REPORT OF THE QUINQUENNIAL REVIEW TEAM ON ALL INDIA COORDINATED RESEARCH PROJECT ON BIOLOGICAL CONTROL OF CROP PESTS AND WEEDS

2007-2012

Members of QRT

Chairman:	**Dr. G. K. Veeresh**
Members:	**Dr. V. Ragunathan**
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Member Secretary:	**Dr. B. S. Bhumannavar**

Indian Council of Agricultural Research

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AICRP on Biological Control of Crop Pests and Weeds

QRT Executive Summary of Performance Review and Recommendations

ICAR commissioned the Quinquennial Review of the All India Coordinated Research Project on Biological Control of Crop Pests and Weeds for the period 2007-2012, by a team of eminent experts with Dr. G. K. Veeresh as Chairman and Dr. L. K. Hazarika, Dr. V. Ragunathan, Dr. Suresh Pal and Dr. B. S. Bhumannavar (Member Secretary) as members. From March to July, 2012, members of the QRT visited and reviewed the work of five AICRP centres and PC Unit for the period from 2007-2012. Team members evaluated the mandate of the project, performance of assigned research activities to each centre, physical facilities and human resources of the project and financial support. The project output in terms of publications, human resources development-training and other outcomes was also assessed. The QRT assessed the impact of the project *vis*-a-*vis* its mandate.

This project has a team of 22 scientists and 24 technical staff and 4 supporting staff working across the country in twenty centres (list included) (no staff in 4 voluntary centres). The scientific and technical staff worked for five years on various aspects of biological control of crop pests and weeds. The AICRP on Biological control functioned with a budget of Rs. 1331 lakh, out of which Rs. 813 lakh was spent on salaries; Rs. 234.2 lakh on equipment, Rs. 113.4 lakh on civil works; Rs. 22.5 lakh on TA and Rs. 146.7 lakh as recurring contingency.

Overall performance rating of the project

The major thrust of this project has been on biological control of major pests of sugarcane, rice, cotton, pulses, oilseeds, vegetables, fruits, coconut and weeds. The project activities remained biased towards research and extension about biological control of pests of crops. The other part of the project, *i.e.* mass multiplication and supply of biological control agents received less attention and the outcome of the second component remained less than desired level in this area. The QRT is of the opinion (believes) that reasons for this may have been on account of inherent shortcomings in the infrastructure and availability of technical staff.

I. Highlights of the research achievements of the project during the period in reference are shown below:

1. TNAU, Coimbatore, MPKV, Pune and IIHR, Bangalore centres were actively involved in the management of papaya mealybug through classical biological control and the mealybug has been successfully suppressed in Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Maharashtra and Tripura. The farmers of Tamil Nadu alone have saved about Rs. 400 crores from crop losses according to their own assessment.
2. GBPUAS & T, Pantnagar centre has developed five commercial formulations of *T. harzianum* (PBAT-43), *P. fluorescens* (PBAP-27), *T. harzianum* & *P. fluorescens* (PBAT-43 +PBAP-27), *P. fluorescens* (PBAP-2 +3), *Beauveria bassiana* (PBB-1), developed field application method through FYM enrichment and supplied 3.5 tons of formulation to Tarai organic farmers' association for the management of foliar diseases of rice (neck blast, sheath blight, brown spot and sheath rot), chilli (anthracnose), chickpea, lentil, vegetable pea and wheat.
3. AAU, Anand, MPKV, Pune and TNAU, Coimbatore centres have successfully managed the pigeonpea cyst nematode (*Heterodera cajani*) through combined application of

NBAII isolates of *T. harzianum* @ 5 kg /ha + *P. chlamydosporia* @ 20 kg /ha resulting in reduced eggs/ cyst population, seedling mortality and increased seed germination, plant height and yield.

4. AAU, Anand centre could effectively manage the nematode damage in pomegranate by combined application of NBAII isolate of *P. chlamydosporia* (100g/plant) and mustard cake (2 t/ha).
5. The Plassey borer of sugarcane could be effectively managed by nine releases of *T. chilonis* @ 50,000/ha at 10 days interval in Assam by AAU, Jorhat.
6. The PAU, Ludhiana centre has validated a BIPM package of practices to farmers of Punjab which include eight releases of temperature tolerant strain of *Trichogramma chilonis* @ 50,000/ha from April to June at 10 days interval for the management of early shoot borer, *Chilo infuscatellus* and eight releases of *Trichogramma japonicum* @ 50,000/ha from April to June at 10 days interval for the management of top borer, *Scirpophaga excerptalis.*
7. MPKV, Pune and AAU, Anand centres have validated a BIPM package consisting of seed treatment with *Trichoderma*, border rows of maize, erection of 10 bird perches/ha, release of *Chrysoperla*, spraying of NSK 5% suspension, SlNPV and three releases of *Tr. bactrae* for the suppression of sucking pests and boll worms of cotton
8. ANGRAU, Hyderabad centre found out that pigeonpea intercropped with sunflower and border crop of sorghum recorded the population of *H. armigera* larvae (23/10 plants) and higher yield (1256 kg/ha) compared to pigeonpea intercropped with sunflower and border crop of maize (42/10 plants) and the sole pigeonpea module (80/10 plants).
9. CTRI, Rajahmundry centre found that for satisfactory control of *Spodoptera litura* in tobacco nurseries, water with pH 6-8 to be used in *Sl*NPV spray fluid. Spray fluid with pH below 6 or above 8 was detrimental to *Sl*NPV under field conditions.
10. SKUAS & T, Jammu centre could effectively reduce the plant damage by cutworm, *Agrotis ipsilon* by the application of *Heterorhabditis indica* @ 2 billion /ha with significant increase of grain yield in maize at Jammu.
11. MPKV, Pune, MPUAT, Udaipur, TNAU, Coimbatore, CAU, Pasighat and OUAT, Bhubaneswar centres have confirmed effective management of *H. armigera* with increased yield of marketable tomato by the release of thelytokous strain of *Trichogramma pretiosum* @ 1 lakh/ha at weekly interval starting from 45 days after transplanting.
12. Leafhoppers on mango could be effectively managed by one spray of *M. anisopliae* @ 1 x 10^9 spores/ml on tree trunk during off season and two sprays during flowering season at weekly interval by TNAU, Coimbatore and IIHR, Bangalore centres.
13. The coconut leaf caterpillar *Opisina arenosella* could be effectively managed by sequential release of *Cardiastethus exiguus* and *Goniozus nephantidis* in Kerala by KAU, Thrissur centre.
14. The rhinoceros beetle of coconut was successfully managed by the integration of baculovirus targeting the adult population and application of *Metarrhizium anisopliae* in the FYM pits targeting the grub population by CPCRI, Kayangulam centre.
15. The diamond back moth, *Plutella xylostella* could be effectively managed by six releases of the exotic parasitoid, *T. brassicae* @ 1 lakh/ha in cauliflower and cabbage with a higher C:B ratio by AAU, Jorhat, MPKV, Pune, TNAU, Coimbatore and MPUAT, Udaipur centres.

Observations of the QRT: There are significant achievements in terms of value addition to economic, social and environmental aspects.

II. The specific recommendations of the QRT for different centres of AICRP on biological control include the following:

AAU, Anand

1. Concerted steps are to be taken by AAU, Anand centre to initiate survey, collection and diversity analysis of spiders in arid zones of India.
2. The mapping of EPN diversity in Gujarat should be initiated by AAU, Anand centre.
3. AAU, Anand centre should undertake evaluation of fungal and bacterial antagonists against collar rot of groundnut caused by *Aspergillus* spp. and *Sclerotium rolfsii*.

PAU, Ludhiana

1. Evaluation of fungal and bacterial antagonists for the management of foot rot of citrus (kinnow) caused by *Phytophthora* spp and evaluation of fungal and bacterial antagonists for the management of fusarial wilt of cucurbits can be taken up by PAU, Ludhiana centre.
2. Release of *T. chilonis* and *T. japonicum* for the management of different borers in sugarcane is followed during the last five years. PAU, Ludhiana centre has to assess the reduction in pesticide consumption due to release of these parasitoids.

IIHR, Bangalore

1. The IIHR centre should identify hot spots of major insect pests of important horticultural crops in the country and their natural enemies for further exploitation.
2. The IIHR centre should prepare a list of potential invasive pests of horticultural crops and their natural enemies for the benefit of other centres.
3. Economic analysis and documentation of impact of release of *Acerophagus papayae* on papaya production, seed production, papain industry along with savings in cost of insecticide and their application can be done.

MPKV, Pune

1. The MPKV, Pune centre has to explore the possibility of biological control of whitegrubs in sugarcane in Maharashtra.
2. Economic analysis and documentation of impact of release of *Acerophagus papayae* on papaya production, seed production, papain industry along with savings in cost of insecticide and their application should be done.

TNAU, Coimbatore

1. Documentation of natural enemies of spiraling whitefly in Tamil Nadu should be done by TNAU, Coimbatore.
2. Economic analysis and documentation of impact of release of *Acerophagus papayae* on papaya production, seed production, papain industry, mulberry and tapioca along with savings in cost of insecticide and their application should be done.

GBPUA & T, Pantnagar

1. Efforts should be made by GBPUA & T, Pantnagar to assess the performance of *Trichoderma* spp. In acid soils.
2. The proven isolates of *Trichoderma, Paecilomyces* and *Beauveria* developed by GBPUA & T, Pantnagar should be supplied to other AICRP centres for multi-location trials.

CTRI, Rajahmundry

1. CTRI, Rajahmundry centre should document the extent of loss caused by tobacco stem borer *Scrobipalpa heliopa* and initiate planned research work for its management.
2. CTRI, Rajahmundry centre should popularize *Sl* NPV through KVKs.
3. CTRI, Rajahmundry centre should record potential biological control agents (insects, pathogens) on *Orobanche* spp.

CPCRI, Kayangulam

1. Economic analysis biological control of *Oryctes rhinoceros* and *Opisina arenosella* should be done by CPCRI, Kayangulam.
2. Forecasting model should be developed by CPCRI, Kayangulam for the outbreaks of *Opisina arenosella* in Kerala and neighboring states including Karnataka.
3. KAU, Thrissur and CPCRI, Kayangulam centre should develop a common management package for the coconut pests.
4. The CPCRI centre should come out with a status paper on scarlet mite on plantation crops.

KAU, Thrissur

1. Based on the last five years work, KAU, Thrissur and CPCRI, Kayangulam centre should come out with recommendations for the management of coconut pests.
2. Survey and collection of natural enemies of banana weevil and banana aphid, pollu beetle and root mealybug of pepper including Entomopathogens should be taken up by KAU, Thrissur.

SKUAS & T

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 should be taken up by SKUAS & T, Srinagar and YSPUH & T, Solan.

YSPUH & T, Solan

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 can be taken up by SKUAS & T, Srinagar and YSPUH & T, Solan.
2. Evaluation of entomopathogenic fungi and EPNs for the suppression of apple root borer, *Dorysthenes hugelii* under field condition should be continued by YSPUH & T, Solan.

OUAT, Bhubaneshwar

1. OUAT, Bhubaneshwar centre should document natural enemies associated with cashew tea mosquito bug and mango pulp borer.
2. Large cacti species are grown in Odisha and work should be initiated on natural enemies associated with mealybugs of cacti by OUAT, Bhubaneshwar.

III. The overall general recommendations of the QRT for different centres of AICRP on biological control include the following:

1. Many of the biological control centres are addressing only their regional mandate at a narrow radius, whereas the AICRP should cover entire region cutting across state borders.
2. All the centres which report success of biological control should submit economic analysis with supporting data.

3. All the centres should report cost: benefit ratio along with statistical analysis for all the field trials conducted by them.
4. All centres should continue surveillance for alien invasive pests viz., *Brontispa longissima*, *Aleyrodicus digessi*, *Phenacoccus manihoti, Paracoccus marginatus, and Phenacoccus madeirensis*.
5. The QRT observed that the yield levels in BIPM treatments across crops are either on par or less than pesticide treatments resulting in not recommending BIPM. Even though the yields are slightly low, biological control treatments have to be promoted as it reduces not only the pesticide load in the environment but also minimizes the harmful effects of pesticides on human and animal health and other biological components of the environment.
6. QRT recommends that NBAII should organize one week training programme on identification of natural enemies along with molecular systematics and DNA bar coding on a preferential basis to different AICRP staff.
7. QRT strongly feels that Andaman centre is not represented and CARI should be part of AICRP on biological control.
8. The work of biological control of whitegrubs by EPN seems to hold good promise and additional support and finance may be provided in the XII plan and AICRP on biological control and AINP on whitegrubs should work hand in hand in solving the problem.

The outcome of discussion held with the project coordinator are given below:

a) Closing of existing centres- 1) Sugarcane Breeding Institute, Coimbatore, 2) Indian Institute of Sugarcane Research, Lucknow and 3) JNKVV, Jabalpur

Justification: The Director, SBI, Coimbatore has expressed his opinion that SBI would not be a part of AICRP on Biological Control. It is very unfortunate that when the biological control approach for managing whitegrubs and borers on sugarcane is so critical; both ICAR institutes (SBI, Coimbatore and IISR, Lucknow) mandated to carry out research exclusively on sugarcane did not actively undertake any research work on biological control. ICAR should seriously take note of this development and in case they do not participate in research work on biological control, the posts allocated to these two institutes for the said purpose should be transferred to NBAII. The QRT also suggests for closure of one SAU based AICRP on Biological control centre at JNKVV, Jabalpur as the centre's performance is not to the expected level and no post is provided under AICRP.

b) Opening of new centres; 1) UAS, Raichur, Karnataka 2) NCIPM, New Delhi and 3) CARI, Andaman and Nicobar Islands

Justification: The northern districts of Karnataka including Raichur, Bellary, etc. are cultivating agricultural crops on vast area and it has become a hot spot area for very high chemical pesticides use. The QRT strongly recommends that a centre for AICRP on Biological Control should be established at UAS (Raichur) to initiate the work on BIPM. Similarly Andaman & Nicobar islands are not represented at AICRP on Biological control and CARI, Port Blair has been made as new ICAR based centre. One more ICAR based centres is suggested at NCIPM, New Delhi as they are going to provide building space for future collaborative research work.

c) Redeployment of existing scientific posts- It is suggested for downsizing the scientific posts at AAU, Anand (*one entomology scientist), PAU, Ludhiana (** two assistant entomologist

posts) and Dr YSPUH & F, Solan (*** one entomology assistant professor post). These four posts may be re-deployed one each to CAU, Pasighat, OUAT, Bhubaneshwar, MPUAT, Udaipur and UAS, Raichur (proposed new centre).

d) QRT recommended additional manpower (one scientific and one technical post and one personal secretary) in the XII plan in PC Cell at NBAII, Bangalore.
e) To enable proper functioning of each centre there should be at least 2 scientists, 2 technical staff and 2 supporting staff. This should be the minimum requirement of staff for each centre.
f) QRT observed that certain voluntary and ICAR based centres without adequate funding have not performed satisfactorily. Therefore QRT recommends for allocating sufficient funds to these centres.
g) The overall performance of various centres is given at Annexure-III.
h) Contingency amount should be increased by 2.5 times to enable centres to meet increasing costs on fuel, contingency expenditure on field surveys, large scale field experiments and other project related activities. Budget for the project should be considerably increased to Rs. 3500 lakh in the XII plan.
i) Suitable policy has to be evolved to see that the vacant positions do not exist for too long at different centres.
j) It has come to the notice of the QRT that because of non availability of proper transport facility, many field survey and field experiments are not satisfactorily carried out. There is a need to fill this gap.

IV. SWOT Analysis of the Project

Strength

i. Vast diversity in cropping systems, agro ecologies, agri business opportunities
ii. AICRP on biological control has successfully demonstrated the benefits (superiority) of bio-intensive pest management practices (BIPM) in several crops. Biological suppression or BIPM methods of crop protection are eco-friendly, do not produce harmful side effects, and provide long-term benefits such as suppression of crop pests and conservation of natural resources for the future generations.
iii. Presently all AICRP centres have either strengthened or established new biological control laboratories for the mass production of several potential biological control agents and have acquired the skill in the production of biocontrol agents.
iv. India is blessed with rich biodiversity. Twenty-two species of egg parasitoids have been recorded on *Scirpophaga incertulas* from different countries of which 17 occur in India.
v. Among larval parasitoids out of 74 species recorded, 52 species are from India. Out of 31 species of egg parasitoids and 76 species of nymphal / adult parasitoids recorded all over the world on rice hoppers, 16 and 32, respectively, are from India.
vi. At least 27 natural enemies of Indian origin have established in other countries. The economic benefits of one of these natural enemies improved the Texas (USA) economy by millions of dollars. Out of 18 species of parasitoids imported into USA for biological control of *Heliothis* and *Helicoverpa*, eleven species were from India.
vii. More farmers are turning towards organic farming. In organic farming the rich natural biodiversity is well conserved due to non-use of toxic pesticides. Augmentation of natural enemies in organic farming as well as in several other situations helps not only in conservation and enhancement of the existing biodiversity of natural enemies but also adds value to the crops protected.

Weaknesses

i. Correct identity of the pest and their natural enemy is a prerequisite for any successful classical biological control programme. The diminishing numbers of insect taxonomists in India and in particular at NBAII is a big weakness. The role of biosystematics is of prime importance for knowledge build-up in the field of biodiversity. Presently NBAII is having only seven insect taxonomists, which is grossly inadequate considering more than 80% of known specimens are insects and other arthropods.

ii. There is very little awareness among the growers about the toxic side effects of pesticides, particularly on natural enemies. There is lack of awareness about the long term beneficial effects of use of parasites and predators for the suppression of crop pests. Even today, most of the growers apply the insecticides indiscriminately, killing the beneficial organisms first before killing the crop pests.

iii. Unlike microbial bio-pesticides that have at least one year shelf life, the parasitoids and predators have to be used immediately. In some cases, they can be stored maximum for a week. The growers have to plan well in advance for using the natural enemies in their crops. The private biological control laboratories are not interested in multiplying parasitoids and predators as these cannot be stored. In addition the supply orders are cancelled abruptly by the growers leading to loss to the producers. This has prompted several private laboratories to discontinue the production of parasitoids and predators for use in biological control programmes.

Opportunities

i. Use of antagonistic pathogens through seed treatment was a limiting factor in saline soils. But the recent breakthrough in identifying saline tolerant strains of *Trichoderma* has opened the doors for the management of soil borne diseases in saline soils. Similarly identification of *T. harzianum* isolates tolerant to carbendazim has also given new avenues for the management of soil borne diseases through seed treatment.

ii. Identification of virulent strains of entomopathogens like *Beauveria bassiana*, *Metarrhizium anisopliae*, *Verticillium lecanii* and *Nomuraea rileyi* and entomopathogenic nematodes has paved the way for developing improved formulations with long shelf-life for the management of crop pests.

iii. Use of wettable powder formulations of antagonistic pathogens on grapes and other fruits was problematic as they left powder residues over fruit surface which affected the export of these fruits. But the development of liquid formulations of *Trichoderma* has solved this problem and has given new opportunity for enhanced usage for the management of powdery mildew on grapes and post-harvest fruit rot on mango.

iv. The rich biodiversity in our country gives us ample opportunity to be a potential exporter of natural enemies and earn valuable foreign exchange.

v. Availability of rich talent pool of scientists and hostel facilities for trainees at NBAII is an added advantage for human resource development in the field of biological control of crop pests and weeds.

vi. The human health problems on account of chemical pesticide residues in food and food commodities due to their indiscriminate uses have prompted consumers shifting their preferences for organically produced food worldwide. In India also several organizations are producing organically produced food which is fetching premium price. Augmentation of natural enemies in organic farming as well as in several other situations helps not only in the conservation and enhancement of the existing biodiversity of natural enemies but also adds value to the crops protected. Organic farming has given tremendous opportunities for popularizing biological control methods for the suppression of crop pests and weeds.

Threats

i. New molecules of insecticides with quick knock-down effect are entering the market every day and farmers are tempted to use them for pest management. In the absence of proper evaluation of such new molecules on the harmful effects on natural enemies and other components of environment it is likely to pose greater danger to the bio diversity and natural resources of the country.
ii. With the opening up of the economy to the world markets, the danger of introduction of alien invasive pests like *Brontispa longissima, Aleurodicus dugesii, Phenacoccus manihoti,Phenacoccus madeirensis* and many more invasive species has increased greatly.
iii. The absence of a declared policy in recognizing biological control as a high priority area in pest management is another major constraint.
iv. Introduction of genetically modified Bt cotton and other crops might also bring in negative influence the biodiversity of natural enemies associated with the lepidopteron defoliators and borers, whose population is altered or imbalanced. Hyperparasitoids in certain seasons nullify the effect of inundative release of natural enemies. Further, in-depth studies will provide the answer to such vexed problems.
v. The biggest threat to biological control is from the continued and indiscriminate use of broad spectrum pesticides which decimate the population of natural enemies. Only a small percentage (1%) of pesticides applied to the crop reaches the target pest while more than 99% reaches non- target sectors of the ecosystem. Surveys in different parts of India have revealed pesticide contamination in several foodstuffs. This threat can only be countered by adopting BIPM methods. Despite availability of mass production techniques for some natural enemies, private companies are not coming forward in a big way for producing natural enemies. The non-availability of natural enemies at appropriate time is hampering the adoption of biological control on a large scale. Proper cold storage and transport facilities and lack of quality control testing mechanism are the major threats to promoting biological suppression of crop pests in a sustainable manner.
vi. Our extension system through different media is biased towards pesticides largely because of business interest.

V. Coordinating Unit and Governance of the project

Based on the report submitted by the project coordinator, the QRT observed that:
The present Project Coordinating Unit functioning at NBAII, Bangalore is an administrative unit fully catering to the technical needs of the project. The Director, NBAII by default is the project coordinator and regularly visited different AICRP centres at frequent intervals and reviewed the progress of research and extension activities. The project coordinator conducted the annual group meeting of all the biological control research scientists from different AICRP centres during May of each year, reviewed the progress and incorporated appropriate midcourse modifications of the technical programme for every two years. Subsequent changes were also made in the technical programme as and when felt very essential. The PIs of four new voluntary centre were provided training on the mass production of biological control agents at NBAII, Bangalore for a period of 10 days.

VI. Future of the project

Keeping in view the strategic and economic interests of the nation biological control of pests of crops has to emerge as one of the efficient methods of pest management to facilitate reducing the usage of pesticides thereby bringing down the pesticide load in the environment, eliminating or reducing pesticide residue problem on food, feed and non-target organisms. Though the yield levels in biological control treatments are almost on par with insecticides or slightly lower, biological control method has to be popularized for minimizing the hazards to human and animal health and other components of environment caused by pesticides. Efforts should also be made by all the AICRP centres in providing training and inputs to all the KVKs located nearby on the mass production and utilization of biological control agents.

There is an urgent need for assessing the impact of biological control *vis* a *vis* the pesticide usage in the country for proper future planning. For the last five years biological control experiments conducted at 20 centres in addition to SAU's and ICAR institutes working on similar lines, the impact studies have not been made anywhere. For want of data the economic and environmental benefits derived out of biological control have not been appreciated. Thus QRT strongly recommends for the constitution of an expert committee to assess the impact of biological control and reduction in pesticide usage. It would greatly help in the formulation of future plans for plant protection.

A. INTRODUCTION

The Director General, Indian Council of Agricultural Research (ICAR) constituted the Quinquennial Review Team (QRT) with the following experts to review the progress of research and its impact and other relevant activities undertaken by (i) National Bureau of Agriculturally Important Insects (NBII), Bangalore, (ii) AICRP on Biological Control of Crop pests and Weeds, (iii) AINP on Whitegrubs and other Soil Arthropods, (iv) AINP on Agricultural Ornithology and (v) AINP on Agricultural Acarology during the five year period from 2007-08 to 2011-12 vide Council's order F. No. 15(2)/07-IA.III Dated 23rd February, 2012.

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   Former Vice Chancellor, UAS, Bangalore,
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The terms of reference, as provided in the ICAR Guidelines for QRT, followed for the review are given in Annexure-I.

B. THE PROCESS

The first meeting of the QRT with Dr. Swapan K. Dutta, Deputy Director General (Crop Science), ICAR, New Delhi, Dr. T. P. Rajendran, Assistant Director General (Plant Protection), ICAR, New Delhi and Dr. N. K. Krishna Kumar, Director, NBAII, Bangalore was held on 16th March, 2012 in the chamber of the DDG (CS), ICAR, Krishi Bhavan, New Delhi at 11.00 am. The DDG (CS) discussed about the need for review of the AICRP on biological control of crop pests in terms of the changing scenario from indiscriminate use of pesticides to bio-intensive pest management by way of mass production, utilization, augmentation and conservation of biological control agents. The QRT members were apprised of terms of reference of this project. The members were also provided with the background information of the project, previous QRT reports, important publications, evaluation proforma for the centres and recent ICAR Guidelines

for the QRT. Since the QRT had to review the work of 39 centres (both AICRP and AINPs), four rounds of meetings were held at New Delhi, PAU, Ludhiana (North Zone), AAU, Jorhat (East Zone), NBAII, Bangalore (South Zone) and MPKV, Pune (West Zone) and the nearby centres of each zone were asked to present their reports.

Tour itinerary of the QRT

Date	Place	Centres reviewed	Members present
16.3.2012	IARI, New Delhi	First meeting of QRT with DDG (CS) and ADG (PP) IARI, Delhi IISR, Lucknow NCIPM, New Delhi	Dr. G. K. Veeresh Dr. L. K. Hazarika Dr. V. Ragunathan Dr. N. K. Krishna Kumar Dr. B. S. Bhumannavar
16-19, April, 2012	PAU, Ludhiana	PAU, Ludhiana SKUAS & T, Srinagar YSPUA & F, Solan GBPAU & T, Pantnagar	Dr. G. K. Veeresh Dr. L. K. Hazarika Dr. Suresh Pal Dr. N. K. Krishna Kumar Dr. B. S. Bhumannavar
12-15, June, 2012	AAU, Jorhat	AAU, Jorhat CAU, Pasighat	Dr. G. K. Veeresh Dr. L. K. Hazarika Dr. V. Ragunathan Dr. B. S. Bhumannavar
26-28 June, 2012	NBAII, Bangalore	IIHR, Bangalore KAU, Thrissur OUAT, Bhubaneswar CTRI, Rajahmundry TNAU, Coimbatore CPCRI, Kayangulam	Dr. G. K. Veeresh Dr. L. K. Hazarika Dr. Suresh Pal Dr. N. K. Krishna Kumar Dr. B. S. Bhumannavar
19 July,2012	NBAII, Bangalore	ANGRAU, Hyderabad	Dr. G. K. Veeresh Dr. V. Ragunathan Dr. Suresh Pal Dr. B. S. Bhumannavar Dr. N. K. Krishna Kumar
20-21 July, 2012	MPKV, College of Agriculture, Pune	MPKV, Pune AAU, Anand	Dr. G. K. Veeresh Dr. V. Ragunathan Dr. B. S. Bhumannavar Dr. N. K. Krishna Kumar

The methodology adopted by the QRT during the review allowed the members to have more time for interactive sessions with the PIs of the different centres as well as stakeholders and others. The PIs of different centres were requested to present the work done during the period followed by a discussion with all the members. The members have expressed their views about the methodology followed for the different experiments and also critically analyzed the results. Wherever possible the members met the Head of the Department (Entomology), Director of Research and Vice-Chancellor of the university and shared their views about the centre's performance and sought their opinion.

A proforma was also developed to evaluate the centres (Annexure-III)

C. MAIN REPORT

i. Brief History of the Project

The National Agricultural Policy has laid a special emphasis on Integrated Pest Management (IPM) and use of biotic agents in order to minimize the indiscriminate and injudicious use of chemical pesticides, the cardinal principle of the Government of India on plant protection. The IPM implementation at national level has proved effective not only in reducing pesticide but also in reducing pest induced losses in the country, amply evidencing a bright future for the successful use of biological control agents in pest control programmes. India is rich in natural enemy biodiversity and facilitated as many as 27 natural enemies of Indian origin being established in other countries for crop pest suppression. Thus, there is ample opportunity in India for effective management of pests, diseases and weeds through effective utilization of its vast natural enemy fauna.

Biological control of crop pests and weeds made its humble beginning with the launching of the All India Coordinated Research Project (AICRP) in 1977 at Bangalore with full financial support by the Department of Science and Technology, Government of India. Recognition of the importance of biological control came during the VIII plan with the creation of **Biological Control Centre** (BCC) which was functioning under the administrative control of NCIPM, Faridabad. A greater thrust for planned biological control programme started in 1987 when ICAR took over the erstwhile ***Commonwealth Institute of Biological Control*** (CIBC), its insect collections, physical facilities including the prime land on Bellary Road on NH-7, Bangalore. The BCC which was functioning as the PC Cell of AICRP on Biological Control of Crop Pests and Weeds was upgraded to the ***Project Directorate of Biological control*** (PDBC) with headquarters at Bangalore. The Directorate started functioning from 19th October 1993 with six laboratories and 16 AICRP centres. In the XI plan, the PDBC was renamed and reoriented into ***National Bureau of Agriculturally Important Insects*** (NBAII) on 25th June, 2009 and the mandate was redefined. The AICRP has 16 centres along with 4 voluntary centres (added during XI plan) and all functioning under the Bureau.

Sl. No.	Centres	Mandatory Crops	Year of start
State Agricultural University-based centres			
1	AAU, Anand	Cotton, pulses, oilseeds, vegetables & weeds	1978
2	KAU, Thrissur	Rice, coconut, fruits, vegetables & weeds	1978
3	PAU, Ludhiana	Sugarcane, cotton, pulses, rice, oilseeds & weeds	1978
4	SKUAS & T, Srinagar	Temperate fruits	1978
5	ANGRAU, Hyderabad	Cotton, pulses, coconut, vegetables & weeds	1983
6	Dr.YSPUH & F, Nauni, Solan	Temperate fruits, vegetables & weeds	1986
7	TNAU, Coimbatore	Cotton, pulses, rice, coconut & fruits	1986
8	AAU, Jorhat	Rice and weeds	1987
9	MPKV (Rahuri), Pune	Cotton, rice, vegetables, potato & weeds	1989
10	GBPUA & T, Pantnagar	Basic research - Plant disease antagonists	1996
ICAR Institutes-based centres			
11	IIHR, Bangalore	Fruits & vegetables	1977
12	SBI, Coimbatore	Sugarcane	1978

13	IISR, Lucknow	Sugarcane	1978
14	CTRI, Rajahmundry	Tobacco	1978
15	CPCRI, Kayangulam	Coconut	1978
16	IARI, New Delhi	Basic research - pathogens	1978
	Voluntary centres		
17	JNKVV, Jabalpur	Maize, pulses, oilseeds, vegetables & polyhouses	2009
18	MPUAT, Udaipur	pulses, oilseeds, vegetables, whitegrubs & termites	2009
19	CAU, Pasighat	sugarcane, rice, tropical fruits & vegetables	2009
20	OUAT, Odisha	rice, oilseeds, tropical fruits & vegetables	2009

ii. Mandate of the project and the objectives

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

Objectives

i. Develop effective biological control agents for use in biological suppression of crop pests and diseases
ii. Evaluate various methods of biological control in multi-location field trials
iii. Develop biointensive integrated pest management strategies against pests of cotton, rice, sugarcane, pulses, oilseeds, potato, coconut and a few selected fruits and vegetables crops and crop pests of protected cultivation

iii. Priorities, programmes and research projects (centre-wise)

1. Anand Agricultural University, Anand, Gujarat

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-12)
Nine different species of coccinellids *viz.*, *Cheilomenes sexmaculata*, *Hippodamia variegata*, *Illeis cincta*, *Harmonia octomaculata*, *Coccinella transversalis*, *Brumoides suturalis*, *Propylea dissecta*, *Coccinella septempunctata* and *Anegleis cardoni* have been collected from different crop ecosystems and identified. *Trichogramma chilonis* Ishida and *Chrysoperla zastrowi sillemi* were also noticed most common in many crops. Different parasitoids *viz.*, *Prochiloneurus pulchellus*, *Coccophagus psuedococci*, *Promuscidea unfasciativentris*, *Parachrysocharis javensis*, *Diplazon* sp., *Callaspidia* sp., *Syrphophagus* sp., *Aenasius bambawalei* and *Chrysonotomyia* sp. have been collected and identified.

Biological control of plant diseases and nematodes using antagonistic organisms- Large scale field demonstration of biocontrol technologies in field (2007-09)
Significantly least (5.6%) wilted plants due to *Fusarium* were found in plots of *Trichoderma* seed treatment + application of FYM enriched with *T. harzianum*. Seed treatment with *Trichoderma* + vermicompost colonized with *Pseudomonas fluorescens* was also found to be superior over farmers' practices. Significantly higher grain yield was harvested from the net plots of seed

treatment with *Trichoderma* + FYM colonized with *T. harzianum* than seed treatment with *Trichoderma* + vermicompost colonized with *P. fluorescens* and check. Least (4.2%) wilted plants of castor due to *Fusarium* wilt were found in plots treated with castor cake (1.5 tons/ha) colonized with *T. harzianum* (2 kg/ha) followed by FYM (12.5 tons/ha) enriched with *T. harzianum* (2 kg/ha). Yield of castor seeds was higher in former treatment than the latter treatment.

Isolation and identification of the potential biocontrol agents (especially yeasts) for the management of post harvest losses (AAU, Anand on papaya) (2007-11)
Both the strains of *Pseudomonas* (strain 3 and 27) found equally effective, but proved significantly better than both the strains of *Trichoderma* against fruit rot of papaya. Strain 43 of *Trichoderma* found to be significantly more efficacious in comparison to *Trichoderma* strain 10 in suppressing the fruit rot disease.

Biological control of pigeonpea cyst nematodes and disease complex in redgram to develop suitable protocol for their center & communicate to PDBC (2007-09)
Amongst different biocontrol agents evaluated, the combined treatment of *Trichoderma harzianum* (5 kg/ha) + *Pochonia chlamydosporia* (*Verticillium chlamydosporium*) @ 20 kg/ha registered significantly highest number of unhealthy (parasitized/diseased) cysts in comparison to rest of the treatments evaluated. Individual application of *T. harzianum* and *P. chlamydosporia* was equally effective and found statistically at par with each other, but proved significantly inferior to combined application of both the bioagents. Significantly higher yield was recorded in plots treated with combination of *T. harzianum* and *P. chlamydosporia.*

Biological control of plant parasitic nematodes on vegetables and fruits on pomegranate (2007-11)

Application of *Paecilomycis lilacinus* in combination with *P. chlamydosporia* each @ 100 g/plant or mustard cake (2 ton/ha) controlled root knot nematodes *Meloidogyne* spp. infesting pomegranate, reduced root knot index and improved plant canopy.

