

**Technical Document No. 64**

**Proceedings of the XXII  
Biocontrol Workers' Group Meeting  
and  
Technical Programme for 2013-14 & 2014-15**

**24-25<sup>th</sup> May, 2013  
National Bureau of Agriculturally Important Insects  
Bangalore**

**Compiled and Edited by**

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**AICRP on Biological Control of Crop Pests and Weeds**



**National Bureau of Agriculturally Important Insects  
Post Box No.2491, H. A. Farm Post, Bangalore 560 024**



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I am grateful to **Dr. Swapan Kumar Datta**, Deputy Director General (Crop Sciences) for his unstinted encouragement and support provided during the period-2011-13. His guidance has been instrumental in the successful execution of the various research activities of the NBAII as well as those under the AICRP on Biological Control. I am thankful to **Dr. K.D. Kokate**, Deputy Director General (Extension) for chairing the inaugural session of the workshop and for his suggestions on transfer of biocontrol technologies to the farming community. I also thank **Dr. T. P. Rajendran**, Assistant Director General (PP) for his full support in conducting and chairing some sessions during the Group Meeting as well as guidance in formulating the Technical Programme for the years 2013-15.

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Bangalore  
August, 2013



**Abraham Verghese**  
Director

National Bureau of agriculturally Important Insects  
Bangalore

**ANNUAL GROUP MEET OF ALL INDIA CO-ORDINATED RESEARCH PROJECT  
ON BIOLOGICAL CONTROL OF CROP PESTS AND WEEDS**

Venue: **National Bureau of Agriculturally Important Insects, Yelahanka Campus,  
Attur, Bangalore**

Date : **24<sup>th</sup> - 25<sup>th</sup> May, 2013**

**PROGRAMME: May 24, 2013 (Friday)**

|                         |   |
|-------------------------|---|
| <b>0800-0915</b>        | <b>REGISTRATION( NBAIL Main Campus)</b>   |
| <b>1000-1100</b>        | <b>INAUGURATION (NBAIL, Yelahanka Campus)</b>   |
| Chairman                | <b>Dr. K.D. Kokate</b><br>Deputy Director General (Extension), ICAR, New Delhi                  |
| Invocation              | ICAR Song   |
| Lighting of the Lamp    |   |
| Welcome                 | <b>Dr. B.Ramanujam</b><br>Principal Scientist, NBAIL, Bangalore                                 |
| Opening Remarks         | <b>Dr. T. P. Rajendran</b> , ADG (PP), ICAR, New Delhi  |
| Director's Report       | <b>Dr. Abraham Verghese</b><br>Project Co-ordinator, AICRP-BC and<br>Director, NBAIL, Bangalore |
| Address                 | <b>Dr. B. Senapati</b><br>Chairman RAC, NBAIL, Bangalore  |
| Release of Publications |   |
| Chairman's Remarks      | <b>Dr. K.D. Kokate</b><br>Deputy Director General (Extension), ICAR, New Delhi                  |
| Vote of thanks          | <b>Dr. N. Bakthavastalam</b><br>Principal Scientist, NBAIL, Bangalore                           |
| National Anthem         |   |
| <b>1100-1115</b>        | <b>TEA</b>  |

| <b>PRESENTATION OF PROGRESS REPORTS (May 24, 2013 (Friday))</b> |   |
|---|---|
| <b>May 24, 2013; 1115-1230 hrs</b>                              | <b>SESSION I: BASIC RESEARCH, NBAII</b>   |
| Chairman  | Dr. T. P. Rajendran, ADG (PP), ICAR, New Delhi  |
| Co-Chairman   | Dr. Abraham Verghese, Director, NBAII, Bangalore  |
| Rapporteurs   | Dr. Sunil Joshi NBAII, Bangalore<br>Dr. R. Rangeswaran, NBAII, Bangalore                    |
| <b>Speakers</b>   |   |
| Parasitoids & Predators   | Dr. T. Venkatesan, NBAII, Bangalore   |
| Entomopathogens & Endosymbionts                                 | Dr. P. Sreeramakumar, NBAII, Bangalore  |
| <b>1230-1330 hrs</b>  | <b>SESSION II: BIOLOGICAL CONTROL OF PLANT DISEASES and PPNs</b>                            |
| Chairman  | Dr. B.S. Bhumannavar, Pr. Scientist, NBAII, Bangalore                                       |
| Co-Chairman   | Dr. Rajan, Principal Scientist, ICAR, New Delhi   |
| Rapporteurs   | Dr.G. Sivakumar, NBAII, Bangalore<br>Dr. Neelam Joshi, PAU, Ludhiana                        |
| <b>Speakers</b>   |   |
| Field Evaluation of Antagonists for plant disease management    | Dr. Anand Kumar Tiwari, GBPUA & T, Pantnagar  |
| Biocontrol of PPN (AICRP work) & Basic work on EPN (NBAII work) | Dr. M. Nagesh, NBAII, Bangalore   |
| <b>1330-1415 hrs</b>  | <b>LUNCH</b>  |
| <b>1415-1530 hrs</b>  | <b>SESSION III: BIOLOGICAL SUPPRESSION OF PESTS OF SUGARCANE, COTTON, RICE &amp; MAIZE</b>  |
| Chairman  | Dr. M. Mani, Emeritus Scientist, NBAII, Bangalore   |
| Co-Chairman   | Dr. R.S Tripathi, AICRP-Rodent control, Jodhpur   |
| Rapporteurs   | Dr. Ankitha Gupta, NBAII, Bangalore<br>Dr. G. Anitha, ANGRAU, Hyderabad                     |
| <b>Speakers</b>   |   |
| Sugarcane   | Dr. Naveen Aggarwal, PAU, Ludhiana  |
| Cotton  | Dr. Pokharkar, MPKV, Pune   |
| Rice & Maize  | Dr. S. J. Rahman, ANGRAU, Hyderabad   |
| <b>1530-1645</b>  | <b>SESSION IV: BIOLOGICAL SUPPRESSION OF PESTS OF PULSES, OILSEEDS, TOBACCO AND COCONUT</b> |
| Chairman  | Dr. A. K. Chakravarthi, HOD, Entomology, UAS(B)   |
| Co-Chairman   | Dr. D.S. Pokharkar, PMKV, Pune  |
| Rapporteurs   | Dr. M. Mohan, NBAII, Bangalore<br>Dr. Chandrika Mohan, CPCRI, Kayangulam                    |
| <b>Speakers</b>   |   |
| Pulses & Oilseeds   | Dr. M. Kalyanasundaram, TNAU, Coimbatore  |
| Tobacco   | Dr. M. Mohan, NBAII, Bangalore  |
| Coconut   | Dr. Chandrika Mohan, CPCRI, Kayangulam  |

|   |   |
|---|---|
| <b>Special Lectures: 1645-1730</b>                    | <p>1. Evidence for natural polymorphism in the predation efficiency of <i>Cryptolaemus</i> by Dr.P.Kamala Jayanthi, National Fellow, IIHR, Bangalore</p> <p>2. Field estimation of insect numbers and inter specific associations by Dr. A. Verghese, Director, NBAII</p> |
| <b>May 25, 2013 (Saturday)</b>                        |   |
| <b>May 25, 2012 (Saturday)<br/>0930-1130 hr</b>       | <b>SESSION V: BIOLOGICAL SUPPRESSION OF PESTS OF FRUIT AND VEGETABLE CROPS, POLYHOUSE CROP PESTS, STORAGE PESTS AND WEEDS</b>   |
| Chairperson<br>Co-Chairperson                         | Dr. P. Parvatha Reddy, Ex-Director, IIHR, Bangalore<br>Dr. A. Krishnamoorthy, Head (Ento.), IIHR, Bangalore   |
| Rapporteurs   | Dr.T. Venkatesan, NBAII, Bangalore<br>Dr. Vidhya, KAU, Trissur  |
| <b>Speakers</b>                                       |   |
| Tropical fruits, Mealybugs & TMB                      | Dr. (Mrs.) P. N. Ganga Visalakshy, IIHR, Bangalore  |
| Temperate Fruits                                      | Dr. Jamal Ahmad, SKUAST, Srinagar   |
| Vegetables  | Dr. Lyla, KAU, Trissur  |
| Polyhouse Crop Pests, Storage pests & Weed biocontrol | Dr. Usha Chauhan, YSPUHF, Solan   |
| <b>1130-1230 hrs</b>                                  | <b>SESSION VI:INSTITUTE-INDUSTRY PARTNERSHIP</b>  |
| Chairman<br>Co-Chairman                               | Dr. R. Ramani, Director IING&R, Ranchi<br>Dr. J. Kumar, Dean, GBPUAT, Pantnagar   |
| Rapporteurs   | Dr. T. Venkatesan, NBAII, Bangalore,<br>Dr. Gangavishalakshi, IIHR, Bangalore   |
| <b>Speakers</b>                                       | Dr.S. Sithanantham Sun Agro, Chennai<br>Dr. Mohan, Monsanto, Bangalore<br>Dr. Dr. Ghosh, BCRL, Bangalore<br>Dr.Jeyabal, Rajashree Sugars, Villupuram<br>Ms. Poovarasi, Rajashree Sugars, Villupuram   |
| <b>1230-1330 hrs</b>                                  | <b>SESSION VII: Plenary Session</b>   |
| Chairman<br>Co- Chairman<br>Co-Chairman               | Dr. C.A. Viraktamath, National Professor, UAS (B)<br>Dr. T. P. Rajendran, ADG (PP), ICAR, New Delhi<br>Dr. Abraham Verghese, Director, NBAII, Bangalore   |
| Rapporteurs   | Dr. B. Ramanujam, NBAII, Bangalore<br>Dr. A.N. Shylesha, NBAII, Bangalore   |
| Speakers  | Presentations of Recommendations by Chairmen of different technical sessions.<br>Finalization of Technical Programme for 2013-14 & 2014-15<br>Remarks by Chairman & Co-Chairmen   |
| <b>1330-1400 hr</b>                                   | <b>LUNCH</b>  |
| <b>1415-1700hr</b>                                    | <b>Plenary Session was continued</b>  |
| Vote of Thanks  | Dr. B. Ramanujam, NBAII, Bangalore  |

## INAUGURAL SESSION

The **XXII Biocontrol Workers' Group Meeting** was conducted under the aegis of the Indian Council of Agricultural Research, New Delhi at National Bureau of Agriculturally Important Insects, Bangalore on 24<sup>th</sup> and 25<sup>th</sup> May, 2013. Delegates and invitees from ICAR Institutes, Agricultural Universities and representatives of private commercial production units attended the Inaugural Session. The programme was as follows:

|                                |  |
|--------------------------------|--|
| Welcome Address:               | <b>Dr. B. Ramanujam</b><br>Principal Scientist<br>NBAIL, Bangalore                 |
| Project Co-ordinator's Report: | <b>Dr. Abraham Verghese</b><br>Project Co-ordinator<br>AICRP on Biological Control |
| Address:                       | <b>Dr. T. P. Rajendran</b><br>ADG (PP), ICAR, New Delhi                            |
| Special Address:               | <b>Dr. B. Senapati</b><br>Chairman, RAC, NBAIL                                     |
| Address by Chairman:           | <b>Dr. K. D. Kokate</b><br>Deputy Director General (Extension)<br>ICAR, New Delhi  |
| Vote of Thanks:                | <b>Dr. N. Bhaktavatsalam</b><br>Principal Scientist<br>NBAIL, Bangalore            |

**Dr. T.P. Rajendran** in his address emphasized the need to intensify work on biocontrol, to identify new organisms/natural enemies for biological control, to come out with good products and to make them available in large quantities to the farming community through KVKs, Self Help Groups and Farmer Family entrepreneurs. **Dr. Abraham Verghese**, Director NBAIL, Bangalore presented the salient achievements of the AICRP-BC for the year 2012-13. Two NBAIL publications on 'Farm level production of *Trichogramma chilonis* on eri silkworm eggs' and a 'Pictorial guide for identification of major aphid species' and a 'technical bulletin of AINP Rodent Control on 'Porcupine' were released. **Dr. B. Senapati, RAC Chairman** appreciated the work done on biocontrol, but added that there is a need to improve the availability of biocontrol products in Eastern part of the country, taking up of biocontrol measures against coconut black headed caterpillar in Orissa, and popularization of biocontrol technologies in vegetable crops & polyhouses. **Dr. K.D. Kokate, DDG (Extension)**, ICAR mentioned about utilization of KVKs for training, production & supply of Biocontrol agents to the farming community. He also emphasized on the importance of conservation of natural enemies in farmers' field and creation of a platform to reward the farmers practicing biocontrol technologies.





|  |             |
|--|-------------|
| ii. Anand Agricultural University                                  | Anand       |
| iii. Assam Agricultural University                                 | Jorhat      |
| iv. Dr. Y.S. Parmar University of Horticulture and Forestry        | Solan       |
| v. Gobind Ballabh Pant University of Agriculture and Technology    | Pantnagar   |
| vi. Kerala Agricultural University                                 | Thrissur    |
| vii. Mahatma Phule Krishi Vidyapeeth                               | Pune        |
| viii. Punjab Agricultural University                               | Ludhiana    |
| ix. Sher-e-Kashmir University of Agricultural Science & Technology | Srinagar    |
| x. Tamil Nadu Agricultural University                              | Coimbatore  |
| xi. Central Agricultural University                                | Pasighat    |
| xii. Jawaharlal Nehru Krishi Vishwa Vidyalaya                      | Jabalpur    |
| xiii. Maharana Pratap University of Agriculture & Technology       | Udaipur     |
| xiv. Orissa University of Agriculture & Technology                 | Bhubaneswar |

### **ICAR Institute- based centers**

|  |             |
|--|-------------|
| i. Central Plantation Crops Research Institute | Kayangulam  |
| ii. Central Tobacco Research Institute         | Rajahmundry |
| iii. Indian Agricultural Research Institute    | New Delhi   |
| iv. Indian Institute of Horticultural Research | Bangalore   |
| v. Indian Institute of Sugarcane Research      | Lucknow     |
| vi. Sugarcane Breeding Institute               | Coimbatore  |

### **Voluntary centers**

|  |           |
|--|-----------|
| i. National Research Center for Soybean            | Indore    |
| ii. National Center for Integrated Pest Management | New Delhi |
| iii. University of Agri. Sciences                  | Raichur   |
| iv. National Research Center on Weed Science       | Jabalpur  |

## **5.0 Executive Summary**

### **5.1 Basic Research**

The National Bureau of Agriculturally Important Insects (NBAIL) backs up the AICRP (BC) with basic and applied research and the salient achievements are presented in this section.

1. Biosystematic studies on agriculturally important insects
2. Biosystematics of *Trichogramma* and *Trichogrammatoidea*
3. Biodiversity of oophagous parasitoids with special reference to Scelionidae (Hymenoptera)
4. Biodiversity of economically important Indian Microgastrinae (Braconidae) supported by molecular phylogenetic studies
5. Biodiversity studies on aphids and mealy bugs and their natural enemies
6. Diversity and distribution of entomopathogenic nematodes in temperate and gangetic plains of India
7. Taxonomic studies on fruit flies (Diptera: Tephritidae) of India
8. Introduction and studies on natural enemies of some new exotic insect pests and weeds

9. Development of production protocols and evaluation of anthocorid and mite predators
10. Influence of elevated levels of carbon dioxide on the tritrophic interactions in some crops
11. Isolation, identification and characterization of endosymbionts of trichogrammatids and their role on the fitness attributes
12. Molecular characterization and identification of endosymbionts of chrysopid predators and their functional role on the biological attributes
13. Studies on *Trichogramma brassicae* and *Cotesia vestalis (plutellae)* interaction with their host in cabbage
14. Nematode-derived fungi and bacteria for exploitation in agriculture
15. Mass production and exploitation of entomopathogenic nematodes against white grubs from diverse habitats
16. Mapping of the cry gene diversity in hot and humid regions of India
17. Evaluation of fungal pathogens on *Aphis craccivora* in cowpea and *Bemisia tabaci* in tomato and capsicum.
18. Mechanism of insecticide resistance in *Leucinodes orbonalis* and *Leucopholis coneophora*
19. Development of computational tool for prediction of insecticide resistance in agriculturally important insects
20. *In situ* conservation of natural enemies and pollinators in pigeon pea and sunflower ecosystem
21. Polymorphism in pheromone reception in *Helicoverpa armigera*.
22. Formulations of pheromones of important borers and other crop pests and kairomones for natural enemies using nanotechnology
23. Semiochemicals for the management of coleopteran pests

In addition, NBAIL has been strongly supporting identification and supply of nucleus cultures of bioagents. It also functions as the repository of all insect fauna collected under biodiversity programmes.

## 5.2 Biological suppression of crop pests and diseases

The co-coordinating centers of the AICRP on Biological Control of Crop Pests and Weeds are validating the various techniques for the bio-intensive management of pests and diseases of sugarcane, tobacco, rice, maize, cotton, pulses, oilseeds, coconut, fruit and vegetable crops, polyhouse crops as well as the biological control of mealy bugs, termites storage pests, and weeds.

