REPORT OF THE QUINQUENNIAL REVIEW TEAM

ON

ALL INDIA COORDINATED RESEARCH PROJECT ON BIOLOGICAL CONTROL OF CROP PESTS AND WEEDS

2012-2017

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ICAR - NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES

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AICRP on Biological Control of Crop Pests and Weeds

QRT Executive Summary of
Performance Review and Recommendations

ICAR constituted the Quinquennial Review of the National Bureau of Agricultural Insect Resources (NBAIR), Bangalore and AICRP on Biological Control for the period 2012-2017, by a team of eminent experts with Dr. J.H.Kulkarni as Chairman and Dr. Mohd. Hayat, Dr. V. V.Ramamurthy, Dr. R.S.Gill, , Dr. H.B.Singh, Dr. Lalith Achooth and Dr. K.Srinivasa Murthy (Member Secretary) as members. From July 2017 members of the QRT visited and reviewed the work of 11 AICRP centres and PC Unit for the period from 2012-2017. Team members evaluated the mandate of the project, performance, assigned research activities to each centre, physical facilities and human resources under the project and financial support provided. 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 26 scientists and 27 technical staff and 2 supporting staff working across the country in sixteen centres (list included). 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. 1924.29 lakhs, out of which Rs. 70.39 lakhs; was spent on TA and Rs. 212.67 lakh as recurring contingency.

Overall performance rating of the project

The AICRP programme on biological control has focused on developing biocontrol technologies for the management of different crop pests and diseases (sugarcane, rice, cotton, pulses, oilseeds, vegetables, fruits, coconut and weeds). Efficient methods of mass multiplication of parasitoids, predators and pathogens against insect pests and antagonists against plant pathogens and plant parasitic nematodes have been developed. The project activities involved research and extension about biological control of pests of crops. This was achieved through mass multiplication and supply of biological control agents, large scale field demonstrations and validations under farmers field conditions. The field demonstartions through AICRP centres have increased the awareness of farmers regarding the usefulness of biological control based pest management. The examples include , BIPM technology for sugarcane borers transferred to sugar mills in Punjab, the pest management in paddy at Adat Panchayat in Kerala, sustenance of classical biological control of papaya mealy bug through conservation of *Acerophagous papayae*, management of Eucalyptus gall wasp, use of pesticide and temperature tolerant strains of bioagents in 12 states, management of white grubs through EPN and pod borers by the use of liquid Bt. formulations. The utilisation of biocontrol agents and adoption of the technologies is promoted through intensive extension activities and linkages with other departments/organizations.

The co-ordinated project provides appropriate platform for research ,exchange of live materials such as bioagents for introduction, efficacious use and integrated efforts on the monitoring and management of invasive pests. The technologies generated are extremely useful to farmers as well as researchers. The AICRP is the only biocontrol based project in the country which is highly relevant considering the current thrusts on sustainable agriculture

and pollution free environment. Further, under organic farming systems biological control provides an ecologically acceptable alternate way for bio-suppression of crop pests to produce residue free crop.

I. Highlights of the research achievements of the project during the period under report (2012-2017).

- **ANGRAU, Anakapalle** was actively involved in the management of sugarcane borers. Trash mulching + *T. chilonis* release @ 50,000/ha from 30 DAP for 6 times and 2 releases after node formation and Trash mulching + *T. chilonis* release @ 75,000/ha from 30 DAP for 6 times and 2 releases after node formation are effective in managing shoot borers in sugarcane with high incremental benefit cost ratio.
- Empowering women farmers and tribal farmers with input supply and implementation of biological control and IPM strategies was the most significant that enabled high returns and socioeconomic status of the farmers

- **CAU, Pasighat,** Stem injection of CAU-1 strain of EPN with 30.5 % reduction in damage of citrus trunk borer. The stem injections of the EPNs were found more effective than their respective cadaver treatments.
  Bacterial wilt of brinjal could be sucessfully managed with seedling root dip + soil drenching of *Pseudomonas fluorescens* (CHF*Pf*-1)..

- **AAU, Jorhat**, The plassey borer *Chilo tumidicostalis* couild be effcetively managed by eleven releases of *T. chilonis* @ 50,000/ha at 10 days intervals from June to November. Reduction in damage to the tune fo 13.5% was obtained with increased cane yield 70.4 -73.3 t/ha
  Application of *Steinernema riobrave* @ 250 ml/pot in aqueous form resulted in 50.2 per cent mortality of *Scirpophaga incertulus* and 42.9 per cent mortality of stem borer *Cnaphalocrosis medinalis*.
  Applicationj of *Beauveria bassiana* (NBAIR-Bb-5a strain) resulted in reduced damage (15.5%) by *Dorylus orientalis* and by *Agrotis ipsilon* (17.25%) with an yield of 85.00 q/ha, Foliar sprays of *B. bassiana* Bb5a has minimized significantly the damage of sucking pests in hot chilli and improved the yield (51.29q/ha)
- **AAU, Anand**, The pigeon pea pod borer, *Helicoverpa armigera* could be effectively suppressed by spraying NBAII-BT G4 at 2% concentration. Maximum grain yield of 1775kg/ha was obtained.
  Application of *Beauveria bassiana* or *Verticillium lecanii* @ 40 g/ 10 liter was effective in reducing the incidence of jassid, whitefly, aphid and thrips population per leaf in cotton and yield was on par with the chemical treatment.
  The mustard aphid was effectively suppressed with treatment of *B. bassiana* + *L. lecanii* @ 5g/ liter (1.88) with highest seed yield (9.66 q/ha) followed by *L. lecanii* + *M. anisopliae* @ 5g/ liter (9.24 q/ha).. Seedling dip and foliar spray of *Pichia guilliermondii* (Y12) resulted in low anthracnose disease intensity (6.23 %) and higher yield (83.27 q/ha)..

- **Dr.YSPUH & F, Solan** Soil application of *B. bassiana, M. anisopliae, H. indica* and *Steinernema carpocapsae* resulted in low potato tuber damage by the white grubs (31.4-38.0%) as compared to control (59.2%).
  Entomopathogenic fungi and EPNs suppressed the Apple root borer, *Dorysthenes hugelii*.. Grub mortality of 74.4% was achived with the application of *Metarhizium anisopliae* (10^6 conidia/cm^2)., as against 8.5 per cent in untreated control.
  Heterorhabditis indica and *Steinernema carpocapsae* (80 IJ/cm^2 each) were moderately effective
  The rose aphid, *Macrosiphum rosaeiformis*, could be effectively suppressed by azadirachtin (1500ppm; 3ml/L), *Hippodamyia variegata* (10 beetles/plant) and *Lecanicillium lecanii* (5g/L of 108 conidia/g) were equally effective resulting in 50.8 to 69.1 per cent reduction in the aphid population.

- **SKUAS&T, Kashmir**, Root dip treatment of tomato seedlings with *Paecilomyces lilacinus* @ 2.0 x 10^8 spores/ litre of water 15 minutes before transplantation significantly decreased the soil population of root-knot nematodes, *Meloidogyne hapla* by 85% and increased the yield up to 84%

  Two sequential releases of *Trichogramma* spp. @ 2500- 3000 adult wasps/ tree and twice use of pheromone traps @ 4 traps/ orchard effectively suppressed codling moth, *Cydia pomonella*

  Five weekly releases of 2^{nd} instar grubs of *Coccinella septumpunctata* @ 5/plant. Resulted in maximum reduction (68.2%) of cabbage aphid under polyhouse conditions.

- **KAU, Thrissur**, Treatment with *Metarhizium anisopliae* and *Beauvera bassiana* @10^8 spores/ml was effective against banana pseudostem weevil, *Odoiporus longicollis*

  The IPM practices (*Pseudomonas fluorescens* @ 10 g/kg of seed, followed by five releases of *Trichogramma japonicum* @ 1 lakh/ha starting from 20 days after transplanting or 40 days after sowing) recorded higher incidence of natural enemies and resulted in reduction in stem borer population in rice by 37%.

  The fungus *Lecanicilium lecanii* @ 10^9 spores/ml effectively suppressed the pine apple.root mealy bug *Dysmicoccus brevipes*.

- **MPKV, Pune,** Three sprays of *M. anisopliae* @ 10^8 cfu/ml or six releases of *Blastothecus. pallescens* @ 20 nymphs/m rows reduced the thrips, *Thrips tabaci* population in onion .

  Spraying of *M. anisopliae* @ $1x10^9$ spores/ml during offseason reduced the population of mango hoppers (10.4-12.0) and increased the fruit set (11.8-12.0 per inflorescence) .

Release of *T. chilonis* @ 50,000 parasitoids/ha followed by spraying of NSKE 5% and *B. thuringiensis* @ 1 lit./ha twice at weekly interval effectively suppressed the brinjal fruit and shoot borer, *Leucinodes orbonalis*

- **OUAT, Bhubaneshwar**, Release of anthocorid predator, *Blaptostethus pallescens* @ 30/plant both in brinjal and okra effectively reduced the mite, *Tetranichus urticae* population in brinjal.
  Releases of egg parasitoid *Trichogramma chilonis* @ 1 lakh/ha against ESB and internode borer (IB) and *T. japonicum* against TSB at 10 days interval starting from 30 DAG on sugarcane was effective in reducing the borers

  Application of *Metarrhizium anisopliae* @ 2×10^8 cfu followed by Bt spray @ 1 kg/ha reduced the sucking and fruit borer pests in Okra

- **PAU, Ludhiana**, Sequential release of Tricho cards of *T. chilonis* (tts) @ 50,000/ha during July-October resulted in reduction of 57.4% of stalk borer, *Chilo auricilius* incidence in sugarcane.

  Release of anthocorid predator, *Blaptostethus pallescens* @ 30 nymphs/ m row along with chemical control (Omite 750 ml/ha) could effectively manage the two-spotted spider mite, *Tetranychus urticae* on okra.

  Application of botanical (Neem baan 1% @ 1250 and 1500 ml/ha) and biopesticides (*Lecanicillium lecanii* 2% AS and *Metarhizium anisopliae* 1% WP @ 1200 ml/ha) was effective in suppressing cotton whitefly.