Isolation of native *Bt* isolates from soil (2011-12)
Soil samples have been collected from various villages of Anand and Bharuch district and 389 suspected *Bt* isolates have been isolated. The soil samples were sent to NBAII, Bangalore for exploring the possibilities of presence of potential antagonistic microorganisms. Total 17 *Trichoderma*, 2 *Pseudomonas* and 4 *Bacillus* isolates have been isolated by NBAII, Bangalore. The samples are also being processed at Anand for isolation of potential indigenous isolates.

Surveillance for alien invasive pests in vulnerable areas (*Brontispa longissima; Aleurodicus dugesii; Phenacoccus manihoti; Paracoccus marginatus; Phenacoccus madeirensis*) (2011-12)
In order to monitor the occurrence of papaya mealybug, *Paracoccus marginatus*, a regular survey was carried out in papaya growing areas of middle Gujarat. Incidence of the new invasive pest was not noticed in middle Gujarat region. Its absence was also confirmed throughout the state.

Demonstration of Bio-Intensive Pest Management (BIPM) in *Bt* cotton (2007-09)
BIPM module v/s farmers' practices (as check) were evaluated and demonstrated in *Bt* cotton. Results revealed that significantly low population of sucking pests was recorded in BIPM module (seed treatment with *Trichoderma* @ 8 g/kg seed + border row of maize crop around the cotton

crop + 2 to 3 releases of *Chrysoperla* larvae @ 14,000/ha + spray of NSKE 5 % + release of *T. chilonis* @ 1.5 lakh/ha) over the module of farmers' practices.

Bio-intensive pest management of pink boll worm, *Pectinophora gossypiella* on cotton (2007-09)

Larval population of *P. gosspiella* and its damage to green bolls was found at low level in BIPM practices (module) [seed treatment with *Trichoderma* @ 8 g/kg seeds + border of maize crop around cotton field + bird perches @ 10/ha + release of *Trichogrammatoidea bactrae* @ 1.5 lakh/ha/week + 2 to 3 releases of *C. z. sillemi* larvae @ 14000/ha + spray of NSKE 5%] over the treatment (module) of farmers practices (FP) and untreated check (absolute control). Maximum seed cotton yield was registered in BIPM module followed by FP.

Enhancement of natural enemies population in cotton by habitat manipulation in rainfed cotton (2007-09)

Studies on impact of habitat manipulation on natural enemies of cotton pests, concluded that lowest number of sucking pests (aphids, leafhoppers and whitefly), lower damage to buds, green bolls and locules due to bollworms and highest yield of seed cotton was recorded in module consisted treatment of cotton seeds with *Trichoderma* @ 5 g/kg seeds + cotton interspersed with *Cassia occidentalis* (6:1) + planting of maize and zinnia @ 10 % plants + one release of *T. chilonis* @ 1.5 lakh/ha + one release of *C. carnea* (5000 grubs/ha) coinciding with the appearance of aphids. The habitat manipulation plot also recorded higher predator population and parasitism by *T. chilonis*.

Identification of natural enemies of mealybugs on cotton and evaluation of potential natural enemies (2007-09)

Aenasius bambawalei Hayat has been identified as one of the promising biocontrol agent on cotton mealybug. Significantly least (8.86%) per cent of mealybug infested plants were registered in insecticidal treated plots followed by *Cryptolaemus montrouzieri* released plots (10.52%) over untreated check (12.39%). With respect to mealybug infestation on bolls, the treatment of *C. montrouzieri* released and untreated control plot were found at par. *C. montrouzieri* released plots produced 11.05% higher seed cotton yield than untreated check.

Monitoring the biodiversity and outbreaks of invasive mealybugs and their natural enemies on horticultural field/ medicinal and aromatic crops (2009-11)

Parasitism due to *A. bambawalei* on *P. solenopsis* ranged from 15.66 to 21.15% with an average value of 17.63%. Initially (16.84%) parasitism was found to be low during early phase of the crop which increased in subsequent weeks and attained a maximum (26.72%). Maximum parasitism (21.15%) due to *A. bambawalei* on *P. solenopsis* was found in Khandha location of Vadodara taluka, whereas, minimum (15.66%) parasitism at Bhilapur location of Dabhoi taluka.

Bio-efficacy of some microbial insecticides against *Spodoptera litura* in tobacco nursery (2007-09)

Experiment was laid-out at Bidi Tobacco Research Station, AAU, Anand nursery for two successive years (2007-08 and 2008-09), but due to inadequate pest population in experimental plots, valid inference could not be drawn.

Seasonal abundance of predatory spiders in rice ecosystem (2011-12)

Out of 69 specimens of predatory spiders collected from different paddy fields of middle Gujarat region, 18 species belonging to seven different families were identified. Among the different species of predatory spiders, Araneidae is found to be predominant species followed by Tetragnathidae and Salticidae.

Demonstration of biocontrol of pests and diseases of Pigeonpea (2007-09)

BIPM practices evaluated against pests and diseases of pigeonpea revealed that significantly lowest (4.35%) green pod damage by *H. armigera* with higher (1042 kg/ha) grain yield were recorded in the treatment of BIPM practices (seed treatment with *Trichoderma* @ 6 g/kg seeds + soil application of *P. chlamydosporium* @ 20 kg/ha, + application of NSKE 5 % at flowering + application of HearNPV on appearance of *H. armigera* larvae) over the treatment of local recommendation and farmer's practice. Incidence of blue butterfly, *Lampedes boeticus*, plume moth, *Exalastis atomosa* and podfly, *Melanoagromyza obtusa* did not differ significantly amongst the treatments. Very low incidence of wilt disease was recorded in various treatments.

Fixing economic threshold level for NPV application for the control of *Helicoverpa armigera* on chickpea (2007-09)

During 2007-08, the experiment was conducted at Anand but vitiated as the incidence of *H. armigera* was not up to the threshold level in chickpea. During 2008-09, same experiment was conducted at Agril. Res. Station, Arnej (Dist. Ahmedabad) where chickpea crop is widely grown by the farmers of the region. Due to heavy disease incidence in the experimental plots, the plant stand could not be maintained and the incidence of *H. armigera* also did not reach the ETL in respective plots. Hence, the trial could not be concluded.

Impact of bio-suppression of *H. armigera* on the incidence of other lepidopteran and borer species of pigeonpea (2008-11)

Studies on impact of bio-suppression of *H. armigera* on other pod borer species of pigeonpea revealed that the larval population and its damage to developing pods reduced significantly in the plots treated with HaNPV ($1.5X\ 10^{12}$ POB/ha) + hand collection of grown-up larvae as compared to check (absolute control). The treatment of biological pest suppression of *H. armigera* did not show any impact on the succession of two other species of pod borers *viz;* podfly, *Melanoagromyza obtusa* and plume moth, *Exelastis atomosa* infesting pigeonpea.

Influence of crop habitat diversity on biodiversity of pests of pigeonpea and their natural enemies (2009-11)

Studies on influence of crop habitat diversity on biodiversity of natural enemies in pigeonpea revealed that the pigeonpea intercropped with sunflower in the ratio of 9:1 with maize or sorghum as border crop enhanced the population of predatory insects such as chrysopids and coccinellids which suppressed the incidence of *H. armigera* on pigeonpea.

Evaluation of NBAII liquid formulations (PDBC-BT1 and NBAII-BTG4) and IARI *Bt* against pigeonpea pod borer (*Helicoverpa armigera*) and legume pod borer (*Maruca testulalis*) (2011-12)

Three *Bt* isolates (PDBC-BT1, NBAII-BTG-4 and IARI Bt) were evaluated at 1 and 2 % concentration against pigeonpea pod borer, *H. armigera* and revealed that all the three *Bt* formulations were equally effective in suppressing the pest, however relatively less population of the pest was found in IARI isolate followed by PDBC-BT1 and NBAII-BTG-4. With respect to grain damage due to *H. armigera* at harvest, all the *Bt* based microbial insecticides were at par and exhibited grain damage ranging from 7.58 to 9.19%.

Demonstration of Bio-intensive pest management practices in chickpea (2011-12)
Amongst the three different modules evaluated against *H. armigera*, significantly least number of larvae and its damage to green pods were recorded in Bio-intensive Pest Management (BIPM) module over the module of farmers' practice (only insecticidal spray) and control (untreated check). BIPM module exhibited significantly least number of dried plants due to wilt disease than the module of farmers practice. Significantly highest (940 kg/ha) grain yield was harvested from the BIPM module in comparison to rest of the two other modules.

Biological management of root-knot nematodes infesting tomato in polyhouses (2009-12) (In linkage with AICRP-Nematodes)
Bio-efficacy of talc based formulations of *P. lilacinus*, *P. chlamydospora* and *Arthrobothra oligospora* @ 20 kg/ha evaluated against root knot nematodes revealed that there was no significant difference in parasitism in egg masses and no root galling was found at 45 and 90 days after transplanting. Yield differences were also non-significant amongst different treatment.

Enabling large scale adoption of proven biocontrol technologies- *Bt* cotton (2009-10)
Demonstration on large scale adoption of BIPM practices in *Bt* cotton on farmers' field revealed that the population of sucking pests was reduced significantly in BIPM module over FP and untreated check. Significantly lower bollworm damage to green bolls and locules with higher seed cotton yield was registered in BIPM in comparison to FP.

Establishment of mass production units (at all the AICRP centres)
This centre has established mass production unit for *T. chilonis* (egg-parasitoid of lepidopteran pests) and *C. zastrowi sillemi* (predator of soft-bodied insects). These bioagents are supplied to the farmers as and when demanded.

Production, process, technologies developed

- The centre had established mass production unit for *T. chilonis* and *Chrysoperla z. sillemi* and supplying to farmers on demand.
- Large scale demonstration of BIPM practices in Bt cotton on farmers' field was conducted.
- The centre had validated the BIPM module in cotton which resulted in significantly low population of sucking pests over the module of farmers' practices of spraying insecticides.
- The centre had validated the BIPM module in pigeonpea which recorded significantly lowest green pod damage (4.35%) by *H. armigera* with higher grain yield (1042 kg/ha) over the farmer's practice of insecticide application.
- Similarly the centre had validated BIPM module in chickpea which recorded least incidence of *H. armigera* (0.06 larvae/plant), pod damage (1.77%) and highest yield (940 kg/h) of chickpea.

Infrastructure and physical facilities developed
The centre had established biological control laboratory for the mass production of biocontrol agents.

Human resource development efforts

The PI and other workers in the centre participated in several national conference, seminars and workshops and presented research articles.

Publications

Scientific articles published in journals	-	82
Scientific articles presented in symposia, seminars, etc.	-	71
Popular articles published in local languages	-	143

Best publication

Shamim, M., Shekh, A. M., Patel, V. J., Dodia, J. F., Korat, D. M. and Mehta, A. M. 2009. Effect of weather population dynamics of green leaf hopper and white backed plant hopper in paddy grown in middle Gujarat region. Journal of Agrometerology, 11(2): 172-174.

Observations of the QRT

i. Perusal of the five years report revealed that in some of the years the experiments were not conducted either due to low pest incidence or due to other reasons like heavy rains or no rains.

ii. BIPM module (seed treatment with *Trichoderma* @ 8 g/kg seed + border row of maize crop around the cotton crop + 2 to 3 releases of *Chrysoperla* larvae @ 14,000/ha + spray of NSKE 5 % + release of *T. chilonis* @ 1.5 lakh/ha) in cotton resulted in significantly low population of sucking pests over the module of farmers' practices of spraying insecticides.

iii. In pigeonpea significantly lowest (4.35%) green pod damage by *H. armigera* with higher grain yield (1042 kg/ha) were recorded in BIPM practices (seed treatment with *Trichoderma* @ 6 g/kg seeds + soil application of *P. chlamydosporium* @ 20 kg/ha, + application of NSKE 5 % at flowering + application of HearNPV on appearance of *H. armigera* larvae) over the farmer's practice of insecticide application.

iv. BIPM module (Seed treatment with *T. viride* @ 8 g/kg + FYM enriched with *T. viride* @ 10t/ha + *H. armigera* pheromone traps @ 40/h + alternate spraying of HearNPA @ 6 x 10^{12} POB/h and NSKE @ 5% at flowering stage) recorded least incidence of *H. armigera* (0.06 larvae/plant), pod damage (1.77%) and highest yield (940 kg/h) of chickpea.

Recommendations of the QRT

1. Reasons given for not conducting the experiments appear vague, centre needs commitment in conducting the experiments.
2. Concerted steps are to be taken by the centre to initiate survey, collection & diversity analysis of spiders in arid zones of India.
3. The mapping of EPN diversity in Gujarat should be initiated.
4. On groundnut collar rot is becoming more severe. Evaluation of fungal and bacterial antagonists against collar rot of groundnut caused by *Aspergillus* spp. and *Sclerotium rolfsii* can be taken up.
5. More data to be generated on the efficacy of NBAII liquid formulations (PDBC-BT1 and NBAII-BTG4) and IARI Bt against pigeon pea pod borer (*H. armigera*) and legume pod borer (*M. testulalis*).

Overall assessment

Good

2. Kerala Agricultural University, Thrissur

Brief Achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-12)
Collected all the bioagents and sent to NBAII. Soil samples were collected and sent to NBAII for isolation of EPN and antagonistic pathogens. Collected anthocorids from the coconut leaflets infested with *Opisina arenosella* from Palakkad district of Kerala. The anthocorids were identified as *Physopleurella armata*. This is the first report from India.

Large-scale demonstration of IPM for rice pests and diseases in the farmer's field (2007-09)
Release of *Trichogramma japonicum* @ 1 lakh/ha significantly reduced the population of stem borer and leaf folder. Significantly high incidence of coccinellids and spiders were recorded in IPM. Grain yield was significantly high in IPM. IPM with biocontrol techniques is a well adopted technology among farmers of Kerala.

Validation of biointensive pest management practices in organic rice production (2007-09)
Release of *T. japonicum* @ 1 lakh/ha significantly reduced the population of stem borer and leaf folder. Predatory population was significantly high in organic farming. Grain yield was significantly high in conventional farming.

Preliminary evaluation/ screening of EPN against YSB, striped borer and leaf folder in rice (2009-11)
Stem borer and leaf folder incidences were significantly low in chemical control. EPN treated plants and control plants were on par in pest incidences.

Survey for the identification of potential natural enemies of the gundhi bug, *Leptocorisa* sp. (2009-11) Collected eggs and nymphs of rice bug from rice fields and kept for parasitoid emergence and disease incidence. No natural enemy was found on *Leptocorisa* sp.

Laboratory evaluation of fungal pathogens on gundhi bug, *Leptocorisa* sp. (2011-12)
Disease incidence was not observed after spraying the entomopathogens at a concentration of 2 x 10^7 spores/ ml. It is proposed to continue the experiment at higher concentration.

Studies on Granulosis virus of rice leaf folder, *Cnaphalocrocis medinalis* (2009-11)
Random survey was carried out in Thrissur district and collected live caterpillars from the field. Disease incidence was not recorded.

Seasonal abundance of predatory spiders in rice ecosystem (2011-12)
Twelve species of spiders were identified. *Pardosa pseudoannulata* was seen in large numbers. Worked out the species richness and diversity. Total number of spiders collected in sample was 21 and there were five species. Species diversity was worked out using Shannon-weiner index of diversity and was 1.5.

Validation of Biocontrol Technologies in rice – Tribal Sub Plan (2011-12)
There was no significant difference in pest incidence. Natural enemies were significantly high in IPM.

Large scale validation on biocontrol of coconut leaf caterpillar *Opisina arenosella* in Kerala (2007-09)

There was significant reduction in *Opisina* population after release of natural enemies when compared to control. The treatments – release of *Goniozus nephantidis* adults, Sequential release of *Cardiastethus exiguus* & *G. nephantidis* and Sequential release of *Trichogramma embryophagum* & *G. nephantidis* showed significantly low population of *Opisina* and they were on par.

Evaluation of *Hirsutella thompsonii* for the biocontrol of coconut eriophyid mite (2007-08)

There was no significant difference between treatments. However, the percentage reduction over untreated control was maximum in Dicofol treated palms followed by the treatment *H. thompsonii* Mycelia + Glycerin and H. *thompsonii* Mycelia+Conidia+Glycerin. There was reduction in mite count in treated palms when compared to control.

Large area demonstration of *Oryctes rhinoceros* management using *Metarrhizium anisopliae* var. *major* and baculovirus in Kerala (2007-09)

After application of *Metarhizium anisopliae* var. *major* @ 5 x 10^{11} spores/ m^3 in cowdung pits all the grubs and pupae were found diseased. The release of OBV treated beetles @ 10 nos. /ha reduced the pest infestation on the palm.

Evaluation of *Trichogramma chilonis,* EPN and *Bt.* against fruit borer of brinjal and Okra (2007-08)

There was no significant variation in pest infestation on shoot and fruits. The treatments EPN 2b/ha, B.t. 2 kg/ha, and *T. chilonis* @ 50000/ha were on par in fruit weight after fifth spray and on par with chemical control. After 2^{nd}, 3^{rd} and 4^{th} sprays, there was no significant difference in yield between treatments.

In Okra shoot and fruit infestations were significantly low in *B.t.* treated plots when compared to control.

Biocontrol of *Aphis craccivora* in cowpea using entomofungal pathogens. (2007-09)

Evaluation of entomopathogens @ 10^{10} conidia /l against cowpea aphid was carried in two years and concluded that lowest aphid count was recorded in *Verticillium lecanii* treated plot and it was on par with *Fusarium pallidoroseum* (6.5x 10^6 spores/ml), *Beauveria bassiana*, *Metarhizium anisopliae* and chemical treated plots. Significantly high population was recorded in control. Pod yield was on par in the treatment plots when compared to control.

Biocontrol of cowpea aphid (2009-12)

Cheilomenes sexmaculata released plots were on par with the chemical treated plots. Cow pea aphid population was significantly high in control plots. High incidence of natural predators like coccinellids and syrphids were found in control plots through out the cropping period.

Field evaluation of *Metarhizium anisopliae* formulation against mango hoppers (2011-12)

There was no significant difference in hopper count between treatments. Fruit set was significantly high in chemical treated plots. *M. anisopliae* treated plots were found on par with control.

Survey and record of incidence of papaya mealybug and its natural enemies on papaya and other alternate hosts (2010-12)

Acerophagus papayae successfully suppressed the population of papaya mealybug in Kerala. In some areas papaya mealybug was found but the parasitoid was also present in all the colonies. *Spalgis epius* and *Scymnus* sp. were the predators seen in mealybug colonies. Papaya mealybug was a threat to silk industry of Kerala because mulberry is a host plant of PMB. Now by suppressing the PMB the silk industry is flourishing well in Kerala.

Establishment of *Acerophagus papayae* on *Paracoccus marginatus* in Lakshadweep and their impact. (2011-12)

The parasitoid was released in Kavarathi and Agathi islands during May, 2011. The parasitoid established in the islands and suppressed the pest. During February, 2012 two days training programme was carried out on biosuppression of papaya mealybug at Androth Island. Officers from different islands participated in the programme and supplied the parasitoid to all participants for releasing in their islands. The parasitoid established in Androth, Kalpeni, Kadmat, Amini and Kildan.

Evaluation of biological control agents against sucking pests of vegetables and ornamentals under polyhouse conditions KAU: Gerbera (2007-08)

Beauveria bassiana and *Verticillium lecanii* were on par with chemical control in reducing the thrips population. *Metarhizium anisopliae* treated plants performed better than control plants

Evaluation of anthocorid predator, *Blaptostethus pallescens* against spider mites on Bhindi in polyhouses (2007-12)

There was significant reduction in the population of mites in bhindi. Chemical treatment performed better followed by the release of *Blaptostethus pallescens* @ 20 nos. / plant and 10 nos./ plant.

Biological management of root-knot nematodes infesting tomato in polyhouses (2009-12)

Samples of 1g root and 200 cc soil were collected and washed for nematode isolation. Since there was no root knot infestation the treatments were not applied

Evaluation of biocontrol agents against sap sucking insect pests of ornamentals in polyhouses (2011-12)

After 4th spray all the treatments (*B. bassiana, M. anisopliae, V. lecanii, B. pallescens)* were on par with the chemical treatment. There was significant reduction in the population of thrips seven days after first application of imidacloprid. The thrips population was significantly high in control plants.

Biocontrol of *Cyperus rotundus* (2007-09)

A mealy bug was collected from the roots of the weed and it was identified as *Geococcus citrinus*. But it is a pest of banana in Kerala. A caterpillar causing dead heart symptoms on the weed was collected from Mannuthy area and reared in the laboratory. The adults were identified as *Nephopteryx* sp. (Phycitidae)- a pest of cashew.

Biocontrol of *Chromolaena odorata* using *Cecidochares connexa* (2007-11)

The biocontrol agent established successfully in Kerala and produced galls on plants. In plants with galls there was significant decrease in plant height and number of branches when compared to control plants.

Investigations on the differential performance of *Cyrtobagous salviniae* against *Salvinia* (2007-9)
Water and plant analysis were carried out but there was no significant difference. *Cyrtobagous* weevils were present in all the areas surveyed.

Establishment of mass production units (at all the AICRP centres)(2007-08)
Established a mass production unit and started the production of *Trichogramma japonicum*, *T. chilonis, Pseudomonas fluorescens, Trichoderma* sp., *Verticillium lecanii, Beauveria bassiana*, *Metarhizium anisopliae* var. *major*, *M. anisopliae* var. *anisopliae*.

Survey for the natural enemies of tea mosquito bug (2009-10)
The ants collected as predators of tea mosquito bug are *Oecophylla smaragdina* Fabr., *Camponotus compressus, Crematogaster* sp. and *Tetraponera* sp., belonging to the family Formicidae. Spiders preying on cashew mirid bug were also collected and identified. The common spiders collected are *Hyllus diacanthes* (Salticidae), *Telamonia elagans* (Salticidae), *Oxyopes sunandae* (Oxyopidae) and *Oxyopes swetha* (Oxyopidae).

Enabling large scale adoption of proven biocontrol technologies- Rice (2009-12)
IPM area increased year after year and it spread to different districts of Kerala. Spider and coccinellid population was significantly high in IPM plot. Grain yield was on par with conventional farming.

Evaluation of anthocorid predators against storage pests in rice (2011-12)
Release of *Xylocoris flavipes* @ 30 nos./ bin was found to be effective for managing the storage pest *Corcyra cephalonica* followed by *Xylocoris flavipes* @ 20 nos./bin.

Surveillance and need-based control of coconut leaf caterpillar, *Opisina arenosella* in Kerala (2009-11)
Four releases of the biocontrol agents *Goniozus nephantidis* adults @ 10 nos. /palm at fortnightly intervals and six releases of *Cardiastethus exiguus* nymphs @ 50Nos. /palm at five days interval significantly reduced the population of the *Opisina arenosella*. This is a well adopted technology by the coconut farmers of Kerala.

Production, process and technology developed

- Biocontrol laboratory established for mass production of several biocontrol agents

- Equipments acquired: BOD Incubator, autoclave, deep freezer, humidifier, mixers, Ac, vacuum cleaner, electronic balance, UV chamber, sealing machine, centrifuge, fridge, microwave oven, photocopier, scanner multimedia projector, pulverizer, Insect rearing cages, racks, stereoscopic microscope with digital camera, camera SLR

Human resource development

The scientists in the project got training on mass production of papaya mealybug at NBAII and rodent management. Five trainings were organized on mass production and release of the parasitoids of papaya mealybug and mass production of biocontrol agents to in-service personal and farmers.

Publications:

Research articles in journals	- 6
Research articles presented in symposia/workshops	- 3
Popular articles and extension bulletins published	- 8

Best publication

Lyla, K.R., Beevi, S.P., Philip, B. M., and Jalali, S.K. 2010. Biological control of rice pests in '*kole'* lands of Kerala. *J. Biol.Control* 24(3): 268-270

Observations of the QRT

i. All the 29 experiments/ programmes allotted during 2007-2012 were conducted by the centre on different crops and useful information has been generated.
ii. The Adat panchayat model of IPM of rice pests has spread to other nearby panchayats for the management of rice insect pests and diseases.
iii. The incidence of papaya mealybug has been successfully suppressed by the release of *Acerophagus papayae.*
iv. The centre had collected 21 species of predatory spiders in rice crop habitat.

Recommendations of the QRT

1. In addition to conducting the experiments/ programmes allotted to the centre, the QRT recommends the following research activities to this centre.
2. KAU, Thrissur and CPCRI, Kayangulam centre should develop a common management package for coconut pests.
3. Abamectin should be discontinued from future field trials.
4. Survey and collection of natural enemies of banana weevil and banana aphid, pollu beetle and root mealybug of pepper including Entomopathogens should be taken up.
5. The KAU centre has to concentrate on field crops and CPCRI centre on the plantation crops.
6. Extent of parasitism of *A. papayae* on tapioca in different agro-climate zones of Kerala.

Overall assessment

Very Good

3. Punjab Agricultural University, Ludhiana

Brief achievements

Demonstration on the use of *Trichogramma chilonis* (tts) against early shoot borer, *Chilo infuscatellus*

Demonstrations on use of temperature tolerant strain of *T. chilonis* were conducted over 200 ha at different location during 2007-2012. Eight releases @ 50,000 per ha at 10 days interval from mid-April to end June reduced the incidence of early shoot borer *Chilo infuscatellus* by 57.9 per cent over untreated control. The cost: benefit ratio in release fields (1:21.3) was higher than chemical control (1:9.5)**.** The technology was recommended and transferred to Punjab sugar mills.

Use of *Trichogramma chilonis* temperature tolerant strain (tts) against early shoot borer, *Chilo infuscatellus* in collaboration with sugar mills. (2010-11 & 2011-12)

Large scale demonstration of effectiveness of *T. chilonis* (tts) @50,000 per ha at 10 days interval during mid - April to end June, was conducted over an area of 800 ha at farmers' fields in collaboration with two sugar mills of the state for the management of early shoot borer, *Chilo infuscatellus*. The incidence of early shoot borer was reduced its incidence by 52.7 per cent.

Field evaluation of *Trichogramma japonicum* against *Scirpophaga excerptalis*

Large-scale demonstration on efficiency of *Trichogramma japonicum* against top borer, *S. excerptalis* was carried out over an area of 160 ha during 2008-12. The eight releases of *T. japonicum* at 10 days interval during April to June @ 50,000/ha resulted in reduction of top borer incidence by 55.7 per cent. The cost: benefit ratio in release fields (1:22.2) was higher than chemical control (1:7.9)**.** The technology was recommended and transferred to Punjab sugar mills.

Use of *Trichogramma japonicum* for the suppression of top borer, *Scirpophaga excerptalis* of sugarcane in collaboration with two sugar mills. (2010-11 & 2011-12)

Large-scale demonstration on efficiency of *Trichogramma japonicum* against top borer, *S. excerptalis* was carried out in collaboration with two sugar mills over an area of 800 ha during 2010-12. The mean incidence of *Scirpophaga excerptalis* in release fields was 1.3 per cent as compared to 2.6 per cent in control fields. Thus the mean reduction in damage over control in these two mills area was 50.0 percent.

Demonstration of efficacy of *Trichogramma chilonis* for the management of *Chilo auricilius*

The efficacy of *T. chilonis* was demonstrated over an area of 160 ha at different locations (8) during 2007-2011 for the management of stalk borer, *Chilo auricilius*. The incidence of stalk borer in control was 11.3 per cent as compared to 4.9 per cent in release field**,** which resulted in 56.9 per cent reduction in damage. The percent parasitisation in release fields was high (55.1%) as compared to control (4.6%).

Large-scale demonstration of biocontrol based IPM against stalk borer, *Chilo auricilius* in collaboration with sugar mills

Large scale demonstration of effectiveness of *T. chilonis* against stalk borer over an area of 9200 ha was carried out in collaboration with three sugar mills of the state. The reduction in damage over control in these three mills varied from 50.4 to 63.8 percent, during different years. However, the mean reduction was 56.0 per cent.

Evaluation of Entomopathogenic fungi against stalk borer in sugarcane

Two fungi namely *Metarhizium anisoplae, Beauveria bassiana* procured from NBAII and the commercially available Mycojaal (*Beauveria bassiana*) were evaluated by applying @ 1, 2 ad 3 litre per hectare thrice during August- September at an interval of 15 days. The percent mean incidence of stalk borer in all the treatments (13.33-14.44%) was significantly lower than control (25.00%). The lowest stalk borer incidence (10.00%) was recorded in *Metarhizium* @2 l and 3 l/ha (10.00%) followed by *Beuveria bassiana* NBAII 3 l/ha(11.66%) and Mycojaal 3 l/ha (11.67%) and incidence in all these was significantly higher than lower dose (1l/ha) of Mycojaal (18.33%) and Metarhizium (23.33%) and control but at a par with other treatments.

Demonstration of Biointensive integrated pest management of *Bt* cotton pests

Demonstration of BIPM of Bt cotton was conducted in 46 ha during 2007-2009. The mean population of cotton leafhopper (1.9 and 2.0 nymphs/plant) and cotton whitefly (6.2 and 5.3 adults /plant) in BIPM and farmers practices was comparable. The mean predator population in BIPM (0.4 per plant) was higher than farmer practice (0.2 per plant). The mean seed cotton yield in BIPM plot and farmer practice was 27.1 and 27.6 q/ha, respectively.

Enhancement of natural enemy population in cotton by habitat manipulation

The mean leafhopper population was significantly lower (1.8 nymphs/3 leaves) in the insecticidal control plot as compared to habitat management (3.0 nymphs/ 3 leaves) and BIPM (3.3 nymphs/ 3 leaves) plots. Similar trend was observed for mean whitefly population. Lowest mean bollworm incidence (4.5%) was recorded in insecticidal control followed by habitat management (11.0%) and BIPM (10.1%). Significantly higher population of natural enemies was recorded in habitat management (1.6 per plant) and BIPM plot (1.2 per plant) than insecticidal control (0.2 per plant). The seed cotton yield in insecticidal plot was significantly higher (11.9q/ha) than habitat management (11.0%) and BIPM (10.1%). The net returns in insecticidal plot was highest (Rs 17671/-) followed by habitat management (Rs11959/-) and BIPM (Rs. 10973/-).

Monitoring the biodiversity and outbreaks of mealy bug and its natural enemies

During 2009-11, parasitisation of mealybug, *Phenacoccus solenopsis* by *Aenasius bambawalei* varied from 10 to 90 percent on different hosts of mealy bug. Among predators, lady bird beetle, *Brumus suturalis* was the most abundant followed by *Cheilomenes sexmaculata*, *Chrysoperla zastrowi sillemi*, *Nephus regularis* and *Scymnus coccivora*.

Evaluation of DOR Bt against Leaf Folder of Rice

Evaluation of DOR Bt against leaf folder of rice during 2005-2007 revealed that DOR Bt @ 2.0 kg/ha was as effective as chemical control (Monocrotophos 36 SL @ 1.4l/ha) for the management of rice leaf folder and increasing the grain yield of rice. The maximum mean yield (61.1 q/ha) was harvested from Monocrotophos 36 SL @ 1.4l/ha which was at a par with higher dose (2.0 kg/ha) of DOR Bt (60.8qha).

Validation of bio-intensive pest management practices in organic rice production during 2007 &2008

Six to seven releases of *T. chilonis* and *T. japonicum* @ 1, 00,000 per ha reduced the incidence of leaf folder and stem borer in organic coarse rice during 2007 and basmati rice during 2008. The percent leaves folded, dead hearts, white ears and yield in IPM plots were on par with farmer practice. The cost benefit analysis showed the net return of organic package Rs. 1,12,798/- as compared to conventional package of Rs. 98,188/-

Large scale demonstration of IPM for rice pests and diseases in farmer's field during 2007–2009

Large scale demonstration of biocontrol based IPM (7 releases of *T. chilonis* and *T. japonicum* each @ 1, 00,000/ha) of *Basmati* Rice was carried out during the year 2007 – 2009 over an area of 50 acres at different locations of Punjab. The percent leaves folded, dead hearts, white ears and yield in IPM plots were on par with farmer practice. The cost benefit analysis of three years showed the net return of Rs. 70,563 in IPM package as compared to farmer's practice of Rs70, 621.

Enabling large scale demonstration of IPM for rice pests and diseases in farmer's field during 2010 & 2011.

Large scale demonstration of biocontrol based IPM in *Basmati* Rice was carried out over an area of 90 ha at farmers' fields. The percent leaves folded, dead hearts, white ears and yield in IPM plots were on par with farmer practice. IPM (6 releases of *T. chilonis* and *T. japonicum* each @ 1, 00,000/ha) proved as effective as chemical control on large scale for the management of leaf folder and stem borer of *Basmati* rice. The cost benefit analysis of two years showed the net return of Rs. 55,602 in IPM package as compared to Rs. 57,012 in farmer's practice.

Preliminary evaluation/screening of EPN against yellow stem borer and leaf folder in rice during 2009.

Among the EPN treatments, *Steinernema feltiae* shows better results as compared to S. *riobrave*. The aqueous formulation of these two EPN's proved to be better than the wettable powder formulations. However, the chemical control (Chlorpyriphos 20 EC) proved to be the best among all the treatments where 100 percent larval mortality was observed after 7 days of treatment in case of yellow stem borer and leaf folder.

Preliminary evaluation/screening of EPN against yellow stem borer and leaf folder in rice during 2010

Among the EPN formulations, PDBCEPN-4 showed significantly higher mortality of larvae of both pests as compared to PDBCEPN-3 after 7 & 10 days of treatment. However, the chemical control Chlorpyriphos 20 EC (@ 10 ml/litre proved to be the best among all the treatments where 100 percent larval mortality was observed after 7 days of treatment in case of yellow stem borer and leaf folder.

Fixing economic threshold level for NPV application for the control of *Helicoverpa armigera* on chickpea (2009-10 & 2010-11)

Larval population was lowest (4.52 larvae/10 plants) in plot where spray was initiated at one larva/ 10 plants. Whereas mean per cent pod damage in plot at 1 larvae/ 10 plants (6.15%), and at flowering stage (6.85%) and at 2 larvae/ 10 plants (7.14%) were on par with each other but better than remaining treatments. The mean yield (14.85q/ha) in plot sprayed at 1 larvae/ 10 plants 2 larva/ 10 plants (13.75q/ha) and sprayed at flowering stage (13.78q/ha) was on par. The maximum net profit per hectare (Rs. 3874/-) over control was obtained in plots when spray was initiated at one larva per ten plant followed by flowering stage (Rs. 2781/-) and two larvae per ten plant (Rs. 2668/-).

