

DIRECTOR'S REPORT

XXIV Biocontrol Workers
Group Meeting 2-3 June, 2015



ICAR - National Bureau of
Agricultural Insect Resources
Bangalore 560 024

**All India Co-ordinated Research Project on
Biological Control of Crop Pests**

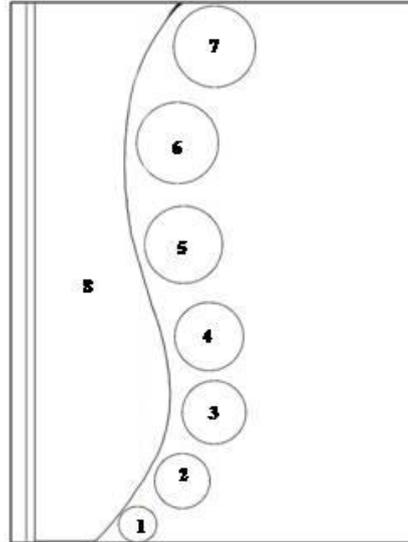
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Cover page

1. *Oligosita giraulti* Crawford (Hymenoptera: Trichogrammatidae)
2. *Anisopteromachus indicus* Gupta and Sureshan (Hymenoptera: Pteromalidae)
3. A species of *Kikiki* Huber & Beardsley (Hymenoptera: Mymaridae)
4. *Pseudococcus calceolariae* (Maskell) (Hemiptera: Pseudococcidae)
5. *Uroleucon compositae* (Theobald) (Hemiptera: Aphididae)
6. *Cardiastethus exiguus* Poppius (Hemiptera: Anthocoridae)
7. *Leucinodes orbonalis* (Guenee) (Lepidoptera: Crambidae)
8. Lab to land programs and Director's visit to different AICRP centers

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Abraham Verghese
Director, NBAIR

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DIRECTOR'S REPORT

1. Introduction

Environmental pollution, food and water contamination and insect resistance to pesticides have become major concerns post green revolution due to extensive use of agrochemicals. AICRP in Biological Control was initiated during the year 1977 to minimize the application of chemical pesticides and to develop eco-friendly biological control methods for the sustainable management of pests. As a result, several new approaches have been made and biocontrol technologies have been improved and field-tested for wider acceptance by the end users (farmers). Efficient methods of mass multiplication of parasitoids, predators and pathogens against insect pests and antagonists against plant pathogens and plant parasitic nematodes have been developed. Similarly, biocontrol technologies for weed management have been developed. The field demonstrations through AICRP centres have increased the awareness of farmers regarding the usefulness of biological control in IPM.

The work under the XII plan encompasses i. Survey and collection of natural enemies viz., insects, mites, spiders, EPN and pathogens, ii. Surveillance for possible entry of potential alien invasives like *Brontispa*, *Phenacoccus manihoti* the giant whitefly, *Frankliniella occidentalis* the western flower thrips etc. and classical biological control intervention, if needed, iii. Characterization/Identification of natural enemies. Promising natural enemies will be taken up for further studies on bionomics, behaviour, seasonal cycles and assessment of potentials, iv. Utilization of natural enemies: Pilot studies to assess their potential against insect pests & diseases in crops and in storage, v. Validation of established and potential natural enemies and area-wide demonstration and vi. Technologies for mass multiplication/product development of microbes.

Spectacular success was achieved during the past five years in the management of the papaya mealybug, sugarcane woolly aphid, eucalyptus gall was using predators and parasitoids. Diversity of natural enemies, nematodes, entomopathogens and plant disease antagonists have been given importance and collection and cataloguing have been carried out covering vast geographical areas. Large scale demonstrations in farmers' fields were made towards facilitating the adoption of non-chemical methods of plant protection by farmers.

2. Mandate of AICRP on Biological control of crop pests

- Promotion of biological control as a component of integrated pest and disease management in agricultural and horticultural crops for sustainable crop production
- Demonstration of usefulness of biocontrol in IPM in farmers' fields.

3. Objectives

- i. Development of effective biocontrol agents for use in biological suppression of crop pests and diseases.
- ii. Evaluation of various methods of biological control in multi-location field trials.
- iii. Development of biointensive integrated pest management strategies for cotton, rice, sugarcane, pulses, oilseeds, potato, coconut and a few selected fruits and vegetable crops.
- iv. Demonstration of biocontrol agents and biopesticides as a component of IPM in farmers' fields

4. Setup

With a view to fulfil the mandate effectively and efficiently, the Bureau is functioning in close coordination with the following State Agricultural Universities and ICAR Institutes.

State Agricultural University–based centers

1. Anand Agricultural University	Anand
2. Assam Agricultural University	Jorhat
3. Dr. Y.S. Parmar University of Horticulture and Forestry	Solan
4. Gobind Ballabh Pant University of Agriculture and Technology	Pantnagar
5. Kerala Agricultural University	Thrissur
6. Mahatma Phule Krishi Vidyapeeth	Pune
7. Pandit Jayashankar Telangana State Agricultural University	Hyderabad
8. Punjab Agricultural University	Ludhiana
9. Sher-e-Kashmir University of Agricultural Science & Technology	Srinagar
10. Tamil Nadu Agricultural University	Coimbatore
11. Central Agricultural University	Pasighat
12. Maharana Pratap University of Agriculture & Technology	Udaipur
13. Orissa University of Agriculture & Technology	Bhubaneswar
14. University of Agricultural science (Raichur)	Raichur

ICAR Institute–based centres

1. Central Institute of Subtropical Horticulture	Lucknow
2. Central Plantation Crops Research Institute	Kayangulam
3. Central Tobacco Research Institute	Rajahmundry
4. Directorate of Rice Research	Hyderabad
5. Directorate of Seed Research	Mau
6. Indian Institute of Millet Research	Hyderabad
7. Directorate of Soybean Research	Indore
8. Directorate of Weed Science Research	Jabalpur
9. Indian Agricultural Research Institute	New Delhi
10. Indian Institute of Horticultural Research	Bangalore
11. Indian Institute of Sugarcane Research	Lucknow
12. Indian Institute of Vegetable research	Varanasi
13. National Centre for Integrated Pest Management	New Delhi

The results from the various experiments conducted at centres across the country during the year 2014-15 are presented below.

5. Brief summary of research achievements

5.1. Basic research work at National Bureau of Agricultural Insect Resources

5.1.1. Biosystematic studies on agricultural insects

a. Taxonomic studies on parasites & predators of insect pests

Calvia explanata Poorani and *Micraspis pusillus* Poorani (Coleoptera: Coccinellidae) were described from northeastern India. *Platynaspis flavoguttata* (Gorham)(Coleoptera, Coccinellidae), a rare species from Karnataka, was redescribed and the male genitalia were illustrated for the first time. The genus *Kikiki*, the smallest genus of flying insects, was collected from Arunachal Pradesh and Tamil Nadu. *Dicopus longipes* (Subba Rao) was recorded from India for the first time. *Paraphaenodiscus monawari* (Encyrtidae) was recorded on *Pulvinaria polygonata*, a new host. Based on a recent publication on the parasitoids of erythrina gall wasp, the species commonly occurring in southern India was identified as *Aprostocetus* sp. (*causalis*-group).

b. Biodiversity of economically important Indian Microgastrinae (Braconidae)

Three thousand five hundred specimens of microgastrine wasps (Hymenoptera: Braconidae) were compiled across India. The caterpillar inventory recovered over two hundred morpho-species within 22 families of Lepidoptera yielded more than 90 morpho-species of microgastrine wasps distributed among 13 genera. The present study adds eight new host records and provides illustrations of 40 species of wasps (including types). The Indian species of *Deuterixys ruidus* (Wilkinson, 1928) is transferred to the genus *Cotesia*. *Microgaster carinicollis* Cameron is transferred to the genus *Microplitis*.

c. Biodiversity of oophagous parasitoids with special reference to Scelionidae (Hymenoptera)

Surveys were conducted for Platygastroidea in eight states and the genus *Apteroscelio* (Scelioninae) is reported for the first time from India. The genus *Embidobia* was initially reported in 1912 from Kumoan, Himalayas and now reported for the first time from S. India (Karnataka and Tamil Nadu). Forty five genera of Platygastriidae are reported from Arunachal Pradesh, from where till now only a single genus *Protelenomus* was reported. A new genus *Chakra*, with type species *Chakra sarvatra* was described from Andaman Islands. Twelve new species of Platygastroidea were described as new to science. Five new species of *Phanuromyia*, were described. Two new species of *Amitus* and two new species of *Synopeas* were also described.

d. Biosystematics of Trichogrammatidae (Hymenoptera)

Surveys for trichogrammatids were conducted in North-east and south India. Over 900 specimens were collected and slides prepared. Ten genera of Trichogrammatidae were added to the collections of the Bureau. Of these, *Prestwichia*, *Burksiella*, *Paracentrobia*, *Aphelinoidea* and *Tumidiclava* are new genera being recorded from the Andaman Islands. *Trichogramma flandersi*, *T. achaea*, *T. manii*, *Trichogrammatoidea cryptophlebiae* and *T. nana* were collected and recorded for the first time from the Andaman islands. *Oligosita*

giraulti, a South American species was collected for the first time from India which extends its range to South and Southeast Asia. *Mymaromma ignatii*, a new species of *Mymarommatoidea* was described the first time from India.

e. Biodiversity of aphids, coccids and their natural enemies

Seventeen species of aphids, a species of soft scale and mealybug each, were reported for the first time from Sikkim. Two species of aphids were recorded for the first time from India. Among natural enemies of aphids and coccids, twelve species of coccinellids and two species of braconids, one species each of Aphelinidae and Pteromalidae were recorded during the survey. Four new host associations of coccinellid predators were reported through this study. Records of *Oenopia mimica* (Weise) on *Taokia indica* (Ghosh and Raychaudhuri), *Calvia explanata* Poorani and *Calvia sykesii* Crotch and *Alloneda dodecaspilota* (Hope) on *Macrosiphoniella artemisiae* (Boyer de Fonscolombe) are new records of host associations.

5.1.2. Molecular Characterization and DNA barcoding of agriculturally important parasitoids and predators

Molecular characterization using cytochrome oxidase 1 gene (CO1) was done for the following parasitoids namely Encyrtid *Aenasius advena* (KJ850498), *Blepyrus insularis* (KJ850500), *Neastymachus axillaris* (KM095502); Aphelinid *Myiocnema comperei* (KJ955498); Eulophid *Diglyphus isaea* (KM016074); Braconid *Aphidius ervi* (KM054518), *Aphidius colemani* (KM054519) *Cotesia* sp (KM875666), *Glyptapanteles* sp (Bidar) (KM887912), *Glyptapanteles* sp (Valparai) (KM887913), *Apanteles phycodis* (KP055616), *Bracon greeni* (KP055617), *Micropilitis macullipennis* (KP759288); Vespid *Ropalidia* sp (KM054517); Scelionid *Macrotelia* sp (KM095503), *Idris* sp (KP271246); Ichneumonid *Pristomerus sulci* (KM875667); Chalcidid *Brachymeria tachardiae* (KP055618).