- **MPUAT, Udaipur**, Application of *Bacillus thuringiensis kurstaki* @ 1 kg /ha, followed by spray of *Nomuraea rileyi* @ 1.5×10^{13} conidia/ha with a second spray of SlNPV @ 1.5×10^{12} POBs/ha was more effective in reducing *Spodoptera litura* population in sunflower.

  Four release of *T. chilonis* @ 150000 parasitoids/ha at 10 days intervals starting from 25^{th} days after germination was most effective in suppressing the maize stem borer, *Chilo partellus*
  Soil application of *Metarrhizium anisopliae* followed by two sprays of NSKE 5% effectively suppressed the major soybean pests.

- **TNAU, Coimbatore,** Releases of coccinellid beetle, *Stethorus pauperculus* and predatory mite, *Amblyseius* sp @ 10 and 5 mites/ plant were effective in reducing two spotted spider mite, *Tetranychus urticae* followed by *Beauveria bassiana* 10^8 CFU/ ml spray.

  Talc formulation of *Metarhizium anisopliae* of IIHR strain @ 1kg/100L recorded 77.1 per cent mortality of mango hoppers

The application of EPN (NBAIR formulation) 20kg/ha along with *Metarhizium anisopliae* (NBAIR formulation) 5kg/ha mixed with 250 kg FYM/ha was superior which recorded 87.74 per cent reduction of ash weevil in brinjal

Application of *Beauveria bassiana* (NBAIR formulation) at 5g/ litre of water along with 6 releases of *Trichogramma chilonis* at 10 days interval from bud initiation stage suppressed the jasmine bud borer with minimum bud damage of 2.9 per cent

- **PJTSAU, Hyderabad,** Releases of *Trichogramma chilonis* @ 75,000 and 1,00,000 parasitoids per ha) at 15 Days after seedling emergence , three times at weekly interval was effective in reducing maize stem borer *Chilo partellus* damage with higher cob yields.

  Soil application of *Metarhizium anisopliae* @ $5x10^{13}$ spores/ha (42.9%) was effective in the management of termites in sugarcane with increased the cane germination upto 42.9%.

  FYM enriched *Metarhizium anisopliae* @ $5x10^{13}$ spores/ha at one month after ratooning, reduced the white grub, *Holotrichia consanguinea* damage and its grub population (1.4% and 1.7 grubs/10 m row)

- **GBPUAT, Pantnagar**, The invert emulsion based *Trichoderma* formulation (IEF2) was found most effective in managing seed and seedling mortality in chickpea due to wilt disease.

  Trichoderma isolates, Th-14, Th-89, Th-82, TCMS 43, TCMS 9 and TCMS 36 were found most effective in reducing rice sheath blight by 60 per cent and brown spot disease by 50 per cent in rice.

  Trichoderma harzianum (Th-3) and *Pichiaguillier mondii* (Y-12) isolate was effective in reducing fruit rot incidence and increasing yield of Chilli.

- **UAS, Raichur**, Application of NBAII *Bt* strain (NBAII BTG 4) @ 2% effectively suppressed pigeon pea pod borer, *Helicoverpa armigera*.

  Biocontrol agents like *Trichogramma* (500 cards), *Metarhizium anisopliae* (350 Kg) and *Beauveria bassiana* (300 Kg) were produced and demonstrated in sugarcane and rice ecosystem.

  In collaboration with KSDA, Ballari successfully demonstrated and managed the root grub in sugarcane (210 acre) in Hampsagar by using *M. anisopliae* (2016-17). Similarly, following biocontrol agents like *Trichogramma* (1000 cards), *Metarhizium anisopliae* (300 Kg) and *Beauveria bassiana* (3750 Kg) were produced.

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

- **ANGRAU, Anakapalle**

1. Sugarcane community fund – under sugar mills can be explored for the activities related to biological control of sugarcane pests.
2. Data to be generated on resources supplied to the farmers, area of adoption, benefits obtained and economics.
3. Important to map the visibility of bioagents – the spread and adoption rates to be quantified to indicate the impact of the technologies.

- **AAU, Anand**

1. Vice Chancellor AAU expressed interest in providing funds for generating toxicological data for the NBAIR isolates of biopesticides. To explore the possibility of preparing a joint MoU between AAU and NBAIR for the same.
2. Standard chemical check to be included in all experiments.
3. Quantification of spider diversity and its predatory potential and relationship with pest incidence are to be included.
4. Production of macrobials to be intensified.

- **AAU, Jorhat**

1. Search for local isolates/strains of bio agents.
2. Success story on biocontrol of cabbage diamond back moth and potato cut worm to be prepared in three months' time and to be hosted on University and ICAR-NBAIR websites.
3. Centre to strengthen the mass production program for tricho-cards and other biocontrol agents.
4. Networking with state Biocontrol labs and KVKs for mass production and dissemination of proven technologies.
5. Identified duplicate specimens may be sent to ICAR-NBAIR museum.
6. The centre should focus on supply of biocontrol agents to farmers.

- **PJTSAU, Hyderabad**

1. Spider fauna recorded may be identified in collaboration with NBAIR.
2. The trials on maize with biocontrol agents may be dropped/deleted as there is no pest incidence.
3. Local strains of *Metarhizium* and *Lecanicillium lecanii* may be provided by the centre for evaluation by other centres.
4. Monitoring of the programmes must be ensured based on the requirements of the farmers
5. The biocontrol recommendations may be included under the package of practices of the University.

- **PAU, Ludhiana**

1. Success stories on Organic Basmathi, Maize and Sugarcane to be disseminated through booklets and University website
2. White fly genetic groups to be checked and to be related with early and late sown crops.
3. Parasitisation of white flies to be studied in detail.

- **MPKV, Pune**

1. The centre should have tie up with biocontrol agent producers. Important to compare the local commercial products with the products formulated by the centre.
2. Status paper on quality control of biopesticides to be prepared. A programme has to be launched to take up Quality analysis of commercial products without revealing the source of the products.

- **TNAU, Coimbatore**

1. Parasitism to be measured as percentage parasitism (not as number of adults emerged / percent adult emergence).
2. Status of pin worm *Tuta absoluta* in Tamilnadu to be re-checked in Erode and surrounding areas.

- **GBPUA & T, Pantnagar**

1. To aim towards commercialisation and registration of potential isolates. The centre to generate toxicology data for the potential isolates through applying for lateral funding. The potential isolates to be shared with other AICRP/Institutes for generation of field efficiency data in different agroecological zones.
2. To prepare success stories for the potential isolates PBAT-3 and PBAT-14 in English and local languages and put up on website of University and NBAIR.

- **KAU, Thrissur**

1. Promising microbials may be supplied/distributed to farmers on a non commercial basis (free of cost)
2. Technical bulletins/brochures to be brought out in local languages for wider dissemination, on the value of bio-control agents.
3. Budgetary support for meeting the registration costs for biopesticides may be provided. Financial support for popularizing biocontrol agents may be sought from funding agencies viz. RKVY and MOEF.

- **SKUAS & T, Srinagar**

1. Strengthen mass production of EPN and supply to farmers.
2. A complete comprehensive management protocol for codling moth to be prepared.
3. Success story on Codling moth management, to brought out in three months time and put up on University/NBAIR website.
4. The technology for predatory mite production developed at YSPUHF to be

adopted at SKUAST.

5. Unidentified species of natural enemies including spiders to be sent to NBAIR for identification.
6. Identified duplicate specimens may be sent to NBAIR museum.
7. Attempts to be made to publish/patent the refined production structure for *Corcyra* developed by the centre with supporting data.

- **YSPUH & F, Solan**

1. Search for local isolates/strains of bioagents.
2. Success story to be prepared on apple root borer in three months time.
3. To strengthen mass production programme for *Metarhizium* and predatory mites.
4. Net-working with state Biocontrol labs and KVKs for mass production and dissemination of proven technologies.
5. It was recommended that the pathology/nematology component can be included for the centre for specific crops without any additional financial commitment.
6. The centre should focus on supply of *Metarhizium* and mites to farmers.

- **OUAT, Bhubaneshwar**

1. Adequate funding support to be provided by the University for the AICRP-BC work.
2. Experiments on plant disease management with *Trichoderm*a and other biocontrol agents may be taken up. Strains from NBAIR to be evaluated.
3. A new PI for the biocontrol project to be identified at the earliest as the current PI is due for retirement.
4. Centre to focus on few bioagents with larger coverage area to be followed up with proper monitoring.

- **MPUAT, Udaipur**

1. To prioritize crop/pest/ bioagents for future work.
2. To focus on production of specific bioagents, maximum area coverage and farmers involvement in the field trials.

- **UAS,Raichur**

1. Continuous monitoring of treated fields during successive seasons
2. Quantified data to be prepared on area covered with bio-agents, number of farmers benefitted, economic benefits and impact analysis.

- **CAU, Pasighat, Arunachal Pradesh**

1. Experiments on rice may be stopped as pest incidence for last 3-4 years is much below ETL level, and work on *Pseudomonas* may be continued for rice blast disease.
2. Since the PI is having Nematology background, it was suggested that PI should propose experiments on nematology work in one month's time and this should be incorporated in AICRP-BC technical programme for 2017-18 & 2018-19 e.g. Management of Root-Knot nematodes in vegetables.

3. More emphasis should be on documentation of diversity that includes both insect pests and natural enemies.
4. Unidentified species of natural enemies including spiders to be sent to ICAR-NBAIR for identification.
5. Identified duplicate specimens to be sent to ICAR-NBAIR museum.

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

- All the centres which report success of biological control should submit economic analysis with supporting data.
- Accountability for contingencies to be provided for AICRP centres.
- Safety precautions to be followed by all workers while handling bio-agents/biopesticides
- Digitization of data and submission by all co-ordinating centres
- Production of macrobials and microbials and area coverage to be committed as fixed targets to commensurate with the contingency funding.
- All centres should contribute towards the NBAIR museum in terms of specimens/digitized materials.
- When required, Young Professionals may be hired as per ICAR norms for SAU centres.
- Sucess stories in English, Hindi and local languages to be sent to ICAR-NBAIR and respective Universities for putting up on the websites.
- Attempts to be made to include all proven technologies brought out by the respective AICRP centre in the University package of practices.
- Attempts to be made to register/commercialise the proven isolates/technologies
- All centres should document the quantum of production and supply to farmers and area covered under biocontrol. Farmer feedback on impact should also be documented. This information should be presented in all reports.
- Cost-benefit to be documented not only in terms of economics of actual cost involved and profit, but also based on environmental safety since, North Eastern region is mainly focusing on organic farming.