Impact of Biosuppression of *H armigera* on the incidence of other lepidopteran pod borer species of pigeonpea.

The population of *H.armigera* larvae in HaNPV treated plots was at par with chemical control (Thiodan @1 l/ acre) but significantly lower than control. Among other lepidopteran pod borers, the population of *Grapholitica ertica* larvae did not vary significantly among various treatments. Population of *Maruca testulatis* larvae recorded in HaNPV treated plots was on a par with control, however significantly lower population was recorded in chemical treated plot. The per cent pod damage and grain yield in NPV treated plot were at par with chemical treated plot.

Evaluation of NBAII liquid formulations (PDBC-BT1 and NBAII-BTG4) and IARI *Bt* against pigeon pea pod (*Helicoverpa armigera*) and legume pod borer (*Maruca testulalis*)

The population of *H. armigera* larvae was lowest (0.2) in NBAII-BTG4 (2%) treated plot and was at par with NBAII-BTG4 (1%), PDBC-BT1 (1%), PDBC-BT1 (2%), and chemical control

(Chlorpyrifos 0.2%) and were significantly better than other treatments. The population of *Maruca testulatis* larvae did not vary significantly among various treatments. Lowest per cent pod damage (15.4%) was recorded in NBAII-BTG4 (2%) which was at par with PDBC-BT1 (2%) (16.5%), Mycojal @ 2.0 Kg/ha (17.0%) and chemical control (chlorpyrifos 0.2%) (16.2%). Similar trend was observed for seed damage. The grain yield in NBAII-BTG4 (2%) (8.1q/ha) treated plot was at par with chloropyriphos 0.2% (8.2 q/ha).

Evaluation of Biocontrol Technology against Tomato Diseases and Tomato Fruit borer *Helicoverpa armigera*

Foliar disease incidence was not reported during 2007-2008. However during 2008-2009 both the bioagents technologies involving *P. flourescens* colonized in farm yard manure as well as in vermicompost and recommended farmers' practice were proved effective in suppressing the early bight disease. The incidence of early blight of tomato was lowest in farmers' practice plot (10.3%), followed by both bioagents treated plots (FYM + *Psf* (17.7%) and vermicompost + *Psf* (15.7%) The latter two were on par with each other and significantly better than control (29.2%). Treatments viz. FYM + *Psf*, vermicompost + *Psf* and recommended farmer's practice significantly better than untreated control in reducing fruit damage due to fruit borer and increasing the marketable yield.

Demonstration of biological control of seed/soil borne disease of chickpea and *H. armigera* (2007-08 & 2008-09)

The biocontrol package resulted in 41.0 per cent reduction in pod damage over control. The yield from biocontrol package (13.4 q/ha) was at a par with chemical control (15.3 q/ha) but significantly higher than unsprayed control (10.7 q/ha). The cost benefit ratio in biocontrol package was 0.55 and in chemical control. Plant population difference was non-significant in all the treatments. The plant final height during 2008 and 2009 was maximum in biocontrol package plants (56.7cm and 51.7 cm, respectively) followed by chemical control (48.2cm and 44.2cm, respectively). The canopy width was also significantly better in biocontrol package as compared to the other treatments. There was no disease incidence in all treatments during both the years.

Field evaluation of promising strains of *Trichoderma* spp. under rain fed conditions on chickpea

Shoot length during April in all treatments was significantly better than untreated control (44.6 cm). Initially the root length was maximum (7.6 cm) in *Trichoderma harzianum* treated plot and was at par with, *Trichoderma viride* but better than carbendazim. Final root length (during April) in all the treatments was at par and significantly better than control. During March-April maximum plant stand was in carbendazim treated plot plants/sq m) and was at par with *Trichoderma viride* and *Trichoderma harzianum* but significantly higher than *Trichoderma virens* and untreated control. Lowest disease incidence (0.7%) was recorded in *Trichoderma viridae* treated plot which was at par with carbendazim treated plot and *Trichoderma harzianum* (0.8%) but significantly lower than *Trichoderma virens* (0.9%). Rhizosphere population of antagonist increased in all *Trichoderma* treated plots

Isolation and identification of the potential biocontrol agents (especially yeasts) for the management of postharvest losses in mango (Chausa & Dusehri)

Out of three local isolates, only one yeast isolate, (*Candida* spp) gave zone of inhibition in dual plating against post-harvest pathogen, *C. gleosporioides.* This local isolate (*Candida* spp) was further evaluated along with two microbial agents *Alcaligens* spp. (NBAII PHD-A1) and

Candida tropicalis (NBAII PHD-Ct1) against postharvest pathogen in two verities of mango viz. Dusehri and Chausa during 2007 and 2008. Though in mango Chausa, the two microbial isolates, *Alcaligens* spp. and *C. tropicalis* were effective in checking the pathogen to some extent i.e. up to 5th day but in mango Dusehri, local *Candida* sp. and *C. tropicalis* were more effective in delaying the rotting of fruits. However, microbial isolates failed to arrest the development of deep seated latent infection.

Evaluation of *Trichogramma chilonis*, EPN and *Bt* against fruit borer of Okra from 2007 to 2009

In 2007, seven treatments *viz*. DOR Bt @ 2.0 kg/ha, DOR Bt @ 1.5 kg/ha, *Trichogramma chilonis* @ 50,000/ha, EPN (*Steinernema carpocapsae*) @ 2 billion/ha, EPN @ 1 billion/ha, chemical control and control were evaluated for the management of fruit borer on Okra. In 2008, DOR Bt was replaced by commercial Bt formulation i.e. Halt. DOR Bt/ Halt @ 2.0kg/ha (commercial *Bt* formulation) was as effective as chemical control in reducing the incidence of fruit and shoot borer in okra and increasing the marketable yield. DOR Bt/ Halt 1.5 kg/ ha and EPN @ 2 billion/ ha were the next best treatments for the management of fruit borer *Earias* spp. on okra.

Evaluation of *Trichogramma chilonis*, EPN and *Bt* against fruit borer of brinjal from 2007 to 2009

In 2007, six different treatments *viz*. DOR Bt @ 2.0 kg/ha, *Trichogramma chilonis* @ 50,000/ ha, EPN (*Steinernema carpocapsae*) @ 2 billion/ ha, EPN @ 1 billion/ha, chemical control (Hostathion 40 EC @ 500 ml/acre) and control were evaluated against fruit and shoot borer of brinjal. In 2008, DOR Bt was replaced by commercial Bt formulation i.e. Halt. DOR Bt/ Halt @ 2.0 kg/ ha and chemical control (triazophos 40 EC @ 500ml/acre) were the best treatments, followed by DOR Bt/ Halt @ 1.5 kg/ ha and EPN @ 2 billion/ ha for the management of fruit borer *L. orbonalis* on brinjal.

Demonstration of biological control of tomato fruit borer *Helicoverpa armigera* from 2007 to 2009

BIPM practices (*T. pretiosum* @ 1 lakh/ ha at 10 days interval + HaNPV @ 1.5 x 10^{12} POB/ ha + transplantation of one row of marigold after ten rows of tomato talc formulation of *Pochonia chlamydosporia* @ 20 kg/ Ha (10^8 spores/ g) and farmers' practices (endosulfan 35 EC @ 800 ml/ acre) were significantly on par with each other and better than control for the management of tomato fruit borers. The percent fruit borer damage and marketable yield (26.9% and 248.3 q/ha) in BIPM and farmers' practices (21.1% &272.5 q/ ha) was at par. The parasitisation of 35.3% was recorded in the BIPM plot.

Preliminary field evaluation of thelytokous *Trichogramma pretiosum* against *Helicoverpa armigera* of tomato from 2009 to 2011

Both the strains of *Trichogramma* i.e. *T. pretiosum* thelytokous and *T. pretiosum* arrhenotokous were effective and on par with each other in controlling *Helicoverpa armigera* on tomato and increasing the marketable yield. The mean percent parasitization by *T. pretiosum* arrhenotokous (28.8%) was higher than that of *T. pretiosum* thelytokous (20.2%), whereas there was no natural parasitization in the control plot.

Evaluation of biological control of DBM and other lepidopteran pests on cabbage (2009-10)

Lowest larval population (0.51) was recorded in plots treated with *Bacillus thuringiensis* which was at par with Spinosad treated plot (0.54). This was followed by plot treated with NSKE and

EPN which were at par with each other and significantly better than *Trichogramma brassicae* and untreated plot. The yield in *Bacillus thuringiensis*@1Kg/ha was on a par with chemical control but significantly better than control.

Evaluation of Bt strains (PDBCBT1 & PDBCBT2 against *Helicoverpa armigera*

Evaluation of Bt isolates PDBCBT1 and PDBCBT2 against *Helicoverpa armigera* was conducted and compared with standard HD1 Strain and unsprayed control under laboratory conditions. It was observed that all the treatments were better than unsprayed control. The effect of Bt1 strain was on par with HD1 strain. However, highest mean cumulative mortality was observed with HD1 strain followed by Bt 1 strain after 3r^{d}, 5th, 7th and 10th days of treatment. The lowest mean cumulative mortality was with Bt2 strain. Mean cumulative mortality at higher concentrations of different treatment was more than lower concentrations.

Evaluation of Bt strains (PDBCBT1 and PDBCBT2) against *Plutella xylostella*

Evaluation of Bt strains against *Plutella xylostella* larvae on cabbage leaves under laboratory conditions revealed that maximum mean cumulative mortality (86.25%) was in Bt1 strain followed by Bt2 and HD1 which were at par with each other. However all the strains were better than untreated control. Among the different dilutions, the maximum mean cumulative mortality (75.00%) was in dilutions 10^{-1} to 10^{-3} and this was at par with each other except on 2nd day when mortality in first dilution was significantly higher than all other dilutions. Dilutions up to 10^{-3} of all the three treatment (Bt1, Bt2 and HD1) were on par with each other and better than control till tenth days of treatment. However at the dilution 10^{-4} the Bt1 was better than other two treatments (Bt2 and HD1).

Development of bio-intensive IPM package for the pests of Cole crops (Cauliflower) (2011-2012)

BIPM practice (*Chrysoperla zastrowi sillemi* @ 5 larvae/ plant at weekly interval + Econeem @ 20-25 ml/acre@ 20-25 ml/acre at 10 days interval + Planting of mustard crop as trap crop) and farmers' practice (Spinosad 45% SC @ 60 ml/acre at 10 days interval) were at par and effective in reducing the aphids population on cauliflower during winter season. Mean aphid populations per plant in BIPM plots and farmers' practices plots were 9.9 aphids 9.5 aphids. There was no incidence of any lepidopteran pest viz., *Pieris brassicae, Spodoptera litura* and *Plutella xylostella*.

Evaluation of anthocorid predators against mite, *Tetranychus urticae* on brinjal (2011)

The predatory performance of *B. pallescens* against two-spotted spider mite, *T. urticae* in the laboratory revealed that it significantly reduced the population of two-spotted spider mite. The possibility of controlling two-spotted spider mite by releasing 7-days old anthocorid bug at the level of 1:50 (predator: prey ratio) gave good results under laboratory conditions. Under poly house condition, the release of 6-7 days old nymphs of *B. pallescens* twice at weekly interval on the brinjal, significantly reduced the population of mites. All the doses of anthocorids were at par with the chemical control (Omite @ 300 ml/ acre).

Evaluation of anthocorid predators against storage pests in rice (2009 to 2011)

X. flavipes @ 20 and 30 nymphs were on par with each other in reducing the emergence of *Corcyra* in infested stored rice (11.9 and 15.5 moths emerged, respectively) and were significantly better than all other treatments. Demonstration of release of six to seven days old nymphs of anthocorid predator, *Xylocoris flavipes* @ 1500 nymphs/ 6 q rice in a bin against rice moth, *Corcyra cephalonica* conducted on rice at storage godown of Ladhowal Research Farm,

Punjab Agriculture University, Ludhiana revealed that *Xylocoris flavipes* effectively suppressed the population(74.6 %) of rice moth, *Corcyra cephalonica* under storage conditions.

Biodiversity of biocontrol agents from various agro- ecological zones (2009-12)
During last three years the bioagent collected/isolated from insect cadavers are:
Trichogramma–8; *Chrysoperla*-3; Entomopathogenic fungi-6; *Bacillus thuringiensis* -6 & EPN-5

Evaluation of isolated bioagents:
Among four local isolates (PAUF1, PAUF2, PAUF3, PAUF4), $PAUF_2$ at 10^8 conidia / ml gave better mortality i.e. 50 per cent, in *S. litura* under laboratory conditions as compared to other three isolates. Six native fungal isolates were evaluated for their efficacy against second instar larvae of *H.armigera.* Maximum cumulative per cent mortality (50.0%) was observed in isolate PAU F2 which was at par with PAU F1, PAU F7 and PAU F5 which recorded 43.3, 41.7 and 39.2 per cent mortality, respectively. Three local isolates of entomopathogenic nematodes obtained from soil collected from various districts of Punjab while one *S. abassi* species was procured from NBAII and tested against 2nd and 3rd instar larvae of *P. xylostella*. The percentage mortality of 2nd instar larvae for N14 and N17 ranges between 24 to100% and 28 to 100% using concentrations 10 and 75 IJ/ml respectively. In 3rd instar larvae highest mortality 84% and 52% was observed at 100 IJ/ml. The 2nd and 3rd instar larvae were susceptible to both N14 and N17. In case of *S. abassi*, the highest mortality of 100% for 2nd instar larvae was obtained at 50 IJ/ml while 80% mortality was recorded at 100 IJ/ml for 3rd instar.

Production, process and technology developed

- *Trichogramma chilonis* @ 50,000/ha (8 releases) from April to June at 10 days interval against early shoot borer, *Chilo infuscatellus.* (included in Package of Practices of crops of Punjab- *Kharif* 2010)
- *Trichogramma japonicum* @ 50,000/ha (8 releases) from April to June at 10 days interval against top borer, *Scirpophaga excerptalis.* (included in Package of Practices of crops of Punjab- *Kharif* 2010)
- *B. thuringiensis* based biopesticides were found highly effective against the diamondback moth *P. xylostella* damaging cole crops. Based on these studies, Dipel 8L @ 750ml/ha and Halt WP @ 750 gm/ha have been recommended by the university for DBM management (2011).

Infrastructure developed

Biocontrol laboratory was renovated for mass production of biocontrol agents.
Equipments procured; BOD orbital shaker, Microscope, vertical deep freezer were procured.

Human resource development

Dr Jaspal Singh Virk and Dr Vikas Jindal participated in the training programme on "Advances in Design and Analysis of Agricultural Experiments" held at IASRI, Pusa Institute, New Delhi from January 14 to February 3, 2009.
Dr Neelam Joshi participated in Winter School on "Immunological and Molecular techniques for Diagnosis of Infectious Diseases of Domestic animals and Poultry" from December 2-22, 2008 at Department of Microbiology, GADVASU, Ludhiana.

Dr Rabinder Kaur participated in advanced training programme on "Recent Advances in Pest Population Dynamics and its Monitoring Techniques" at Chowdhary Charan Singh Haryana Agricultural University, Hisar from February 17- March 9, 2009.

Publications

Research articles published in journals	- 47
Research articles presented in symposium/ workshops/ seminars	- 49
Popular articles	- 16
TV/ radio talks	- 8

Best publication

Kaur, H. and Virk J. S. 2012. Feeding potential of *Cryptolaemus montrouzieri* against the mealybug, *Phenacoccus solenopsis, Phytoparasitica* 40:131–136.

Observations of the QRT

i. The centre had conducted all the 33 experiments/ programmes allotted to them.
ii. The centre had validated and come out with a package of practices to farmers of Punjab which include that eight releases of temperature tolerant strain of *Trichogramma chilonis* @ 50,000/ha from April to June at 10 days interval for the management of against early shoot borer, *Chilo infuscatellus* and eight releases of *Trichogramma japonicum* @ 50,000/ha from April to June at 10 days interval for the management of top borer, *Scirpophaga excerptalis.*

Recommendations of the QRT

1. Release of *T. chilonis* and *T. japonicum* for the management of different borers of sugarcane is followed during the last five years. The centre has to assess the reduction in pesticide consumption due to release of these parasitoids.
2. Evaluation of *Trichoderma* spp. against chickpea wilt should be done in sick plots.
3. Natural enemy complex of rice yellow stem borer, rice leaf folder, cotton aphids, cotton mirid bug and onion thrips.
4. Mapping of EPN diversity in Punjab & Haryana.
5. Evaluation of fungal and bacterial antagonists for the management of foot rot of citrus (kinnow) caused by *Phytophthora* spp.
6. Evaluation of fungal and bacterial antagonists for the management of fusarial wilt of cucurbits

Overall assessment

Good

4. Sher-E-Kashmir University of Agricultural Sciences and Technology, Srinagar

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-12)

T. kashmirica, *T. chilonis* (Local strain from *Chilo partellus*), *T. chilonis* (from eggs of semi looper), Unidentified *Trichogramma* sp. (from eggs of Neuroptera) and Unidentified

Trichogramma (from sentinel cards on Pomegranate) have already been sent to NBAII. *T. chilonis,* isolated from *Chilo partellus* is being used against maize stalk borer at district Gander bal. Materials from Kashmir, collected from apple, led the Scientists of NBAII to make nomenclatural change from *Chrysoperla carnea* to *Chrysoperla zastrowsky*. Nine different specimens of spiders collected during 2010 and 2011 from different agro ecological zones including Anantnag, Ganderbal, Srinagar and Kargil have already been sent to NBAII. Dead samples of anthocorids, associated with codling moth, *Cydia pomonella* at Kargil (Laddakh) have been sent to NBAII. The materials will be collected this year again and reared in laboratory.

Development of bio-intensive IPM for San Jose Scale, *Quadraspidiotus perniciosus* in apple ecosystem (2007-8)

Augmentative releases of *Encarsia perniciosi*, against San Jose scale caused increase in per cent parasitism from 8.9 to 22.2 in IPM managed orchard. Actual rise of parasitism in IPM orchard over unmanaged orchard, was however 0.8 to 9.5 per cent.

Field evaluation of *Trichogramma embryophagum* against the codling moth, *Cydia pomonella* on apple (2007-12)

Trichogramma embryophagum and *T. cacoeciae* along with the use of pheromone traps proved useful, in partial suppression of the apple fruit borer, *Cydia pomonella* at Kargil. Trunk banding, debarking of apple and adjacent trees and destruction of damaged fruits was advised to farmers as cultural practice for suppression of codling moth.

Evaluation of microbial pesticides against tree stem borer (*Aeolesthes sata*) (2007-9)

Local strains of *Beauveria bassiana* and *Metarhizium anisopliae* @$1x10^8$ spore/ml, caused 47.8 and 47.5 per cent mortality of apple stem borer (*Aeolesthes sarta*) on 21st day after application. Highest mortality (88.0 per cent) was achieved by dichlorvos (1.0 %).

Survey for identification of suitable natural enemies of codling moth (2008-12)

One species each of ichneumonid, braconid and an anthocorid bug were found associated with *Cydia pomonella.* No indigenously occurring *Trichogramma* or GV were found entomopathogenically dead cadavers of *Cydia pomonella* were also collected and sent to NBAII for identification of the causative agent.

Validation of bio-intensive management of codling moth, *Cydia pomonella* on apple, in the tribal areas of Leh and Kargil under Tribal Sub Plan (2011-12)

Use of *Trichogramma embryophagum* was found a little successful at Kargil, because of years of release of the parasitoids here. Farmers' negligence, and also some religious taboo, both at Leh and Kargil were found the sole reason for high infestation of apple by codling moth. Use of pheromone traps was found highly promising

Natural enemies of seed infesting chalcid, *Eurytoma* of apricots in Laddakh (2011-12)

Eurytoma sp. was found infesting apricot fruits (seeds), both at Leh and Kargil. So far no natural enemy of the pest has been recorded

Evaluation of *Trichogramma brassicae* against *Pieris brassicae* on cabbage (2007-9)

Maximum egg parasitism of *Pieris brassicae* by T. *brassicae* and *T. chilonis* in field condition was 2.2 and 10.4 respectively. Because of poor performance of the above mentioned parasitoids, the larval density increased in treated plots, causing significant damage to plants. Use of insecticides in farmers' plot however kept the larvae under check.

Evaluation of microbials and summer oil against *Pieris brassicae* on Cabbage (2007-9).
Local strains of *Beauveria bassiana* and *Metarhizium anisopliae* were found promising against the cabbage butterfly larvae, *Pieris brassicae*. Maximum mortality was recorded as 60.0 and 56.3 per cent respectively, on 16th day after application. D.C. Tron Plus though caused 63.3 % but proved highly phytotoxic.

Biological control of cabbage aphids (*Brevicoryne brassicae*) (2007-11)
Five releases of late 2nd instars of *Coccinella septumpunctata*, *C. undecimpunctata* and *Chrysoperla* z. silemi caused an average drop in aphid population, from 541.1(Untreated check) to 218.5, 200.8 and 282.5^{-plant} respectively. Average reduction in aphid population by *Coccinella septempunctata*, *C. undecimpunctata* and *Chrysoperla* was worked out as 34.01, 42.63 and 47.55 per cent respectively. Efficacy of *Coccinella septempunctata*, *C. undecimpunctata* and *Chrysoperla* sp. against cabbage aphids, *Brevicoryne brassicae* was found statistically on par.

Developing bio-intensive IPM package for the pests of cole crops (2011-12)
Three releases of *T. chilonis* and *T. brassicae* @ 1.0 lakh/ ha. has resulted in average larval density of DBM to decline up to 12.2 and 13.8 respectively in comparison to 20.2, as in untreated check.

Biological management of root-knot nematodes infesting tomato and carnation in polyhouses (2009-10)
Since carnation is not cultivated in Kashmir valley, and in poly house, the experiment was not done

Evaluation of anthocorid predator, *Blaptosthetus pallescens* against spider mites in polyhouses (2011-12)
Three releases of 20 bugs per plant indicated a significant decline in spider mites with 61.5 per cent reduction over control. Use of 20 bugs^{-plant} was found superior to release of 10 bugs but statistically at par with one spray of abamectin @ 0.3ml/ lit.

Evaluation of predatory mite, *Neoseiulus longispinosus* against phytophagus mite in rose under polyhouse condition (2011-12)
This experiment was not done because of lack of poly house facility.

Biological management of root-knot nematode infesting tomato in polyhouses (2011-12)
Both root dip and soil treatments, individually, with *Paecilomyces lilacinus* and abamectin caused a sharp decline in the population of nematodes, *M. hapla*. 81.83 and 94.7 per cent reduction in root knot nematodes, in soil and root was caused by *Paecilomyces lilacinus*. The root-knot index with *P. lilacinus* was 1.0, as compared to 3.4 in untreated control.

Evaluation of anthocorid predators against storage pests in rice (2011-12)
Use of 10, 20 and 30 anthocorid bugs, *Blaptostethus pallescence* indicated 53.5, 76.6 and 93.4 per cent reduction in the emergence of *Corcyra cephalonica*, respectively.

Establishment of mass production units (at all the AICRP centres)
The following biocontrol agents were multiplied; PDBC strains of *T. embryophagum*; *T. cacoeciae; T. brassicae; Blaptostethus pallescens; Sitotroga cerealella*; and Local strains of *Bracon hebetor T. chlionis; Cocinella septempunctata; Coccinella undecimpunctata; Chrysoperla* sp.; *Quadraspidiotus perniciosus; Corcyra cephalonica; Plodia* sp and *Xylocoris*

Production, process, technologies developed

i. *Trichogramma embryopagum* and *T. cacoeciae* were mass multiplied and approximately 2.5 million *Trichogramma* spp. were distributed to farmers for the field release for the biological control of codling moth on apple in Kargil and Leh.
ii. Local strain of *T. chilonis* collected from *Chilo partellus* was successfully field released in Gander Bal district for the biological control of *C. partellus* on maize.

Infrastructure and physical facilities developed

i. Two storied biocontrol laboratory was constructed during 2007 and a new polyhouse construction has been completed. Temperature and humidity control system were installed in the laboratory and photoperiodic simulating racks were installed to elevate temperature during sub-zero conditions during winter.

Human resource development efforts

i. The scientists working at this centre did not go for HRD in either national or international laboratories during the last five years period. However regular training was imparted to the AEO, SMS, JAA, SDO's and farmers about the biological control techniques for the control of pests of apple and vegetables

1. Best Publication

Ahmad, M. J., Ahmad, Bilal. S and Khan, Athar Ali. 2009. Impact of hyper parasitism on the dynamics of *Apanteles* sp. (Hymenoptera: Braconidae) against rice skipper, *Parnara guttata* Bremer & Grey in Anantnag, Kashmir. *Journal of Biological Control*, **23** (2): 121-125.

Observation of the QRT

The centre could not conduct polyhouse experiments as polyhouses were not available.

Recommendations of the QRT

1. Observations on the natural enemies of seed infesting *Eurytoma* of apricots in Laddakh
2. 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 should be taken up.
3. There is lack of coordination between the two scientists working at this centre and AICRP may find difficult to support such centre in future.

Overall assessment

Good

5. Achrya N. G. Ranga Agricultural University, Hyderabad

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-2012)
Not done

To evaluate the potential of selected agents in the management of fruit rot in mango, papaya and guava (2007-9)
Not conducted

Isolation and identification of the potential biocontrol agents (especially yeasts) for the management of post harvest losses. ANGRAU (on mango in collaboration with the plant pathologist at Fruit Research Station at Sangareddy)
Not conducted

Evaluation of the biocontrol potential of selected bioagents
Not conducted

Validation of biocontrol technologies for management of pests of castor (2011-12)
Will be conducted in the next season.

Field evaluation of *Trichogramma chilonis* produced using Eri-silk worm eggs as factitious host (2011-12)
The initial observations recorded showed that early shoot borer incidence was 16.54% in plot where T*richogramma* reared on eri-silk work eggs was released and 14.96% in plots where *Corcyra* reared *Trichogramma* was released and in control plot the early shoot borer incidence was very high (48.73%). The experiment is in progress.

Testing the bioefficacy of entomopathogenic fungi in suppression of termite incidence in sugarcane (2011-12)
The trial was laid in February, 2012 and is in progress at Rudur, Anakapalle and Vuyyuru.

Demonstration of bio-Intensive Pest Management (BIPM) in *Bt* cotton (2007-9)
Data from the experiment laid out in a farmers' field at Kothapalli Village during *Kharif* 2008 showed that the mean square and boll damage was significantly less and the yield was higher in *Bt* cotton with BIPM module as compared to farmers practice and local check. The yield in BIPM plot was 1823 kg/ha while it was 1757 in farmers practice. The cost:benefit ratio was 1:1.81 in BIPM package compared to 1:1.03 in farmers' practice. Higher egg parasitism and coccinellid and spider population were recorded in BIPM package compared to farmers practice.

Bio-intensive pest management of pink boll worm, *Pectinophora gossypiella* on cotton (2007-9)
The incidence of pink bollworm was low in both the years. The per cent damage in BIPM package to square (3.7%), boll (3.9%) and locule (5.1%) was lower than in farmers practice (square-4.3%, boll-4.2% and locule-6.9%). The higher yield of 1923 kg/ha was recorded in BIPM package compared to 1754 kg/ha in farmers practice and 1325 kg/ha in control.

Enhancement of natural enemy population in cotton by habitat manipulation in rainfed cotton (2007-9)

The population of aphids, leaf hoppers, whitefly was lowest in habitat management plot compared to BIPM and Insecticidal spray plots. The per cent square and boll damage by spotted bollworm was lowest in habitat management plot as compared to BIPM and farmers practice. Habitat management plot recorded significantly highest yield of 1,852 kg/ha as compared to BIPM plot (1,578 kg) and farmers practice (1,627 kg). Habitat management plot also recorded high population of *C. carnea* (21.5), coccinellids (21.1), spiders (15.2) per 25 plants. The corresponding figures in BIPM and farmers practice were 13.7 and 0.7, 11.3 and 0.8, 6.7 and 3.1 respectively. Natural parasitism by *T. chilonis* was 3.21% in Habitat management plot as compared to 2.78% in BIPM and only 0.92% in farmers practice.

Identification of natural enemies of mealy bugs on cotton and evaluation of potential natural enemies (2007-9)

The mealybug species largely recorded on cotton was *Maconellicoccus hirsutus* followed by *Planococcus solenopsis*.

Monitoring the biodiversity and outbreaks of invasive mealybugs and their natural enemies on horticultural/ field/ medicinal and aromatic crops (2009-12)

Mealybug incidence was monitored only on cotton.

Evaluation of coccinellid predators against cotton mealybug (2009-12)

Among the three predators used, *C. montrouzieri* recorded lesser per cent infestation by mealy bug (graded as low) and lesser per cent infested bolls (15.3%) compared to the other two predators, *B. suturalis* and *Scymnus coccivora* which recorded higher per cent infestation (graded as medium) and higher per cent infested bolls (25.3% and 28.3% respectively).

Evaluation of different microbial formulations for the management of rice panicle mite, *Stenotarsonemus spinkii* (2011-12)

The fungal pathogens failed to show efficacy against the panicle mite in the laboratory conditions.

Seasonal abundance of predatory spiders in rice ecosystem (2011-12)

The experiment is in progress, however at five sites different spiders present in rice cropping system were collected and preserved for further identification.

Demonstration of biocontrol of pests and diseases of Pigeonpea (2007-9)

In the BIPM module (seed treatment with *Trichoderma* (6g/kg); intercrop with maize 1 in 10 rows; application of HearNPV @ 1.5 x 1012 POB/h; application of Bt @ 1 kg/ha -2 times; NSKE 5% - 2 times) lower incidence of pod borer was recorded with higher yield of 1751 kg/ha compared farmers practice (1678 kg/ha). CBR was 1:1.71 in BIPM module while it was 1:1.57 in farmers practice.

Survey for natural enemies of pigeonpea pod wasp, *Tanaostigmodes cajaninae* and pod fly, *Melanagromyza obtusa* (2007-9)

No natural enemies of pod wasp, *T. cajaninae* and pod fly, *M. obtusa* were recorded as the parasitization was nil, however 12.0 % damage was recorded by pod wasp and 9.0 % by pod fly in Tandur region of Andhra Pradesh.

Evaluation of EPN (*Heterorhabditis* sp.) against lepidopteran pod borers (2007-9)
Application *Heterorhabditis* sp. @ 1.0 and 1.5 billion/ha recorded 4.10 and 3.9 larvae of *H. armigera* 10 days after application and recorded 10.2 % and 11.5% pod damage and 1702 kg/ha and 1752 kg/ha yield of pigeonpea, respectively and the pod damage was 23.7% and yield was 1582 kg/ha in control plot.

Microbial control of *H. armigera* and *Adisura atkinsoni* on *Dolichos lablab* (2007-11)
Application of Bt @ 1 kg/ha recorded 11 larvae of *A. atkinsoni*/10 plants, 1.35% pod damage and yield of 3650 kg/ha in *Dolichos lablab* compared to 23.3 larvae/ 10 plants, 14.8% pod damage and yield of 550 kg/ha in control. Bt was better than endosulfan @ 2 ml/l.

Influence of crop habitat diversity on biodiversity of pests of pigeonpea and their natural enemies (2009-12)
Pigeonpea intercropped with sunflower and maize as border crop recorded 13.3 larvae of *H. armigera*/10 plants and yield of 1250 kg/ha compared to pigeonpea intercropped with sunflower and sorghum as border crop which recorded 15.2 larvae and 1159 kg/ha yield.

Evaluation of NBAII liquid formulations (PDBC-BT1 and NBAII-BTG4 and IARI Bt. Against pigeon pea pod borer (*H. armigera*) and legume pod borer (*Maruca testulalis*) (2011-12)
Application of 3 sprays of Bt liquid formulation NBAIIBTG4 @ 1 and 2% recorded lower pod damage of 11.78 and 8.23% by *H. armigera* and higher yield 1240 and 1337 kg/ha, respectively. In other treatments there was higher pod damage and lower yield. The pod damage was 21.9% and yield was 467 kg/ha in control plot.

Evaluation of BIPM package for castor pests (2007-11)
The BIPM package consisted of release of *Telenomus remus* @ 1,00,000/ha, release of *T. achaeae* @ 1,00,000/ha, spray of SlNPV@ 1.5 x 10^{12} POB/ha + 0.5% crude sugar and spray of Dipel @ 0.5 l/ha for *Achaeae janata* and *Dichocrocis punctiferalis.* The results revealed lower incidence of *S. litura, A. janata* and *D. punctiferalis*, lesser insect damage and higher yield in BIPM package in comparison to farmers practice.

Laboratory evaluation of Trichogrammatids against castor capsule borer (2007-11)
The results revealed that 28.7% castor capsule borer eggs were parasitized by *T. chilonis* followed by *Trichogrammatoidea bactrae* (22.7%). *T. japonicum and T. achaea* could parasitize only 12.7 and 15.2 per cent eggs, respectively.

Biological suppression of *Uroleucon carthami* in non spiny safflower varieties (2007-12)
The treatments included two release of *Chrysoperla carnea* @ 6000/ha, NSKE 5%, *V. lecani* @ 1x 10^{13} conidia/ha, *B. bassiana* @ 1x 10^{13} conidia/ha, *M. anisopliae* @ 1x 10^{13} conidia/ha, Bt @ 1.0 kg/ha, chemical check and untreated control. There was no significant difference between the treatments with respect to aphid population after treatment imposition. Yield data showed that *Bt* treated plots recorded higher yields but were on par with NSKE.

Biological suppression of *Spodoptera litura* and *Uroleucon carthami* in non spiny safflower varieties (2009-11)
Biocontrol package (Application of SlNPV, Bt, *N. rileyi*) recorded 536 and 496 aphids per 10 plants while untreated control recorded 1014 and 1217 aphids per 10 plants after two applications

of treatments respectively. Yield in biocontrol package was 501 kg/ha while it was 323 kg/ha in untreated control proving the efficacy of bioagents and biopesticides in managing the pest.

Evaluation of *Hirsutella thompsonii* for the biocontrol of coconut eriophyid mite (2007-8)
Field application of *H. thompsonii* against coconut mite resulted with no mycelia fragments in the mite colonies and no reduction in mite population was recorded.

Entomopathogenic nematodes for management of red palm weevil (2011-12)
Not conducted

Evaluation of biological control agents against mango hoppers (2007-12)
There was no reduction in the population of mango hoppers even after application of *M. anisopliae* in off season and also weekly sprays during flowering season.