Molecular characterization of trichogrammatids belonging to 21 species was characterized using CO-1 and ITS-2 regions was done. Exotic biocontrol agents viz., *Aphidius ervi*, (KM054518), *Aphidius colemani* (KM054519), *Orius laevigatus* (KM016075), *Phytoseiulus persimilis* (KM035535), *Diglyphus isaea* (KM016074), *Amblyseius swirskii* (KM035534) and *Cryptolaemus montrouzieri* (KM0160730) were also characterized.

5.1.3. Diversity of Indian Anthocoridae

Orius minutus (Linnaeus 1958) collected from Pasighat; *Physopleurella pessonii* Carayon 1956 and *Rajburicoris stysi* Carpinetro and Dellapé from Palani hills are new records for India. Three new records of *Xylocoris* spp. were documented: *Xylocoris* (*Proxylocoris*) *afer* (Reuter 1884) which was collected from dry fruits of *Ficus* and *Lagerstromia*; *Xylocoris* (*Proxylocoris*) *confusus* Carayon, 1972 and *Xylocoris* (*Arrostelus*) *ampoli* Yamada and Yasunaga 2013 from maize ecosystem.

a. Evaluation of *Amphiareus constrictus* (Stål, 1860) against brown plant hopper infesting paddy

Anthocorid predator *Amphiareus constrictus* was evaluated against BPH in paddy. The pre-counts of number of adult and nymphal hoppers per tiller in control was 6.2 and 8.4, respectively, while the corresponding pre-count values in the treatment cages were 14.5 and

12.3, respectively. After five releases, the adult and nymphal counts in treatment cages were 1.8 and 1.4, respectively, while in control, the corresponding values were 6.3 and 3.3, respectively.

b. Infestation by *Aleurothrixus trachoides* (Back) on capsicum and natural predation

This species of whitefly was originally described as *Aleurotrachelus trachoides* Back (solanum whitefly). This is reported for the first time in India. This was primarily found to attack *Duranta* spp. in Bangalore. Highly significant correlation was recorded between the population of the predatory grubs and the populations of eggs+nymphs and pupae of *A. trachoides*.

5.1.4. Studies on the new invasive pest *Tuta absoluta* (Meyrick, 1917)

Tuta absoluta infestation was observed to be severe in Karnataka and Tamil Nadu and infestation was observed in all growth stages of tomato plant. The natural enemies, which could be recorded from the infested fields were *Nesidiocoris tenuis* Reuter, *Trichogramma achaeae* Nagaraja and Nagarkatti, *Neochrysocharis formosa* (Westwood), *Habrobracon* sp. and *Goniozuz* sp. Four species of *Trichogramma* were evaluated for their ability to parasitize *T. absoluta* eggs and maximum emergence was from eggs parasitized by *T. pretiosum* and *Tr. bactrae*.

5.1.5. Studies on parasitoids of litchi stink bug *Tessaratoma javanica* Thunberg

Eggs of Eri silkworm (ESW) stored in the deep freeze for 2 to 6 days are suitable for rearing *Anastatus acherontiae* Narayanan *et al.* and *A. bangaloriensis* Mani and Kurian. Percent parasitism values recorded was 41.4 to 63.3% in the case of the former and 39.3 to 55% parasitism in the case of the latter. ESW eggs parasitized by *A. acherontiae* were stored for 7, 15 and 21 days and the per cent adult emergence recorded were 85.7, 72.5 and 63.8, respectively.

5.1.6. Optimising mass rearing of *Trichogramma chilonis*

Large cages (3ftx 2ft) can be used for large scale production of Tricho cards. Thirty to forty cards can be exposed to adult Trichogrammatids (emerging from three mother cards) in large cages and parasitism ranging from 79 to 81% could be recorded.

5.1.7. Monitoring of invasive pests

a. Monitoring of papaya mealy bug and its natural enemies on papaya and other alternate hosts

Based on the survey conducted in different parts of the state and also the feedback from various AICRP (BC) centers revealed that the papaya mealybug, *Paracoccus marginatus* did not reach pest status in any of the commonly occurring crops like papaya, mulberry and butter fruit (Avocado). However, incidence of very low level (< 5%) was recorded on tapioca in Salem and Dharmapuri areas of Tamil Nadu.

b. Occurrence of papaya mealybug on Papaya, weeds and other host plants in Karnataka

Incidence of papaya mealybug was very low in six districts surveyed in Karnataka. Damages in the score of 1 (1- 5Scale) and below only were observed very sporadically in homesteads. In the homesteads, > 85 % parasitization by *Acerophagus papayae* and also by *Pseudleptomastix mexicana* was found in all the places where ever papaya mealybug was observed. *Spalgius apius* was also recorded as one of the major factors for reduction of the pest. Mealybug infestation on tapioca was found associated with *P. madeirrensis* and parasitization by *A. papayae* was very high (>82%). Several weeds which were previously found to harbor papaya mealybug, viz., *Parthenium*, *Sida acuta*, *Acalypha*, *Abutilon* and crotons were free from papaya mealybug.

c. Classical Biocontrol of papaya mealybug

- No severe incidence of papaya mealybug in Karnataka, Kerala, Andhra Pradesh, Maharashtra and Tamil Nadu.
- PMB was reported from New Delhi (in polyhouse) and Gujarat but not in severe form. *A. papayae* was supplied to these areas and very good parasitization was observed in the new localities.
- Very high incidence of hyper parasitoids *Chartocerus sp.* was recorded in Bangalore (up to 15% in one sample).

d. Erythrina gall wasp management

Erythrina gall wasp, *Quadrastichus erythrinae* was found in low populations in Kolar, Mandya and Ramnagar districts. *Aprostocetus gala* was found to be the major parasitoid of *Q. erythrinae* and 7-15% parasitization was observed in field. It was clearly established that *Aprostocetus gala* was always found associated with *Q. erythrinae* and is not a gall former on *Erythrina* plants but a very good parasitoid of *Q. erythrinae*.

e. Establishment of *Cecidochares connexa* gall fly

Chromolaena weed biocontrol agent *C. connexa* released at different places has established upto 15 galls per 5 minutes search in 450 m around the released spot. In Puttur (Karnataka), it has spread around 8 km from the released spot and in Tataguni estate it has sprad to the nearby forest area. Whereas in GKVK, Bangalore it has been localised because of the availability of host insects. *Ormyrus sp.* parasitization was recorded upto 7% in GKVK, Bangalore.

f. Host range of invasive Jack Beardsley mealybug (*Pseudococcus jackbeardsleyi* Gimpel and Miller) in Karnataka

Survey for invasive insects in South India revealed the occurrence of *P. jackbeardsleyi* in Tamil Nadu and Karnataka. It was found associated with papaya mealybug on papaya and with Madeira mealybug in hibiscus, *Cordyline terminalis* (Agavaceae), and *Defembekia sp.* Recently it was found to be severe on cocoa. This invasive mealybug is expanding slowly. Some of the local natural enemies like *Cryptolaemus montrouzieri* Mulsant, *Spalgius apius* West Wood and indeterminate species of gnats are keeping the spread

of this mealybug under check. *Nephus regularis* was found to be a major predator on eggs of *P. jackbeardsleyi*.

5.1.8. New invasives and host extensions

- *Tuta absoluta* recorded in Karnataka, Tamilnadu, Gujarat. Zoophytophagus plant bug *Nesidiocoris* sp. (Miridae) recorded associated with the pest.
- Western flower thrips *Frankliniella occidentalis* (Pergande) reported from Bangalore by ZSI.
- Banana skipper *Erionota thrax* (Hespiridae: lepidoptera) has become severe in Kerala, Karnataka, Mizoram, Assam and other states.
- Bruchid on seeds of *Hibiscus subdariffa* (to be identified)
- *Pseudococcus jackbeardsley* recorded on cocoa in Dakshina Kannada dist.
- *Phenacoccus madeirensis* recorded on cashew in Malur area in Karnataka
- Root mealybugs, *Formicococcus polysperes* Williams was observed on pepper

5.1.9. Biosystematics and diversity of entomogenous nematodes in India

Two hundred soil samples were collected from Andhra Pradesh Karnataka and Tamil Nadu from vegetable crops, banana and forest areas. Ecological parameters, soil type, habitat and GPS coordinates were recorded. Five insect associated nematodes were isolated from these places. An insect associated nematode, *Oscheius* sp. was isolated from Utthanapalli village of Tamil Nadu. Pathogenicity of *Oscheius* sp. on the pupae of *Bactrocera cucurbitae* showed 80% of pupal mortality at 48h after treatment with a dose of 200 IJs/pupa.

5.1.10. Mapping of the cry gene diversity in hot and humid regions of India

A total of 80 isolates of *Bacillus thuringiensis* were purified from soil and insect cadaver samples of Almora region. Forty of these isolates were screened for cry gene diversity using degenerate primers. All of them harboured *cry1* and *cry2* genes.

The *vip3a* gene was amplified using by PCR and the 2.3Kb product was sequenced and confirmed. PCR amplicon (~2.3Kb) was successfully cloned into a cloning vector (pUC29) at NdeI and XhoI restriction sites. Sub-Cloning of Sequence Confirmed *vip3a* gene in pET21a was confirmed by PCR amplification.

The VIP3A protein was purified from the *pET21a-Vip3a* clone by IPTG induction for 4 and 16h and the induced protein collected at 4h exhibited an LC₅₀ value of 1.9 µg/ml against *Plutella xylostella*. Induced protein collected at 16h exhibited an LC₅₀ value of 0.423 µg/ml. Bioassay of purified cloned *vip3A* protein was also studied against *Spodoptera litura*. Observations were recorded at 72h and 96h. At 72h the protein collected at 4h of induction with IPTG exhibited an LC₅₀ value of 12.35 µg/ml (Table 4) and at 96h the LC₅₀ value was calculated as 6.87 µg/ml (Table 5). The protein collected at 16h of induction incited an LC₅₀ value of 4.87 µg/ml at 72h and at 96h the LC₅₀ was 2.68 µg/ml.