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

- The project Coordinator is of the opinion to redeploy existing scientific staff and downsize them. The contingency grant provided for the centres should be increased.
- To enable proper functioning of each centre there should be an increase in the manpower in terms of technical and supporting staff.
- Sufficient funds may be allocated for voluntary centres to carry out the activities.
- Budget for the project should be considerably increased to carry out field surveys and demonstrations under the programmes.

The overall performance of various centres is given at Annexure-III.

1. **SWOT Analysis of the Project**

Strength

I. Our country holds vast diversity in cropping systems, agro ecologies and agri business opportunities AICRP on biological control has successfully demonstrated the benefits 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.

II. Presently all AICRP centres have either strengthened their existing laboratories 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. The potential of these biogents have been demonstrated across the country covering wide range of crops with comparative studies on chemical control.

III. NBAIR- nodal centre of AICRP-BC holds a rich repository of biological agents and the expertise in the field of biological control.

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. Many more have been recorded from different parts of the country through the AICRP-BC cedntres.

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. The potential of the biocontrol agents is being realised by more number of farmers who are switching over to organic farming. Conservation practices with crop habitat management strategies are gaining ground to effectively use the bioagents and reduce the necessity to use toxic insecticides. Further, augmentation of natural enemies leads to enhancement of the existing biodiversity of natural enemies and adds value to the crops protected.

Weaknesses

I. Identification of the pest and their natural enemy complex is a prerequisite for any successful classical biological control programme. The role of biosystematics is of prime importance for knowledge build-up in the field of biodiversity. Insect taxonomists' particular to each group must be engaged considering the vast diversity of insects and their natural enemies. Though NBAIR now holds a good number of taxonomies on specific groups, more taxonomists on some important pest and natural

enemy groups are lacking.

II. There is lack of awareness about the long term beneficial effects of use of parasitoids, predators and microbials for the suppression of crop pests. The inherent lacunae of the bioagents, the timing of releases coinciding with the stage of the pest under field conditions, the gap between demand and supply needs to be addressed for convincing the farmers. Educating the farmers on the long term benefits of these organisms and environmental safety continues to be challenging task with the marketing strategies by the pesticide insdustry.

III. The shelf life of the biaogents, availability, production on commercial scale to meet the yawing gap between demand and supply needs to be addresssed.

Opportunities

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

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. The development of liquid formulations of *Bacillus thurigiensis.* has given new opportunity for enhanced usage for the management of several lepidopteran pests of crops.

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

V. 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

Threats

I. The introduction of alien invasive pests like *Brontispa longissima, Aleurodicus dugesii* and *Phenacoccus manihoti,* is a major threat. The absence of a declared policy in recognizing biological control as a high priority area in pest management is another major constraint.

II. 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. The absence of proper evaluation of the harmful effects of new insecticide molecules on the natural enemies and other components of environment is likely to pose greater danger to the bio diversity and natural resources of the country.

III. The biggest threat to biological control is from the continued and indiscriminate use

of broad spectrum pesticides which decimate the population of natural enemies .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.

I. Co-ordinating Unit and Governance of the project

Based on the report submitted by the project coordinator, the QRT observed that:

The present Project Coordinating Unit is functioning at NBAIR, Bangalore as an administrative unit fully catering to the technical needs of the project. The Director, NBAIR by default is the Project Coordinator to review the progress of research and extension activities of the various AICRP centres.

The coordinator visited different centres at frequent intervals and conducted the Annual group meeting of the biological control AICRP during May-June of each year. The progress is monitored, reviewed and appropriate midcourse modifications are incorporated in the technical programme for every two years. Subsequent changes were also made in the technical programme as and when felt necessary.

II. Future of the project

An integrated Intensive farming system has been the order of present cultivation practices of crops. Sustainable farming with environmental protection and safety concern is a challenging task. Now all stake holders have realized that the usage of pesticides to contain pests and diseases is not a solution as the common man is concerned for envirinmental safety and hazards involved.

Biological control of pests is one of the alternative strategy to rely upon and curtail the use of synthetic pesticides. The potential of the naturally existing organisms (microbials and macrobials) needs to be tapped for effective pest management. The organisms need to be conserved, mass produced and augmented. Eco friendly farming without pesticide usage is the need of the hour. Biological control is a viable alternative to facilitate reducing the usage of chemical pesticides, thereby bringing down the chemical pesticide load in the environment and eliminating or reducing chemical pesticide residue problem in food, feed and non-target organisms.

Though the yield levels in biological control treatments are almost on par with the insecticide treatments 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.

The 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.
The team also recommends to give importance to native crops and varieties, cropping systems to reduce the population load of pests. Proper nutrient management and native formulations of biopesticides suitability to weather conditions may be addressed by the centres.

INTRODUCTION

The Director General, Indian Council of Agricultural Research (ICAR) constituted the VII Quinquennial Review Team (QRT) with the following experts to review the progress of research and impact and other relevant activities undertaken by the National Bureau of Agriculturally Important Insect Resourcess (NBAIR), Bangalore and the AICRP on Biological Control of Insects Pests, during the five year period from 2012-13 to 2017-18 vide **Council's order F. No. CS. 15/3/2017-IA-III dated 11th Janaury 2018**

1.	Dr. J.H.Kulkarni Former Vice Chancellor, University of Agricultural Sciences, Dharwad 560006 (Karnataka)	Chairman
2.	Dr. Mohammed Hayat Department of Zoology Aligarh Muslim University Aligarh - 2012 002 (UP)	Member
3.	Dr. R.S.Gill Professor & Head (Retd.,) Departmet of Entomology Punjab Agricultural University Ludhiana 141 003.	Member
4.	Dr. H.B.Singh Benaras Hindu University Banaras - 221 005 (UP) Varanasi	Mem,ber
5.	Dr. Lalith Achoth Professor & Head Department of Diary Economics & Business Management, Dairy Sience College, Hebbal Bangalore 560 024	Member
6.	Dr. V. V.Ramamurthy Ex-Principal Scientist (Entomology) IARI, Pusa, New Delhi 110 012	Member
7.	Dr. K.Srinivasa Murthy Principal Scientist NBAIR, Bangalore-560 024.	Member Secretary

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

A. THE PROCESS

The Indian Council of Agricultural Research, New Delhi constituted a five member Quinquennial Review Team under the chairmanship of Dr. J.H.Kulakarni to review the research work undertaken by National Bureau of Agriculturally Important Insect Resources, AICRP on Biological Control of Insects and Weeds, for the period 2012-2017 in February, 2018.

The first interface meeting of the QRT with **Dr.A.K.Singh,** Deputy Director General (Crop Science), ICAR, New Delhi, Dr. P,Chakrabarthy, Assistant Director General (Plant Protection and Biosafety), ICAR, New Delhi along with Dr. Chandish. R.Ballal, Director, NBAIR, Bangalore was held on 3rd Fenbruary 2018 in the conference room at NAAS, Complex, Pusa, New Delhi at 8.30 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 and previous QRT reports of the centres, important publications, evaluation proforma for the centres and recent ICAR Guidelines for the QRT.

Since the QRT had to review the work of **15** centres, five meetings were held at NBAIR (for MPUAT, Pune, UAS,Raichur, TNAU, Coimbatore and KAU, Thrissur), PJTSAU, Hyderabad (PJTSAU, Hyderabad, ANGRAU, Anakapalle and OUAT, Bhubaneshwar), AAU, Anand (AAU, Anand, PAU, Ludhiana and MPAUT, Udaipur), AAU, Jorhat (Assam Agricultural University, Jorhat and CAU, Pasighat) and YSPUH&F (YSPUH&F, Solan, SKUAS&T, Srinagar and GBPUAT, Pantnagar).

Tour itinerary of the QRT

Sl. No	Date	Place	Centres reviewed
1	3rd February 2018	NAAS complex, Pusa, New Delhi	First meeting of QRT with DDG (CS) and ADG (PP)
2	26th February 2018	NBAIR, Bangalore	MPUAT, Pune
3	27th February 2018	NBAIR, Bangalore	UAS,Raichur, TNAU, Coimbatore KAU, Thrissur
4	28th February 2018	PJTSAU, Hyderabad	PJTSAU, Hyderabad, ANGRAU, Anakapalle OUAT, Bhubaneshwar
5	11th April 2018	AAU, Anand	AAU, Anand, PAU, Ludhiana MPAUT, Udaipur
6	21st August 2018.	Assam Agricultural University, Jorhat, Assam	Assam Agricultural University, Jorhat, CAU, College of Horticulture, Pasighat,
7	22nd June 2018.	Dr. Y. S. Parmer University of Horticulture & Forestry, Solan	YSPUH&F, Solan SKUAS&T, Srinagar GBPUAT, Pantnagar

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 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 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)

B. MAIN REPORT

i. Brief History of the Project

The National Agricultural Policy has laid special emphasis on Integrated Pest Management (IPM) and use of biocontrol agents in order to minimize the indiscriminate and injudicious use of chemical pesticides, which is also 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 useage, 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 and in the 12th five year plan, it was rechristened to the present name **(ICAR - National Bureau of Agricultural Insect Resources)** with effect from 24th September, 2014.

The AICRP-BC has 16 regular SAU centres (PC unit, 11 regular SAU centres with salary and contingencies and 4 with only contingencies).

1. AICRP PC Cell, NBAIR, Bangalore
2. Acharya N. G. Ranga Agricultural University, Anakapalle
3. Professor Jayashankar Telangana State Agricultural Unuiversity, Hyderabad
4. Anand Agricultural University, Anand

5 Assam Agricultural University, Jorhat

6. Govind Ballabh Plant University of Agriculture and Technology, Pantnagar
7. Kerala Agricultural University, Thrissur
8. Mahatma Phule Krishi Vidyapeeth, College of Agriculture, Pune
9. Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar
10. Punjab Agricultural University, Ludhiana
11. Tamil Nadu Agricultural University, Coimbatore
12. Yashwant Singh Parmar Univeristy of Horticulture and Forestry, Solan
13. Central Agricultural University, Pasighat*
14. Maharana Pratap University of Agriculture and Technology, Udaipur*
15. Orissa University of Agriculture and Technology, Bhubaneswar*
16. University of Agricultural Sciences, Raichur*.