### Profile of experiments and demonstrations carried out during 2012-13

| Crop/Insect | Experiments | Large scale Demonstrations* |
|-------------|-------------|-----------------------------|
| Rice        | 3           | 3                           |
| Maize       | 1           | 1                           |

|                    |           |           |
|--------------------|-----------|-----------|
| Sugarcane          | 3         | 5         |
| Cotton             | 2         | 0         |
| Tobacco            | 2         | 0         |
| Pulses             | 2         | 0         |
| Oil seeds          | 3         | 0         |
| Vegetables         | 9         | 0         |
| Tropical fruits    | 7         | 0         |
| Temperate fruits   | 5         | 0         |
| Coconut            | 3         | 1         |
| Tea mosquito bug   | 2         | 0         |
| Mealybugs          | 3         | 0         |
| Storage pests      | 2         | 0         |
| Weeds              | 2         | 0         |
| PPNs & Antagonists | 8         | 1         |
| Polyhouse crops    | 6         | 0         |
| <b>Total</b>       | <b>63</b> | <b>11</b> |

#### 6. Director's visit to AICRP centers

NBAII Director visited different centers of the All India Coordinated Research Project on Biological Control to review the work, to understand the difficulties and to solve problems faced in the implementation of the programmes. The centers visited with dates are as follows.

| S. N | Dates              | Place of visit              | Highlights of visit  |
|------|--------------------|-----------------------------|--|
| 1.   | 3.4.12 to 6.4.12   | AAU-Jorhat and CAU-Pasighat | Reviewed the progress of work of AICRP on BC centres at College of Horticulture and Forestry, Pasighat on 4 <sup>th</sup> April, 2012. Reviewed the progress of work of AICRP on BC centres at Assam Agricultural University, Jorhat on 5 <sup>th</sup> and 6 <sup>th</sup> April, 2012                          |
| 2.   | 16.4.12 to 19.4.12 | PAU, Ludhiana               | Organized QRT meeting of the NBAII at PAU, Ludhiana from 16 <sup>th</sup> to 19 <sup>th</sup> April, 2012. . The chairman and members of QRT, NBAII were present   |
| 3.   | 21.5.12 to 22.5.12 | ANGRAU Hyderabad,           | Organised the workers group meeting of AICRP on BC at ANGRAU, Hyderabad from 21 <sup>st</sup> to 22 <sup>nd</sup> May, 2012  |
| 4.   | 30.5.12            | OUAT, Bhubaneswar           | Due to outbreak of papaya mealybug a serious problem on horticultural and other crops in Bhubaneswar and the concerned authorities at Bhubaneswar have requested this bureau to release the parasitoids. Accordingly the cultures of the parasitoids were released on 30 <sup>th</sup> May, 2012 at Bhubaneswar. |

|    |                    |                 |   |
|----|--------------------|-----------------|---|
| 5. | 5.11.12 to 6.11.12 | AAU, Anand      | Reviewed the progress of work of AICRP on BC centre at Anand Agricultural University, Anand on 5 <sup>th</sup> November, 2012. Participated in the Farmers Meet on 6 <sup>th</sup> November, 2012 Umiyanagar in Palanpur wherein large scale demonstration took place in order to create awareness and to educate them about the technologies available for the control of root knot nematodes in pomegranate crop amongst the farmers. |
| 6. | 5.12.12 to 7.12.12 | New Delhi       | Participated in the meeting of Project Coordinators of AICRPs and Network Project Coordinators under the chairmanship of Hon'ble DG, ICAR held on 5 <sup>th</sup> and 6 <sup>th</sup> December, 2012 at NBPGR auditorium, New Delhi.  |
| 7. | 11.2.13 to 14.2.13 | IARI, New Delhi | Reviewed the progress of work of AICRP centre at IARI, Pusa Centre on 11 <sup>th</sup> February, 2013.  |
| 8. | 18.3.13 to 22.3.13 | ICAR New Delhi  | Had discussions on XII plan fund allocation with AICRP on BC at IARI, New Delhi centre on 21 <sup>st</sup> March, 2013.   |

## 7. Publications

During the year 2012-13, a total of 217 research papers, scientific/symposium papers/review/Technical Bulletins, etc., were published by the different centers (based on information provided by centers). The details on number of publications from each.

| Center            | Research papers published in scientific journals | Papers presented in symposia / seminars etc. | Book chapters/Tech. Bulletin/ popular articles etc. | Total     |
|-------------------|--|--|---|-----------|
| NBAII, Bangalore  | 40   | 45   | 7   | <b>92</b> |
| ANGRAU, Hyderabad | -  | -  | -   | -         |
| AAU, Anand        | 2  | 19   | 2   | <b>23</b> |
| AAU, Jorhat       | 1  | -  | 6   | <b>7</b>  |
| GBPUAT, Pantnagar | 8  | 13   | -   | <b>21</b> |
| KAU, Thrissur     | 1  | 1  | -   | <b>2</b>  |
| MPKV, Pune        | 3  | 2  | 4   | <b>9</b>  |
| PAU, Ludhiana     | 8  | 6  | 6   | <b>20</b> |
| SKUAST, Srinagar  | -  | -  | -   | -         |
| TNAU, Coimbatore  | 9  | 3  | -   | <b>12</b> |
| YSPUHF, Solan     | 1  | 3  | 3   | <b>7</b>  |
| CAU Pasighat      | -  | -  | -   | -         |
| JNKVV, Jabalpur   | -  | -  | -   | -         |
| MPUAT, Udaipur    | -  | -  | -   | -         |
| OUAT, Bhubaneswar | 3  | -  | -   | <b>3</b>  |
| CPCRI, Kayangulam | 4  | 4  | 2   | <b>10</b> |
| CTRI, Rajamundry  | -  | 2  | 1   | <b>3</b>  |
| IIHR, Bangalore   | 4  | 4  | -   | <b>8</b>  |
| IARI, New Delhi   | -  | -  | -   | -         |

|               |           |            |           |            |
|---------------|-----------|------------|-----------|------------|
| IISR, Lucknow | -         | -          | -         | -          |
| <b>Total</b>  | <b>84</b> | <b>102</b> | <b>31</b> | <b>217</b> |

## SALIENT FINDINGS DURING 2012-13

### 1. BASIC RESEARCH AT NBAIL, BAGALORE

- *Coccipolipus synonymychae* (Acari: Podapolipidae) was described as a parasite of the giant bamboo ladybird, *Synonycha grandis*.
- *Anagyrus qadrii* and a fortuitously introduced species of *Anagyrus* were recorded as parasitoids of the Madeira mealybug in and around Bangalore.
- Surveys were conducted in agricultural and natural ecosystems in parts of South and Western India as well as the Andaman and Nicobar islands for their *Trichogramma/Trichogrammatoidea* fauna. First record of *Trichogramma rabindraii* from outside Karnataka / Madhya Pradesh reported. First record of *T. bactrae* from the eggs of *Prosotas nora* (Lepidoptera: Lycaenidae) on citrus is also reported.
- Continuous rearing of *T. embryophagum* for 151 generations on Erisilkworm (ESW) eggs resulted in 92.2% parasitism and 70.7% adult emergence.
- Five releases of *T. chilonis* reared on Eri silk worm eggs were made @ 10 cards per release at 10 days intervals against paddy borers in AP. The savings in bio-control plot was Rs 1214 per acre.
- Eighteen populations of *Cotesia vestalis*, the parasitoid of the diamondback moth were collected from different geographical locations of the country, while *Trichogramma brassicae* was collected from Karnataka region.
- *Lohiella longicornis* (Noyes & Hayat) was recorded for the first time from India parasitizing *Drepanococcus chiton* (Green) which is also a new host association.
- For the first time, Anthacorid bug, *Montandoniola* sp. was recorded on *Butea monosperma*, *Anthacorini* gen. et. sp. from Ficus tree, *Orius maxidentex* recorded from Andaman Nicobar islands, an undescribed species of *Blaptostethoides* from sugarcane, *Xylocoris afer* was recorded from India. In Karnataka, *Cardiastethus pseudococci* from mango inflorescence, *Cardiastethus affinis* as a predator of *Hemiberlesia lataniae* on agave.
- *Blaptostethus pallescens* was field evaluated against mulberry thrips in Salem. After three releases, the thrips count reduced from a pre-count of 94.8 to a post count of 20.5.
- Recurring incidence of papaya mealybug was observed in few locations in Karnataka, Penukonda, Kothanur from Andhra Pradesh, Andaman and Nicobar Islands, Salem and Erode districts of Tamil Nadu. A total of 43 requests for *Acerophagus papayae* were received from April 2012 to February 2013.
- Genetic stocks of twelve different geographical populations of *C. z. sillemi* and 6 different populations of *C. montrouzieri* were maintained.
- Field evaluation of pesticide tolerant strains (PTS) against sucking pests of cotton revealed that two releases of PTS (Cza-8) at 15 days interval in combination with two sprays of acephate (0.67g/li) (13.4aphids/plant) were effective against *A. gossypii*, *Thrips tabaci* and also had highest cotton yield (1533 kg/ha).
- Pesticide tolerant strain of *C. z. sillemi* (Cza-8) (tolerant to OP, endosulfan and synthetic pyrethroids) was mass produced and 12,000 nos. were supplied for field release against

sucking pests of capsicum in UP. 5,000 nos. were supplied to contain tea mosquito bug in Assam.

- Eight new EPN strains isolated and catalogued. Identity of 10 different geographical isolates of *S. abbasi*, *S. feltiae*, *H. indica* and *H. bacteriophora* was validated and confirmed using COI, ITS and SSU RNA gene sequences and RFLP studies were carried out.
- NBAII isolates of *H. indica*, *S. abbasi* and *S. glaseri* were effective at  $2.5 \times 10^9$  IJs/ha causing a mortality of 80-96% of white grubs. in soil column assay in 7days.
- Application of wettable powder preparations/formulations of *H. indica*, *S. abbasi* and *S. glaseri* at  $2.0 \times 10^{13}$  IJs/ha at transplanting reduced incidence of grubs of *Myloccerus subfasciatus* in brinjal (Purple Round) by 44-68% in field and improved yield by 18-24% over control.
- Seven isolates were characterized for the coleopteran specific *cry3A* gene and the complete coding sequence (1.9kb) of *cry3A* and was amplified in 2 isolates. Another coleopteran toxic cry gene (*cry8a*) was characterized in 8 isolates. Sequence analysis of *vip3A* gene (broad spectrum lepidopteran activity) was completed in 8 isolates. Crude preparations of *vip3A* protein obtained from 20 isolates were tested against *Spodoptera litura* and the protein from two of the isolates (EG1 and BtAN4) showed high toxicity with a  $LC_{50}$  value of 9.09 and 9.92  $\mu\text{g/ml}$  respectively.

## 2. BIOLOGICAL CONTROL OF PLANT DISEASES AND NEMATODES (PPNS)

- Large scale demonstration was carried out at Palanpur to control white grub and root knot nematodes. Forty-five pomegranate growers of the Banaskantha region were present. Scientists from NBAII explained to the farmers the incidence and factors affecting the activity and mode of action of *Pochonia chlamydosporia* as well as different EPN formulation and demonstrated the methods of application and dose (AAU).
- Soil application of *Paecilomyces lilacinus* @ 20 kg formulated dust/ha + organic manure FYM at *bahar* treatment was found most effective in reducing root-knot nematode population in soil (31.7%) and number of root galls/5 g roots (25.4%), and increased fruit yield (19.1 t/ha) with 1:17.3 ICBR. However, *Pochonia chlamydosporium* @ 20 kg/ha + organic manure gave maximum yield (19.2 t/ha) of pomegranate (MPKV).
- Biological management of root-knot nematodes, *Meloidogyne hapla* infesting tomato cv. Shalimar 1 in pot: Root dip treatment of tomato seedlings with *Paecilomyces lilacinus* @  $2.0 \times 10^8$  spores/ litre of water 15 minutes before transplantation significantly decreased the soil population of *Meloidogyne hapla* by 85% and increased the yield up to 84% (SKUAST).
- Ninety *Pseudomonas* isolates were tested against *Fusarium udum* and 47 of them were found effective. Maximum *Pseudomonas* population was found at Undel region of Assam. Among 114 Bacillus isolates tested only 30 were found effective against *F. udum* (AAU-A).
- Development of oil-based formulations of selected isolates of *Trichoderma harzianum* and study of their shelf life: Among various isolates maximum CFU was observed in Th-14 ( $25.7 \times 10^8$  CFU/ml) at five months of storage (GBUAT).
- Field evaluation of invert-emulsion formulation of *T. harzianum* for the management of foliar and soil borne disease of chick pea crop variety (PG-186) showed that maximum

plant stand was observed in carbendazim (69.75 & 110.36%) over control at 45 and 90 days respectively. Least mortality between 45 to 90 DAS was recorded in IEF2 (6.80%) followed by talc (8.66%) as compared to control (32.99%). In rice among all the promising isolates evaluated under field conditions Th-14 was found best in reducing disease and increasing plant vigour and yield of rice (cv Kalanamak-3131). In Lentil (PL5) maximum plant stand was observed in Th-14 (54.08 & 78.52%). Minimum root rot incidence was observed in Th-14 (5.21%) as compared to control (18.19%). In chickpea (PG-186) maximum plant stand was observed in Th-14 (46.30 & 78.52%). Minimum root rot incidence was observed in Th-14 (7.36%) (GBUAT).

- Among all fungal formulations tested for foot rot infection in Kinnow, talc formulation of *Trichoderma harzianum* (soil application) and chemical control (Ridomil gold) were on par with each other and yielded maximum number of fruits and fruit weight as compared to other treatments (PAU).

### 3. BIOLOGICAL SUPPRESSION OF PESTS OF SUGARCANE, COTTON, RICE & MAIZE

#### Sugarcane

- The sugarcane woolly aphid (SWA) incidence and occurrence of natural enemies (*Dipha aphidivora*, *Micromus igorotus*, *Encarsia flavoscutellum*, syrphid, spider) were recorded at five agro-ecological zones of western Maharashtra. The average pest incidence and intensity were 0.44 per cent and 1.39, respectively (MPKV).
- The natural enemies recorded in the SWA infested fields were mainly predators like *Dipha aphidivora* (0.5-2.3 larvae/leaf), *Micromus igorotus* (1.2-5.1 grubs/leaf), syrphid, *Eupeodes confrateor* (0.03-1.1 larvae/leaf) and spider (0.02-0.5 per leaf). The parasitoid, *Encarsia flavoscutellum* was observed in Pune and Satara districts. These natural enemies were found to be distributed and established well in sugarcane fields and regulated the SWA in western Maharashtra (MPKV).
- The sugarcane woolly aphid incidence and occurrence of natural enemies were recorded from seven major sugarcane growing districts covering different agro-ecological zones of Tamil Nadu. The SWA was noticed in patches and the occurrence of *Encarsia flavoscutellum*, *Dipha aphidivora* and *Micromus igorotus* was observed. A maximum of 68.2 *Encarsia*/ leaf was observed in Coimbatore during December 2012. SWA incidence was noticed in all the locations from September-October 2012 to January 2013. *Dipha* and *Micromus* populations were also observed during October 2012 to January 2013 (TNAU).
- Field evaluation against sugarcane internode borer with release of *Trichogramma* reared on Eri silkworm eggs or on *Corcyra* eggs @ 20,000/acre was done. Preliminary laboratory studies showed that difference in parasitisation between *Trichogramma* reared on Eri silk worm eggs and that reared on *Corcyra* eggs was only five percent (ANGRAU).
- There was a significant reduction in the incidence and intensity of damage due to internode borer infestation by the release of *T. chilonis* reared on Eri silkworm eggs @ 20,000 / acre and release of *T. chilonis* reared on *Corcyra* moth eggs @ 20,000/ acre than the unreleased fields. After eighth release, release of *T. chilonis* reared on Eri silkworm



eggs @ 20,000/acre recorded significant reduction of INB (5.4%) as compared to release of *T. chilonis* reared on *Corcyra* eggs @ 20,000/ acre (7.2%). The untreated control recorded higher INB incidence (21.8%) (TNAU)

- An evaluation was done in a farmer's field on a 45 days old ratoon crop of sugarcane. The farmer had noticed severe damage by early shoot borer with the symptoms of dead hearts in this field. *T. chilonis* releases were initiated at higher dosages of 40,000 per acre and totally fourteen releases were made. The pest incidence, intensity and infestation index were significantly lower in the treatment plots in comparison to those in the control plot. There was a build up in the pest population and the final yield was recorded as 34.7 tonnes / acre (NBAII).

### **Cotton**

- The *Bt* cotton var. Ankur, Bollgard II was raised separately in the research farm of College of Agriculture, Pune. The sucking pests and natural enemies were recorded from 25 randomly selected tagged plants from the plot at fortnightly interval. Peak incidence of jassids and thrips was recorded during 1<sup>st</sup> week of November 2012 (46<sup>th</sup> MW) and whiteflies in subsequent fortnight (48<sup>th</sup> MW). The aphid population was maximum during 2<sup>nd</sup> week of January 2013 (2<sup>nd</sup> MW). Mealybugs incidence and mirids were not observed throughout the crop growth period (MPKV).
- Among various sucking insect pests, leafhoppers were maximum during September-October month and moderate during August. Thrips population peaked during August and was low during December month. In general whiteflies population was low during the season. Maximum mirid bug population was recorded in December. Similarly the activity of mealy bug was noticed in first week of December and continued till January and the peak activity of parasitoid was noticed in January Second week (UAS-Raichur).

### **Rice**

- Evaluation of IPM on rice was done at three locations of East Siang District of Arunachal Pradesh. The incidence of stem borers in the IPM field (2.37 per cent WEH) was comparable with farmer's practice (1.41 per cent WEH) (CAU).
- Significantly higher infestation of rice gundhi bug was recorded in untreated control than the other two treatments. The highest grain yield of 46.55q/ha was recorded in farmer's practice field and it was closely followed by IPM practice (43.65q/ha) at Sille. Similarly, at Mebo also, the grain yield of Farmer's practice (42.51q/ha) was comparable with IPM (40.66q/ha). However, at Pasighat, farmers practice (43.84q/ha) gave significantly higher yield than IPM practice (40.37q/ha) (CAU).

## **4. BIOLOGICAL SUPPRESSION OF PESTS OF PULSES, OILSEEDS, TOBACCO AND COCONUT**

### **Pulses**

- Lower population of *H. armigera* larvae was found in PDBC-BTG4, PDBC-BTG1, IARI Bt isolates, and NBAII-BT G4 sprayed at 2% concentration (AAU-A, ANGRAU, MPKV, PAU, TNAU, JNKVV, UAS-Raichur).
- Among three modules tested, pigeonpea module with sorghum as the border crop and sunflower as the intercrop recorded least population of *Helicoverpa armigera* larvae. It also recorded maximum population of coccinellids. The population of predatory stink bugs was higher in the pigeonpea module with sorghum as border crop (ANGRAU).
- Among the bioagents and botanicals, 2 sprays of 5% CASE was more effective in reducing the mean pod damage (14.52%) followed by two sprays of *B. bassiana* (16.17%) (MPUAT).

### Oilseeds

- *Verticillium lecanii* was better than *Metarhizium anisopliae* and *Beauveria bassiana* in bringing down population of safflower aphid, *Uroleucon compositae*. *V. lecanii* was on par with neem oil and together they were on par with the insecticidal check on its lower side in recording minimum aphid population (65-123 aphids/10 plants) and maximum yield (469-509 kg/ha) (ANGRAU).
- Three sprays of dimethoate @ 1.45 ml/lit at fortnightly interval were significantly superior over other treatments in suppressing the safflower aphid population (4.4 aphids/5 cm apical twig) on non-spiny variety of safflower and increased the yield (11.2 q/ha). The treatments with *M. anisopliae* and NSKE 5% were statistically comparable with the superior treatment in respect of safflower yield (MPKV).
- In groundnut, the incidence of *S.litura* in SINPV treatment (0.9) was on par with the insecticidal treatment (0.7). In case of hairy caterpillars, insecticide treatment recorded the lowest pest incidence (0.1) followed by Bt (0.4) and NSKE (0.6).
- Three sprays of SINPV @ 250 LE/ha ( $1.5 \times 10^{12}$  POBs/ ha) was significantly superior in suppressing the larval population of *S. litura* (3.0 larvae/m row) with 78.5 per cent mortality due to virus infection and gave maximum of 21.6 q/ha yield of soybean (MPKV).

### Tobacco

- No invasive pests were recorded from tobacco eco system.
- Survey on Orabanche parasite recorded no natural enemies or diseases

### Coconut

- Moderate incidence of *Opisina arenosella* in coconut was noticed in Puthiyavila (Trivandrum) with leaf infestation of 59.6% and population of 141/100 leaflet.
- Regular monitoring and release of stage specific parasitoids resulted in 55.7% reduction of leaf damage and 94% reduction in pest population over a period of 8 months. Outbreak of *O. arenosella* was also noticed in Kallara (Kottayam) region during August 2012 with leaf infestation of 83.4% and pest population 288/100 leaflets.
- Systematic monitoring and release of larval parasitoids viz., *Goniozus nephantidis* and *Bracon brevicornis* could reduce leaf damage (42%) and pest population (93%) in a period of seven months (CPCRI).

- The local isolate *H. indica* was found to be more virulent inducing 92.5% mortality of red palm weevil grubs @ 1500 infective juveniles (IJ) /grub (CPCRI).