Degenerate primers were designed for partial *cry1* gene (277 bp), *cry2* gene (689–701 bp), *cry3* gene (589-604bp), *cry4* gene (439 bp), *cry 5, 12, 14, 21* genes (474-489 bp), *cry 7-8* gene (420 bp), *cry9* genes (351-359 bp), *cry11* genes (305 bp), *vip3* genes (1000 bp), *cyt1* genes (522-525 bp) and *cyt2* genes (469 bp). Degenerate primers were also designed to detect

cry gene sub types like *cry1Aa*, *cry3Aa*, *cry4Aa*, *cry7Aa*, *cry8Aa*, *cry9Aa*, *cry2Aa*, *cry11Aa* and *cry14Aa*

5.1.11. Exploitation of *Beauveria bassiana* for management of stem borer (*Chilo partellus*) in maize and sorghum through endophytic establishment

a. Screening of *Beauveria bassiana* isolates against maize stem borer, *Chilo partellus* (Laboratory Bioassay)

Bioassay studies were conducted with 87 isolates of *B. Bassiana* against second instar larvae of *Chilo partellus*. Among the 87 isolates tested, five isolates (Bb-7, 14, 19, 23 and 45) showed significantly higher mortality (86.4.-100%). Among these five isolates significantly higher mycosis (84.4-97.8%) was shown by Bb-14, 23 & 45. Dose and time mortality studies indicated the lowest LC₅₀ (5.02×10^4 conidia ml⁻¹) and LT₅₀ (136.25 hr) values with Bb-45 isolate.

b. Establishment of *Beauveria bassiana* as endophyte in maize

Pot culture studies were conducted with six promising isolates of *B.bassiana* (Bb-5a, 7, 14, 19, 23 & 45) to test their ability to establish as endophytes in maize through seed treatment/ foliar spray on two susceptible varieties of maize viz., COH(M)10) and Bio9681. In foliar application, colonization of Bb-45 isolate was observed in the leaf tissues up to 60 DAT, whereas Bb-23 isolate colonized the leaf tissues up to 30DAT and Bb-14 isolate till 15 DAT of the maize variety-COH(M)10. In case of Bio-9681 maize variety, colonization of Bb-19 isolate was observed in stem & root tissues for a period of 30 days after treatment and in leaf tissues only for 15 DAT. Bb-14 isolate colonized leaf and stem tissues for a period of 30 days after treatment whereas Bb-23 & Bb-45 isolates could colonize leaf and stem tissues for 15 days. In untreated control plant tissues, no *B. bassiana* colonization was detected by plating and PCR at 15/30/45DAT. In a field trial with three isolates of *B. bassiana* (Bb-14, 23 & 45) foliar application (1×10^8 spores/ml)/ at 30 days of crop age showed that Bb-14 and Bb-45 colonized stem and leaf tissues for a period of 15days after treatment. In crown application method, Bb-23 and Bb-45 isolates colonized in leaf tissues for a period of 15days after treatment.

5.2. All India Coordinated Research Project on Biological Control of Crop Pests

5.2.1. Biodiversity of biocontrol agents from various agro ecological zones

AAU-A: The populations of the biocontrol agents, viz., *Trichogramma*, *Chrysoperla*, *Cryptolaemus*, spiders and entomopathogenic nematodes (EPNs) were collected from different crop ecosystems at Anand, Kheda, Baroda and Ahmedabad districts, during *Kharif* 2014. Among the predators, *Chrysoperla zastrowisillemi* (Esben-Peterson) was found in all the populations. Similarly the activity of coccinellids and *Cryptolaemus* was studied. No anthocorids were recorded during the period. About 23 spiders were collected from paddy ecosystem. Soil samples for EPNs collected from different regions showed no EPN infectivity. *Bt* isolates were obtained from 49 soil samples out of the 300 samples collected from six taluks of Ahmedabad districts.

AAU-J: *Cryptolaemus* sp. was collected from different crops like papaya, sugarcane and in *kharif* as well as *rabi* vegetables in Jorhat district. Coccinellids collected on different *rabi* vegetables infested by aphids and whiteflies were *Coccinella septempunctata*, *C. transversalis* and *Micraspis* sp. Twenty five types of spiders were collected from different habitats such as grasses, moist places, under stones, pebbles, dead leaves, humus, bushes, on the bark and branches of trees, houses and huts. The most dominant spiders collected from rice ecosystem were *Oxyopes* sp. *Tetragnatha* sp. *Lycosa pseudoannulata* and *Argiope catenulata*. No anthocorid predators could be detected from thrips and mite infested crops (chilli, okra, brinjal, tomato and French-bean). An anthocorid predator collected on papaya mealybug was sent to NBAIR.

KAU: Earwigs were collected from the areas of banana pseudostem infested areas and were identified as *Auchenomus hincksi* Ramamurthi (Dermaptera: Labiidae) and were found feeding on eggs of this pest. Earwigs, *Paralabis dohrni* (Kisby) (Dermaptera: Labiidae), *Charhospania nigriceps* (Kisby) and *Euborellia shabi* Dohrn were collected as predators of banana rhizome weevil. These were found predated on the eggs and early instar grubs of the rhizome weevil. Coccinellids predators like, *Pseudaspidimerus trinotatus* (Thunberg), *Scymnus pyrocheilus* (Mulsant), *Jaurovia soror* Weise, *Scymnus* sp. *Cheilomenes sexmaculata* (Fab.) and *Sticholitis* sp were recorded on banana aphid *Pentalonia nigronervosa* Coq. No natural enemies on root mealybugs of pepper were noticed. *Beauveria bassiana* has been isolated from the rice bug.

MPKV: In Maharashtra the natural enemies recorded were coccinellids, *Coccinella septempunctata* L. *Menochilus sexmaculata* (F.), *Scymnus coccivora* Ayyar, *Encarsia flavoscutellum*, *Dipha aphidivora* Meyrick, *Micromus igorotus* Bank., syrphids on Sugarcane woolly aphid, *Coccinella transversalis* F., *M. sexmaculata*, *Brumoides suturalis* (F.), *Triomata coccidivora* and *B. suturalis* on mealy bug of custard apple, *Acerophagus papayae* N. and S. and *Pseudleptomastix mexicana* N. and S. and *Mallada boninensis* Okam. and *Spalgis epius* on papaya mealy bug. The predator of lac insect, *Berginus maindron*, *Cybocephalus nipponicus* on scales, *Hyperaspis maindroni* Sicard on *M. hirsutus* on hibiscus, *Tetrastychus* sp., the parasitoid of sugarcane borer are collected from Pune region of Maharashtra. The chrysopid, *Chrysoperla zastrowi sillemi* Esb. was recorded in cotton, maize, pigeon pea, french bean, rabi jawar and brinjal while *Mallada boninensis* Okam on cotton, sunflower, french beans, mango and papaya. The *Cryptolaemus* adults were recovered from the pre-released plots of custard apple and papaya.

PAU: Among the lepidopteran insect pests of rice, the population of leaf folders varied from 0.0 to 3.1 larvae per plant. The incidence of damaged leaves due to leaf folder ranged from 0.0 to 5.6 per cent throughout the cropping season. The overall incidence of stem borers in terms of dead hearts remained low throughout the cropping season and it ranged from 0.00 to 2.16 per cent. The incidence of white ears was 2.39 per cent which was recorded at maturity. There was no incidence of plant hoppers during the season. Among the predators, dragonflies, damselflies, coccinellids and spiders were recorded. The population of dragonflies, damselflies and coccinellids varied from 0.0 to 0.1, 0.0 to 1.6 and 0.0 to 0.1 per plant, respectively. The population of spiders was quite high (0.1 to 2.0 spiders/plant) during the season with maximum population (2.0 spiders/plant) during 38th SMW (3rd week of September). Ten species of parasitoids were found associated with stem borer and leaf folder. Three species of egg parasitoids, namely, *T. chilonis*, *T. japonicum* and *Telenomus* sp were recorded from stem borer only. *Stenobracon nicevillei* was recorded from stem borer larvae and *Cotesia* sp was recorded from leaf folder larvae, while *Bracon* sp (larval parasitoid) was associated with both stem borer and leaf folder. Among the pupal parasitoids, *Brachymeria* sp, *Tetrastichus* sp and *Xanthopimpla* sp were recorded from the pupae of stem borer whereas *Brachymeria* sp. and *Tetrastichus* sp were recorded from leaf folder.

PJSTAU: Collection of *Trichogramma* from rice, sunflower, maize, castor, cabbage and chilli crops by using sentinel cards showed that the natural parasitization varied among individual crop ecosystems. Maximum parasitization of 7.9% was recorded on castor, followed by rice with 6.05 per cent, maize with 2.6 per cent and cabbage with 0.9%. It is also inferred that the parasitization is found to be marginally more in *Kharif* as compared to *Rabi*. Similar trend was noticed in the abundance of *Chrysoperla*.

YSPUHF: *Chrysoperla zastrowi sillemi* was collected on *Microsiphum rosaeformis*, *Trialeurodes vaporariorum* and *Eriosoma lanigerum* infested on rose, apple and cucumber at vegetative and fruit bearing stages from Solan Nerwa, Kotkhai, Kullu and Rekongpeo. Predatory coccinellid and staphylinid beetles feeding on nymphs and adults of aphids, mites and Sanjose scale of apple were collected during the period. The predators, *Hippodamia varigata*, *Coccinella septempunctata*, *Cheilomenes sexmaculata*, *Coccinella luteopicta*, *Priscibrumus uropygialis*, *Pharoscymnus*, *Propylea lutiopustulata*, *Oenopiakirbyi*, *O. sauzeti*, *O. sexareata*, *Coelophora bissetata*, *Chilocorus infernalis*, *Scymnus posticalis*, *Stethorus aptus* and *Oligota* sp. were collected from radish, apple, cabbage, cauliflower, mustard, cucurbits, capsicum, tomato, okra, brinjal, carnation, Unimus, chrysanthemum, stone fruits, ashwagandha and weeds, from Kalpa, Sangla valley, Kullu valley, Nerwa and Solan. Syrphid flies, *Episyrphus balteatus*, *Metasyrphus confrator*, *M. corolae*, *Eupeodes frequens*, *Melanostoma univittatum*, *Betasyrphus serarius*, *Sphaerophoria indiana*, *Ischiodon scutellaris* and *Scaeva pyrastris* were collected from Solan, Nerwa, Kullu and Rekongpeo on different flowering plants.

SKUAST: Surveys on different horticultural crops including apple, apricot, plum, pear, peach, cherry, walnut and almonds were conducted in Kashmir valley as well as Kargil. Among important natural enemies, aphelinid parasitoids, *Encarsia perniciosi*, *Aphytis proclia*, *Ablerus* sp. and coccinellid predator, *Chilocorus infernalis* were found on San Jose scale exclusively in unmanaged orchards. *Aphelinus mali* was found actively associated with woolly aphids of apple, *Eriosoma lanigerum*. Unidentified predatory mites were found with spider mites on apple during July and coccinellid beetles *Harmonia* sp. on pear Psylla.

CISH: An isolate of entomopathogenic nematode, *Heterorhabditis* sp. has been recovered from a mango orchard in Sitapur district, Uttar Pradesh and it has been designated as *Heterorhabditis* sp.