* with only contengency support.

Sl. No.	Centres	Mandatory Crops
State Agricultural University-based centres		
1	AAU, Anand	Cotton, pulses, oilseeds, vegetables and weeds
2	KAU, Thrissur	Rice, coconut, fruits, vegetables & weeds
3	PAU, Ludhiana	Sugarcane, cotton, pulses, rice, oilseeds and weeds
4	SKUAS & T, Srinagar	Temperate fruits
5	ANGRAU, Anakapalle	Cotton, pulses, coconut, vegetables and weeds
6	PJTSAU, Hyderabad	Cotton, pulses, vegetables
7	Dr.YSPUH & F, Nauni, Solan	Temperate fruits, vegetables & weeds
8	TNAU, Coimbatore	Cotton, pulses, rice, coconut & fruits
9	AAU, Jorhat	Rice and weeds
10	MPKV (Rahuri), Pune	Cotton, rice, vegetables, potato & weeds
11	GBPUA & T, Pantnagar	Basic research - Plant disease antagonists
Voluntary centres (Contingency funded)		
12	MPUAT, Udaipur	pulses, oilseeds, vegetables, whitegrubs & termites
13	CAU, Pasighat	sugarcane, rice, tropical fruits & vegetables
14	OUAT, Odisha	rice, oilseeds, tropical fruits & vegetables
15	UAS, Raichur	Pulses and Oilseeds

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

- Development of effective biocontrol agents for use in biological suppression of crop pests and diseases.
- Evaluation of various methods of biological control in multi-location field trials.
- Develop biointensive integrated pest management strategies for cotton, rice, sugarcane, pulses, oilseeds, potato, coconut and a few selected fruits and vegetables and crop pests of protected cultivation.
- Demonstration of usefulness of usefulness of biocontrol in IPM in farmers'fields

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

Trichogramma chilonis Ishida and *Chrysoperla zastrowi sillemi* were collected from paddy, maize, sugarcane, groundnut and castor fieldscrops.

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. *Crypolaemus montrouzieri* was predominant than others in many crops.

Spider specimens were also collected from pitfall traps in paddy ecosystem. About 207 spider specimens were collected and sent to NBAIR for identification.
Insect derived EPNs (27) were also collected and sent to NBAIR Native Bt. isolates were isolated from soil samples from 28 villages. 18 were effective against *Helicoverpa armigera*

Seasonal abundance of predatory spiders in rice ecosystem

A total of 478 specimens collected from paddy ecosystem, identified under 7 families. species richness was observed for *Neoscona theisi* (133), Leucauze sp. (133), *Crytophora cicatrosa* (72), *Argipos* sp. (72), *Tetragnatha javana* (72) and *Argiope anasuja* (65), *Leucauge decarate* (65).

Biological suppression of plant diseases using antagonist organisms

Isolation, identification of *Pseudomonas fluorescense* and *Bacillus* strains effective gainst Fusarium wilt in pigeonpea

A total of 181 isolates of *Pseudomonas fluorescense* were isolated from different villages of middle Gujarat. A total of 159 isolates of *Bacilli* were isolated.

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*)

All formulations were found equally effective in suppressing the pests. Minimum pod damage (6.79%) was recorded in PDBC-BT1 @ 2%. NBAII-BT G4 @ 2% and IARI Bt @1% proved equally effective. Beuveria bassiana and NSKE @ 5% were found less effective in controlling the pest.

Survey and Monitoring of Papaya mealybug *Paracoccus marginatus*

Survey in all papaya growing areas in different districts. Trace incidence was recorded. The parasitoid *Acerphagous papayae* was observed in the infested fields.

Biological control of Chilli Fruit Rot (Anthrocnose) disease

Treatments with *Pichia guilliermondi* (Y12) or *Pseudomonas fluorescens* (Pf-1) in sequence was found effective for management as seed treatment(10g /kg seed, seedling root dip (20g /litre for 5 minutes, four foliar sprays 10 g/litre, 1% AS, $2x10^{8}$ cfu/g at fortnightly intervals from the initiation of fruit ripeniong.

Bioefficacy of microbial insecticides against sucking pests in Bt cotton

Leucaniciluim lecanii and *Beuveria bassiana* @ 40 g/10 litres resulted effective suppresion of the pests and registered higher yeilds.

Survey and Surveillance of Pinworm *Tuta absoluta* on tomato

The outbreak of *Tuta absoluta* was carried out farmers' fields. Higher incidence (80%) was recorded in Idar and Sabarkantha districts (2015-16 and 2016-17).

Biological suppression of mustard aphid *Lipaphis erysmi*

Beuaveria bassiana + *Lecanicilium lecanii* @ 5g/litre resulted in good suppression of the pest and and highest seed yield was obtained. (9.66q/ha)

Demonstration Trials

1. Biological control of plant parasitic nematodes using antagonistic organisms- Demonstration of Biocontrol practices for management of root knot nematode in pomegranate

Large scale demosntration carried out to contro white grub and root knot nematodes in 45 pomegranate growers. The mode of action of Pochonia chalmydosporia and different EPN formulations was demonstrated .

2. Large scale demonstration of BIPM technology for management of *Helicoverpa armigera* in Tomato

Tricho cards were distributed to farmers and BIPM technology was found effective. Lowest number of *H.armigera*/plant and fruit damage was recorded in BIPM module (1.15, 0.25%) followed by farmers practice 91.51, 12.74%), with higher yield (16.84 t/ha) comapred to farmers practice (15.06/ha)

3. Large scale demonstration of NBAII liquid formulations (PDBC Bt1 and NBAII BTG4) against pigeon pea pod borer (*Helicoverpa armigera*)

Large scale validation was done in two farmers fields. Effcetive management of the pest with Bt formulations of NBAIR was recorded. NBAII BTG 4 @ 2% recorded lower incidence of larvae (0.52-0.56/plant) as well as pod damage (8-010%). Reductiion in the usage of chemical pesticides to the tune of 40-50% was noticed.

4. TSP on Biocontrol Technologies for management of fusarium wilt and pod borer (*Helicoverpa armigera*) in pigeon pea and chick pea.

Fifty tribal farmers selected and were provided with biocontrol inputs viz., *Trichoderma viride*, pheromone traps, Bt - 1 kg/farmer, *Pseudomonas* -1 kg/farmer, azadiractin 1 kg/farmer and Helicoverpa lure -10 lures/farmer, for the management of pest and diseases. The demonstrations were done in colloboration with Tribal Research and Training Centre , Devgadh bariya. With the use of biocontrol based IPM technologies 15-20% increase in yeld and 50-60% reduction in pest and diseases was observed.

5. Biological interventions to enhance the production and productivity of okjra in Tribal areas of TAPI distrct in Gujarat.

Two hundred tribal farmers were selected from Tapi district and distributed with bio-agents viz., *Trichoderma viride*, pheromone traps and lures for *Earias*,10 numers/farmer, Bt - 1 kg/farmer, *Paecilomyces/Pochonia* -1 kg/farmer, azadiractin 1 kg/farmer.

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	:	9
Papers presented in symposia, seminars, etc.	:	21
Popular articles published in local languages	:	11
Technical bulletins	:	4

Observations of the QRT

- All the activities under the program during the period have been addressed and carried out.
- Extensive surveys, large scale demonstration of BIPM technologies for the management of pests and diseases have been carried out.
- Tribal farmers have also been educated on biocontrol technologies for the management of pod borers.

Recommendations of the QRT

- Vice Chancellor AAU expressed interest in providing funds for generating toxicological data for the NBAIR isolates. To explore the possibility of preparing a joint MOU between AAU and NBAIR for the same.
- Standard chemical check to be included in all experiments.
- Quantification of spider diversity and its predatory potential and relationship with pest incidence are to be included.in their studies.
- Production of macrobials to be intensified.

Overall assessment

The centre has conducted all the experiments under the program during the period. Extensive surveys, large scale demonstration of BIPM technologies for the management of pests and diseases have been advocated to the farmers including tribal farmers and other stakeholders. The centre has created excellent infrastructure and physical facilities for mass production of biocontrol agents. TSP on biocontrol technologies for management of fusarium wilt and pod borer (*Helicoverpa armigera*) in pigeon pea and chick pea was the signficant achievement**.**
Technical bulletins and other publications in local languages brought out by the centre had immensely benefitted the farming community, researchers and students which was evident on interactionfo the team with some of them**.**
The centre has done very good work and is graded"A. "

Publications

Scientific articles published in journals	:	9
Papers presented in symposia, seminars, etc.	:	21
Popular articles published in local languages	:	11
Technical bulletins	:	4

2. Kerala Agricultural University, Thrissur

The centre had conducted 49 experiments in the period under review, out of which nineteen involved survey and documentation of natural enemies, twenty four experiments involved evaluation of natural enemies and five were large scale validation trials in rice.

Trials conducted

Diversirty of biocontrol agents from various agro ecological zones.

Rice: Laboratory evaluation of fungal pathogens on gundhi bug *Leptocorista* sp. Enabling large scale adoption of proven biocontrol technologies in rice.

Tropical Fruits:
Field evaluation of *Metarhizium anisopliae* formulations against mango hoppers Idioscopus niveasparsus.
Monitor and record of incidence of papapya mealy bug and its natural nemeies on papaya and other alternate hosts.
Labortory and field evelaution of entomopthogenic fungi against pseudostem borer *Odotporus longicollis*
Labortory and field evelaution of entomopthogenic fungi against banana root mealy bug *Geococcus citrinus*
Labortory and field evelaution of entomopthogenic fungi against pepper root mealybug *Formicoccus polysperes.*
Field evelaution of entomopthogenic fungi against pineapple mealybug *Dysmtcoccus brevipes*

Pulses:

Evaluation of biocontrol agents against pod bores of cowpea
Vegetables:

Survey and Surveillance for natural enemies of South American pin worm *Tuta absoluta*
Monitoring invasive maelybugs on major horticultural crops

Brief Achievements
Thirty natural enemies including one entomopathogen have been reported from different agroecosystems of Kerala through surveys.

