DAT**	**36 DAT**	**22 DAT**	**22 DAT**	**71 DAT**	**kg/ ha**
F1- Sri Nand Gopal	IPM	10.11 ± 2.63	9.99 ± 1.03	12.32 ± 1.37	2.59 ± 0.49	2.91 ± 0.74	1.95 ± 0.64	46.0 ± 2.02	5664 ± 88
	FP	9.89 ± 1.47	8.63 ± 1.24	7.25 ± 1.57	2.04 ± 0.44	2.44 ± 1.02	1.89 ± 0.97	31.80 ± 1.59	5869 ± 135
F2 - Prabhash Sarkar	IPM	6.04 ± 1.64	10.35 ± 1.23	14.30 ± 1.91	1.95 ± 0.50	4.78 ± 0.87	3.52 ± 0.78	46.80 ± 4.35	5423 ± 111
	FP	8.19 ± 1.96	14.26 ± 1.95	7.11 ± 1.41	1.31 ± 0.49	5.51 ± 1.91	3.43 ± 1.24	29.20 ± 1.71	5689 ± 134
F3 = Sri Sachin Mandal	IPM	6.18 ± 0.72	5.36 ± 1.33	8.55 ± 1.34	3.61 ± 0.60	5.00 ± 1.68	2.91 ± 1.34	15.60 ± 2.44	5667 ± 133
	FP	6.09 ± 1.26	3.34 ± 0.65	6.07 ± 0.90	0.98 ± 0.43	6.97 ± 2.30	1.97 ± 1.02	14.40 ± 1.96	5948 ± 46
IPM		7.44	8.57	11.72	2.72	4.23	2.79	36.13	5585
FP		8.06	8.74	6.81	1.44	4.97	2.43	25.13	5835

Low incidence of leaf folder, whorl maggot, hispa, BPH, WBPH and GLH was observed in both IPM and FP plots **(Table 2.68)**. Stem borer damage crossed ETL in IPM and FP plots during 43 to 57 DAT. Grain yield ranged from 5423 to 5948 kg/ha in both the treatments wwwith higher yield in FP plot (5835 kg/ ha).

Pusa: IPM trial was conducted in three farmer's fields i.e., two farmers Samastipur area *viz.*, Sri Sushil Kumar Rhakur and Smt Sukhsagar Devi from Ratras, Warisnagar, Samastipur and one from Darbhanga area, Sri Ram Sevak Rai of Khutwara, Kabariya, Darbhanga in Bihar State. Varieties grown and practices followed in IPM and FP plots are given below in a Table.

Incidence of stem borer and leaf folder was observed in both the treatments. Damage by both pests was low in IPM field as compared to farmer's practices fields. Weed population and weed biomass was also relatively low in IPM at both 30 DAT and 60 DAT **(Table 2.69)**. Grain yield varied from 41.22 to 59.82 q/ha and resulted in high BC ratio in IPM plot (2.96) compared to farmer's practices plots (2.56 – 2.79) **(Table 2.70)**.

Practices followed in IPMs trial at Pusa, *Kharif* 2019

	Pusa farm	Sri Sushil Kumar Rhakur	Smt Sukhsagar Devi	Sri Ram Sevak Rai
	IPM	**FP1**	**FP2**	**FP3**
Area	1 acre	1 acre	1 acre	1 acre
Variety	Rajendra Mansuri	Rajendra Mansuri	Rajendra Mansuri	Rajendra Mansuri
Main Field	• Seed treatment with Carbendazim @ 2 g/ kg seed • Transplanting at 20 x 15 cm spacing • Application of RDF • Application of Butachlor @ 1.5 kg ai/ ha after one week of transplantation • Installed pheromone traps for YSB @ 3/ acre • Application of Bispyribac sodium 20 g ai/ ha at 20 DAT • Application cartap hydrochloride 50 WP @ 600g / ha at 50 DAT	• Transplanting at 20 x 15 cm spacing • Application of RDF • Sprayed Chlorpyriphos 20 EC @ 500 ml ai/ ha at 20 DAT	• Transplanting at 20 x 15 cm spacing • Application of RDF • Hand weeding at 30 DAT • Application of Carbaryl 50 WP @ 30 kg/ ha	• Transplanting at 20 x 15 cm spacing • Application of RDF • Hand weeding at 30 DAT

Table 2.69 Insect pest incidence and weed parameters in IPMs trial at Pusa, *kharif* 2019

Treatments	% DH		% WE	% LFDL		Weed population (No./ m²)		Weed dry mass (g/m²)	
	30 DAT	50 DAT	Pre har	30 DAT	50 DAT	30 DAT	60 DAT	30 DAT	60 DAT
IPM	5.18 ± 0.49	5.78 ± 0.35	6.31 ± 0.40	6.33 ± 0.37	5.48 ± 0.41	8.54 ± 0.49	9.78 ± 0.47	10.96 ± 0.40	12.32 ± 0.51
FP1	10.22 ± 0.68	11.34 ± 0.76	12.21 ± 0.46	7.55 ± 0.34	8.35 ± 0.54	9.82 ± 0.40	12.26 ± 0.39	13.60 ± 0.82	14.54 ± 1.08
FP2	12.41 ± 0.62	13.62 ± 0.76	13.68 ± 0.64	9.42 ± 0.30	11.26 ± 0.45	12.72 ± 0.36	16.24 ± 0.35	18.83 ± 0.57	20.44 ± 0.52
FP3	13.63 ± 0.69	13.74 ± 0.79	14.39 ± 1.01	10.15 ± 0.90	13.54 ± 0.50	14.12 ± 0.38	15.76 ± 0.37	19.94 ± 0.47	19.64 ± 0.34
IPM	5.18	5.78	6.31	6.33	5.48	9	10	10.96	12.32
FP	12.09	12.9	13.42	9.04	11.05	12	15	17.46	18.21

Table 2.70 Grain yield & BC ratio in IPMs trial at Pusa, *Kharif* 2019

Treatments	Yield Q/ ha	Gross Returns (Rs.)	Cost of cultivation (Rs.)	Net Returns (Rs.)	BC ratio
IPM	59.82	109770	37133	72637	2.96
FP1	50.48	92631	33155	59476	2.79
FP2	43.26	79382	30950	48432	2.56
FP3	41.22	75639	29320	46319	2.58
IPM	59.82	109770	37133	72637	2.96
FP	44.99	82551	31142	51409	2.65

Price of paddy = Rs.1835/q

Rajendranagar: IPMs trial was conducted at Boorjugadda thanda, Shamshabad mandal, Rangareddy district of Telangana State in six farmers' fields with three IPM farmers (Sri M. Kishan, Sri M. Tariya and Sri A.Srisailam) and three non IPM farmers (Sri L Mudavath, Sri M Basha and Sri M Seethiya). Practices followed in IPM and FP fields are given below:

Practices followed in IPMs trial at Rajendranagar, *Kharif* 2019

	IPM Practices	Farmers Practices
Variety	RNR 15048	Tellahamsa
Nursery	• Applied of 4 kg urea, 6 kg SSP and 2 kg MOP • Applied Carbofuran 3 G	• Application of 4 kg urea, 6 kg SSP and 2 kg MOP
Main field	• Applied 80 kg N, 90 kg P and 15 kg K • Applied Chlorantraniliprole @ 0.3 ml/liter water (60ml/ acre) at panicle initiation stage • Adopted alleyways • Applied weedicide Topstar @ 36 g/ acre at 3-5 DAT(except farmer 3) + one hand weeding	• Application of 110 kg N, 100 kg P and 0 kg K. • Sprayed Chlorpyriphos @ 2.5 ml/ liter water • Sprayed Flubendamide @ 40 ml/acre • Sprayed Tricyclazole @ 120 g/ acre • Hand weeding

Table 2.71 Pest incidence and BC ratio in IPMs trial at Rajendranagar, *Kharif* 2019

Farmer's names	Treatments	% DH	% WE	% LFDL	Weed Population No./m²	Yield Q/ha	Gross returns (Rs.)	Cost of cultivation (Rs.)	Net returns (Rs.)	BC ratio
Sri M Kishan	IPM	1.42 ± 0.48	3.98 ± 1.14	0.00 ± 0.00	10.80 ± 1.28	59.50	119000	53650	65350	2.22
Sri L Mudavath	FP	0.00 ± 0.00	12.89 ± 3.53	2.36 ± 0.42	21.2 ± 6.40	49.00	87955	61895	26060	1.42
Sri M Jariya	IPM	8.28 ± 1.06	0.00 ± 0.00	0.14 ± 0.09	9.8 ± 1.46	56.01	112020	49075	62945	2.28
Sri M Basha	FP	2.55 ± 0.43	9.05 ± 0.86	0.21 ± 0.21	2.40 ±1.21	50.75	91096	58658	32438	1.55
Sri A Srisailam	IPM	1.88 ± 0.87	0.17 ± 0.17	0.00 ± 0.00	98.80 ± 6.87	61.25	122500	49025	73475	2.50
Sri M seethiya	FP	1.58 ± 0.68	0.00 ± 0.00	0.00 ± 0.00	48.40 ±10.94	56.00	100520	58220	42300	1.73
IPM		3.86	1.38	0.05	336	5892	117840	50583	67257	2.33
FP		1.38	7.31	0.86	24	5192	93190	59591	33599	1.57

Price of paddy = Rs.2000/q (IPM farmers); Rs.1795/q (non IPM farmers)

Low incidence of stem borer and leaf folder damage was observed in both IPM and FP farmer's fields except in FP plot of Sri L Mudavath wherein white ear damage exceeded the ETL (12.9%). Weed population was found very high in IPM field of Sri A Srisailam (98.80/m^2) and FP plot of Sri M Seethya (48.40/m^2). Grain yield was relatively high resulting in high BC ratio in IPM fields (2.33) compared to FP fields (1.57) **(Table 2.71)**.

Raipur: IPM trial was carried out in three farmers fields, i.e, Sri Bhagwat Yadaw, Sri Yogendra Yadaw, Sri Ved Prakash Yadaw and data for farmers practices was taken from Sri Govardhan Sahu's field in Bhothle village, Arang block, Raipur district of Chattisgarh State. Practices followed in both IPM and farmers practices were given in the table below **(Table 2.72)**

Practices followed in IPMs trial at Raipur, *Kharif* 2019

	IPM Practices followed	Farmers Practices followed
Area	3 acres (1 acre each farmer)	1 acre
Variety	Swarna	Swarna
Nursery	• Seed treatment with Carbendazim @ 2 g/ kg seed • Application of 10 kg urea	• Application of 10 kg urea
Main field	• Application of 50 kg DAP, 15 kg MOP & 50 kg Urea • Alley ways of 30 cm after every 2 m • Early stage weed control (Sathi & Nominee Gold) • Regular monitoring • Installation of pheromone traps • Need based application of cartap hydrochloride and hexaconazole	• Application of 50 kg DAP, 50 kg Urea / acre • Random planting • Application of Profenophos + Cypermethrin • Spraying of Propiconazole 25 EC @ 1ml/ liter

Table 2.72 Pest incidence, Returns and BC ratio in IPMs trial at Raipur, *Kharif* 2019

Farmer name	Treatments	% DH	% WE	% LFDL	BPH
F1 - Bhagwat yadaw	IPM 1	6.20 ± 3.23 (88 DAT)	8.85 ± 3.89 (137 DAT)	2.25 ± 0.59 (81 DAT)	13.60 ± 2.52 (102 DAT)
F2 - Yogendra yadaw	IPM 2	7.06 ± 2.32 (81 DAT)	6.02 ± 2.92 (137 DAT)	3.37 ±1.25 (60 DAT)	21.80 ± 2.40 (109 DAT)
F3 -Vedprakash Yadaw	IPM 3	23.61 ± 19.23 (109 DAT)	6.20 ± 3.86 (137 DAT)	2.43 ± 0.74 (67 DAT)	13.60 ± 6.57 (116 DAT)
F4 - Govardhan Sahu	FP	9.72 ± 4.21 (102 DAT)	8.44 ± 3.81 (137 DAT)	2.83 ± 0.96 (102 DAT)	38.80 ± 2.63 (95 DAT)
IPM		12.29	7.02	2.68	16
FP		9.72	8.44	2.83	39
Treatments	**Yield (q/ ha)**	**Gross Returns (Rs.)**	**Cost of cultivation (Rs.)**	**Net Returns (Rs.)**	**BC ratio**
IPM	50.60	91839	19500	72339	4.71
FP	46.32	84071	21813	62258	3.85

Price of paddy = Rs. 1815/q

Low incidence of stem borer, leaf folder and BPH was noticed in all the farmers' fields. Slight incidence of hispa, thrips and WBPH was observed. The weed population was 14 and 16.6% higher at 30 and 60 DAS respectively in farmers practice adopted fields. The weed biomass was also 18% and 10% higher in farmers practice fields than IPM implemented fields. High grain yield was recorded in IPM (50.6 q/ ha) resulting in high returns

and high BC ratio (4.71) compared to FP plot (46.32 q/ ha & 3.85, respectively).

Practices followed in IPMs trial at Sakoli, *Kharif* 2019

Name of the farmer: Sri Suka Raoji Khandait, Village: Dharmapuri, Tahsil: Sakoli; Bhandara district, Maharashtra		
	IPM Practices	**Farmer Practices**
Variety	Shri Sai	Shri Sai
Nursery	• Seed treatment with 3% salt solution • Seed treatment with Carbandezim @ 2g/ kg seed • Applied 12 kg urea • Applied Carbofuran @ 1.1 kg ai/ ha, 5 days before pulling seedlings	• Seed treatment with 3% salt solution • Applied urea 12 kg/ ha • Applied Phorate 10 G @ 10 kg/ ha, 5 days before pulling seedlings
Main field	• Application of fertilizer, 20:20:0:13 - 188 kg /ha • Seedlings planted at spacing of 20 x 15 cm • Left alleyways of 30 cm after every 2 m or 10 rows. • Applied Butachlor @ 1.5 kg a.i./ ha on 5th day after transplanting + 1 manual weeding • Applied Cartap hydrochloride 50 WP @ 600g / ha at 60 DAT • Installation of pheromone traps with 5 mg lure @ 8 traps/ ha for stem borer monitoring • Application of Propiconazole 0.1% at 70 DAT • Mid season drainage for BPH management	• Application of 20:20:0:13 - 188 kg/ ha • Seedlings were planted randomly • One manual weeding • Top dressing urea @ 63 kg/ha at 32 DAT
Name of the farmer: Sri. Rupchand Genduji Khotele; Village:Dharmapuri,Tahsil: Sakoli; Bhandara district		
	IPM Practices	**Farmers Practices**
Variety	DRK 2	DRK 2
Nursery	• Seed treatment with 3% salt solution • Seed treatment with Carbandezim @ 2 g/ kg • Application of Carbofuran @ 1.1kg ai/ ha, 5 days before pulling seedlings and Applied urea @ 10 kg/ ha	• Seed treatment with 3% salt solution and Carbandezim @ 2 g/ kg Applied urea @ 10 kg/ ha
Main field	• Application of Urea DAP briquette – 175 kg/ ha • Seedlings transplanted at spacing of 20 x 15 cm • Alleyways of 30 cm after every 2 m or 10 rows. • Application of Butachlor @ 1.5 kg a.i./ ha on 4th day after transplanting + 2 manual weedings • Installation of pheromone traps with 5 mg lure @ 8 traps/ha for stem borer monitoring • Applied Cartap hydrochloride 50 WP @ 600 g/ha at 62 DAT. • Application of Propiconazole 0.1% at 80 DAT • Mid season drainage for BPH management	• Application of Urea DAP briquette – 175 kg/ ha • Seedlings were transplanted randomly • Two manual weedings
Name of the farmer: Sri. Anil Tularam Khotele, Village: Dharmapuri; Tahsil: Sakoli, Bhandara district, Maharashtra		
	IPM Practices	**Farmers Practices**
Variety	MTU 1008	MTU 1008
Nursery	• Seed treatment with Carbandezim @ 2 g/ kg seed • Applied Carbofuran @ 1.1kg ai/ ha, 5 days before pulling seedlings from nursery	• Applied 20:20:00:13 @ 12 kg • Applied Phorate 10G @ 1 kg, 4 days before pulling the seedlings
Main field	• Applied DAP 125 kg/ ha • Alleyways of 30 cm after every 2 m or 10 rows. • Applied Butachlor @ 1.5 kg a.i./ ha on 3rd day after transplanting + 2 manual weedings • Installation of pheromone traps with 5 mg lure @ 8 traps/ha for stem borer monitoring • Applied Carbofuran 3G @ 25 kg/ ha at 45 DAT • Applied Cartap 50 WP @ 600 g / ha 64 DAT. • Application of Propiconazole 0.1% at 85 DAT • Applied Flubendamide 50% WG @ 150g/ ha at 94 DAT • Mid season drainage for BPH management	• Applied DAP 125 kg/ ha • Seedlings were transplanted randomly • Two manual weedings done