DRR: Survey was made in different rice fields of Pattambi, Kerala to record the pests and natural enemies. A total of 117 species belonging to 8 orders, 63 families of insects and spiders were collected and identified, of which 45 were pest species, 44 predators, 24 parasitoids and 4 in neutral or saprophagous group. Three species of egg parasitoids were observed on eggs of *S. incertulus* and *S. fuscifluaviz.*, *Tetrastichus schoenobii*, *Trichogramma japonicum* and *Telenomus* spp. The yellow hairy caterpillar *Psalis pennatula* was found in large numbers and 10 per cent larvae were parasitized by *Brachymeria* sp. In West Bengal the skipper *Parnara guttata* was prevalent with 75 per cent parasitisation by *Apanteles* sp. At DRR research farm, fortnightly collection by sweep nets yielded 140 species of natural enemies of which 75 were predators and 65 parasitoids.

5.2.1a. Surveillance for alien invasive pests

No alien invasive insect pests like *Brontispa longissimi*, *Aleurodicus dugesii*, *Phenacoccus manihoti* and *Phenacoccus madeirensis* were observed in any of the centres. Mealybugs recorded on papaya in Tamil Nadu were *Paracococcus marginatus* and *Pseudococcus jackbeardsleyi*. In Maharashtra, *Pseudococcus jackbeardsleyi* was recorded on custard apple in Pune and *P. marginatus* was observed in the papaya orchards of western Maharashtra along with the encyrtid parasitoid *A. papayae* and *P. mexicana*. A new parasitoid *Aprostocetes* nr. *purpureus* reported for the first time from PMB colonies in Rahuri region of Maharashtra.

5.2.2. Biological suppression of plant diseases in field

a. Biological control of diseases of rice, wheat and chickpea

GBPUAT: In rice among 21 *Trichoderma* isolates tested, TCMS 43, TCMS 9, TCMS 36 and Th-14 were found effective in improving plant health, reducing sheath blight and brown spot diseases and in increasing yield. In wheat, TCMS 16 and TCMS 65 in combination with chitosan (500ppm) and cow urine (10%) reduced yellow and brown rust. In chickpea Th-75, Th-3 and TRPCh-4 were found very promising in reducing seed as well plant mortality in the field.

b. Management of bacterial wilt of brinjal with *Pseudomonas fluorescens* (CHPf-1)

CAU: In the susceptible variety Anamika (brinjal), the lowest incidence of bacterial wilt of 16% was recorded in the plot treated with seedling root dip + soil drenching with CHPf-1 and it was on par with soil drenching with CHPf-1 (20% wilted plants). Soil drenching with CHPf-1 was comparable with soil drenching with streptomycin (19.66% wilted plants). The highest average plant height (68.00cm), highest average number of fruits per plant (9.20 fruits) and average fruit weight (113.46g/fruit) was recorded in seedling root dip + soil drenching with CHPf-1. The highest yield was recorded in the treatment with seedling root dip + soil drenching with CHPf-1 (242.60q/ha) and it was comparable with soil drenching with CHPf-1 (221.80q/ha).

c. Biological control of chilli anthracnose diseases

AAU-Anand: Minimum disease intensity (10.27 %) was observed in fungicidal treatment (Carbendazim 50% WP @ 0.05%) with 85.72 per cent disease control. The next best treatment was *Pichia guilliermondii* (Y12) seed treatment, seedling dip and foliar spray (2×10^8 cfu ml⁻¹) with 72.78% disease control. Significantly higher green chilli fruit yield was recorded with recommended fungicide (105 q/ha) as compared to untreated check (70.0 q/ha). The other best treatment with respect of yield was *P. guilliermondii* (Y12) with an yield of 95.00 q/ha.

PAU: Lowest per cent fruit rot of 6.78% was recorded in chemical control and was at par with *Trichoderma harzanium* treatment with 9.3% fruit rot as against 19.87% of fruit rot in untreated control. Highest yield of 72.25 q/acre was recorded in chemical treatment followed by *T. harzanium* treatment with an yield of 71.5 q/acre as against the yield of 67.45 q/acre in untreated control.

GBPUAT: Seedling growth was very good in *Pichia guilliermondii* (Y-12) and *Hanseniaspora uvarum* (Y73) as compared to other treatments in the nursery,

5.2.3. Biological suppression of sugarcane pests

a. Monitoring of sugarcane woolly aphid and its natural enemies

MPKV: Monitoring of sugarcane woolly aphid (SWA) incidence and impact assessment of natural enemies on its biosuppression was carried out in Maharashtra. The average pest incidence and intensity were 1.27 per cent and 1.35, respectively. The natural enemies recorded in the SWA infested fields were mainly predators like *Dipha aphidivora* (0.8-2.7 larvae/leaf), *Micromus igorotus* (1.1-5.8 grubs/leaf), syrphid, *Eupeodes confrator* (0.4-0.8 larvae/leaf) and spider (0.1-0.3 /leaf) during July to March, 2015. The parasitoid, *Encarsia flavoscutellum* was distributed and established well in sugarcane fields and suppressed the SWA incidence in Solapur, Pune and Satara districts.

TNAU: The SWA was noted in patches in Tamil Nadu and the occurrence of *D. aphidivora*. *M. igorotus* and *E. flavoscutellum* were also observed along with the population of SWA. In general, incidence of SWA was noted from November 2014 (0.0 -10.2 SWA/2.5sq.cm). The population escalated from January 2015 and the maximum population ranged up to 14.2 SWA/2.5 sq.cm leaf area during February 2015 in Tiruppur district followed by Erode district (12.6 SWA /2-5 sq. cm).

PJTSAU: In Andhra Pradesh, sporadic incidence was noticed in Chittoor and adjoining areas of southern Andhra Pradesh.

5.2.4. Cotton

a. Bioefficacy of microbial insecticides against sucking pests in *Bt* cotton

AAU-A: Significantly minimum number of jassids (1.24 /leaf), whiteflies (1.04 /leaf), aphids (2.49 /leaf) and thrips (0.71 /leaf) were registered in insecticide treated plots. However *Beauveria bassiana* or *Lecanicillium lecanii* @ 40 g/ 10 liter also proved better by recording

lower number of the pests. Similarly, the highest seed cotton yield was noted in plot treated with chemical insecticide and it was at par with *B. bassiana* or *L. lecanii* treated plots.

b. Monitoring of mealybugs and other sucking pests in *Bt* cotton

MPKV: The recording of mealybug incidence was carried out in cotton from 1st fortnight of August 2014 till January, 2015 in the experimental plot. However, the mealybug was not observed on cotton till January, 2015. The natural enemies generally present in cotton ecosystem were predatory coccinellids, *Coccinella*, *Menochilus* and *Scymnus*, chrysalides, *Brumoides* and spiders. Very less infestation of mealybug was noticed in the months of November, December, 2014 in the farmers fields during November-December 2014. The parasitism of *A. bambawalei* was found on cotton, parthenium, marigold and *Hibiscus*. The cotton mealybug on *Hibiscus* was effectively controlled by *A. bambawalei*.

PAU: Regular surveys of mealy bugs and its natural enemies from different hosts during June to September 2014 revealed only one mealybug species, *Phenacoccus solenopsis* on cotton. There was no major outbreak of pests on cotton. However, coccinellid predators such as *C. sexmaculata*, *C. septempunctata* and *B. suturalis* and green lace wing, *Chrysoperla zastrowi sillemi* were noticed at the rate of 0.2 to 3.4 predators per plant. The parasitization by parasitoids under field conditions varied from 42-73 per cent, out of which endoparasitoid *Aenasius bambawalei* (75.7%) was predominant. The per cent emergence of *Aenasius* females (61.7 %) was more as compared to males (38.3 %) and ratio of male to female was 1: 1.61. Among sucking insect pests, leafhopper, *Amrasca biguttula biguttula* and whitefly *Bemisia tabaci* were key pests on *Bt* cotton hybrid (Ankur 3028 BG II) and remained active through the cropping season in Ludhiana. The population of leafhopper, whitefly, thrips and aphid varied from 0.0 to 9.2, 0.2 to 55.6, 0.0 to 33.0 and 0.0 to 0.4 per three leaves, respectively. Among predators population of coccinellids, *Chrysoperla* and spiders varied from 0.0 to 9.5, 0.0 to 2.5 and 0.0 to 4.0 per 10 plants, respectively. The seasonal incidence of sucking pests was also recorded at the PAU Regional Station, Bathinda on *Bt* cotton hybrid (RCH 134 Bt). The population of leaf hopper, whitefly and thrips varied from 0.00 to 14.8, 0.00 to 98.0 and 0.0 to 15.2 per 3 leaves, respectively. The population of coccinellids, *Chrysoperla* and spiders varied from 0.0 to 2.0, 0.0 to 0.5 and 0.0 to 2.5 per 10 plants, respectively.

PJTSAU: Largely, three genera of mealy bugs, viz., cotton mealy bug, papaya mealy bug and grape mealy bug were noticed in *Bt* cotton. Among them, cotton mealy bug, *Phenacoccus solenopsis* was found to be predominant with nearly 85.33 per cent incidence.

TNAU: Survey conducted in Coimbatore, Erode and Tiruppur districts of Tamil Nadu on cotton host plants indicated the incidence of five species of mealybugs and *Paracoccus* was predominant.

UAS-R: To monitor the activity of cotton mealybug, cotton hybrid, RCH-668 BG-II was grown in an area of 500 sqmt under unprotected situation. The results indicated that the activity of mealybug appeared during second fortnight of August and continued till the harvest of the crop. The peak activity was noticed during January with average population of 191.69 crawlers per 10 cm shoot length. The peak activity of coccinellids (0.31/plant) was noticed during December while the spiders and chrysoperla activity was high during September. The predominant parasitoid associated with mealybug was *Aenasius bambawalei*

(12.30%) followed by *Anagyrus dactylopii* (3.01%), *Promuscidea unfasciiventris* (2.66%), *Hamalotylus eytelweinii* (2.43%) and *Prochiloneurus pulchellus* (1.68%).

5.2.5. Rice

a. Seasonal abundance of predatory spiders in rice ecosystem

PAU: Regular surveys were conducted to collect spiders from rice growing areas (Ludhiana, Patiala, Bathinda, Fatehgarh Sahib) of Punjab. The population of spiders was quite high (0.1 to 2.0 spiders/plant) during the season with maximum population (2.0 spiders/plant) during 38th SMW (3rd week of September). Eight species in the areas of Ludhiana and six species of spiders in the areas of Nabha were noticed.

5.2.6. Sorghum

IIMR: The application of *Metarhizium anisopliae* (NBAIR-Ma 36 & Ma 35) formulations caused significantly low dead hearts (9.1, 9.3 %), low stem tunnelling (3.5 and 3.3 %); less exit holes/ stalk (1.5, 1.4 nos/ stalk) and realized significantly higher grain yield (5.54 and 5.48 kg/ plot) over the control. However, application of Carbofuran 3G was the superior treatments in terms of damage reduction and yield increase.