Effect of off-season release of *Cryptolaemus montrouzieri* to suppress the mealy bug in the main season on custard apple (2007-9)
The off-season release of *C. montrouzieri* helped the predator establishment and lesser incidence of mealybug was recorded during main fruiting season on custard apple. (No data is provided)

Establishment of mass production units (at all the AICRP centres) (2007-8)
A new biocontrol laboratory has been established for the mass production various biocontrol agents.

Biological management of root-knot nematodes infesting tomato / carnation in polyhouses (2009-12)
Not conducted due to non-availability of polyhouses

Evaluation of anthocorid predator, *Blaptostethus pallescens* against spider mite in polyhouses on roses/ carnation (2011-12)
Not conducted due to non-availability of polyhouses

Evaluation of biocontrol agents against sap sucking insect pests of ornamentals in polyhouses (2011-12)
Not conducted due to non-availability of polyhouses

Biological management of root-knot nematode infesting tomato in polyhouses (2011-12)
Not conducted due to non-availability of polyhouses

Evaluation of anthocorid predators against storage pests in rice (2011-12)
The anthocorid bugs could effectively control the *Corcyra cephalonica* larvae as lesser adult moths emerged. Nymphs of *Xylocoris flavipes* performed better than those of *Blaptostethus pallescens* in controlling the moths. The survival of *Xylocoris* was much better than *B. pallescens* in all dosages.

Enabling large scale adoption of proven biocontrol technologies
Farmers fields were identified in Nalgonda district. Sowing were completed by July end. But incessant rains and floods forced the farmers to abandon the sown crop and go for maize.

***Oryctes rhinoceros* management using *Metarrhizium aniosopliae* var. *majo*r and *baculovirus* in Andhra Pradesh (2009-12)**
Not done

Surveillance and need-based control of coconut leaf caterpillar, *Opisina arenosella* in Andhra Pradesh (2009-12)
Not done

Surveillance for alien invasive pests in vulnerable areas (*Brontispa longissima; Aleurodicus dugesii; Phenacoccus manihoti; Paracococcus marginatus; Phenacoccus madeirensis*) (2011-12)
The areas were surveyed but the pests mentioned were not recorded.

Production, process, technologies developed

Sequential application of bioagents, *Bt*-HaNPV-endosulfan-*Bt* in pigeonpea against *Helicoverpa armigera*.
Biointensive management of pod borer complex through *Ha*NPV-NSKE alternation in pigeonpea.
Combination of *T. pretiosum* @ 50,000/ha- 3 times and *Ha*NPV @ 250 LE/ha – 3 times to manage *H. armigera* in tomato.

Infrastructure and physical facilities developed

Established a new biological control laboratory for the mass production of various biocontrol agents.

Human resource development efforts

The field demonstrations were conducted in farmers fields.

Publications

Research articles published in journals - nil
Research articles published in symposia -2

Observations of the QRT

i. The experiments in polyhouses were not conducted due to non availability of polyhouses.
ii. The centre concentrated their research work mostly in cotton, pigeonpea, castor and safflower.
iii. The BIPM module was found superior in management the pests in cotton, pigeonpea and castor.

Recommendations of the QRT

1. Since pesticides are applied indiscriminately in Andhra Pradesh, efforts should be made to collect various natural enemies in different cropping systems to identify pesticide tolerant strains of natural enemies.

2. The centre should put more emphasis for documenting different species of spiders in rice crop system.

Overall assessment

Very Good (The centre has been accredited as National Referral Laboratory for biopesticides)

6. Dr. Y. S. Parmar University of Horticulture & Forestry, Solan

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-12)
Two populations of *Trichogramma* were collected from *Helicoverpa armigera* on Tomato and Rose during 2009-10. *Chrysoperla zastrowi sillemi* was collected from greenhouse whitefly on Cucumber. Adults were also collected under light. No *Cryptolaemus* was found in any of the ecosystem. Three species of spiders were collected from vegetable ecosystem No EPNs were trapped. Soil samples were also sent to NBAII

Biodiversity of insect pests and their natural enemies in horticultural ecosystems
Larval parasitoids *Neochrysocharis formosa, Chrysocharis* sp, *Asecodes delucchi, A. erxias* and *Diglyphus* sp; and one larval pupal parasitoid, *Opius* sp were recorded from *Liriomyza trifolii* on tomato. Thirty species of Coccinellids were collected from various ecosystems of different agro climatic zones of HP. *Zetzellia* sp, *Stethorus* sp and *Neoseiulus* sp were recorded from phytophagous mites in apple ecosystem. *Scolothrips sexmaculata,* Stephylinid beetle and predatory midge were recorded on mite in rose. Two species of sawflies were recorded on Rose. One of them was identified as *Arge fumipennis,* whereas, the identity of the other could not be established. Two species of endoparasitoids each were recorded on green peach aphid, *Myzus persicae*, cabbage aphid, *Brevicoryne brassicae* and Peach leaf curl phid, *Brachycaudus helichrysi.* Natural infection of *Entomophthora* was recorded on *Myzus persicae* infesting Capsicum crop under polyhouse conditions. Local isolate of *Nomuraea rileyi* was isolated from *Spodoptera litura* and was found effective against *S.litura* under laboratory conditions. Two species of *Orius* and one of *Anthocoris* were collected from vegetable crops and peach.

Evaluation of fungal pathogens against the apple wooly aphid (*Eriosoma lanigerum*) on apple (2007-9).
Beauveria bassiana, Metarrhizium anisopliae and *Verticillium lecanii*(10^7 conidia/ml each) and *Hirsutella thompsoni*(5g/L) were evaluated against apple woolly aphid and none of them proved effective in reducing the woolly apple aphid (Colony number and size) significantly.

Laboratory evaluation of some bioagents against the root borer *Dorysthenes hugelii* as pest of apple (2007-11)
Beauveria bassiana and *Metarrhizium anisopliae* (10^5 to10^7 conidia/cm^2 each) resulted in 36.6 to 63.3 % ; and *Steinernema carpocapsae and Heterorhabditis indica* (20IJ/cm^2) caused 66.7 to 83.3 % mortality of root borer grubs as against 96.7% by chlorpyriphos(0.06%) under laboratory conditions. During 2011, the experiment was conducted under field conditions and it was found that different biopesticides treated apple plant had on an average 5.4 to 7.6 root borer grubs /tree as against 2.0 and 10 borers in chlorpyriphos treated and untreated plants respectively.

Studies on the predators of phytophagous mites on apple and beans (2007-11)
Mass multiplication of *Neoseiulus longispinosus* has been standardized and predator: prey ratio of 1:30 has been worked out to be effective. Three sequential releases of predator were as effective as profenophos (0.15%) in the field. During 2011, the predatory mite alone and in combination with HMO reduced the mite population significantly (8.2 and10.0 mites/leaf, respectively over control (31.0 mites/leaf)

Study on natural enemies of the serpentine leaf miner, *Liriomyza trifolii* on tomato and their possible exploitation for its suppression (2007-11)
Six parasitoids viz; *Neochrysocharis formosa, Chrysocharis* sp, *Asecodes delucchi, Asecodes erxias, Diglyphus* sp; and *Opius* sp were recorded from *Liriomyza trifolii* on tomato. Total parasitization due to these parasitoids ranged from 6-21., 16.6-33.3, 13.6-25.0 and 7.9-30.0 % during 2008-9, 2009-10, 2010-11 and 2011-12, respectively. These parasitoids require more humidity for their survival and were more active during July-August.

Demonstration of bio-intensive package for the pests of cole crops (2007-11) Bio intensive IPM package had effect on cabbage aphid but the release of *Trichogramma brassicae* (100000/ha) was ineffective against *Pieris brassicae.* Now the new module replacing *T.brassicae* with *T. pieridis* is being evaluated and the experiment is in progress.

Biocontrol of greenhouse whiteflies (GHWF) on beans/cucumber/tomato (2007-9)
Three parasitoids namely *Encarsia sophia, E. inaron* and *Eretmocerus delhiensis* were recorded on greenhouse whitefly. *E. sophia* was prevalent from mid-July to November, *E. inaron* from April to June and *E. delhiensis* throughout the year. Predatory potential of *Chrysoperla* was tested against greenhouse whitefly and it was found to consume 228.6 nymphs in 10 days.

Preliminary field evaluation of thelytokous *Trichogramma pretiosum* against *Helicoverpa armigera* of tomato (2009-11)
Due to negligible incidence of *H. armigera* the experiment could not be conducted during 2010-11.

Biological suppression of scarabaeids (*Brahmina cariacea*) – Potato- (2007-11)
Biopesticide treated plots (*Beauveria bassiana, B.brongniartii, Metarrhizium anisopliae, Steinernema feltiae and Heterorhabditis bacteriophora)* had 18-45.3, 23.1-35.2, 28.4-37.4 and 31.4-39.9 per cent potato damage as against 61.3, 50.4, 55.7 and 55.7 % in control during 2007-8, 2008-9, 2009-10 and 2010-11, respectively.

Biological management of root-knot nematodes infesting tomato and carnation in polyhouses (2009-10)
The said experiment was allotted only to the centers where AICRP on nematodes is also running.

Biocontrol of greenhouse whiteflies (GHWF) on beans/ cucumber/ rose under polyhouse conditions (2009-10)
Three parasitoids namely *Encarsia sophia, E. inaron* and *Eretmocerus delhiensis* were recorded on greenhouse whitefly. Combination of *V. lecanii* and *E. sophia* resulted in 78.33% mortality of the whitefly under glasshouse conditions.

Surveillance for alien invasive pests in vulnerable areas (*Brontispa longissima; Aleurodicus dugesii; Phenacoccus manihoti; Paracococcus marginatus; Phenacoccus madeirensis*) (2011-12)

Survey was conducted during 2011-12, but none of the mentioned pests were encountered in any ecosystem.

Production, process, technologies developed

Management of Brevicoryne brassicae and Pieris *brassicae* through neem and Bt application and mechanical destruction of egg masses of Pieris brassicae.
Management of *Tetranychus urticae* by predatory mite, *Neoseiulus longispinosus* in polyhouse.

Infrastructure and physical facilities developed

Biocontrol laboratory was renovated

Human resource development efforts

Dr. Usha Chauhan attended XIII International congress of acarology at Recife-PE, Brazil from 23-27 August, 2010 and also attended AMRQC 12th Workshop at Vienna, Austria from 19-22 October, 2010.
Conducted 16 training programmes for the farmers.
Demonstration trials conducted in farmers fields.

Publications

Research articles published in journals	-15
Research papers presented in symposia and workshops	-12
Extension bulletins published	-04

Best publication

Usha Chauhan, Kumar, R. and Thakur, M. 2009. Winter survival and reproduction of *Amblyseius longispinosus*, a potential predator of spider mites on roses in Himachal Pradesh: Trends in Acarology (2009) M. W. Sabelis & J. Bruin (eds.) pages: 435-437.

Observations of the QRT

i. No conclusive recommendations are emerging from the research conducted at this centre.
ii. While collecting the natural enemies, details of crop, stage of the crop should be noted along with the pests available on that crop.
iii. The scientific names of plants, insect pests and natural enemies should be mentioned instead the common names.

Recommendations of the QRT

1. More efforts should be made to collect different groups of natural enemies along with proper details like date of collection, crop and crop stage, pest incidence, level of parasitisation, etc.
2. More data has to be generated on the predator efficiency of *Neoseiulus longispinosus* against phytophagus mite in carnation under polyhouse condition.

3. Evaluation of entomopathogenic fungi and EPNs for the suppression of apple root borer, *Dorysthenes hugelii* under field condition should be continued.
4. Survey and collection of natural enemy complex of pests of apple, apricot, plum, pear, peach, cherry, walnut and almonds.
5. The field experiments conducted does not meet the minimum standards.

Overall assessment

Average

7. Tamil Nadu Agricultural University, Coimbatore

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-12)
As per protocol, the pest and natural enemy samples collected from TNAU centre were sent to NBAII for identification and further studies at regular intervals**.**

Management of wilt disease complex in tomato (2008-9) Soil application of Farm Yard Manure @ 12.5 t/ha along with *Pseudomonas fluorescens* @ 2.5 kg./ha. is effective to minimize the nematode fungal disease complex and to enhance the fruit yield of tomato.

Biological control of pigeonpea cyst nematode and disease complex in redgram (2007-9)
Soil application of Neem cake @ 100 g./m^2 along with *Trichoderma viride* @ 2.5 Kg./ha. was found effective for the management of *Heterodera cajani* pigeon pea cyst and disease complex.

Demonstration on use of bioagents for management of sugarcane woolly aphid (2007-8)
The field experiments conducted at 3 locations to demonstrate the use of predator *Dipha* revealed a significant reduction in SWA population (94 to 96%) compared to farmers practice. The bioagent released plots also recorded higher yield and cost benefit ratio (1: 1.22 to 1:1.30) in all the three locations.

Development of IPM strategies for sugarcane woolly aphid (2007-8)
There was a significant reduction of SWA in IPM module over the farmers practice with a cost benefit ratio of 1:2.6. The higher natural enemy occurrence in IPM module over the farmers practice may be due to paired row planting, optimum use of nitrogenous fertilizer coupled with groundnut as inter crop and cow pea as border row crop with proper detrashing practices which enhanced the entomophages activity remarkably.

Studies on *Encarsia flavoscutellum* (2007-9)
The SWA incidence was remarkably reduced in the released and adjacent plots. Establishment of *Encarsia* was observed in both the released and adjoining fields. However, there was a significantly higher population of *Encarsia* in the released field (6.4/clump) compared to nearby adjoining fields (1.8 to 3.9).

Field evaluation of *Trichogramma chilonis* produced using Eri-silk worm eggs as factitious host (2011-12)

After eighth release, in the release of *Trichogramma chilonis* reared on Eri Silk worm eggs @ 20,000/acre recorded significant reduction of INB (7.2%) as compared to release of *Trichogramma* chilonis reared on *Corcyra* worm eggs @ 20,000/ acre (11.3%). The untreated control recorded higher INB incidence (20.1%).

Survey for the identification of potential natural enemies of the gundhi bug, *Leptocorosa* sp. (2009-11)

During the survey, the following natural enemies were observed on *Leptocorisa acuta*. *Conocephalus longipennis, Micraspis discolor, Ooencyrtus* sp. and *Gryon* sp.

Seasonal abundance of predatory spiders in rice ecosystem (2011-12)

The spiders viz., *Lycosa pseudoannulata, Oxyopes javanus, Tetragnatha sp.* and *Argiope catanulata* were observed in the rice ecosystem. The analysis of spider diversity through Shanon-Weiner method indicate that more number of diversity of spider species occurred during the vegetative period of the crop (45 DAT = 1.1945) and also during the maturity period crop (67 DAT = 1.0609) during the Kharif 2011 season. Milking stage of the crop recorded lesser diversity and species richness of spiders in both seasons of the rice crop.

Demonstration of bio-Intensive Pest Management (BIPM) in *Bt* cotton (2007-9)

BIPM module recorded lower population of aphids, thrips, leafhopper, whiteflies, *Earias* and *Helicoverpa armigera* incidence compared to farmers practice. In *Bt.* farmers practice field, the per cent parasitism by *Trichogramma,* braconids, ichneumonids and tachnids was significantly lower during 2007-08. A higher seed cotton yield of 2169 kg / ha. was recorded in *Bt*. BIPM field with a cost benefit ratio of 1 :1.9 whereas a significantly lower seed cotton yield (1894 kg/ha) was recorded in *Bt.* farmers practice field during 2008-09.

BIPM of pink boll worm, *Pectinophora gossypiella* on cotton (2007-9)

The average larval population, boll damage and locule damage due to PBW of cotton were lower in the egg parasitoid *(Trichogrammatoidea bactrae*)(14.3 and 8.6% boll and locule damage) + BIPM coupled with higher yield. It was vice versa in the untreated check (25.7 and 19.9%). Farmers practice recorded higher larval population, boll damage and locule damage as compared to Parasitoid release + BIPM.

Identification of natural enemies of mealy bugs on cotton and evaluation of potential natural enemies (2007-10)

The natural enemies such as *Crytolaemus montrouzieri, Brumoides suturalis, Cheilomenes sexmaculatus, Cladiscodes sacchari and Spalgis epius* were recorded in different parts of Tamil Nadu. A severe outbreak of three mealybug species *viz.,Phenacoccus solani, P. solenalpsis and Paracoccus marginatus* was recorded (2008-09). *Brumoides suturalis* beetles released plot @ 2 - 4 / infested plant thrice with an interval of 15 days and farmers practice plot were significantly superior and statistically on a par in managing the mealybug followed by release of *Scymnus coccivora* grubs @ 4-8 and *Cryptolaemus montrouzieri* grubs @ 2 - 4 / infested plant thrice at an interval of 15 days.

Monitoring the biodiversity and outbreaks of invasive mealybugs and their natural enemies on horticultural/ field/ medicinal land aromatic crops (2009-12)

The papaya mealybug has been recorded on more than 55 host plants in more than 25 genera. Natural enemies of the papaya mealybug recorded during the survey include the commercially available mealybug destroyer *Cryptolaemus montrouzieri, Scymnus coccivora* and the lycaenid butterfly predator *Spalgis epius* Other predators like lacewings and hover flies have also been recorded as potential predators on mealybug populations (2008-09)
During a period of one year and six months, 20,00,000 *Acerophagus papayae* parasitoids were mass multiplied by TNAU and released in farmers field @ 100 parasitoids/village **at free of cost** in all the 32 districts of Tamil Nadu**.** After the introduction of parasitoids, the mealybug incidence was remarkably controlled on papaya, mulberry, cassava, Jatropa, vegetables and fruit crops (2009-11).

Demonstration of biocontrol of pests and diseases of Pigeonpea (2007-9)
BIPM module was compared with Farmers' Practice (FP) .The results indicated that lower incidence of pod borers (7.7 vs 16.1%), pod damage by *H. armigera* and *Maruca testulalis*, higher pod yield and higher CB ratio in BIPM than the Farmers Practice (FP).

Influence of crop habitat diversity on biodiversity of pests of pigeonpea and their natural enemies (2009-12)
Pigeonpea intercropped with sunflower and maize or sorghum as border crop recorded significantly lower larval population of *Helicoverpa armigera* and *Maruca testulalis* compared to pigeon pea as sole crop. The natural enemy population was remarkably higher in pigeonpea intercropped with sunflower and maize or sorghum as border crop than pigeonpea as sole crop. Similarly, the activity of natural enemies on the intercrop and border crop was also higher.

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*) (2011-12)
Evaluation of different *Bt* liquid formulations, two doses of *Beauveria bassiana*, NSKE 5% and chlorpyriphos 0.04% showed that PDBC-BT1 @ 2% spray, IARI *Bt* isolates @ 2% spray and chlorpyriphos 0.04% were highly effective in reducing the larval population of *Helicoverpa armigera* and *Maruca testulalis* in all stages *viz.*, pre-flowering, post flowering and pod emergence with lesser pod and seed damage in pigeon pea and recording higher yield.

Biological control of groundnut leaf miner (2007-11)
Among biocontrol agents and NSKE, *Bt* @ 1 kg/ha is highly effective followed by four releases of *Trichogramma chilonis* @ 100,000/ha at 10 days interval and NSKE 5% spray (two times) were effective against groundnut leaf miner *Aproaerema modicella* by reducing the larval population and per cent damage. However, endosulfan was significantly superior to *T. chilonis* and NSKE 5% treated plots.

Evaluation of *Hirsutella thompsonii* for the biocontrol of coconut mite (2007-8)
The mycohit formulations *(Hirsutella thompsonii*) received from PDBC was evaluated against coconut eriophyid mite. Mycohit 50 g lit^{-1} was found to be effective in reducing the mite population.

Evaluation of biological control agents against mango hoppers (2007-9)
Application of *M. anisopliae* @ $1xl0^{7}$ and *V. lecani* @ $1xl0^{9}$ spores/ml on tree trunk during off season and at flowering recorded the lowest mean mango hopper population of 12.5 and 12.7/ inflorescence as compared to 35.8/inflorescence in control 7 days after third spray. However, one

spray of imidacloprid @ 0.3 ml/lit during off season followed by one spray at flowering period recorded the lowest hopper population (7.1) one week after third spray.

Large scale field evaluation of Metarhizium anisopliae against mango hoppers (2009-11)
Application of *M. anisopliae* @ $1xl0^9$ spores/ml on tree trunk during off season + two sprays during season at weekly interval and application of *M anisopliae* @ $1xl0^9$ spores/ml on tree trunk during the season alone recorded significantly lower mango hopper populations (2009-11).

Evaluation of biological control agents against mango nut weevil (2009-10)
Among biocontrol treatments raking the soil followed by i)soil application of *Beauveria bassiana* @ 300 g ($1x10^8$ CFU/g) + 5 Kg. FYM followed by swabbing tree trunk and foliar application of *Beauveria bassiana* $1x10^8$ CFU/ml recorded lower nut weevil damage. However insecticidal check is the most effective treatment in reducing the nut weevil damage

Evaluation of *Trichogramma brassicae* against *Plutella xylostella* on cabbage (2007-9)
The larval population of DBM reduced significantly in *T. brassicae* and *T. chilonis* released field with a higher yield. The cost benefit ratio of *T. brassicae* and *T.chilonis* released fields were 1:2.5 and 1:1.7 respectively.

Preliminary field evaluation of thelytokous *Trichogramma pretiosum* against *Helicoverpa armigera* of tomato (2009-12)
The egg parasitism recorded from field collected *Helicoverpa* eggs after 6 releases showed that 15% parasitism in *T. pretiosum* thelytokous released field as compared to 8% in *T. pretiosum* arrhenotokous released plot coupled with significantly less fruit damage with higher yield. The parasitism was absent in the unreleased plot.

Survey for the natural enemies of tea mosquito bug on Guava and Cashew (2009-11)
Acetamiprid 0.2 g/l and cyhalothrin 0.5ml/l were found significantly superior in reducing the tea mosquito bug population followed by *Beauveria bassiana* (IIHR) strain. The treatments Neem soap 10g/l and *Beauveria bassiana* (the other commercial formulation) were moderately effective in managing the Tea mosquito bug population but better than control.

Biological control of cotton mealybug (*Phenacoccus solenapsis*) (2009-10)
The grub of *Brumoides suturalis* beetles released plot @ 2 -4 / infested plant thrice with an interval of 15 days and farmers practice plot were significantly superior and statistically on a par in managing the mealybug followed by release of *Scymnus coccivora* grubs @ 4-8 and *Cryptolaemus montrouzieri* grubs @ 2 - 4 / infested plant thrice at an interval of 15 days.

Biological control of papaya mealybug (2009-11)
The plots released with mealybug parasitoid *Acerophagus papayae* at 100 numbers proved superior to unreleased field, in causing reduction in mealybug population besides higher level of parasitoid activity. There was a remarkable reduction (84 to 99 per cent) in mealybug population 90 days after release from five locations studied. *A. papayae* was found to establish in the papaya field within a month of release at all the sampling sites. A spectacular success was achieved within four months after the release.

Standardization of mass production technique for papaya mealybug parasitoid, *Cladiscodes sacchari* (2009-11)
Attempts made to mass produce papaya mealybug parasitoid, *Cladiscodes sacchari* has not brought desirable results under laboratory conditions.

Evaluation of coccinellid predators against papaya mealybug (2009-11)
Three releases of *Scymnus coccivora* @ 20 beetles / infested tree at an interval of 15 days reduced the mealy bugs of papaya (2009-10).

Biological management of root-knot nematodes infesting tomato and carnation in polyhouses (2009-10)
Not conducted

Evaluation of biological control agents against mites in carnation under polyhouse conditions (2009-11)
Release of coccinellid beetle, *Stethorus pauperculus* and release of predatory mite, *Amblyseius* sp @ 10 mites/ plant were effective in reducing two spotted spider mite, *Tetranychus urticae* followed by *Hirsutella thompsonii* 10^8 CFU/ml and *Beauveria bassiana* 10^8 CFU/ ml. (2009-10).
Release of coccinellid beetle, *Stethorus pauperculus* and release of predatory mite, *Amblyseius* sp @ 10 mites/ plant were effective in reducing two spotted spider mite, *Tetranychus urticae* followed by *Hirsutella thompsonii* 10^8 CFU/ml and *Beauveria bassiana* 10^8 CFU/ ml.

Evaluation of anthocorid predators against storage pests in rice (2009-11)
The inoculative release of *Xylocoris flavipes* 30 nymphs per 10 Kg of rice reduce significantly the emergence of *Corcyra* moths followed *Blaptostethus pallescens* 30 nymphs per 10 Kg of rice.

Enabling large scale adoption of proven biocontrol technologies (Bt cotton)
The large scale field demonstration of Bt cotton was covered in 25 hectares during 2009-10 and the detailed investigations were carried out in 1 hectare Bt cotton crop where the treatments were imposed at Ariyalur in RCH 2. The population and boll damage due to *Earias* was significantly lower in Bt demonstration field than farmers practice. The seed cotton yield was significantly higher in Bt demonstration field than farmers practice.

Coconut- Surveillance and need-based control of coconut leaf caterpillar, *Opisina arenosella* in Tamil Nadu (2009-11)
Four releases of *Goniozus nephantidis* adults @ 10/palm at fortnightly interval coinciding with larval stage of the pest followed by three releases of *Cardiastethus exiguus* nymphs @ 50/palm at 5 days interval coinciding the pupal stages recorded a significant reduction of coconut leaf caterpillar, *Opisina arenosella* compared to the unreleased field.

Survey for the spread of the pet, base line data on the mealybug and natural enemies, mass production and release of imported parasitoids, establishment, conservation and impact assessment (2010-11)
Papaya mealybug, *Paracoccus marginatus* was first recorded in Tamil Nadu Agricultural University (TNAU) campus, Coimbatore, Tamil Nadu during July, 2008. Survey was conducted immediately throughout the state of Tamil Nadu to study the extent of damage and spread of the invasive mealybug, *P. marginatus.* Severe infestation (80 to 90 %) was observed *on* the crops viz., papaya, mulberry, tapioca, brinjal, tomato, bhendi and flower crops. The mealybug infestation varied from 50-90 per cent in crops like papaya, mulberry and cassava resulting in a

monetary loss of rupees 435 crores in the above three crops alone in Tamil Nadu. During a period of one year and six months, 20,00,000 *Acerophagus papayae* parasitoids were mass multiplied by TNAU and released in farmers field @ 100 parasitoids/village at free of cost in all the 32 districts of Tamil Nadu**.** The plots released with mealybug parasitoid *Acerophagus papayae* at 100 numbers proved superior to unreleased field, in causing 84 to 99 per cent reduction in mealybug population besides higher level of parasitoid activity. *A. papayae* was found to establish in the papaya field within a month of release at all the sampling sites. A spectacular success was achieved within four months after the release.

Establishment of mass production units (at all the AICRP centres) (2007-8)
Mass production units were established for *Trichogramma, Chrysopa, Cryptolaemus*, Braconids, *Chelonus*, *Acerophagus papaya, Zygogramma,* NPV of *Helicoverpa* and *Spodoptera,* Entomopathogenic fungus like *Beauveria* and *Verticillium*

Production, process, technologies developed in the last five years:

Production and process technologies were developed for mass production of predator *Dipha aphidivora* and parasitoid *Acerophagus papayae.*

Infrastructure and physical facilities developed in the last five years:

Established insect net house. Glass house, rearing rooms.
Equipments acquired: Ice maker, image analyzer, environmental chamber, PCR, modern work tables, micro ovens, cages, humidifiers, growth chambers, air conditioning units, refrigerators, autoclaves, generator, microscopes, electronic balance, UV chambers, rearing racks *etc*.,

Human resource development efforts in the last five years;

The scientists working in the project attended training on mass production of papaya mealy bug parasitoids at NBAII, Bangalore – 24th – 26th September, 2009; visited Adelaide University, Australia during February, 2009 for IPM training; undergone training on quality control of Biopesticides during 2011 at NIPHM , Hyderabad and visited leading commercial biopesticide centres at Bangalore and Chennai

Publications

Research articles published in journals	- 48
Research papers presented in symposium/workshops	- 6
Popular articles including extension folders	- 2

Best publication

Jeyarani,S., P. Karuppuchamy and N.Sathiah. 2011. Influence of *Pseudomonas fluorescens* induced plant defenses on the efficacy of nucleopolyhedrovirus of *Helicoverpa agrmigera* (Hubner) Investigations on the enhancing efficacy of granulovirus on nucleopolyhedrovirus of *Helicoverpa armigera* in Okra and Tomato. *International Journal of Vegetable Science* 17(3) 283 – 295.

Observations of the QRT

i. The centre had conducted all the 34 research programmes allotted to them.
ii. The sugarcane woolly aphid was successfully managed by the release of two predators and one parasitoid and the centre continued the monitor the woolly aphid during this XI plan period.
iii. Efforts made by the centre in mass production and distribution of exotic parasitoid, *Acerophagus papayae* for the successful biological control of papaya mealybug are appreciated by the QRT.
iv. During the period from 2007-12, the centre took up various extension activities regularly for the promotion and popularization of biological control/BIPM strategies against major crop pests and diseases through large scale demonstrations, farmer participated trials, famers, extension scientists and producers training programmes and mass production and distribution of biocontrol agents, etc.

Recommendations of the QRT

1. Economic analysis and documentation of impact of release of *Acerophagous papayae* on papaya production, seed production, papain industry, mulberry and tapioca along with savings in cost of insecticide and their application should be done.
2. Proper documentation of indigenous parasitoids associated with papaya mealybug.
3. Natural enemy complexes of different species of mealybugs on different crops in different seasons in Tamil Nadu.
4. A network project on mealybug has to be proposed with broad outline for in depth study.
5. Documentation of natural enemies of spiraling whitefly in Tamil Nadu.

Overall assessment

Very Good

8. Assam Agricultural University, Jorhat

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-12)
The recovery of *Trichogramma* sp. was made only from rice, sugarcane and Castor ecosystem. However, the recovery of T*richogramma* sp. from tea eco system was found during 2009 -10 and 2010 -11 and the live culture of the *Trichogramma* is still in progress in bio control laboratory, AAU, Jorhat. *Trichogramma* recovered from castor have been sent to NBAII for confirmation.
The survey of Chrysopids was made with the appearance of wooly aphids in the sugarcane areas of Golaghat and Jorhat district. The mean population of SWA was very low (5.2 /2.5 sq.cm leaf during 2011 -12. The infestation of SWA was generally observed in the field from October onwards to till February during the survey periods of 2009 -12. Besides *Chrysopids Dipha aphidovora,and Encarsia sp.* were also found in association of SWA. During the survey period 2009 -11, the activity of *Cryptolaemus* predator was not observed in *Kharif* as well as *Rabi* season crops.
Spiders collected from different types of habitat 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, houses and huts have been collected and sent to NBAII, Bangalore for identification.

Soil samples from different survey areas have been collected to isolate local EPN. Insect (*Corcyra* larvae) suspected to be affected by EPN were isolated and placed in 50 cc soil in polythene bags and sent to NBAII, Bangalore for identification.
Soil samples were collected from a depth of 15 cc from the upper surface soil including rhizosphere and rhizoplane from five different places and the composite samples were thoroughly mixed and sent to NBAII, Bangalore for isolation of antagonistic organism.

Biological control of plant parasitic nematodes on Vegetables and fruits - Tomato (2007-8)
Field study carried out to evaluate comparative performance of *Paecilomyces lilacinus* and *Pochonia chlamydosporia* @ 20 kg/ha against *Meloidogyne incognita* in tomato (Cv. Pusa Ruby) revealed that a significant difference in the plants treated with *P. lilacinus* exhibited good impact on egg parasitization (8.80) compared to *P. Chlamydosporia* (10.72) after 45 DAP of crop, but at harvest both the treatments were at par in their efficacy.

Demonstration of *Trichogramma chilonis* against the Plassey borer *Chilo tumidicostalis* (2007-9)
Nine releases of *Trichogramma chilonis* @ 50,000/ha/release at 10 days interval from July 2nd week to October 1st week, 2008 resulted in significant reduction of *Chilo tumidicostalis* infested cane and contributed high cane yield (84,450 kg /ha).

Studies on *Encarsia flavoscutellum* (2007-9)
Monitoring of *Encarsia flavoscutellum* from October, 2007 to January, 2008 revealed that the SWA population decreased from 41.3 to 15.7 /leaf and the number of *E. flavoscutellum* varied from 3.0 to 2.4 /leaf and *Dipha aphidovora* from 9.2 to 5.2 /leaf indicating the suppressing effect of the parasitoids and the predators on SWA population.

Large-scale demonstration of IPM for rice pests and diseases in the farmer's field (2007-9)
Large scale demonstration of IPM over an area of 10 hectares of plot (Cv. mashuri) for rice pests and diseases revealed that much lower incidences of *Nephotettix sp, Cnaphalocrocis* sp. and dead heart due to *Scirpophaga sp* compared to farmer's practice. Higher yield was obtained in IPM package than farmer's practice and realized net return of Rs. 8550.00 over farmer's practice.

Validation of biointensive pest management practices in organic rice production (2007-9)
Validation of BIPM practice on 10 hectares of organic rice (Cv. Ranjit) resulted in lesser incidence of *Nephotettix* sp, *Cnaphalocrocis* sp and dead heart due to *Scirpophaga sp* incidence in rice in Assam. Even though the grain yield (3368) was higher in conventional method, the net return Rs. 4550 was higher in BIPM.

Preliminary evaluation/ screening of EPN against YSB, striped borer and leaf folder in rice (2007-11)
Evaluation of aqueous and WP formulation of EPN against *Scirpophaga sp* and C. *medinalis* revealed that *Steinernema feltiae* when applied in aqueous form recorded 15.2 per cent mortality of YSB and 42.9 % morality of rice leaf folder, but was inferior to chemical control.

Survey for the identification of potential natural enemies of the gundhi bug, *Leptocorisa* sp. (2007-11)
Seventy egg masses were collected during a survey in Jorhat, Golaghat and Sivsagar district during Kharif '2009, and parasitoids emerged only from two egg masses and were sent to NBAII for identification.

Seasonal abundance of predatory spiders in rice ecosystem (2011-12)
Out of seven numbers of predatory spiders obtained during the cropping season 2011-12, the species *Oxyope javanus, Tetragnatha sp., Lycosa pseudoannulata, Argiope catenulata* were found to be dominant in all the locations. *Oxyope javanus* was found to be most dominated spider species followed by *Tetragnatha* sp., *L. pseudoanulata* and *A. catenulata*.