## 5. BIOLOGICAL SUPPRESSION OF PESTS OF FRUIT AND VEGETABLE CROPS, POLYHOUSE CROP PESTS AND STORAGE PESTS

### Fruits

- *Metarhizium anisopliae* @  $1 \times 10^9$  spores/ml reduced population of hoppers on mango effectively. *M. anisopliae* treatments recorded 2.6-2.7 hoppers/inflorescence. The chemical spray however recorded the least population (0.5 hoppers/inflorescence), while the control recorded maximum population (6.3 hoppers/inflorescence) (ANGRAU).
- Spraying of *M. anisopliae* @  $1 \times 10^9$  spores/ml during off season in the month of December followed by four sprays of the pathogen mixed with adjuvant (sunflower oil 1 ml/lit + Triton- X 100 @ 0.1 ml/lit) at weekly interval during flowering was significantly superior over other treatments in suppressing the hopper population and increased fruit setting. The mean surviving population was recorded as 10.4 hoppers and 12.1 fruit set per inflorescence in this treatment as against 52.1 hoppers and 6.0 fruits set of mango per inflorescence in untreated control block (MPKV).
- Two releases of *Scymnus coccivora* @ 10 grubs per infested tree at monthly interval during July-August 2012 were found to be significantly superior in suppressing the population of *M. hirsutus* (9.8 mealy bugs/fruit) and *F. virgata* (3.3 mealy bugs/fruit) in custard apple orchards and increased yield of marketable fruits (34.1 kg/tree). It was, however, on par with similar releases of *Cryptolaemus montrouzieri* @ 5 grubs per infested tree. The pest intensity rating was recorded low (1.0-1.1) in orchards with these treatments (MPKV).
- Economic analysis of biological control of papaya mealybug with the release of parasitoid *Acerophagus papayae* in farmer's fields in papaya, tapioca and mulberry resulted in a saving of Rs 714.55 crores during 2012-13. The savings from papaya, tapioca and mulberry are 59.95, 514.5 and 140 crores, respectively (TNAU).
- Stem injection of EPN resulted in significant reduction of *A. versteegi* infestation. Lowest infestation of 1.13 trunk borer/ plant was recorded in CAUH-1 during July and 0.87trunk borer/plant in NBAlI-01 and CAU-1 in August. No significant difference was observed in trunk borer infestation between the different EPN collections during August. Similarly at Ringing, significantly lower infestation of trunk borer was observed in all the EPN collections than the untreated control during July and August except NBAlI-01 (1.47 trunk borer/ plant) during July and CAU-2 (1.13 trunk borer/ plant) during August (CAU).
- Two sequential releases of *Trichogramma* spp. @ 2500- 3000 adult wasps/ tree and twice use of pheromone traps @ 4 traps/ orchard were made during the year 2012. Average apple fruit damage (on tree + dropped) in treated orchards ranged between 56.8 and 70.2 per cent, as compared to 79.5 per cent in untreated control. Average catch of codling moth per trap during June and July ranged 119.8 and 41.6 respectively. In terms of per cent reduction in

damage over control, treatment T<sub>3</sub> (use of *Trichogramma* + pheromone) was found superior to both T<sub>2</sub> (traps only) and T<sub>1</sub> (use of *Trichogramma* only) (SKUAST).

- Evaluation of entomopathogenic fungi and EPNs for the suppression of Apple root borer, *Dorysthenes hugelii* under field conditions revealed that chlorpyrifos (0.06%) gave highest grub mortality (86.4%) followed by (74.4%) by *Metarhizium anisopliae* (10<sup>6</sup> conidia/cm<sup>2</sup>). Other biopesticides like *Beauveria bassiana* (10<sup>6</sup> conidia/cm<sup>2</sup>), *Heterorhabditis indica* and *Steinernema carpocapsae* (80 IJ/cm<sup>2</sup> each) were moderately effective against apple root borer resulting in 34.0, 45.9 and 34.9 per cent mortality of the grubs, respectively, as against 8.5 per cent in untreated control (YSPUHF).
- Testing of predatory mite, *Neoseiulus longispinosus* along with HMO, NeemBaan and fenazaquin against phytophagous mites of apple was conducted on 2-3 year old trees. Three sprays of fenazaquin (0.0025%) at three weeks interval was the most effective showing an average mite population of 2.4 mites/leaf. Three releases of *N. longispinosus* at three weeks interval and HMO (1.0%) + 2 releases of *N. longispinosus* were statistically on par with fenazaquin (0.0025%) (YSPUHF)

## Vegetables

- In BIPM package in cabbage, the population of *Pieris brassicae* and DBM significantly reduced from 2.45 to 1.34 and 4.85 to 1.94 whereas in farmers practice they were 2.6 to 1.4 and 4.65 to 1.97, respectively after 55 DAT (third spray) (AAU-J).
- Dipel spray was better in reducing the number of larvae of *P. brassicae* (4.9 larvae/ plant) on cauliflower and it was significantly on par with quinalphos (5.8 larvae/ plant) (PAU).
- Comparison of *T. chilonis* and *T. brassicae* in terms of reduction of DBM larvae after each release indicated significant difference between the two species used. Overall per cent decline in larval density caused by *T. chilonis* and *T. brassicae* was 33.7 and 20.1, respectively which indicated the supremacy of *T. chilonis* over *T. brassicae* against DBM on Knol khol (SKUAST).
- One round of spray of profenophos recorded lowest population of DBM (0.02 larvae/leaf) followed by EPN (CAUH-I), Bt (NBAlI) and EPN (CAU-I). Among the entomopathogenic microbes, Bt (NBAlI) recorded the lowest population (0.22 larvae/leaf). *M. anisopliae* was found as least effective (CAU).
- Six releases of *T. pretiosum* thelytokous strain @ 1 lakh parasitoid/ha at weekly interval was significantly superior in suppressing *H. armigera* (1.9 larvae/10 plants) and increasing marketable fruit yield of tomato (223.5 t/ha) compared to arrhenotokous strain of the parasitoid. The parasitism was higher in thelytokous (56.2%) than arrhenotokous (46.5%) strain of the parasitoid (MPKV).
- BIPM module consisting release of *T. chilonis* followed by spraying of NSKE 5% and Bt @ 1 lit./ha twice at weekly interval was the next best treatment showing 9.9% shoot and 15.3% fruit infestation by *L. orbonalis* with 42.5% parasitism (MPKV).
- BIPM treatment was on par with rynaxypyr in all locations recording 11.4 to 12.8% shoot borer incidence as against 29.3 to 29.9 % in untreated control. The control plots recorded 36.0 to 39.7% fruit damage (OUAT).

- Three sprays of profenophos at fortnightly interval were found significantly superior to other treatments in suppressing thrips on onion (3.1 thrips/plant) with 1 rating of intensity of white patches. However, 3 sprays of *M. anisopliae* @  $10^8$  cfu/ml which showed av. 7.5 thrips/plant and 1.5 rating of white patches on leaves was the next best treatment in this respect (MPKV).
- In brinjal release of *B. palleescens* @ 10 per plant recorded 110.40 mites/10 plants which was far superior as the untreated plots recorded 765.80 mites/10 plants. Maximum webbings/10 plants were observed in control plots (29.75) followed by predator released plots at 30, 20 and 10 *B. palleescens*/10 plants, respectively (OUAT).
- In okra release of *B. palleescens* @ 10/plant recorded 151.30 mites/10 plants which was far superior compared to untreated plots (326.8 mites/10 plants). Maximum webbing/10 plants was observed in control plots (21.4) followed by *B. palleescens* released plots at 30, 20 and 10 /10 plants, respectively (PAU).
- Among the different bioagents and botanicals evaluated, the mean per cent reduction in aphid population in mustard was more in 2 sprays of NSKE 5% (54.82), which was statistically at par with 2 sprays of *Veticilium* sp. (52.58) However, 2 sprays of imidacloprid was most effective in mean per cent reduction (79.74) of *L. erysimi* population at 7 days after 2<sup>nd</sup> spray and yielded 9.52, 9.44, 10.85 q/ha, respectively over control 6.20 q/ha (MPUAT).

### Polyhouse crop pests

- Release of coccinellid beetle, *Stethorus pauperculus* and predatory mite, *Amblyseius* sp @ 10 and 5 mites/ plant were effective in reducing two spotted spider mite, *Tetranychus urticae* in carnation which were on par, followed by *Beauveria bassiana*  $10^8$  CFU/ ml spray. The highest yield of 2465 numbers of flush/ plot were recorded in abamectin treated plot followed by *Stethorus*, *Amblyseius* sp, *Beauveria bassiana* biocontrol plots (TNAU).
- Three releases of predatory mite, *Neoseiulus longispinosus* at 1:10 predator: prey ratio resulted in 73.8% which was on par with profenophos (0.05%) treatment (YSPUHF).
- The effectiveness of biological control agents Entomopathogens and predator *B. palleescens*, botanicals, and chemicals were carried out against *S. dorsalis* on capsicum F1 hybrid, Indra. Results indicated no increase in the rating of thrips in all treatments while in control it recorded 2.6 (ranged from 1.0 to 5.0 rating) (IIHR).
- In a pot trial conducted to evaluate the fungal biocontrol agent *Paecilomyces lilacinus* and chemical, abamectin against root-knot nematode *Meloidogyne hapla* infesting tomato cv. Shalimar 1, a significant reduction in soil population of nematodes was observed in treated seedlings as compared to untreated. Highest reduction in soil population of nematodes was 85% in *P. lilacinus* ( $2.0 \times 10^8$  spores/ lit of water) followed by Abamectin (1.0 ml/ lit of water) where it was 78.0% (SKUAST).

### Storage Pests

- Inoculative release of *Xylocoris flavipes* @ 30 nymphs per kg of stored rice (18.00 moths/ container) was significantly superior to all other treatments in reducing the emergence of *Corcyra* moths. However, *B palleescens*, @ 30 nymphs/container and *X. flavipes* @ 10

nymphs / container were on par with each other where 32.5 and 36.0 moths emerged respectively from these treatments (AAU-J)

## PROCEEDINGS OF THE TECHNICAL SESSIONS

The results of the experiments from each centre were presented through six sessions. In the VI<sup>th</sup> session on Institute-industry/Public private partnership, Dr.S.Sithanantham Sun Agro, Chennai, Dr. Mohan, Monsanto, Bangalore, Dr. Ghosh, BCRL, Bangalore, Dr.Jeyabal & Ms. Poovarasi, Rajashree Sugars, Villupuram discussed about the critical needs of industry and the need for collaboration with research institutes. The meeting concluded with a plenary session chaired by **Dr. C.A. Viraktamath**, consultant on Insect taxonomy, UAS (B) and co-chaired by **Dr. T. P. Rajendran**, ADG (PP) and **Dr. A. Verghese**, Director, NBAII where the thrust areas for biocontrol research in XII Plan and the Technical Programme for 2013-14 & 2014-15 for various AICRP centers were finalized.

### SESSION 1

#### BASIC RESEARCH

Chairman : **Dr. T. P. Rajendran**, ADG (PP), ICAR, New Delhi  
Co- Chairman : **Dr. Abraham Verghese**, Director, NBAII, Bangalore Bangalore  
**Rapporteurs:** : **Dr. Sunil Joshi**, NBAII, Bangalore  
: **Dr. R. Rangeshwaran**, NBAII, Bangalore

#### Speakers and Topics :

**Dr. T. Venkatesan** : Parasitoids & Predators  
**Dr. P. Sreeramkumar** : Entomopathogens and Endosymbionts

#### Recommendations

1. Data on interaction of Eucalyptus gall wasp with native parasitoids may be generated (NBAII; Dr. A.N. Shylesha).
2. It was felt that endosymbionts associated with endosulfan and high temperature tolerant insects need to be studied (NBAII; S.K. Jalali & T. Venkatesan)
3. There is a need for constitution of a panel of senior systematists at NBAII for validating reports of new species and for following proper nomenclature rules. Also it is necessary to obtain prior consent before naming a species after a personality (NBAII; Prashanth Mohanraj) .
4. Entomopathogenic fungi like, *Beauveria bassiana*, *Metarhizium anisopliae* & *Nomuraea rileyi* of NBAII may be tested on soybean pests with emphasis on *Helicoverpa armigera* (NBAII; B. Ramanujam, DSR; Y. Sridhar)
5. Data required for registration under 9.3 section for the Bt Formulation developed at NBAII may be generated and the promising Bt strains of NBAII may be deposited and registered at NBAIM Mau (NBAII; R. Rangeshwaran)

6. Studies on the interaction of *Quadrastichus mendeli* and *Megastigmus viggiani* may be taken up at NBAII (NBAII; Dr. A.N. Shylesha)



## Session II

### Basic Research; Biological control of plant diseases and PPNs

**Chairman** : Dr. B. S. Bhumannavar, NBAII, Bangalore

**Co- Chairman** : Dr. Rajan, ICAR, New Delhi

**Rapporteurs** : Dr. G. Sivakumar, NBAII, Bangalore

Dr. M. Neelam Joshi, PAU, Ludhiana

#### Speakers and Topics:

**Dr. A. K. Tiwari** : Field Evaluation of Antagonists for plant disease management

**Dr. M. Nagesh**: Biocontrol of PPN (AICRP work) & Basic work on EPN (NBAII work)

#### Recommendations

1. *Trichoderma harzianum* strain Th-17 was reported as an effective antagonist for the management of sheath blight of rice and *T. harzianum* strain Th 3 as an effective antagonist for the management of root rot and wilt disease of chickpea. These two strains have to be included in the package of practices of the university and should be made available to the farmers (GBPUAT, Pantnagar).
2. Taxonomic studies may be intensified for resolving the identity of different species of EPNs using standard morphological characters and morphometrics/molecular characterization (NBAII; M. Nagesh)
3. The large scale field demonstrations of EPN against the grubs of *Myloccerus* sp. may be taken up at multilocations.

### **Session III**

#### **Biological Suppression of pests of Sugarcane, Cotton, Rice & Maize**

**Chairman** : Dr. M. Mani, Emeritus Scientist, NBAII, Bangalore

**Co- Chairman** : Dr. R.S. Tripathi, PC, AICRP-Rodent control, Jodhpur

**Rapporteurs** : Dr. Ankita Gupta, NBAII, Bangalore  
Dr. Anitha, ANGRAU, Hyderabad

#### **Speakers and Topics:**

**Dr. Naveen Aggarwal, PAU, Ludhiana** : Sugarcane  
**Dr. Pokharkar, MPKV, Pune** : Cotton  
**Dr. M. Mohan, NBAII, Bangalore** : Rice & Maize

#### **Recommendations**

1. The results of the field experiments are to be reported uniformly by the respective centers as per the Technical Programme (All AICRP Centers)
2. Attempts should be made to explore mired bug species infesting cotton (Centers dealing with Cotton)
3. The data on termite experiment should be presented more systematically with mention of appropriate species of termites involved (Centers dealing with termite experiments)

**Session IV**  
**Biological Suppression of Pests of Pulses, Oilseeds, Tobacco and Coconut**

**Chairman** : Dr. A. K. Chakravarthi, HOD, Ent, UAS(B)

**Co- Chairman** : Dr. Pokharkar, MPKV, Pune

**Rapporteurs:** Dr. M. Mohan, NBAII  
Dr. Chandrika Mohan, CPCRI.

**Speakers and Topics:**

Dr. M. Kalyanasundaram, TNAU, Coimbatore : Pulses & Oilseeds

Dr. M. Mohan, NBAII, Bangalore : Tobacco

Dr. Chandrika Mohan, CPCRI, Kayangulam : Coconut

**Recommendations**

1. Seasonal incidence on natural enemies of pests of oilseeds and pulses should be recorded (All centres dealing with oilseeds and pulses)
2. Uniformity in recording observations and presentation of properly analyzed results while conducting the same trial at different centers (All centres dealing with oilseeds and pulses).
3. Nil data has been reported on all the experiments allotted under tobacco. It was suggested that proper experiments should be laid out to record the data on natural enemies of tobacco pests. Experiment on tobacco intercropping system also stressed to record natural enemies (CTRI).
4. Participation of some more centers on biological control of coconut pests was suggested. OUAT centre may take up work on coconut black-headed caterpillar (OUAT)
5. Validation of EPN against red palm weevil under field conditions may be taken up (CPCRI)

## Session V

### Biological Suppression of Pests of Fruit and Vegetable Crops, Polyhouse crop Pests, Storage Pests and Weeds

**Chairman:** Dr. P. Parvatha Reddy, Ex-Director, IIHR, Bangalore

**Co- Chairman:** Dr. A. Krishnamoorthy, Head (Ento.), IIHR, Bangalore

**Rapporteurs:** Dr.T. Venkatesan, NBAII, Bangalore & Dr. Vidhya, KAU, Trissur

#### Speakers and Topics:

Dr. Ganga Visalakshy, IIHR, Bangalore: Tropical fruits, Mealybugs & Tea Mosquito bug

Dr. Jamal Ahmad, SKUAST, Srinagar: Temperate Fruits

Dr. Lyla, KAU, Trissur : Vegetables

Dr. Usha Chauhan, YSPUHF, Solan : Polyhouse crop pests, Storage pests & Weeds

#### Recommendations

1. Cost benefit ratio may be worked out in the centers where *Metarhizium anisoliae* is used on mango leafhoppers in order to help commercialization (IIHR, TNAU, MPKV & ANGRAU).
2. Parasitisation level by *Acerophagus papayae* on alternate hosts may be worked out (All centres dealing with PMB)
3. Cultures of *A. papayae* need to be maintained by all AICRP centers working on papaya mealybug (All centres dealing with PMB)
4. State wise annual economic gain due to the biological control of papaya mealybug may be provided by centres working on PMB (All centres dealing with PMB).
5. Before field release of exotic parasitoid *Anagyrus kamali*, it may be compared with the local populations of *A. kamali* on biosystematics, efficacy, host range etc (NBAII; A.N. Shylesha).

## Session VI

### Institute – Industry Partnership

**Chairman:** Dr. R. Ramani, Director IING&R, Ranchi

**Co-Chairman:** Dr. J. Kumar, Dean, GBPUAT, Pantnagar

**Rapporteurs:** Dr. T. Venkatesan, NBAII & Dr. Gangavishalakshi, IIHR

**Speakers:** Dr.S. Sithanantham Sun Agro, Chennai

Dr. Mohan, Monsanto, Bangalore

Dr. Dr. Ghosh, BCRL, Bangalore

Dr.Jeyabal, Rajashree Sugars, Coimbatore

Ms. Poovarasi, Rajashree Sugars, Villupuram

### Recommendations

1. Specific researchable issues/opportunities suggested by the industry to be compiled and taken up by the concerned research institute.
2. Research in partnership mode with industry from conception to commercialization to be taken up.
3. Regular mechanism of partnership between SAUs and ICAR institute – industry for researchable issues, generating evaluation data, production statistics, manufacturers information etc. to be taken up.

## **Session VII**

### **Plenary Session & Formulation of Technical Programme**

**Chairman: Dr. Viraktamath**

**Co-Chairman: Dr. T.P. Rajendran and Dr. Abraham Verghese**

**Rapporteurs: Dr. A.N. Shylesha and Dr. Ramanujam.**

The recommendations of each session was discussed and the changes suggested were incorporated in the session recommendations. The Technical Programme for different centers of AICRP on Biological Control of Crop Pests & Weeds for the year 2013-15 was discussed thoroughly and has been finalized and given as Annexure-II.