5.2.7. Pulses

a Evaluation of *Bt* formulations against pulse borer (*Helicoverpa armigera*) and legume pod borer (*Maruca testulalis*)

MPKV: Pooled analysis of three years data revealed that three sprays of chlorpyrifos 0.05% at fortnightly interval was significantly superior over other treatments in suppressing the larval population of *H. armigera* (av. 0.8 larvae/plant) and *M. vitrata* (av. 2.1 larvae/25 inflorescence) on pigeon pea and recorded minimum pod damage (9.0%) and seed damage (6.4 %) with an yield of 16.4 q/ha. It was however, at par with the *Bt* strain NBAII-BTG4 @ 2% in respect of pod damage (9.8%) and yield (15.0 q/ha). The *Bt* strain NBAII-BTG4 @ 2% ranked next best to the insecticidal spray in recording surviving larval population of *H. armigera* (av. 1.9 larvae/plant) and *M. vitrata* (4.6 larvae/25 inflorescence).

UAS-R: Three years of experimentation on efficacy of *Bt* formulations showed that NBAII BTG 4 *Bt* @2g/lit was effective in reducing pod borer population with higher grain yield in pigeon pea ecosystem. Large scale demonstration of NBAII BTG 4 *Bt* was done in a Kallur of Raichur taluka over an area of 5 ha. Minimum per cent pod damage of 9.46 was observed in farmers practice which was statistically superior compared to NBAII BTG 4 *Bt* (13.46%). Similarly lowest grain damage (1.44%) was noticed in farmers practice compared to NBAII BTG 4 *Bt* (2.19%). Higher grain yield of 14.98 q/ha was noticed in farmers practice compared to NBAII BTG 4 *Bt* which recorded 12.14q/ha grain yield.

PJSTAU: Evaluation against pulse pod borers showed that NBAII-BTG 4 (2%) maintained its supremacy in *Helicoverpa* management by recording the least no. of larvae (0.4 to 0.9/plant) followed by *Beauveria bassiana* (0.8 to 1.1/plant /plant) and are comparable with insecticidal check (0.4 to 1.3/plant). Least pod damage was also noticed in NBAII-BTG4 (2%)

followed by *B. bassiana* confirming their supremacy in *Helicoverpa* management in pigeon pea

PAU: PDBC-BT1 (2%) and Delfin (1 or 2 kh/ha) treatments gave the lowest pod damage in moong bean and at par with each other, followed by chlorpyrifos 20 EC @ 1.5 l/acre.

5.2.8. Oil seeds

a. Biological suppression of safflower aphid

MPKV: Pooled analysis of three years data revealed that three sprays of dimethoate @ 0.05 % at fortnightly interval found significantly superior over other treatments in suppressing the aphid population (4.54 aphids/5 cm apical twig) on non-spiny variety of safflower and increased the yield (11.21 q/ha). However, similar sprays of *M. anisopliae* @ 10^{13} conidia/ha given at fortnightly interval was found to be the next best treatment in reducing the aphid population (7.45 aphids/5 cm apical twig and 10.79 q/ha).

PJSTAU: Among the botanicals and biopesticides tested, *Lecanicillium lecanii* recorded significantly lesser populations of aphids (4.89 aphids) followed by neem oil (7.01) on top five cm of shoot of five randomly selected plants per plot.

b. Management of white grubs in groundnut

NCIPM: Thirteen different IPM treatments were carried out in groundnut field for the management of white grub (*Holotrichia consanguinea*) in one acre area of the sandy loam soil at village Phogat, Bhiwani, Haryana. Lowest root grub infestation (18%) was recorded in FYM+ *M. anisopliae* 500 ml/50 kg as against 35% infestation in untreated control. Higher yield of (22.90 kg/100 sqm) was found in the treatment with *Rhizobium* + FYM+ *M. anisopliae* 500 ml/50 kg.

c. Evaluation of entomopathogens and botanicals against soybean pest complex

MPKV: Pooled analysis of three years data revealed that three sprays of *SINPV* @ 250 LE/ha (1.5×10^{12} POBs/ ha) was significantly superior in suppressing the larval population of *S. litura* (2.0 larvae/m row) with 77.5 per cent mortality due to virus infection and gave maximum of 22 q/ha yield of soybean. It was, however, at par with *N. rileyi* strains of MPKV as well as NBAIR. The MPKV strain of *N. rileyi* showed 2.5 surviving larval population of *S. litura* per m row with 63.8 per cent mortality and 19.9 q/ha yield.

d. Validation of IPM module in soybean

MPUAT: Soil application of *Metarhizium anisopliae* and two sprays of NSKE 5% were found significantly effective in controlling major pests of soybean (green semi looper and sucking pests) and produced higher grain yield of 16.05 q/ha against 8.75 q/ha in the farmers practice.

e. Biological suppression of mustard aphid, *Lipaphis erysimi*

MPKV: Three sprays of dimethoate @ 0.5 % at fortnightly interval found significantly superior over rest of the treatments in suppressing the mustard aphid population (4.4 aphids/5

cm apical twig) and increased the yield (7.4 q/ha). However, it was at par with combination treatment of *L. lecanii* @ 10^8 conidia/ml + *M. anisopliae* @ 10^8 conidia/ml in reducing the mustard aphid population (6.0 aphids/5 cm apical twig) and increase in seed yield of mustard (7.2 q/ha).

5.2.9. Coconut

a. Demonstration on Integrated management of *Opisina arenosella* in Kerala and Karnataka

CPCRI: An outbreak of *O arenosella* was noticed in Trivandrum during April 2014. Monthly releases of larval parasitoids viz., *Goniozus nephantidis* and *Bracon brevicornis* were undertaken and the plot was monitored. 49.3% reduction of the pest population was noticed. Demonstration of IPM of *O arenosella* initiated in December 2013 at Jajuru village, Arasikere (Tq.), Hassan (Dist.) in Karnataka was monitored during 2014-15 and stage specific parasitoids viz., *Goniozus nephantidis* and *Bracon brevicornis* @ 20 parasitoids/palm were released subsequently. Significant recovery of the palms was noticed in the demonstration plot. There was no fresh feeding damage by the pest and this forms a model plot for nearby farmers to emulate the IPM strategies in the management of *O. arenosella*

5.2.10. Tropical Fruits

a. Field evaluation of *Metarhizium anisopliae* formulations against mango hoppers *Idioscopus niveosparsus*

KAU: Field evaluation of *Metarhizium anisopliae* formulations against mango hoppers *Idioscopus niveosparsus* showed significant reduction in hopper population in Imidacloprid and Nimbecidine treated plots (94.4 & 91.1% reduction) and were on par. Oil and talc formulations of *M. anisopliae* showed 57.4 & 47.4% reduction of hopper population.

MPKV: The pooled data of three years indicated that the spraying of *M. anisopliae* @ 1×10^9 spores/ml during offseason in the month of December followed by four sprays of the entomofungal pathogen mixed with adjuvant (sunflower oil 1 ml/lit + Triton- X 100 @ 0.1 ml/lit) at weekly interval during flowering found significantly superior over other treatments in suppressing the hopper population and increased fruit setting. The mean surviving population was recorded as 11.0 hoppers and 11.8 fruit sets per inflorescence in this treatment as against 54.4 hoppers and 6.0 fruits set per inflorescence in untreated control.

TNAU: Maximum fruit set of 2.7 / inflorescence was recorded in liquid formulation of *M. anisopliae* treatment whereas the least fruit set of 1.1 / inflorescence was noted in untreated check. Though superior performance of imidacloprid in checking the hopper population was noted, the fruit set (2.5 /inflorescence) was comparable with *M. anisopliae* liquid formulation. The *M. anisopliae* spray recorded a fruit set ranging from 2.1 to 2.7 fruits / inflorescence. The order of efficacy among the different formulations of *M. anisopliae* in checking the hopper population was liquid formulations > talc formulation > oil formulation.

b. Field evaluation of entomopathogenic fungi against banana pseudo stem borer *Odoiporus longicollis*

KAU: Leaf axil filling of *M. anisopliae* (10^8 spores/ml) was next best treatment to the chemical control with 12.5% pest incidence as against 65.5% pest incidence in untreated control plot.

c. Field evaluation of entomopathogenic fungi against pineapple mealybug, *Dysmicoccus brevipes*

KAU: Spraying of *Lecanicillium lecanii* ($10^7 \cdot 10^8$ and 10^9 spores/ml) gave 65.7-76.03% reduction of pineapple mealbug population and was found to be the next best treatment to the chemical control of imidacloprid (0.3/l).

d. Bioefficacy of EPNs against citrus trunk borer, *Pseudonemophas versteegi*

CAU: Bio-efficacy of EPNs against citrus trunk borer, *Pseudonemophas versteegi* were carried out at two locations viz. Pasighat and Rengging of Arunachal Pradesh. In both the locations, all the treatments recorded a significant reduction in the trunk borer infestation than the untreated control. Among the EPN treatments, CAU-1 stem injection (40.5 % reduction) was observed as the best treatment and it was closely followed by CAUH-1 stem injection (36.50% reduction). However, at Rengging, CAUH-1 stem injection gave the highest reduction in trunk borer infestation (36.64%) and it was closely followed by CAU-1 stem injection (36.0% reduction). The stem injections of the EPNs were found more effective than their respective cadaver treatments.

NBAIR: At Kolazib, Mizoram, a demonstration of organic sealer cum healer for the management of citrus borer was done and found to be effective against the pest.