Evaluation of Trichogrammatids against the mustard sawfly (2007-9)
The results revealed that none of the *Trichogrammatids* sp. could parasitize the mustard saw fly eggs, instead newly emerged larvae of mustard saw fly could be observed.

Field evaluation of *Trichogramma brassicae* against *Plutella xylostella* on cabbage (2007-9)
Six releases of *Trichogramma brassica*e @ I,00,000 lakhs/ha resulted in reduction of *Plutella xylostella* incidence and increased the cabbage yield (18425.0 Kg/ha) in Assam.

Potato Tuber Moth suppression by releasing *Copidosoma koehleri* (2007-9)
Survey was made to find out potato tuber moth infested farmer's field in the district of Joirhat, Sivsagar and Golaghat for the field release of *Copidosoma koehleri*, but the incidence of *Pthorimaea operculella* was not recorded, amd the incidence of *Dorylus orientalis* was recorded on potato.

Evaluation of *Trichogramma chilonis*, EPN and Bt against fruit borer of brinjal and Okra (2008-9)
In a field trial at Allengmora Assam, application of EPN @ 2 billion/ha two times was most effective in reducing brinjal fruit and shoot damage (17.8%) which was significantly superior to Bt and *T. chilonis*. Highest yield was recorded in EPN @ 2 billion/ha which was on par with insecticidal treatment.

Survey of natural enemies of *Cyperus rotundus* (2007-9)
The survey of natural enemies of *C. rotundus* in Jorhat, Golaghat and Sivsagar districts revealed the occurrence of a borer pest attacking *C. rotundus*. However, the pathogen specific to this weed could not be detected. The borer pests were sent to NBAII for identification.

Biocontrol of *Chromolaena odorata* using *Cecidochares connexa* (2007-11)
The exotic stem gall fly *Cecidochares connexa* released against *Chromalaena odorata* established in agro climatic condition of Assam from August '2007. More than 10 galls /plant were recorded.

Establishment of mass production units (at all the AICRP centres)
AAU, Jorhat centre has established a new bio control laboratory to produce bio control agents relevant to the technical programme of the work. The laboratory is presently being utilized by the UG students in the production of biotic agents under the programme 'Hands on training". NBAII has released Rs. 5, 00,000.00 for the laboratory and AAU has merged more laboratory space along with bio control laboratory for Experiential learning course. The laboratory is now well equipped for the production biotic agents/ biopesticides etc.

Enabling large scale adoption of proven biocontrol technologies- sugarcane -Demonstration of biocontrol for the suppression of Plassey borer, *Chilo tumidicostalis* using *Trichogramma chilonis* and *Cotesia flavipes* (2009-11)

Eleven releases of *Trichogramma chilonis* @ 50,000/release in a farmer's field (200 ha) located at Buragoan in Golaghat district significantly reduced the incidence of *Chilo tumidicostalis* from 29.5 to 13.6 per cent. Maximum sugarcane yield was recorded in parasitoid released plots (73320 kg/ha) as against farmer's practice (71430 kg/ha) and the highest net return was obtained in *Trichogramma* released plot.

Enabling large scale adoption of proven biocontrol technologies- rice (2010-11-AAU, J)
Validation of BIPM practice carried out in an area of 200 hectares in two villages. The investigation revealed that the population of *Nephotettix* sp as well as damaged by *Scirpophaga* sp and *Cnaphalocrocis* sp. were much lower in BIPM package compared to farmer's practice. Higher grain yield in BIPM package (3280 kg/h) than farmer's practice (2935 kg/ha). The incidence of dead heart, white ear head and *Cnaphalocrocis* was much lower (<5%) in BIPM plots as against farmer's practice.

Surveillance for alien invasive pests in vulnerable areas (*Brontispa longissima; Aleurodicus dugesii; Phenacoccus manihoti; Paracococcus marginatus; Phenacoccus madeirensis*) (2011-12)
Surveillance for alien invasive pests in vulnerable areas was made in Alengmora and Uttar Garomara of Jorhat and Golaghat districts. The mealybugs collected on guava were sent to NBAII during March, 2012 for identification. Regular survey in the vegetable market yards of Jorhat, Golaghat and Sivsagar town at weekly intervals revealed that there was no infestation of mealybugs on fruits and vegetables.

Population dynamics of tea mosquito bugs in tea and its natural enemies (2011-12)
The experiment is in progress.

Evaluation of *Beauveria bassiana* (IIHR isolate) against Tea mosquito bug in Tea (2011-12)
The experiment could not be done during 2011 as the centre did not receive the IIHR strain of *Beauveria bassiana* for evaluation against tea mosquito bugs, which was the mandate of the experiment. The experiment will be continued during 2012.

Survey for mealybugs and their natural enemies on horticultural crops-papaya, hibiscus, tapioca, brinjal, tomato and okra (2011-12)
The survey revealed that there was no incidence of papaya mealybug, *Paracoccus marginatus* on papaya, hibiscus, tapioca, brinjal, tomato and okra in Jorhat and surrounding areas.

Evaluation of anthocorid predators against storage pests in rice (2011-12)
The innoculative release *of Xylocoris flavipes* 30 nymphs / kg of stored rice could reduce the emergence of Corcyra moths (22.3 moths / container) followed by *X. flavipes* @20nymphs (27.8 moths /container). In an average, maximum number of living nymphs of *Xylocoris flavipes* was also found in the same treatments with 30 nymphs (11.750) and 20 nymphs (6.75).

Production, process, technologies developed

The biocontrol agents were produced and utilized for field experiments.

IPM package for the management of pests of rice has been demonstrated in 100 hectares in the farmers' fields.

Infrastructure and physical facilities developed

A new well equipped bio control laboratory has been established for the production of bio control agents.

Human resource development efforts: Nil

Publications:

Research articles published in journals	- 6
Extension bulletins and popular articles	- 7
Radio/ TV talks	- 6

Best Publication

Sarmah, S., Saikia, D. K., Bhattacharyya, B. and Dutta, S. K. 2007. Population fluctuation of sugarcane wooly aphid, *Ceratovacuna lanigera* Zehnter (Homoptera; Aphididae) and its natural enemies in plant and ratton crops in Assam. *J. Biological control,* 21 (2): 241-246

Observations of the QRT

i. The centre had conducted all the 22 experiments/ technical programmes allotted.
ii. While working out the cost: benefit ratio, the loss in control plot has to be suitably considered.
iii. *Trichogramma chilonis* @ 50,000/ha/release at 10 days interval from July 2nd week to October 1st week, showed promise in suppression of sugarcane plassy borer, *Chilo tumidicostalis* and recorded higher cane yield (84,450 kg /ha).
iv. *Trichogramma brassica*e showed promise in suppression of diamond back moth, *Plutella xylostella* which is a serious pest of cole crops in Assam.

Recommendations of the QRT

1. Efforts should be made to collect predatory spiders in rice cropping system.
2. The survey for different natural enemies should be continued as Assam is an organic agriculture state and there is more chances of recording new biocontrol agents on different pests of crops.
3. The cost: benefit ratio has to be worked in several experiments, especially on vegetables.
4. The centre should develop effective collaboration with Tea Research Association, Toklai and develop biological control techniques for the pests of Tea.
5. The newly established biocontrol laboratory should produce and supply the biocontrol agents to farmers.

Overall assessment

Good

9. Mahatma Phule Krishi Vidyapeeth, College of Agriculture, Pune

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-12)
Trichogramma spp. not recorded from cotton, sugarcane, paddy, maize, potato and pomegranate fields. *Chrysoperla zastrowi sillemi* recorded from cotton, maize and grapevine. *Mallada boninensis* Okam recorded from pomegranate, guava, papaya and mango. Not recovered from grapevine and custard apple orchards. *Coccinella septempunctata*, *Cheilomenes sexmaculata*, *Hippodamia variegata*, *Illeis cincta*, *Hyperaspis maindroni* S., *Scymnus* sp. on cotton and mulberry; *Coccinella transversalis*, *Brumoides suturalis* on chilli. *Nomuraea rileyi* and *Sl*NPV infected larvae of *Spodoptera litura* in soybean. Unidentified species of spiders recorded from cotton, paddy, sugarcane, maize, pigeon pea, soybean, papaya and mulberry. *Steinernema* sp. received from *Leucopholis lepidophora.* Soil samples from capsicum, tomato, carnation, rose and coco-peat samples from gerbera sent to NBAII, Bangalore.

Biodiversity of insect pests and their natural enemies in horticultural ecosystems
Scymnus coccivora Ayyar, *Triomata coccidivora*, *B. suturalis* on mealy bugs in custard apple; *Chrysoperla* sp. on thrips in grapevine. *C. septempunctata*, *S. coccivora*, *B. suturalis*, *Spalgius epius* (Westwood) and encyrtid parasitoid, *Acerophagus papayae* N. & S. on papaya mealybug, *Paracoccus marginatus* W. & G.

Biological control of plant diseases and nematodes using antagonists (in collaboration with AICRP on plant parasitic nematodes) (2009-10)
The experiments on biological control of plant parasitic nematodes using antagonistic organisms against reniform nematodes in pigeon pea, citrus nematodes in citrus and root-knot nematodes in pomegranate conducted in collaboration with AICRP on plant parasitic nematodes, MPKV, Rahuri.

Biological control of reniform nematodes and disease complex in red gram (2007-09)
Soil application of *Trichoderma harzianum* @ 5 kg/ha + *Pochonia chlamydosporia* @ 20 kg/ha mixed with FYM found significantly superior in reducing the reniform nematode population in soil (48.6%) and female population in roots (38.5%) with 34.7 per cent increase in yield pigeon pea.

Biological control of plant parasitic nematodes on citrus (2007-09)
Soil application of *Paecilomyces lilacinus* @ 20 kg/ha along with FYM at *bahar* treatment found significantly effective in declining the citrus nematode, *Tylenchulus semipenetrans* population in soil (43.8%) and females in roots (31.8%) with 18.6 per cent increase in yield of citrus.

Biological control of plant parasitic nematodes on pomegranate (2007-11)
Soil application of *Pseudomonas fluorescens* @ 20 g/m^2 mixed with FYM at *bahar* treatment was significantly superior in reducing root-knot nematode, *Meloidogyne incognita* population in soil (34.5%) and root galls (26.7%) with 19.4 per cent increase in yield of pomegranate.

Demonstration on use of bioagents for management of sugarcane woolly aphid (2007-08)
Inoculative release of *Dipha aphidivora* @ 1,000 larvae or pupae/ha at 10 spots in sugarcane fields found significantly effective in suppressing the SWA population, pest intensity rating (1.9) and increased the predatory population as well as cane yield over farmer's practice.

Development of IPM strategies for sugarcane woolly aphid (2007-08)
The IPM module consisting paired row planting of cane, normal dose of N (250N:115P:115K), intercrop of ground nut, border rows cowpea and two releases of *D. aphidivora* @ 1,000 larvae/ha found significantly effective in suppressing SWA infestation and increased the predatory fauna.

Studies on *Encarsia flavoscutellum* (2007-09)
The parasitoid, *E. flavoscutellum* was introduced from Assam in SWA infested sugarcane fields in Maharashtra during December 2006. Its parasitism recorded up to 12.6% in Pune region during 2007-08. Later on, it was distributed in adjoining areas and established in Pune and Satara districts of the state.

Evaluation of *T. chilonis* against sugarcane internode borer (2007-08)
Six releases of *T. chilonis* TTS @ 1 lakh/ha at weekly interval found significantly effective in suppressing the incidence (7.35%) and intensity (1.2%) of INB in sugarcane with 85.9 kg per 50 canes yield.

Survey and surveillance of sugarcane woolly aphid (SWA) and its major natural enemies (2008-09)
The incidence of SWA recorded in dense sugarcane growing areas of western Maharashtra covering mainly 10 districts and five agro-climatic zones with 1.85% incidence and 1.52 pest intensity rating. The pest incidence was reduced from 25.45% during 2003-04 (176,023 ha) to 1.85% during 2008-09 (20,217 ha). Major natural enemies recorded were *Dipha aphidivora*, *Micromus igorotus*, *Eupoderes cofractor* and spiders besides coccinellids, chrysopids and Brumoids.

Monitoring the sugarcane woolly aphid incidence and impact assessment of natural enemies on its biosuppression (2011-12)
The SWA incidence was recorded to the extent of 0.42 to 0.87% with 1.46 to 1.62 pest intensity rating from 2009-10 to 2011-12. The natural enemies *D. aphidivora*, *M. igorotus*, syrphids, spiders and parasitoid *E. flavoscutellum* established well and played major role in suppressing the pest incidence.

Demonstration of bio-Intensive Pest Management (BIPM) in *Bt* cotton (2007-09)
The BIPM package consisting seed treatment with *Trichoderma* @ 8 g/kg seeds, border rows of maize, erection of 10 bird perches/ha, release of *Chrysoperla* @ 14,000 larvae/ha, spraying NSKE 5% suspension, *Sl*NPV @ 1.5 x 10^{12} POBs/ha and three releases of *Trichogrammatoidea bactrae* @ 1.5 lakh/ ha at weekly interval from the appearance of pink bollworm found effective over farmer's practice in suppressing the sucking pests as well as bollworm complex and increased the coccinellid fauna and yield of seed cotton.

Bio-intensive pest management of cotton pink bollworm, *Pectinophora gossypiella* (2007-09)
Inundative release of *T. bactrae* @ 1.5 lakh/ha three times at weekly interval with BIPM practice starting from 80 days after germination found effective in reducing PBW incidence and increased the seed cotton yield over untreated control.

Enhancement of natural enemy population in cotton by habitat manipulation in rain-fed cotton (2007-09)

Habitat management in cotton consisting four paired rows planting followed by intercropping of cowpea and marigold, border rows of maize, release of *Chrysoperla* @ 5,000 larvae/ ha and four releases of *T. chilonis* @ 1.5 lakh/ha at weekly interval and BIPM practices were significantly effective over farmer's practice in suppressing sucking pests' population and bollworm damage and increased the natural enemies (coccinellids, chrysopids) number and yield of seed cotton.

Identification of natural enemies of mealy bugs on cotton and evaluation of potential natural enemies (2007-11)

The natural enemies on cotton mealybug, *Phenacoccus solenopsis* recorded were *Coccinella septempunctata, Cheilomenes sexmaculata, Chrysoperla zastrowi sillemi*, *Spalgius epius*, *Brumoides* sp., spiders and parasitoids, *Aenasius bambawalei* and *Anagyrus* sp. Three releases of *Cryptolaemus montrouzieri* @ 2-4 grubs/ plant found statistically effective over farmer's practice in suppressing mealybug population and increased the predatory fauna and yield of seed cotton (17.7 q/ha).

Monitoring the biodiversity and outbreaks of invasive mealy bugs and their natural enemies on horticultural/ field/ medicinal and aromatic crops (2009-12)

The mealybug, *P. solenopsis* recorded in eight districts of western and central Maharashtra during September-October and January-February on cotton, parthenium, hibiscus, hollyhock, okra, acalifa, sunflower, soybean, marigold and *aboli*. Natural enemies recorded were *A. bambawalei*, parasitic dipteran flies, Aphelinids and *Anagyrus* sp. and predatory *Coccinella* sp., *Scymnus* sp., *Brumoides* sp., chrysopids, *Spalgius epius*, anthocorids and spiders. The invasive mealybug species *Paracoccus marginatus* recorded on papaya and its parasitoid *Acerophagus papayae* was the first report from Pune region in India.

Monitoring the biodiversity and outbreaks of sap sucking pests, mirids and their natural enemies in *Bt* cotton ecosystem (2011-12)

The incidence of aphids, leafhoppers and thrips noticed from 4th week of July, while white flies and mites recorded from 2nd and 4th weeks of August, respectively. The mealybug observed from November to January in *Bt* cotton plots. The major natural enemies recorded were *C. septempunctata, C. sexmaculata, Chrysoperla zastrowi sillemi, Micromus* sp., *A. bambawalei* and spiders.

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*) (2011-12)

Three sprays of *Bt* strains, NBAII-BTG4 and PDBC-BT1 @ 2% at fortnightly interval found statistically comparable with chemical insecticide chlorpyriphos 0.05% in suppressing the damage of *H. armigera* and *M. vitrata* and increased the yield of pigeon pea.

Evaluation of entomopathogens against soybean insect pest complex (2011-12)

Three sprays of *Sl*NPV @ 250 LE/ha ($1.5x10^{12}$ POBs/ha) at 15 days interval found significantly effective in suppressing the larval population of *S. litura* with 76% mortality and gave maximum of 22.2 q/ha yield of soybean. It was, however, at pat with MPKV and NBAII strains of *Nomuraea rileyi.*

Biological suppression of safflower aphid, *Uroleucon compositae* on safflower (2011-12)
Three sprays of *Metarhizium anisopliae* @ 10^{13} conidia/ha at 15 days interval found statistically comparable with dimethoate @ 1.45 ml/lit in reducing the aphid population on non-spiny variety of safflower and increasing the yield.

Evaluation of biological control agents against mango hoppers (2007-09)
Three sprays of *M. anisopliae* @ $1x10^7$ conidia/lit on tree trunk during off-season as well as similar sprays during flowering at 15 days interval found effective in suppressing the hopper population (16.8 hoppers/inflorescence) on mango.

Evaluation of *Metarhizium anisopliae* formulation against mango hoppers (2011-12)
Spraying of *M. anisopliae* @ $1x10^9$ spores/ml mixed with adjuvant (sunflower oil 1 ml + Triton-X 100 @ 0.1 ml/lit) during off season (December) followed by four sprays of the fungal pathogen at weekly interval during flowering (January-February) found significantly superior in suppressing the hopper population (12 hoppers/inflorescence) and increased the fruit set (11.6 / inflorescence) in mango.

Demonstration on biological suppression of pink mealy bugs, *M. hirsutus* on custard apple, grapes (2007-09)
Inoculative release of *C. montrouzieri* @ 2,500 beetles/ha found effective in suppressing the mealybug population (74%) with 36% increase in yield of marketable fruits of custard apple over farmer's practice. Release of *C. montrouzieri* @ 5,000 beetles/ha during off season (August) as well as two months after October pruning found effective in suppressing the mealybug infestation in grapevine orchards.

Survey and record of natural enemies of thrips on pomegranate and grapes (2008-09)
The natural enemies recorded on thrips were *Chrysoperla* sp. and *Mallada* sp. in pomegranate orchards in Solapur district, whereas no natural enemies were observed in grapevine yards.

Survey and record of incidence of papaya mealybug and its natural enemies on papaya and other alternate hosts (Tritrophic interaction) (2011-12)
The papaya mealybug, *P. marginatus* recorded first in Pune region of Maharashtra in July 2010. The pest was spread over six districts in western and central parts of the state. The pest incidence was recorded 55 to 90% during 2010-11 which was reduced up to 6 to 28% during 2011-12. Besides ten indigenous predatory species, the encyrtid parasitoid *Acerophagus papayae* was the first record from Pune region during August 2010. The mealybug species was recorded on 11 weed plants and 5 other alternate hosts including mulberry.

Field evaluation of *Trichogramma brassicae* against *Plutella xylostella* on cabbage (2007-09)
Five releases of *T. brassicae* @ 1 lakh/ha at weekly interval found significantly superior over farmer's practice in suppressing the larval population of *P. xylostella* with 51% parasitism and increased the yield of marketable cabbage heads (28.87 t/ha).

Potato tuber moth suppression by releasing *Copidosoma koehleri* (2007-09)
Inundative release of *C. koehleri* @ 5000 mummies/ha in four equal dosages at weekly interval by placing 3-4 mummies in each perforated plastic vials and hung 5 m apart in potato field found significantly effective over farmer's practice in reducing the PTM damage (5.05%) and increased the yield of marketable potato (200.4 q/ha).

Preliminary field evaluation of thelytokous *Trichogramma pretiosum* against *Helicoverpa armigera* on tomato (2009-12)
Six releases of *T. pretiosum* thalytokous @ 1 lakh/ha at weekly interval starting from 45 days after transplanting found significantly superior to arrhentokous strain as well as farmer's practice in reducing fruit damage (14.56%) due to *H. armigera* with 55.9% parasitism and increased the yield of marketable tomato (223.3 t/ha).

Validation of different BIPM modules against shoot and fruit borer, *Leucinodes orbonalis* in brinjal (2011-12)
The trial is conducted and harvesting of fruits is in progress.

Biological suppression of onion thrips, *Thrips tabaci* with predatory anthocorid and microbial agents (2011-12)
Three sprays of *M. anisopliae* @ 10^8 cfu/ml at 15 days interval (9.4 thrips/plant) and six releases of *Blaptostethus pallescens* @ 20 nymphs/m row at weekly interval (10 thrips/plant) found effective and next best to profenophos 0.05% in suppressing the thrips population in onion.

Biological suppression of white grubs on potato (2007-09)
The estimated LC_{50} values of local strains of *M. anisopliae* and *B. bassiana* against third instar grubs of *Holotrichia consanguinea* were 5.8 x 10^5 and 7.5 x 10^5 conidia/ml. The LT_{50} values for these fungal pathogens at 8 x 10^5 conidia/ml were 4.9 and 6.7 days, respectively. Soil application of *M. anisopliae* enriched FYM (2 x 10^{10} conidia/kg) @ 20 kg/plot at the time of planting of tubers found significantly effective and comparable with chemical insecticides in suppressing the white grub population as well as tuber damage (6.25%) with 48.5% mycosis and recorded maximum yield (26.5 t/ha).

Mass Production of *B. brongniartii* and *B. bassiana* using adult white grubs (MPKV, Kolhapur) (2007-09)
The trial was allotted to Entomology Section, College of Agriculture, Kolhapur for the white grub species *Leucopholis lepidophora* on voluntary basis, but it was not reported by the concerned scientist.

Evaluation of biological control agents against sucking pests of rose (2007-09) and chillies/capsicum under polyhouse conditions (2007-08)
Three sprays of *Hirsutella thompsonii* @ 10 g dust/lit found significantly effective in suppressing the mite population (*T. urticae*) and it was however, at par with *Verticillium lecanii* @ 10^{10} conidia/lit. The capsicum was not grown in polyhouse at this centre during 2007-08.

Evaluation of anthocorid predator, *Blaptostethus pallescens* against spider mites on rose and carnation in polyhouse (2007-11)
Four releases of anthocorid *B. pallescens* @ 20 nymphs/plant at weekly interval found effective in reducing mite (*T. urticae*) population on rose (28 mites/5 leaves/plant) as well as carnation (32.7 mites/flower bud) and it was next best to spraying of abamectin @ 0.3 ml/lit twice at fortnightly interval.

Evaluation of Biocontrol agents for management of sucking pests on rose / carnation in polyhouse (2009-11)
Amongst the fungal pathogens and anthocorid tested, three sprays of *H. thompsonii* @ 10 g formulated dust/lit found significantly superior in suppressing the mite population on rose (36.1

mites/5 leaves/plant) as well as carnation (5.0 mites/flower bud). It was followed by *V. lecanii* @ 10^8 cfu/ml.

Biological management of root-knot nematodes infesting tomato and carnation in polyhouse (2009-12)

Soil application of *Paecilomyces lilacinus* @ 20 kg dust/ha mixed with FYM found effective and ranked next best to carbofuran 3G @ 2 kg a.i./ha in declining RKN population in soil (41.1%) and reducing root gall index (25.5%) in carnation. The trial on tomato was conducted in field conditions. Soil application of carbofuran 3G @ 1 kg a.i./ha found statistically superior to fungal pathogens in reducing the RKN population in soil as well as root gall index and gave maximum yield of tomato (49.4 t/ha). However, *P. lilacinus* @ 20 kg/ha was on par with carbofuran in respect of reduction in gall index (28.7%) and yield (46.4 t/ha).

Biological management of root-knot nematodes infesting gerbera in polyhouse (2011-12)

Soil application of *Paecilomyces lilacinus* @ 20 kg dust/ha mixed with FYM found comparable with carbofuran 3G @ 1 kg a.i./ha in reducing the root gall index (30.1%) in gerbera. However, carbofuran was significantly superior treatment showing 61.1% decline in RKN population in soil.

Utilization of indigenous strains of *Anagyrus* spp. for the management of pink hibiscus mealybug, *Maconellicoccus hirsutus* on fruit and ornamental crops (2011-12)

The mealybug *M. hirsutus* colonies were collected from grapevine yards, guava, custard apple, citrus, sapota, pomegranate orchards as well as hibiscus, hollyhock and rose. The parasitoids *Triomata coccidivora, Anagyrus* sp. and unidentified species were recovered from the mealy bugs. But, the parasitoid (*Anagyrus*) failed to parasitize mealybug colonies maintained on red pumpkins in the laboratory.

Evaluation of anthocorid predators against storage pests in rice and wheat (2009-12)

Inoculative release of anthocorid *Xylocoris flavipes* @ 30 nymphs/10 kg stored rice / wheat was significantly superior in reducing the moth emergence of *Corcyra cephalonica* (11.2-18.6 moths/container). However, *B. pallescens* @ 30 nymphs/ 10 kg rice was the next best treatment to superior ones.

Establishment of mass production units (at all the AICRP centres)

Mass culturing of parasitoids (11), predators (4), microbial agents (4) and host insects (4) carried out in the laboratory. The bioagents were utilized for trials, demonstrations and distribution to farmers. The Trichocards (*Trichogramma* sp.), *C. blackburni, A. papayae, C. montrouzieri, Ha*NPV, *Sl*NPV, *N. rileyi* and *M. anisopliae* were mass cultured and demonstrated for their effectiveness on farmers' fields.

Enabling large scale adoption of proven biocontrol technologies-Bt Cotton (2009-10)

Large scale demonstration of BIPM practice in *Bt* cotton was conducted at village Morane, Dist. Dhule over 59 ha. The BIPM package found effective in suppressing the sucking pests as well as bollworm damage and increased the natural enemies (coccinellids, chrysopids) population and seed cotton yield. There was 25.35% increase in net return from BIPM package over farmer's practice with 1: 1.96 ICBR.

Demonstration of temperature tolerant strain of *Trichogramma chilonis* against early shoot borer in *Suru* planting of sugarcane (2011-12)

Demonstration on effectiveness of temperature tolerant strain (TTS) of *T. chilonis* against early shoot borer on sugarcane conducted during *rabi*-summer 2012 over 1 ha. The treatment applications and recording of observations are in progress.

Production, process, technologies developed

Standardized mass production technique of predator *Dipha aphidivora* on sugarcane woolly aphids (SWA) under shade net conditions.

Standardized field release technique of parasitoid, *Copidosoma koehleri* against potato tuber moth (PTM) under field conditions.

Standardized mass multiplication of parasitoid, *Acerophagus papayae* against papaya mealybug.

Mass production of *Nomuraea rileyi* for the control of *Spodoptera litura* Fab. on soybean and potato

Mass production of *Metarhizium anisopliae* against sucking pests

Infrastructure and physical facilities developed by the centre in last five years.

A well equipped new biological control laboratory has been established for mass multiplication of bicontrol agents.

Laboratory equipments worth of Rs. 33 lakhs are purchased during 2008-12.

3

Human resource development efforts in the last five years

Dr. D. S. Pokharkar and Dr. R. V. Nakat attended training programme for mass production techniques of *Acerophagus papayae*, a parasitoid of papaya mealybug at NBAII, Bangalore on September 6-8, 2010.

Shri. N. D. Tamboli attended two days training on Techniques in fermenter technology at MPKV, Rahuri on December 30-31, 2009.

Model Training Course on Mass multiplication of biopesticides and bioagents' organized at the Department of Entomology, MPKV, Rahuri and financed by Directorate of Extension, GOI, New Delhi held during December 13-20, 2011. Dr. D. S. Pokharkar and Dr. R. V. Nakat delivered lectures and conducted practicals for the trainees (30) from the Department of Agriculture, Maharashtra State.

Publications

Research articles published in journals	- 10
Research papers presented in symposium/workshops	- 11
Popular articles including extension bulletins	- 5

Best publication

Kulye, M. S. and Pokharkar, D. S. 2009. Evaluation of two species of entomopathogenic fungi against white grub, *Holotrichia consanguinea* (Blanchard) infesting potato, *Solanum tuberosum* (Linn.) in Maharashtra. *J. Biol. Control*, 23 (1): 1-4.

Observations of the QRT

i. The QRT appreciates the active role played by the centre in the classical biological control of papaya mealybug.
ii. The centre had conducted 38 experiments out of 40 allotted.
iii. The centre has contributed immensely on biological suppression of potato tuber moth, sugarcane woolly aphid earlier and papaya mealybug now.
iv. Biological control of potato tuber moth in the field and storage through the release of *Copidosoma koehleri* is a notable contribution of the centre. But it is heartening to note that the culture of *C. koehleri* is lost at the centre.

Recommendations of the QRT

1. Efforts should be made to recover the parasitoid *Copidosoma koehleri* from the field and again build up the culture for future studies.
2. The impact of application of persistent pesticides like phorate on the incidence of insect pests and their natural enemies should be documented in sugarcane/rice or any other crop where phorate is applied.
3. Economic analysis and documentation of impact of release of *Acerophagous papayae* on papaya production, seed production and papain industry along with savings in cost of insecticide and their application should be done.
4. While recording natural enemies, the scientific names of pests should be mentioned instead of common names.
5. There is a need to generate data on the effect of release of natural enemies on the reduction of incidence of sugarcane woolly aphid.
6. The yield levels in BIPM treatments are either on par or less than pesticide treatments. The biocontrol treatment has to be promoted as it reduces the pesticide load in the environment and the harmful effects of pesticides are eliminated.
7. The centre has to initiate biocontrol of whitegrubs in sugarcane in Maharashtra.
8. The centre has to document the occurrence of citrus black fly in Maharashtra.

Overall assessment

Very Good

10. Govind Ballabh Pant University of Agricultural Science & Technology, Pantnagar

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-12)
Not reported

***In vitro* and Green house testing, screening of available isolates of antagonists for their tolerance to abiotic stresses (i.e. cold, drought, salinity) under *in vitro* condition and their performance under rain-fed conditions of hills and plains (normal & *Usar* soils) (2007-12)**
99 *Trichoderma* isolates (Th-1 to Th-99), screened out in vitro and in vivo for their tolerance to abiotic stress. Ten isolates selected as stress tolerant as they induced stress tolerance in plants by altering physiological and biochemical parameters. Salinity tolerant- Th-13, Th-14, Th-19, Th-33 and Th-55. Drought tolerant – Th-56, Th-62, Th-75, Th-82 and Th-89

Field evaluation of promising strains under rain-fed conditions (2007-12)

Twenty isolates of *T. harzianum* tested in different crops.

Rice: Non-significant effect on growth and yield poarameters of rice (cv.Kalanamak) under field conditions was observed. However, maximum yield was obtained with Th-82 (44.33 q/h) followed by Th-39 (44. 17 q/h) as compared to control (38.92 q/h). All the isolates significantly reduced the incidence of neck blast, sheath blight, brown spot and sheath rot diseases. However Th-56, Th-3 and Th-5 were found best in suppressing stem borer, grasshopper and leaf folder respectively.

Lentil: Significantly least mortality was recorded with Th-56 (2.2%) followed by Th-55 and Th-45 (3.3%) over control (30.0%) at 60 DAS. Significantly highest grain yield (q/h) was recorded in T-14 (12.05) followed by T-55 (11.06) and Th-45 (10.99) as compared to control (7.06).

Chickpea: Significantly least mortality was recorded with Th-56 (4.43%) followed by Th-55 and Th-39 (5.33%) over control (44.33%) at 60 DAS. Significantly highest grain yield (q/h) was recorded in Th-14 (23.26) followed by isolates Th-55 (22.88), Th-1 (22.33) and Th-39 (22.22) as compared to control (12.6).

Wheat: Maximum per cent increase in germination was observed in Th-82 (29.6%) followed by Th-39 (29.4%) over control. Significantly maximum grain yield (q/h) was observed in Th-56 (16.4) followed by Th-67 (14.7) and Th-39 (14.53) as compared to control (10.8).

Large scale field demonstration of biocontrol technologies in field (2007-12)

Demonstrations in plains

Rice: Area 2170 acre. *Trichoderma harzianum* and *Pseudomonas fluorescens* effectively suppressed both BLB and stem borers in organically cultivated rice. The average yield of organically cultivated rice was 30.0 q/ha as compared to farmer's practice (35q/ha) under non-organic cultivation. The organically cultivated rice fetched a price of Rs 2600.0/q which on an average was higher by Rs. 600.0/q when compared to conventionally grown crop. The major diseases encountered were bacterial leaf blight brown plant hopper and stem borer, which caused heavy damage to the rice crop.

Pea: Area 100acre. An increase yield of 40% was recorded in bio agents treated plots (87. 5q/ha) as compared to farmer's practice (62.5q/ha). The major diseases encountered were *Rhizoctonia* root rot and *Fusarium* wilt complex.

Tomato: Area 100 acre. An increase in yield of 27.8% was recorded in bioagents treated plots (225.5 q/ha) as compared to farmer's practice (176.4 q/ha). Crop was mainly affected by late blight, bacterial wilt, fruit rot and fruit fly.

Demonstrations in hills.

Capsicum: Area 10 acre. An increase in yield of 33.2% was recorded in bio agents treated plots (77.5 q/ha) as compared to farmer's practice (176.4 q/ha). Crop was mainly affected by late blight, bacterial Root rot, bacterial wilt, cut worm, aphid and thrips.

Brinjal: Area 5 acre. An increase in yield of 4.7% was recorded in bioagents treated plots (291.9q/ha). As compared to farmer's practice (278.8q/ha) Crop was mainly affected by Root rot and fruit borer.

Cabbage: Area 5 acre. An increase in yield of 23.8% was recorded in bioagents treated plots (220.1 q/ha) as compared to farmer's practice (178.4 q/ha). Crop was mainly affected Alteraria leaf spot.

Isolation and identification of the potential biocontrol agents (especially yeasts) for the management of post harvest losses (2007-11)

A total of 765 *Trichoderma* isolates (PBAT-1 to 46 and PB-1 to PB-30) and 31 Pseudomonas (PBAP-1 to PBAP-3) 1 have been isolated and identified from different farming situation of Uttarakhand and some of potential isolates have been chosen for their different bio control activities including post harvest losses. All the non-chemical treatments along with pre-harvest spray of mixed formulation of *Trichoderma* (PBAT-43) and *Pseodomonas* (PBAP-27 and post harvest dip in suspension of *P. fluorescens* were effective in suppressing post harvest rotting in mango cv. Dashehri, however ineffective in controlling post harvest decay in litchi, guava and papaya.