#### **General Recommendations:**

1. While compiling the data, there should be a synthesis of results of work done across India. The compiled data should be meaningfully interpreted.
2. The quality of slides presented by some centers were poor and should be improved.
3. Standardized methodology for experimentation has to be followed and the experiments should be self explanatory
4. Proper monitoring of the experiments to be done by a competent team.

## TECHNICAL PROGRAMME 2013-14 & 2014-15

### I. BIODIVERSITY OF BIOCONTROL AGENTS FROM VARIOUS AGRO ECOLOGICAL ZONES

#### AAU-A:

1. Survey, collection & diversity analysis of spiders in arid zones of India
2. Mapping of EPN diversity in Gujarat

#### AAU-Jorhat

1. Survey, collection & diversity analysis of *Trichogramma*, *Chrysoperla*, coccinellids, Spiders, anthocorids, entomopathogens

#### ANGRAU

1. Survey, collection and diversity analysis of *Trichogramma*, *Chrysoperla*, *Goniozus* and *Braconid* species, *Cryptolaemus*, Spiders, entomopathogens

#### KAU

1. Survey and collection of natural enemies of banana weevil and banana aphid, pollu beetle and root mealybug of pepper, Entomopathogens

#### MPKV, Pune

1. Survey and collection of natural enemies of *Trichogramma*, *Chrysoperla*, *Cryptolaemus*, spiders, entomopathogens

#### PAU, Ludhiana

1. Natural enemy complex of rice yellow stem borer & leaf folder, cotton aphids & cotton mirid bug, onion thrips
2. Mapping of EPN diversity in Punjab & Haryana

#### SKUAST- Srinagar

1. Survey and collection of natural enemy complex of pests of apple (stem borer, San Jose scale, mite & other pests), apricot (borer from Ladak and other pests), plum, pear, peach, cherry, walnut and almonds

#### TNAU

1. Survey and collection of natural enemies of coconut black headed caterpillar, *Trichogramma*, *Chrysoperla*, *Cryptolaemus*, spiders

#### YSPUHF

1. Survey and collection of natural enemies of *Trichogramma*, *Chrysoperla*, predatory mites *Coccinellids*, spiders, entomopathogens

#### CAU

1. Survey and collection of *Trichogramma*, *Chrysoperla*, *Cryptolaemus*, entomopathogens

#### MPUAT

1. Survey and collection of *Trichogramma*, *Chrysoperla*, *Cryptolaemus*

**OUAT**

1. Survey and collection of natural enemies of coconut black headed caterpillar, *Trichogramma*, *Chrysoperla*, spiders from rice

**UAS- Raichur**

1. Survey and collection of *Trichogramma*, *Chrysoperla*, *Cryptolaemus*

**CPCRI**

1. Survey and collection of natural enemies of coconut black headed caterpillar, eriophid mite, red palm weevil

**CTRI**

1. Survey and collection of spiders and parasitoids in tobacco intercropping systems

**IARI**

1. *Trichogramma* strains from different agroclimatic zone of India

**Dir. Soybean Research, Indore**

1. Survey and collection of natural enemies of soybean pests

**IIVR**

Survey, collection and identification of mealy bug infesting major vegetable crops and its natural enemies

**CISH**

1. Survey and collection of natural enemies of mango pests

**Directorate of Sorghum Research, Hyderabad**

1. Survey and collection of natural enemies of sorghum pests

**Directorate of Rice Research, Hyderabad**

1. Survey and collection of natural enemies of rice pests

**For All Centres:**

- As per ICAR instructions, all centres should additionally collect at periodic monthly intervals all insects of their agro-ecosystems, and send curated labelled specimens to the NBARI repository (please refer methodologies on page 29).
- For biodiversity analysis, Dr. M. Pratheepa, Scientist (SS), Computer applications, NBARI may be contacted (mpratheepa.nbari@gmail.com) 080-2351 1982 Extn. 340



## Methodologies for Collection & Diversity studies

### 1) *Trichogramma*

Ten geographical populations to be collected by each centre from different crop eco-systems by placing sentinel cards with eggs of *Corcyra cephalonica*/ original host eggs. Eggs of insect pests may also be collected from different crops and maintained for the emergence of *Trichogramma*. In the event of *Trichogramma* emerging from these eggs, they may be supplied with freshly laid, UV treated *Corcyra* eggs for parasitisation. Freshly parasitized eggs/ live *Trichogramma* with UV treated *Corcyra* eggs should then be sent by speed post in suitable aerated containers to NBAII, Bangalore.

The cultures are also to be maintained at the respective centres from where they are collected for their own studies. Dead *Trichogramma* are to be preserved in 70 per cent alcohol and sent to NBAII, Bangalore for identification (**All Centres**).

*Trichogramma* are to be collected from different crop eco-systems, in particular rice, sugarcane, cotton, castor, cashew, tea, ground nut, castor, maize, sunflower.

Protocol for collection of *Trichogramma* and other egg parasitoids:

*Trichogramma* and other egg parasitoids

- a) Put sentinel cards of *Corcyra* egg in the field. Make egg cards with about 100 eggs/card and put cards in the entire field, about 6 cards well distributed. Collect back all 6 cards after 24h of field exposure and record parasitism. Repeat this exposure method once in a fortnight for entire cropping season. Maintain emerged parasitoids on *Corcyra* eggs and ship both live and dead specimens to NBAII, Bangalore for repository maintenance and correct identification.
- b) Collect eggs/egg masses wherever possible at fortnightly intervals. Collect at least 20 eggs/ 5 egg masses each time. Observe for parasitism. Maintain emerged parasitoids on *Corcyra* eggs in the laboratory. Collection to be done for entire cropping season.

All egg parasitoids are to be preserved in 70% ethyl alcohol along with data on host plant, insect host, date and place of collection and sent by post to Dr. K. Veena Kumari, Principal Scientist NBAII.

### 2) *Chrysoperla*

Five geographic populations (at least 20 in each population) are to be collected by each centre and live individuals (eggs/larvae/adults) are to be sent by speed post to NBAII, Bangalore in proper aerated containers (**All Centres**).

Blister trays will be supplied by BCRL for isolating the larvae of chrysopids individually (to avoid cannibalism) when being despatched by post.

### 3) *Goniozus* and Braconid species

Five geographical populations are to be collected by those centres in coconut growing areas and live individuals are to be sent by speed post to NBAII, Bangalore

### 4) *Cryptolaemus*

Five geographical populations are to be collected by each centre and live individuals (eggs/larvae/adults) are to be sent by speed post to NBAII, Bangalore. Blister trays will be

supplied by BCRL for confining the larvae of *Cryptolaemus* individually (to avoid cannibalism) when being despatched by post.

### **5) Entomopathogens**

The cadavers of insects infected by entomopathogens are to be collected in dry sterile vials and sent to NBAIL, Bangalore by speed post for identification.

### **6) Spiders**

#### **Methodology for spider collection and preservation**

##### **a) Pitfall Trap method**

10 plastic traps having 10.5 cm diameter and 11 cm depth may be placed with bottom in the soil and mouth at the surface level, containing 5% formaldehyde solution as a preservative filling the bottom of it up to 2 cm height per trap.

Traps should be placed equi-distant from each other.

The spiders and insects falling in the trap should be collected twice a week, washed with D/W and preserved in 70% ethyl alcohol with proper labelling of trap number and date.

##### **b) General collection**

1. The area should be surveyed extensively to collect specimens from all the types of habitats such as roots of grasses, dry hay and grasses, moist places under stones, pebbles, dead leaves, humus, bushes, on the bark and branches of trees, water logged localities, houses and huts, etc.
2. Collections should be made by hand picking or directly into the specimen tubes of 7.2 X 2.5 cms size with screw caps.
3. Stones and logs should be removed and searched for.
4. Web builders can be easily located.
5. In some cases spiders can even be traced out in their retreats made on the lower side of leaf connected by a radial thread, sometimes in the dried crumpled leaf hanging on the threads of the broken orb.
6. The branches of trees should be beaten and jerked with stick to collect the spiders hanging with the silken thread and trying to go up.
7. The bark on the tree trunk should also be searched for.
8. Even the dried bark of dead trees should be peeled off to search for spiders.
9. The holes and gaps on the tree trunks, gaps and crevices on and under the boulders should also be searched for the spiders.
10. All such spiders found were collected and transferred into the specimen tubes.
11. Spiders thus collected should be kept alive, each specimen in a separate tube, as most of the species are cannibals by nature. As soon as the collections are over, the spiders should be killed and preserved in 70% ethyl alcohol.
12. All such specimens should be kept collectively in the tubes properly labeled with date, locality and other notes of importance.
13. After two to three days, the preservative of the tubes should be changed with the fresh one.
14. These specimens should then be sent to NBAIL, Bangalore.

## 7) **Insect-derived EPNs**

- Collect 250cc soil samples during wet season from different areas of survey (root zone depth) and place in plastic containers with lid and send one set of soil samples to NBAII and the other set of soil samples can be used for isolation of EPN by the centres.
- Place 5 healthy 5<sup>th</sup> instar *Galleria* or *Corcyra* larvae at the bottom of containers before filling the samples.
- Examine the larvae for mortality at 24h intervals for 7 days.
- Separate the cadavers from soil and label the samples.
- Preliminary identification of cadavers with EPN: Cadavers do not putrify and do not rot. Cadavers look reddish brown in colour in case of *Heterorhabditis* and creamy white in case of *Steinernema* infection.
- Segregate such cadavers, place in 50cc soil in a plastic container/polythene bag, label and parcel to NBAII for correct identity, recover live EPN and catalogue the natural biodiversity of insect-derived EPN.
- Similarly, collect cadavers of insect larvae/grubs from field during ploughing and field preparation before planting for collecting the natural EPN populations.

## 8) **Soil samples for isolation of antagonistic organisms**

Samples of 250g soil are to be collected and sent to NBAII, Bangalore. Samples have to be sent for the isolation of the antagonists for the management of soil borne disease. Soil samples should be collected from a field where the pathogen is known to be present but disease occurrence is low. Soil should be collected to a depth of 15 cm in the upper surface including rhizosphere and rhizoplane. The rhizosphere soil has to be collected from different places (5-6) in a field and a composite sample has to be thoroughly mixed and 250g sample has to be sent.

## 9) **Anthocorids**

Search for anthocorid predators on thrips and mite-infested host plants. Collect the adult and nymphal stages. Place in pearlpet containers with the host insects on host plant materials. Additionally provide *Corcyra* or *Sitotroga* eggs (for feeding), french bean pieces and cotton strands (for oviposition). Fresh eggs and bean pieces to be provided on alternate days. The dead adults and the bean pieces/host plant materials/cotton strands (containing the anthocorid eggs) to be sent to NBAII in aerated boxes by speed post for identification.

## 10) **Isolation of native *Bt* isolates from soil**

Isolation of *Bacillus thuringiensis* is done according to the method.

- i. One gram of soil sample was suspended in 10 ml sterile distilled water.
- ii. They were heated for some time.
- iii. One ml of each sample was added to 10 ml of Luria Bertani broth buffered by 0.25M sodium acetate PH 6.8.

- iv. The suspension was incubated at 30°C for growth and then heated to 80 °C again for a short time.
- v. Resulting suspension was serially diluted up to 10<sup>-6</sup>. Dilutions 10<sup>-5</sup> and 10<sup>-6</sup> are serially diluted on T3 agar plates and kept for incubation at 28°C - 30°C for 3 days or 5 days.
- vi. Cream coloured colonies represented by fried egg shaped appearance.
- vii. Smears were made on glass slides and Amidoblack staining was done.
- viii. Slides were observed under light microscope at 100X magnification to observe the parasporal crystals of the bacterium.

For isolation of *Bacillus thuringiensis* from the dead larvae was also done by the same process except the pre pasteurization step.

**The information should be collected as given below for diversity analyses of natural enemies complexes**

**Name of Insect/ microbial agent:**

|  |  |
|--|--|
| <b>Geographical &amp; other details</b>                                  |  |
| Scientific name of the insect/ <b>microbial agent</b>                    |  |
| Common name of the insect  |  |
| Location   |  |
| Taluk, District & Agro-climatic zone                                     |  |
| Distance from the HQ   |  |
| Date of survey   |  |
| Host crop/ sole crop/ intercrop/ etc.                                    |  |
| Stage of the crop  |  |
| Stage of the insect  |  |
| Weather parameters recorded (max, min temp; rainfall, no. of rainy days) |  |
| GIS data   |  |
| Pesticide usage pattern  |  |

### **11) Surveillance for alien invasive pests in vulnerable areas (all centres)**

**a. *Brontispa longissima***

**b. *Aleurodicus dugesii***

**c. *Phenacoccus manihoti***

**d. *Paracococcus marginatus***

**e. *Phenacoccus madeirensis***

**f. Alien invasive pests of fruits and vegetables in the market yards.**

**g. Others**

## II. BIOLOGICAL SUPPRESSION OF PESTS AND DISEASES IN FIELD

### 1. PLANT DISEASES AND NEMATODES

#### 1. Development of cost-effective WP/EC-based *Trichoderma* (Th-14) formulations and delivery system to increase longevity and efficacy under field conditions (GBPUAT)

**Crops: Rice and chickpea.**

##### **Methodology:**

- *Trichoderma* isolate (Th-14) will be mass multiplied on modified solid substrate and / or on modified liquid media to get higher CFUs. The medium found best in terms of yielding high CFUs would be used for the mass multiplication of the bioagent (1<sup>st</sup> year).
- Different formulations (WP/EC) will be prepared using different carriers and adjuvants to increase the shelf-life of *Trichoderma* (upto 1 year with a CFU of 10<sup>7</sup>) during storage: at 28-30<sup>0</sup>C and at 4<sup>0</sup>C (1<sup>st</sup> year).
- Formulations found good in their shelf-life would be tested under field conditions for their efficacy to improve crop health (2<sup>nd</sup> year).

##### **Observations to be recorded:**

- i. CFU/spore concentration in different modified solid and liquid media (10-15 days after incubation)
- ii. Shelf-life (viability) of *Trichoderma* in different formulations at 1 month interval up to 1 year during storage at 28-30<sup>0</sup>C and at 4<sup>0</sup>C
- iii. Plant stand/mortality in chickpea (45 & 90 DAS)
- iv. Disease incidence/severity
- v. Yield (q/ha)
- vi. *Trichoderma* population in rhizosphere and rhizoplane at 0, 45, 90 DAS

#### 2. Identification, evaluation and exploitation of ISR activity of PGPR against spot blotch of wheat under controlled conditions (GBPUAT)

##### **Crop: Wheat**

**Disease: Spot blotch (*Drechslera sorokiniana*)**

**Bioagent: PGPR (*Pseudomonas* spp.)**

**Method of application:** Seed biopriming (10g/kg seed) followed by soil drenching (10g/lit. water) 4 days before pathogen inoculation

##### **Observation to be recorded:**

- i. Estimation of biochemical parameters related to ISR activity: Proline content, Hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>), Total phenolics, Peroxidase activity, Polyphenol Oxidase activity (PPO), Phenylalanine ammonia lyase activity (PAL) and Superoxide dismutase activity will be evaluated from 0 days i.e. before inoculation for 1 week at 24 hrs interval

ii. Percent disease severity

### 3. Selection and promotion of plant growth promoting *Trichoderma* isolates for crop health under sustainable agriculture (GBPUAT)

**Crop: rice, wheat, mustard and chickpea**

#### **Methodology:**

- Isolation and purification of *Trichoderma* from rhizosphere and rhizoplane of wheat, mustard, chickpea and rice.
- Screening of *Trichoderma* isolates for their growth promotion effect *in vitro* (towel paper method) and *in vivo* (glasshouse conditions) in their native crop (1st year).
- Selection of best *Trichoderma* isolate from each crop and further evaluation in all the four crops for their growth promoting effect (2nd year).
- Evaluation of selected *Trichoderma* isolates for their antagonistic potential against some important plant pathogens (*Rhizoctonia*, *Fusarium*, *Sclerotinia*, *Sclerotium*, *Drechslera*, *Alternaria* etc) *in vitro* (2nd year).

#### **Method of application:**

- Seed bioprimering (10g/kg seed)
- Soil application (@10g/kg vermicompost)
- Spray (@10g/lit.) at 10 DAS

#### **Observation to be recorded:**

- i. Radical and plumule length (Towel paper method)
- ii. Plant vigour (shoot length & weight, root length & weight, total plant weight) at 1 month after sowing (Glasshouse)
- iii. Per cent growth inhibition of the fungal pathogens (Dual culture)

### 4. Field evaluation of promising *Trichoderma* isolates for the management of soil-borne and foliar diseases (GBPUAT)

Selected promising strains of GBPUAT and NBAII will be tested.

**Crops:** rice, chickpea, lentil

**Plot size:** 10m<sup>2</sup>

**Treatment:** 19 *Trichoderma* isolates will be selected and used as Talc based formulation along with control i.e. without any *Trichoderma* formulation.

**Mode of application:** soil application with *Trichoderma* enriched FYM/vermicompost (1kg formulation/100kg FYM or vermicompost/acre) seed treatment (@10g/kg seeds), seedling dip treatment @ 10g/lit. For rice (12 hours before transplanting) and foliar spray (30 & 60 DAS).

#### **Observations to be recorded:**

- i. Plant stand/mortality in chickpea and lentil (45 & 90 DAS)
- ii. Disease incidence/severity
- iii. Rhizosphere and rhizoplane population (0, 45 & 90 DAS)
- iv. No. of tiller/hill in rice
- v. Root and shoot weight at the time of harvesting
- vi. Yield

## 5. Large scale field demonstration of biocontrol technologies (GBPUAT)

**Biocontrol agents:** *Trichoderma* and /or *Pseudomonas fluorescens*

**Crops and diseases:** Root and foliar diseases of rice, pea, tomato, capsicum, etc.

**Plot size:** Minimum 100 m<sup>2</sup>

**Area covered under each crop:** 5-10 acre

### **Treatment 1:**

- i. Seed treatment with *Trichoderma* and /or *Pseudomonas fluorescens* (@10g/kg seed)
- ii. Seedling root dip treatment with *Trichoderma* and/or *Pseudomonas fluorescens* (rice, tomato, capsicum) @10g/lit. of water
- iii. Soil application of FYM/vermicompost enriched with *Trichoderma* and /or *Pseudomonas fluorescens* (1kg formulation/100kg FYM or vermicompost/acre)

### **Treatment 2:**

Farmer's practices

### **Observations to be recorded:**

- i. Disease incidence/severity
- ii. Yield

## 6. Dose response of different fungicides with biocontrol agents for seed treatment (GBPUAT)

**Crops: Rice and Chickpea**

### **Methodology:**

- Recommended fungicides will be tested at different concentrations (100, 250 & 500 ppm) *in vitro* for their compatibility with *Trichoderma* (Th-14). The compatible fungicides will be further tested at different doses (1.0, 1.5, & 2.0 g/kg seed) along with *Trichoderma* as seed treatment (1<sup>st</sup> year).
- Application of *Trichoderma* along with compatible fungicides for the management of soil and foliar diseases of rice and chickpea (2<sup>nd</sup> year).