5.2.11. Temperate Fruits

a. Evaluations of entomopathogenic fungi and EPNs for the suppression of apple root borer, *Dorystenes hugelii*

YSPUHF: Among different biopesticides tested, *Metarhizium anisopliae* (10^6 conidia/cm²) was the most effective with 77.1% mortality of grubs and was on par with chlorpyrifos, 0.06% which resulted in 82.9 per cent mortality of the grubs

5.2.12. Vegetables

a. Field demonstration of BIPM package for the management of key pests of tomato

TNAU: Experimental plot of BIPM, farmers practice and control showed the presence of sucking pests like thrips, whiteflies and *Helicoverpa armigera*. The population of sucking pests like thrips (2-4 per plant) and whiteflies (1-3 per plant) were low in BIPM plots as compared to farmer's practice which had a thrips population of 7-11 per plant and whitefly population of 4-6 per plant. The BIPM package was able to contain the sucking pests population up to 60 DAT better than the farmer's practice plots. The fruit damage of *H. armigera* was higher in plots of farmer's practice (10-13%) as compared to 4-6 per cent in BIPM plots. Untreated plots recorded maximum pest populations. The occurrence of

predators like green lace wings and coccinellids were higher in plots which received the BIPM package and lower in plots of farmer's practice. The total fruit yield was 32.6 t/ha in BIPM as against 28.3 t/ha in farmer's practice. The untreated plot showed a fruit yield of 25.6 t/ha. The cost benefit ratio in BIPM plot was 1:3 whereas farmer's practice with insecticide sprays showed 1:2.6. This has clearly indicated that the BIPM module was able to contain the pests to below injury level with minimal damage to natural enemies realising higher yield.

b. Validation of *Ha* NPV in tomato against *H. armigera* at farmers field

MPUAT: IPM module comprised of five weekly releases of *T. Chilonis* @ 1 lakh/ha followed with 2 sprays of *Ha* NPV, first at the occurrence of pest and second spray after 15 days of first spray. Farmer practices included three applications of insecticides. Result indicated that the fruit damage was significantly low in IPM modules (12.5%) as against 18.2% fruit damage observed in Farmer practices. The yield observed in IPM module was higher (240 q/ha) than the yield recorded in Farmer practices (225 q/ha).

c. Validation of different BIPM modules against shoot and fruit borer, *Leucinodes orbonalis* in brinjal

MPKV: Three sprays of profenophos 0.05% at fortnightly interval was effective with the least shoot damage (9.1%) and fruit damage (9.4%) and gave maximum yield (228.6 q/ha). However, the BIPM module consisting release of *T. chilonis* @ 50,000 parasitoids/ha followed by spraying of NSKE 5% and *B. thuringiensis* @ 1 lit./ha twice at weekly interval was the next best treatment showing 10.6% shoot and 15.3% fruit infestation with 42.5% parasitism of *T. chilonis* and gave 217.8 q/ha yield.

d. Biological control of brinjal mealybug *Coccidohystrix insolitus*

TNAU: The insecticide treated plot showed minimum number of mealybug per plant (1.4) after 15 days of first spray and 1.8 mealybugs per plant after 15 days of second spray with an yield of 70 t/ha. The next best treatment was release of *Cryptolaemus* @ 1500/ha with a population of mealybugs of 32.4/plant after 15 days of 1st release and 5.3/plant after 15 days of second release with an yield of 67.8t/ha. Highest number of predators were found in the treatment with *Cryptolaemus* @ 1500/ha (5.3 and 8.6/10 plants after 1st and 2nd release respectively).

e. Field evaluation of biocontrol based IPM module against pests of cauliflower/ (*Plutella xylostella*, *Spodoptera litura*, *Pieris brassicae*)

PAU: The chemical control treated plots and BIPM module showed minimum number of *Pieris* larvae / plant (4.27 & 3.32 respectively) and aphids/plant (11.08 & 8.82 respectively) and were on par with each other. The untreated control plot showed higher *Pieris* larvae / plant (37.27) and aphids/plant (15.13). The BIPM module showed maximum population of natural enemies per plant (4.41 coccinellids + 2.5 syrphid larva + 2 cocoon cluster of *Cotesia glomeratus*), where as insecticidal treated plot did not show any population of natural enemies. The highest marketable yields were obtained in chemical treated plots and BIPM module plots (47.32 and 43.12 q/acre) as against 29.56 q/acre recoded in the untreated plots.

f. Efficacy of *Bt* strains against diamond back moth in cauliflower

TNAU: NBAII BTG4 and PDBC BT1 *Bt* strains @ 2% spray were effective in reducing the larval population up to 59 per cent over control after 1st round of spray. But, these *Bt* strains were found less effective as compared to insecticides which had 79 per cent reduction of larval population over control. After three rounds of spraying, the *Bt* strains were able to reduce the larval population of DBM up to 84 per cent (NBAII BTG 4 @ 2%) as compared to 90 per cent reduction of larval population in insecticide treated plot. Both *Bt* strains were on par in their efficacy in checking the larval population of DBM. The curd yield was maximum in insecticide treated plot (12.4t/ha) as against 11.32 to 11.86 t/ha in *Bt* strains treated plots. The order of efficacy among the *Bt* strains in containing the larval population of DBM was NBAII BTG4 2% > PDBC BT1 2% > NBAII BTG4 1% > PDBC BT1 1%.

g. Evaluation of fungal pathogens against sucking pest of hot chilli (*Capsicum sinensis*)

AAU-J: The mean population of *Aphis gossypi* and *Scirtithrips dorsalis* was 6.25 and 1.25 per 10 leaves in imidacloprid treated plot followed by NBAIR Bb 5a strain with 8.50 and 2.50 per 10 leaves after third spray and both the treatments were on par in their efficacies. In untreated control plots, the sucking pest's population were persistently high throughout the experimental period. Maximum numbers of *A. gossypi* (32.00 /10 leaves) and *S. dorsalis* (15.5 /10 leaves) were recorded in untreated control plot. Highest yield of hot chilli (53.8q/ha) was recorded in imidacloprid @ 20g ai/ha treated plot. This was followed by NBAIR-Bb5a with an yield of 51.29q/ha.

h. Validation of BIPM on thrips of onion

IIHR: Validation of BIPM trial against *Thrips tabaci* on onion with var. Arka Niketan indicated a significant reduction in thrips population by 73 % and 79% with liquid spray of *Beauveria bassiana* @ 1×10^7 spores/ml and *Metarhizium. anisopliae* @ 1×10^7 spores/ml, respectively.

MPKV: Pooled analysis of three years data revealed that three sprays of profenophos 0.05% at fortnightly interval found significantly superior over other treatments in suppressing the thrips population and gave 20.0 t/ha yield of onion bulbs. However, three sprays of *M. anisopliae* @ 10^8 cfu/ml (av. 7.6 thrips/plant)/six releases of *B. pallens* @ 20 nymphs/m row (av. 9.9 thrips/plant) were the next best treatments in the bio suppression of pest population and also with regard to yield (18.7 & 18.1 q/ha respectively)

i. Evaluation of local and NBAIR entomopathogenic strains against soil insects in potato

AAU-J: NBAIR-Bb-5a strain treated plots showed 15.5% damage by *Dorylus orientalis* and 17.25% damage by *Agrotis ipsilon* with an yield of 85.00 q/ha, although imidacloprid treated plots showed lesser tuber damage (10.25 & 9.0% respectively) with higher yield of 89.5q/ha. Significantly less incidence of *D.orientalis* and *A.ipsilon* was registered in all microbial treated plots over untreated check. Maximum number of infested tubers due to attack of *D.orientalis* and *A. ipsilon* was 34.25 and 36.5 per cent, respectively in untreated check.

j. Biological suppression of fruit borer, *Earias vitella* in okra

MPKV: Three sprays of *B. thuringiensis* @ 1 kg/ha at fortnightly interval was superior in reducing the shoot (8.8 %) and fruit (19.5 %) infestation and gave maximum marketable yield of 180 q/ha. However, this was on par with Chlorpyrifos @ 0.04% treatment which showed 10.7 % shoot and 24.2 % fruit infestation with 173.2 q/ha yield.

k. Evaluation of biointensive IPM module against *Aleurodicus dispersus* on cassava

TNAU: The implementation of BIPM module effectively reduced the spiralling whitefly population (86.34 whiteflies per plant) as compared to 335.41 whiteflies per plant in insecticide sprays. The untreated check harboured 450.61 whiteflies per plant. The population reduction of spiralling whitefly achieved by BIPM was 77.03% as compared to 25.89 % in farmer's practice with three rounds of insecticide sprays. The plots imposed with BIPM was free from sooty mould whereas the plots with insecticide sprays and untreated had severe incidence sooty mould. The yield of tubers in BIPM plot was 33.25t/ha which was superior to the tuber yield of 29.62 t/ha recorded in farmer's practice. The untreated plot showed a tuber yield of 25.30 t/ha. The BCR was 1:3.26 in BIPM plot and 1:2.34 in farmer's practice

5.2.13. Monitoring the diversity and outbreak of invasive mealybugs on major horticultural crops

TNAU: The survey on invasive mealybug was made in four districts viz., Coimbatore, Tiruppur, Erode and Salem districts during the period under report. The incidence of *Phenacoccus* was noticed in tapioca and okra. The incidence of *Paracoccus marginatus* was noted in mulberry, tapioca, papaya, jatropha and not observed on okra. The occurrence of *Pseudococcus jackberdislei* was recorded only on papaya and tapioca. Among the parasitoids *Acerophagus papayee* was constantly associated with papaya mealybug on all hosts infested with the pest. The occurrence of *Cryptolaemus montrouzieri* and *Spalgis epius* were noted in all the hosts infested with papaya mealybug.

IIVR: Extensive surveys conducted in and around Varanasi revealed the occurrence of two mealybug species viz., *Phenacoccus solenopsis* (Tinsley) and *Centroccoccus insolitus* (Green) (Pseudococcidae: Homoptera) infesting major vegetables during April, 2014 to March, 2015. The dominant species identified was *P. solenopsis* infesting several vegetables namely tomato, brinjal, *Capsicum*, okra and cucurbits. Incidence of this mealybug was observed almost thorough out the year on one or other vegetable crops available in the region except in peak summer during May-June. In case of tomato, this mealybug existed from February to April where as in brinjal the infestation was recorded during March-April. Similarly, in cucurbits and okra its infestations were noted during July- August and September to October, respectively. From October to December its incidence was documented on *Capsicum* grown mainly poly-house condition. During peak summer (May-June) the incidence of *P. solenopsis* was restricted to weeds particularly *Parthenium hysterophorus*. In case of brinjal, another mealybug species, *C. insolitus* was recorded particularly during September-October.

5.2.14. Tea mosquito bug

AAU-J: Thiamethoxam @30 gm ai/ha was found superior to *B. bassiana* (IIHR strain) in reducing the *H. theivora* population in tea after 30days of second spray. No significant

difference were observed between the treatments of *B. bassiana* IIHR strain (18.6/10 plants) and pestoneem (20.3/10 plants).

5.2.15. Biological suppression of polyhouse crop pests

a. Monitoring of pests and natural enemies in *Chrysanthemum* under polyhouse conditions.