Sakoli: The trial was carried out in three farmers' field's *viz.*, Sri Devram Rushi Fande and Sri Timaji Govinda Waghmare of Dharmapuri village, Sri Yadaorao Ramaji Kapgate of Sakoli village, Sakoli tehsil in Bhandara district of Maharashtra State. Details of farmers and practices followed are given below:

Table 2.73 Insect pest incidence in IPMs trial at Sakoli, *Kharif* 2019

Farmer Name	Treatments	% DH	% WE	% SS		BPH (No./ 5 hills)			WBPH	GLH
		43 DAT	Prehar	64 DAT	78 DAT	78 DAT	92 DAT	106 DAT	78 DAT	85 DAT
F1- Sri. Suka Raoji Khandait	IPM	10.9 ± 5.3	5.7 ± 0.6	2.8 ± 0.4	2.7 ± 0.6	166 ± 2.1	126 ± 1.7		49 ± 0.5	52 ± 0.8
	FP	1.0 ± 0.7	10.4 ± 1.6	9.3 ± 1.6	4.1 ± 0.8	212 ± 2.2	146 ± 1.3		54 ± 1.5	45 ± 1.0
F2 - Sri. Rupchand Genduji Khotele	IPM	1.7 ± 0.8	4.8 ± 0.6	4.2 ± 0.3	2.3 ± 0.5	143 ± 1.4	195 ± 2.8	190 ± 2.1	41 ± 1.4	41 ± 1.5
	FP	0.4 ± 0.4	10.3 ± 2.0	3.9 ± 0.8	2.8 ± 0.3	141 ± 1.0	147 ± 2.2	196 ± 2.0	32 ± 1.3	49 ± 1.2
F3- Sri. Anil Tularam Khotele	IPM	8.1 ± 1.7	6.9 ± 1.6	15.8 ± 0.6	26.8 ± 1.6	325 ± 2.0	298 ± 2.7	292 ± 3.8	104 ± 1.2	61 ± 1.0
	FP	14.6 ± 2.8	14.4 ± 1.9	20.5 ± 0.5	27.0 ± 1.8	320 ± 3.5	290 ± 2.4	285 ± 2.4	102 ± 1.4	61 ± 0.9
IPM		6.9	5.8	7.6	10.6	211	206	241	65	51
FP		5.3	11.7	11.2	11.3	224	292	241	63	52

Incidence of stem borer, gall midge, leaffolder, BPH, WBPH and GLH was observed in both IPM and FP plots of all the three farmers' fields **(Table 2.73)**. Dead heart and white ear damage was high in Sri Anil Tularam's (F3) FP plot (14.6% DH & 14.4% WE) followed by Sri Suka raoji's (F1) IPM plot (10.9% DH) and Sri Rupchand Genduji's (F2) FP plot (10.35% WE). Mean of all the three farmer's fields data revealed that dead heart damage was low in FP plots (5.3%) than IPM plots (6.9%) whereas white ears were higher in FP plots (11.7% WE) compared to IPM plots (5.8% WE). Very low incidence of leaf folder was observed in both IPM and FP plots across farmers. Gall midge incidence was high in only F3 fields in both FP (20.5–27% SS) and IPM plots (15.8–26.8% SS). BPH and WBPH incidence started at 36 DAT and continued till harvest in F1 and F3 fields whereas it started at 50 DAT in F2 fields. Maximum population was noticed in F3 fields in both IPM (292–325 BPH/5hills) and FP plots (285–320 BPH/ 5hills) followed by F2 fields (143–195 BPH/5hills in IPM and 141–196 BPH/ 5hills in FP) and F1 fields (126-166 BPH/5 hills in IPM & 146–212 BPH/ 5 hills in FP). Similar trend was observed with respect to WBPH and GLH incidence with high numbers in F3 fields. Weed population and weed dry mass data recorded at 30 DAT and 60 DAT revealed that IPM implemented plots had low population and biomass as compared to farmer practices plots **(Table 2.74)**. Weed dry mass was very high in FP plots of all the three farmers at 30 DAT (19.4–25.2 g/ m^2).

Table 2.74 Weed Population and weed biomass in IPMs trial at Sakoli, Kharif 2019

Farmer Name	Treat ments	Weed population (No./m2)		Weed biomass (g/m2)	
		30 DAT	60 DAT	30 DAT	60 DAT
F1- Sri. Suka Raoji Khandait	IPM	11.4 ± 1.2	10.8 ± 1.2	8.8 ± 1.1	9.3 ± 0.9
	FP	16.4 ± 1.4	13.6 ± 1.4	21.5 ± 2.4	13.1 ± 1.0
F2 - Sri. Rupchand Genduji Khotele	IPM	10.6 ± 1.1	9.4 ± 1.0	7.8 ± 0.4	8.8 ± 0.8
	FP	15.4 ± 0.9	14.8 ± 1.7	19.4 ± 2.9	13.8 ± 1.3
F3- Sri. Anil Tularam Khotele	IPM	13.8 ± 1.1	10.6 ± 0.7	12.1 ± 1.2	8.8 ± 0.3
	FP	23.4 ± 1.3	15.6 ± 0.7	25.2 ± 2.0	13.4 ± 1.5
IPM		11.9	10.3	9.6	9.0
FP		18.4	14.7	22.0	13.4

Table 2.75 Returns and BC ratio in IPMs trial at Sakoli, *Kharif* 2019

Farmer Name	Treat-ments	Yield (Q/ ha)	Gross Returns (Rs.)	Cost of cultivation (Rs.)	Net Returns (Rs.)	BC ratio
F1- Sri. Suka Raoji Khandait	IPM	44.81	80658	39818	40840	2.03
	FP	34.81	62658	34667	27991	1.81
F2 - Sri. Rupchand Genduji Khotele	IPM	41.20	74160	44064	30096	1.68
	FP	36.02	64836	38996	25840	1.66
F3- Sri. Anil Tularam Khotele	IPM	41.98	75564	48588	26976	1.56
	FP	35.99	64782	39788	24994	1.63
IPM		42.66	76794	44157	32637	1.75
FP		35.61	64092	37817	26275	1.70

Price of Paddy = Rs. 1800/q

Grain yields were relatively high in IPM implemented fields (42.66 q/ ha) as compared to FP plots (35.61 q/ha) resulting in high returns **(Table 2.75)**. BC ratio was relatively high in IPM (1.75) than in FP plots (1.70).

Titabar: The trial was conducted at Sri Debanand Das's field at Mazgoan village, Titabar mandal, Jorhat district of Assam. Ranjit sub-1 variety was grown in both IPM and FP blocks. Practices followed were given in the table below.

Practices followed in IPMs trial at Titabar, *Kharif* 2019

	IPM Practices	Farmers Practices
Variety	Ranjit Sub-1	Ranjit Sub-1
Nursery	• Seed treatment with Bavistin @ 2 g/ kg seed and Chlorpyriphos 2ml/kg seed	
Main field	• Fertilizer application @ 30:20:40 kg NPK/ha • Applied Pretilachlor within a week of transplanting • Applied paddy weeder to lessen weeds • Installed pheromone traps @ 20/ ha for stem borer mass trapping • At 60 DAT, applied chlorpyriphos 20EC @ 2ml/L for stem borer management • Placed tricho cards for stem borer and leaffolder management • Sprayed fresh cowdung solution @250g/L water at mid tillering stage against BLB	• Fertilizer application @20:10:10 kg NPK/ha • Manual weeding two times

Incidence of stem borer, gall midge, leaf folder, whorl maggot and GLH was observed in both IPM and FP plots at this location **(Table 2.76)**. The pest incidence in IPM implemented plots was far below the economic injury level

whereas in FP plot, damage was very high. Stem borer incidence was high starting from 29 DAT and continued till harvest in FP plot (24.1 – 49.8% DH & 15.3% WE). Similarly, gall midge damage crossed ETL from 36 DAT onwards till 85 DAT in FP plot (10.2 – 36.1% SS). High damage by leaf folder was reported from 29 to 85 DAT (23.8 – 38.9% LFDL) and whorl maggot from 36 – 71 DAT (16.9 – 25.8% DL) in FP plot alone. IPM implemented fields recorded 63% lower weed population and 47% lower weed biomass compared to farmers practice adopted fields. High grain yield was recorded in IPM plot (52q/ ha) compared to FP plot (39.5q/ ha) resulting in high returns and high BC ratio **(Table 2.77)**.

Table 2.76 Insect pests, diseases and weed incidence in IPMs trial at Titabar, *kharif* 2019

Treat-ments	% DH				% WE	% SS				
	29 DAT	43 DAT	57 DAT	85 DAT	Pre har	36 DAT	43 DAT	57 DAT	78 DAT	85 DAT
IPM	1.2 ± 0.8	1.7 ± 0.6	1.4 ± 0.4	0.8 ± 0.3	0.9 ± 0.4	0.9 ± 0.5	1.4 ± 0.3	1.1 ± 0.5	0.5 ± 0.2	0.3 ± 0.2
FP	24.1 ± 4.8	49.8 ± 3.2	38.0 ± 1.5	25.1 ± 1.2	15.3 ± 0.5	24.4 ± 2.3	36.1 ± 4.3	29.9 ± 1.1	19.6 ± 0.9	10.2 ± 0.8

Treat-ments	% LFDL					% WMDL	
	29 DAT	36 DAT	43 DAT	64 DAT	78 DAT	36 DAT	57 DAT
IPM	1.3 ± 0.5	1.5 ± 0.7	1.6 ± 0.5	0.6 ± 0.2	0.5 ± 0.2	1.5 ± 0.7	0.6 ± 0.3
FP	23.8 ± 3.4	38.9 ± 3.8	35.5 ± 1.4	34.7 ± 1.2	23.8 ± 2.1	16.9 ± 1.6	25.8 ± 2.3

Table 2.77 Returns and BC ratio in IPMs trial at Titabar, *Kharif* 2019

Treatments	Yield (Q/ ha)	Gross Returns (Rs.)	Cost of cultivation (Rs.)	Net Returns (Rs.)	BC ratio
IPM	52.02	85833	41035	44798	2.09
FP	39.50	65175	35725	29450	1.82

Price of paddy = Rs. 1650/q

During *Kharif* 2019, IPMs trial was conducted in 13 locations in 28 farmer's fields. Across the locations, stem borer damage was reported from 12 locations with low damage in IPM plots. Both dead heart and white ear damage exceeded ETL only at Karjat, Pusa, Raipur and Titabar with maximum damage in FP plot at Titabar (34.25% DH & 15.3% WE). Leaf folder damage was low at all the reported 10 locations in both IPM and FP plots, except at Pusa (10.04% LFDL) and Titabar (31.34% LFDL) in FP plot. Similarly, Whorl maggot damage was found high in FP plot at Titabar (21.35% WMDL) followed by IPM plot at Jagdalpur (11.74% WMDL). Gall midge incidence was observed at only two locations with maximum damage in FP plots compared to IPM plots **(Table 2.78)**. Maximum Hispa damage was reported from Malan in FP plot (96.6% HDL).

Planthopper incidence was recorded at 7 locations with maximum numbers at Sakoli in both IPM (219/ 5 hills) and FP plots (252/ 5 hills) and at Gangavathi in FP plot (248/5 hills). Similarly, WBPH was reported high in FP plot at Gangavathi (355/ 5 hills). Grain yield ranged between 1688 and 7352 kg/ ha in different treatments across locations. Yield was high in IPM plots compared to FP plots at all the locations with maximum yield at

Ludhiana in IPM field (7352 kg/ ha). Similarly, BC ratio varied from 0.88 to 4.71 at various locations in both IPM and FP plots.

Table 2.78 Pest incidence, Grain yield and BC ratio in IPM and FP plots across locations, *Kharif* 2019

	% Dead hearts											
	CHN	GNV	JDP	KJT	LDN	MND	PNT	PSA	RNR	RPR	SKL	TTB
IPM	0.25	1.56	2.81	9.4	4.45	3.67	9.24	5.48	3.86	12.29	6.9	1.3
FP	7.81	2.05	1.13	15.1	5.86	5.93	7.87	12.5	1.38	9.72	5.3	34.25
	% White Ears											
	CHN	JDP	LDN	MND	PSA	RNR	RPR	SKL	TTB			
IPM	0.74	5.46	3.56	4.07	6.31	1.38	7.02	5.8	0.9			
FP	8.74	1.72	5.28	5.97	13.42	7.31	8.44	11.7	15.3			
	% Leaf folder damaged leaves											
	CHN	GNV	JDP	LDN	MND	PNT	PSA	RNR	RPR	TTB		
IPM	0.05	0.79	5.24	5.06	1.43	2.72	5.91	0.05	2.68	1.1		
FP	0.7	0.92	7.09	7.98	4.43	1.44	10.04	0.86	2.83	31.34		
	% Whorl maggot damaged leaves						% Silver shoots			% HDL		
	CHN	JDP	LDN	PNT	TTB		SKL	TTB		CHN	MLN	PNT
IPM	0.94	11.74	4.24	4.23	1.05		9.1	0.84		0.00	8.81	2.79
FP	2.53	7.02	5.63	4.97	21.35		11.3	24.04		0.74	96.6	2.43
	BPH (No./ 5 hills)								WBPH			
	CHN	GNV	LDN	MND	PNT	RPR	SKL		CHN	GNV	LDN	SKL
IPM	0	54	19	6	36	16	219		0.8	73	21	65
FP	14	248	13	13	25	39	252		3.2	355	30	63
	Grain yield (Kg/ ha)											
	CHN	GNV	JDP	KJT	LDN	MLN	MND	PSA	RNR	RPR	SKL	TTB
IPM	4534	6788	4016	2965	7352	3488	5273	5982	5892	5060	4266	5202
FP	3981	6366	3428	2405	7248	1688	4617	4499	5192	4632	3561	3950
	BC ratio											
	CHN	GNV	JDP	KJT	LDN	MLN	MND	PSA	RNR	RPR	SKL	TTB
IPM	1.59	2.23	3.83	1.42	3.26	1.37	1.73	2.96	2.33	4.71	1.75	2.09
FP	1.45	1.85	3.03	1.1	2.93	0.88	1.33	2.65	1.57	3.85	1.7	1.82

Integrated Pest Management special (IPMs) trial was conducted at 13 locations involving 28 farmers' in a participatory mode across the Country with an objective of managing insects, diseases and weeds in a holistic way by providing a basket of options to the farmers. In general, during Kharif 2019 the pest incidence was low across the locations. However, insect pest incidence exceeded ETL at 8 locations and was observed high in farmer practices plots as compared to IPM plots. Stem borer damage was low in IPM plots than FP plots at 4 locations while dead heart damage was very high in FP plots at Titabar (49.8%), Pusa, Karjat and Sakoli. Gall midge incidence was low in IPM plots (<2% SS) compared to FP plots (10.2 – 36.1% SS) at Titabar while the incidence was high in both IPM and FP plots at Sakoli. Leaf folder incidence was low in IPM at Titabar (<2% LFDL) compared to FP plots (23.8 – 38.9% LFDL). Hispa incidence was low in IPM (8.81-24.8% HDL) compared to FP plots (33.3 – 96.6% HDL) throughout the crop growth period at Malan. Though the populations of planthoppers was high initially in IPM plots (177-391/ 5 hills), they got reduced later with the adoption of IPM practices (< 50/5 hills) at Gangavathi and Raipur.

2.7. POPULATION DYNAMICS OF RICE INSECT PESTS ASSESSED THROUGH LIGHT TRAP CATCHES

The population dynamics of insect pests and their natural enemies vary with the geographic location and cropping system. Insect pest populations, during the crop season are always a function of abiotic and biotic factors. Besides biotic potential, to a large extent, abiotic factors like temperature, rainfall, relative humidity, sun shine hours, etc. and biotic factors such as predators, parasitoids, entomopathogenic organisms, etc. determine the abundance of insect pests in a crop ecosystem. Therefore, to design any effective location specific pest management strategies, knowledge of population dynamics of insect pests in relation to abiotic and biotic factors becomes vital. Since rice is grown in diverse agro-climatic zones in India, concerted efforts are being made under AICRIP to study the population dynamics of insect pests of rice at different locations across the country to understand short- and long term changes in rice pest scenario.