### **Method of application:**

- i. Soil application with *Trichoderma* enriched FYM/vermicompost (1kg formulation/100kg FYM or vermicompost/acre),
- ii. Seed treatment with *Trichoderma* (@10g/kg seeds),
- iii. Seedling dip treatment @ 10g/lit for rice and
- iv. Foliar spray (45 DAS & 60 DAS) along with the compatible fungicide(s).

### **Observations to be recorded:**

- i. Per cent mycelial inhibition (Food Poison technique for compatibility estimation)
- ii. CFU of *Trichoderma* on seed treated with compatible fungicides just after treatment and at 10 days interval up to 1 month, and would be compared with seeds treated only with *Trichoderma*
- iii. Disease incidence/disease severity
- iv. Plant stand/mortality in chickpea 45 & 90 DAS
- v. CFU of *Trichoderma* in rhizosphere and rhizoplane at 0, 45 and 90 DAS

vi. Yield

## 7. Estimation of threshold levels of soil borne plant pathogens for biocontrol efficacy of *Trichoderma* (Th-14) under glasshouse conditions (GBPUAT)

**Crop:** Chickpea

### Methodology:

#### i. Pathogen inoculum:

The soil borne plant pathogens viz. *Fusarium*, *Rhizoctonia* and *Sclerotium* will be multiplied on sorghum grains. The grains colonized by different pathogens will be inoculated into the soil at different doses one week before sowing.

a. **Inoculum dose:** 2g, 4g, 5g & 10g/kg soil.

#### ii. Method of application of *Trichoderma*:

- a. Soil application (@10g/kg vermicompost)
- b. Seed treatment (@10g/kg seeds)
- c. Soil drenching (10 DAS)

### Observations to be recorded:

- i. **Population dynamics:** Soil borne plant pathogens and *Trichoderma*
  - a. Soil (just after sowing), and
  - b. Rhizosphere and rhizoplane (at 15 days interval up to 2 months).
- ii. **Germination:** 10 days after sowing
- iii. **Plant stand/mortality:** at 15 days interval after germination up to 2 month
- iv. **Plant vigour** (root and shoot length & weight at 60 DAS)

## 8. Evaluation of fungal and bacterial antagonists against collar rot of groundnut caused by *Aspergillus* spp. and *Sclerotium rolfsii* (AAU-A)

### Treatments

1. *Trichoderma harzianum* (NBAlI Th 10) talc formulation (seed treatment and soil application)
2. *T. asperellum* (NBAlI Ta 23) talc formulation (seed treatment and soil application)
3. *T. virens* talc (NBAlI Tvs 12) formulation (seed treatment and soil application)
4. *Pseudomonas fluorescens* (NBAlI) talc formulation (seed treatment and soil application)
5. *Trichoderma harzianum* (NBAlI Th 10) invert-emulsion formulation (seed treatment and soil application)
6. Carbendazim (seed treatment)
7. Control

**Seed treatment:** Talc formulation: 10g/kg of seeds, inert-emulsion: 10ml/ kg of seed, carbendazim: 10g / kg of seed

**Soil application:** 100 kg Completely dried FYM enriched with 1kg talc formulation for 1 ac land (according to the size of the plot the amount has to be calculated) Neem cake 5kg for each 100kg of enriched FYM can be mixed



**Replications: 4**

Size of the plot: Minimum of 25 m<sup>2</sup>

The formulations will be supplied by NBAII.

**The observations to be taken**

1. % germination
2. Number of collar rot or root rot affected plants at monthly interval from 30 DAS
3. Yield parameters (number of pods per plant\*, yield per plant\* and yield per plot)  
\* from randomly selected 10 plants per plot
4. Plant growth parameters (root length, shoot length, dry weight of root and shoot at 45 DAS and before harvest)
5. Rhizosphere colonization by *Trichoderma* (by plating 25 root bits collected randomly on *Trichoderma* specific medium)

**9. Management of bacterial wilt different isolates of *Pseudomonas fluorescence* (CAU)****Treatments**

1. Root dip with CAUPF-1 @20gm of 2X10<sup>8</sup>cfu/g in one litre of water and dipping for 30 mins
2. Root dip with CAUPF-3 @20gm of 2X10<sup>8</sup>cfu/g in one litre of water and dipping for 30 mins
3. Root dip with CAUPF-3 @20gm of 2X10<sup>8</sup>cfu/g in one litre of water and dipping for 30 mins
4. Root dip with Su- Mona (*Pseudomonas fluorescence*) @20gm of 2X10<sup>8</sup>cfu/g in one litre of water and dipping for 30 mins
5. Soil drenching with CAUPF-1 (Soil drenching after planting of 50 ml of solution prepared as mixing 20gm of 2X10<sup>8</sup>cfu/g in one litre of water).
6. Soil drenching with CAUPF-2 (Soil drenching after planting of 50 ml of solution prepared as mixing 20gm of 2X10<sup>8</sup>cfu/g in one litre of water).
7. Soil drenching with CAUPF-3 (Soil drenching after planting of 50 ml of solution prepared as mixing 20gm of 2X10<sup>8</sup>cfu/g in one litre of water).
8. Soil drenching with Su- Mona (*Pseudomonas fluorescence*) (Soil drenching after planting of 50 ml of solution prepared as mixing 20gm of 2X10<sup>8</sup>cfu/g in one litre of water).
9. Untreated control.

Experiment will be laid out in RBD with the above treatments and each experiment will be replicated three times. Per cent wilted plants will be recorded at monthly interval. For confirmation wilted plant will be observed for the presence of *Ralstonia solani*.

## 2. SUGARCANE

### 1. Monitoring the sugarcane woolly aphid incidence and impact assessment of natural enemies on its biosuppression (MPKV, TNAU, UAS-Raichur, ANGRAU)

The sugarcane woolly aphid incidence and occurrence of natural enemies (*Dipha aphidivora*, *Micromus igorotus*, *Encarsia flavoscutellum*, syrphid and spider) will be recorded from different agro-ecological zones of Maharashtra, Tamil Nadu and Karnataka and correlated with abiotic factors.

#### Observations:

Record per cent incidence of SWA, pest intensity rating and natural enemies population on leaf at five spots and five clumps/ spot at monthly interval during crop growth period.

### 2. Field evaluation of *Trichogramma chilonis* produced using Eri-silk worm eggs as factitious host (NBAII)

Eri silk worm eggs will be used as a factitious host for mass production of the available strains of trichogrammatids under laboratory condition. The efficiency of *T. chilonis* produced using Eri silk worm eggs will be compared with the parasitoids produced using *Corcyra* eggs in the field evaluation against sugarcane internode borer.

#### Treatments:

T1: Release of *Trichogramma* reared on Eri Silk worm eggs @ 20,000/acre

T2: Release of *Trichogramma* reared on *Corcyra* worm eggs @ 20,000/ acre

T3: Untreated control.

**Area:** One acre for each treatment. Each treatment to be separated from others and control by atleast a distance of 100 metres.

#### Release:

Release *Trichogramma* @ weekly intervals for 8 weeks after 4<sup>th</sup> month of planting.

#### Observations:

- i. Collection of egg masses to record percentage egg parasitism. Collect sufficient batches of eggs.
- ii. Record percentage infestation and percentage intensity from at least 10 random spots in 1 acre.
- iii. Record yield.

### **3. COTTON**

#### **1. Monitoring Biodiversity and outbreaks for invasive Mealy Bugs on Cotton (ANGRAU, MPKV, TNAU, PAU)**

##### **Survey for incidence of mealy bugs on cotton and collection of their natural enemies.**

1. Fortnightly surveys will be conducted in orchards/fields for mealy bug incidence. Infested plant parts to be brought back to the laboratory and held under caged conditions for emergence of natural enemies.
2. Alternate host plants, if any, to be recorded.
3. Specimens of mealy bugs and natural enemies collected will be sent to NBAII.
4. Crop - wise records will be maintained for extent of damage by the mealy bug, level of natural enemies present, etc. to be maintained
5. If invasive species of mealy bugs are observed during the surveys, it is to be brought to the notice of the Director, NBAII for initiation of appropriate action.

#### **2. Monitoring the biodiversity and outbreaks of sap sucking pests, mirids and their natural enemies in *Bt* cotton ecosystem (MPKV)**

The *Bt* cotton plots will be monitored at fortnightly intervals for the incidence of sap sucking pests and occurrence of natural enemies. At least 25 plants per plot/ ha will be observed and quantitative data will be gathered to study the effect of *Bt* cotton on biodiversity of pests and indigenous fauna of natural enemies.

#### **4. TOBACCO**

##### **Diversity of biocontrol agents from various agro ecological zones**

1. Survey and collection of spiders and parasitoids in tobacco intercropping systems  
The information should be collected as given below during diversity analyses of natural enemies complexes
2. Survey and record of biocontrol agents (insects, pathogens) on *Orobanche* spp.
3. Natural enemies of aphids infesting different types of tobacco cultivated in different regions of the country
4. Surveillance for alien invasive pests *Brontispa longissima*, *Aleyrodicus digessi*, *Phenacoccus manihoti*, *Paracoccus marginatus*, *Phenacoccus madeirensis* and others

## 5. RICE

### 1. Seasonal abundance of predatory spiders in rice ecosystem (ANGRAU, SKUAST)

**Objective:** To determine the diversity and fluctuation of spiders in relation to environmental factors as well as insect pests (prey).

Collection will be made during morning hours in two seasons

1. Kharif
2. Summer

Population dynamics of the predatory spiders will be worked out using quadrature method.

#### Methodology to be followed:

1. Five fields of paddy will be randomly selected from the intense paddy growing area.
2. All the spiders will be collected from 10 quadrates (1×1m) from each field at weekly interval. Conspicuous spiders through size colour and webs on the top of the plant will be collected first. Later, each plant will be searched from top to bottom on leaves, tillers and panicles for spiders. Ground area near each plant within the quadrature will be searched. Collected specimens will be preserved in 70% ethanol with proper labelling of locality, date and area of the field.
3. Five pitfall traps on each border (20/field) will be installed in each field. Collections will be made on alternate days.
4. Adult males and females shall be identified upto species level with the help of available literature. Help from Dr. B. H. Patel, Retd. Professor of Zoology, Bhavnagar University, (expert in spider taxonomy) residing at Anand will be sought.
5. Data collected shall be subjected to analyses.
  - a) Species richness will be calculated using formula  
Species richness (S) = number of species collected
  - b) Species diversity ( $H'$ ) will be computed using Shannon-weiner index of diversity

$$\text{Species diversity } (H') = - \sum_{i=1}^k p_i \ln p_i$$

where,  $p_i$  = Proportion of  $i$ th species in the total sample  
 $p_i = f_i/n$   
 $n$  = Total number of specimen in the sample  
 $f_i$  = Number of specimen of the  $i$ th species  
 $k$  = total number of species  
 $\ln$  = natural logarithm ( $\log_e$ )

- c) Species evenness or equitability (E) will be calculated using Kreb's formula

$$E = \frac{H}{H'_{\max}}$$

Where,  $H'_{\max}$  = natural logarithm of the number of species present

$0 < E \leq 1$ , the maximum value being possible in a community in which all species are equally abundant

Any logarithmic base i.e. e, 10 and 2 may be used to compute  $H'$  and E, evenness value will remain the same.

d) Total spider density will be calculated. The data shall be subjected to

$\sqrt{x+1}$  transformation and subjected to ANOVA using CRD and finally DNMRT

6. Comparison between the seasons and comparison with the data available of the year 2000 shall be carried out.

## **2. Laboratory and field evaluation of fungal pathogens on gundhi bug, *Leptocorisa acuta*. (KAU)**

a. Laboratory bioassay tests may be carried against *Leptocorisa acuta*. out with

1. *Beauveria bassiana* @  $2 \times 10^8$  spores/ml &  $2 \times 10^9$  spores/ml

2. *Metarhizium anisopliae* @  $2 \times 10^8$  spores/ml &  $2 \times 10^9$  spores/ml

3. *Lecanicillium lecanii* @  $2 \times 10^8$  spores/ml &  $2 \times 10^9$  spores/ml

4. *Paecilomyces fumosoroseus* @  $2 \times 10^8$  spores/ml &  $2 \times 10^9$  spores/ml

b. Based on the results of the laboratory bioassay studies, field trials may be proposed

## **6. MAIZE**

### **1. Demonstration of *Trichogramma chilonis* against Maize stem borer *Chilo partellus* (MPUAT)**

#### **Treatments:**

1. 1. Two releases of *Trichogramma chilonis* @ 100000 parasitoids/ha at 6 & 25 days after germination
  
2. 2. Four releases of *Trichogramma chilonis* @ 150000 parasitoids/ha at 10 days intervals starting 25 days after germination

**Plot size:** 5 ha in Mavali, Badgaon & Girwa areas.

#### **Observations:**

- i. Divide the plot of 1 ha. into 10 segments of equal size to serve as 10 replications. Observations will be recorded in each segment as detailed below.
- ii. Per cent egg parasitism by collecting 10 egg masses from field at random, keeping in glass vials, observe for emergence under laboratory condition to confirm the parasitism.
- iii. Record dead hearts from 50 randomly selected plants.
- iv. Grain yield from plots
- v. The data will be analyzed using 't' test.

## 7. SORGHUM

### **Project 1: Field evaluation of NBAII entomopathogenic strains against sugarcane stem borer, *Chilo partellus*(Swinhoe) in Kharif sorghum (Dir. Sorghum Res.)**

Plot size 15 Sq m, Rep 03, Design: RBD,  
August, 2013

Likely Date of sowing: second week of

#### **Treatments**

1. Isolate-1 of *Beauveria bassiana*
2. Isolate-2 of *Beauveria bassiana*
3. Isolate-3 of *Beauveria bassiana*
4. Isolate-1 of *Metarhizium anisopliae*
5. Isolate-2 of *Metarhizium anisopliae*
6. Isolate-3 of *Metarhizium anisopliae*
7. Recommended practice (Insecticides)
8. Control (Untreated)

Formulated isolates will be supplied by NBAII, Bangalore and will be applied thrice at an interval of 30 days, starting from 20 day after emergence of plant.



## 8. PULSES

1. Evaluation of NBAII liquid formulations (PDBC-BT1 and NBAII-BTG4) and IARI *Bt* against pigeon pea pod borer (*Helicoverpa armigera*) and legume pod borer (*Maruca testulalis*). (AAU-A, MPKV, ANGRAU, PAU, UAS-Raichur).

Treatments : 11

1. PDBC-BT1 @ 1% spray
2. PDBC-BT1 @ 2% spray
3. NBAII-BTG4 @ 1% spray
4. NBAII-BTG4 @ 2% spray
5. IARI *Bt* isolates @ 1% spray
6. IARI *Bt* isolates @ 2% spray
7. *Beauveria bassiana* @ 1.5kg/ha
8. *Beauveria bassiana* @ 2.0kg/ha
9. NSKE 5%
10. Chlorpyrifos @ 0.04 % spray
11. Control

**Spray schedule:** 3 sprays (pre flowering, post flowering and pod emergence)

**Design:** RBD

**Replications:** 3

**Crop / variety:** pigeon pea

**Spacing:** 30 x 10 cm (pigeon pea)

**Plot size:** 5 x 8 m.

**Observations:**

1. % pod damage.
2. % seed damage
3. Pest severity
4. Yield data

***Bt* formulations will be supplied by NBAII and IARI for the trials.**

## **2. Evaluation of microbial agents for management of Lepidopteran pests on Moong bean (*Spodoptera litura*, *Helicoverpa armigera*) (PAU) (New)**

**Treatments:** 09

1. PDBC-BT1 @ 1% spray
2. PDBC-BT1 @ 2% spray
3. NBAlI-BTG4 @ 1% spray
4. NBAlI-BTG4 @ 2% spray
5. Commercial formulation of Bt@ 300 g/acre
6. *Beauveria bassiana* @ 1.5kg/ha
7. *Beauveria bassiana* @ 2.0kg/ha
8. Chlorpyrifos @ 0.04 % spray
9. Control

**Spray schedule:** 3 sprays (pre flowering, post flowering and pod emergence)

**Design:** RBD

**Replications:** 3

**Crop / variety:** Any recommended variety

**Spacing:** 30 x 10 cm

**Plot size:** 5 x 8 m.

**Observations:**

5. Pest incidence will be recorded weekly
6. % pod damage.
7. Yield data

## **3. BIPM against *H. armigera* in chick pea (MPUAT):**

**Treatments:**

1. Installation of pheromone trap 5/ha.
2. Two sprays of Bt @ 1 kg/ha first at flowering stage and second after 15 days of first spray
3. Two sprays of HaNPV first at flowering stage and second after 15 days of first spray

## 9. OILSEEDS

### 1. Biological suppression of safflower aphid, *Uroleucon compositae* on safflower (ANGRAU, MPKV)

#### a. ANGRAU:

##### **Objective of Experimentation:**

As Non Spiny safflower is mainly used for Herbal Tea and other ancillary usages, evolving of certain eco friendly management practices for thier efficacy under field conditions became imperative to meet the requirement. Hence, the experimentation is planned to be carried out with the following set of treatments.

##### **Treatments:**

- T1 *Chrysoperla zastrowi sillemi* @ 6000/ha – 2 releases
- T2 NSKE 5%
- T3 *Verticillium lecanii* @  $1.5 \times 10^{13}$  conidia/ha
- T4 *N. rileyi* @  $1.5 \times 10^{13}$  conidia/ha
- T5 Insecticidal check
- T6 Untreated Control

**Net Plot size:** 40 sq.mt (5 x 8m)

**No. of Replications:** 4

**Design:** RBD

**Variety:** Nari 11

##### **Timing of Treatmental Applications:**

The first spray to be given on initial occurrence of the pest and rest based on abundance of pest. Cloth screen to be used to avoid drift into neighboring plots.

##### **Observational Protocol:**

Aphid population in 10 randomly selected plants (terminal shoots) from each plot will be recorded before treatment and 10 days after each treatment. Yield per plot will be recorded at harvest.

#### b. MPKV

##### **Treatments:**

1. *Chrysoperla zastrowi sillemi* @ 5,000 grubs/ ha, 2 releases at fortnightly interval
2. *Verticillium lecanii* @  $10^{13}$  conidia/ ha,
3. *Beauveria bassiana* @  $10^{13}$  conidia/ ha,
4. *Metarhizium anisopliae* @  $10^{13}$  conidia/ ha,

5. *Fusarium pallidosporium* @  $10^{13}$  conidia/ ha,
6. NSKE 5% suspension
7. Untreated control.

**Plot size:**

5x12 m divided into three subplots as replicates

**Methodology:**

The treatment applications will be started at initial occurrence of aphid colonies. In all, three sprays will be given during evening hours at fortnightly interval. Besides, a blanket application of *S/NPV* will be followed to suppress the infestation by *Spodoptera litura*.

**Observations:**

1. Aphid population on 5 cm apical twig/ plant from 10 randomly selected plants in each treatment plot, a day before treatment and 7 days after each spray,
2. Record seed yield per plot.