Introduction of new antagonists in a consortium formulation of biocontrol and biofertilizer agents (GBPUA&T)

The screening of the 10 isolates of *Trichoderma* revealed that Th-56 and Th-19 were most compatible with PBB-4 isolate of *B. bassiana*, while Th-1, and Th-75 were not found compatible with PBB-4 isolates of *B. bassiana* as *Trichoderma* isolates did not allow B. bassiana to grow along with it.

Impact assessment of biocontrol technologies transferred to the farmers of Uttarakhand through AICRP on Biological control (GBPUA&T)

Developed five commercial formulations of bio-agents viz., pant Bio-control Agent-(*T. harzianum* PBAT-43), Pant Bio-control Agent 2 (*P. fluorescens* PBAP-27), Pant Bio-control Agent-3 (*T. harzianum* PBAT-43 + *P. fluorescens* PBAP-27) Pant Bio-control gent -4 (*P. fluorescens* PBAP-1) and supplied 3.5 ton formulation of these antagonist to the members of Tarai Organic Fameres Association along with several other farmers including members of *Swatantrata Sangram Sainanin jaivika Krishi Samiti* and members of *Rishi Parashar Jaivik Krishi Shodh Samiti* from district Udham Singh Nagar for cultivation of rice under organic farming. Presently more that 1000 farmers of Utarakhand (hills and plains) and UP have been using PBAT-1, 2 and 3 for the management of plant diseases and improvement of soil and crop health under organic farming and IDM/IPM programme since last five years. In tomato, IPM module have been used by the farmers f *Golapar-Chorgalia,*
Haldwani, Uttarakhand for growing tomatoes which is known to be one of the biggest producers of hybrid tomato. Presently we are producing 12-15 quintal/month antagonistic products as per demands for research and farmers.
Developed Technology for mass multiplication of *Trichoderma harzianum* and *Pseudomonas fluorescens* on cow dung, FYM and vermin-compost at farmers field which were found very effective in decomposing organic matter and improving soil fertility along with soil health. The mass multiplication technology of *Pseudomonas fluorescens* on cow dung has been patented.
Seed bio-priming is now being recommended by GBPUAT, Pantnagar and Government of Uttaranchal as general agricultural technology to be followed by all the farmers irrespective of crop. Presently it is being followed by a large number of farmers both in hills and plains.

Development of oil based formulations of selected isolates of Trichoderma harzianum and study of their shelf life (2011-12)

Among various formulation (groundnut oil, paraffin oil and talcum powder) of selected *Trichoderma* isolates, groundnut formulation was found to be best as it showed maximum CFU/ml (6.78-12.69 $x10^9$) , even after 4 months. Among various *Trichoderma* isolates, Th-14 (12.69-32.00 $x10^9$) was found best in terms of the viability. The experiment is under progress.

Field evaluation of invert-emulsion formulations of *T. harzianum* for the management of foliar and soil borne diseases of chickpea (2011-12)

The study on the effect of various treatments revealed that carbendazim was found best to increase germination percentage and in increasing shoot and root length Minimum wilt incidendence was observed in talc. Maximum rhizosphere and rhizoplane population (90 DAS) was observed in invert emulsion (17.40 $x10^3$ & 27.42 x 10^4). The treatment viz. carbendazim, talc and invert emulsion were at par with each other. The yield data will be done in the last week of April after harvesting the crop.

Preliminary evaluation/ screening of EPN against YSB, striped borer and leaf folder in rice (2009-11)

Not reported

Biological management of root-knot nematodes infesting tomato/ carnation in polyhouses (2009-12)

Not reported

Surveillance for alien invasive pests in vulnerable areas (all centers) (2011-12)

The study on the effect of various treatments revealed that carbendazim was found best to increase germination percentage and in increasing shoot and root length Minimum wilt incidendence was observed in talc. Maximum rhizosphere and rhizoplane population (90 DAS) was observed in invert emulsion (17.40 $x10^3$ & 27.42 x 10^4). The treatment viz. carbendazim, talc and invert emulsion were at par with each other. The yield data will be done in the last week of April after harvesting the crop.

Surveillance and monitoring for the mealybugs (2011-12)

Not reported

Production, process and technologies developed

Isolated, identified and formulated salinity tolerant, drought tolerant strains of Trichoderma harzianum.

Successfully field demonstrated the biological control of plant diseases through the application of *Trichoderma harzianum* in rice, lentil, chickpea and wheat.

Developed five commercial formulations of *T.harzianum* (PBAT-43), *P. fluorescens* (PBAP-27), *T. harzianum* & *P. fluorescens* (PBAT-43 +PBAP-27), *P. fluorescens* (PBAP-2 +3), *Beauveria bassiana* (PBB-1) and supplied 3.5 ton formulation to Tarai organic farmers' association.

Infrastructure developed

Plant pathology laboratory was renovated and well equipped for conducting laboratory screening work.

Human resource development activities

The scientists working under this project attended several workshops/ conferences/ symposiums to get first hand information and knowledge in the area of their research.

Publications

Research articles published in journals	- 17
Research papers presented in symposium/workshop	-9
Patent filed	-1
Book chapters	-3
Popular articles	-5

Best publication

Sharma, K. K., Zaidi, N. W., Pundhir, V. S. and Singh, U. S. 2010. Study of genetic diversity in Rhizospheric *Trichoderma* isolates from Uttarkhand. *Annals of Plant Protection*, 18(2): 204-210.

Observations of the QRT

i. The entomological experiments are either not conducted at the centre or have not been reported.
ii. The basic and applied research on biological control of seed and soil borne plant diseases through use of antagonists was the priority area of research of this centre which has made significant contributions in identifying and developing formulations of *T. harzianum* and *P. fluorescens*.
iii. The centre has given adequate attention to transfer of relevant technologies particularly on organic farming which is in practice in a limited scale in Uttaranchal.
iv. QRT appreciates the quality of work undertaken and useful information generated by the centre on biological control of plant diseases.

Recommendations of the QRT

1. Efforts should be made to assess the performance of *Trichoderma* spp. in acid soils.
2. Proven Isolates of *Trichoderma*, *Paecilomyces* and *Bauveria* developed at this centre should be provided to other AICRP centres for multi-location trials.

Overall assessment

Very Good

11. Indian Institute of Horticultural Research, Bangalore

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-2012)
Regular surveys are conducted for collecting the different species.

Evaluation of biological control agents against mango hoppers (2007-2009)
Initial field evaluation of *Metarhizium. anisopliae* @1x10^7 and *Verticillium lecanii* @1x10^9 spores /ml was carried out against mango hoppers at IIHR farm in variety Alphonso. Off-season spraying of the entomopathogens *M. anisopliae* and *V. lecanii* @ 1x10^7 and 1x10^9 spores / ml, respectively twice at weekly intervals and spraying at flowering indicated very low population

of hoppers. However, based on subsequent evaluation, *M. anisopliae* at $1x10^9$ spores / ml was very effective. *Metarhizium anisopliae* @ $1x10^9$ spores/ml with oil and sticker caused a mean of 51% mortality. Addition of UV protectant increased the mortlality to 64. 61%. Both the treatments however were at par to each other and significant to control.

Field evaluation of *M. anisopliae* formulation against mango hoppers (2011-12).
A field demonstration on 780 mango plants at Mother India Farm, Dharmapuri District, Tamil Nadu, with three sprays of *Metarhizium anisopliae* @ $1x10^9$ spores/ml at five days interval revealed that the hopper population in *M. anisopliae* treated trees had a mean of 5.4 hoppers as against 62.6 hoppers in the control. Since last year results were promising at all the places like TNAU, Coimbatore and MPKV, Rahuri, besides IIHR, Bangalore where efficacy of the pathogen was evaluated against mango hopper.

Biological control of papaya mealybug, *Paracoccus marginatus* (2009-2012)
The exotic parasitoid *Acerophagous papaya* was inoculatively released in 11 farmers' field where the mealybug infestation ranged from 8% to 69.49%. The parasitoid readily established in all the orchards and complete control of the pest was achieved within 3-4 months of release. The parasitoid later on found established in the region and offered continued control of exotic mealybug.

Survey and record of incidence of papaya mealybug and its natural enemies on papaya and other alternate hosts (Tritrophic interaction) (2011-12).
During survey for collection of natural enemies of papaya mealybug, *Paracoccus marginatus*, only a lepidopteran predator, *Spalgis epius* was predominantly found preying on the mealybug. No local parasitoid was found parasitizing the mealybug.

Evaluation of *Beauvria bassiana* (IIHR isolate) against ta mosquito bug in guava (2011-2012).
A field experiment, to compare the efficacy of new molecules, botanical formulations and bioagent, *Beauveria bassiana*, was conducted. Observations were recorded on the healthy and damaged fruits on trees treated with above treatments. From the 2^{nd} week of spraying, fruit damage was reduced considerably on plants treated with lamda–cyhalothrin, acetamiprid and *B. bassiana* (IIHR strain), whereas there was no significant reduction of fruit damage in plants treated with botanicals and *B. bassiana* (PCI) compared to control.

Utilization of indigenous strains of *Anagyrus* spp., for the management of pink hibiscus mealybug, *Maconellicoccus hirsutus* on fruit and ornamental crops (2011-12).
Angyrus dactylopii was field collected and reared on pink mealybug. As there was no incidence of pink mealybug on grapes, the parasitoid was not released.

Evaluation of *Trichogramma brassicae, B. bassiana* and *S. carpocapsae* against lepidopterous pests of cruciferous crops (cabbage) (2007-2009)
A mean larval population of 9.3 per plant was recorded in DOR Bt as against 17.9 in *B. bassiana* and 12.6 in *S. carpocapsae*. Whereas the egg parasitoid release and egg parasitoid + Bt sprayed plots had less than 1 larva per plant.

Preliminary field evaluation of thelytokous *Trichogramma pretiosum* against *Helicoverpa armigera* of tomato (2009-2012)

Trichogramma pretiosum thelytokous and arrhenotokous were evaluated on tomato against fruit borer *Helicoverpa armigera*. The per cent parasitism in the field initially was 13 % and 10% in the case of thelytokous and arrhenotokous strains, respectively. The parasitism level gradually increased to 55% for thelytokous while it was 32% in arrhenotokous during the same period. The fruit borer damage was 2.77 % and 4.43% in thelytokous and arrhenotokous strains, respectively as against 12.69% in the control during 2009-10.

Demonstration of biological control of DBM and other lepidopteran pests on cabbage (2009-2012)

Potential of biocontrol agents such as egg parasitoids, *Trichogrammatoidea bactrae* and *Trichogramma brassicae* were evaluated under field conditions with Bt, trap crop, etc during the period under report. Egg parasitoids with two sprays of Bt gave excellent control of DBM. The DBM larval population in biocontrol treated fields were less than 1 larva/ plan as against up to 5 lavae / plant in control.

Farmer participatory demonstration of bio-control based IPM for important pests of brinjal (2009-2012)

Farmer's participattary field demonstration on biocontrol based IPM for important pests of brinjal carried out on three varieties of brinjal namely Black star (Indo American Hybrid), Green long PHP009 and Purple round & white stripe (Manjarigota type) (Mahyco) with following treatment. BIPM module (erection of pheromone trap @1 /400 sq.m. + weekly release of egg parasitoid *Trichogramma chilonis* @50,000 adults/ha + two sprays of Bt formulations @ 1m/l at 10 days interval with 50 % flowering. The borer damage was 1.16. 3.42 and 2.29 on Black star, Green long PHP009 and Purple round & white stripe, respectively as against 30-57% damage in control.

Monitoring biodiversity and out breaks for invasive mealybugs on horticultural crops (2009-2012)

Monitoring biodiversity and out breaks for invasive mealybugs on horticultural crops was continuously carried out. However during the period under report no invasive mealybug was observed on horticultural crops.

Enabling large scale adoption of proven biocontrol technologies – Brinjal (2009-2012)

Awareness has been created among farmers about the usefulness of biocontrol agents in effectively controlling the shoot and fruit borer of brinjal. Efforts are made to demonstrate the technique on large scale during 2012- 14.

Validation of different BIPM modules against shoot land fruit borer, *Leucinodes orbonalis* (2011-2012)

The experiment was carried out in exploded block design on Arka Anand with the following treatments**:**

BIPM module (erection of pheromone trap @1 /400 sq.m. + weekly release of egg parasitoid *Trichogramma chilonis* @50,000 adults/hac+ twp sprays of Bt formulations @ 1m/l at 10 days interval with 50 % flowering) Botanicals + chemicals (application of Neem cake @ 250kg/ha in pots+ spraying of Neem soap @ 10g/L+ cymermethrin alternated with neem soap + endosulfan at fortnightly intervals) Check spraying of Coragen at fortnightly intervals and Control –no spray. BIPM treatment recorded a mean of 6.59% fruit bored at harvest, followed by 8.46 and 8.85 in

check and IPM treatments respectively. Control recorded 31 per cent fruit borer. A corresponding increase in yield was also recorded. BIPM recorded 45 t/ha followed by 42, 38 in IPM and check while control recorded 31 t/ha.

Biological suppression of onion thrips, *Thrips tabaci* with predatory anthocorid and microbial agents (2011-12).

Confirmatory trail was conducted on var. Arka Niketan with three different entomopathogens, predator *Blaptostethus pallescens* @2 /plant. Since the pest incidence was very low, the study was could not be concluded.

Surveillance for alien invasive pests in vulnerable areas (all centers) (2011-12)

Surveillance for alien invasive pests was periodically conducted and found no invasiveness of any pest on horticultural crops during 2011-12.

Surveillance and monitoring for the mealybugs (2011-12)

The mealybug occurrence on several horticultural crops were monitored and found that the incidence was found generally less during the period under report.

Production, process, technologies developed

Three entomopathogens were isolated from thrips, mango hoppers and tea mosquito bug were evaluated and found to have potential for commercialization. Efforts were made to generate toxicological data for these organisms before commercialization.

Infrastructure and physical facilities developed: Nil

Human resource development efforts

The scientists working under this project attended several conferences, symposium and workshops to update themselves in the area of biological control.

Best publication

Mani, M., Ganga Visalakshy, P. N., Krishnamoorthy A.and Venugopalan, R 2008. Role of *Coccophagus* sp. in the suppression of the soft green scale *Coccus viridis* (Green) (Hompoptera: Coccidae) on sapota *Biocontrol Sci. Tech.*, 18**:** 7,721- 725.

Observations of the QRT

i. No funding was provided to this centre as it is an ICAR institute based centre.
ii. Off season application of *Metarhizium anisopliae* appeared to be promising for the management of mango leafhoppers.
iii. The centre had taken pro-active role in the classical biological control of papaya mealybug.
iv. The BIPM module was found promising for the management of brinjal fruit borer.
v. The thelytokous *Trichogramma pretiosum* performed better than arrenotokous against *Helicoverpa armigera* of tomato.

Recommendations of the QRT

1. The institute is working on 43 horticultural crops whereas the biocontrol work is restricted to only a few crops and the centre should take up more responsibility.
2. The centre should identify hot spots of major insect pests of important horticultural crops in the country and their natural enemies for further exploitation.
3. The centre should initiate biocontrol work which can address the ecological dimensions, parasitoids: prey relationships, numerical responses that add meaning to the success or failure.
4. The centre should provide leadership to temperate horticulture where there is lack of human resource on natural enemies of these crops.
5. Should prepare a list of potential invasive of horticultural crops and their natural enemies for the benefit of others.
6. The centre should concentrate on biological control of red spider mite in polyhouse cultivation and biological control of onion thrips.

Overall assessment

Good

12. Sugarcane Breeding Institute, Coimbatore

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-12)
Not reported

Demonstration on use of bioagents for management of sugarcane woolly aphid (2007-2008)
Not conducted

Development of IPM strategies for sugarcane woolly aphid (2007-2008)
Not conducted

To study the influence of plant structural complexity on the behaviour of *T. chilonis* (2007-2011)
Choice of plants for parasitization based on plant architecture was studied on sugarcane at different age up to 210 days were compared with flowering /maturity stage of cotton, tomato, soybean, finger millet, pearl millet, sorghum and maize. Results indicated that the monocots fared better than the dicots with increased parasitization efficacy.
The choice of plant species (in combinations of two or three crop species) were conducted at the crop age of 45 days and 60 days. In one set, the plants were not covered and in the other the plants were caged. Sugarcane, cotton, tomato, soybean, pearl millet, finger millet, sorghum and maize were used. Contrary to the multiple choice increased parasitism was observed on all crops in two choices. When the plants were not covered, lower parasitism was observed on all crops.

To study the kairomonal effect of host pheromone on *T. chilonis* (2007-2008)
The per cent parasitoids responding to the olfactory cues, namely, the hexane-washings of eggs, scales, adult body and pheromone lures of *Chilo infuscatellus* Snellen and *Chilo sacchariphagus indicus* (Kapur) was assessed (in comparison to *C. cephalonica)* in no choice and dual-choice

bioassays in a "Y"-tube olfactometer washing were used. The results indicated attraction of *T. chilonis* to volatiles from washings of all host sources at different levels with highest per cent parasitoids attracted to *C. sacchariphagus indicus* egg washings. Overlapping significant levels of attraction was found with the scale and adult body washings of fresh mated moths of all three species in no-choice tests, while C. *sacchariphagus indicus* was the most preferred in dual-choice tests. Volatiles from male moths were more attractive to *T. chilonis* than those from female moths. The parasitoids failed to respond to the body washings of >72h old moths of all the three species. Attraction of *T. chilonis* to the synthetic sex pheromone lures of two native hosts was observed but the parasitoid did not discriminate between them.

Field evaluation of *T. chilonis* in combination with pheromones (2007-2008)

In the field trials conducted to evaluate *T. chilonis* Ishii and pheromone, either alone or in combination, showed that in terms of per cent incidence, per cent intensity, number of internodes per cane, yield and cost benefit ratio, the parasitoid was the best in INB management. Combination of two technologies neither suppressed the pest more nor resulted in additional benefits. Utilization of *T. chilonis* resulted in the highest cost: benefit ratio of 1:11.2 while it was 1:2.9 for both pheromone alone and combination of *T. chilonis* + pheromone. The overall performance of pheromone when used alone was inferior to *T. chilonis* as well as the combination of *T. chilonis* and pheromone and inconsistent in management of *Chilo sacchariphagus indicus*.

To standardize group rearing of the host for mass production of GV of *C. infuscatellus* (2007-11)

Rearing of larvae in ambient condition does not yield uniform stage of the larvae. Influence of the temperature and humidity leads to a wide variation in the larval growth and larval harvest for viral inoculation. Controlled rearing conditions are required. Flat box studies revealed 30% of larval recovery but the larval growth was better. Single vial inoculations gave more than 80% recovery of larvae.

To collect GV isolates from different factory zones and assess the virulence of GV isolates on *Chilo infuscatellus* (2007-11)

Bioassays with the viral isolates from Assam, Gujarat, Karnal, KCP sugars, Sakthi, Coimbatore, Dharani, Saraswathi and Harinagar against various instars have been completed and overlapping fiducial limits of the low LC50 values of many of the isolates indicated uniform high virulence against II and III instars larvae. However there were marked differences in the virulence of the isolates when tested against IV instar in the mortality as well as sub-lethal effects.

Evaluation of *T. chilonis* against sugarcane internode borer (2008-9)

Four field trials were conducted to assess the efficacy of weekly releases of *T. chilonis* at double the recommended dose *i.e.* 50,000/ha (2.5 cc/ha), 5 cc/ha and higher dose 12.5 cc/ha for managing the internode borer (INB), *Chilo sacchariphagus indicus* (Kapur). Results indicated that there was a significant reduction in incidence and intensity of INB damage resulting in significantly higher yields in parasitoid-released plots over control plots. Releases at 12.5 cc/ha resulted in the highest reduction of INB incidence (29.95%) and intensity of damage (29.41%) over control plots. Yields were consistently higher in parasitoid-released plots with 13.29 to 25.89% increase over control plots. The pooled cost benefit analysis showed that releases at 5 cc/ha was more gainful (1: 6.5) than 12.5 cc/ha (1:2.4).

Survey and surveillance of sugarcane woolly aphid and its major natural enemies(2008-2009) Not conducted

Evaluation of *Metarhizium anisopliae* and EPNs against termites (2008-2009)
Not conducted

Production, process, technologies developed

Developed *Trichogramma chilonis* release package for INB management in sugarcane.
Developed Granulosis Virus (GV) production technology using diet-reared shoot borer larvae.

Infrastructure and physical facilities developed: Nil

Human resource development efforts:

Guided 5 M. Sc Students on biological control experiments.

Best publication

Geetha, N., Esther, D., Shekinah, and Rakkiyappan, P., 2009. Comparative impact of release frequency of *Trichogramma chilonis* Ishii against *Chilo sacchariphagus indicus* (Kapur) in sugarcane. *J. Biol. Control*, 23(4): 343–351.

Observations of the QRT

i. No funding was provided to this centre as it is an ICAR institute based centre.
ii. The PI did not attend QRT review meeting at Bangalore in spite of request letter by the member secretary.
iii. The Director of SBI, Coimbatore had mentioned that the Institute/Centre did not have any research experiments under AICRP on biological control.

Recommendations of the QRT

1. Since SBI, Coimbatore did not conduct the allotted research programmes, there is no justification in continuing this centre, and QRT recommends for the discontinuation of this centre.

Overall assessment

Average (The centre is recommended for closure)

13. Indian Institute of Sugarcane Research, Lucknow

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-2012)
Sugarcane adapted *Trichogramma chilonis* emerged from interned borer eggs and *Stenobracon* spp. the larval parasitoid of top borer was sent to NBAII for identification.

Bio-intensive management of stalk borer, *Chilo auricilius* Dudgeon and internode borer, *Chilo sacchariphagus indicus* (Kapur) (2007-2009)
Eight release of *T. chilonis* @ 50,000/ha @ 10 days interval from July to October recorded lowest 5.62 per cent incidence of internode borer at harvest compared to 12.71 in control. Release of *Cotesia flavipes* @ 500 adults/ha or *Tetrastichus howardi* @ 5000 adults/ha or combined release of all the three did not reduce internode borer incidence below 5.62%. Eight releases of *Cotesia flavipes* @500.ha from July to October at 7 days interval recorded lowest stalk borer incidence of 5.55% at harvest compared to 17.24 in control.

Evaluation of EPNs against termites (2007-2009)
Single application of *Heterorhabditis indica* PDBC EN 13.31 at 2.5 b/ha and 5 b/ha or *Steinernema crpocapsae* PDBC EN 11 @ 2.5b/ha and 5 b/ha failed to control termite in sugarcane.

Evaluation of *Metarhizium anisopliae* against termites (2009-2012)
The germination percent was 23.33 in chlorpyriphos (20EC @1 kg a.i./ha) treatment followed by 18.22 in FYM enriched with *Metarhizium anisopliae* strain 4 containing 10^{10} conidia/m^2 where as in control it was 13.82%. During May, the cane damage was 8.98% in chlorpyriphos treatment followed by *M. anisopliae* (strain 3) 10.73%. There was significant difference in cane damage at harvest between treatments.

Surveillance for alien invasive pests in vulnerable areas (all centers) (2011-12)
No report

Surveillance and monitoring for the mealybugs (2011-12)
No report

Production, process and technologies developed: Nil

Successfully introduction, establishment and colonization of *Epiricania melanoleuca* against *Pyrilla perpusilla* in Ahmednagar (MS).

Infrastructure and other facilities developed: Nil

Human resource development activities: Nil

Publications

Research articles published in journals - 5
Research papers presented in symposium - 2

Best Publication

Srivastava, D. C., Baitha, A. and Singh, M. R. 2012. Natural parasitisation and incidence of sugarcane top borer, *Scripophaga excerptalis* Walker. *Sugarcane International.*

Observations of the QRT

i. No funding was provided to this centre as it is an ICAR institute based centre.
ii. Out of six experiments allotted, the centre had conducted only four experiments.
iii. The progress in these three experiments is not satisfactory as the experiments were conducted only once, though they were in operation for three years.
iv. The pest incidence was very low in the field experiments which do not give proper analysis of the biocontrol treatments.
v. In all the cases the chemical treatment appeared to be the best compared to the biological control treatments.
vi. The PI informed that the number of staff strength at the Entomology Department, IISR had come down drastically and most of them are engaged in other Institute activities and with meager staff it is not possible to carry out the technical programme allotted to the centre.
vii. No separate funding is provided for meeting the expenditure in conducting the field experiments, hence the centre is unable to conduct the field experiments.
viii. No economic analysis of the treatments or cost: benefit ratio of the best treatment is not done.

Suggestions/ Comments of the QRT

1. As per the guidelines ICAR based centres will not be given any funds for AICRP work. The AICRP work expenditure to be met out Institute grants.
2. Since the staff strength is dwindling and the PI has already indicated that with the meager staff, it is not possible to conduct the field experiments.
3. Though the Institute is working on one crop, large demonstration trial was not conducted by the centre on sugarcane.
4. In the absence of adequate staff and funding, there is no justification for the continuation of this centre in the XII plan.

Overall assessment

Average (The centre is recommended for closure)

14. Central Tobacco Research Institute, Rajahmundry

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-12) Local strains of *Bemisia tabaci, Myzus nicotianae* and *Plutella xylostella* were sent to NBAII for identification and characterization.

Studies on the influence of water quality on the efficacy of entomopathogens against tobacco pests. (2007-2012)
It was concluded that water solutions of *Sl* NPV with p^H ranging from 6-8 and E.C.0.5 dS/m to 6 dS/m can be used for control of *S. litura* It was concluded that B.t.*k.* can be sprayed in a aqueous solution with E.C. ranging from 0.5 to 6.0 dS/m and p^H 7 for effective suppression of *S. litura* in

tobacco nursery. It was concluded that application of *B. bassiana* at pH 7 to pH 8 and 0.5 dS/m was effective in minimizing the incidence of *S. litura* in tobacco nurseries.

Comparative study of virulence of different isolates of *Spodoptera litura* NPV in tobacco, soybean and chilly ecosystem. (2007-2009)
At a dose of 1.5 x 10^{12} PIB/ha, *Sl* NPV strains from Rajahmundry, Jeelugumilli and Jeddangi were equally effective in suppressing green leaf damage to tobacco

Comparative study of performance of different isolates of *H. armigera* NPV from coastal A.P. (2009-2012)
Ha NPV isolates @ 1.5 x10^{12} PIB/ha from NBAII and Rajahmundry were effective in suppressing *Helivocerpa armigera* damage to tobacco crop in laboratory and field.

Studies on Biological control options for suppression of tobacco stem borer *Scrobipalpa heliopa* Low (Lepidoptera, Gelichidae) (2007-2009)
In pot culture studies *B.t* (PDBC) strain @1:10 and 1:100 dilutions could bring about mortality of larvae in stem from 53.6 and 37.81 percent respectively. However gall formation was not affected by larval mortality. *Telenomus remus* did not develop on stem borer eggs.

Studies on the performance of *B. bassiana* and Pseudomonas fluorescens as endophytyic microbes in suppression of tobacco stem borer *Scrobipalpa helipoa* (2009-2012)
B. bassiana @ 10 ^{8} spores per ml or g , as seed dressing , spray, soil application and all the treatments combined is not effective in suppressing the stem borer infestation.

Standardization of mass multiplication of *Spodoptera exigua* and SeNPV (2007-2009)
Biological parameters were highly favourable for mass multiplication of *S. exigua and Se NPV* on *Amaranthus viridis* and *Boerhavia diffusa*, besides burley tobacco seedlings.

Popularization of Biocontrol Techniques in farmers' fields (2007-2009)
Training programmes were conducted in farmers' fields in collaboration with the Tobacco Board on IPM and use of bioagents.

Development of software and field manuals for identification and utilization of bioagents for alternative cropping systems to tobacco (2009-2012)
Development of an expert system for identification of biological control agents of tobacco pests is in progress. Graphical user interface was created in Visual Basic was developed.

Isolation and identification of indigenous pathogens of tobacco stem borer and their utilization along with other pathogens for suppression of tobacco stem borer (2011-12)
In field collections of stem borer larvae from FCV, burley and lanka tobacco did not yield any pathogens.

Influence of cropping rotations and tillage operations in tobacco on the diversity of plant and soil dwelling faunal assemblages (2011-12)
In soybean and maize ecosystems, Homoptera/ Hemiptera, Coleoptera and Arachinida in the recommended tillage plots showed higher diversity values. In case of Hymenoptera and Lepidoptera minimum tillage plots carried better diversity as indicated by Shannon-weiner index. In case of soil dwelling fauna also minimum tillage plots showed higher diversity index compared to recommended tillage plots in soybean, maize or tobacco ecosystems.

Production, process and technologies developed

Tobacco farmers adapting boarder crop of castor for *S. litura* and marigold for *H. armigera* management.
Sl NPV was produced and supplied to tobacco farmers

Infrastructure and other facilities developed

Human resource developmental activities

Dr. Gunneswara Rao participated in biocontrol workers group meeting and national symposium on tobacco.

Publications

Research articles published in journals - 6
Papers presented in symposium and workshops -3

Best publication

Prasad, J. V. and Gunneswara Rao, S. 208. Life table studies of the beet armyworm, *Spodoptera exigua* on two host plants, *Amaranthus viridis* and *Cicer arietinum*. Indian Journal of Entomology, 70(1): 40-43.

Observations of the QRT

i. No funding was provided to this centre as it is an ICAR institute based centre.
ii. From the report it is apparently clear that the major focus was on testing SlNPV with proper pH and EC for higher mortality of *S. litura*.

Only laboratory experiment was conducted on tobacco stem borer.

Recommendations of the QRT

1. The centre should initiate work on influence of crop rotations and tillage operations in tobacco on the diversity of plant and soil dwelling fauna.
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. The centre should popularize *Sl*NPV through KVKs.
5. Work has to be initiated on the role of potash on the incidence of pests and natural enemies of tobacco.
6. The centre should document the extent of loss caused by tobacco stem borer *Scrobipalpa heliopa* and initiate planned research work on this stem borer.

Overall assessment

Good

15. Central Plantation Crops Research Institute, Regional Station, Kayangulam

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-2012) Spiders from coconut ecosystem were collected and sent for identification. Two EPN were collected form Kayamkulam (*Heterorhabditis* sp)

Collection of geographic populations of braconid parasitoids of coconut black headed caterpillar and evaluation of efficiency (2007-08)
Survey in endemic *O. arenosella* infested tracts of Kerala (5 districts), Karnataka, Tamil Nadu and Orissa revealed incidence of two closely related species *viz., B. hebetor* and *B. brevicornis.* Bio-efficiency studies of different collections of these parasitoids indicated significant variation in biotic characters *viz.,* fecundity (48 to 140 eggs/ female), longevity (32 to 49 days), number of host larvae parasitized (3.9 to 8.1 larvae/parasitoid), number of female progeny (13.1 to 45.8) and percentage of female progeny (17.8 to 39.99 %). Kasaragod and Trivandrum (Kerala) collections were superior. Between the two species, *B. brevicornis* was better in parasitizing *O. arenosella* with 85% parasitism. *Braconid species* diversity indicated occurrence of *Meteoridea hutsoni* in North Kerala and Karnataka and *Bracon spp.* and *Apanteles taragamae* in all the locations.

Monitoring incidence of *Opisina* and collection of geographic populations of braconid parasitoids of coconut black headed caterpillar and evaluation of efficiency (2008-9)
Black headed caterpillar (*Opisina arenosella*) incidence in Kerala remained very low to medium intensity in various endemic areas during 2008-09. Valiyathura (Trivandrum), Wellington Island (Ernakulam), Kanjikkode (Palakkad), Thirur (Malappuram), Kumbla and Manjeswar (Kasaragod) areas showed pest incidence in less than 200 palms with leaf infestation ranging from 10-60 %.

Surveillance and need-based control of coconut leaf caterpillar, Opisina *arenosella* in Kerala (2011-12)
An outbreak of *Opisina arenosella* noticed in Vechoor (Kottayam district, Kerala) with leaf damage to the tune of 61.4% and pest population of 304/ 100 leaflets was brought under control by releases of parasitoids (*Goniozus nephantidis* and *Bracon brevicornis* @10 parasitoids/ palm) at monthly intervals. Population of the pest showed a sharp decline (91 % reduction) after release of parasitoids over a period of 8 months. There is complete recovery of *O. arenosella* incidence in the parasitoid released plot in a period of 2 years. Moderate level of *Opisina arenosella* infestation was observed in Trivandrum district in 62.5% coconut palms (WCT variety) with 61% leaf infestation during 2011-12. Monitoring and release of stage specific parasitoids *viz, Goniozus nephantidis* and *Bracon brevicornis* could reduce leaf damage to the tune of 63% and population of *O. arenosella* to the tune of 91.3% in a period of eight months

Evaluation of *Hirsutella thompsonii* for the biocontrol of coconut mite (2007-8).
Conducted field evaluation studies of *Hirsutella thompsonii* formulation supplied by NBAII. There was no significant difference in population count of coconut mite before and after 45 days of treatment (9.93 -13.8 in pre-treatment and 6.8 to 11.4 in post treatment).

Large area demonstration of *Oryctes rhinoceros* management using *Metarrhizium anisopliae* var. *major* and baculovirus in Kerala (2007-2009)

The leaf and fresh spindle damage showed reduction of 53.4% and 74% respectively over the pre-treatment period by adopting biological control of *O. rhinoceros*. The breeding sites treated with *M. anisopliae* were free of pest stages during post treatment period. An average of 16 beetles/trap/month were collected during peak adult emergence period of May-August

Scaling up utilization of *M. anisopliae* through technology transfer (2011-12).

To increase awareness and adoption of biocontrol technology for management of *Orcytes rhinoceros* using the green muscardine fungus (GMF) *Metarhizium anisopliae*, transfer of technology programmes such as on and off campus training programmes, seminars and method demonstrations were undertaken. Community based participatory management methodology was found to be appropriate for scaling up adoption of *M. anisopliae* (GMF) among small and marginal coconut farmers and was undertaken as a pilot programme in Edava Panchayat of Trivandrum District, Kerala through educated rural women farmers.

Field studies on management of *Oryctes* through integration of Green muscardine fungus (GMF), *Oryctes* Baculovirus (OBV) and attractant baited pheromone traps (2007-2008)

Large area field demonstration for management of *O. rhinoceros* (10 ha) through integrated biocontrol methods (OrV, GMF and pheromone trap) initiated at Kattanam (Alappuzha Dist.) during April 2008 showed 42% reduction in pest incidence, 36.3% reduction in leaf damage, and 72.2% reduction in spindle damage over the pre-treatment period (in 10 months). The breeding sites treated with *M. anisopliae* were free of pest stages during post treatment period.

Large area demonstration of integrated biocontrol technology against *Oryctes rhinoceros* (2010-2012).