During 2019, insect populations in rice ecosystems were recorded daily, throughout the year using light traps (Chinsurah/Robinson type) in 26 locations. Corresponding weather data on temperature, rainfall, relative humidity, sunshine hours, etc. were also collected. Weekly cumulative catches of insects and weekly averages of weather parameters were worked out on standard week (SW) basis. Highlights and trends of the data collected during the year 2019 are presented zone-wise hereunder:

Zone I- Hills

1. **Himachal Pradesh-Malan (22-44 SW):** WSB, CW, LF, BPH, WBPH, GLH and black beetle were recorded at this location. LF was found active during 27th to 42nd standard weeks and catches were highest during 37th SW (864 moths). WSB made its first appearance in 27th SW and continued up to 43rd SW with a peak population of 63 moths in 32nd SW. CW was found in 22nd to 27th SWs and 33rd to 44th SWs and the moth catches were maximum (62) in 41st SW. Black beetle was recorded continuously up to 40th SW, except during 24 and 25 SWs with a highest catch of 37 beetles in 33rd SW. GLH and BPH were found continuously from 26th to 42nd SW. GLH reached its peak population in 40th SW (38) while BPH catches were highest in 31st SW (29). Stray occurrences of WBPH were also noticed during 28th to 30th SW.

2. **Jammu & Kashmir-Khudwani (14-44 SW):** Grasshoppers (GH), skippers, LF, scarabaeids, and cutworms were recorded at this centre.GH appeared continuously from 25th to 41st SWs with maximum catch of 26 in 40th SW. LF was found during 29 to 39 SWs with peak activity in 37th SW. Scarabaeids were active from 19th to 23rd SW and highest numbers were observed in 22nd and 23rd SWs (51). Cutworms showed staggered occurrence with moderate catches (24 in 26th SW) in 14 to 15, 25 to 26 and 34 to 35 SWs. Data shows that GH, skipper, and LF were inactive below 10 °C of minimum temperature.

Zone II- Northern

3. **Haryana-Kaul (35-52SW):** Three stem borers; YSB, WSB, and PSB; LF, BPH and WBPH were recorded at this location. PSB was dominant amongst the stem borers and was found continuously from 39 to 51 SWs. Maximum number of moths (23) were trapped in 41st SW. LF was recorded during 38 to 46 SWs with highest catch of 28 moths in 38th SW. BPH was found during 38 to 43 SWs and highest population was recorded in 39th SW. WBPH was noticed only in 28th and 39th SWs.

4. **Jammu & Kashmir-Chatha (1-52 SW):** White grub, GSB, GH, LF, GLH and water beetles were recorded. White grub appeared continuously from 16-46 SWs. There were two peaks, one at 28th SW (252) and another at 39th SW (114). GSB started appearing continuously from 14 to 49 SWs and the catches were highest (40) during 20th SW. GH was recorded from 19th SW onwards with peak activity in 28th SW (70). LF activity was recorded from 36th to 51st SW and was at peak in 47th SW (110). GLH was observed throughout the cropping season. Largest catches were found during 47th SW (110).

5. **Punjab-Ludhiana (1-48 SW):** Three species of stem borers - YSB, PSB and WSB were recorded at this location. YSB and WSB catches were low (22 and 10 respectively), while PSB showed two distinct periods of activity corresponding to the crop growth seasons and highest catch (31) was found in 40th SW. LF, BPH, and WBPH were found only in the *Kharif* season. LF catches were recorded continuously from 28 to 48 SWs and the highest number of moths (260) was observed in 44th SW. BPH was found during 34 to 46 SWs with a peak population of 7700 in 40th SW. WBPH catches were small, highest being 100 in 40th SW. Small numbers of GLH and predators - mirid bugs and rove beetles also were recorded.

6. **Uttarakhand-Pantnagar (22-48 SW):** YSB, GM, LF, GLH, BPH, WBPH, RH and RGB were recorded at this location. YSB appeared early in the season, from 25th SW and catches consisted of mostly females. Highest count was recorded in 34th SW (373 females and 63 males) followed by a gradual decline. LF also was recorded from 25th SW and showed maximum activity in 31st SW (25). GLH and BPH were active during 32-43 SWs whereas, WBPH was active during 38 to 41 SWs. BPH and WBPH were most active, (667 and 97, respectively) in 38th SW. RGB was found active during 36 to 42 SWs with a peak catch of 72 in 41st SW.

Zone III-Eastern

7. **Assam-Titabar (1-52 SW):** YSB, WSB, GM, LF, GLH, WM, CW, blue beetle, black bug, mole cricket, gundhi bug and GH were recorded at this location. SBs, GM, and LF were recorded throughout the year but were more abundant during the *Kharif* season. Populations of both the SBs showed gradual increase with progress of the season despite fluctuations. YSB reached the highest population (1967 females and 2061 males) in

38th SW. WSB population was highest (2233) in 40th SW. LF was most active in 40th SW. Two species of GLH - *Nephotettix virescence* and *N. nigropictus* occurred from 18th SW onwards. *N. virescence* reached its peak population (20158) in 38 SW, whereas the *N. nigropictus* (19829) in 40th SW. WM, CW and blue beetle were also observed from 18th SW reaching peak during 40thSW (WM - 365, black bug - 10661 and mole cricket - 340). Large number (up to 11860) of blue beetle was also recorded during 28th SW. Gundhi bug and grasshopper also were recorded in considerable numbers during the crop season. Among the natural enemies; dragonflies, damsel flies, and ground beetles were recorded.

8. **Odisha-Chiplima (27-52 SW):** SB, GM, LF, GLH, BPH, WBPH and CW were reported from this centre. Pest activity was found only during 34 to 50 SWs. YSB first appeared in 34th SW and catches increased gradually reaching its maximum in 44th SW (19 females, 26 males) followed by a decline. GM showed peak activity in 41st SW (167). Both the species of GLH, *N. virescens* and *N. nigropictus* were recorded and the combined catch was largest (1492) in 44th SW. BPH and WBPH were found active late in the season during 38 to 49 SWs and peak catches were observed in 45th SW in case of BPH (2396) and 43rd SW in case of WBPH (523). LF was found in moderate numbers reaching up to 36 in 40th SW.

9. **West Bengal-Chinsurah (1-52 SW):** SBs, LF, GLH, BPH, WBPH, WLH and RGB were found active throughout the year. However, temporal distribution of the insect populations revealed two distinct peaks coinciding with *Kharif* and *Rabi* seasons. Also, insect catches in *Kharif* were larger as compared to *Rabi*, particularly that of YSB. In case of YSB, males were more abundant. Maximum number of moths (717 females and 1657 males) were trapped in 20th SW. GLH catches were recorded up to 54 in 44th SW, while BPH and WBPH were most active in 15th SW (375 and 57 respectively). Moderate numbers of WLH were also observed and highest catch was recorded in 16th SW (38).

Zone V- Central

10. **Chhattisgarh-Raipur (1-52 SW):** SBs, LF, GLH, BPH, ZZLH, CW, RGB and blue beetle and *Spodoptera* sp. were recorded at this location. Among the SBs, YSB and PSB were found throughout the year. YSB catches were highest (77 females and 43 males) in 21st SW. LF was found active in *Kharif* season for a limited period *i.e.,*38 to 49 SWs and maximum catch (55) was in 45th SW. GLH catches reached peak during the same period (1204) though the pest made its appearance in 35th SW. BPH was found most active during 11 to 23 SWs in *Rabi* and 38 to 51 SWs in *Kharif* and the catch was highest (18000) in 48th SW. Significant catches of ZZLH were also observed during *kharif* season, with a maximum catch (12782) in 48th SW. Blue beetle population reached up to a maximum of 880 in 47th SW. *Spodoptera* moths were attracted in small numbers throughout the year. Generalist predators like coccinellids, ground beetles, rove beetles, and earwigs also were recorded round the year.

Rove beetle catches were considerable and highest count of 112 was recorded in 11th SW.

11. Chhattisgarh-Jagdalpur (1-52 SW): YSB, GM, CW, LF, GLH, BPH, WBPH, ZZLH, RGB, and GH were recorded at this location.YSB occurred throughout the year and was more abundant during the crop growth period. Maximum population was recorded in 8th SW (46 females and 45 males). GM was found during 34 to 45 SWs only with a maximum catch of 14 in 44th SW. LF occurrence was also found restricted to 34 to 50 SWs. GLH was more active during the *Kharif* season and the combined catch of *N. virescens* and *N. nigropictus* reached up to 21874 in 48th SW. BPH was present throughout the year with highest count of 251 in 43rd SW, while WBPH numbers were not considerable. ZZLH population was recorded up to 391 hoppers in 43rd SW. Grasshopper activity picked up from 35th SW and was highest during 48th SW (52). Among the natural enemies, coccinellid and ground beetles were recorded round the year with a maximum of 380 and 201 in 47 and 48 SWs, respectively.

12. Maharashtra-Sakoli (1-52 SW): YSB, GM, LF, GLH, BPH, WBPH and rice moth were recorded at this location. YSB was found active throughout the year. In *Rabi,* YSB was most active (300 females and 64 males) in 18th SW whereas, during *Kharif* the catches were highest during 34th SW (105 females and 32 males). GM occurred during 34 to 46 SWs and the highest catch was recorded in 40th SW (401). LF catch was maximum (48) during 43rd SW. Hoppers showed a distinct seasonal activity during crop growth period. GLH population was highest (539) in 13th SW. BPH and WPH populations reached maximum ((1167 and 409 respectively) in 44 SW. Considerable catches of rice moth (up to a maximum of 52 in 3rd SW) were also recorded. Among the natural enemies, coccinellids were recorded during rainy season.

13. Uttar Pradesh-Mashoda (22-52 SW): YSB, LF, GLH, CW and grasshoppers were recorded from this location throughout the recording period with an increased abundance from August month onwards. YSB showed two peaks one in 34th SW (770) and other in 47th SW (674). LF catch was also maximum during 34th SW (1023). GLH was highest (2871) in 44th SW. CW moth population also was considerable at this location, with a highest catch of 1720 moths in 47th SW. GH were most active in 42nd SW (765).

Zone VI- Western

14. Gujarat-Navsari (1-52 SW): SBs, LF, GLH, BPH, WBPH, RGB, and paddy skipper were found in light trap catches. YSB appeared from 22nd SW and increased gradually along with other SBs reaching peak population (332 females+142 males and 58 respectively) in 37th SW followed by a decline. LF catches also started from 22nd SW and reached peak in 34th SW (196). Sucking pests appeared late in the season and GLH (*N. virescens* and *N. nigropictus*) catches were highest (89 and 65) in 43rd SW. BPH and WBPH also were found in small numbers. Paddy

skipper was first recorded in 26th SW and increased up to 189 in 36th SW followed by a gradual decline.

15. Maharashtra-Karjat (1-52 SW): YSB, LF, GLH, BPH, and WBPH were recorded at this centre, but numbers were not considerable.

VII-Southern

16. Andhra Pradesh-Maruteru (22-52 SW): YSB, GM, LF, GLH, BPH, WBPH, ZZLH, black bug, coccinellids and mirid bug were reported from this centre. YSB catches were highest (1013 females and 713 males) in 49th SW. GM was most active (500) during 44th SW. LF occurred from 36th SW onwards reaching maximum population (999) in 45th SW. BPH and WBPH which appeared from 35th and 37th SW respectively, were found most active during 45th SW with 17133 and 5119 hoppers respectively per trap, while GLH catches were up to 1338 during the same period. ZZLH also was found in considerably higher numbers; up to a maximum of 6844 in 45th SW. Black bug was found throughout the recording period and was most active (1184) in 51st SW. Among the natural enemies, mirid bugs were recorded and the largest catch (2591) was in 44th SW.

17. Andhra Pradesh-Bapatla (31-52 SW): YSB, LF, GLH, BPH, WBPH, ZZLH, CW and natural enemies were reported from this centre. YSB occurred in 31st to 36th SWs and 42nd to 2nd SW. Population was highest (36) in 47th SW. Leaf folder catches were maximum (178) in 46th SW. CW started appearing from 35th SW and was most active (132) in 43rd SW. BPH and WBPH catches started from 33rd and 39th SWs respectively. BPH population was maximum (775) in 44th SW and WBPH (325) in 45th SW. ZZLH also occurred in small numbers. Among the natural enemies, mirid bug catches were considerable and 1202 bugs were recorded in 44th SW.

18. Telangana-Rajendra Nagar (1-52 SW): YSB, PSB, CW, LF, GLH, BPH, blue beetle, GLH, GSB, coccinellids and mirid bugs were recorded at this centre. Overall, insect catches were small. Highest count of YSB (32 females and 48 males) was recorded in 2nd SW. BPH was most active during 43rd and 44th SWs (177).

19. Telangana-Warangal (1-52 SW): YSB, WSB, GM, LF, BPH, WBPH, GLH, and GSB were recorded at this centre. YSB occurred during1st to 25th SW and again in 38th to 50th SW period. In *Kharif* season population was higher with predominantly males. Population attained maximum level in 47th SW (66 males and 44 females). GM was found throughout the year but was most active in 43rd SW (180 males and 120 females). LF catches were small and found mostly in *Kharif*. Plant hoppers also active mostly in the rainy season. WBPH reached its peak activity (1004) in 44th SW, whereas, in case of BPH, peak population of 2997 was recorded in 48th SW. GLH though recorded throughout the year, was most active in rainy season with a maximum population of 340 in 48th SW. Among the natural enemies; coccinellids, mirid bug and rove beetles were recorded.

Mirid bug was most active during 48th and 49th SWs, coinciding with the maximum population of plant hoppers.

20. Tamil Nadu-Aduthurai (1-52 SW): YSB, LF, GLH, WLH, BPH, GSB, black bug, blue beetle, mole cricket, cricket and water beetle were recorded at this location. Except LF and black bug all the insects were active throughout the year. The insect population showed a sudden spurt in 33rd SW. YSB, GLH, WLH, and blue beetle populations reached highest levels of 3187, 1608, 6346, and 19052 respectively in this week. BPH was most active in 2nd SW (8895) and black bug was most abundant (17468) in 29th SW. Coccinellids, ground beetle, and rove beetle numbers were highest in 33rd SW with catches of 34913, 4776, and 15905 respectively.

21. Tamil Nadu-Coimbatore (1-52 SW): YSB, PSB, CW, LF, GLH, BPH, WBPH, WLH, RGB, GSB, and mirid bugs were recorded but overall, the catches were small. Rove beetles showed a maximum population of 107 in 43rd SW.

22. Kerala-Moncompu (1-52 SW): SBs, LF, GLH, BPH, WBPH, black bug, and natural enemies were recorded. However, data could not be recorded during 33rd SW due to floods. YSB was active till 19th SW with a peak population of (76 males + 62 females) in 7th SW. In rainy season YSB catches were low. Water bug was found almost throughout the year, with a peak population of 233 in 38th SW.

23. Kerala-Pattambi (1-52 SW): YSB, WSB, GM, LF, GLH, BPH, WLH, and CW were recorded in light trap catches. Though YSB was more active in initial four standard weeks, the highest population (359) was recorded in 52nd SW. WSB catches were comparatively smaller and maximum (23) was in 39th SW. GM was active during 30th to 47th SWs with a maximum catch of 602 in 39th SW. Both the GLH species, *N. nigropictus* (3550) and *N. virescens* (1825) reached their peak population levels in the 45th SW. WLH occurred throughout the year. BPH was more active late in the season; and maximum population (1400) was recorded in 43rd SW. CW was found throughout the year except during 19th to 21st SWs and maximum population (130) was recorded in 39th SW. Among the natural enemies, ground beetles, rove beetles and mirid bugs were recorded. Maximum mirid bug catches (1728) occurred in 48th SW.

24. Karnataka-Mandya (1-52 SW): YSB, LF, CW, GLH, and BPH were recorded at this centre. Overall, pest activity was low. YSB was found throughout the year except 23rd and 24th SWs. The pest was more active in *kharif* season with maximum population (229 females and 146 males) in 41st SW. LF appeared from 5th SW and gradually increased up to 13th SW (115 moths) followed by a decline in following summer months. The pest population picked up again in 34th SW and reached a maximum of 190 in 44th SW. CW occurred in 8th to 15th and 30th to 45th SWs, with a maximum population (87) in 37th SW. GLH and BPH activity was low and limited to 35th to 47th SWs and 42nd to 52nd SWs respectively.

25. Karnataka-Gangavati (1-52 SW): YSB, LF, CW, GLH, BPH and WBPH were recorded at this location. All the pests were recorded throughout the year and showed near uniform distribution. YSB populations were moderate and sex ratio was highly skewed towards females. The population was higher in 6th SW with 63 females and 20 males. LF catches also were highest (71) in the same SW. GLH (*N. virescens* and *N. nigropictus*) catches were maximum (170 and 369 respectively) in 47th SW. Among the plant hoppers, WBPH was dominant with a highest population of 400 in 43rd SW.

26. Puducherry-Karaikal (1-52 SW): SBs, GM, LF, GLH, BPH, WBPH, WLH, and natural enemies were recorded in small numbers at this centre. Among the natural enemies, ground beetle, coccinellids, and rove beetles were recorded. However, staphylinid predator catches were considerable during the crop season with a catch of 348 in 38th SW.