**2. Evaluation of Entomopathogens against soyabean insect pest complex (MPKV)**

**Treatments:**

1. MPKV strain of *N. rileyi* @  $10^8$  conidia/ ml
2. NBAIL strain of *N. rileyi* @  $10^8$  conidia/ ml
3. *S/NPV* @ 250 LE/ ha ( $1.5 \times 10^{12}$  POB/ ha)
4. EPN- *Heterorhabditis indica* @ 1 billion IJs/ ha
5. NSKE 5 % Suspension
6. Untreated control.

Plot size: 4.0 X 5.0 m replications: four

**Methodology:**

Three sprays will be applied at fortnightly intervals, starting from the appearance of sufficient pest population monitored using pheromone traps.

**Observations:**

1. Pre-treatment larval population in 1 m row at 5 spots from each plot.
2. Post treatment surviving larval population will be recorded a week after each spray.
3. Collect atleast 20 larvae/ plot after spray and maintain them in the laboratory on food from the same treatment plots till death/ pupation to record per cent mortality due to diseased conditions.
4. Record grain yield per plot.

**3. Validation of IPM module in soybean (MPUAT)**

**Treatments:**

- i. Seed treatment with Trichoderma @8g/kg. seed.

- ii. Soil application of *Metarhizium anisopliae* @  $2.5 \times 10^{13}$  spores/ha along with FYM for control of white grubs
- iii. Two releases of *Trichogramma* @ 1 lakh/ha at 10 days intervals starting at flowering
- iv. Two sprays of NSKE 5%.
- v. Two sprays of Spray of *Nomurea rileyi* @  $1.5 \times 10^{11}$  conidia/ha. against *Spodoptera*

**Observations to be taken:**

Pest incidence and damage in control and treated plots will be studied

**4. Field Evaluation of entomofungal pathogens against Soybean defoliators (Dir. Soybean Res.)**

**Objective:**

To test the efficacy of different isolates of entomopathogenic fungi against important soybean defoliators under field conditions.

**Treatments:** T<sub>1</sub>: DSRBB1 of *Beauveria bassiana*  
 T<sub>2</sub>: DSRBB2 of *B. bassiana*  
 T<sub>3</sub>: DSRBB3 of *B. bassiana*  
 T<sub>4</sub>: DSRBB1 of *B. bassiana*  
 T<sub>5</sub>: NBAIIBB1 of *B. bassiana*  
 T<sub>6</sub>: NBAIIBB2 of *B. bassiana*  
 T<sub>7</sub>: NBAIINR1 of *Nomurea rileyi*  
 T<sub>8</sub>: commercial strain *B. bassiana*  
 T<sub>9</sub>: Control

**Seasons:** Kharif, 2013 and 2014

**Field Design:** Randomized completely blocked design with three replications

**Target Pests:** Soybean defoliators

**No. of Sprays:** 1-2 rounds of foliar spray at 15 days interval. Spay strength  $10^8$  spores/ml.

**Observations:** 1. Per cent infection of larvae per meter crop row length  
 2. Grain Yield

**5. Biological control of pests of gingelly (OUAT)**

Field experiments will be laid out in RBD with three replications and eight treatments for the purpose of evaluating different bio pesticides against the pests of Gingelly(Sesamum), during Summer, 2013 and Kharif, 2013-14.

**Treatments:**

T<sub>1</sub>. Release of *Trichogramma chilonis* @ 1,00,000 parasitoids/ha from 30 DAG to 70 DAG at 10 day intervals

T<sub>2</sub>. *T.chilonis* release as in T<sub>1</sub> followed by spray of Bt 1.0 kg/ha twice at 40 and 60 DAG

T<sub>3</sub>. *T.chilonis* release as in T<sub>1</sub> followed by spray of *Beauveria bassiana*@ 1x10<sup>8</sup>cfu at 40 and 60 DAG

T<sub>4</sub>. *T.chilonis* release as in T<sub>1</sub> followed by spray of spray of Bt 1.5 kg/ha twice at 40 and 60 DAG

T<sub>5</sub>. *T.chilonis* release as in T<sub>1</sub> followed by spray of *Beauveria bassiana*@ 2x10<sup>8</sup>cfu at 40 and 60 DAG

T<sub>6</sub>. *T.chilonis* release as in T<sub>1</sub> followed by spray of Neemazal 5% at 20,30,40,50 and 60 DAG

T<sub>7</sub>. Application of Acetamiprid 0.025% and Spinosad 0.4% as in T<sub>1</sub>.

T<sub>8</sub>. Untreated control

**Observations:**

1. Incidence of Leaf webber, hawk moth, pod borers in different treatments.
2. Yield at harvest

## 10. COCONUT

### 1. Surveillance and need-based control of coconut leaf caterpillar, *Opisina arenosella* in Kerala (CPCRI)

1. *Goniozus nephantidis* adults @ 10/palm. Four releases at fortnightly intervals coinciding with larval stage (4-7 instar) of the pest during summer months (February to May). The release should be carried out preferably in the morning. Parasitoids will be released on the trunk or nearest fronds (if it is a small palm) with the help of cotton wool.
2. *Cardiastethus exiguus* nymphs @ 50/palm. Three releases at 5 days interval/brood on seeing pupal cases and continue similar releases whenever pupal cases are observed

**Note:** *O. arenosella* pheromone to be obtained from BCRL for monitoring purpose.

#### Observations to be recorded:

1. Initial population of different stages of *O. arenosella* as well as natural enemies will be observed by taking samples of 10 leaflets/palm. Similarly, post release samples at fortnightly intervals will be taken.
2. Additionally eggs of *O. arenosella* to be exposed to *T. embryophagum* in the lab to assess its parasitisation rate.
  - If nucleus culture of any natural enemy is required from NBAII, request should be received one month in advance.
  - Co-ordination with AICRP palms is required.

### 2. Scaling up utilization of *M. anisopliae* through technology transfer (CPCRI)

Imparting training to farmer groups for production of fungus to cater to local needs

### 3. Entomopathogenic nematodes for management of Red palm weevil (*Rhynchophorus ferrugineus*) (CPCRI)

Isolation, pathogenicity studies & Field testing of EPN

#### Protocol:

T1: *H. indica* NBAII strain talc formulation 100g/palm

T2: *S. carpocapsae* NBAII strain talc formulation 100g/palm

T3: *S. abbasi* NBAII strain talc formulation 100g/palm

T4: *H. Indica* CPCRI talc formulation 100g/palm

T5: *S. carpocapsae* CPCRI strain talc formulation 100g/palm

T6: Chemical recommendation

**NBAII to provide EPN formulations for the trials**

**Replications:** 10 plants each

Treatments to be imposed as per the entomological requirements. Observe for infected grubs/adults 7-10 days after treatment.

## 11. TROPICAL FRUITS

### 1. Field evaluation of *Metarhizium anisopliae* formulation against mango hoppers (KAU, MPKV)

#### Protocol

1. Selection of mango orchard: Orchards having about 50- 100 trees are to be selected.
2. The selected blocks must be isolated from each other since hoppers are migratory.

#### Treatments:

##### BLOCK-1

| S. No | No. of trees | Details of treatment  | Frequency of spray   | Observation   |
|-------|--------------|---|--|---|
| 1     | 25 -50       | <i>M.aniisopliae</i> 1x10 <sup>9</sup> spores/ml with adjuvants | one spray of <i>M. anisopliae</i> during off season ( November/ December)<br>+<br>Weekly ( a total of three-four sprays) ( with the incidence of hoppers-first generation)<br><br>If hopper population is very severe the spray can be done once in 5 days | Observations from 10 trees to be made from each tree four inflorescence<br>No. of hoppers/ inflorescence (pre and post count on early, late and adult population separately may be made)<br>No of fruits set. |

##### BLOCK-2

| S. No | No. of trees | Details of treatment  | Frequency of spray   | Observation   |
|-------|--------------|---|--|---|
| 1     | 25 -50       | <i>M.aniisopliae</i> 1x10 <sup>9</sup> spores/ml with adjuvants | Weekly( a total of three-four sprays) ( with the incidence of hoppers-first generation)<br>If hopper population is very severe the spray can be done once in 5 | Observations from 10 trees to be made from each tree four inflorescence<br>No. of hoppers/ inflorescence(pre and post count on early, late and adult population separately may be made) |



|  |  |  |      |                   |
|--|--|--|------|-------------------|
|  |  |  | days | No of fruits set. |
|--|--|--|------|-------------------|

**BLOCK-3**

| S. No | No. of trees | Details of treatment  | Frequency of spray  | Observation  |
|-------|--------------|---|---|--|
| 1     | 25 -50       | <i>M.aniisopliae</i><br>1x10 <sup>7</sup> spores/ml<br>with adjuvants | Weekly( a total of three-<br>four sprays)<br>( with the incidence of<br>hoppers-first<br>generation)<br>If hopper population is<br>very severe the spray<br>can be done once in 5<br>days | Observations from 10<br>trees to be made<br>from each tree four<br>inflorescence<br>No. of hoppers/<br>inflorescence (pre and<br>post count on early, late<br>and adult population<br>separately may be made)<br><br>No of fruits set. |

**BLOCK4**

| S. No | No. of trees | Details of treatment                      | Frequency of spray              | Observation  |
|-------|--------------|---|---------------------------------|--|
| 1     | 25 -50       | Check-Spray<br>imidachlorprid<br>@0.3ml/L | One spray at pre –<br>flowering | Observations from 10<br>trees to be made from<br>each tree four<br>inflorescence<br><br>No. of hoppers/<br>inflorescence (pre and<br>post count on early, late<br>and adult population<br>separately may be made)<br><br>No of fruits set. |

**BLOCK5**

| S. No | No. of trees | Details of treatment | Frequency of spray | Observation   |
|-------|--------------|----------------------|--------------------|---|
| 1     | 25 -50       | control              | no spray           | Observations from 10<br>trees to be made from<br>each tree four<br>inflorescence<br><br>No. of hoppers/<br>inflorescence (pre and<br>post count on early, late<br>and adult population<br>separately may be made) |

|  |  |  |  |                   |
|--|--|--|--|-------------------|
|  |  |  |  | No of fruits set. |
|--|--|--|--|-------------------|

**2. Survey, Collection, Identification and Mass Culturing of Trichogrammatids and Entomopathogenic Nematodes from Mango Ecosystem in Uttar Pradesh and Uttarakhand for evaluation against mango leaf webber (*Orthaga euadrusalis*) (CISH)**

**i. Entomopathogenic nematodes:**

a. Survey and collection of soil samples and isolation of entomopathogenic nematodes (*Steinernema* spp. and *Heterorhabditis* spp.) from mango orchards of Uttar Pradesh and Uttarakhand.

Methodology:

Survey and collection of soil samples

Baiting with last instar larvae of greater wax moth

Isolation of entomopathogenic nematodes

Confirmation of Koch postulates and mass multiplication

b. Testing the bioefficacy of the isolated strains of entomopathogenic nematodes against mango leaf webber (*Orthaga euadrusalis*) under laboratory conditions.

Methodology:

Test insect: Last instar larvae of mango leaf webber (*Orthaga euadrusalis*)

EPN: Fresh infective juveniles (IJs) of *Steinernema/Heterorhabditis*

Doze: 50 and 500 IJs/insect

Arena: 6 well bioassay plate

Temperature and Relative humidity: 28 C and 65% in BOD

**ii. Parasitoids**

Survey and collection of natural enemies (predators and parasitoids) from mango orchards of Uttar Pradesh and Uttarakhand.

Lab rearing and Evaluation of trichogrammatids against leaf webber (*Orthaga euadrusalis*)

**3. Biological suppression of mealy bugs, *Maconellicoccus hirsutus* and *Ferrisia virgata* with *Scymnus coccivora* on custard apple (MPKV)**

**Treatments:**

1. Release of *Scymnus coccivora* @ 5 grubs/ infested plants
2. Release of *Scymnus coccivora* @ 10 grubs/ infested plants
3. Spray of *V. lecanii* @10<sup>13</sup>/ ha.
4. Release of *Cryptolaemus montrouzieri* @ 5 grubs/ infested plants
5. Untreated control

**Plot size:** 10 trees,

**Replications:** four

**Methodology:** Select mealy bug infested custard apple orchards in one village and record mealy bug incidence species wise. Release the predators in separate orchard. Two releases will be made at monthly interval starting from fruit formation stage of custard apple.

**Observations:**

1. Record pre-release incidence of each mealy bug species from five randomly selected trees and population from 10 fruits/ tree.
2. Record post count of each mealy bug species wise at 15 and 30 days after each release of the predators
3. Grade mealy bugs incidence in a 1-5 scale  
(1= very low, < 10% surface area of the fruits covered by the mealy bugs colonies,  
2= low 11-25% surface area of the fruits covered by the mealy bugs colonies,  
3= moderate 26-50% surface area of the fruits covered by the mealy bugs colonies,  
4= high 51-75% surface area of the fruits covered by the mealy bugs colonies,  
5= very high >76% surface area of the fruits covered by the mealy bugs colonies,  
0 rating for no incidence of mealy bugs.)
4. Yield of marketable fruits/tree

**4. Monitor and record of incidence of papaya mealy bug and its natural enemies on papaya and other alternate hosts (MPKV, KAU, OUAT, TNAU, IHR, NBAII)**

Monitor for the occurrence of papaya mealy bug on papaya & other hosts

Check for occurrence of *Acerophagus papayae*

Collect *A. papayae* from the host plants where they occur and distribute on host plants where the parasitoids are absent or less.

Other species of mealy bugs competitive to PMB for invasion of papaya and other crops will be recorded from different zones.

**5. Biocontrol of papaya mealy bug in Gujarat (AAU-A)**

**Proforma for survey of the papaya mealybug *Paracoccus marginatus***

1. Location (5 randomly - selected villages/district)
2. GPS data if available
3. Date of survey
4. Name and full address of the farmer:
5. Non crop hosts and weeds affected
6. Area affected (District wise)
- 7(i) Percentage of plants infested (Crop / weed wise) (Assess from 25 randomly selected plants)
- (ii) Intensity of damage (grade in the scale of 1-5) Assess from 25 randomly selected infested plants

| Grade | Population |
|-------|------------|
| 1     | Very low   |
| 2     | Low        |
| 3     | Medium     |
| 4     | High       |
| 5     | Very high  |

8. Chemical pesticides if any used with dose
9. Anticipated yield loss / ha (crop - wise)
10. Existing natural enemies in 25 randomly selected plants in a hectare
11. **Release of parasitoids:** In mealybug affected villages, release 100 nos. of parasitoids. Severely affected plants may be covered with a nylon/muslin net cage, and parasitoids released inside. Provide paper strips streaked with 10% honey as adult feed. After 4 days, the nets can be removed. After about 14 days, parasitoid pupae can be observed among the mummified mealybugs. Emergence of adults will happen in about 4-5 days from pupation. About 1250 parasitoids are expected to emerge after the first release. If necessary some pupae of the parasitoids can be collected in plastic containers with muslin cloth windows to collect the emerging adults which can be redistributed to nearby villages where the papaya mealybug infestation are observed.
12. **Second rapid survey:** Repeat the survey 3 months after the release of the parasitoids and collect information required in columns as per serial no. 1 - 10. Additionally collect 25 shoots (infested heavily with the mealybug) (6" length) from each host plant species per location and confine them in transparent plastic containers with windows.  
 Similarly, infested papaya fruits with heavy infestations can be kept in transparent jars to observe for parasitoid emergence. Paper strips streaked with 10% honey can be provided inside the jars/tubes as food for the emerging adults. Record daily the number of parasitoids emerged until 10 days.  
 Since three species of parasitoids are released record the population of parasitoids species- wise.  
 These parasitoids can be released in 10 new areas for further spread. A few specimens can be sent to NBAII for confirming the identity.
13. **Third rapid survey:** Repeat the survey after 3 months (i.e, after 6 months of first release and record data as per 1 to 12.  
 Hyper parasitoids may also be observed on the parasitoids. These should be preserved in 70% ethanol and sent to NBAII for identification.

**Note:**

- a) After each survey, the data sheets should be sent to NBAII for compilation
- b) In areas where the releases are made, the farmers should be advised not to take up chemical insecticidal sprays
- c) As the papaya mealybugs are known to multiply profusely on weed plants like *Parthenium*, *Acalypha indica*, *Plumeria alba* and several others, such mealybug infested plants should not be destroyed, as they can be precious reservoirs for the parasitoids. Mealybug colonies carrying parasitoids can also be distributed to new areas for papaya mealybug control.

- d) The establishment of the parasitoids should also be documented through good quality high resolution digital photographs and video clippings. The views of the farmers on the impact of the classical biological control of the papaya mealybug should also be videotaped for further compiling the success story.

## **6. Bio-efficacy of EPNs against Citrus trunk borer, *Anoplophora versteegi* (CAU)**

**Replication** : 10 no (Trees)

**Design** : RBD

### Treatments

1. Stem injection with CAU-1 @50 ijs/ml
2. Stem injection with CAU-2@50 ijs/ml
3. Stem injection with CAU-3@50 ijs/ml
4. Stem injection with CAUH-1@50 ijs/ml
5. Stem injection with CAUH-2@50 ijs/ml
6. Cadaver application with CAU-1 @ 2 cadaver/plant (wrapping cadaver by muslin cloth and binding at one meter height from the ground level).
7. Cadaver application with CAU-2 @ 2 cadaver/plant (wrapping cadaver by muslin cloth and binding at one meter height from the ground level).
8. Cadaver application with CAU-3 @ 2 cadaver/plant (wrapping cadaver by muslin cloth and binding at one meter height from the ground level).
9. Cadaver application with CAUH-1 @ 2 cadaver/plant (wrapping cadaver by muslin cloth and binding at one meter height from the ground level).
10. Cadaver application with CAUH-2 @ 2 cadaver/plant (wrapping cadaver by muslin cloth and binding at one meter height from the ground level).
11. Stem injection with NBAII-1@50 ijs/ml
12. Cadaver application with NBAII @ 2 cadaver/plant (wrapping cadaver by muslin cloth and binding at one meter height from the ground level).
13. Untreated control

The experiment will be carried out at two locations (Pasighat and Ringging) of Arunachal Pradesh against Citrus trunk borer, *Anoplophora versteegi*. Two rounds of application will be made once during last week of April and the second application at second week of May. Observations will be recorded at monthly interval starting one month after the first application of the EPNs upto August by counting the number of spots where fresh frass materials expelled. For application of the EPNs, in each location three orchards will be selected and in each orchard, five infested plants will selected for each treatment.