Large scale adoption of biocontrol technology for rhinoceros beetle of coconut resulted in 28-30% reduction of leaf damage in a period of 9 months in the demonstration area.

Studies on natural enemies of red palm weevil (2008-2012).

Field collected life stages (Grubs, Pupae and adults of red palm weevil) did not reveal any natural enemies. Inviro pathogenicity test with insect pathogens *viz. Metarhizium anisopliae*, *Isaria* sp., *Hirsutella thompsonii* and *Beauveria bassiana* was attempted on red palm weevil showing pathogenicity only with *B.bassiana*.

Isolation, pathogenicity of EPN and studies on synergistic effect with neonicotinoid and chitosan formulations against red palm weevil (2011-12)

Among the three species of EPN evaluated against the grubs of red palm weevil in filter paper based bioassay, the local isolate *H. indicus* was found to be more virulent than *H. bacteriophora*. *H. indicus* and *H. bacteriophora* infected the grubs of red palm weevil in the laboratory on filter paper bioassay technique whereas *S. abbasi* could not. Among the Entomopathogenic nematodes tested, the local isolate *Heterorhabditis indicus* was found to be more virulent inducing 92.5% mortality of red palm weevil grubs in filter paper bioassay @ 1500 IJ/grub than *H. bacteriophora* which caused 65% mortality. At the same concentration *Steinernema carpocapsae* and *S. abbasi* caused mortality to the tune of 20% and 15%, respectively. Talc based EPN formulation of *H. indicus* elicited higher mortality (70%) than water suspension based formulation (<10%) on coconut petiole based bioassay.

Field testing of EPN against red palm weevil

Leaf axil filling of talc based local strain of entomopathogenic nematode (*H. Indicus*) formulation fortified with chitosan 0.25% and mixed with sand was undertaken as prophylactic treatment against Red Palm Weevil (RPW) in coconut palms (CGD variety). Treated palms showed less RPW incidence (5.6%) compared to untreated control palms (33.3%). Synergistic interaction of *H. indicus* (1500 IJ) with imidacloprid (0.002%) against red palm weevil grubs was observed accelerating the kill (95%) within a period of 48 h in lab. bioassay.

Surveillance and monitoring for the mealybugs (2011-12)
Mealy bug specimens collected from various plant parts of coconut were identified as *Pseudococcus sp.nr. cryptus* on inflorescence and leaf *Palmicultor palmarum* on spathe and spindle. *Dysmicoccus neobrevipes* was obtained from ornamental palms.

Surveillance for alien invasive pests in vulnerable areas (all centers) (2011-12)
Surveillance surveys undertaken in Kerala and Lakshadweep Islands *viz.*, Minicoy, Kavaratti and Kalpeni did not record any incidence of invasive pest on coconut including coconut leaf beetle, *Brontispa longissima.*

Production, process, technologies developed
Biological control technology for two major pests of coconut *Oryctes rhinoceros* and *Opisina arenosella* including technology refinement was undertaken and field validated.

Infrastructure and physical facilities developed: Nil

Human resource development efforts
Regular training was imparted on biological control of coconut pests to the farmers.

Publications

Research articles published in journals	- 12
Papers presented in symposia/workshops	- 8
Extension bulletins, etc.	- 18

Best publication
Chandrika Mohan and Sathiamma, B. 2007. Potential for lab rearing *Apanteles taragamae*, the larval endoparasitoid of coconut pest *Opisina arenosella*, on the rice moth *Corcyra cephalonica. BioControl* **52:** 747-752

Observations of the QRT

i. Being an ICAR Institute based centre, no funding was provided to this centre.
ii. The centre had done good work on the biological control of *Oryctes rhinoceros* and *Opisina arenosella* two major pests of coconut.

Recommendations of the QRT

1. Economic analysis of earlier experiments conducted on biological control of *Oryctes rhinoceros* and *Opisina arenosella* should be done.
2. The centre should attempt for the transfer of technology through KVKs.
3. Attempts should be made to develop early warning system for the outbreaks of *Opisina arenosella* in Kerala and neighboring states.

4. KAU, Thrissur and CPCRI, Kayangulam centre should come out with common package for the management of coconut pests.
5. The centre should come out a status paper on scarlet mite on plantation crops.

Overall assessment

Good

16. Indian Agricultural Research Institute, New Delhi

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-2012)
No report

Isolation, characterisation and evaluation of potential *Bt* isolates (2007-2012)
Of the four isolates of *B. thuringiensis* tested, *viz*., AUG-4, AUG-5, AUG-7 and SEPT-1 against diamondback moth, Cabbage butterfly, American bollworm, tobacco caterpillar, Bihar hairy caterpillar, and Eri silkworm, isolate AUG-5 gave 100 per cent mortality of *Diacrisia obliqua* and *Pericallia ricini* followed by *Helicoverpa armigera* (96.7 %) and *Plutella xylostella* (96 %). However, these *Bt* isolates were not as effective as standard *Bt* strains against *Pieris brassicae.* Aug-5, a prospective *Bt* isolate, effectively reduced *P. xylostella* and *P. brassicae* populations on cabbage under the field conditions. Isolation of Bt strains from soil samples collected from Haldwani, Govindghat, Hisar, Hemkund, Punjab and W. Bengal was done.

Characterization of toxicity of Bt isolates against pests of cole crops (2011-12).
Since the incidence of *Plutellal xylostella* was very low no field evaluation of Bt strains was taken up. Soil samples were collected from several places in northern India and ten Bt strains (GTG-1 to GTG-10) were isolated. Laboratory evaluation of these Bt strains against *Chilo partellus* revealed that seven days after the treatment the mortality of the larvae ranged from 8.9 to 31.0 per cent only.

Surveillance for alien invasive pests in vulnerable areas (all centers) (2011-12)
Not reported

Surveillance and monitoring for the mealybugs (2011-12)
Not reported

Production, process and technologies developed: Nil

Infrastructure and other facilities developed: Nil

Human resource development activities: Nil

Publications: not mentioned

Observations of the QRT

i. Out of five works allotted, the centre had carried only two experiments.

ii. The progress in these two experiments is not satisfactory
iii. The PI informed that the number of staff strength at the Division of Entomology, IARI had come down from 30 to 16 and most of them are engaged in teaching and with meager staff it is not possible to carry out the technical programme allotted to the centre.
iv. No separate funding is provided for meeting the expenditure in conducting the field experiments, hence the centre is unable to conduct the field experiments.
v. No economic analysis of the treatments or cost: benefit ratio of the best treatment is not done.

Suggestions/ Comments of the QRT

1. Since the staff strength is dwindling and the PI has already indicated that the meager staff is engaged in teaching which is their major activity.
2. The centre should strengthen the Bt research activity in future.

Overall assessment

Average

17. Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-12)
Not reported

Demonstration of biological control of maize stem borer, *Chilo partellus* using *Trichogramma chilonis* and *Cotessia flavipes* (2009-12)
Informed in 2009 to the Project Director, that maize was not a major crop of Jabalpur and hence trials were not conducted.

Influence of crop habitat diversity on biodiversity of pests of pigeonpea and their natural enemies (2009-12)
Natural enemies recorded on pigeonpea were Lady Bird beetle, *Cheilomenes sexmaculatus*; Spiders; Dragon fly, Mud wasps and *Cotesia* (=*Apanteles*) sp., respectively. Maximum populations of all the natural enemies were observed on sole pigeonpea crop followed by pigeonpea crop bordered with maize and sorghum respectively.

Impact of bio-suppression of *H. armigera* on the incidence of other lepidopteran pod borer species of pigeonpea (2009-12)
Informed in 2009 to the project Director, that in pigeonpea, *Helicoverpa armigera* was not a major pest under Jabalpur conditions and hence trials were not conducted

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*) (2011-12)
Chlorpyriphos 20EC @ 0.4% recorded minimum grain damage by Lepidopteran borers and maximum grain yield which was followed by NSKE @ 5% and PDBC – BT-1 @ 2%.

Evaluation of entomophagous pathogens against defoliators infesting soybean (2009-12)
Treatments *M. anisopliae* @ 10^{13} spores/ha, *V. lecanii* @ 10^{13} spores/ha, Dipel @ 1 Kg/ha and Spinosad 45% SC @ 73 g *a. i.* /ha were on par with each other with respect to *S. litura* infestation in soybean and were significantly better than control

Preliminary screening of EPN against *Spodoptera litura* in soybean (2009-12)
Treatment EPN 3 aqueous formulation @ 2 billion Infected juveniles / ha was found to be most effective against Lepidopteran defoliator complex of soybean and also registered highest grain yield

Validation of different BIPM modules against shoot and fruit borer, *Leucinodes orbonalis* on brinjal (2011-12)
Trial in progress

Evaluation of biocontrol agents against sap sucking insect pests of ornamentals in polyhouse (2011-12)
Trial in progress

Surveillance and monitoring for the mealy bugs (2011-12)
Not a major pest in Jabalpur

Surveillance for alien invasive pests in vulnerable areas (all centers) (2011-12)
No threat of any alien invasive pest observed in Jabalpur

Validation of biocontrol technologies for management of crop pests and diseases under Tribal Sub Plan- *Fusarium* wilt management in pigeon pea (2011-12)
Demonstrations on chickpea in progress in tribal districts of Dindori and Mandla and not yet harvested

Production, process, technologies developed: Nil

Infrastructure and physical facilities developed: Nil

Human resource development efforts

The PI of this project trained on the mass production of biocontrol agents at NBAII, Bangalore.

Best publication

Das, S. B., Uday Pawar and Veda, O. P. 2011. Insect Biodiversity on Pigeonpea *Cajanus cajan* L. (Millsp.) Ecosystem at Jabalpur, Madhya Pradesh Presented in National Symposium on "Harnessing Biodiversity for Biological Control of Crop Pests" from 25th – 26th May, 2011 held at NBAII, Bangalore.

Observations of the QRT

i. It is a voluntary, hence limited funding was provided.
ii. Out of 11 technical programmes, only 8 were attended by the PI.
iii. The progress of research work at this centre is not satisfactory.

Recommendations of the QRT

1. The performance of this centre is below expectation. The project coordinator had requested for the closure of this centre.

Overall assessment

Average (The centre is recommended for closure)

18. Maharana Pratap University of Agriculture & Technology, Udaipur

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-12)
Not collected

Preliminary field evaluation of thelytokous *Trichogramma pretiosum* against *Helicoverpa armigera* of tomato (2009-12)
A field experiment was conducted on tomato (var. Namdhari -UTSAV). Six releases of thelytokous form of *T. pretiosum* recorded lowest fruit damage and highest marketable fruit yield and was on par with arrhenotokous form of *T. pretiosum*. Both the treatments were superior to control.

Evaluation of different bioagents against cumin aphid (2009-12)
The treatments included (a) three times release of *Chysoperla* sp. @ 50,000/ha, (b) spray of *B. bassiana* @ 1 x 10^7 spores/ha, (c) spray of *M. anisopliae* @ 1 x 10^7 spores/ha, (d) spray of *V. lecanii* @ 1 x 10^7 spores/ha, (e) spray of Azadiractin 0.03% @ 3 ml/l (f) spray of imidacloprid @ 30 g a.i./ha and control. The results indicated that among the biocontrol agents, *V. lecanii* recorded higher aphid mortality (86.7%) which was superior to other biocontrol agents but inferior to imidacloprid. Highest grain yield was recorded in azadiractin plots (1004 kg/ha) which was significantly inferior to imidacloprid.

Evaluation of biocontrol agents against cumin wilt (2009-12)
The treatments included seed treatment with (a) *T. harzianum* (PDBC) (b) *T. harzianum* (RCA, Udaipur), (c) *P. fluorescens* (NCIPM), (d) *T. viride* (PDBC), (e) carbendazium and (f) control. The antagonists were also applied to soil @ 2.5 kg/ha. The results revealed that seed treatment with *T. harzianum* (PDBC) recorded lowest disease incidence (2%) and highest grain yield of cumin (1135 kg/ha).

Influence of crop habitat diversity on biodiversity of natural enemies in pigeonpea through FLD/OFD (2011-12)
Not done

Evaluation of entomopathogens against soybean insect pest complex (2011-12)
First spray with *Bt* var. *kurstaki* @ 1 kg /ha, followed by spray of *Nomuraea rileyi* @ 1.5 x 10^{13} conidia/ha and second spray with SlNPV @ 1.5x10^{12} POBs/ha was more effective in reducing *S. litura* population on soybean.

Validation of BIPM of major insect pests in tomato at farmers' field (2011-12)
Not done

Identification of major aphid parasitoids and their extent of parasitism in mustard and cabbage (2011-12)
Not done

Biological suppression of scarabaeids infesting groundnut (2009-12)
A field experiment was conducted to evaluate the entomopathogenic fungi and EPN against whitegrubs attacking groundnut (var. TAG-24). The results revealed that significantly lowest plant mortality (4.8%) and highest grain yield (1512 kg/ha) were recorded in *M. anisopliae* @ 1 x 10^{13} conidia/ha. This tretament was however, not as good as chlorpyriphos in ehancing the yield.

Augmentation of microbes for biological suppression of termite in wheat (2009-12)
During 2009, application of *M. anisopliae* @ 1 x 10^{13} conidia/ha effectively suppressed termite damage and recorded signifcantly less plant mortality of wheat (4.6%) and higher yield (4230 kg/ha) compared to EPN but was inferior to chlorpyriphos.
During 2010, application of *M. anisopliae* @ 1 x 10^{13} conidia/ha and *S. carpocapsae* EN-11 @ 5bIj/ha effectively suppressed termite damage and recorded signifcantly less plant mortality of wheat (5.12 and 4.72%) and higher yield (4,020 and 3,960 kg/ha) compared to other EPN but was inferior to chlorpyriphos.

Validation of pigeonpea pest complex under tribal area (2011-12) Testing the bio-efficacy of entomopathogenic fungi in suppression of termite incidence (Maize) (2011-12)
Not done

Surveillance and monitoring for the mealybugs (2011-12)
Not done

Surveillance for alien invasive pests in vulnerable areas (all centers) (2011-12)
Not done

Production, process, technologies developed: Nil

Infrastructure and physical facilities developed: Nil

Human resource development efforts

The PI of the centre was trained on the mass production of biocontrol agents at NBAII, Bangalore

Best publication: Nil

Observations of the QRT

i. Being a voluntary centre, very limited funding was provided
ii. The natural enemies on different crop pests were not collected by the centre
iii. The centre did not conduct one experiment on pulse and two experiments on vegetables.

Recommendations of the QRT

1. Efforts should be made to collect the natural enemies of several crop pests grown in Madhya Pradesh.
2. The field trials on pulses and vegetables should be conducted.
3. Efforts should be made to document the occurrence of different species of mealybugs and their natural enemies on crops.

Overall assessment

Good

19. Central Agricultural University, Pasighat

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-12) EPN *Steinernema* spp. have been collected from five different locations of Arunachal Pradesh and sent for identification to NBAII, Bangalore. Other natural enemies were not surveyed.

Field evaluation of *Trichogramma chilonis* produced using Eri-silk worm eggs as factitious host (On rice) (2011-12)
Not done

Preliminary evaluation/ screening of EPN against YSB, striped borer and leaf folder in rice (2009-12)
The results revealed that among the EPN strains, *Steinernema* sp. (Runne) @8 lakh/pot recorded the highest mortality of *C. supressalis* (60.5%) and *C. medinalis* (82.0%) whereas profenophos @ 0.05% recorded 77.6% mortality of *C. suppressalis* and 94.0% mortality of *C. medinalis*

Survey for the identification of potential natural enemies of the gundhi bug, *Leptocorisa* sp. (2009-11)
The survey did not reveal any natural enemies on the gundhi bug.

Seasonal abundance of predatory spiders in rice ecosystem (2011-12)
Not done

Laboratory evaluation of fungal pathogens on gundhi bug, *Leptocorisa* sp. (2011-12)
The gundhi bug not noticed.

Evaluation of IPM for upland rice pests and diseases (2011-12)
At Sille, the IPM module was on par with the untreated control in stem borer infestation in the early crop stage; however, after four rounds of EPN application at 85 DAT, % WEH (2.44) is significantly lower than the untreated control (5.14).
At Pasighat, significantly lower incidence of stem borers in the IPM module than the control from 65 DAT. Average per cent infested grains in IPM module was 0.81, 0.76 and 0.94 at Sille, Pasighat and Mebo, respectively. The grain yield of IPM practice was on par with the farmers' practice in all the locations.

Evaluation of entomopathogenic fungi against citrus trunk borer, *Anoplophora versteegi* (2011-12)

Evaluation of seven strains (collections) of entomopathogenic nematodes (EPNs) *viz*. NBAII-01, NBAII-04, CAU-1, CAU-2 and CAU-3, CAUH-1 and CAUH-2 against citrus trunk borer *Anoplophora versteegi* revealed that at 72 hrs, mortality ranged from 72 to 88 per cent and at 96 hrs all the grubs died (CAU).

Preliminary field evaluation of thelytokous *Trichogramma pretiosum* against *Helicoverpa armigera* of tomato (2009-12)

Six releases of thelytokous form of *T. pretiosum* was found to be significantly superior in recording less fruit damage (4.61%) and marketable fruit yield (16,010 kg/ha) compared to arrhenotokous form which recorded 5.35 % fruit damage and 15,850 kg fruits per ha. In the control plot the fruit damage was 11.2% and fruit yield was 13,310 kg/ha.

Demonstration of biocontrol based IPM module against pests of cauliflower (2009-12)

The results revealed that the population reduction of *P. xylostella* in biocontrol-based IPM (The IPM module included planting of mustard as trap crop to collect and destroy *P. xylostella*; mechanical collection and destruction of egg masses and first instar larvae of *S. litura*; release of *T. brassicae* @ 1,00,000/ha against *P. xylostella*; need based application of SlNPV and application of NSKE 5%) plot was superior to control and inferior to farmers practice. But there was no significant difference in the population of *S. litura* larvae in biocontrol-based IPM plots and farmers practice plots. *Bt*-NBAII sprayed at 5ml/lit. of water was observed as the most effective treatment with average *P. xylostella* population of 0.33 and 0.20 larvae/leaf in 1st and 2nd spray, respectively and it was comparable to 0.05 per cent profenophos.

Validation of bio-control based IPM for important pests of tomato (2009-12)

The results indicated that there was no significant difference in per cent plant mortality in the nursery, per cent fruit damage and marketable yield of tomato between biocontrol-based IPM plot and farmers practice. However, both the treatments were superior to control.

Farmer participatory demonstration of bio-control based IPM for important pests of brinjal (2009-12)

The results indicated that there was no significant difference in per cent plant mortality in the nursery, per cent fruit damage and marketable yield of brinjal between biocontrol-based IPM (Biocontrol-based IPM included: Treatment of seeds with *T. veride* @ 4g/ kg of seed, eight releases of *Trichogramma chilonis* @ 50,000/ha was made at weekly interval starting from 45DAT, installation of pheromone traps of *L. orbonalis* @ 12 traps /ha. and spraying of neem oil @ 4ml/lit at weekly interval from 80 DAT.) plot and farmers practice (The farmers' practice included application of carbofuran @ 1 kg a.i./ha before sowing, soil drenching with blitox 50 WP @ 0.25 per cent and spraying of Profenophos @ 0.05% at 45, 60 , 75 and 90 DAT). However, both the treatments were superior to control.

Validation of biocontrol technologies for potato pests and diseases under Tribal Sub Plan (2011-12)

It was carried out at three locations in East Siang district. Plukharaj variety of potato was used. The results revealed that the incidence of bacterial wilt was lower in the IPM module (1.5%) than untreated control (10.0%). The yield of potato in IPM plot was 224.4 q/h, which on par with farmers' practice 239.7 q/ha but much higher than untreated control 186.35 q/h).

Surveillance and monitoring for the mealybugs (2011-12)
Not done

Surveillance for alien invasive pests in vulnerable areas (all centers) (2011-12)
The survey revealed that none of the alien pests listed were recorded at Arunachal Pradesh.

Production, process, technologies developed: Nil

Infrastructure and physical facilities developed: Nil

Human resource development efforts

The PI of the project was trained on the mass production of biocontrol agents at NBAII, Bangalore.

Best publication: Nil

Observations of the QRT

i. Being a voluntary centre, only limited funding was provided
ii. The natural enemies on various crop pests have not been collected.
iii. The survey on mealybugs and their natural enemies has not been undertaken.

Recommendations of the QRT

1. Efforts should be made to collect natural enemies on various crop pests in Arunachal Pradesh as organic farming is practiced and there is more chances of recording new biocontrol agents on pests of crops.
2. Lizards and birds feeding on giant African snails can be documented at Arunachal Pradesh.
3. Efforts should be made to popularize the IPM module even though the yields are slightly lower than the farmers' practice of application of insecticides as the hazards of pesticides are minimized.

Overall assessment

Good

20. Orissa University of Agriculture & Technology, Bhubaneshwar

Brief achievements

Biodiversity of biocontrol agents from various agro-ecological zones (2009-12)
Two species of *Chrysoperla* has been sent for identification. Braconids have been sent to NBAII in 2010-11. Soil samples from eight districts of Odisha has been sent to NBAII

Preliminary evaluation/ screening of EPN against YSB, striped borer and leaf folder in rice (2009-11)

Aqueous formulations of EPN are more effective than powdered formulation. *S. riobrave* controlled stem borers more effectively than *S. feltiae*

Large-scale demonstration of IPM for rice pests and diseases in the farmer's field (2009-11)
IPM package managed the rice pests more effectively than farmers' practice giving the farmers a net profit of Rs 14,235 to Rs 18,345/ ha over farmers' practice.

Seasonal abundance of predatory spiders in rice ecosystem (2011-12)
Not reported

Biological control of groundnut pests (Rabi, 2011-12)
Against different pests of groundnut, Bt was found to be at par with insecticidal treatments for control of all pests. NPV recorded significant control of *Spodoptera* whereas, *Trichogramma* was very effective against leaf miner.

Survey and record of incidence of papaya mealybug and its natural enemies on papaya and other alternate hosts (Tritrophic interaction) (2011-12)
Papaya mealy bug was noticed in Bhubaneswar during May, 2011. A survey conducted in all 30 districts of Odisha revealed that, it has spread to almost all districts now. The population was at its peak during August, 2011 after which it came to negligible state due to heavy rain. Its population is again on rise from March, 2012.

Biocontrol of papaya mealybug in Orissa (2011-12)
Not reported

Preliminary field evaluation of thelytokous *Trichogramma pretiosum* against *Helicoverpa armigera* of tomato (2009-11)
Thlyotokous *T. pretiosum* is more effective than arrhenotokous *T. pretiosum* in controlling *Helicoverpa armigera*. However, both the parasitoids exerted significantly more control of the pest over the control.

Farmer participatory demonstration of bio-control based IPM for important pests of brinjal (2009-11)
IPM demonstrations in different locations for important pests of brinjal at OUAT, Bhubaneswar during 2010-11 indicated that the IPM package was far superior to the farmers practice resulting in significantly less wilt, shoot borer and fruit borer and significant increase in yield producing net return of ₹ 63,988 to ₹ 73,423 over the farmers' practice.

Validation of different BIPM modules against shoot and fruit borer, *Leucinodes orbonalis* on brinjal (2011-12)
BIPM treatment was at par with the insecticidal treatment in all locations recording 9.3 to 11.5% shoot borer incidence as against 22.8 to 29.4% in untreated control. But, fruit borer incidence was least in BIPM treatments recording 17.5 to 19.1% at different locations where as, insecticide treatment recorded 18.5 to 23.8 % incidence though both BIPM and insecticide were at par in their effectiveness. The control plots recorded 22.8 to 29.4% shoot infestation and 29.8 to 33.7% fruit damage.

Evaluation of anthocorid predators against mite, *Tetranychus urticae* on brinjal and okra (2011-12)
Release of 20 or 30 anthocorid bugs/plant significantly reduced the spider mite population in brinjal and okra and substantially increased the yield.

Evaluation of some biocontrol agents for the control of brinjal mealybug, *Coccidohystrix insolitus* (2009-11)
Release of 10-20 first instar grubs of the beetle, *Cryptolaemus montrouzieri* reduced the mealy bug population significantly. The predator could control mealybug effectively better than the insecticidal control.

Validation of Biocontrol Technologies for management of crop pests and diseases under Tribal Sub Plan
Sixty tribal farmers were trained on mass production and use of different bio control agents *T. viridae* – 100 kg, *T. harzianum* – 200 Kg, *B. bassiana* -50 Kg, *V. lecanii* – 50 Kg and *M. anisopliae* – 50 Kg produced which will be distributed to tribal farmers in the coming Kharif season.

Enabling large scale adoption of proven biocontrol technologies- Rice- OUAT 10 ha (2011-12)
In large scale demonstration of BIPM in paddy it was recorded that, there was significant reduction in stem borer, leaf folder, caseworm population and increase in the predatory fauna. BIPM adopting farmers got an increased return of Rs 18,480.00/ha over the non-adopting farmers.

Large-scale demonstration on the use of *T. chilonis* (Temperature tolerant strain) against early shoot borer and internode borer of sugarcane in farmers' field – 50 ha (2011-12)
There was substantial reduction of Early shoot borer and internode borer population in the demonstration plots where *T. chilonis* was released @ 1,00,000/week starting from 20 DAT.

Surveillance and monitoring for the mealybugs (2011-12)
Not reported

Surveillance for alien invasive pests in vulnerable areas (all centers) (2011-12)
Not reported

Production, process, technologies developed: Nil

Infrastructure and physical facilities developed: Nil

Human resource development efforts

The PI of the project was trained on the mass production of different biocontrol agents at NBAII, Bangalore.

Best publication :

Mishra, B. K. and Sarangi, P. K. 2009. Predatory potential of *Coccinella septempunctata* on *Aphis craccivora* Koch. *J. Plant Prot. Environ* 6 (2): 100-101.

Observations of the QRT

i. It is new voluntary centre, hence limited funding is provided.
ii. In most of the field experiments, the pest incidence was very low.
iii. In tomato field experiment, harvest-wise analysis to be done.

Recommendations of the QRT

1. Since large area cultivation of cashew is undertaken in Odisha, work should be initiated on natural enemies associated with cashew tea mosquito bug.
2. In bunch type mango varieties, mango pulp borer is becoming serious and work has to be initiated on natural enemies associated with mango pulp borer
3. Large cacti species are grown in Odisha and work should be initiated on natural enemies associated with mealybugs of cacti.

Overall assessment

Good

Project Coordinating Unit, NBAII, Bangalore

The present Project Coordinating Unit functioning at NBAII, Bangalore is an administrative unit fully catering to the technical needs of the project. The activities of the project coordinator are mentioned below:

1. Annual group meetings of biological control research workers were organized in ANGRAU, Hyderabad on 18-19 May, 2007 & 22-23 May, 2012, YSPUH & F, Nauni, Solan on 29-30 May, 2008, AAU, Jorhat on 29-30 May, 2009, SKUA & T, Srinagar on 29-30 May, 2010 and NBAII, Bangalore on 27-28 May, 2011.
2. Four new centres were added during 2009 at CAU, Pasighat, Arunachal Pradesh, JNKVV, Jabalpur, OUAT, Bhubaneshwar and MPUAT, Udaipur without any staff but with limited funding.
3. The PIs of four new voluntary centres were provided training on the mass production of biocontrol agents at NBAII, Bangalore for a period of 10 days.
4. The project coordinator arranged and conducted more than 10 meetings at various places during 2010-11, in different states for creating awareness on the possible entry of alien insects, especially coconut leaf beetle, *Brontispa longissima*. The AICRP centres located in and around coastal areas were asked to keep vigil and conduct regular survey for the early detection of alien pests for quick containment, if required.
5. A one day training programme was organized on the mass production of exotic parasitoids of papaya mealybug to more than 250 entomologists from different AICRP centres, SAU's, NGO and private enterprenuers at NBAII during 2011.
6. XI plan EFC document was prepared and submitted.
7. Compilation of combined annual report of AICRP on Biological Control and NBAII, Bangalore every year.
8. Monitoring of implementation of technical programme by AICRP centres from time to time.
9. Fund allocation to different centres through NBAII, Bangalore and monitoring of expenditure.
10. Development of linkages with other projects, agencies, institutions, etc.

Comments and recommendations of the QRT

1. The Director of NBAII who is also the project coordinator is presently looking after the monitoring of the technical programme as well as fund allocation. The QRT is satisfied about the functioning of the project coordinator of this AICRP considering the mandate of NBAII, importance of biological control at national level.
2. There is a need to create one scientific and technical staff along with a personal secretary in the XII plan to work in the AICRP Project Coordinators cell at NBAII for looking after day-to-day correspondence and other activities.

iv. Structure and organization

Centre and Scientist	Scientist	Technical	Administrative & Supporting
NBAII, Bangalore			
Dr. N. K. Krishna Kumar, Project Coordinator			
AAU, Anand	3*	4	1 Driver
Dr. D. M. Korat, Pr. Research Scientist (Ento.) Dr. J. J. Jani, Assoc.Research. Scientist (Micro.) Sh. N. B. Patel, Asst. Research. Scientist (Ento.)			
AAU, Jorhat	2 (Vacant 1)	2 (Vacant 1)	-
Dr. D. K. Saikia – Pr. Scientist (Entomology) Scientist (Entomology) (Vacant)			
ANGRAU, Hyderabad	2	4	-
Dr. S. J. Rehaman, Principal Scientist Mrs. G. Anitha, Scientist (Ento.)			
GBPUA & T, Panthnagar	1	1	1 attender
Dr. J. Kumar, Professor Dr. (Mrs.) Roopali Sharma, Jr. Res. Offi.			
KAU, Thrissur	2	2 (Vacant 1)	1 Driver
Dr. K.R. Lyla, Professor Smt. C.V. Vidya, Asst. Professor			
MPKV, Pune	2	2	-
Dr. D. S. Pokharkar, Entomologist Dr. R. V. Nakat, Asst. Entomologist			
PAU, Ludhiana	4**	3	1 attender
Dr. Naveen Aggarwal, Entomologist Dr. (Mrs) Neel am Joshi, Asst. Microbiologist Dr. Rabindra Kaur, Asst. Entomologist Sh. Sudhendu Sharma, Asst. Entomologist			
SKUAS & T, Srinagar	2	2	-
Dr. M. Jamal Ahmad, Assoc. Professor Dr. Dr. G.M. Lone, Assoc. Professor			
TNAU, Coimbatore	2	2	-
Dr. P. Karuppuchamy, Professor Dr. M. Kalyanasundaram, Professor			
Dr. YSPUH & F, Solan	2***	2	-
Dr Usha Chauhan, Sr. Entomologist Dr. P. L. Sharma, Asst. Professor			
ICAR based centers			
IIHR, Bangalore	-	-	-
SBI, Coimbatore	-	-	-

CPCRI, Kayangulam	-	-	-
CTRI, Rajahmundry	-	-	-
IISR, Lucknow	-	-	-
IARI, New Delhi	-	-	-
Voluntary centres			
CAU, Pasighat	-	-	-
JNKVV, Jabalpur	-	-	-
MPUA & T, Udaipur	-	-	-
OUAT, Bhubaneswar	-	-	-
Total	22	24	4

*One post of entomology scientist from AAU, Anand to be redeployed to CAU, Pasighat
**Two posts of asst. entomologist from PAU, Ludhiana to be redeployed, one to OUAT, Bhubaneshwar and another one to MPUAT, Udaipur.
***One post of Asst. professor of entomology from Dr. YSPUH & F, Solan to be redeployed to UAS, Raichur (new centre)

Comments and suggestions of QRT

1. The QRT had detailed discussions with the project coordinator regarding closing certain centres, opening new centres and redeployment of scientific posts found excess in some centres to other centres.
2. The Director, SBI, Coimbatore has expressed his opinion that SBI would not be a part of AICRP on BC. It is very unfortunate that when the biological control works for managing whitegrubs and borers on sugarcane is so critical, both ICAR institutes (SBI, Coimbatore and IISR, Lucknow) working exclusively on sugarcane did not actively involve on biological control of sugarcane pests. ICAR should seriously view this unexpected trend by ICAR sister institutions and in case both SBI, Coimbatore and IISR, Lucknow do not express interest to participate in the biological control of sugarcane pests, the posts earmarked for the purpose could be transferred to NBAII.
3. The QRT also suggests for closure of one SAU based AICRP on biological control centre at JNKVV, Jabalpur as the performance of the centre is not up to the expected level and no post should be provided under AICRP.
4. The northern districts of Karnataka including Raichur, Bellary, etc. are cultivating agricultural crops on vast area and become Mecca of chemical pesticides. The QRT strongly recommends that a centre for AICRP on BC should be established at UAS (Raichur) to initiate the work on biological control, so much needed in this hot spot area where chemicals pesticides are applied injudiciously.
5. It is suggested for creating one new centre with one scientific post (through redeployment) at UAS, Raichur (Karnataka) and two voluntary centres, one at NCIPM, New Delhi and another at CARI, Port Blair, Andaman & Nicobar Islands as AICRP on Biological control will have the future research collaborations at these centres.
6. It is suggested for downsizing the scientific posts at AAU, Anand (*one entomology scientist), PAU, Ludhiana (** two assistant entomologist posts) and Dr YSPUH & F, Solan (*** one entomology assistant professor post). These four posts may to be redeployed one each to CAU, Pasighat, OUAT, Bhubaneshwar, MPUAT, Udaipur and UAS, Raichur (new centre).
7. QRT recommended additional manpower (one scientific and one technical post and one personal secretary) in the XII plan in PC Cell located at NBAII, Bangalore.