The evaluations have revealed that a local isolate of *Beauveria bassiana* has been effective in managing rice bug populations. Similarly, *Lecanicillium lecanii* has been found to be effective against the pineapple mealybug *Dysmicoccus brevipe*s.*Metarhizium* anisopliae was found to be promising against Pseudostem weevil on banana.

Large scale trials have confirmed the validity of the BIPM package in managing pests in rice without using insecticides. The appreciable increase in yields combined with reduction in

cost of plant protection has confirmed not only the ecological soundness of the approach but also its economic viability.Adoption of IPM resulted in 40% more yield than framers practice. The cost of cultivation was reduced by 10% and the increase in profit was Rs. 32,626/h with cost benefit ratio at 2.15 higher than the 1.45 obtained in non IPM fields (2016-17)

Production of *Trichogramma* parasitoids by farmers group by providing training (both men and women) and its host *Corcyra cephalonica*.

Production, process and technology developed

The biocontrol agents were produced at the centre : *Pseudomonas florescens, Trichodeerma viride, Beuaveria bassiana, Lecanicillium lecani , Metarhizhium anisopliae, Trichogramma*
A total revenue of Rs. 18,77,360 and Rs.18,44,876 was generated during the years 2015-16 and 2016-17, respectively.

A local isolate of the entomopthogenic fungus *Beauveria bassiana* from ricebug was isolated. Characterised and evaluated for efficacy against rice bug, *Leptocorisa* spp.
An oil based formulation of the fungus is under evaluation.

Infrastructure and physical facilities developed

A field insectary unit for mass production of arthropod naturtal enmeis has been conbstructed and is awiting electrification.

A facility for mixing and storage of talc based formulations has been operationalised.

An automated filling and bottling unit for liquid formulations of microbial biopesticides is proposed to be established during 2018-19.

Human resource development

The scientists in the project got training on New Frontiers in IPM in rice and rice based cropping systems at DRR, Hyderabad and Microbial pesticides in Pest management at NBAIR.

Training to farmers: Production of *Trichogramma* parasitoids by farmers group by providing training (both men and women) and its host *Corcyra cephalonica*

Publications:

Research articles in journals	:	4
Research articles presented in symposia/workshops	:	5

Observations of the QRT

- All the trials under the program have been successfully carried out which included large scale adoption of biocontrol technologies in rice.
- Field evaluation of entomopathogenic fungi against borer and mealybugs was done**.**
- Farmers were educated on the production of *Trichograma* parasitoids.

Recommendations of the QRT

- Promising microbials may be supplied/distributed to farmers on a non commercial basis (free of cost).
- Technical bulletins/brochures to be brought out in local languages for wider dissemination of the value of bio-control agents.
- Budgetary support for meeting the registration costs for biopesticides may be provided. Financial support for popularizing biocontrol agents may be sought from funding agencies viz. RKVY and MOEF.

Overall assessment

The centre has carried out all the experiments assigned during the period under report. Large scale demonstration of BIPM technologies for the management of rice pests and diseases had been the hall mark of the centre. The Adat Panchayat success story on rice pest management through BIPM practices is a significant achievement.The technology is put to practice through out the state,through support from government

The centre has created excellent infrastructure and physical facilities for production of biocontrol agents. The centre has generated a total rvenue of Rs. 18,77,360 and Rs.18,44,876 was generated during the years 2015-16 and 2016-17, respectively through sale of bioagents.

The centre has done very good work and is graded 'A."

3. Punjab Agricultural University, Ludhiana

Brief achievements

- Technology for the management of maize stem borer, *Chilo partellus* with two releases of biocontrol agent, *Trichogramma chilonis* @ 1,00,000/ ha; first release on 10 days old crop and second release a week thereafter has been recommended for the farmers of Punjab.
- Technology for the management of diamondback moth, *Plutella xylostella* with bacterial (*Bacillus thuringiensis kurstaki*) biopesticide Delfin WG @ 750 g/ha in cole crops has been recommended for the farmers of Punjab.
- BIPM module involving cultural control (time of sowing- first fortnight of July), plant spacing (33 hills/m^2), biological control (six releases of *Trichogramma chilonis* and *T. japonicum* @ 1,00,000/ ha each starting from 30 DAT + bird perches @ 20/ha) + Bt spray @ 1 kg/ha) and bio-rational approaches (mass trapping pheromone traps @ 20/ha) against lepidopteran pests in organic *basmati* rice has been recommended for the farmers of Punjab.

- BIPM module comprising integration of *T.chilonis* @ 50,000/ha (2 releases - 45 & 66 DAS), application of neem oil @ 1250 ml/ha (2 sprays at 52 & 73 DAS) and Bt formulation Delfin WG @ 1 kg/ha (2 sprays at 59 & 80 DAS) against *Leucinodes orbonalis* in brinjal.
- Validation and dissemination of biocontrol technologies for the management of sugarcane borers at farmers' fields using bioagents, *T. chilonis* and *T. japonicum* in sugarcane conducted over an area of 1840, 2820, 2446, 3906 and 4230 hectares at farmers' fields during 2012-13, 2013-14, 2014-15, 2015-16 and 2016-17, respectively in collaboration with sugar mills of Punjab.
- Validation and dissemination of bio-suppression of maize stem borer, *C.partellus* using egg parasitoid, *T. chilonis* at farmers' fields in maize cropconducted at farmer's fields over an area of 20, 10, 81, 130 and 142 hectares during 2012-13, 2013-14, 2014-15, 2015-16 and 2016-17, respectively.
- Validation and dissemination of biocontrol based pest management technologies using bioagents, *T. chilonis* and *T. japonicum* for the management of leaffolder, *Cnaphalocrocis medinalis* and yellow stem borer *Scirpophaga incertulas* conducted over an area of 20, 20, 60 and 66 hectares during 2013-14, 2014-15, 2015 and 2016- 17, respectively at farmers' fields in organic rice.
- Protocol standardized for mass production of local isolates of *Bacillus thuringiensis* (PAU Bt) and *Beauveria bassiana* (Talc based formulation).
- Eight native *Bacillus* isolates obtained from field crop soil samples collected from different districts of Punjab were isolated and identified as *Bacillus cereus* (2 isolates), *Bacillus pichinotyi* (1 isolate), *Bacillus firmus* (1 isolate), *B.thuringiensis* (2 isolates) and remaining *Bacillus* spp.
- Fourteen fungal isolates obtained from *Galleria* bait from soil samples collected from different districts of Punjab were identified as *Lecanicillium lecanii* (1 isolate),*B.bassiana* (5 isolates) and remaining were *Aspergillus* spp. and *Penicillium* spp.

Infrastructure developed

Established Biocontrol laboratory for mass production of biocontrol agents (Parasitoids and microbials).

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Human resource development

- International Training : 02
- National Training : 04

Publications

- Research papers published in Journals : 45
- Paper presented in Symposium : 40
- Book Chapters : 06

- Teaching Manuals : 02
- Extension literature : 23

Observations of the QRT

- The centre had conducted all the experiments/ programmes allotted to them.
- BIPM technology for the management of Maize stem borer and rice stem borer has been recommended for the farmers in Punjab.
- BIPM technology for management of sugar cane borers effectively implemented in collaboration with sugar mills.

Recommendations of the QRT

- Success stories on Organic Basmathi, Maize and Sugarcane to be disseminated through booklets and website.
- White fly genetic groups to be checked and to be related with early and late sown crops.
- Parasitisation of white flies to be studied in detail.
- Production of macrobials and microbials and area coverage to be committed as fixed targets to commensurate with the contingency funding.

Overall assessment

The centre had conducted all the experiments/ programmes allotted to them. Large scale demonstration of BIPM technologies for the management of rice, sugarcane and maize pests have been very successful and the technology for the management of maize stem borer and rice stem borer has been recommended for the farmers in Punjab. The technologies have been adapted by the farmers on large scale. Good number of publications , both under research and extension have been brought out. Very good extension activities were carried out by the centre and literature on organic basmati, maize and sugarcane is noteworthy. There success stories on the management of pests in these crops needs to be dissiminated.
The performance of the centre is commendable and is graded A+ (Excellent)

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

Brief achievements

1. More than twenty coccinellid species, and a number of parasitoids and hyper parasitoids were found associated with fruit pests in Kashmir valley.
2. No invasive pests as per ICAR were reported from Kashmir valley.
3. Unidentified braconids and ichneumonids (1-4.0 per cent parasitism) were found associated with the diapausing larvae of codling moth in the apple orchards of Kargil.
4. Use of one spray of Chlorpyriphos 20EC @ 1.5 ml/lit. + two sequential releases of *T. cacoeciae*+ one spray of Azadirachtin 1500 ppm @ 3.0 ml./ lit. + trunk banding + disposal of infested fruits + pheromone traps resulted in 52.92 per cent reduction in damage over control in Kargil.
5. No natural enemy was reported from Eurytoma infesting seed of apricot in Ladakh.
6. Five weekly releases of *T. chilonis* and *T. brassicae* @1.0 lakh^{-ha} caused 33.7 and 20.1 per cent decline in pest density respectively.
7. Both *Paecilomyces lilacinus* @ 1.0, 1.5 and 2.0 x 10^8 spores and Abamectin @ 0.25, 0.5 and 1.0 ml/ liter of water proved effective in suppressing the root and soil population of root-knot nematode *Meloidogyne hapla* in tomato.
8. 25 genera and 34 species of spiders under eleven families were recorded in temperate rice ecosystem of Kashmir.
9. Five weekly releases of 2nd instar grubs of *Coccinella septempunctata* and *Chrysoperla zastrowi sillemi* resulted 76.52 and 63.09 per cent reduction in aphid density over control, respectively.
10. *Blastothecus pallescens* showed positive response against ERM on apple causing 89.7, 37.9, 13.9 and 4.3 per cent failure of eggs of *Panonychus ulmi* when predator: prey ratio was kept as 1:5, 1:10, 1:15 and 1:20 respectively.
11. Field release of *Blaptostethus pallescens* against saffron thrip, *Haplothrips* sp. was found unsuccessful because of an survival ability of bugs in the month of November' 2015.
12. Eighteen small groups of farmers, each comprising 8-10 farmers, from eight different localities were distributed materials and equipments under Tribal sub Plan
13. Two releases of anthocorid bugs @ 100 and 200 / plant of apple nursery caused 21.19 and 30.12 and 28. 4 and 34.6 percent reduction in two spotted spider mites.