## **7. Laboratory & field evaluation of entomopathogens against banana pseudostem weevil (KAU)**

Different stages of the pest (grub, pupae and adult) will be exposed to the entomopathogens

Design: CRD

Treatments: 6  
Replication: 3

**Treatments**

T1: *Metarhizium anisopliae*( $10^7$  spores/ml)  
T2: *Metarhizium anisopliae*( $10^8$  spores/ml)  
T3: *Beauveria bassiana* ( $10^7$  spores/ml)  
T4: *Beauveria bassiana* ( $10^8$  spores/ml)  
T5: Chemical control  
T6: Control

**8. Laboratory and field evaluation of entomopathogens against pineapple mealybug  
*Dysmicoccus brevipes* (Cockerell) (Hemiptera: Pseudococcidae) (KAU)**

Design: CRD  
Treatments: 11  
Replication: 3

**Treatments**

T1: *Metarhizium anisopliae*( $10^7$  spores/ml)  
T2: *Metarhizium anisopliae*( $10^8$  spores/ml)  
T3: *Metarhizium anisopliae*( $10^9$  spores/ml)  
T4: *Beauveria bassiana* ( $10^7$  spores/ml)  
T5: *Beauveria bassiana* ( $10^8$  spores/ml)  
T6: *Beauveria bassiana* ( $10^9$  spores/ml)  
T7: *Lecanicillium lecanii* ( $10^7$  spores/ml)  
T8: *Lecanicillium lecanii* ( $10^8$  spores/ml)  
T9: *Lecanicillium lecanii* ( $10^9$  spores/ml)  
T10: Chemical control  
T11: Control (Distilled water)

## 12. TEMPERATE FRUITS

### 1. Evaluation of entomopathogenic fungi and EPNs for the suppression of Apple root borer, *Dorystenes hugelii* under field conditions. (YSPUHF)

#### Treatments:

- T1: *Steinernema* sp. 80 IJ/cm<sup>2</sup>
- T2: *Heterorhabditis* sp. 80 IJ /cm<sup>2</sup>
- T3: *Beauveria bassiana* @10<sup>6</sup> conidia/cm<sup>2</sup>
- T4: *Metarrhizium anisoplae* @ 10<sup>6</sup> conidia / cm<sup>2</sup>
- T5: Chlorpyrifos @ 0.06%
- T6: Absolute Control

**Replications:** 4

#### Observation to be recorded:

The treatments will be applied during July (at the time of fresh infestation). The observations will be recorded during November.

The larval population in different treatments will be compared with control. The soil sample will also be drawn for the recovery of EPNs.

### 2. Survey for identification of suitable natural enemies of codling moth (SKUAST)

**Location:** Leh & Kargil

1. Survey of apple and apricot orchards for the presence of GV, *Trichogramma* and other natural enemies
2. Collection of infested larvae of codling moth and identification of associated entomopathogens
3. Exploration of indigenous *Trichogramma* spp., through sentinel cards, their identification and mass production for future exploitation

### 3. Field evaluation of *Trichogramma embryophagum* and *T. cacoeciae* against codling moth, *Cydia pomonella* on apple (SKUAST)

- 1: *T.embryophagum* @ 100,000/ ha.
- 2: *T. cacoeciae* @ 100, 000/ha.
- 3: Insect pheromone subject to availability

**Location:** Laddakh

**Plot size:** Approximately 500 m<sup>2</sup> each (As per the availability of plants)

**Replication:** 10

#### Observations to be recorded:

- i. Field persistence of parasitoids by placing sentinel *Corcyra* egg cards
- ii. Per cent fruit damage
- iii. Yield at harvest

### 13. VEGETABLES

#### 1. Field demonstration of BIPM package for the management of key pests of Tomato (TNAU)

##### T<sub>1</sub> BIPM package

- Seedling root dip with *Pseudomonas* 2% solution
- African Marigold as trap crop
- Installation of yellow sticky trap @ 50 No's /ha.
- Installation of bird perches @ 10/ha.
- Need based application of *B.t* and NPV based on pheromone monitoring
- Sucking pests management through Azadirachtin spray
- Release of *Trichogramma pretiosum* @ 50,000 No's /ha.
- Release of *Chrysopa* grubs @ 50,000 No's /ha.

##### T<sub>2</sub> Farmer's practice

**Plot size :** one acre/treatment

##### **Observations**

- Population of aphids, thrips, leafhoppers whiteflies and fruit borer will be recorded at 15 days interval
- Natural enemy activity will be recorded
- Yield will be recorded at harvest

#### 2. BIPM against *H. armigera* in tomato (MPUAT)

##### **Treatments:**

1. Installation of pheromone trap 5/ha.
2. Six release of *Trichogramma* starting at flowering stage in tomato.
3. Two sprays of Bt @ 1 kg/ha first at flowering stage and second after 15 days of first
4. Two sprays of HaNPV first at flowering stage and second after 15 days of first spray

#### 3. Biological control of Brinjal mealy bug *Coccidohystrix insolitus* (TNAU)

T<sub>1</sub> Release of *cryptolaemus* @ 1500/ha

T<sub>2</sub> Release of *Scymnus*@ 1500/ha

T<sub>3</sub> Release of *Brumus suturoides* @ 1500/ha

T<sub>4</sub> *Verticillium lecanii* 10<sup>8</sup> cfu /ml

T<sub>5</sub> *Chrysopa* 50,000 first instar grubs/ha

T<sub>6</sub> Profenphos 50 EC 2ml /l

T<sub>7</sub> Control

**Plot size:** 4x5m



**No. of releases:** Based on pest intensity

**Observations:**

- i. Observations on mealybug will be recorded on 3 leaves/plant.
- ii. Record number of predators (adult)/plant.
- iii. Yield data at harvest

**4. Validation of different BIPM modules against shoot and fruit borer, *Leucinodes orbonalis* in brinjal fruit borer (MPKV)**

**Treatments:**

- i. *Trichogramma chilonis* (Tc) @ 50,000/ ha, 6 releases
- ii. *Trichogramma chilonis* + NSKE 5% suspension (Tc+Tc+NSKE+Tc+Tc+NSKE)
- iii. *Trichogramma chilonis*+ *Bacillus thuringiensis* @1 kg/ha (Tc+Tc+Bt+Tc+Tc+Bt)
- iv. *Trichogramma chilonis*+ NSE 5% suspension + *Bacillus thuringiensis* @ 1 kg/ ha (Tc+ NSKE +Bt+Tc +NSKE+Bt)
- v. NSE 5% suspension+ *B. thuringiensis* @ 1 kg/ha (NSKE + NSKE + Bt + NSKE + NSKE+Bt)
- vi. Farmer's practice
- vii. Untreated control.

**Plot size:** 15×6 m block divided into 3 subplots as replicates.

**Methodology:**

- i. Hand collection and destruction of infested shoots along with larval stages of *L. orbonalis* before treatment and application
- ii. Monitoring the incidence of *L. orbonalis* using pheromone traps
- iii. Releases of parasitoids and/or sprays of NSE and *Bt* will be followed at weekly intervals starting from 50% flowering stage of the crop.

**Observations:**

Observations will be recorded from five randomly selected plants/plot

- i. Pre-treatment pest incidence based on percent shoots infested and catches from pheromone traps
- ii. Post counts of percent shoot and fruit infestation at weekly intervals
- iii. Record percent parasitism by *T.chilonis* through retrieval by placing sentinel *Corcyra* egg-cards containing 100 eggs each at three spots in each block.
- iv. Yield of healthy marketable fruits at each picking.

**5. Management of major pests of brinjal (MPUAT):**

Technical programme

1. Raising of disease and insect free seedlings applying *Trichoderma* and neem based insecticide.
2. Application of yellow sticky traps @ 5/ha and six release of *Trichogramma* species @ 1 lac/ha starting from flowering stage.

3. Two sprays of *Verticillium lecani* against sucking pests followed with six releases of *Trichogramma* species @ 1 lac/ha starting from flowering stage.
4. Two sprays of NSKE six release of *Trichogramma* species @ 1 lac/ha starting from flowering stage.

## 6. Efficacy of B.t strains against Diamond backmoth in Cauliflower (TNAU)

### Treatments:

- T<sub>1</sub> PDBC-BT1 @ 1% spray
- T<sub>2</sub> PDBC-BT1 @ 2% spray
- T<sub>3</sub> NBAII-BTG4 @ 1% spray
- T<sub>4</sub> NBAII-BTG4 @ 2% spray
- T<sub>5</sub> *Beauveria bassiana* @ 2.0kg/ha
- T<sub>6</sub> NSKE 5%
- T<sub>7</sub> Chlorpyrifos @ 0.04 % spray
- T<sub>8</sub> control

**Spray schedule:** 3 sprays at 15 days interval

**Design:** RBD

**Replications:** 3

**Crop / variety:** cauliflower **Plot size:** 5 x 8 m.

### Observations:

8. Pest population at 15 days interval
9. Yield data at harvest

**B.t formulations will be supplied by NBAII for the trials.**

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

### Treatments:

- i. Release of *Chrysoperla zastrowi sillemi* @ 5 larvae/ plant against aphids
- ii. Planting of mustard crop to collect and destroy eggs of *P. xylostella*
- iii. Spray of NSKE 5%
- iv. Release of *T. chilonis* and *T. brassicae* @ 1,00,000/ ha against *S. litura* and *P. xylostella* respectively at seven days interval when the moths or eggs are seen in the field.
- v. Release of *T. pieridis* @1,00,000/ ha against *P. brassicae*
- vi. Spray of *S/NPV* at 15 days interval
- vii. Mechanical collection and destruction of *P. brassicae* eggs at weekly interval.
- viii. Spray of *B. thuringiensis* of NBAII @ 1.0 kg /ha

**a. Farmers Practice:** Need based application of chemical insecticides like Spinosad 2.5%

### b. Control

Replications 4, Plot size 4×4 m, Design RBD

### Observation to be recorded:

- i. Population of lepidopteran pests at 15 days interval on 5 plants / replication

- ii. Population of natural enemies on observed plants
- iii. Yield at harvest

### **8. Evaluation of commercial formulations of *Bacillus thuringiensis* and potential microbial isolates against cabbage butterfly, *Pieris brassicae* (PAU)**

**Treatment:**

- 1 PDBC Bt 1 @ 1%
- 2 PDBC Bt 1 @ 2%
- 3 NBAII Bt 1@1%
- 4 NBAII Bt 1@ 2 %
- 5 Commercial Bt formulation @ 300g/ acre
- 6 Chemical spray (Spinosad 2.5 SC @240ml/ acre)
- 7 Untreated Control

**Variety:** Recommended variety

**Plot size:** 5 x 2m<sup>2</sup>

**No. of sprays:** Three sprays of bioagents at ten days intervals and two sprays of chemical at fifteen days intervals at the start of pest incidence.

**Replication:** Four

#### **Observation to be recorded:**

- (a) Number of larvae will be recorded at weekly interval from five cabbage plants.
- (b) Number of infected leaves by *Pieris brassicae* will be recorded from five cabbage plants.
- (c) Yield will be recorded.

### **9. Evaluation of fungal pathogens against sucking pests of hot chilli (*Capsicum sinensis*) (AAU-J)**

**Target pests:** aphid, Jassid and mite

Plot size: 3mx3m

Replication: Three

Treatment: to be included

Treatment details:

1.) *Metarhizium anisopliae*: 10<sup>9</sup> cfu/ml

2) *Beauveria bassiana* : 10<sup>9</sup> cfu/ml

3) Imidacloprid @15 g ai/ha

4) Untreated control

**The NBAII entomopathogenic strains are to be included in the treatment details along with local strains**

The treatment will be imposed coinciding with the occurrence of Sucking pests (aphid, Jassid and mite)

**Observations:**

- Population of the pests will be recorded from 5 randomly selected plants before treatment as well as 5 and 7 days after each treatment
- Population of natural enemies of target pest
- Per cent leaf damage by target pests
- Yield per plot
- C:B ratio

**10. Biological suppression of onion thrips, *Thrips tabaci* with predatory anthocorid and or microbial agents (MPKV).****Treatments:**

1. Release of *Blastothethus pallescens* @ 10 nymphs/m row
2. Release of *Blastothethus pallescens* @ 20 nymphs/m row
3. *Metarhizium anisopliae* @  $10^8$  cfu/ml
4. *Beauveria bassiana* @  $10^8$  cfu/ml
5. *Verticillium lecanii* @  $10^8$  cfu/ml
6. Standard chemical check
7. Untreated control

IIHR to provide the cultures of *M. anisopliae* & *V. lecanii* for the trials

**Plot size:** 2×3 m;

**Replications:** three

**Methodology:**

1. Transplanting of onion seedlings will be carried out in *rabi* season on ridges and furrows at 10×15 cm spacing
2. Treatments to be imposed on appearance of sufficient pest population or at 45 days after transplanting
3. Anthocorid nymphs will be released 4-6 times at weekly intervals
4. Application of microbial agents as 3-4 sprays at 10-15 days interval
5. Add Sandovit 0.1% as surfactant in the spray fluid of microbial agents

**Observations:**

1. Pre-treatment pest population to be recorded on 10 randomly selected plants
2. Record post count of nymphs and adults at 7 days after each release of anthocorids and sprays of the microbial agents
3. Record per cent infection due to fungal pathogens
4. Record intensity of white patches due to feeding of thrips in 1-5 scale
5. Record yield of onion bulbs per plot.

## 11. Validation of BIPM of thrips on onion (IIHR)

**Crop/Variety:** Onion/Arka Niketan (susceptible variety to thrips)

**Treatment details:**

1. *M. anisoplaie* formulation @ 1 ml/ 5l
2. *B. bassiana* @ 1gm/ 1L
3. control

**Observations** – weekly observations on number of thrips /plant  
Marketable yield in different treatments

## 12. Evaluation of local and NBAII entomopathogenic strains against soil insects in Potato (AAU-J)

**Target pests:** a) *Agrotis ipsilon* (cut worm)  
b) *Dorylus orientalis* (Red ant)

**Objectives:** To evaluate the efficacy of local and NBAII entomopathogenic strains against the soil insects of potato

**Plot size:** 3 mx3m

**Replication:** Three

**Design:** RBD

**Treatment details:**

- 1) *Metarhizium anisopliae* @ 15 kg/ha as soil application (sowing time, 60 and 80 DAS)
- 2) *Beauveria bassiana* @ 15 kg/ha as soil application (sowing time, 60 and 80 DAS)
- 3) Imidacloprid @10 g ai/ha as soil application
- 4) Malathion 5% dust @ 40 kg/ha as soil application
- 5) Untreated control

**The NBAII entomopathogenic strains are to be included in the treatment details along with local strain**

**Observations:**

- Pre and post treatment count of target pest population.
- Percent incidence of damage seedlings/tubers by *Agrotis ipsilon* (cut worm) and *Dorylus orientalis* (Red ant)
- Yield at harvest
- C:B ratio

## 13. BIPM in Okra (OUAT)

Field experiments will be laid out in RBD with three replications and eight treatments for the purpose of evaluating different bio pesticides against the pests of Okra, during Summer, 2013 and Kharif, 2013-14.

## Treatments

- T<sub>1</sub> – Application of *Beauveria bassiana* @ 1x10<sup>8</sup>cfu at 15 and 30 DAG followed by spray of Bt @ 1.5 kg/ha at 40 and 55 DAG (Days after Germination)
- T<sub>2</sub> – Application of *Metarrhizium anisopliae* @ 1x10<sup>8</sup> cfu and Bt @ 1.5 kg/ha as in T<sub>1</sub>
- T<sub>3</sub> – Application of *Verticillium lecanii* @ 1x10<sup>8</sup> cfu and Bt @ 1.5 kg/ha as in T<sub>1</sub>
- T<sub>4</sub> – Application of Neemazal 4% at 15 and 30 DAG and Bt as in T<sub>1</sub>
- T<sub>5</sub> – Application of *Beauveria bassiana* @ 2x10<sup>8</sup>cfu at 15 and 30 DAG followed by spray of Bt @ 1.0 kg/ha at 40 and 55 DAG
- T<sub>6</sub> - Application of *Metarrhizium anisopliae* @ 2x10<sup>8</sup> cfu and Bt @ 1.0 kg/ha as in T<sub>5</sub>
- T<sub>7</sub>- Application of *Verticillium lecanii* @ 2x10<sup>8</sup> cfu and Bt @ 1.0 kg/ha as in T<sub>5</sub>
- T<sub>8</sub> - Application of Neemazal 5% at 15 and 30 DAG and Bt @ 1.0 kg/ha as in T<sub>5</sub>
- T<sub>9</sub> – Application of Acetamiprid 0.025% and Spinosad 0.4% as in T<sub>1</sub>
- T<sub>10</sub> – Untreated control

## Observations:

1. Observations will be taken on the incidence of sucking pests one day before and 3, 5 and 7 days after the treatments. The incidence of shoot and fruit borer will also be taken one day before and 7 and 10 days after the treatments.
2. Observations on the occurrence of different predators and parasitoids will be taken at weekly intervals.
3. The fruit yield will be taken per plot and data will be statistically analysed

## 14. Evaluation of Bio-intensive IPM module against *Aleurodicus dispersus* on cassava (TNAU)

Crop: Tapioca  
Design: RBD  
Spacing: 60 x 60 cm

### T<sub>1</sub> Bio-intensive IPM

The bio-intensive IPM consists of the following components

- Yellow sticky traps @ 12 per ha for monitoring
- Release of *Encarsia gaudalopae* @ 4 parasitized pupae per plant
- Release of *Mallada* @ 50,000 first instar grubs per ha
- Application of entomopathogens viz., *V. lecanii* and *P. fumosoroseus* @ 2 x 10<sup>9</sup> conidia per ml

- Application of NSKE 5% or neem oil 3%
- Application of triazophos 20% EC @ 2 ml/l or acephate 75 SP @ 2 g/l

**T<sub>2</sub> Farmer's practice**

**T<sub>3</sub> Control**

**Observations:** *A. dispersus* population per leaf and population of parasitoids and predators will be recorded from 10 randomly selected plants at 15 days interval. Economic analysis of BIPM modules involving yield and the cost benefit ratio (CBR) will be estimated.

**14. Collection, evaluation of *Trichogramma chilonis* strains on cole crop insect pests (viz., cauliflower and cabbage) (IARI)**

- To carry out surveys and collection of *Trichogramma* strains from Uttarkhand state.
- To evaluate the collected *Trichogramma* strains for searching efficiency, temperature tolerance and fecundity.
- To breed the better performing strains under laboratory conditions.
- To carry out greenhouse/net house trials for evaluating the performance of improved *Trichogramma chilonis* strains on cole crop insect pests (viz., cauliflower and cabbage).

## 14. TEA MOSQUITO BUG

### 1. Evaluation of *Beauveria bassiana* (IIHR isolate) against Tea mosquito bug in Tea (AAU-J)

#### Treatments:

1. Thiamethoxam @ 30g ai/ha
2. Pestoneem @ 2ml/lit
3. *Beauveria bassiana* (any other commercial product)
4. *Beauveria bassiana* (IIHR)
5. Control

**No. of rounds:** Two at 30 days interval (based on insecticide)

**Replications:** Four

**Plot size:** One hectare area will be divided into 24 equal plots

#### Observations:

Pre treatment count and post treatment count of adults/10 plants representing each plot will be made at 15 days interval. Known number of eggs collected from each treatment will be brought and observed in the laboratory for emergence of natural enemies.



## **15. MEALYBUGS**

### **1. Monitoring the biodiversity and outbreaks of invasive mealy bugs on major horticultural crops (TNAU)**

- a. Fortnightly surveys will be conducted in orchards/fields for mealy bug incidence. Infested plant parts will be brought back to the laboratory and held under caged conditions for emergence of natural enemies.
- b. Alternate host plants, if any, to be recorded.
- c. Specimens of mealy bugs and natural enemies collected will be sent to NBAII.
- d. Crop - wise records will be maintained for extent of damage by the mealy bug, level of natural enemies present, etc. to be maintained
- e. If invasive species of mealy bugs are observed during the surveys, it is to be brought to the notice of the Director, NBAII.