Pest-wise analysis of light trap catches:

Stem borer

Yellow stem borer was recorded in 23 locations, except in KHD, MLN and CHT. Annual cumulative catches were highest at TTB (50144) followed by MTU (16755) and CHN (13710). Weekly highest catches also showed similar trend, highest being in TTB (4028) in 38th SW, MTU (1726) in 49th SW and CHN (2374) in 20th SW. In the previous year highest weekly catch was recorded at PTB (3651) followed by MTU (1843) and PNT (1439) **(Fig. 2.15)**.

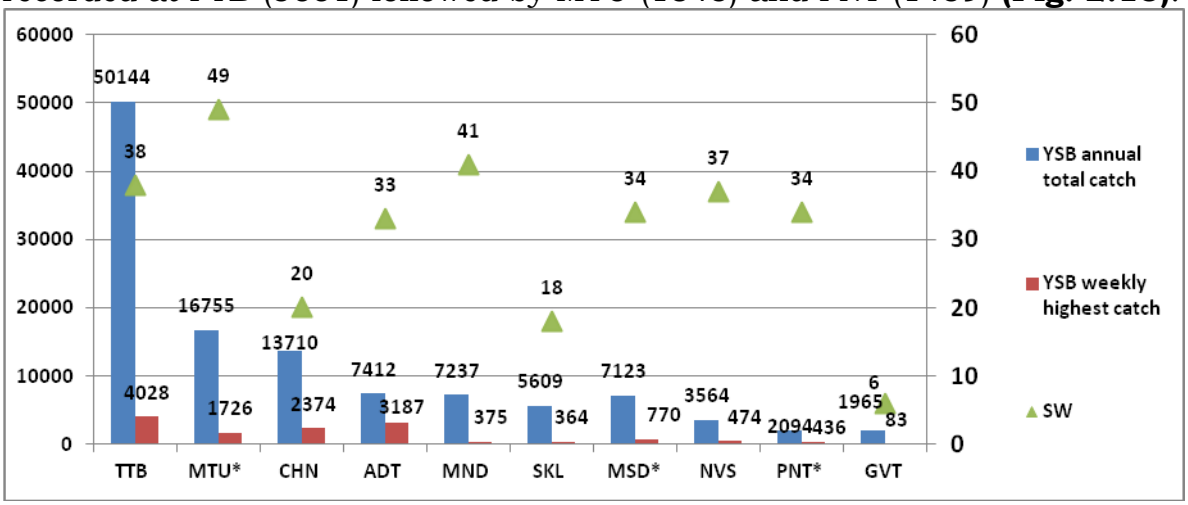


Fig. 2.15 Annual and weekly cumulative light trap catches of yellow stem borer* only *kharif* data. SW- Peak catch standard week

Gall midge

Gall midge occurrence was observed in nine locations. It was not recorded from Hills and Western Zone. In the Northern Zone it was found in stray incidence at PNT (2). Annual cumulative catches were highest in TTB (3746) followed by MTU (3470) and SKL (2335). In terms of weekly cumulative catches, it was most active in TTB (335) and SKL (401) in 40th SW followed by MTU (500) in 44th SW. Data reveals that late rainy season conditions are favourable for its population build up. In the previous year, it was most active in MTU (5185) followed by BPT (3248) and SKL (600) **(Fig. 2.16)**.

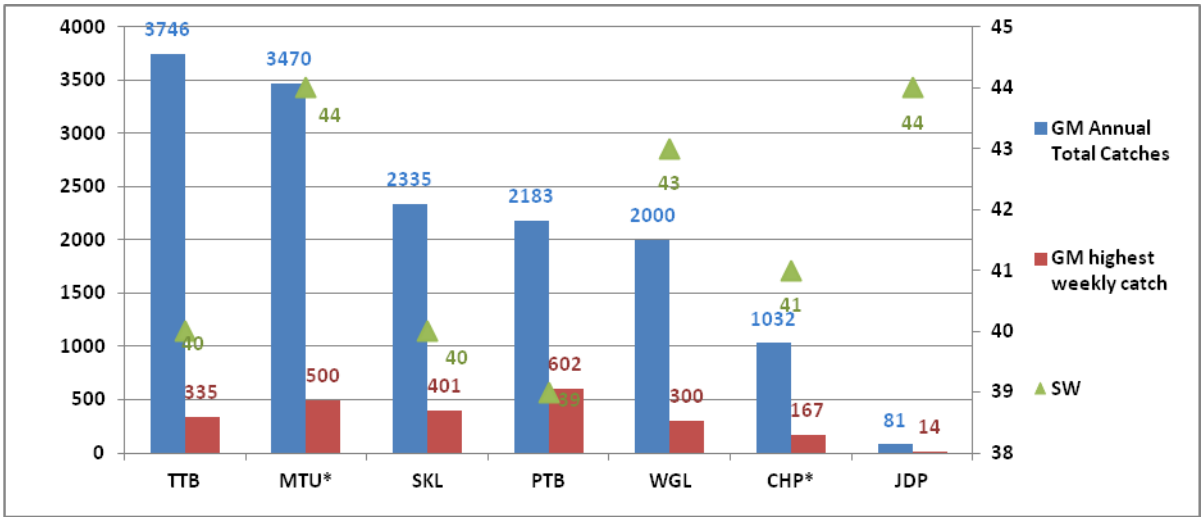


Fig. 2.16 Annual and weekly cumulative light trap catches of gall midge

* only *kharif* data SW- Peak catch standard week

Leaf folder

Leaf folder was recorded at all the 26 reporting centres across the regions. It was most active in TTB (20368), followed by MSD (8867) and MLN (3200) in terms of annual cumulative catches. Whereas, weekly cumulative catches were maximum at TTB (2319) in 40th SW, followed by MSD (1023) in 34th SW, and MTU (999) in 45th SW. In the previous year highest weekly cumulative population was recorded at MLN (1100) followed by BPT (896), and NVS (446) **(Fig.2.17)**

Green leafhopper

Green leafhopper was recorded from 24 centres except KUL and KHD. In TTB (295769) annual cumulative catches were highest followed by JDP (140788), and MSD (42439). Weekly cumulative catches were highest in TTB (36967) in 40th SW, followed by JDP (21874) in 48th SW and PTB (5375) in 45th SW. In the previous year, GLH was reported from 22 locations spread over all the zones. Maximum weekly catches were recorded at JDP (14455) followed by PTB (2053) and GVT (1503) **(Fig. 2.18)**.

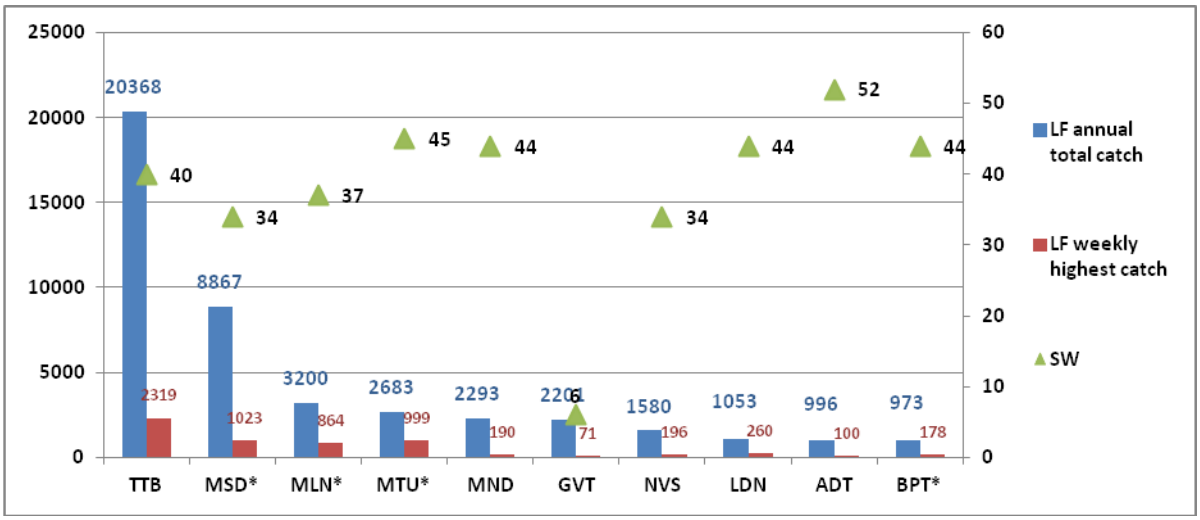


Fig. 2.17 Annual and weekly cumulative light trap catches of leaf folder

* only *kharif* data SW- Peak catch standard week

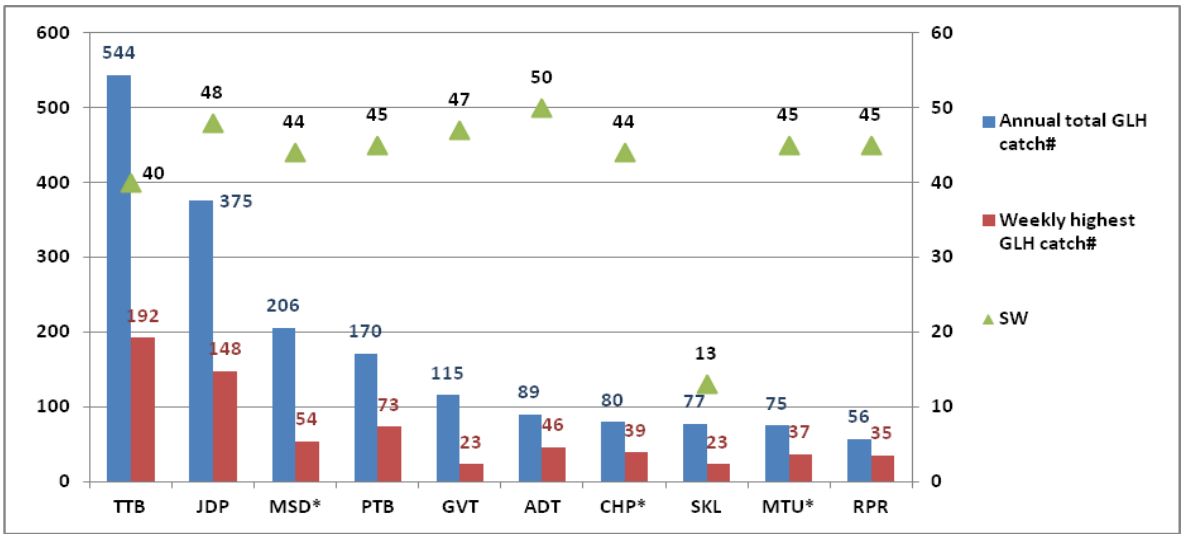


Fig. 2.18 Annual and weekly cumulative light trap catches of Green leafhopper * only *kharif* data #square root transformed SW- Peak catch standard week

Brown planthopper

Brown plant hopper was recorded in 22 locations and did not occur at KHD, CHT, MSD, and TTB. It is interesting to note that the pest was not recorded in TTB, otherwise reported for high incidence of other pests. BPH was most abundant in RPR (71422), followed by MTU (68637) and ADT (23481) on yearly basis. Except in ADT and CHN, where it was found most active in the *rabi* season, in the remaining locations it reached peak population levels in October and November months. Weekly cumulative catches were highest in RPR (18000) in 48th SW, followed by MTU (17133) in 45th SW and ADT (8865) in 2nd SW. In the previous year, it was recorded at all the locations except KHD. Highest weekly population was recorded at ADT (64722) followed by PTB (19300), and GVT (17487) **(Fig. 2.19)**.

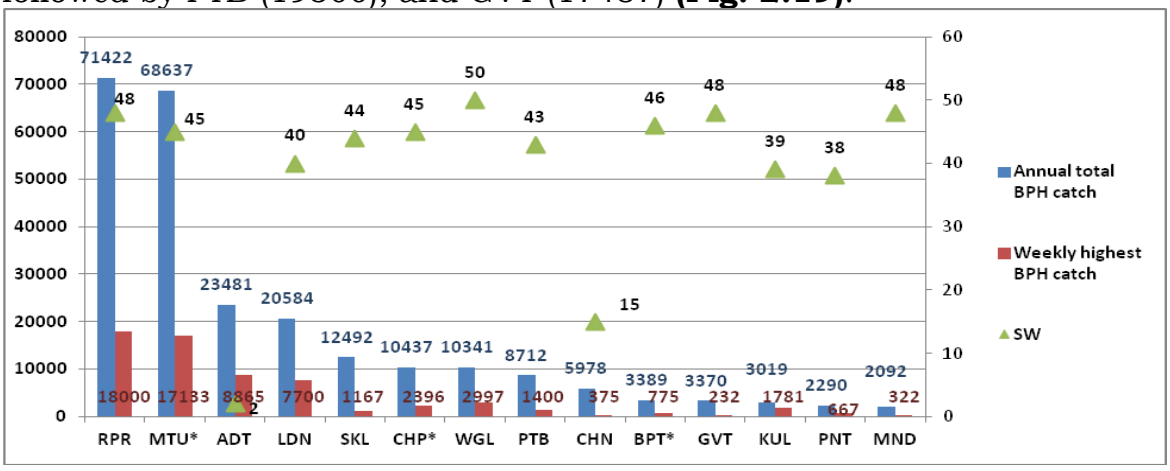


Fig. 2.19 Annual and weekly cumulative light trap catches of brown planthopper * only *kharif* data SW- Peak catch standard week

Whitebacked planthopper

White backed plant hopper was recorded in 16 locations. Annual cumulative catches were highest in MTU (15935) followed by GNV (63745) and SKL

(6217). Whereas, weekly cumulative catches were highest in MTU (5119) in 45th SW followed by WGL (1004) in 44th SW and SKL (409) in 46th SW. In the preceding year it was recorded at 18 locations in all the zones except Hills. Highest weekly cumulative population was recorded in GNV (15685) followed by MTU (5952) and LDN (5215) **(Fig. 2.20)**

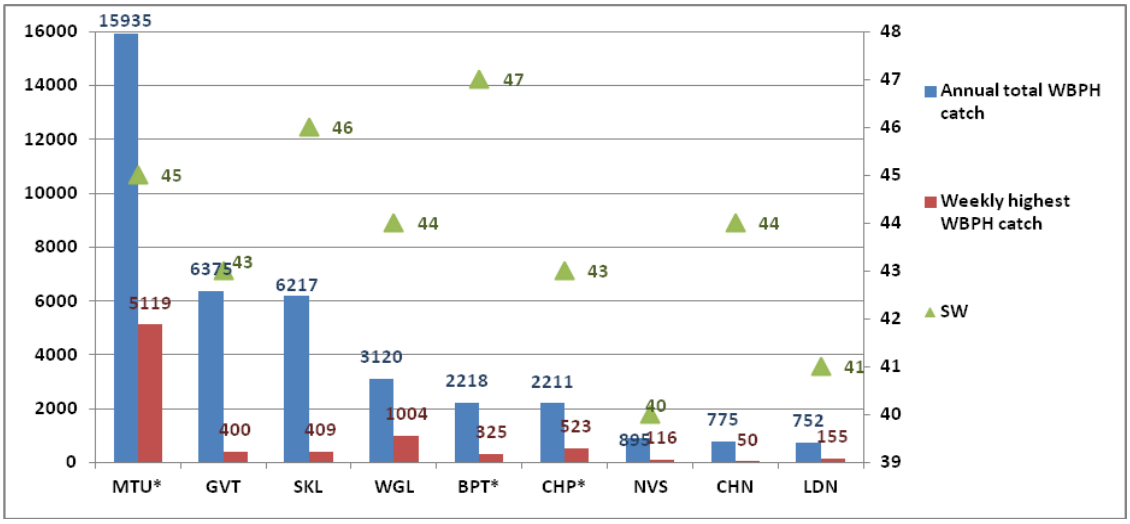


Fig. 2.20 Annual and weekly cumulative light trap catches of white-backed plant hopper * only *kharif* data SW- Peak catch standard week

Among the insect pests of minor importance, **case worm** was recorded in 12 locations: MSD, TTB, PTB, GNV, RPR, MND, BPT, JDP, MLN, CHP, CBT, and RNR. It was most active in MSD (18613), followed by TTB (2009) and PTB (1487). **Black bug** was reported from 5 locations: ADT (43446), TTB (39331), MTU (4164), MLN (273), and MNC (41). **White stem borer** was reported from TTB (25852), MLN (389), PTB (198), LDN (54), and KUL (36). At TTB, it was active throughout the year except in the first, 51st and 52nd SWs with a peak population of 2233 in 40th SW. **Pink stem borer** was also reported from 5 locations: RPR (470), LDN (337), KUL (166), RNR (23) and CBT (7). **Rice gundhi bug** was recorded at 7 locations: TTB (9128), NVS (1225), JDP (483), PNT (197), CHN (161), CBT (69) and RPR (6). It was found more active in September and October months coinciding with the reproductive stage of the crop. **Zigzag leaf hopper** was found in 4 locations: RPR (30856), MTU (19038), JDP (483) and BPT (241). Paddy skipper was reported from Khudwani and Navsari. White grub was a concern at KHD and CHT.