14. A third instar grub of *C. infernalis* consumed an average of 90.0, 86.66 and 66.65 per cent *Parthenolecanium corni* scale, infesting plum, when 10, 15 and 20 prey was supplied to a single grub.

Production, process, technologies developed

- The centre has established mass production unit for different *Trichogramma* spp. anthocorid bug, *Blaptostethus pallescens* and EPN.
- A semi automatic *Corcyra* rearing equipment has also been designed that ensures *Corcyra* production without interference of rats or *Bracon hebetor.*
- The centre has also popularized the use of Trichogramma spp., pheromone traps, trunk banding, and disposal of infested fruits to manage Codling moth, *Cydia pomonella* in Ladkh.

Infrastructure and physical facilities developed

- New polyhouse constructed
- Temperature and humidity control systems installed.

Human resource development efforts

- 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

Publications : 26

Observation of the QRT

- The centre has carried out all the allocated experiments during the period under the report.
- Field demonstrations on the release of anthocorid*s* against thrips and mites have been successfully carried out.
- Biocontrol technologies have been dessiminated to tribal farmers under the tribal sub-plan.

Recommendations of the QRT

- Strengthen mass production of EPN and supply to farmers.
- A complete comprehensive management protocol for codling moth.
- Success story on Codling moth mangement to be brought out in three months time and put up on University/NBAIR website.
- The technology for predatory mite production developed at YSPUHF to be adopted at SKUAST.
- Unidentified species of natural enemies including spiders to be sent to NBAIR for identification.

- Identified duplicate specimens may be sent to NBAIR museum.
- Attempts to be made to publish/patent the refinded production structure for *Corcyra* developed by the centre with supporting data.

Overall assessment

The centre's has done good work on management of codling moth in apple and has established good biocontrol laboratory for mass production of biocontrol agents. The success story on Codling moth mangement needs to be documented enabling promotion of the technology developed in other temperate fruit growing areas of the country. The centre has established a polyhouse facility and has documented the spider fauna in rice ecosystem, Biocontrol technologies have been dessiminated to farmers

The overall performance of the centre is good and is graded "B" (Good)

5. Acharya N. G. Ranga Agricultural University, Anakapalle

Brief achievements

New AICRP on Biocontrol centre was sanctioned to Acharya NG Ranga Agricultural University, Andhra Pradesh and is functioning at Regional Agricultural Research Station, Anakapalle, Visakhapatnam District from 01.04.2015, as a result of bifurcation of Andhra Pradesh State into Andhra Pradesh and Telangana states.

Management of White grub, *Holotrichia consanguinea* Blanch in sugarcane using Bioagents :

NBAIR EPN isolates (Heterorhabditis indica & Steinernema sp) were studied to combat white grub problem in endemic areas of farmers fields of sugarcane yielding excellent results.

Soil application of entomopathogenic nematode, *Heterorhabditis indica* / *Steinernema* sp @ 20 kg ha-1 in 150 kg moist sand ha-1 two times application at monthly interval; entomopathogenic fungi , *Metarrhizium anisopliae / Beauveria bassiana* @ 5 kg ha-1 (1 x108spores/ gm) in 250 kg FYM ha-1 in sugarcane after the onset of mansoon rains were found effective with high per cent reduction in white grub damage resulted in higher cane yield i.e., *Metarrhizium anisopliae* (80.11t/ha); *Heterorhabditis indica* (76.63t/ha) ; *Steinernema* sp (73.49 t/ha) ; *Beauveria bassiana* (71.44t/ha)) compared to chemical treatment, phorate (53.2t/ha) and untreated control (42.05 t/ha).

Bioefficacy of entomopathogenic fungi and entomopathogenic nematodes in suppression of termite incidence in sugarcane : Entomopathogenic nematode, *Heterorhabditis indica* @ 20 kg ha-1 in 150 kg moist sand ha-1 and entomopathogenic fungi, *Metarhizium anisopliae* @ 5 kg ha-1 (1 x108spores/ gm) in 250 kg FYM ha-1 were effective in reducing plant mortality (12.46 % and 20.07%) in sugarcane due to termites resulted in higher cane yield (65.71 t/ha and 64.41 t/ha) compared to untreated control (41.44 t/ha).

IPM module for the sustainable management of early shoot borer (*Chilo infuscatellus*) and internode borer (*Chilo infuscatellus Chilo sacchariphagus indicus*) in sugarcane: IPM module with trash mulching (3 t/ha) + *Trichogramma chilonis* release @ 50,000 per ha per release from 30 days after planting for 6 times and 2 times after node formation was effective in management of early shoot borer and internode borer in sugarcane with high cane yield (118.2 t/ha) and incremental benefit cost ratio (96.3) compared to trash mulching (3 t/ha) + carbofuran application with cane yield (101.3 t/ha) and incremental benefit cost ratio (5.5).

Bio suppression of *Chilo partellus* with *Trichogramma chilonis* on rabi Maize:

Field release of *Trichogramma chilonis* from 15 Days after seedling emergence @ 75,000 parasitoids per ha per release, three times was found effective in reducing maize stem borer damage (1.84% DH) with high cob yield (81.7 '000cobs /ha) compared to parasitoid releases from 20 days after seedling emergence (5.24% DH & 74.86'000cobs /ha) or 25 days after seedling emergence (6.5% DH & 72.79 '000cobs /ha)

Evaluation of NBAII entomopathogenic strains against maize stem borer

Evaluation of NBAII entomopathogenic strains against maize stem borer on rabi maize showed that maize stem borer damage recorded was low (<2%) in entomopathogenic strains compared to control (8.53%). Cob yield recorded high in Bb19 (78.19 '000 cobs /ha) compared to carbofuran whorl application (60.49'000 cobs /ha) untreated control (50.62 '000cobs /ha).

Empowering tribal farmers through Tribal Sub Plan programmes

ICAR- Tribal sub Plan Programme implemented by AICRP on Biological Control Scheme, Arakuvalley Tribal Farmers with small land holdings of half an acre to one acre were benefited. Front line demonstrations, training programmes, method demonstrations, field days were conducted on Organic farming techniques in 83 acres area of paddy, 50 acres of rajmah and 50 acres of ginger at six villages i.e., Kothavalasa and Gunjariguda, Dumbriguda mandal, Araku valley and Naduguda, Ramguda of Araku valley and Asarada, Idulabailu of Chinthapalli areas Visakhapatnam district, Andhra pradesh during 2015-16 and 2016-17.

Organic farming was spread in acres of paddy, ramah and ginger in Arakuvalley and Chinthapalli agency areas in Visakhapatnam district benefiting 95 farmers.

Adoption of eco-friendly low cost biocontrol agent , *Trichogramma chilonis* production system by tribal farmers through establishment of eri silk worm based tricho card production unit at Asarada village, Chinthapalli. Training imparted to 25 tribal farmers on *Trichogramma chilonis* production.

Issued improved seed (Paddy seed , MTU 1075, RNR 15048), biofertilizers (*Azospirillum* and *Phosphobacteria , Azotobacter*) biocontrol agents (*Pseudomonas flourescens,* Trichocards of *Trichogramma japanicum* and *Trichogramma chilonis, Trichoderma viridae and Metarhizium anisopliae*) , harvest and post harvest appliances (sickels, kurpas, tarpalene, seed storage drums

Production, process, technologies developed

Soil application of entomopathogenic nematode, *Heterorhabditis indica* / *Steinernema* sp @ 20 kg ha-1 in 150 kg moist sand ha-1 two times application at monthly interval; 1 in sugarcane after the onset of monsoon rains was effective with high per cent reduction in white grub damage

Entomopathogenic nematode, *Heterorhabditis indica* @ 20 kg ha-1 in 150 kg moist sand ha-1 and entomopathogenic fungi, *Metarhizium anisopliae*@ 5 kg ha-1 (1 x10^8spores/ gm) in 250 kg FYM ha-1 effective in reducing plant mortality in sugarcane due to termites and resulted in higher cane yield

IPM module with trash mulching (3 t/ha) + *Trichogramma chilonis* release @ 50,000 per ha per release from 30 days after planting for 6 times and 2 times after node formation was effective in management of early shoot borer and internode borer in sugarcane.

Field release of *Trichogramma chilonis* from 15 Days after seedling emergence @ 75,000 parasitoids per ha per release, three times was found effective in reducing maize stem borer damage (1.84% DH) with high cob yield

Rearing of *Trichogramma chilonis* on Eri Silk worm eggs the technology for the benefit of tribal farmers.

Infrastructure and physical facilities developed

Established a new biological control laboratory for the mass production of various biocontrol agents (*Trichogramma chilonis*, . entomopathogenic fungi *Metarhizium anisopliae* and *Beauveria bassiana*)

Technical guidance to New Biocontrol labs at Sugar factories , KCP Sugars, Vuyyur, Krishna District & Navabharath Ventures, Samarlakota, East Godavari District during 2015-16 and EID Parry sugars Ltd, Sankili, Srikakulam district (2016-17) in establishing Trichocard production systems in a small scale. The Department of Agriculture, Horticulture University and individual farmers were also supplied with bioagents on cost basis and a revenue of Rs. 1,73,665.00 was generated.

Human resource development efforts

Technical guidance to New Biocontrol labs at Sugar factories , KCP Sugars, Vuyyur, Krishna District & Navabharath Ventures, Samarlakota, East Godavari District during 2015-16 and

EID Parry sugars Ltd, Sankili, Srikakulam district (2016-17) in establishing Trichocard production systems in a small scale.

Tribal sub Plan Programme implemented by AICRP on Biological Control Scheme, Arakuvalley Tribal Farmers with small land holdings of half an acre to one acre were benefited. Front line demonstrations, training programmes, method demonstrations were given on use of biocontrol asgents.

Publications

- Research articles published in journals - 8
- Research articles published in symposia - 3

Observations of the QRT

- All the trials during the period under report have been successfully carried out.