8. To enable proper functioning of each centre there should be at least 2 scientists, 2 technical staff and 2 supporting staff. This would be the minimum requirement of staff for each centre.
9. The overall performance of various centres is given in Annexure IV.

v. Management practices

Budget and Finance

XI Plan Budget (2007-2012)

	Centre	Pay	Pay arrears	TA	RC	Equip.	Works	TSP	Total
1	AAU, Anand	94.50	30.67	2.24	11.50	15.00	7.50	1.00	162.41
2	AAU, Jorhat	69.98	23.87	1.39	7.82	15.00	3.75	0.00	121.81
3	ANGRAU, Hyderabad	76.95	17.79	1.35	7.74	15.00	7.50	1.00	127.33
4	Dr.YSPUH&F & F, Solan	40.08	15.61	1.50	7.92	15.00	7.50	0.00	87.61
5	GPUAT, Pantnagar	33.02	4.72	0.75	4.37	13.86	3.75	0.00	60.47
6	KAU, Thrissur	64.84	16.19	1.50	7.34	14.75	7.50	1.00	113.12
7	MPKV, Pune	65.57	23.99	1.30	7.89	12.00	3.75	0.00	114.50
8	PAU, Ludhiana	73.90	18.12	3.00	14.74	15.00	3.75	0.00	128.51
9	SKUAT, Srinagar	46.01	6.69	1.25	6.99	12.75	7.50	1.00	82.19
10	TNAU, Coimbatore	69.14	12.82	1.50	7.52	15.00	7.50	1.00	114.48
11	MPUAT, Udaipur	0.00	0.00	0.00	5.00	0.00	0.00	1.00	6.00
12	JNKVV, Jabalpur	0.00	0.00	0.00	5.00	0.00	0.00	1.00	6.00
13	OUAT, Bhubaneswar	0.00	0.00	0.00	5.00	0.00	0.00	2.00	7.00
14	CAU, Pasighat	0.00	0.00	0.00	5.00	10.00	0.00	1.00	16.00
15	PC Cell, Bangalore	0.00	0.00	6.70	42.84	80.86	53.38	0.00	183.78
	Total	**633.99**	**179.47**	**22.45**	**146.67**	**234.22**	**113.38**	**10.00**	**1331.21**

Comments and suggestions of QRT

1. Contingency amount should be increased by 2.5 times to enable centres to meet increasing fuel, contingency for surveys, conduct large scale field experiments and other project related activities.
2. Budget for the project should be considerably increased in the XII plan to Rs. 3500 lakh.
3. Centres that are involved in transfer of persons should ensure that the vacant post is filled immediately.
4. The QRT suggests for up gradation of computers and their accessories at all the centres.
5. The QRT suggests for replacement of old vehicles following proper protocol.

vi. Collaboration with other institutes, linkages with clients, end users, etc.

The project has linkages with other AICRPs on Honeybees and pollinators, AINP on Agricultural Acarology, AINP on whitegrubs and other soil arthropods and AICRP on nematodes. The project has linkages with NCIPM, New Delhi, CARI, Port Blair, Chaudhary Charan Singh Haryana Agricultural University, Hissar, College of Agriculture, Kolhapur, NRC for Soybean, Indore, National Research Centre for Weed Science, Jabalpur, Navasari Agricultural University, S. D. Agricultural University, UAS, Bangalore, UAS, Raichur, UAS, Dharwad, Vasantdada Sugar Institute, Pune and several KVKs like KVK, Puducherry, etc. The project also has linkages with several private industries like M/s DOW AgroScience, Mumbai, M/s Sri Biotech Laboratories

India Ltd., Hyderabad, M/s Multiplex Biotech Pvt. Ltd., Bangalore, M/s Venkateshwara Chemicals, Secunderabad and M/s Agri Bio-Tech Research Centre, Kerala.

vii. Planning for the future

The QRT has made detailed suggestions for different centres which are included in consolidated recommendations under research.

D. OVERALL ASSESSMENT

The AICRP centres have done good research work on biological control of major pests of sugarcane, rice, cotton, pulses, oilseeds, vegetables, fruits, coconut and weeds. This was also substantiated by the way farming community have expressed their happiness and appreciation at various places indicating penetration of biological control technology at grass root levels. The project activities focused more towards research and extension on biological control of crop pests. The other component of the project, *i.e.* mass multiplication and supply of biological control agents has not received full attention and the outcome of the second component is less satisfying. The QRT is of the opinion that reasons for the short comings could be attributed to insufficient infrastructure and technical staff. During the XI plan period most of the centres have either upgraded their existing biological control laboratories or established new biological control laboratories for the mass production of several biological control agents and QRT strongly express their views that in the XII plan these facilities should be fully utilized for the mass production and utilization of biological control agents. Additionally all the centres should harness the possibility of training the nearby KVK staff in the mass production of biological control agents to facilitate meeting the local demands.

Some of the notable major outputs recognized by the QRT include the following:

1. TNAU, Coimbatore, MPKV, Pune and IIHR, Bangalore centres were actively involved in the management of papaya mealybug through classical biological control and the mealybug has been successfully suppressed in Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Maharashtra and Tripura. The farmers of Tamil Nadu alone have saved about Rs. 400 crores worth of crop according to their own assessment.
2. GBPUAS & T, Pantnagar centre has developed five commercial formulations of *T. harzianum* (PBAT-43), *P. fluorescens* (PBAP-27), *T. harzianum* & *P. fluorescens* (PBAT-43 +PBAP-27), *P. fluorescens* (PBAP-2 +3), *Beauveria bassiana* (PBB-1), developed field application method through FYM enrichment and supplied 3.5 tons of formulation to Tarai organic farmers' association for the management of foliar diseases of rice (neck blast, sheath blight, brown spot and sheath rot), chilli (anthracnose), chickpea, lentil, vegetable pea and wheat.
3. AAU, Anand, MPKV, Pune and TNAU, Coimbatore centres have successfully managed the pigeonpea cyst nematode (*Heterodera cajani*) through combined application of NBAII isolates of *T. harzianum* @ 5 kg /ha + *P. chlamydosporia* @ 20 kg /ha resulting in reduced eggs/ cyst population, seedling mortality and increased seed germination, plant height and yield.
4. AAU, Anand centre could effectively manage the nematode damage in pomegranate by combined application of NBAII isolate of *P. chlamydosporia* (100g/plant) and mustard cake (2 t/ha).

5. The Plassey borer of sugarcane could be effectively managed by nine releases of *T. chilonis* @ 50,000/ha at 10 days interval in Assam by AAU, Jorhat.
6. The PAU, Ludhiana centre has validated a BIPM package of practices to farmers of Punjab which include eight releases of temperature tolerant strain of *Trichogramma chilonis* @ 50,000/ha from April to June at 10 days interval for the management of early shoot borer, *Chilo infuscatellus* and eight releases of *Trichogramma japonicum* @ 50,000/ha from April to June at 10 days interval for the management of top borer, *Scirpophaga excerptalis.*
7. MPKV, Pune and AAU, Anand centres have validated a BIPM package consisting of seed treatment with *Trichoderma*, border rows of maize, erection of 10 bird perches/ha, release of *Chrysoperla*, spraying of NSK 5% suspension, SlNPV and three releases of *Tr. bactrae* for the suppression of sucking pests and boll worms.
8. ANGRAU, Hyderabad centre found out that pigeonpea intercropped with sunflower and border crop of sorghum recorded the least population of *H. armigera* larvae (23/10 plants) and higher yield (1256 kg/ha) compared to pigeonpea intercropped with sunflower and border crop of maize (42/10 plants) and the sole pigeonpea module (80/10 plants).
9. CTRI, Rajahmundry centre found that for satisfactory control of *Spodoptera litura* in tobacco nurseries, water with pH 6-8 to be used in *Sl*NPV spray fluid. Spray fluid with pH below 6 or above 8 was detrimental to SlNPV under field conditions.
10. SKUAS & T, Jammu centre could effectively reduce the plant damage by cutworm, *Agrotis ipsilon* by the application of *Heterorhabditis indica* @ 2 billion /ha with significant increase of grain yield in maize at Jammu.
11. MPKV, Pune, MPUAT, Udaipur, TNAU, Coimbatore, CAU, Pasighat and OUAT, Bhubaneshwar centres have confirmed effective management of *H. armigera* with increased yield of marketable tomato by the release of thelytokous strain of *Trichogramma pretiosum* @ 1 lakh/ha at weekly interval starting from 45 days after transplanting.
12. Leafhoppers on mango could be effectively managed by one spray of *M. anisopliae* @ 1 x 10^9 spores/ml on tree trunk during off season and two sprays during flowering season at weekly interval by TNAU, Coimbatore and IIHR, Bangalore centres.
13. The coconut leaf caterpillar *Opisina arenosella* could be effectively managed by sequential release of *Cardiastethus exiguus* and *Goniozus nephantidis* in Kerala by KAU, Thrissur centre.
14. The rhinoceros beetle of coconut was successfully managed by the integration of baculovirus targeting the adult population and application of *Metarrhizium anisopliae* in the FYM pits targeting the grub population by CPCRI, Kayangulam centre.
15. The diamond back moth, *Plutella xylostella* could be effectively managed by six releases of the exotic parasitoid, *T. brassicae* @ 1 lakh/ha in cauliflower and cabbage with a higher C:B ratio by AAU, Jorhat, MPKV, Pune, TNAU, Coimbatore and MPUAT, Udaipur centres.

E. CONSOLIDATED RECOMMENDATIONS

Research

Specific Recommendations

AAU, Anand

6. The centre should demonstrate its commitment as the reasons given for not conducting the experiments are not justifiable and appear very vague.
7. The centre should take concerted efforts to initiate survey, collection & diversity analysis of spiders in arid zones of India.

8. The mapping of EPN diversity in Gujarat should be initiated by AAU, Anand centre.
9. The centre should undertake evaluation of fungal and bacterial antagonists against collar rot of groundnut caused by *Aspergillus* spp. and *Sclerotium rolfsii*.

AAU, Jorhat

1. The PI knowledge in biological control is very much limited and need improvement
2. The newly established biological control laboratory does not appear to be involved in mass multiplication of the natural enemies which are required for their own field experiments as also for supplying to farmers.

PAU, Ludhiana

1. Evaluation of fungal and bacterial antagonists for the management of foot rot of citrus (kinnow) caused by *Phytophthora* spp and evaluation of fungal and bacterial antagonists for the management of fusarial wilt of cucurbits can be taken up by PAU, Ludhiana centre.
2. Release of *T. chilonis* and *T. japonicum* for the management of different borers of sugarcane is followed for the last five years. The centre has to assess the reduction in pesticide consumption due to release of these parasitoids.
3. The scientist, who is not part of biological control, presented the research achievements and left to foreign country. It is the responsibility of the Head of the Department to ensure that the concerned scientist present the project works.
4. In those field experiments recording low pest infestation, it appears that the pest is not a problematic one in that area.

IIHR, Bangalore

7. The institute is working on 43 horticultural crops whereas the biological control work is restricted to only a few crops. It would be more appropriate if the centre takes up more responsibility to cover other horticultural crops.
8. The centre should identify hot spots of major insect pests of important horticultural crops in the country and their natural enemies for futher exploitation.
9. The centre should initiate biological control work which can address the ecological dimensions, parasitoids: prey relationships, numerical responses that add meaning to the success or failure.
10. The centre should provide leadership to temperate horticulture where there is lack of human resource on natural enemies of these crops.
11. The centre should prepare a list of potential invasive pests of horticultural crops and their natural enemies for the benefit of other scientists working on biological control.

ANGRAU, Hyderabad

1. The centre had done excellent work in the production and supply of various biocontrol agents for various field experiments.
2. The centre had established excellent laboratory for the production of biological control agents and also the laboratory has been accredited as a referral laboratory by Government of Andhra Pradesh for biopesticide sample testing.

Note:(Recently FAO has approved Biochemical Pest Control Agents and Microbial Pest Control Agents for biopesticides based on the consultancy report of Dr.T.P.Rajendran, ADG (PP): Ref: FAO RAP Publication 2012/13 Guidelines for Harmonizing pesticide regulatory Management in Southeast Asia)

MPKV, Pune

1. Efforts should be made by MPKV, Pune to recover the parasitoid *Copidosoma koehleri* from the field and again build up the culture for future studies.
2. The centre should initiate biological control of whitegrubs in sugarcane in Maharashtra.
3. The centre should document the occurrence of citrus black fly in Maharashtra.

TNAU, Coimbatore

1. Documentation of natural enemies of spiraling whitefly in Tamil Nadu by TNAU, Coimbatore.
2. The centre is taking more experiments than it can handle. Instead the centre should take up few experiments and conduct in-depth studies.
3. Economic analysis and documentation of impact of release of *Acerophagus papayae* on papaya production, seed production, papain industry, mulberry and tapioca along with savings in cost of insecticide and their application should be done.

GBPAU & T, Pantnagar

1. Efforts should be made by GBPUA & T, Pantnagar to assess the performance of *Trichoderma* spp. in acid soils.
2. Proven isolates of *Trichoderma, Paecilomyces* and *Beauveria* developed by GBPUA & T, Pantnagar should be provided to other AICRP centres for multi-location trials.

CTRI, Rajahmundry

1. CTRI, Rajahmundry centre should document the extent of loss caused by tobacco stem borer *Scrobipalpa heliopa* and initiate planned research work on this stem borer.
2. CTRI, Rajahmundry centre should popularize *Sl*NPVthrough KVKs.
3. CTRI, Rajahmundry centre should document the natural enemies of aphids infesting different types of tobacco cultivated in different regions of the country.
4. CTRI, Rajahmundry centre should record of biological control agents (insects, pathogens) on *Orobanche* spp.

CPCRI, Kayangulam

1. Economic analysis of earlier experiments conducted on biological control of *Oryctes rhinoceros* and *Opisina arenosella* should be done by CPCRI, Kayangulam.
2. Forecasting model should be developed by the centre for the outbreaks of *Opisina arenosella* in Kerala and neighboring states including Karnataka.
3. KAU, Thrissur and CPCRI, Kayangulam centre should come out with a common package for the management of coconut pests.
4. The centre should come out with a status paper on scarlet mite on plantation crops.

KAU, Thrissur

1. Survey and collection of natural enemies of banana weevil and banana aphid, pollu beetle and root mealybug of pepper including Entomopathogens can be taken up by KAU, Thrissur.
2. KAU, Thrissur and CPCRI, Kayangulam centre should come out with common package s for the management of coconut pests.

SKUAS & T, 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 should be taken up by SKUAS & T, Srinagar and YSPUH & T, Solan.

2. There is lack of coordination between the two scientists working at this centre and AICRP may find it difficult to support such centre in future.

YSPUH & T, Solan

1. Evaluation of entomopathogenic fungi and EPNs for the suppression of apple root borer, *Dorysthenes hugelii* under field condition should be continued by YSPUH & T, Solan.
2. 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 should be taken up by SKUAS & T, Srinagar and YSPUH & T, Solan.
3. The field experiments conducted does not meet the minimum standards.
4. Problem choosing appears superficial and *there is a need for all round improvement.*

OUAT, Bhubaneswar

1. OUAT, Bhubaneshwar centre should document natural enemies associated with cashew tea mosquito bug and mango pulp borer.
2. Large cacti species are grown in Odisha and work should be initiated on natural enemies associated with mealybugs of cacti by OUAT, Bhubaneshwar.

General Recommendations

1. Many of the biological control centres are addressing only their regional mandate at a narrow radius, whereas the AICRP should cover entire region cutting across narrow state borders.
2. All the centres which report success of biological control should submit economic analysis with supporting data.
3. All the centres should report cost: benefit ratio along with statistical analysis for all the field trials conducted by them.
4. Economic analysis and documentation of impact of release of *Acerophagus papayae* on papaya production, seed production, papain industry, mulberry and tapioca along with savings on account of non use of insecticides should be done by TNAU, Coimbatore, MPKV, Pune and IIHR, Bangalore.
5. All centres should continue surveillance for alien invasive pests viz., *Brontispa longissima, Aleyrodicus digessi, Phenacoccus manihoti, Paracoccus marginatus and Phenacoccus madeirensis*.
6. The QRT observed that the yield levels in BIPM treatments across crops are either on par or less than pesticide treatments resulting in not recommending BIPM. Even though the yields are slightly low, biological control treatment has to be promoted as it reduces the pesticide load in the environment as also the harmful effects of pesticides on human and animal health are eliminated.
7. QRT recommends that NBAII should organize one week training programme on identification of natural enemies along with molecular systematics and DNA bar coding on a preferential basis to different AICRP staff.
8. QRT strongly feels that Andaman centre is not represented and CARI should be part of AICRP on biological control.
9. The work of biological control of whitegrubs by EPN seems to hold good promise and additional support and finance may be provided in the XII plan and AICRP on biological control and AINP on whitegrubs should work hand in hand in solving the problem.
10. Only approved pesticides by the Registration Committee should be selected for all comparative efficacy trials with biopesticides (Microbial pest control agents and Biochemical pest control agents) in the future programmes.

11. Efforts should be made to collect pesticides-tolerant strains of parasitoids from high pesticides use areas to facilitate selecting potential ones for further screening for tolerance for more number of pesticides. Studies with specific pesticide like Endosulphan, tolerant parasitoids may be discontinued as this pesticide is under review by the Supreme Court due to its inherent toxicity to human health and environment.

Organisation, structure and coordination

1. The QRT had detailed discussions with the project coordinator regarding closing certain centres, opening new centres and redeployment of scientific posts which are excess in some centres to other centres.
2. The Director, SBI, Coimbatore has expressed his opinion that SBI would not be a part of AICRP on BC. It is very unfortunate that when the biological control works for managing whitegrubs and borers on sugarcane is so critical, both ICAR institutes (SBI, Coimbatore and IISR, Lucknow) mandated to carry out research exclusively on sugarcane did not actively involve on biological control of sugarcane pests. ICAR should seriously view this unexpected trend by ICAR sister institutions and in case both SBI, Coimbatore and IISR, Lucknow do not express interest to participate in the biological control of sugarcane pests, the posts earmarked for the purpose should be transferred to NBAII.
3. The QRT also suggests for closure of one SAU based AICRP on Biological Control centre at JNKVV, Jabalpur as the performance of the centre is not up to the expected level and no post should be provided under AICRP.
4. The northern districts of Karnataka including Raichur, Bellary, etc. are cultivating agricultural crops on vast area it has become a hot spot area for very high chemical pesticides use. The QRT strongly recommends that a centre for AICRP on BC should be at UAS (Raichur) to initiate the work on BIPM.
5. It is suggested for creating one new centre with one scientific post (through redeployment) at UAS, Raichur (Karnataka) and two voluntary centres, one at NCIPM, New Delhi and another at CARI, Port Blair, Andaman & Nicobar Islands as AICRP on Biological control will have the future research collaborations at these centres.
6. It is suggested for downsizing the scientific posts at AAU, Anand (*one entomology scientist), PAU, Ludhiana (** two assistant entomologist posts) and Dr YSPUH & F, Solan (*** one entomology assistant professor post). These four posts will be re-deployed one each to CAU, Pasighat, OUAT, Bhubaneshwar, MPUAT, Udaipur and UAS, Raichur (new centre).
7. QRT recommended additional manpower (one scientific and one technical post and one personal secretary) in the XII plan in PC Cell located at NBAII, Bangalore.
8. To enable proper functioning of each centre there should be at least 2 scientists, 2 technical staff and 2 supporting staff. This would be the minimum requirement of staff for each centre.
9. The overall performance of various centres is given at Annexure III.
10. Contingency amount should be increased by 2.5 times to enable centres to meet increasing fuel, contingency for surveys, conduct large scale field experiments and other project related activities.
11. Budget for the project should be considerably increased in the XII plan to Rs. 3500 lakh.
12. Centres that transfer persons should be ensure that the vacant post is filled immediately.
13. The QRT suggests for up gradation of computers and their accessories at all centres.
14. The QRT suggests for replacement of old vehicles following proper protocol.

F. LIST OF ANNEXURES

ANNEXURE I

TERMS OF REFERENCE FOR QRT

1. To analyse growth of manpower, number of co-operating centres both in terms of funds as well as staff resources.
2. To critically examine and evaluate achievements of the AICRPs in research with reference to (i) focus on national programmes; (ii) multi-location testing; (iii) evaluation of pests and diseases; (iv) exchange of scientific information; (v) inter-institutional and interdisciplinary linkages; (vi) development of strategic plans; (vii) linkages with international programmes; (viii) information on technology base; (ix) encouragement and guidance by the PC; (x) off-season nursery facilities; (xi) healthy competition in Annual Workshops and professional challenge; (xii) quality of recommendations of the Annual Workshops (group meetings) and follow-up on those recommendations; (xiii) whether research is of routine nature on trodden path or they are breaking new grounds; (xiv) whether there is individual initiative; (xv) whether there is too much of regimentation/rigidity; and (xvi) whether the resources including manpower are optimally utilized.

Budget

3. To examine sufficiency of the budget of the Coordinating Centre as a part of the total budget of the SAU and of the ICAR.

Organization and Management

4. Integration of research – whether the work being carried out under the co-ordinating project derives full support from other related programmes, including basic and strategic researches.
5. What is the monitoring mechanism of the co-ordinated project in the co-operating centres to avoid distortions/duplication/overlapping in programmes of the AICRP and the SAU, including those at the regional stations?
6. Whether a strategic plan for the respective crop, commodity or natural resource with major emphasis on sustainability of production system developed by the co-ordinating unit in close collaboration with the co-operating centres?
7. How much operating funds does each scientist get under co-ordinated projects? Is it at least Rs. 60,000/- per scientist per year?
8. Whether the PC is located in the ICAR Institute or the SAU? Whether institute scientists working in co-ordinated projects form the cadre strength of the institute, and their work forms the priority work of the institute? Do they get additional fund for the travel for the work of co-ordinated project?

Annual Workshops (Group Meetings)

9. How the Annual Workshop is organized? Is it serving as a focus of generation of new ideas? Do the senior officials from the Departments of Agriculture and Extension attend workshops? Do scientists from private sector participate?
10. Is a policy brief prepared after the workshop for use by policy-makers and planners? If so, what has been the outcome? Does the co-ordinating unit maintain an extensive database on the crop/commodity/natural resource?
11. How is the HRD programme organized for the young scientists working in the Project and also other staff working in the project?

ANNEXURE II

QRT observations to the terms of reference

Sl. No.		Terms of reference	QRT observations
1		To analyse growth of manpower, number of co-operating centres both in terms of funds as well as staff resources.	The manpower in the project both at NBAII and the AICRP centres have remained constant. However, the QRT is suggesting closing three centres and redeploying the scientists in the new three centres. In the XI plan under AICRP, four voluntary centres were added without providing any manpower. Regarding funds, it has been recommended to increase by two and half times to the existing budget.
To critically examine and evaluate achievements of the AICRPs in research with reference to:			
2	i	Focus on national programmes	Both NBAII and AICRPs 20 centres are all involved in national programme
	ii	Multi-location testing	AINPs are basically multi-location testing centres.
	iii	Evaluation of pests and diseases	The centres have taken care to focus on existing pests and diseases causing economic loss and did not attempted on non significant pests and diseases.
	iv	Exchange of scientific information	NBAII emerged as centre of excellence in insect molecular taxonomy including DNA barcoding is exchanging the knowledge with several AICRP centres and also other SAUs.
	v	Inter-institutional and interdiscplinary linkages:	The NBAII has active collaboration with PAU, Ludhiana, AAU, Anand, RAU, Sriganganagar, UAS, Dharwad, UAS, Bangalore TNAU, Coimbatore, MPKV, Rahuri, CSR & TI, Mysore, NCIPM, New Delhi, ITC, Bangalore and CICR, Nagpur. AICRP centres are actively involved with their respective SAUs and ICAR Institutes of that area.
	vi	Development of strategic plans:	The NBAII has developed strategic plans for the biological control of sugarcane woolly aphid, papaya mealybug and eucalyptus gall wasp.
	vii	Linkages with international programmes	The NBAII/AICRP on BC has linkages with international institutes like USDA, CABI and AVRDC.
	viii	Information on technology base	The NBAII is having the latest information on technologies for the development of

			insect molecular taxonomy including DNA bar coding, commercialization of EPN and liquid formulation of Bt.
	ix	Encouragement and guidance by the PC	The NBAII is the source of strength for many scientists in respect of insect systematic and mass production of biocontrol agents and the Director of NBAII is the Project Coordinator for the AICRP on BC.
	x	Off-season nursery facilities:	Not applicable
	xi	Healthy competition in Annual Workshops and professional challenge	Annual workshops are regularly conducted in the beginning of the season and all the research experiments are reviewed and suitably modified.
	xii	Quality of recommendations of the Annual Workshops (group meetings) and follow-up on those recommendations	Recommendations of annual workshops are suitably incorporated in the technical programmes of the AICRPs.
	xiii	Whether research is of routine nature on trodden path or they are breaking new grounds:	Break through has been done in areas like papaya mealybug control, sugarcane woolly aphid control, eucalyptus gall wasp control, molecular taxonomy of insects and DNA barcoding.
	xiv	Whether there is individual initiative	Because of the personal initiative of the NBAII Director, break through has been done in controlling the papaya mealybug, sugarcane woolly aphid and eucalyptus gall wasp.
	xv	Whether there is too much of regimentation/rigidity	The coordinating centres have flexibility of conducting field trials in the farmers fields of their choice and also produce potential biocontrol agents at their laboratories.
	xvi	whether the resources including manpower are optimally utilized	Most of the AICRP on BC centres have optimally utilized the man power. In cases where the man power is not optimally utilized are suggested for redeployment.
Budget			
3		To examine sufficiency of the budget of the Coordinating Centre as a part of the total budget of the SAU and of the ICAR.	Several AICRP centres could not undertake surveys due to shortage of contingency grant for hiring vehicles. The QRT recommends for adequate funding under contingency in the XII plan.
Organization and Management			
4		Integration of research – whether the work being carried out under the co-ordinating project derives full support from other related programmes, including basic and strategic researches.	NBAII is focusing both on the strategic and basic research related to the biological control of crop pests and diseases.

5		What is the monitoring mechanism of the co-ordinated project in the co-operating centres to avoid distortions/duplication/overlapping in programmes of the AICRP and the SAU, including those at the regional stations?	While formulating the technical programme, distortions/ duplication and overlapping is avoided at different coordinating centres.
6		Whether a strategic plan for the respective crop, commodity or natural resource with major emphasis on sustainability of production system developed by the coordinating unit in close collaboration with the co-operating centres?	The experiments were planned for the coordinating centres keeping in view the major crops grown by the state where the centre is located.
7		How much operating funds does each scientist get under co-ordinated projects? Is it at least Rs. 60,000/- per scientist per year?	All the coordinating centres are governed by the guidelines of ICAR.
8		Whether the PC is located in the ICAR Institute or the SAU? Whether institute scientists working in coordinated projects form the cadre strength of the institute, and their work forms the priority work of the institute? Do they get additional fund for the travel for the work of co-ordinated project?	Project coordinator is located in the ICAR institute and scientists in ten coordinating centres are located from the SAUs, 6 coordinating centres are located in the ICAR institutes and four voluntary centres located in SAUs, no staff has been provided.
Annual Workshops (Group Meetings)			
9	i	i)How the Annual Workshop is organized?	For the annual workshop of biological control workers group meeting, scientists from the SAUs, State agricultural departments and private industry were invited. After detailed discussions, identified the strategic problems and technical programmes are drawn for the next year. **The Director, NBAII** organized one day national meeting on Agricultural Entomology for 21st Century at NBAII, Bangalore wherein more than 300 entomologists working across India have participated and drawn future research programmes in agricultural entomology and the proceedings has been approved by the Council and suitably incorporated in the technical programme of the AICRP/ AINPs.
	ii	Is it serving as a focus of generation of new ideas?	Yes

	iii	Do the senior officials from the Departments of Agriculture and Extension attend workshops?	Many a times they do not attend
	iv	Do scientists from private sector participate?	Yes, if the research is concerned to them
10	i	Is a policy brief prepared after the workshop for use by policy-makers and planners?	Does not arise as such policy brief is available
	ii	If so, what has been the outcome?	Not applicable
	iii	Does the co-ordinating unit maintain an extensive database on the crop/commodity/natural resource?	The coordinating unit has new data base on crop commodity and natural resources.
11.		How is the HRD programme organized for the young scientists working in the Project and also other staff working in the project?	The NBAII which is a coordinating unit has conducted 5 days training programme for the scientists at the four new centres and also the young scientists who are posted in the AICRP/ AINP centres.

Annexure-III

Interaction of QRT Members with stake holders

1. The QRT members interacted with farmers of Paprali village, near Co-operative sugar mill, Morinda, LUDHIANA

The QRT visited AICRP- Biocontrol Centre, PAU, Ludhiana on 16th- 18th April, 2012 to review the research work of five years (2007 to 2012). On 17th April, 2012, QRT visited Co-operative Sugar mill, Morinda and sugarcane field area in village Paprali and interacted with the farmers. About 100-120 farmers reached the interaction site and during interaction farmers expressed their full satisfaction regarding BIPM in sugarcane.

QRT members group discussion with the farmers

During field visit of QRT, farmers were very much convinced with the efficacy of *Trichogramma chilonis* and *T. japonicum* against sugarcane borers. Farmers elaborated the success of BIPM in sugarcane as the incidence of stalk borer has been reduced considerably along with a decline in insecticidal consumption. Several farmers shared their individual experiences with the team members. A farmer Amarjeet Singh told that he is practicing BIPM in sugarcane since last 15 years and was very much convinced with the efficacy of *Trichogramma chilonis* against stalk borer. Similarly the farmers Bhupinder Singh and Mahinder Singh showed their BIPM fields to QRT and were satisfied with adoption of BIPM in sugarcane. They exhibit how they are practicing the intercropping of onions in their sugarcane fields. They further discussed many innovative ideas of intercropping in sugarcane with the team members. The farmers appreciated the efforts of PAU entomologists in conducting the BIPM practices in collaboration with Morinda Sugar Mill on an area of 500 acres during the year 2011-12 alone and they were convinced with the adoption of BIPM in sugarcane as they could curtail the use of pesticides by 59.6 percent. The biocontrol unit established at Morinda Sugar mill under the technical guidance of Biological control unit of Department of Entomology, PAU, Ludhiana is going to increase their production of bioagents and will cover 2000 acres during 2012-13.

During interaction, farmers also expressed their desire for training in mass production of bioagents. They showed their willingness to cover more and more area under biocontrol programme not only in sugarcane but also in other crops like rice, maize and vegetables to reduce insecticidal load and improve their financial status. The director NBAII and other team members intermingled with the farmers personally and were surprised to see the interest of farmers in biocontrol programmes.

The farmers enquired from them about other technologies being developed by NBAII. Director NBAII immediately opened his laptop and showed the farmers about the various programmes running at NBAII and in other parts of the country. This gesture of him touched the hearts of the farmers and they are now demanding to attend the training programmes at NBAII, Bengaluru. Some of the farmers showed keen interest in the protected cultivation of vegetable crops especially in bell pepper and asked Director NBAII to arrange some training at Bengaluru. The team members in their interaction with the farmers encouraged them to form small cooperative units for the mass production of biocontrol agents so more and more area under different crops should come under biocontrol umbrella and the response was instantaneous. They also requested the team to arrange a platform where farmers from other states of India, who have adopted the BIPM programmes, could come and share their experiences and benefits after adopting the programme. QRT members and scientists of Biocontrol section, PAU Ludhiana discussed and shared the various BIPM technologies developed and recommended in the Package and Practices of PAU with the farmers in Sugarcane, organic rice and maize crops. This Package is a very important tool for disseminating the BIPM technologies as farmer's and Government agencies in the state follow these recommendations. Farmers' also thanked PAU scientists and sugar mill management for their interest and timely help to them. After the field visit the team visited the biocontrol laboratory at Morinda sugar mill and sees the rearing of rice moth, *Corcyra cephalonica* and production of trichocards. Thus, the QRT team of ICAR was satisfied with the encouraging response of the farmers and the adoption of BIPM in sugarcane.

2. QRT interaction with Shri. Dattatraya Haribhau Kand, papaya farmer,Loni-Kand, Maharashtra

The QRT visited the papaya orchard of Shri. Dattatraya Haribhau Kand, At & Post – Loni-Kand, Tal. Haveli, Dist. Pune. The farmer planted Taiwan-786 (red lady) papaya. When the papaya plant is 6 months old, mealybug, *Paracoccus marginatus* incidence was noticed and immediately the parasitoid, *Acerophagus papayae* was released. When the QRT visited, the mealybug was under control and the farmer said that he will not get crop for next three months i.e. 25-30% of total yield is lost. Had he not released the parasitoid, he would have lost entire crop. According to the farmer the total yield from one hectare (2000 plants) would be 1,25,000 kg (@ 50 fruits/plant and 1.5 kg/fruit) which translates into Rs. 12,50,000 (@Rs. 10/kg). He would have lost all the money had he not released the parasitoids. Now by releasing the parasitoid, he says that he cold harvest 17,500 less fruits which translates into 26,250 kg fruit loss and Rs. 2,62,500 loss (@Rs. 10/kg for 26,250 kg fruits). The benefit accrued to the farmer due to release of the parasitoid is Rs. 9,12,500 (Rs. 12,50,000 – Rs. 3,37,500) including the cost of weedicides.

ANNEXURE – IV

EVALUATION PROFORMA FOR THE CENTRES

Centre……..

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks assigned
1	Staff position and vacancy		10	
2	Research achievements in terms of technical programme		10	
3	Quality of work output		10	
4	Quantity of work in relation to staff in position		10	
5	Technologies developed		10	
6	Technologies adopted		10	
7	Infrastructure and facilities developed		10	
8	HRD		05	
9	Extension activities		10	
10	Publications		05	
11	Utilization of budget		10	
		Total	**100**	

Any other general remarks, comments, suggestions for the improvement/strengthening the centre:

Overall assessment and remarks on continuation of the centre:

Date: Signature of the QRT Chairman

ANNEXURE - V

OVERALL PERFORMANCE OF CENTRES

Sl. No.	Centres	Overall performance
	State Agricultural University-based centres	
1	Anand Agricultural University, Anand	Good
2	Kerala Agricultural University, Thrissur	Very Good
3	Punjab Agricultural University, Ludhiana	Good
4	Sher-e-Kashmir University of Agricultural Sciences & Technology,Srinagar	Good
5	Acharya N G Ranga Agricultural University, Hyderabad	Very Good
6	Dr.YS Parmar University of Horticulture & Forestry, Nauni, Solan	Average
7	Tamil Nadu Agricultural University, Coimbatore	Very Good
8	Assam Agricultural University, Jorhat	Good
9	Mahatma Phule Krishi Vidyapeeth, College of Agriculture, Pune	Very Good
10	Govind Ballabh Pant University of Agriculture and Technology, Pantnagar	Very Good
	ICAR Institutes-based centres	
11	Indian Institute of Horticultural Research, Bangalore	Good
12	Sugarcane Breeding Institute, Coimbatore	Average
13	Indian Institute of Sugarcane Research, Lucknow	Average
14	Central Tobacco Research Institute, Rajahmundry	Good
15	Central Plantation Crops Research Institute, Regional Station, Kayangulam	Good
16	Indian Agricultural Research Institute, New Delhi	Average
	Voluntary centres	
17	Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur	Average
18	Maharana Pratap University of Agriculture & Technology, Udaipur	Good
19	Central Agricultural University, Pasighat, Arunachal Pradesh	Good
20	Orissa University of Agriculture & Technology, Odisha	Good