Overall, yellow stem borer leaf folder, and hoppers continued to be the most important pests in terms of numbers as well as spread across the locations. Gall midge continues to be an endemic pest. However, case worm, white stem borer, pink stem borer, black bug, gundhi bug, and zigzag leaf hopper showed an increase in the spread and intensity of incidence posing concern for future. Patterns in seasonal incidence and population build up on the basis of light trap data indicates that the key pests are reaching their peak levels in the months of October and November in the kharif season. Therefore, strategies are to be timed accordingly for the effective management of insect pests in rice.

Entomology Rabi 2018-19

SUMMARY

2.1 Host Plant Resistance Studies

Two trials, *viz.*, Stem borer screening trial (SBST) and Multiple pest resistance Screening Trial (MRST).

Stem borer screening trial (SBST) - Evaluation of entries in 5 valid field tests identified 13 entries as promising in 2 to 3 of the 5 tests in terms of low dead hearts, white ear damage and high grain yield. Recovery resistance and tolerance could be the mechanism in these entries as they yielded higher despite damage. The mean no. of larvae in the stubbles in these entries varied from ranged from 0.13-1.68/hill.

Multiple resistance screening trial (MRST) - Twenty-three entries were evaluated at Maruteru (MTU) and Rajendranagar (RNR) for multiple pest damage. RP 2068-18-3-5, KAUPTB 0627-2-11, KAUPTB 0627-2-14 and KAUPTB 0627-2-15 showed DS of 5.0 in the field reaction against planthoppers.The stem borer damage level was low at both locations.

2.2 Chemical Control studies

Botanical insecticides trial (BIET) was carried out at 5 locations to evaluate the efficacy of four essential oils and neemazal along with recommended insecticides, dinotefuran and rynaxypyr against major insect pests of rice and consequent impact on natural enemies and grain yield. Based on the performance of the treatments in reducing the pest incidence at various locations, the insecticide – rynaxypyr, cedar wood oil and camphor oil were found effective against stem borer damage. Dinotefuran was the most effective treatment against plant hoppers followed by Lemongrass oil. Against leaf folder and whorl maggot, cedar wood oil and eucalyptus oils were found effective and their efficacy was superior to control. Highest grain yield of 4176.6 kg/ha was recorded in rynaxypyr treatment, while among botanicals, eucalyptus oil treatment recorded highest yield (3771.4 kg/ha).

2.3 Ecological Studies

Effect of planting dates on insect pest incidence (EPDP) trial was conducted at Chinsurah and Maruteru. Incidence of stem borer, whorl maggot, BPH and WBPH was observed at both the locations in addition to leaf folder, GLH at Chinsurah and hispa at Maruteru. Stem borer damage crossed ETL in late planting (11.21% DH) at Chinsurah and in normal planting at Maruteru (12.09% WE). At Chinsurah, BPH population was very high at pre-harvest in normal planting (929 hoppers / 5 hills) and between 50 to 60 DAT in late planting (234-548 hoppers/ 5 hills). Incidence of other pests was low in all the three plantings.

2.4 Biocontrol and biodiversity studies

Ecological engineering for planthopper management (EEPM) was taken up in Maruteru and Moncompu with a combination of interventions such as organic manuring and growing of flowering plants on bunds. There were no significant differences between the two treatments due to lower population of hoppers during this season.

Bio intensive pest management trial (BIPM) was taken up at Pattambi. The stem borer incidence at vegetative stage was significantly less and natural enemy population was higher in BIPM plots which also recorded higher yields compared to Farmers practices.

2.5 Integrated pest management studies

Yield loss estimation trial (YLET) was conducted at two locations *viz.*, Chinsurah and Pattambi. Regression analysis revealed a significant negative relationship between white ears and grain yield at Chinsurah (R^2 = 0.5350) resulting in 1.7 g reduction in grain yield for every 10% increase in white ear damage. The relationship between white ears and grain yield was negative but not significant at Pattambi.

Integrated Pest Management special (IPMs) trial was conducted at four locations, Chinsurah, Karjat, Maruteru and Pattambi. In general, pest incidence was low to moderate across locations. Incidence of dead hearts was low in both IPM and FP plots at all the locations except at Karjat wherein IPM plot recorded low damage (8.51%DH) as against FP plot (12.07% DH). Similarly, white ear incidence was high only at Pattambi in both IPM (12.74% WE) and FP (14.85%WE) plots. Gall midge incidence was low in IPM plot at 29 DAT (8.64% SS) but later increased to 14.1% at 43DAT at Maruteru. BPH population was also relatively high in IPM plot (67/5hills) than in FP plot (58/5 hills). Net returns were high in IPM plots at all the locations due to high grain yield and low cost of cultivation resulting in higher BC ratio in IPM plots (1.45–2.53) than farmer practice plots (1.13–2.41).

Rabi 2018-19

2.1. Host Plant Resistance Studies

i) Stem borer screening trial (SBST):

Stem borer Screening trial (SBST) initiated in 2015 was continued during rabi 2018-2019 with 62 entries including nominations from IIRR, Jagtial, and Pattambi, which were specifically bred for stem borer tolerance. The entries were evaluated at 6 locations and observations were recorded on dead heart at vegetative phase, white ear damage and grain yield as well as the larval survival in the stubbles, at harvest. For effective screening two staggered sowings were taken up in most of the locations. The results of the evaluation against yellow stem borer damage from the valid tests are discussed below **(Table 2.79)**:

Dead heart damage: The dead heart damage in the trial varied from 2.0 to 42.5% with an average damage of 18.2% DH across 2 locations in 3 valid tests. Evaluation of entries for dead heart damage in two staggered sowings helped in identification of JGL 24267 and RP 5588-B-B-B-B-238 as promising in 2 of the 3 tests with ≤10% DH (DS 3.0).

White ear damage: The white ear damage across two locations in 2 valid tests varied from 14.81 to 50.79% with a mean of 15.8%WE. Evaluation of entries identified, JGL 33510, KAUPTB 0627-2-15, RP 5587-B-B-B-253-13, BK 49-76 and BK 39-179 as promising in both the valid tests with ≤10% WE (DS3.0). The larval survival per entry varied from 1to 3 larvae/hill in the stubbles with a mean of one larvae/hill.

Grain yield: JGL 33145*, KAUPTB 0627-2-11, RP 5587-B-B-B-273-1*, RP 5587-B-B-B-46-2, RP 5587-B-B-B-253-2, RP 5587-B-B-B-258-1, RP 5587-B-B-B-274-6, RP 5588-B-B-B-B-61, RP 5588-B-B-B-B-177, RP 5588-B-B-B-B-232, RP5587, JGL 32429, JGL 32979, JGL 33080, JGL 33124, BK 35-155 BK 64-116 and Sasyasree were promising in one of the valid tests with ≥15g/hill for grain yield /hill despite stem borer damage. JGL 32429, JGL 33080, KAUPTB 0627-2-11, RP 5587-B-B-B-253-2, RP 5587-B-B-B-258-1, RP 5587-B-B-B-274-6,RP 5587-B-B-B-273-1, RP 5588-B-B-B-B-232, BK 64-116 and RP5587 which were promising in terms of low stem borer damage in 1-2 tests of the 5 valid tests were also promising for grain yield (≥15g/hill).

Evaluation of entries in 5 valid field tests identified 13 entries as promising in 2 to 3 of the 5 tests in terms of low dead hearts, white ear damage and high grain yield. Recovery resistance and tolerance could be the mechanism in these entries as they yielded higher despite damage. The mean no. of larvae in the stubbles in these entries varied from ranged from 0.13-1.68/hill.

Table 2.79 Reaction of cultures to stemborer in SBST, *Rabi* 2018- 2019.

Entry No.	Designation	IIRR	PTB	PTB	**SBDH**	MTU	PTB	**SBWE**	**SBDH+ SBWE**		PTB
		65DT	30DT	50DT	**NPT**			**NPT**	**NPT**		GY/H (G)
		%DH	%DH	%DH	**3**	%WE	%WE	**2**	**5**		
58	BK 39-179	21.05	6.17	22.75	**1**	8.76	5.36	**2**	**3**		12.0
21	JGL 33510	24.02	18.76	17.17	**0**	5.33	2.50	**2**	**2**		10.0
33	KAUPTB 0627-2-15	18.84	13.86	12.33	**0**	2.00	5.56	**2**	**2**		14.5
39	RP 5587-B-B-B-253-13	15.36	19.33	21.34	**0**	7.87	7.14	**2**	**2**		10.5
57	BK 49-76	23.22	10.33	13.88	**0**	7.11	4.69	**2**	**2**		10.0
23	JGL 34505	21.35	3.67	13.21	**1**	6.68	17.24	**1**	**2**		10.0
24	JGL 34508	21.57	18.83	6.92	**1**	5.69	16.67	**1**	**2**		7.5
34	HWR 17	17.80	4.00	15.57	**1**	6.82	10.81	**1**	**2**		9.0
40	**RP 5587**	19.18	11.44	5.86	**1**	12.15	3.64	**1**	**2**		25.0
50	**RP 5588**	18.80	3.61	13.28	**1**	9.60	33.33	**1**	**2**		12.5
59	BK 49-42	19.51	9.33	18.11	**1**	6.04	14.29	**1**	**2**		10.5
56	RP 5588-B-B-B-B-238	19.43	3.61	8.44	**2**	24.85	23.53	**0**	**2**		12.5
1	JGL 24267	5.51	11.78	2.00	**2**	17.12	14.81	**0**	**2**		10.0

ii) Multiple resistance screening trial (MRST)

The trial was constituted with 23 entries and evaluated at Maruteru (MTU) and Rajendranagar (RNR) for multiple pest damage. At MTU, white ear damage due to stem borer and Planthopper counts were reported. RP 2068-18-3-5, KAUPTB 0627-2-11, KAUPTB 0627-2-14 and KAUPTB 0627-2-15 showed DS of 5.0 in the field reaction against planthoppers. The stem borer damage level was low at both locations.

2.2 Botanical and Insecticide Evaluation Trial

Botanical and insecticides Evaluation trial (BIET) was carried out at 5 locations to evaluate the efficacy of four essential oils and neemazal along with recommended insecticides, dinotefuran and rynaxypyr against major insect pests of rice and consequent impact on natural enemies and grain yield during Rabi, 2018-19. The details of number and time of applications are given below:

Sl. No.	Location	Date of sowing	Date of planting	Date of harvesting	No of applications	Times of application (DAT)
1	Coimbatore	22-02-2019	20-03-2019	18-06-2019	2	20 & 65
2	Chiplima	12-01-2019	23-02-2019	27-06-2019	3	25, 50 & 65
3	Karjat	18-01-2019	12-02-2019	20-05-2019	2	32 & 51
4	Pattambi	05-11-2018	26-11-2018	28-02-2019	4	15, 40, 60 & 75
5	Raipur	07-01-2019	13-02--019	24-05-2019	3	29, 50 & 72
6	Chinsurah	15-12-2018	07-02-2019	15-05-2019	3	15, 30 & 50

Observations were recorded on pest incidence, natural enemy counts as well as grain yield as per the standard procedures. The data were subjected to Anova analysis and the performance of the treatments were evaluated based on their efficacy against the major pests specific to each location as well as the grain yields obtained in each treatment.

Pest infestation table (2.80)

Stem borer incidence was recorded in five locations and high dead hearts damage was recorded at Raipur (10.5-20.7%) followed by Pattambi (9.7-17.7%). There were significant differences in damage among the treatments at all locations except, at Raipur at 30 DAT. Mean dead heart damage in treatments with essential oils ranged between 8.9 and 9.9% compared to12.3% in control, while rynaxypyr was the most effective treatment showing 6.8% DH.

Highest white ear damage was reported from Pattambi (31.3%) followed by Raipur with 22.8% WE in untreated control. All botanicals significantly reduced white ear damage (13.1-15.4%) when compared to 18.8% in control. Rynaxypyr was the most effective treatment against stem borer with 10.8% mean white ear damage. Among botanicals, Camphor and Lemon grass oils were found effective.

Brown planthopper incidence was recorded up to 28.0 hoppers/10 hills at Raipur, while **mixed population of planthoppers** was reported up to 61.20 hoppers/10 hills during 55 to 80 DAT, at Chiplima. There were significant differences in the efficacy among the treatments at both locations (Chiplima and Raipur). Dinotefuran was the most effective treatment with lowest mean population of 11.3 BPH/10 hills at Raipur and 17.8 planthoppers/10 hills at Chiplima as compared to 28.0 and 61.2 per 10 hills, respectively, in control. All essential oils showed similar efficacy (16.0 to 22.0 BPH/10 hills and 36.2 to 45.3 PH/10 hills, respectively), while neem azal treatment 18.0 BPH/10 hills and 33.5 PH/10 hills, respectively), at the two locations.

Leaf folder damage was reported from 2 locations and highest leaf damage was recorded in Pattambi (50.3-74.7%) at 75 DAT except in rynaxypyr treatment. There were significant differences in leaf damage among the treatments at both locations (Coimbatore and Pattambi). Rynaxypyr was the most effective treatment showing mean leaf damage of 4.7%. Among the botanials, cedar wood oil recorded lowest infestation (16.8% DL) in comparison to 24.3 % in control.

Whorl maggot damage was recorded only in Pattambi. Lowest mean damage of 1.2% was noticed in rynaxypyr when compared to control (7.0%). Among the botanicals, eucalyptus oil was the most effective treatment with 3.2% damage.

Grain Yield (Table: **2.81)**

There were significant differences in grain yield among the treatments at all 5 locations. Based on mean yield of these locations, rynaxypyr recorded the highest grain yield of 4176.6 kg/ha with 47.1% increase over control (IOC). Among the essential oils, Eucalyptus oil treatment recorded highest yield of 3771.4 kg/ha (32.8% IOC). All the treatments yielded significantly higher than Control (2839.2 kg/ha).

Botanical insecticides trial was carried out at 5 locations to evaluate the efficacy of four essential oils and neemazal along with recommended insecticides, dinotefuran and rynaxypyr against major insect pests of rice and consequent impact on natural enemies and grain yield during Rabi, 2018-19. Based on the performance of the treatments in reducing the pest incidence at various locations, the insecticide –rynaxypyr, cedar wood oil and camphor oil were found effective against stem borer damage. Dinotefuran was the most effective treatment against plant hoppers followed by Lemongrass oil. Against leaf folder and whorl maggot, cedar wood oil and eucalyptus oils were found effective and their efficacy was superior to control. Highest grain yield of 4176.6 *kg/ha was recorded in rynaxypyr treatment, while among botanicals, eucalyptus oil treatment recorded highest yield (*3771.4*kg/ha).*

Table 2.80 Insect pest incidence in different treatments, BIET, *Rabi* 2018-19

S. No.	Common Name	Rate g or ml of form/ha	% Dead hearts								Mean
			CBT		CHP		KJT		PTB		
			32DT	50DT	56DT	75DT	30DT	50DT	30DT	50DT	
1	Camphor Oil	1000	10.3ab	11.0a	2.5bc	1.9b	5.7b	2.1bc	16.2a	17.7a	**9.9**
2	Cedar wood oil	1000	12.0ab	7.1a	2.7b	2.1b	7.7a	2.5b	11.8b	14.6ab	**8.9**
3	Eucalyptus oil	1000	12.6ab	9.6a	1.7cd	1.5b	7.4ab	2.4b	16.0ab	15.3ab	**9.7**
4	Lemon grass oil	1000	11.2ab	11.6a	2.0bc	1.9b	6.2ab	2.6b	16.6a	12.7ab	**9.8**
5	Neem azal	1000	12.1ab	10.2a	1.9bc	1.8b	6.5ab	1.9bc	15.1ab	15.2ab	**9.4**
6	Dinotefuran	200	10.6ab	10.1a	1.7cd	1.7b	1.5c	1.9bc	16.0ab	12.8ab	**8.6**
7	Rynaxypyr	150	7.9b	7.6a	0.8d	0.9b	2.6c	0.9c	12.5ab	9.7b	**6.8**
8	Untreated Control	Water	13.8a	12.5a	5.3a	6.5a	7.9a	4.7a	15.7ab	14.8ab	**12.3**

Table 2.80 Insect pest incidence in different treatments, BIET, *Rabi* 2018-19

S. No.	Common Name	Rate g or ml of form/ha	% White Ears				Mean
			CBT	CHP	PTB	RPR	
1	Camphor Oil	1000	9.7ab	2.9b	19.0ab	20.6a	**13.1**
2	Cedar wood oil	1000	10.3ab	3.2b	27.7ab	19.4a	**15.2**
3	Eucalyptus oil	1000	8.4b	2.2b	30.0a	20.8a	**15.4**
4	Lemon grass oil	1000	9.0ab	2.9b	19.4ab	23.0a	**13.6**
5	Neem azal	1000	9.3ab	2.6b	28.2ab	19.5a	**14.9**
6	Dinotefuran	200	7.0b	1.9bc	24.0ab	19.4a	**13.1**
7	Rynaxypyr	150	7.3b	0.9c	16.0b	19.0a	**10.8**
8	Untreated Control	Water	12.93a	8.2a	31.3a	22.8a	**18.8**