- Transfer of technoloigies have been done through extensive linkages with state departments, NGOs and KVKs

Recommendations of the QRT

- Funds for projects focusing on tribals can be sought from RKVY/ DST/ DBT funds for ST/SCs. Sugarcane community fund – under sugar mills can be explored for the activities related to biological control of sugarcane pests.

- Data to be generated on biocontrol resources supplied to the farmers, area of adoption, benefits obtained and cost economics to be worked out..

- Important to map the visibility of bioagents usage – the spread and adoption rates to be quantified to indicate the impact of the technologies.

Overall assessment

The centre's has successfully carried out all the trials during the period under report. The centre has come out with good management practices against whitegrubs and termites in sugarcane and borers of maize and sugarcane. Good extension activities have been carried out by the centre, technical guidance was provided to sugarcane factories and tribal farmers on biocontrol control agents and their utilisation. Empowering tribal farmers through supply of inputs, field demonstrations on IPM pests and diseases with a significant impact on the farmer's economy is noteworthy. The overall performance of the centre is very good.

The centre is graded "A" (Very Good)

6. Professor Jayashankar Telangana State Agricultural University, Hyderabad.

Brief achievements

Sequential application of bio agents, *Bt-Ha* NPV-endo-*Bt* in pigeon pea against *Helicoverpa* is most promising

Bio intensive management of pod borer complex through *Ha* NPV-NSKE alternation in pigeon pea found promising in lessening the pest and increasing the net returns.

Release technology of *T.chilonis* @ 1,50,000/ha/week through distribution @ 200 strips/ha in cotton is standardized.

BIPM module consisting of alternate eco friendly methods for management *Helicoverpa* in cotton ecosystem increased farmers' net returns.

Effective *Bt* formulations such Biobit & Dipel for managing DBM in cabbage recommended.

Combination of *T.pretiosum* @ 50,000/ha-5 times and NPV @250 LE/ha –3 times to manage *Helicovera* in tomato suppressed infestation and increased yields.

Application of NPV @ 250 LE/ha in pigeon pea – 4 rounds for *H.armigera* is found effective & economical.

Standardization of host distance for better parasitization by *T.chilonis*-1 meter (Optimum) 4 meter (Maximum) proved promising.
1Dipel @ 0.5 kg/ha effective against castor semilooper and safer for *Micropletis* in castor.

Bt @ 1 kg/ha is very effective against Adisura *atkinsoni* on Dolichos bean recording lesser pod damage and good yield.

Pigeonpea bordered with two rows of sorghum and intercropped with sunflower (9:1) gave better yields recording lesser population of pests due to higher biological control activity by natural enemy population compared to the sole crop.

The Anthocorid bug *Xylocoris flavipes* performed better than *Blaptostethus pallescens* in controlling the moth *Corcyra cephalonica* in stored rice grain. Lesser moths of Corcyra emerged from the bin where the grain was treated with *Xylocoris flavipes.*

In situ culturing and production of imported parasitoid, *Acerophagous papaye* through potato seedling technique by using papaya mealy bug, *Paracoccus marginatus* as host. - This method was followed by several farmers to maintain *Acerophagous papaya* populations in local areas of requirement across the state. The parasitoid was released in the infested fields and mealy bug management through Biological Control was achieved.

A case history of successful management of Papaya Mealy Bug through imported parasitoid, *Acerophagous papaye* has been celebrated at National level where in PJTSAU Centre was

invited along with the two successful farmers to share their experiences at national level in the presence of DG, ICAR.

Standardized Bio suppression of aphids, *Uroleucon carthami* in safflower by using Entomo Pathogenic Fungi (EPF) *Verticillium (Lecanicillium) lecanii* - Two sprays of *Verticillium (Lecanicillium) lecanii* @ 5gm/litre at vegetative stage with 10 days interval is standardized as recommendation at national level to manage safflower aphid, *Uroleucon carthami* in non spiny safflower. – This recommendation was presented as an achievement of the PJTSAU centre at International Conference of Safflower held at Directorate of Oilseeds Research (now IIOR)

Developed conservation protocols based on Pest Predator Ratios for Sugarcane Woolly Aphid (SWA), *Ceratovacuna lanigerum* and predators, *Dipha aphidivora* & *Micromus igoratus*- These protocols were discussed and passed on to the managements of three leading Sugar mills in Telangana viz., Gayatri Sugar Mills, Kamareddy; Nizam Deccan Sugars, Medak and Ganapathi Sugars, Sangareddy. - As a result of effective conservation of both *Dipha aphidivora* and *Micromus igoratus,* the populations of SWA continued to be under check as per the present data being obtained through SWA monitoring.

Developed Mass Production Protocols for *Trichogramma*, *Chrysoperla*, *Ha* NPV, *Sl* NPV, *Trichoderma* & *Pseudomonas* amenable for the state of Telangana and they have been officially passed on to stake holders through Department of Agriculture, Govt. of Telangana on the basis of which several decentralized Bio Control Units are being run by rural youth besides nine State owned Bio Control Labs *viz*, Adilabad, Nizamabad, Karimnagar, Sadasivpet (Medak), Mahbubnagar, Rajendranagar (Hyderabad), Warangal, Nalgonda and Khammam.

Upliftment of livelihoods of rural women groups by up scaling NPV production units through active support from NGOs such as Centre for Sustainable Agriculture (CSA) and Centre for Peoples Forestry (CPF).

Feedback analysis of yield gaps in several Horticultural Crops in reference to with or without State Horticulture Mission (SHM) was done to evaluate the programmes of SHM in capacity of member of Technical Support Group (TSG) Bio Agents are recommended as major inputs in the programme.

Production, process, technologies developed

In situ culturing & production of imported parasitoid, *Acerophagous papaye* through potato seedling technique by using papaya mealy bug, *Paracoccus marginatus* as host. -

Standardized Bio suppression of aphids, *Uroleucon carthami* in safflower by using Entomo Pathogenic Fungi (EPF) *Verticillium (Lecanicillium) lecanii* -

Developed Conservation protocols based on Pest Predator Ratios for Sugarcane Woolly Aphid (SWA), *Ceratovacuna lanigerum* and predators, *Dipha aphidivora* & *Micromus igoratus*-

Developed Mass Production Protocols for *Trichogramma*, *Chrysoperla*, *Ha* NPV, *Sl* NPV, *Trichoderma* & *Pseudomonas* amenable for the state of Telangana and they have been officially passed on to stake holders through Department of Agriculture, Govt. of Telangana on the basis of which several decentralized Bio Control Units are being run by rural youth besides nine State owned Bio Control Labs *viz*, Adilabad, Nizamabad, Karimnagar, Sadasivpet (Medak), Mahbubnagar, Rajendranagar (Hyderabad), Warangal, Nalgonda and Khammam.

Infrastructure and physical facilities developed

Transformation of small scheme with obscure facilities in to fully equipped Biological Control Laboratory recognized at state & national level

Net house facility for *in situ* Bio Agent rearing

Bio assay facility for bio pesticides

Quality control facility with image analysis for microbial pesticides

Inoculation chamber for microbial work
Corcyra production unit

Insecticide Act 1968 Compliant lab for quality analysis

]Human resource development

AICRP on Biological Control – PJTSAU Centre is acting as Nodal Centre to all BC labs being run under State Dept. of Agriculture, Govt. of Telangana & Govt. of Andhra Pradesh Inoculum cultures of 6 Egg parasitoids (*Trichogramma* species), one Egg larval parasitoid (*Chelonus*) and one predator (*Chrysoperla*) are made available to Govt. agencies, ICAR Institutes, KVKs, and several NGOs, round the year. Head of AICRP on Biological Control– PJTSAU Centre is acting as consultant to Commissioner of Agriculture, State Dept. of Agriculture, Govt. of Telangana and thereby several recommendations generated in the centre are being transferred to farmers through Extension machinery of the state

Publications

- Research articles published in journals - nil

- Research articles published in symposia - 1

Observations of the QRT

- All the experiments during the period under report were successfully carried out
- The BIPM module for cotton and pulses have been incorporated in the package of practices by the University
- The well established biocontrol laboratory is a referral laboratory for quality analysis of biopesticdes

Recommendations of the QRT

- Spider fauna recorded may be identified in collaboration with NBAIR.
- The trials on maize with biocontrol agents may be dropped/deleted as there is no pest incidence.
- Local strains of *Metarhizium* and *Lecanicillium lecanii* may be provided by the centre for evaluation by other centres.
- Monitoring of the programmes must be ensured based on the requirements of the farmers and the recommendations to be included under package of practices of the University.
- Adequate funding for generation of toxicological data to be earmarked.
- Impact of Biocontrol agents in organic farming to be quantified.

Overall assessment

The centre's has successfully carried out all the trials during the period under report. The centre has come out with biocontrol strategies for management of cotton and pulse crop pests. Good extension activities have been carried out by the centre, technical guidance was provided to sugarcane factories and tribal farmers on biocontrol control agents and their utilisation. The centre has been accredited as referral laboratory for quality analysis by the State Govenment. Good extension activities have been carried out. The impact of biontrol agents needs to be quantified in terms net returns and cost-benefit ratio. Publications have not been brought by the centre in local language and journals.

The overall performance of the centre is good and is graded "B" (Good)

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

Brief achievements

- All the four agro-climatic zones of Himachal Pradesh were surveyed to collect natural enemy biodiversity and a total of 123 species were collected and documented under biodiversity head. Major natural enemies collected were 51 coccinellids, 20 leafminer

parasitoids, 12 predatory mites, 15 thrips, 10 syrphids, *Chrysoperlazastrowi sillemi*,*Zygogramma bicolorata*, *Orius* sp., *Anthocoris* sp., *Anastatus* sp, *Trisolchus* sp, *Baryscapus galactopus*, *Cotesia glomerata*, *Diadegma* pp, *Cotesia vestalis*, *Diadromus collaris*,. *Campoletis chloridae*, *Aphelinusmali* and *Oligota* sp.