TNAU: Survey on the pests of *Chrysanthemum* grown in polyhouse was carried out in different places viz., Kothagiri, Yercaud and Kodaikanal. The survey revealed occurrence of whitefly (*Bemisia tabaci*), serpentine leaf miner (*Liriomyza trifolii*) and tetranychid mite (*Tetranychus urticae*). The population of whitefly ranged 0-3 nos./plant, whereas, tetranychid mites population was 3-12 /2cm². The population of serpentine leaf miner as indicated by leaf mined damage 3-8 nos./plant. Presence of coccinellid *Stethorus* sp. and predatory mite were also noted in *Chrysanthemum*.

b. Evaluation of efficacy of predators against cabbage aphids in polyhouse

SKUAST: *Coccinella septempunctata* was found superior to *C. zastrowi* in terms of pest suppression, as evident from statistically significant differences in aphid densities after second release of predators. Per cent reduction in aphid density were 23.6 to 55.3 and 13.9 to 38.4 for *C. septempunctata* and *C. zastrowi* respectively indicated the supremacy of the former. Differences in per cent reduction in aphid density when compared for the two predators were found statistically significant after first to fifth release. Overall reduction in pest density by *C. septempunctata* and *C. zastrowi* was worked out as 40.6 and 23.8 per cent respectively.

c. Evaluation of predatory mite, *Neoseiulus longispinosus* against phytophagous mite in carnation under polyhouse conditions

YSPUHF: Among different treatments of bio-pesticides and bio-agents, *N. longispinosus* at 1:10 predator: prey ratio was the most effective resulting in 84.7 per cent reduction of mite population over control which was on par with fenazaquin (0.0025%) treatment resulting 92.1 per cent reduction of mites.

d. Evaluation of biocontrol agents against sap sucking insect pests of rose in polyhouses

YSPUHF: Methyldemeton (0.025%) treatment and Neem Baan (1500ppm;3ml/L) were found to be the most effective in reducing the pest population (98.4 & 96.0% reduction respectively) compare to other treatments. The next best treatments were spraying of *Lecanicillium lecanii*/release of *C. septempunctata* with a reduction of 77.4 & 79.4 % respectively.

5.2.16. Biological suppression of storage pests

a. Evaluation of *Uscana* sp. (Trichogrammatidae) against *Callosobruchus* sp. on storability of pigeonpea seed

Dir. Seed Res.: The results of the experiments showed that increase in number of *Uscana* sp. is directly proportional to the level parasitization. The highest parasitization of 42 per cent

was observed in the treatment (40 *Uscana* sp released). Lowest infestation of seed was noticed in the treatment of 40 *Uscana* sp released. The germination of pigeon pea seeds was highest in the treatment of 40 *Uscana* sp released which was 82.33 per cent. In control only 75% of seeds germination was observed.

5.2.17. Biological suppression of weeds

DWRS: In order to check the invasion of *Chromolaena* weed from Chhattisgarh to Maharashtra and Madhya Pradesh, 3000 galls infested with gall fly were released in the infested area during 2012. Symptoms of establishment of bioagent were not observed in 2013. Therefore, again 1500 infested galls were released in the three different sites of Jagdalpur area in September 2013. Again in 2014, about 500 galls were released in teak plantation site. Survey done during 2014 revealed the presence of galls on *Chromolaena odorata* indicating the start of establishment process. Samples taken from nine different plots for gall formation, revealed the presence of galls varying from mean 1.67 to 7.08 per 25 m².

5.2.18. Large scale adoption of proven biocontrol technologies

a. Rice

AAU-J: Large scale demonstration of bio control based IPM package in rice was carried out in the farmer's field at village Borholla in Jorhat district on variety 'Ranjit' covering an area of 30 ha. There was no significant difference in population of *Nephotettix sp/hill* in BIPM and farmers practice. The incidence of dead hearts (3.41%) and damaged leaves due to *Cnaphalocrocis* sp. (3.85 %) was significantly high in farmers' practice plots whereas they were 2.60 and 2.57% in BIPM after 65 DAT, respectively. In case of white ear heads, the per cent incidence was 2.77 in BIPM plots which was significantly superior to farmers' practice plots (3.76) at 125 DAT. Maximum yields of 4126.0 Kg / ha was registered in IPM package which was at par with farmers practice. The yield of farmers' practice plots was 3984.4 Kg/ha. The population of natural enemies like spiders and coccinellids were significantly high in BIPM when compared to farmers' practice. It can be concluded that BIPM package proved as effective as farmers' practice on large scale for the management of important key pests of rice. The cost benefit analysis showed net return of Rs. 36709 /ha in BIPM package as compared to Rs. 29250/ha in farmers' practice.

KAU: The incidence of pests was below ETL in BIPM plots. Natural enemies were found high in BIPM plots. There was no significant difference in grain weight in BIPM and conventional farming. Presently, BIPM is practiced in paddy in all the districts of Kerala.

PAU: Large scale demonstration of biocontrol based IPM (six releases of *T. chilonis* and *T. japonicum* each @ 1, 00,000/ha in four locations in the village Saholi (Patiala) in organic *basmati* rice (var. Pusa 1121) over an area of 50 acres resulted in lower incidence of rice insect pests. The net returns in biocontrol package were Rs 14652 as compared to Rs. 8379 in farmers' practice with cost benefit ratio of 1:3.88 and 1:2.76 respectively.

OUAT: Demonstration in 100 acres of Angul district of Orissa showed IPM practice was superior to the farmers' practice in all locations. Dead heart and white were recorded as 5.2 and 8.2% in IPM package, while in farmers' practice the corresponding figures were 9.3 and 13.6% respectively. Leaf folder, case worm and skipper population in IPM plots were 4.8, 3.2 and 1.8 % respectively whereas, in the non-IPM plots they were 8.1, 6.3 and 3.9 %. The GLH

population in IPM fields was 5.1/hill as against 9.3/hill in non IPM fields. It was observed that the beneficial fauna like spiders and ladybird beetles were more in number in IPM plots which were 7.1/hill and 4.9/hill respectively, whereas the corresponding population in non IPM plots was 1.9 and 1.1/hill respectively. Yields obtained in IPM plots were significantly higher than the non IPM plots.

GBUAT: During Kharif season 2014, large scale field demonstrations of biocontrol technologies were conducted in 42 farmer's fields covering an area of 36.8 hectares in different villages of Nainital district. The Pant bioagent-3 was applied as soil application with FYM/ vermicompost (5-10 t/ha colonized with PBAT-3), as seed treatment (10 g/kg seed), seedling dip treatment (10 g/lit. water) and need-based foliar sprays of PBAT-3 (10g/lit. water) were given. By adopting bio-control technologies, an average yield of 43.0 q/ha was obtained as compared to conventional farmer's practices (36.0 q/h).

b. Sugarcane

PAU: Large scale demonstration of effectiveness of temperature tolerant strain of *Trichogramma chilonis* (tts) @ 50,000 per ha at 10 days interval (eight releases) against early shoot borer (*Chilo infuscatellus*) over an area of 1000 acres at farmers' fields was conducted in collaboration with two sugar mills. Bioagent treated plots showed 54.1 per cent of reduction of pest damage

Release of *T. chilonis* @ 50,000 per ha at 10 days interval during July to October, 2014 (twelve releases) over an area of 3800 acres at farmers' fields in collaboration with two sugar mills reduced the incidence of stalk borer, *Chilo auricilius* by 55.2 per cent. Similarly 59.6 per cent reduction of stalk borer was observed in an area of 140 acres in Jalandhar and Hoshiarpur districts of Punjab,

Large scale demonstration of effectiveness of *T. japonicum* @ 50,000 per ha at 10 days interval during mid-April to June end, 2014 (eight releases) against top borer, *Scirpophaga excerptalis* over an area of 900 acres in collaboration with two sugar mills indicated 53.2 per cent reduction of top borer.

OUAT: Large-scale Demonstration on the use of *T.chilonis* against early shoot borer and internode borer of sugarcane in Farmers' fields covering 100 acres in Korada village of Angul district of Orissa showed lesser incidence of early shoot borer (ESB) ranged from 6.7 to 9.3% in *T.chilonis* released plots. Incidence of ESB ranged from 29.4 to 39.1% in the fields where no parasitoids were released and farmers took their own control measures of pesticide application. Similarly, internode borer incidence was also least in parasitoid released plots (13.8% and 16.3%) as compared to 24.45% and 30.3% in farmers practice. As regards to top shoot borer, the pest incidence was least in parasitoid treatment (2.1% to 3.2%) as compared to the fields where no parasitoid was released (7.9% to 9.8%). The yield was higher (149.8/ha to 159.4t/ha) in parasitoid released plots, whereas, it was 111.5 t/ha to 115.8 t/ha in farmers practice.

c. Maize

PAU: The demonstrations on the biological control of maize stem borer, *Chilo partellus* were conducted at farmer's fields on an area of 202 acres in Hoshiarpur and Ropar districts of Punjab. Dead heart incidence of 6.2 % was observed in fields where *T. chilonis* was released

and was on par with chemical control (4.7 %) as against 14.8% incidence in untreated control. The yields recorded in the bioagent treated plots and in the chemical treated plots were on par (47.89 & 50.10 q/ha respectively) as compared to the yield of 41.17 q/ha in untreated control. The net returns in biocontrol package was Rs. 8630.20/- as compared to Rs.10978.30/- in farmers' practice with cost benefit ratio of 1: 47.91 and 1: 15.25 respectively.

d Coconut: Large area field validation of integrated biocontrol technology against *Oryctes rhinoceros*

CPCRI: This work initiated during 2013 in 1500 ha area covering Krishnapuram, Devikulangara, Kandallor panchayaths and Kayamkulam municipality was continued during 2014-15. Large scale mass multiplication of *M. anisopliae* in semi-cooked rice-based media was undertaken and 899 breeding sites of rhinoceros beetle were treated in the project area. PVC traps with RB pheromone lure obtained from PCI Ltd., Bangalore were installed in the project area and the average catch of beetles per month ranged from 8-13 beetles. There was significant reduction in leaf damage (65.2 to 85.5%) in the project area. Palm damage was also suppressed in these locations ranging from 21.9 to 34.3%.

e. Brinjal

OUAT: Large scale demonstration of BIPM in brinjal covering 100 acres in the village of Karatapeta in Angul district of Orissa was carried out. BIPM adopted included pheromone traps, weekly release of *Trichogramma chilonis* @50,000/ha / week (total of 15 releases) and two sprays of *Bt*. Farmers' practice was spraying of Rynaxypyr (Coragen) @0.3ml/L at fortnightly intervals. The shoot borer and fruit borer incidence was significantly low in BIPM plots recording 12.8 and 21.9 % respectively whereas, it was 29.1 and 43.7 % in farmer's practice plots. Consequently the yield was also higher in the BIPM plots (20,321 kg/ha) with the cost: benefit ratio of 1:5.1 whereas, the yield in farmers practice plot was 12,209 kg/ha with C:B ratio of 1:1.22. The BIPM practice produced a net return of ₹1,62,240 over the farmers practice.

f. Pea:

GBPUAT: During rabi 2014-15, large scale field demonstrations of bio-control technologies was conducted on pea variety Arkil, at 25 farmer's fields at Golapar area in Nainital district covering an area of 36 acres. Pant bioagent-3 (PBAT-3) was applied as soil application with FYM/ vermicompost (5-10 tons/ha) colonized with PBAT-3 followed by seed biopriming (10 g/kg seed). Due to the successive application of biocontrol agents, the farmers got desired yield of green pea of 50-55q/acre as compared to the yield in conventional farmers practices (25-30 q/acre).