Table 2.80 Insect pest incidence in different treatments, BIET, *Rabi* 2018-19

S. No.	Common Name	Rate g or ml of form/ha	Plant hoppers (No./10 hills)							
			BPH+WBPH				Mean	BPH		Mean
			CHP					RPR		
			55DT	60DT	75DT	80DT		50DT	70DT	
1	Camphor Oil	1000	28.3cd	27.6bc	41.6c	47.3cd	**36.2**	17.3a	26.6ab	**22.0**
2	Cedar wood oil	1000	30.6bc	30.3bc	51.3b	57.3b	**42.4**	12.0ab	22.6bc	**17.3**
3	Eucalyptus oil	1000	35.0ab	35.0b	51.0b	60.0b	**45.3**	12.0ab	25.3bc	**18.7**
4	Lemon grass oil	1000	29.0cd	28.0bc	48.0bc	54.3bc	**39.8**	12.0ab	20.0bc	**16.0**
5	Neem azal	1000	24.3de	21.3cd	41.3c	47.0cd	**33.5**	13.3ab	22.6bc	**18.0**
6	Dinotefuran	200	13.0f	13.6d	24.6d	20.3e	**17.8**	6.6b	16.0c	**11.3**
7	Rynaxypyr	150	21.6e	22.0cd	41.3c	44.3d	**32.3**	13.3ab	24.0bc	**18.7**
8	Untreated Control	Water	37.6a	51.6a	71.3a	84.3a	**61.2**	20.0a	36.0a	**28.0**

Table 2.80 Insect pest incidence in different treatments, BIET, *Rabi* 2018-19

S. No.	Common Name	Rate g or ml of form/ha	% Leaf Folder Damage				Mean
			CBT	PTB			
			50DT	45DT	60DT	75DT	
1	Camphor Oil	1000	10.9b	1.7b	9.9a	74.7a	**24.3**
2	Cedar wood oil	1000	12.2b	1.6b	3.0b	50.3a	**16.8**
3	Eucalyptus oil	1000	12.3b	1.4b	7.5ab	68.1a	**22.4**
4	Lemon grass oil	1000	8.6c	0.9b	6.2ab	59.9a	**18.9**
5	Neem azal	1000	11.7b	1.6b	5.1ab	59.6a	**17.5**
6	Dinotefuran	200	6.5cd	2.5ab	8.6a	74.6a	**23.1**
7	Rynaxypyr	150	6.1d	2.5ab	9.0a	1.0b	**4.7**
8	Untreated Control	Water	15.3a	3.9a	8.5a	69.3a	**24.3**

Table 2.80 Insect pest incidence in different treatments, BIET, *Rabi* 2018-19

S. No.	Common Name	Rate g or ml of form/ha	%WM Damage Leaves		Mean
			PTB		
			25DT	45DT	
1	Camphor Oil	1000	9.04	1.04	**5.0**
2	Cedar wood oil	1000	11.10	1.34	**6.2**
3	Eucalyptus oil	1000	5.41	0.91	**3.2**
4	Lemon grass oil	1000	12.61	1.96	**7.3**
5	Neem azal	1000	13.10	1.61	**7.4**
6	Dinotefuran	200	8.02	0.95	**4.5**
7	Rynaxypyr	150	1.24	1.16	**1.2**
8	Untreated Control	Water	11.39	2.63	**7.0**

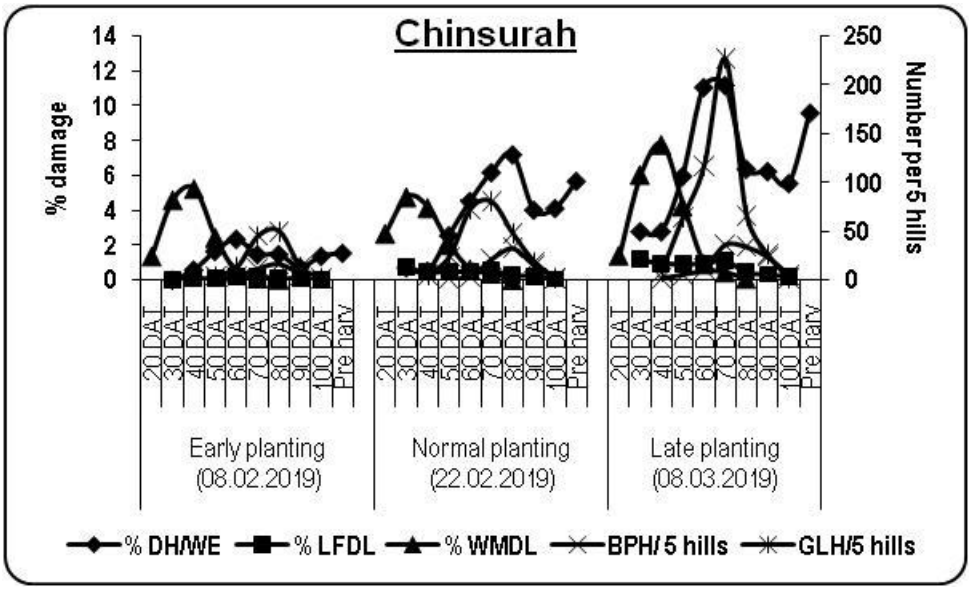
Table 2.81 Grain Yield in different treatments, BIET, *Rabi* 2018-19

S. No.	Common Name	Rate g or ml of form/ha	Yield (kg)/ha						IOC (%)
			CBT	CHP	KJT	PTB	RPR	Mean	
1	Camphor Oil	1000	3088.8ab	4289.1c	3053.3d	3703.7bc	3991.7ab	**3625.3**	**27.7**
2	Cedar wood oil	1000	3170.0ab	4230.3c	3106.6cd	3103.6cd	4008.3ab	**3523.8**	**24.1**
3	Eucalyptus oil	1000	3134.4ab	4426.2bc	3373.3b	3943.8ab	3979.2ab	**3771.4**	**32.8**
4	Lemon grass oil	1000	3073.3ab	4259.7c	2800.0e	3497.9bcd	3900.0b	**3506.2**	**23.5**
5	Neem azal	1000	3177.8ab	4347.8bc	3240.0bc	3480.8bcd	3850.0b	**3619.3**	**27.5**
6	Dinotefuran	200	3322.2a	4524.1b	3666.6a	3309.3bcd	3916.7ab	**3747.8**	**32.0**
7	Rynaxypyr	150	3255.6a	5033.3a	3760.0a	4492.5a	4341.7a	**4176.6**	**47.1**
8	Untreated Control	Water	2886.7b	3388.2d	1720.0f	2863.5d	3337.5c	**2839.2**	

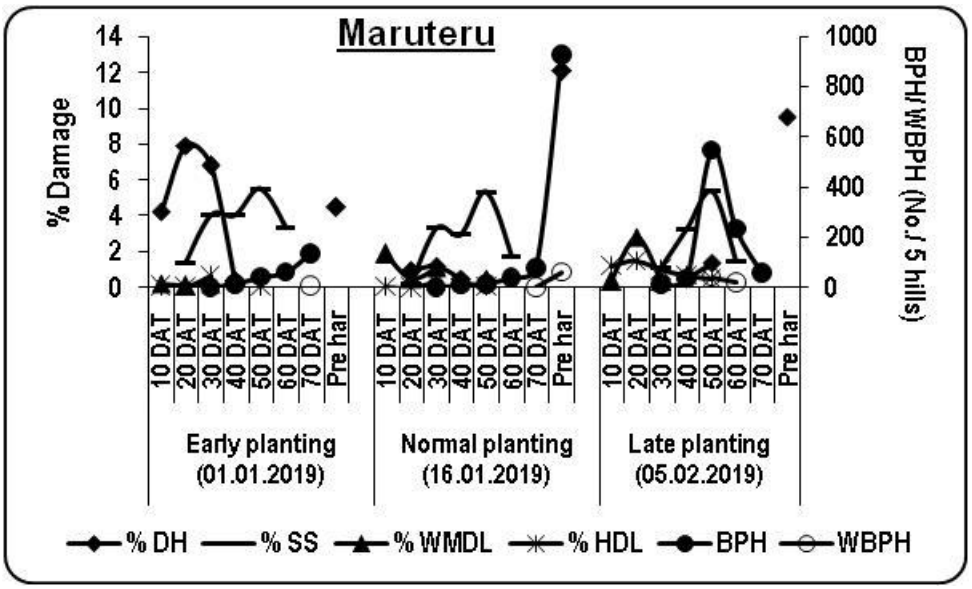
2.3 ECOLOGICAL STUDIES

i) Effect of Planting Dates on Insect Pest Incidence (EPDP)

During *Rabi* 2018-19, the field trial was conducted at two locations, *i.e.,* at Chinsurah and Maruteru. At Chinsuarh, IET 4788 (Satabdi) was grown in all three plantings during boro season. Incidence of stem borer, leaf folder, whorl maggot, BPH, WBPH and GLH was observed. Dead heart damage caused by stem borer exceeded ETL only in late planting at 60 DAT (11.09%DH) and 70 DAT (11.21% DH). Leaf folder (<2% DL), whorl maggot (<8.0% DL) and BPH (2 – 37 hoppers/ 5 hills) incidence was low in all the three plantings. However, GLH incidence was high in late planting starting from 50 DAT to 80 DAT (64 – 227 hoppers/5 hills) followed by normal planting between 60 DAT and 70 DAT (73 – 80 hoppers/5 hills).



At **Maruteru**, incidence of stem borer, whorl maggot, hispa, BPH and WBPH was recorded in IR 64 variety grown in all the three plantings. Stem borer incidence was low in all the three plantings except at pre harvest in normal planting wherein white ears exceeded the ETL (12.09% WE). Incidence of whorl maggot and hispa was very low (< 5% DL) in different plantings. BPH population was high and exceeded ETL at 60 DAT (62 hoppers/5 hills) and 70 DAT (133 hoppers/ 5 hills), in early planting, 70 DAT to pre –harvest (78 – 929 hoppers/ 5 hills) in normal planting, 50 to 70 DAT (58 – 548 hoppers/ 5 hills) in late planting. WBPH population was low in the plantings except at pre-harvest count in normal planting (60 hoppers/ 5 hills).



Effect of planting dates on insect pest incidence (EPDP) trial was conducted at Chinsurah and Maruteru during Rabi 2018-19. Incidence of stem borer, whorl maggot, BPH and WBPH was observed at both the locations in addition to leaf folder, GLH at Chinsurah and hispa at Maruteru. Stem borer damage crossed ETL in late planting (11.21% DH) at Chinsurah and in normal planting at Maruteru (12.09% WE). At Chinsurah, BPH population was very high at pre-harvest in normal planting (929 hoppers/ 5 hills) and between 50 to 60 DAT in late planting (234-548 hoppers/ 5 hills). Incidence of other pests was low in all the three plantings.

2.4. BIOCONTROL AND BIODIVERSITY STUDIES

i) Ecological Engineering for Planthopper Management (EEPM)

This trial was carried out at Maruteru and Moncompu during Rabi 2018-2019.

The EE interventions tested at Maruteru were alleyways, organic manuring and planting of bund flora. The observations on hoppers and their natural enemies were recorded four times starting from 40 DAT. BPH population reached a peak at 75 DAT, however it was on par in EE treatment (27.62 hoppers/hill) and farmers practices (38.36 hoppers/hill) **(Table 2.82)**. The population of natural enemies such as green mirids, spiders and coccinellid were also on par. The EE plots yielded (4921 kg/ha) on par with FP plots (4950 kg/ha).

Table 2.82 Effect of ecological engineering on hoppers and its natural enemies at Maruteru, EEPM, *rabi 2018-19*

Parameters	BPH (No./ hill)		Green mirids (No./10 hills)		Spiders (No./ hill)		Coccinellids (No./hill)		Yield (Kg/ha)	
	EE	FP	EE	FP	EE	FP	EE	FP	EE	FP
Mean	27.62	38.36	22.20	31.00	17.00	16.00	5.4	5.4	4921	4950
t value	1.15 NS		1.23 NS		0.52 NS		0.00 NS		0.21 NS	
df	98		98		98		98		10	
P - value	0.12		0.22		0.60		1.00		0.80	

**projected yield*

Table.2.83 Effect of ecological engineering on hoppers and its natural enemies at Moncompu, EEPM, *rabi 2018-19*

Parameters	BPH (No./10 hills)		Spiders (No./ 10 hills)		Coccinellids (No./ 10 hills)	
	EE	FP	EE	FP	EE	FP
Mean	1.67	1.47	2.84	2.36	7.24	6.44
t value	0.42 NS		0.90 NS		0.80 NS	
df	98		98		98	
P - value	0.68		0.37		0.42	

At Moncompu, Marigold was tested as bund flora. Four observations were recorded on hoppers and their natural enemies, starting from 15 DAT. Hoppers and their natural enemy population was very low and were on par in both, EE treatment and farmers practices **(Table 2.83)**.

Ecological engineering for planthopper management was taken up in Maruteru and Moncompu with a combination of interventions such as organic manuring, and growing of flowering plants on bunds. There were no significant differences between the two treatments due to lower population of hoppers during this season.

ii) Bio-intensive pest management trial (BIPM)

The trial was taken up at Pattambi during the *rabi s*eason.

Pattambi

Observations were recorded on the damage by whorl maggot, leaffolder, caseworm, stem borer and natural enemies like spiders, coccinellids and mirids. The dead heart damage by stem borer was significantly higher in FP plots (19.31%) compared to that of BIPM plots (7.36%) **(Table 2.84)**. However, white ear incidence was at par in both treatments (38.82 and 39.21%, respectively). The natural enemy population *viz.*, number of spiders (16.00/ 10 hills) and coccinellids (13.00/10 hills) was significantly higher in BIPM plots than that of Farmers' practice plots (7.17 and 9.83/ 10 hills respectively). The yield though higher in BIPM plots (3670.33 kg/ha) was on par with that of FP plots (3333.54 kg/ha).

Bio intensive pest management trial was taken up at Pattambi during Rabi 2018. The stem borer incidence at vegetative stage was significantly less and natural enemy population was higher in BIPM plots which also recorded higher yields compared to Farmers practices.

Table 2.84 Pest and natural enemy incidence under Bio-intensive pest management trial at Pattambi, *rabi* 2018-19

A. Pest incidence

Parameters	LF (% damage)		WM (% damage)		SS (% damage)		BB (% damage)		DH (% damage)		WE (% damage)	
	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP
Mean	6.24	5.51	10.19	11.05	6.26	9.30	1.11	4.22	7.56	19.31	38.82	39.21
t value	0.43^{NS}		0.37^{NS}		1.56^{NS}		2.29*		5.02**		0.06^{NS}	
df	26		26		26		26		26		10	
P - value	0.67		0.71		0.13		0.03		<0.01		0.95	

LF- Leaffolder; WM- whorl maggot; DH – Dead heart; WE- white ears; SS- silver shoots; BB- blue beetle

B. Predators

Parameters	Coccinellid (No./10 hills)		Spiders (No./10 hills)		Mirids (No./10 hills)		Yield Kg/ha	
	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP
Mean	13.00	9.83	16.00	7.17	11.00	5.50	3670.83	3333.54
value	1.35*		2.83*		3.01**		0.96^{NS}	
df	12		12		12		10	
P - value	0.04		0.02		0.01		0.36	

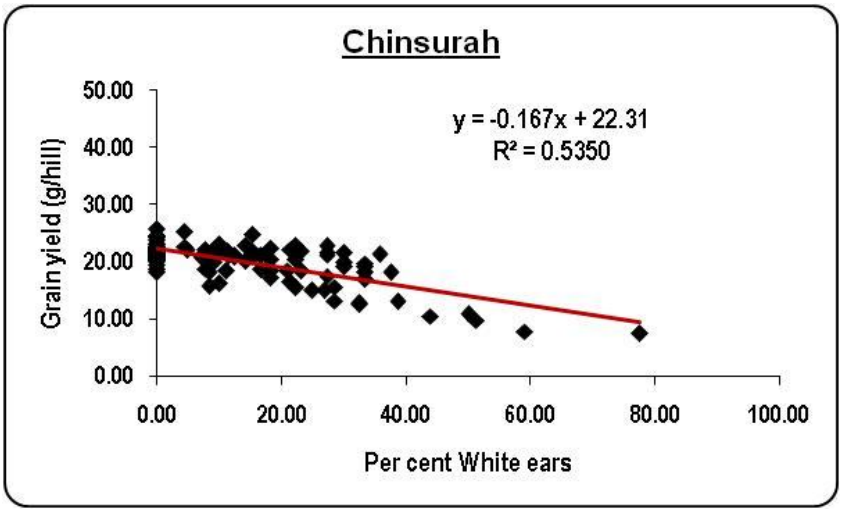
2.5. INTEGRATED PEST MANAGEMENT STUDIES

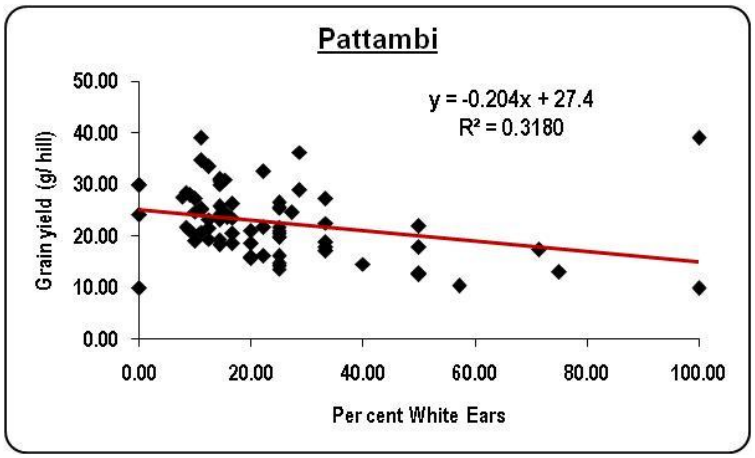
This section consists of two trials *viz.*, i) Yield Loss Estimation Trial (YLET) and ii) Integrated Pest Management special trial (IPMs). Details of these trials are given below:

i) Yield Loss Estimation Trial (YLET)

Target pest: Stem borer

At **Chinsurah**, white ear damage ranged between 0.00 and 77.50% with grain yield of 7.55 to 25.70 g per hill in Khitish variety. Linear regression analysis revealed a significant negative relationship between white ears and grain yield (R^2 = 0.5350). It indica a decrease of 1.67 g yield per hill for every 10% increase in white ears.