### III. BIOLOGICAL SUPPRESSION OF POLYHOUSE CROP PESTS

#### 1. Biological control of leaf miner in chrysanthemum in Poly house conditions (TNAU)

T<sub>1</sub> Release of *Trichogramma*

T<sub>2</sub> *Beauveria* 10<sup>8</sup> cfu /ml

T<sub>3</sub> *Verticillium* 10<sup>8</sup> cfu /ml

T<sub>4</sub> *Metarhizium* 10<sup>8</sup> cfu /ml

T<sub>5</sub> *Hirsutella* 10<sup>8</sup> cfu /ml

T<sub>6</sub> Triazophos 2ml / l

T<sub>7</sub> Control

Design : RBD

Plot size : 2 x 5 m

Replication : Four

#### Observations :

- Population of the pest from 10 randomly selected plants before treatment as well as 10 days after each treatment.
- Record leaf damage.
- Yield per plot

#### 2. Evaluation of anthocorid predator, *Blaptostethus pallescens* against spider mites in poly houses (PAU, ANGRAU)

PAU:

**Crops:** Brinjal, Chilli, Okra

#### Treatments:

a) *Blaptostethus pallescens* @ 10 nymphs/ m row

b) *Blaptostethus pallescens* @ 20 nymphs/m row

c) *Blaptostethus pallescens* @ 30 nymphs/m row

d) Chemical control (Recommended dose of acaricide)

e) Untreated control

- Six releases will be made at weekly intervals on appearance of pest.
- Spray of insecticide as per recommendation
- Plot size: 2×3 m; Net house
- Replications: Three

#### Observations:

- Mite population from 10 randomly selected plants before release or spray
- Mite population from 10 randomly selected plants after 7 days of treatment
- Number of leaves with yellow specks or webbing and percent leaf damage will be calculated
- Marketable yield

## **ANGRAU:**

**Crop:** Carnation

### **Treatment details:**

T1: 10 anthocorids per plant (4 to 5 releases)

T2: 20 anthocorids per plant (4 to 5 releases)

T3: Chemical check with Abamectin

T4: Untreated Control

**Design:** RBD with 4 replications;

**Plot size:** 2.0 x 5.0 m.

### **Observations:**

1. Mite population from 10 randomly selected plants before spray
2. Mite population from 10 randomly selected plants after spray (Number of mites per leaf/flower, choosing randomly 5 flowers and top 5 leaves per plant)
3. Number of leaves/ flowers with yellow specks or webbing (caused by mite damage) on each plant and calculation of % leaves damaged by mites
4. Yield

## **3. Evaluation of efficacy of predators against cabbage aphids in polyhouses (SKUAST)**

**Crop:** Cabbage & Kale

T1: 5 Weekly releases of 2nd instar grubs of *Coccinella septumpunctata* @ 5/ plant

T2: 5 Weekly releases of 2nd instar grubs of *C. undecimpunctata* @ 5/ plant

T3: 5 Weekly releases of 2nd instar grubs of *Chrysoperla z. sillemi* @ 5/ plant

T4: Chemical control (endosulfan @ 1 ml/ lit)

T5: Untreated Check

### **Observations to be recorded:**

- i. No. of aphids/ 10 leaves before treatment
- ii. No. of aphids/ 10 leaves after every treatment
- iii. Per cent Leaf infestation/ 10 plants
- iv. Yield at harvest

## **4. Evaluation of predatory mite, *Neoseiulus longispinosus* against phytophagous mite in rose under polyhouse condition. (YSPUHF, SKUAST)**

### **Treatments:**

T 1: 10 predatory mite / plant /release (4-5 releases)

T 2: 20 predatory mite / plant /release (4- 5 releases)

T 3: 30 predatory mite / plant/release (4-5 releases)

T 4: Neem pesticide 2-3 ml of 0.15% azadirachtin

T 5: Recommended acaricides

T 6: Control

Design: RBD, Replications 5, Plot size 2x5m

**Observation to be recorded:**

- i. 10 rose plants will be selected randomly; Mite population will be recorded on these 10 plants by choosing 5 flowers and 5 top leaves / plant. Similar observations will also be recorded on these plants 7 days after spraying.
- ii. Number of leaves and flowers with yellow specks or webbing caused by mites will be recorded to calculate the percentage of leaves damaged by mites.
- iii. Yield / plot will also be recorded.

**5. Evaluation of entomopathogenic fungi against mite, *Tetranychus urticae* on capsicum/bell pepper under protected conditions (PAU)**

**Treatments:**

1. *Beauveria bassiana* @  $2 \times 10^7$  conidia /ml
2. *Metarrhizium anisopliae* @  $2 \times 10^7$  conidia /ml
3. *Verticillium lecanii* @  $2 \times 10^7$  conidia /ml
4. Standard chemical insecticide/ acaricide
5. Untreated control

**Variety:** Recommended variety

**Replications:** 3

**Observations:**

1. Mite population from selected leaves before spray
2. Mite population from selected plants 7 days after spray.
3. Yield

**6. Evaluation of biocontrol agents against sap sucking insect pests of ornamentals/vegetables in polyhouses. (YSPUHF, ANGRAU)**

**Crops:**

**ANGRAU:** Carnation.

**YSPUHF:** Casicum/Rose

**IIHR:** Capsicum

**YSPUHF & ANGRAU:**

**Design:** RBD

**Plot size:** 2x5m

**Replications: 4**

**Treatments:**

- a. *Beauveria bassiana* @  $2 \times 10^7$  conidia /ml
- b. *Metarrhizium anisopliae* @  $2 \times 10^7$  conidia /ml
- c. *Verticillium lecanii* @  $2 \times 10^7$  conidia /ml
- d. *Hirsutella thompsonii* @  $2 \times 10^7$  conidia /ml
- e. Release of coccinellid beetles
- f. Release of *M. longispinosus*
- g. 20 anthocorids (4-5 releases)
- h. Standard chemical insecticides
- h. Untreated control

**Observations:**

- i. Sap sucking population from 10 randomly selected plants before spray
- ii. Sap sucking population from 10 randomly selected plants 7 days after spray
- iii. No. of leaves/flowers with yellow specks or webbing on each plant and per cent leaves/ flowers damaged by mites to be computed
- iv. Yield to be recorded.

**7. Validation of BIPM of thrips on capsicum under polyhouse (IIHR)**

**Treatments**

1. *M. anisoplaie* formulation @ 1 ml/ 5l
2. *B. bassiana* @ 1gm/ 1L
3. Control

#### **IV. BIOLOGICAL SUPPRESSION OF STORAGE PESTS**

1. Evaluation of *Uscana* sp. (Trichogrammatidae) against *Callosobruchus* sp. on storability of pigeonpea seed. (**Dir. Seed Res.**)

**Objective:**

- To evaluate *Uscana* sp. against *Callosobruchus* sp. damaging pigeonpea seed.
- To assess parasitization effect of *Uscana* sp. on the eggs of *Callosobruchus* sp. under ambient conditions.
- To find out longevity of *Uscana* sp. on the eggs of *Callosobruchus* sp. in pigeonpea seed under storage.
- To monitor the effect of *Uscana* sp. release on seed quality attributes particularly seed viability during storage.

**Treatments:**

1. Release of 50 *Uscana* sp. + 5 pairs of *Callosobruchus* sp.
2. Release of 100 *Uscana* sp. + 5 pairs of *Callosobruchus* sp.
3. Release of 150 *Uscana* sp. + 5 pairs of *Callosobruchus* sp.
4. Release of 200 *Uscana* sp. + 5 pairs of *Callosobruchus* sp.
5. Control: Release of 5 pairs of *Callosobruchus* sp. only.

**Methodology:**

One kg of certified seed with very high percentage of germination and low moisture content (About 10%) will be taken in plastic jars for each treatment. The plastic jars will be closed with lids. Required number of parasitoid, *Uscana* sp. and freshly emerged adults of *Callosobruchus* sp. will be released into plastic jars. Plastic jars will be kept in room under ambient temperature. The temperature and relative humidity of the room will be recorded on standard weekly basis.

**Observation to be recorded:**

1. Seed germination and seed moisture.
2. Insect infestation (% kernel damage).
3. Presence of adult insect.
4. Presence of adult parasitoid.

At every 20 days for a total period of 6 months or loss of germination below Indian Minimum Seed Certification Standard (IMSCS) whichever is early.

## **2. Evaluation of anthocorid predators against storage pests in rice (ANGRAU)**

### **Treatments:**

Untreated rice/wheat is to be stored in bins. Into each bin, 100 eggs of *Corcyra cephalonica* and *Sitotroga cerealella* are to be placed.

T<sub>1</sub> Release of 10 *Blaptostethus pallescens* nymphs

T<sub>2</sub> Release of 30 *Blaptostethus pallescens* nymphs

T<sub>3</sub> Release of 10 *Xylocoris flavipes* nymphs

T<sub>4</sub> Release of 20 *Xylocoris flavipes* nymphs

T<sub>5</sub> Release of 30 *Xylocoris flavipes* nymphs

T<sub>6</sub> Infested grain with no Anthocorid predators

Seven day old nymphs to be released; each treatment with four replications and four infested bins maintained as control.

### **Observations:**

The number of moths emerging after a month in the treatment and control

The number of live anthocorid nymphs or adults in the bins

## **V. BIOLOGICAL SUPPRESSION OF WEEDS**

### **1. Biocontrol of *Chromolaena odorata* in forest area & waste lands of Chattishgarsh utilizing *Cecidochara connexa* by inoculative release (DWSR)**

**Location:** Chhattisgarh forests area & waste land near Raipur

**Treatments:**

1. Released sites
2. Un-released sites (control)

**Repliations:** 3

**Observations to be taken**

1. Monitoring at 3 month interval for establishment parameters like No. of plants infested , No. of galls/plant
2. Impact of bioagent on growth parameters of plants like plant height before release and after release
3. Number of branches in released site and control site.



## **VI. Enabling large scale adoption of proven biocontrol technologies**

### **A. RICE (KAU, AAU-J, PAU, OUAT)**

The Adat model to be replicated

**i. KAU: 100 ha (New Areas)**

**ii. AAU-J: 50ha**

**iii. OUAT: 40ha**

**iv. PAU: 40ha**

- Select a variety moderately resistant to sucking pests
- Seed treatment with *Pseudomonas* @ 8g/kg of seeds/seedling, dip in 2% suspension
- Apply *Beauveria bassiana* 10<sup>13</sup> spores/ha against sucking pests. Repeat sprays if necessary.
- Erect bird perches 10/ha.
- Release of *Trichogramma japonicum* @ 1 lakh/ha when either the leaf folder or stem borer occurrence is noticed. Initiate releases as soon as the moth activity is seen. Repeat releases at weekly intervals depending upon the moth activity.
- Spray *Bt* @2kg/ha, 2-4 sprays depending on the occurrence of caterpillar pests.
- Spray *Pseudomonas fluorescens* (dose as per university recommendation) against foliar diseases.
- Need-based or spot application of botanicals if sucking pests are not controlled by *B. bassiana* (specify the formulation and dosage when applied).

#### **Observations to be recorded:**

- All observations to be recorded in IPM plots as well as plots where farmers' practice will be followed, for making comparisons.
- Dead hearts/white ear and leaf folder damage at 15 days interval starting from imposition of treatments. Observe and record incidence of other lepidopteran pests.
- Population of leaf folder, skippers, caseworms and hairy caterpillar larvae in 10 randomly-selected plants/plot – before treatment as well as 2, 5 and 7 days after treatment with *Bt*. Record leaf damage and dead hearts before and 7 days after each spray from 20 randomly selected plants. Record white ears at late grain formation stage once from 20 randomly- selected plants.
- Number of sucking pests before and seven days after each spray of *B. bassiana* from 10 randomly selected hills, count mycosed insects also separately.
- Record disease incidence
- Yield to be recorded in IPM plots as well as plots with farmers' practice.

## **B. SUGARCANE**

### **1. Demonstration of temperature tolerant strain of *Trichogramma chilonis* against early shoot borer in *Suru* planting of sugarcane (MPKV)**

#### **Treatments:**

1. Release of temperature tolerant strain of *T. chilonis* @ 50,000 adults/ ha at weekly intervals starting from 45 days after germination of the crop. Total 8-10 releases to be made depending on pest intensity.
2. Farmers practice
3. Untreated control

**Plot size:** 1.0 ha per treatment to be divided into 10 equal blocks as replicates.

#### **Observations:**

1. Record pre-release infestation in all three blocks
2. Post release observations of the infestation/dead hearts be recorded at 15 day intervals after initiation of the parasitoid releases up to 4 months old crop. Record dead hearts at 15 spots in each block
3. Record number of tillers on each observation-day at each spot in each of the 15 blocks
4. Record yield data in each of the 15 blocks.

### **2. Enabling large scale adoption of proven biocontrol technologies against early shoot borer, top borer & stalk borer of sugarcane in collaboration with sugar mills (PAU)**

#### **a. Use of *Trichogramma chilonis* temperature-tolerant strain (TTS) against early shoot borer *Chilo infuscatellus***

Area: 200 ha.

Release the TTS of *T. chilonis* on 45<sup>th</sup> day after crop germination @ 50,000/ha at weekly intervals. A total of 8-12 releases are to be made depending on the pest situation.

#### **Observations**

1. Record pre-release infestation of early shoot borer in each field/block.
2. Post release observations on infestation of early shoot borer dead hearts to be recorded at fortnightly intervals after initiation of releases till the crop is 4 months old. Infestation to be recorded at least at 15 spots in each field/ block.
3. Record the number of tillers on each observation day at each spot. The tillers are to be counted at 15 spots in each field/block.
4. Record and compare yields at harvest in each block.

**b. Use of *Trichogramma chilonis* for the suppression of the stalk borer *Chilo auricilus***

**Area:** 1500ha.

Release *T. chilonis* from July to October @ 50,000/ha at weekly intervals. A total of 10-12 releases to be made depending on the pest situation.

**c. Use of *Trichogramma japonicum* for the suppression of Top borer (*Scirpophaga excerptalis*) of sugarcane**

**Area:** 200 ha

**Observations:**

1. Record pre-release infestation of top shoot borer in each field/block.
2. Release of *T. japonicum* @ 50,000/ha, six times at seven days interval starting with the first release after first observation of adult moths.
3. Post release observation on infestation/dead hearts to be recorded at fortnightly intervals after initiation of releases and observations to be recorded till the crop is 4 months old. Infestation to be recorded at least at 15 spots in each field/ block.
4. Record number of tillers on each observation day at each spot. The tillers are to be counted at 15 spots in each field/block.
5. Record yields at harvest and compare with the farmer's field.

**3. BIPM in Sugarcane (OUAT)**

**Area to be covered: Minimum 100 Acres**

**BIPM to be adopted**

- Release of *Trichogramma chilonis* @ 1 lakh parasitoids/ha against ESB and internode borer and *T.japonicum* against Top shoot borer at 10 day intervals,

**Farmers' practice**

- Application of granular insecticides and sprayable insecticides as per availability.

**C. MAIZE**

**1. Demonstration of biological control of maize stem borer, *Chilo partellus* using *Trichogramma chilonis* and *Cotesia flavipes* (PAU)**

**Plot size: 10 ha**

**Replications: Three**

### **Treatments:**

1. *Trichogramma chilonis*@ 50,000 parasitoids/ha at 10, 15 and 20 days after germination. The third release of *T. chilonis* to be accompanied by the release of *Cotesia flavipes* @ 5000/ha
2. Untreated control
3. Farmers Practice

### **Observations:**

1. Percent egg parasitism: Placing sentinel egg cards (*Corcyra* cards/ *Chilo partellus* cards) and collecting the cards at 24-48 hrs after each release of *Trichogramma chilonis* and confirming the adult parasitoid emergence in glass vials
2. Record dead hearts from 20 randomly selected plants
3. Record leaf injury from 20 randomly selected plants
4. Grain yield from plots

## **D. COCONUT**

### **1. Large area field validation of integrated biocontrol technology against *Oryctes rhinoceros* (CPCRI)**

**Area:** 100ha

#### **Biocontrol components:**

- i. *Oryctes rhinoceros* virus (releasing 12 virus infected beetles/ha),
- ii. *Metarhizium anisopliae* (applying fungal spores @  $5 \times 10^{11}$  spores/m<sup>3</sup>),
- iii. Pheromone trapping (placing pheromone traps @ one trap/5ha)

### **2. Large scale demonstration of Biological control of coconut caterpillar in coastal Odisha (OUAT)**

**Area to be covered: Minimum 500 Acres**

**Bio control techniques to be demonstrated :** As soon as the pest appears release of *Goniozus nephantidis* and *Bracon brevicornis* will be done@ 5000 parasitoids each/ ha, six times at 10 day intervals in coconut plantations. The infestation will be compared with the coconut plantations without parasitoid release.

## **E. Brinjal**

### **1. BIPM in Brinjal (OUAT)**

**Area to be covered: Minimum 100 Acres**

**BIPM to be adopted**

- Pheromone traps erected @ 25/ha after 15 DAP
- Weekly release of Egg parasitoid *Trichogramma chilonis* @50,000/ha / week after 20 DAP ( total of 15 releases ) (released till the final harvest)
- Two spray Bt @2 ml/l at 10 days intervals at peak flowering

#### **Farmers' practice**

- Rynaxypyr @0.3ml/l at fortnightly intervals or other insecticide application as per availability

#### **General Recommendations for all centres**

- **All data collected from the various experiments/ field trials should be statistically analyzed with the help of a statistician. For biodiversity indices, Dr. M. Pratheepa, Scientist (SS), Computer applications, NBAII may be contacted (mpratheepa.nbaii@gmail.com) 080-2351 1982 Extn. 340**
- **All centers should publish research papers in highly rated journals**

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| AAU-J  | Assam Agricultural University, Jorhat                                    |
| ANGRAU | Acharya N. G. Ranga Agricultural University                              |
| CAU    | Central Agricultural University, Pasighat                                |
| CISH   | Central Institute of Sub-Tropical Horticulture                           |
| CPCRI  | Central Plantation Crops Research Institute                              |
| CTRI   | Central Tobacco Research Institute                                       |
| DWSR   | Directorate of Weed Science Research                                     |
| YSPUHF | Dr. Y. S. Parmar University of Horticulture & Forestry                   |
| GBPUAT | Gobind Ballabh Pant University of Agriculture & Technology               |
| IARI   | Indian Agricultural Research Institute                                   |
| ICAR   | Indian Council of Agricultural Research                                  |
| IIHR   | Indian Institute of Horticultural Research                               |
| IISR   | Indian Institute of Sugarcane Research                                   |
| KAU    | Kerala Agricultural University   |
| MPKV   | Mahatma Phule Krishi Vidyapeeth  |
| MPUAT  | Maharana Pratap University of Agriculture and Technology                 |
| NBAII  | National Bureau of Agriculturally Important Insects                      |
| OUAT   | Orissa University of Agriculture & Technology                            |
| PAU    | Punjab Agricultural University   |
| SKUAST | Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar |
| TNAU   | Tamil Nadu Agricultural University                                       |
| UAS-R  | University of Agricultural Sciences- Raichur                             |