5.2.19. Tribal Sub Plan Programme (TSP)

AAU-J: The BIPM technology of pest and disease management in vegetable crops was implemented in 24 tribal farmers plots in three villages in Jorhat and Golaghat districts of Assam. Seeds of vegetable crops, bioagents, biopesticides and bio fertilizers were supplied to the farmers and trainings were given to them on BIPM technology. The farmers under TSP programme were economically benefited. Consumers, on the other hand benefitted from receiving pesticide-free produce at lower prices. The inputs provided to the farmers and the

benefit derived from them significantly helped them in their net returns. Moreover, the BIPM technology is now being promoted as organic mode of farming.

AAU-A: Biocontrol technologies for management of *Fusarium* wilt and pod borer (*Helicoverpa armigera*) in chickpea in Gujarat

Under the TSP project 50 tribal farmers were selected from Panchmahal and Mahisagar districts of the Gujarat. Farmers were inspired to use biocontrol based IPM techniques to avoid crop losses due to pest and diseases and to get better production. Biocontrol agents like *Trichoderma viride*, biopesticides like Azadirachtin and pheromone traps were provided as inputs to control pests and diseases. The feedback from the farmers indicated that the BIPM package was very effective in minimizing the losses due to pests and diseases and in increasing the yields of chick pea.

GBPUAT: Promoting BIPM technology amongst Buksa tribal farmers in U.S. Nagar district of Uttarakhand

Under TSP programme during Kharif season (2014) and Rabi season (2014-15) a total of 531 farmers from 4 blocks and 28 villages were adopted and given inputs of 5.5 quintals of bioagent (Pant Bioagent 3), 50 kg earthworms for vermicomposting and polysheet for soil solarization for the crops of rice, French bean, cowpea, okra, cucumber, bittergourd, bottlegourd, green chilli, brinjal, cauliflower, cabbage and onion. A total of nine trainings were held during the two cropping seasons whereby various interventions were introduced to the farmers. The Buksa and Tharu tribes of the adopted villages in Udham Singh Nagar have developed confidence in adopting low cost technology using on farm resources in growing quality vegetables. Now they are well aware about the ill effects of pesticides especially in vegetables.

MPKV: Management of insect pests of horticultural/plantation crops in tribal area in Maharashtra.

Tribal dominating areas of Harsul and Daltpatpur in the Taluka Trimbak of Dist Nasik in Maharashtra were selected for implementation TSP. Fifty Wadis (fruit orchards) of tribal farmers were selected to carry out operation of TSP. Bio fertilizer and bio pesticides and fruit fly and yellow sticky trap has supplied to the selected tribal farmers. The anticipated impact of TSP Project on economic improvement of the tribal people and wealth creation in tribal areas will be known after harvesting of mango and cashew nuts.

MPUAT: Popularization of BIPM modules in kharif maize crop under tribal sub plan programme in Udaipur district of Rajasthan.

Seventy five tribal farmers were selected in five villages of the panchayat Girwa in Udaipur district in Rajasthan for implementation of TSP programme. Inputs like, maize seed (var. HQPM-1), *Trichogramma chilonis* and *HaNPV* were supplied to the tribal farmers. Training on IPM for maize stem borer was imparted to the tribal farmers through Farmer Field Schools (5) and village level training (2) during September-October 2014 at the initiation of the TSP programme. TSP programme implemented in the five villages revealed that four releases of *T. chilonis* @ 150000 parasitoids/ha at 10 days intervals found the most effective against maize stem borer which reduced dead heart to 1.83-3.5% as compared to the higher per cent of dead hearts (15.5-18.7%) in the untreated plots. The yield in the TSP

implemented plots were higher (19.7-22.5 q/ha) compared to the yields in the untreated plots (12.82-15.2 q/ha).

SKUAST: Biointensive management of apple codling moth under TSP in Jammu & Kashmir.

Eighteen small groups of farmers, each comprising 8-10 farmers, from eight different localities including Slikchey, Poyen, Bagh-e-Khomini, Chanigund, Majed Dass, Gound Minji, Hardass and Mangmore were selected for distribution of desired items for use in their apple orchards during 2014-15. Inputs like, pheromone traps, neem formulations, *Bt* formulations and sprayers were given to the tribal farmers. Training was given to the tribal farmers on following management practices of apple codling moth. The impact of the implementation of the TSP programme will be assessed in 2015 when harvesting takes place.

TNAU: Biocontrol methods for vegetable pest management in Tamil Nadu

Under the TSP, two trainings to tribal farmers were organised during the period under report. First training was organised at Sengadu village, Yercaud taluk of Salem district. In this training, forty tribal farmers were trained on the establishment of kitchen garden and its utility on nutritional security with free supply of vegetable seeds and other inputs. They were explained about the bio intensive pest management of vegetable crop to obtain pesticide-free vegetables. Demonstrations were carried out to explain the preparation of neem oil emulsion, neem seed kernel extract, seed treatment, use of sticky traps, pheromone traps and release of tricho cards, *Chrysoperla* and *Cryptolaemus* predators.

UAS-R: IPM in paddy in northern Karnataka.

Eleven tribal farmers in Vaddepalli village in Raichur district were selected for implementation of IPM in paddy under TSP programme. Formulations of bio agents and vermibeds for vermicoposting were supplied to the farmers. Training on production of vermicompost was given to the tribal youths to engage themselves in mitigating the purchase of fertilizers.

CAU: Demonstration on management of insect pests of cabbage with BIPM practice in Arunachal Pradesh

TSP was carried out during rabi, 2014-15. A total of 149 tribal farmers were selected farmers from three locations viz., Jhampani, Ruksin and Pasighat. The benefited farmers were provided with plant protection materials for the management of insect pests. Incidence of insect pests were low and yields were higher in the TSP implemented fields compared to the non TSP implemented fields.

YSPUHF: Use of eco-friendly methods of pest management for apple and vegetable crops in Himachal Pradesh

Three hundred and thirty tribal farmers were selected from five villages in Kinnaur district for implementation of TSP. Inputs like, water traps, Delta sticky lines, Delta sticky traps, yellow sticky traps, blue sticky traps, neem baan, *Helicoverpa* pheromone lure, *Spodoptera* pheromone lure, DBM pheromone lure, *Trichoderma viride* and *Pseudomonas fluorescens* were supplied to the tribal farmers along with training on BIPM practices for pest and disease management of vegetables and apple. The farmers of the tribal area were exposed

to the use of biopesticides for pest management for the first time. In case of vegetable crops like cabbage, cauliflower, peas and beans, there was a reduction of 30 to 40 per cent in chemical pesticide application.

6. Director's and monitoring team visit to AICRP centers during 2014-15

S. N	Dates	Visit of Director/ NBAIR Scientist	Place of visit	Highlights of visit
1.	07-4-2014	Dr. A. Verghese Director, NBAIR	ANGRAU, Hyderabad	Reviewed the progress of work of ANGRAU, Hyderabad
2.	01-05-2014 To 10-05-2014	Dr. P.M. Raj, HOD, Dr. Veenakumari, P S Dr. Sunil Joshi P.S	CAU, Pasighat	Reviewed the progress of work of CAU, Pasighat
3.	25-06-2014 to 28-06-2014	Dr. A. Verghese Director	OUAT, Bhubaneswar	Reviewed the progress of work of OUAT, Bhubaneswar
4.	10-08-2014	Dr. A. Verghese Director	PAU, Ludhiana	Reviewed the progress of work of PAU, Ludhiana
5	September, 2014	Dr. A. Verghese Director	KAU, Thrissur	Reviewed the progress of work of at KAU, Thrissur
6	07-11-2014	Dr. A. Verghese Director	TNAU Coimbatore	Reviewed the progress of work of TNAU, Coimbatore
7	16-12-2014	Dr. C. R. Ballal, HOD, NBAIR	MPKV, Pune	Reviewed the progress of work of MPKV, Pune
8	19-01-2015 to 20-01-2015	Dr. A. Verghese Director	MPKV, Pune	Reviewed the progress of work of MPKV, Pune
9	15-02-2015 to 18-02-2015	Dr. Mohan, Sr. Scientist	AAU-Anand	Conducted survey for exotic tomato borer in Junagadh district along with Dr. Godhani. AAU-A
10	19-02-2015 to 22-02-2015	Dr. B. Ramanujam P.S	AAU-Anand	Reviewed the progress of work at AAU-Anand. Visited the TSP implemented villages & Conducted the survey for exotic tomato borer (<i>Tuta</i>) in Anand district along with Dr. Mehta & Dr. Godhani Scientists, AAU-A
11.	16-03-2015 to 17-03-2015	Dr. B. Ramanujam P.S Dr. A. N. Shylesha P.S	TNAU Coimbatore	Reviewed the progress of work at TNAU, Coimbatore. Visited the AICRP field trial plots. Explained about the procedures of conduct of AICRP workshop in June 2015 at TNAU.
12	20-3-14	Dr. A. Verghese Director	KAU, Thrissur	Reviewed the progress of work at KAU, Thrissur
13	24-03-2015 to 26-03-2015	Dr.N. Bakthavastalam P.S	MPKV, Pune	Guided the usage of pheromone traps in TSP villages for guiding

7. Publications: During the year 2014-15, a total of 247 Research papers/symposium papers/reviews/technical bulletins, etc. were published by the different centres as given below.

Centre	Research papers in journals	Papers in Symposia/Seminars	Books/ Book Chapters /Tech. Bulletins/ Popular articles	Total
NBAIR, Bangalore	62	36	22	120
AAU, Anand	2	2	1	5
AAU, Jorhat	-	2	10	12
GBPUAT, Pantnagar	4	-	-	4
KAU, Thrissur	-	1	-	1
MPKV, Pune	-	15	-	15
PAU, Ludhiana	10	9	9	28
SKUAST, Srinagar	-	-	10	10
TNAU, Coimbatore	4	13	-	17
YSPUHF, Solan	5	5	-	10
MPUAT, Udaipur	3	1	-	4
CISH, Lucknow	-	3	-	3
CPCRI, Kayankulam	2	10	-	12
IIHR	-	5	-	5
IIVR	1	-	-	1
Total	93	102	52	247

8. Profile of experiments and demonstrations carried out during 2014-15

Crop/Insect	Experiments	Large Scale Demonstrations
Biodiversity of biocontrol agents	2	0
Antagonists of crop disease management	4	2
Sugarcane	1	4
Cotton	3	0
Rice	2	4
Maize	1	1
Sorghum	1	0
Pulses	2	0
Oilseeds	7	0
Coconut	4	1
Tropical Fruits	8	0
Temperate Fruits	4	0
Vegetables	18	1
Tea mosquito bug	1	0
Mealybugs	1	0
Polyhouse crops	9	0
Storage pests	1	0
Weeds	1	0
TSP	-	10
Total	70	23