At **Pattambi**, white ear damage ranged from 0.00 to 100.00% resulting in 9.87 to 39.11 g grain yield per hill. The relationship between white ears and grain yield was negative but not significant.

Yield loss estimation trial was conducted at two locations viz, Chinsurah and Pattambi during Rabi 2018-19. Regression analysis revealed a significant negative relationship between white ears and grain yield at Chinsurah (R^2 = 0.5350) resulting in 1.7 g reduction in grain yield for every 10% increase in white ear damage. The relationship between white ears and grain yield was also negative but not significant at Pattambi.

ii) Integrated Pest Management special Trial (IPMs)

IPM special trial was carried out at four locations *viz.*, Chinsurah, Karjat, Maruteru and Pattambi during *Rabi* 2018-19. Location wise details are discussed below:

Chinsurah: IPMs trial was conducted at Sri Narayan Chandra Mondal's field at Village Bele, Radhanagar, Pandua mandal, Hooghly district of West Bengal. Practices followed in IPM and FP plots were given below:

Practices followed in IPMs trial at Chinsurah, *Rabi* 2018-19

	IPM practices	Farmers practices
Area/ variety	0.5 acre; IET 4786 (Satabdi)	0.5 acre; IET 4786 (Satabdi)
Nursery	• Application of 1.5 kg mustard cake	• Application of 5 kg mustard cake
Main field	• Field preparation with power tiller, cutting of bunds and leveling the field • Application of 31 kg 10:26:26 + Urea @ 28 kg • Application of Butachlor + hand weeding • Application of Ferterra @ 4 kg/ acre • Application of Coragen @ 60 ml/ acre • Application of carbendazim • Installation of pheromone traps @ 6/acre for stem borer mass trapping	• Field preparation with power tiller, cutting of bunds and leveling the field • Application of 30 kg SSP, 23 kg MOP, Urea 30 kg • Hand weeding two times • Application of Carbofuran 3G @ 12 kg/ acre • Spraying of Cartap hydrochloride 50 SP @ 500 g/ acre two times • Application of Carbendazim

Incidence of stem borer, whorl maggot, leaf folder and GLH was low in both IPM and FP plots starting from 15 DAT to pre harvest stage **(Table 2.85)**. Grain yield was relatively high in IPM plot resulting in high returns and BC ratio (1.45) compared to farmers practices (1.26) **(Table 2.86)**.

Table 2.85 Pest incidence in IPMs trial at Chinsurah, *Rabi* 2018-19

Treat-ments	% DH				% WE	% WMDL	GLH
	15 DAT	22 DAT	29 DAT	43 DAT	Pre har	22 DAT	64 DAT
IPM	0.71 ± 0.71	2.37 ± 0.41	2.47 ± 0.39	2.34 ± 0.36	2.30 ± 0.18	2.15 ± 0.33	1.20 ± 0.49
FP	4.18 ± 0.70	4.60 ± 0.69	4.81 ± 0.43	3.27 ± 0.56	7.35 ± 1.12	5.21 ± 0.81	1.40 ± 0.68

Table 2.86 Grain yield and Returns in IPMs trial at Chinsurah, *Rabi* 2018-19

Treatments	Yield (Q/ ha)	Gross Returns (Rs.)	Cost of Cultivation (Rs.)	Net Returns (Rs.)	BC ratio
IPM	49.52	84679	58288	26391	1.45
FP	43.84	74966	59333	15633	1.26

Price of paddy = Rs.1710/q

Karjat: IPMs trial was conducted in three farmers' fields' *viz.*, Sri Ashok Narayan Patil of Bhaliwadi village, Sri Mangesh Ganpat Thakre of Tiware village, Sri Ravindra Hagawane of Takwe village in Karjat mandal of Raigad district, Maharashtra State. Practices followed in both IPM and FP plots are given below:

Practices followed in IPMs trial at Karjat, *Rabi* 2018-19		
Practices adopted	IPM block	Farmers practices
Area	1 acre	1 acre
Varieties	1)Sri Ashok Narayan Patill, Bhaliwadi village - Zinia 2) Sri Mangesh Ganpat Thakre, Tiware village- Karjat 3 3) Sri Ravindra Hagawane, Takwe village - Karjat 3	Zinia Karjat 3 Karjat 3
Nursery	Seed treatment with carbendazim @ 10 g/ 10 kg seed Raised bed 3x1m treated with rice husk (hull) ash @3kg/bed	Land burned with waste materials
Main field	• Deep ploughing • Application of FYM 4 T, Suphala 215 Kg, Urea 87 Kg • 2-3 seedlings transplanted at a spacing 20 x15 cm. • Alleyways of 40cm left after every 10 rows • Bispyribasodium 250ml/ha (Nomini gold). • Pheromone traps @ 8 / acre • Use of bird perches in the field • Use Vaibhav sickle for harvesting • Application of Cartap hydrochloride @ 18 kg/ ha	• Deep ploughing • Application of FYM 2 T,Urea 160 kg, Suphala 100 kg • 4-5 seedlings transplanted randomly • Hand weeding once • Phorate 10 kg/ha (two applications)

Incidence of stem borer and leaf folder was observed in both IPM and FP plots in all the three farmers' fields starting from 36 DAT **(Table 2.87)**. Dead heart damage crossed ETL in farmers' practices from 36 to 50 DAT (10.89 – 12.07% DH) compared to IPM plots (7.95 – 10.51% DH). Very low incidence of leaf folder was recorded in only Sri Ravindra Hagawane's field in both IPM and FP plots (<1.0% LFDL). However, BC ratio was low in FP plots (1.29) compared to IPM plots (1.71) due to low grain yield resulting in low gross returns and high cost of cultivation **(Table 2.88)**.

Table 2.87 Pest incidence in IPMs trial at Karjat, *Rabi* 2018-19

Farmer's Name	Treatments	% DH				% LFDL
		36 DAT	43 DAT	50 DAT	57 DAT	43 DAT
Sri Ashok Narayan Patil	IPM	9.83 ± 1.10	10.61 ± 2.12	8.03 ± 0.74	1.60 ± 0.58	0.00 ± 0.00
	FP	14.04 ± 1.4	15.04 ± 1.52	6.38 ± 1.32	2.10 ± 0.90	0.00 ± 0.00
Sri Mangesh Ganpat Thakre	IPM	6.06 ± 1.48	10.87 ± 0.94	11.43 ± 1.53	1.09 ± 0.74	0.00 ± 0.00
	FP	7.74 ± 2.36	13.03 ± 1.59	10.04 ± 2.39	6.16 ± 1.13	0.00 ± 0.00
Sri Ravindra Hagawane	IPM	0.00 ± 0.00	4.04 ± 1.47	12.07 ± 0.84	1.08 ± 0.68	0.49 ± 0.17
	FP	0.00 ± 0.00	8.14 ± 1.77	17.52 ± 1.52	3.36 ± 1.54	0.70 ± 0.18
IPM		7.95	8.51	10.51	1.26	0.49
FP		10.89	12.07	11.31	3.87	0.70

Table 2.88 Grain yield, Returns and BC ratio in IPMs trial at Karjat, *Rabi* 2018-19

Farmer's Name	Treat-ments	Yield Q/ha	Gross Returns (Rs.)	Cost of Cultivation (Rs.)	Net Returns (Rs.)	BC Ratio
Sri Ashok Narayan Patil	IPM	36.48	73875	42183	31692	1.75
	FP	30.00	60875	45850	15025	1.33
Sri Mangesh Ganpat Thakre	IPM	35.04	71000	42183	28817	1.68
	FP	29.52	59875	46850	13025	1.28
Sri Ravindra Hagawane	IPM	35.36	72125	42183	29942	1.71
	FP	28.24	61000	48760	12240	1.25
IPM		35.63	72333	42183	30150	1.71
FP		29.25	60583	47153	13430	1.29

Maruteru: IPMs trial was conducted at two farmer's fields' *viz.,* Sri N Srinivasa Rao of Vaddiparru village, Poduru mandal and Sri P Chakravarthi of Kavurupalem village, Achanta mandal, Andhra Pradesh State. MTU 1121 was grown in both IPM and FP plots. Practices followed in IPM and FP plots are given below:

Practices adopted	IPM block	Farmers practices
Area	2000 sq	2000 sq
Variety	MTU 1121	MTU 1121
Fertilizers	NPK @ 180-90-90 kg/ha	NPK @ 225-80-90 kg/ha
Nursery	Seed treatment with carbendazim @ 10g/ 10kg seeds	
	Application of carbofuran @800g/ 5cents nursery 5 days before pulling seedlings from nursery for transplantation	
Main field	Formation of alleyways of 30 cm after every 2 m	Formation of alleyways of 30 cm after every 2 m
	NPK @ 180-90-90 kg/ha	NPK @ 225-80-90 kg/ha
	Application of Londax power@10kg/ha within one week after transplantation + one manual weeding	Londax power @10kg/ha within one week after transplantation+one manual weeding
	Installed pheromone traps @ 8 traps/ ha for stem borer monitoring.	Application of Dinotefuran, Pymetrozine and Acephate against brown planthoppers
	One spray of Cartap hydrochloride 50 SP @ 1000 g / ha at 60 DAT	Application of Ferterra granules and Cartap hydrochloride granules against stem borer
	Blanket application of Propiconazole @1.0ml/l	Spraying of Tricyclazole against blast (twice)
	Mid-season drainage should be followed in case of BPH endemic areas.	
	Application of Dinotefuran and Pymetrozine against brown planthoppers	
	Spraying of Tricyclazole @0.6g/l against blast	

Incidence of stem borer, gall midge, leaf folder, whorl maggot, hispa, BPH and WBPH was recorded in both the treatments in both the farmer's fields'. Gall midge incidence was found high in FP plots (14.45% SS) compared to IPM plots (8.64% SS) at 29 DAT. However, gall midge damage increased in IPM plots at 36 DAT (10.87% SS) and 43 DAT (14.10% SS) than in FP plots (8.68 – 10.67% SS). BPH population crossed ETL in both IPM and FP plots

at 43 DAT alone (67 hoppers/5 hills in IPM & 58 hoppers/ 5 hills in FP) and declined at later stage. Incidence of other pests was low in all the treatments **(Table 2.89)**.

Table 2.89 Pest incidence in IPMs trial at Maruteru, *Rabi* 2018-19

Farmer's Name	Treat-ments	% DH	% SS			% LFDL	% WMDL	% HDL	BPH*	WBPH*
		29 DAT	29 DAT	36 DAT	43 DAT	36 DAT	15 DAT	15 DAT	43 DAT	43 DAT
Sri N Srinivasa Rao	IPM	1.45 ± 0.4	9.15 ± 0.9	11.42 ± 1.2	15.34 ± 1.4	0.06 ± 0.0	0.55 ± 0.2	0.94 ± 0.2	66 ± 7	7 ± 1
	FP	2.37 ± 0.8	13.37 ± 0.3	7.68 ± 0.8	12.72 ± 0.8	0.04 ± 0.0	0.65 ± 0.2	0.98 ± 0.2	56 ± 7	6 ± 1
Sri P Chakravarthi	IPM	1.10 ± 0.3	8.13 ± 0.9	10.32 ± 1.4	12.86 ± 2.2	0.09 ± 0.0	0.46 ± 0.2	0.79 ± 0.2	68 ± 8	11 ± 1
	FP	3.53 ± 0.5	15.52 ± 0.5	9.68 ± 0.8	8.62 ± 1.2	0.16 ± 0.0	0.74 ± 0.1	0.85 ± 0.3	60 ± 5	7 ± 1
IPM		1.30	8.64	10.87	14.10	0.08	0.51	0.87	67	9
FP		2.95	14.45	8.68	10.67	0.10	0.70	0.92	58	7

*Number per 5 hills

High grain yield was reported from both IPM and FP plots at both the farmer's fields resulting in high returns and high BC ratio **(Table 2.90)**.

Table 2.90 Grain yield, Returns and BC ratio in IPMs trial at Maruteru, *Rabi* 2018-19

Farmer's Name	Treat-ments	Yield (Q/ ha)	Gross Returns (Rs.)	Cost of Cultivation (Rs.)	Net Returns (Rs.)	BC ratio
Sri N Srinivasa Rao	IPM	95.00	160265	59750	100515	2.68
	FP	97.50	164483	64975	99508	2.53
Sri P Chakravarthi	IPM	85.40	144070	60400	83670	2.39
	FP	88.15	148709	65200	83509	2.28
IPM		90.20	152167	60075	92092	2.53
FP		92.83	156596	65088	91508	2.41

Price of paddy = Rs.1687/q

Pattambi: IPMs trial was conducted at Sri Ummer's field in Parambil house, Kondurkara village, Palakkad district, Kerala State. Uma variety was grown in both IPM and FP plots during *Rabi* 2018-19. The following table shows the practices followed in IPM and FP plots.

Incidence of stem borer, gall midge, leaf folder, whorl maggot, case worm and blue beetle was observed in both IPM and FP plots. White ear damage was high in FP plots (14.85% WE) compared to IPM plots (12.74% WE) while dead heart damage was low in both the treatments throughout the crop growth period **(Table 2.91)**. Leaf folder damage was reported from 25 DAT onwards but exceeded ETL in FP plot at 55 DAT (15.32% DL) and 70 DAT (14.31% DL). Incidence of whorl maggot (<4% DL), case worm (<1% DL) and blue beetle (<4% DL) was low in both IPM and FP plots. Grain yield was high in IPM plot (50.80 q/ ha) resulting in higher returns and high BC ratio (1.93) compared to FP plot (1.13) **(Table 2.92)**.

LOCATION: PATTAMBI		
	IPM PRACTICES	**FARMERS PRACTICES**
Farmer 1 – Sri Ummer Haji, Kondurkara village, Palakkad district, Kerala		
Area	4000 sq.m	4000 sq m
Variety	Uma	Uma
Fertilizers	Application of NPK @ 90:45:45	Application of 150 kg Factomphos 75 kg urea and 35 kg Potash
Nursery	• Seed treatment with Pseudomonas @ 10g/kg seed • Seedling dip with Pseudomonas @ 20g/ litre of water	
Main field	• Application of Sathy+Pretilachlor @ 40g+400ml/ acre • Installed pheromone traps for stem borer mass trapping @ 20 traps/ ha • Five sprays with Eco neem 1% at15, 25, 45, 65 and 80 DAT	Spraying of Flubendamide, quinal-phos, Chlorantraniliprole and malathion at 30, 60, 75 and 95 DAT

Table 2.91 Pest incidencein IPMs trial at Pattambi, *Rabi* 2018-19

Treat-ments	% DH	% WE	% SS	% LFDL		% WMDL	% CWDL	% BBDL
	55 DAT	Pre har	45 DAT	55 DAT	70 DAT	35 DAT	25 DAT	25 DAT
IPM	2.03 ± 1.21	12.74 ± 2.60	2.32 ± 0.95	8.48 ± 1.80	8.22 ± 1.79	2.99 ± 0.55	0.23 ± 0.12	3.81 ± 0.60
FP	3.65 ± 1.52	14.85 ± 2.41	1.42 ± 0.40	15.32 ± 0.97	14.31 ± 2.60	3.14 ± 0.62	0.76 ± 0.47	3.24 ± 0.74

Table 2.92 Yield, Returns and BC ratio in IPMs trial at Pattambi, *Rabi* 2018-19

Treatments	Yield (Q/ ha)	Gross Returns (Rs.)	Cost of cultivation (Rs.)	Net Returns (Rs.)	BC Ratio
IPM	50.80	116840	60625	56215	1.93
FP	41.16	94668	83938	10730	1.13

Price of paddy = Rs.2300/q

Across locations, pest incidence in IPMs trial was low to moderate during *Rabi* 2018-19. At Karjat, dead heart damage was low in IPM plot (8.51% DH) compared to FP plot (12.07% DH). At Maruteru, gall midge incidence crossed ETL from 29 to 43 DAT and was high in FP plots (10.67 – 14.45% SS) than in IPM plots (**Fig. 2.21.**). At Pattambi, white ear damage was low in IPM plot (12.74% WE) compared to FP plot (14.85% WE). Leaf folder damage was high in FP plot from 55 to 70 DAT (14.31 – 15.32% DL) than in IPM plots (8.22 – 8.48% DL). At Maruteru, BPH population was relatively high in IPM plot (67 hoppers/5 hills) compared to FP plot (58 hoppers/ 5 hills).

At all the locations, grain yield was high in IPM plots compared to FP plots except at Maruteru wherein FP plot out yielded IPM plot. However, BC ratio was relatively high in IPM plots than in FP plots mainly due to high returns and low cost of cultivation (**Figs. 2.22 and 2.23**).

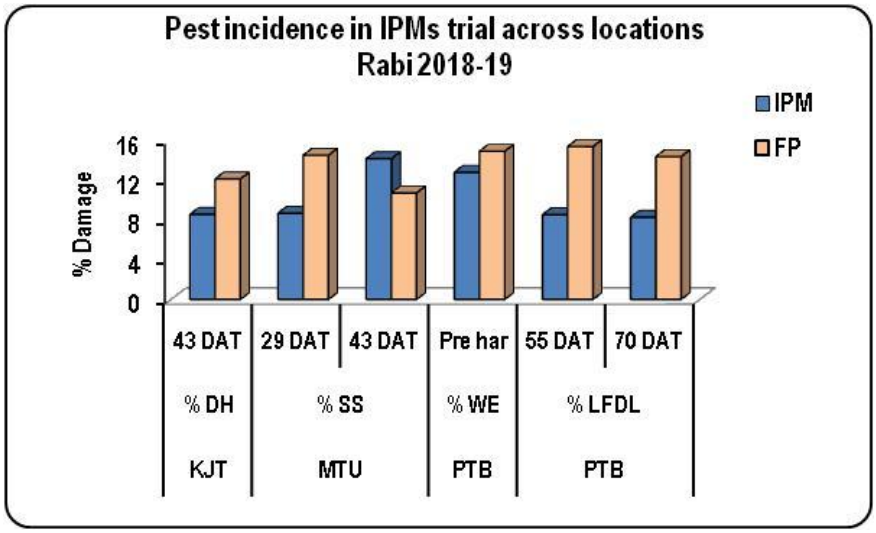


Fig. 2.21. Pest incidence in IPMs trial across locations, *Rabi* 2018-19

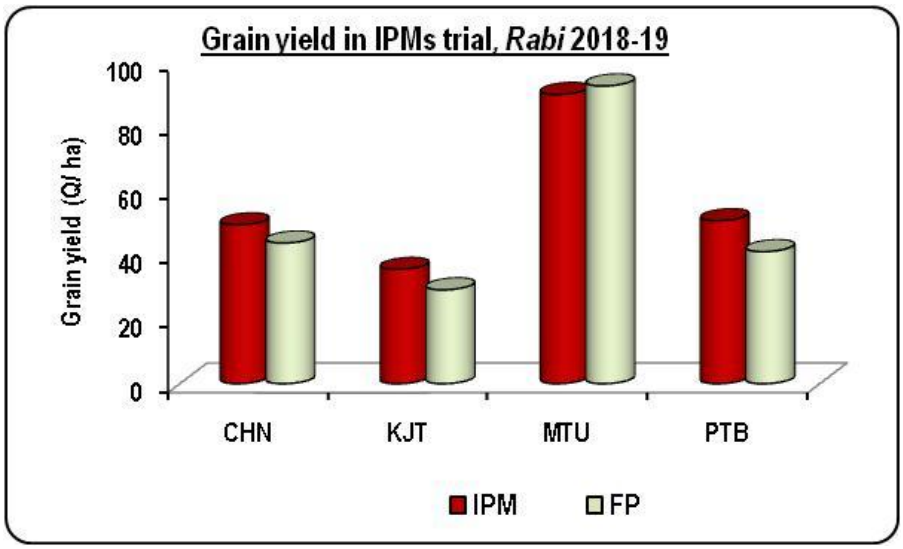


Fig. 2.22. Grain yields in IPMs trial in different locations, *Rabi* 2018-19

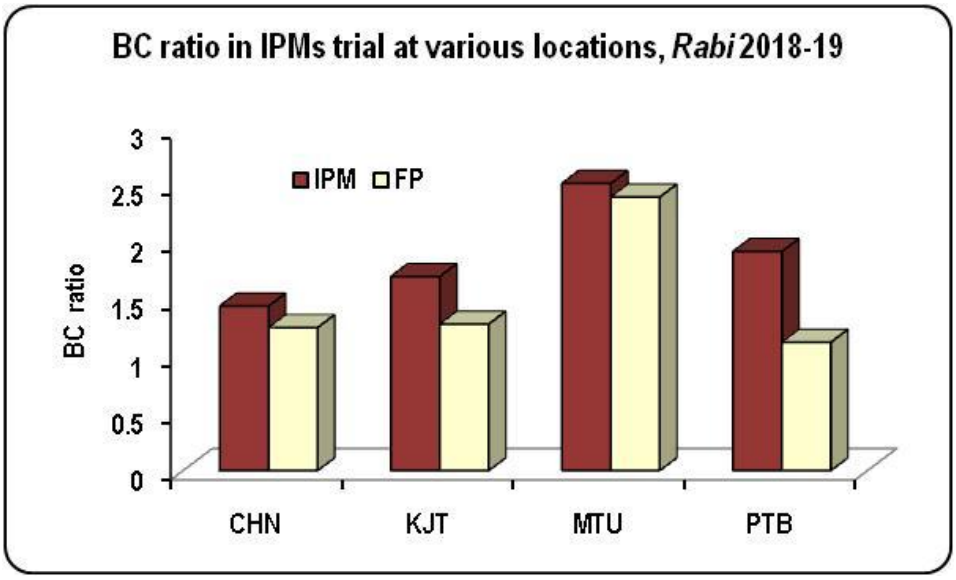


Fig. 2.23. BC ratios in IPMs trial in different locations, *Rabi* 2018-19

Integrated Pest Management special (IPMs) trial was conducted at four locations, Chinsurah, Karjat, Maruteru and Pattambi during Rabi 2018-19. In general, pest incidence was low to moderate across locations. Incidence of dead hearts was low in both IPM and FP plots at all the locations except at Karjat wherein IPM plot recorded low damage (8.51% DH) as against FP plot (12.07% DH). Similarly, white ear incidence was high only at Pattambi in both IPM (12.74% WE) and FP (14.85% WE) plots. Gall midge incidence was low in IPM plot at 29 DAT (8.64% SS) but later increased to 14.1% at 43 DAT at Maruteru. BPH population was also relatively high in IPM plot (67 hoppers/ 5 hills) than in FP plot (58 hoppers/ 5 hills). Net returns were high in IPM plots at all the locations due to high grain yield and low cost of cultivation resulting in higher BC ratio in IPM plots (1.45 – 2.53) than farmer practice plots (1.13 – 2.41).

Appendix-I

IIRR headquarters, Hyderabad: Drs. G. Katti, B. Jhansi Rani, V. Jhansi Lakshmi, A. P. Padmakumari, Chitra Shanker, Ch. Padmavathi & Y. Sridhar

Cooperating centres

Sl. No.	State	Location	Code	Name of the cooperator, Designation
1	Andhra Pradesh	Bapatla*	BPT	Dr. C. V. Rama Rao, Pr.Scientist (Ento.) & Head
2		Maruteru	MTU	Dr. M. Nandkishore, Scientist (Ento.)
3		Nellore*	NLR	Dr. I. Parmasiva, Scientist (Entomology)
4		Ragolu*	RGL	-
5	Assam	Titabar	TTB	Dr. Mayuri Baruah, Junior Scientist
6	Bihar	Pusa	PSA	Dr. A. K. Misra, Professor (Entomology)
7	Chattisgarh	Jagdalpur	JDP	Dr. N. C. Mandawi, Scientist
8		Raipur	RPR	Dr. Sanjay Sharma, Pr. Scientist (Entomology)
9	New Delhi	New Delhi*	NDL	Dr. Subhash Chander, Prof. & P.S(Ento), IARI
10	Jharkhand	Ranchi	RCI	Dr. Rabindra Prasad, Rice Entomologist
11	Gujarat	Nawagam	NWG	Dr. Sanju Thorat, Asst. Res. Scientist
12		Navsari	NVS	Dr. P. D. Ghoghari, Assoc. Res. Scientist (Ento.)
13	Haryana	Kaul	KUL	Dr. Maha Singh Jaglan, Asst. Scientist (Ento.)
14	H.P	Malan	MLN	Dr. Ajai Srivastava, Principal Scientist
15	J & K	Chatha	CHT	Dr. Rajan Salalia, Jr. Scientist(Entomology)
16		Khudwani	KHD	Dr. Md. Ayub Mantoo, Scientist, (Entomology)
17	Karnataka	Mandya	MND	Dr. Kitturmath, Entomologist
18		Gangavathi	GNV	Dr. Sujay Hurali, Scientist (Entomology)
19		Brahmavar	BRM	-
20	Kerala	Moncompu	MNC	Dr. Jyoti Sara Jacob, Asst. Prof. (Entomology)
21		Pattambi	PTB	Dr. K. Karthikeyan, Prof. of Entomology
22	M.P	Rewa	REW	Dr. M. R. Dhingra, Sr. Scientist
23	Maharashtra	Karjat	KJT	Dr. Vinayak Jalgaonkar, Entomologist
24		Sakoli	SKL	Dr. B. N.Chaudhari, Jr. Entomologist
25	Manipur	Iroisemba*	IRS	Dr. K.I.Singh, Assoc. Professor (Entomology)
26		Wangbal	WBL	-
27	Odisha	Cuttack*	CTC	Dr. P. C. Rath, Principal Scientist (Entomology)
28		Chiplima$	CHP	Dr. Atanu Seni, Jr Entomologist
29	Punjab	Ludhiana	LDN	Dr. P. S. Sarao, Principal Scientist
30	Tamil Nadu	Aduthurai	ADT	Dr. P. Anandhi, Asst. Professor
31		Coimbatore	CBT	Dr. V. Balasubramani, Professor
32	Tripura	Arundhutinagar*	AND	Dr. Dhrubajyoti Pal, Entomologist.
33	Telangana State	Jagtial*	JGT	Dr. S. Omprakash, Scientist (Entomology)
34		Rajendranagar	RNR	Dr. N. Ramagopala Varma, Pr. Scientist (Ento.)
35		Warangal	WGL	Dr. S. Malathi, Pr. Scientist (Entomology)
36	Union Territory	Karaikal*	KRK	Dr. K. Kumar, Prof. & Head (Agril. Entomology)
37		Kurumbapet@	KBP	-
38	Uttaranchal	Pantnagar	PNT	Dr. S. N. Tiwari, Prof. of Entomology
39	Uttar Pradesh	Masodha#	MSD	Dr. S.K.S. Rajpoot, Entomologist
40		Ghaghraghat	GGT	- do -
41	West Bengal	Chinsurah	CHN	Dr. Bijoy Choudhary, Entomologist

* - Voluntary Centre.

Appendix II

State	Location	*Rabi* 2018-19		*Kharif* 2019	
		Sent	**Recd.**	**Sent**	**Recd.**
Funded co-operating centres					
Andhra Pradesh	Maruteru	5	5	13	10
Assam	Titabar	1	0	7	7
Bihar	Pusa	0	0	6	6
Chattisgarh	Jagdalpur	0	0	14	14
	Raipur	1	1	12	10
Gujarat	Navsari	0	0	8	7
	Nawagam	0	0	8	7
Haryana	Kaul	0	0	1	1
Himachal Pradesh	Malan	0	0	10	10
Jammu & Kashmir	Chatha	0	0	7	4
	Khudwani	0	0	5	5
Jharkhand	Ranchi	0	0	8	7
Karnataka	Brahmavar	0	0	0	0
	Gangavathi	4*	0*	11	10
	Mandya	0	0	10	10
Kerala	Moncompu	1	1	11	10
	Pattambi	6	6	12	11
Madhya Pradesh	Rewa	0	0	2	1
Maharashtra	Karjat	4	3	7	7
	Sakoli	0	0	11	10
Manipur	Wangbal	0	0	0	0
Odisha	Chiplima	1	1	10	10
Puducherry	Kurumbapet	0	0	0	0
Punjab	Ludhiana	0	0	13	13
Tamil Nadu	Aduthurai	0	0	7	6
	Coimbatore	1	1	13	10
Telangana State	Rajendranagar	4	3	12	11
	Warangal	0	0	11	11
Uttar Pradesh	Ghaghraghat	0	0	4	4
	Masodha	0	0	7	4
Uttaranchal	Pantnagar	0	0	11	9
West Bengal	Chinsurah	5	5	9	9
Total trials in funded centres		**28**	**26**	**260**	**234**
% Receipt of data for *kharif* & *rabi*		**92.9**		**90.0**	
Overall % Receipt of data		**90.0**			

* - Trials not conducted due to water scarcity.

Voluntary centres - *Kharif* 2019		**Sent**	**Recd.**
Andhra Pradesh	Bapatla	5	5
	Ragolu	8	6
	Nellore	7	0
Manipur	Iroisemba	0	0
New Delhi	New Delhi	4	4
Odisha	Cuttack	12	3
Puducherry	Karaikal	3	3
Telangana State	Jagtial	6	5
Tripura	Arundhutinagar	4	1
Total trials in Voluntary centres		**49**	**27**
% Receipt of data		**55.1**	

APPENDIX-III

List of Abbreviations						
a.i.	:	Active ingredient		LF	:	Leaf folder
ADL	:	Average damaged leaves		MB	:	Mirid bug
AT		After treatment		MLB	:	Mealy bug
Av.No./AN	:	Average number		N.n	:	*Nephotettix nigropictus*
AW	:	Army worm		N.v	:	*Nephotettix virescens*
BB	:	Blue beetle		N.vi	:	*Nezara viridula*
BCR	:	Benefit cost ratio		No./10h	:	Number per 10 hills
BPH	:	Brown planthopper		NP	:	Net profit
BT		Before treatment		NPT	:	Number of promising tests
Cocc.	:	Coccinellids		NT	:	Not tested
CPP	:	Cost of plant protection		PH	:	Planthoppers
CW	:	Case worm		PLD	:	Promising level of damage
DAT/DT	:	Days after transplanting		PM	:	Panicle Mite
DG	:	Damaged grain		PSB	:	Pink stem borer
DH	:	Dead hearts		RF	:	Rainfall
DHB	:	Dark Headed borer		RH	:	Relative humidity
DL	:	Damaged leaves		RT	:	Rice thrips
DP	:	Damaged plants		SBDH	:	Stem borer dead heart
DS	:	Damage score		SBWE	:	Stem borer white ear
FR	:	Field reaction		SW		Standard week
RGB	:	Rice Gundhi bug		SS	:	Silver shoots
GH	:	Greenhouse reaction		SSB	:	Striped Stem borer
GHC	:	Green horned caterpillar		SSH	:	Sunshine hours
GLH	:	Green leafhopper		WB	:	Water bug
GMB	:	Gall midge biotype		WBPH	:	White-backed planthopper
Gr. H	:	Grasshopper		WE	:	White ears
GSB	:	Green stink bug		WLH	:	White leafhopper
HB	:	Hopper burn		WM	:	Whorl maggot
HBP	:	Hopper burned plants		WSB	:	White Stem borer
IOC	:	Increase over control		YSB	:	Yellow stem borer
IPD	:	Infested Plants Dead		ZZLH	:	Zigzag leafhopper

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