- During survey,*Tuta absoluta* was recorded from 11 locations of Himachal Pradeshwith 42 to 89 per cent infested plants, 1-11 mines/leaf/infested plant and 0-6 per cent fruit damage. *Nesidiocoris tenuis* and *Neochrysocharisf ormosa*wereassociated with the pest.
- Apple root borer, *Dorysthen eshugelii* was successfully controlled by using *Metarhizium anisopliae* (10^8 conidia/ cm^2 each) and demonstrated to the farmers.
- Predatory mite, *Neoseiulus longispinosus* (1:30) along with HMO (2.0%)was effective against the phytophagous mites in apple.
- Biointensive IPM packagecomprising of sprinkling of fine pulverized mica (0.2%), release of *Chrysoperla zastrowi sillemi* (5 larvae/ plant), growing of border rows of mustard, release of *Trichugramma brassicae* (100 thousand/ha) and spray of Econeem/ Bt was developed and demonstrated for the control of aphid and caterpillar pests of cauliflower.
- Predatory mite, *Neoseiulus longispinosus* (predator: prey ratio of 1:30) was as effective as profenophos (0.05%) for the control of phytophagous mites in carnation.
- Among bio pesticides and botanical, NeemBaan (1500ppm;3ml/L)was the most effective against rose aphid, *Macrosiphum rosae.*
- *Chrysoperlazastrowisillemi* (1 larva/plant), *Lecanicilliumlecanii* (5g/L of 10^8conidia/g) and azadirachtin (1500ppm; 3ml/L) were moderately and equally effective against *Myzus persicae* in capsicum resulting in 54.8 to 61.2 per cent reduction of the aphid population over control.
- *Chrysoperla zastrowi sillemi* (1 larva/plant), *Lecanicillium lecanii* (NBAIR strain) at 5g/L of 108 conidia/g formulation, NeemBaan (1500ppm; 3ml/L) were moderately effective against greenhouse whitefly, *Trialeurodes vaporariorum* in tomato resulting in 50-60.2 per cent control, while *Neoseiulus longispinosus* (5 and 10 mites/plant) and NeemBaan (1500ppm; 3ml/L) were moderately effective (47.9 to 54.5% reduction) against *Tetrnychus urticae*.
- Among different bio-agents evaluated, azadirachtin (1500ppm; 3ml/L), T. achaeae, *T. pretiosum* (each @ 50000/ha) and Bt (1L/Ha) were equally and more effective (56.8 - 69.6% reduction) than *M. anisopliae*, *L. lecaniiand B. bassiana*(32.5 - 33.9% reduction) against *Tuta absoluta* in tomato.
- Progress made under tribal sub plan (TSP): TSP was implemented in 14 villages covering 7 crops, benefited 782 farmers and distributed 13 types of inputs

Production, process, technologies developed

In situ culturing & production of imported parasitoid, *Acerophagous papaye* through potato seedling technique by using papaya mealy bug, *Paracoccus marginatus* as host.

Standardized Bio suppression of aphids, *Uroleucon carthami* in safflower by using Entomo Pathogenic Fungi (EPF) *Verticillium (Lecanicillium) lecanii* -

Developed Conservation protocols based on Pest Predator Ratios for Sugarcane Woolly Aphid (SWA), *Ceratovacuna lanigerum* and predators, *Dipha aphidivora* and *Micromus igoratus*-

Production, process, technologies developed

- Bio-intensive IPM package for the pests of cole crops
- Management of apple root borer, *Dorystheneshugelii* by *Metarhiziumanisopliae*
- Management of phytophagous mites in apple with predatory mite, *Neoseiulus longispinosus* and horticultural mineral oils (HMO).
- Mass multiplication of predatory mite, *Neoseiuluslongispinosus*.
- Management of phytophagus mite in carnation by using predatory mite, *Neoseiulu slongispinosus* under polyhouse condition
- Evaluation of biocontrol agents against rose aphid in polyhouses.

Infrastructure and physical facilities developed

Developed a biocontrol research laboratory with facilities like culture rooms with controlled climatic conditions, BOD incubators, microscopes with image analysis system, Autoclave, fermenter, environmental chamber, incubator shaker, polyhouse, Besides, we have planned to create two more culture rooms with controlled environmental conditions,two microscopes, two BOD incubators and double distillation apparatus to strengthen the research activities and production of bio-agents.

Human resource development efforts for different categories of staff:

Trainings, workshops and demonstrations were given to different stakeholders:

- Trainings : 75 (KVK scientists: 3, Technical/field assistants: 3, Extension officers: 12, Farmers: 52, MeraGaonMera Gaurav (farmers): 5.
- Demonstrations: 24.
- UG and PG courses taught: 34 in 5 years; contact hours: 83 in 5 years.
- PG students guided: 11 students in 5 years.
- Publications: 38 (33 research papers; 5 Extension bulletins and manuals)
- Symposia/ workshops:20.
- TV talks/ radio talks/ newspaper coverage:7.
- Biocontrol laboratory visits: VIP: 1; Farmers: 152

Publications:
38 (33 research papers and 5 Extension bulletins and manuals)

Observations of the QRT

- Management of phytophagous mites and root borer of apple through biocontrol agents have been successfully carried out.
- BIPM package developed for the control of aphids and caterpillar pests of coliflower and Capsicum.
- Neem based pesticides reported effective against mites.

Recommendations of the QRT

- Search for local isolates/strains of bioagents.
- Success story to be prepared on apple root borer in three months time.
  Strenghthen mass production programmes for *Metarhizium* and predatory mites.
- Net-working with state Biocontrol labs and KVKs for mass production and dissemination of proved technologies.
- The pathology/nematology component can be included for the centre for specific crops without any financial commitment for the additional work.
- The centre should focus on supply of *Metarhizium* and mites to farmers.
- Success stories in English and Hindi to be sent to NBAIR and University.
- All proved technologies to be brought out by the centre to be included in the University POP.
- Quantum of production of bioagents, supply to farmers, area covered under biocontrol. Farmer feedback on impact should be documented.

Overall assessment

The centre's has successfully carried out all the trials during the period under report. Management of phytophagous mites and root borer of apple through biocontrol agents have been successfully carried out and implemented.. The proven technologies by the centre need to be included in the package of practices of the Univesity. Success stories on the management of apple root borer aand impact of bioagents supplied needs to be documented. Good infrastructure facilities for the mass production of bioagents exist at the centre. Adequate training programmes and demonstrations were conducted for transfer of technology and good number of publications have been brought out.

The overall performance of the centre is rated Good (Grade "B")

8. Tamil Nadu Agricultural University, Coimbatore

Crops covered: 16,

(Rice, Pulses, Cotton, Sugarcane, Papaya, Mango, Guava, Tomato, Brinjal, Cauliflower, Curryleaf, Cassava, Carnation, Chysanthemum, Jasmine and Mulberry)

Trials conducted: 58

- Survey and collection of natural enemies of different crop pests and *Trichogramma*, *Chrysoperla, Crypolaemus* and spiders.
- Surveillance for alien invasive pests.

- Monitoring the sugarcane woooly aphid incidence and impact assessment of natural enemies on its biosuppression.
- Monitoring of incidence of papaya mealy bug and its natural enemies in papaya and other alternate hosts.
- Monitoring the biodiversity and outbreaks of invasive mealy bugs on major horticultural crops.
- Monitoring the invasive South American Tomato Pinworm, *Tuta absoluta*.
- Monitroing the diversity and outbreak of pests and natural enemies of chrysanthemum under polyhouse.
- Field demosntration of BIPM package for the management of key pests of tomato.
- Biological control of Brinjal mealy bug *Coccihystrix insalitus*.
- Evaluation of EPN formulations of NBAIR against ash weevil in brinjal.
- Efficacy of Bt. Strains agaianst Diamond back moth in cauliflower.
- Evaluation of Bio-intensive IPM module against *Aleurodicus dispersus* on cassava.
- Field evaluation of *Metarhizium anisopliae* formualtions (IIHR) gainst mango hoppers.
- Field evaluation of *Beauveria bassiana* liquid formulations (IIHR) against tea mosquito bug in guava.
- Evaluation of Biointensive IPM module against major pests in curry leaf.
- Biological suppression of budworm and blossom midge in jasmine.

Salient achievements

- Classical biological control of papaya mealybug, *Paracoccus marginatus* with mass multiplication and release of parasitoid, *Acerophagus* saved a crop loss of Rs.435 crores (papaya, tapioca and mulberry) and input cost on pesticides to the tune of Rs.244.5 crores annually in Tamil Nadu .
- BIPM package recorded lesser population of sucking pest viz., thrips and whiteflies and fruit borer *viz., Helicoverpa armigera* incidence and higher natural enemy activity than the farmers practice with a high cost benefit ratio of 1:3.0.
- Bt formulations viz., PDBC BT 1 and NBAII BTG 4 @ 1 and 2% recorded 77.2 to 83.5 per cent reduction of DBM. Maximum yield of 11.86 t/ha was recorded in NBAII BTG 4 @ 2% spray.
- Liquid formulation of *Metarhizium anisopliae* formulations (IIHR) @ 1 ml/2L achieved 89.74 per cent mortality of mango hoppers which was superior to other formulations *viz.*, talc and oil formulation.
- Monitoring the invasive South American tomato pinworm, *Tuta absoluta* indicated the incidence in Thondamuthur and Madukarai block of Coimbatore district and it was absent in Thudiyalur and Annur blocks. The per cent leaf damage was maximum upto 35.4 % in Madukarai and the maximum per cent fruit damage was noted in Thondamuthur (10.6%). The adult trapped was maximum in February 2016 in Thondamuthur and Madukkarai block. The occurrence of pinworm in other crops like potato, brinjal, chilli and tobacco was not observed in any of the survey locations. The incidence of pinworm was noted in tomato crop from October 2015 onwards whereas the crop stand during earlier months did not show the presence of pinworm. The pinworm

incidence was absent in Erode, Perambulur, Cuddalore, Tiruvannamalai districts during random survey

- Biological control of brinjal mealy bug *Coccidohystrix insolitus* with two releases of *Cryptolaemus* @1500 /ha showed 91.5 per cent reduction of mealybug population realising the fruit yield of 63.4 t/ha and found superior next to pesticide treatment with profenophos 50 EC at 0.1% which recorded a population reduction of 92.39 per cent and maximum fruit yield of 65.6 t/ha.
- The application of EPN (NBAIR formulation) 20kg/ha along with *Metarhizium anisopliae* (NBAIR formulation) 5kg/ha mixed with 250 kg FYM/ha was superior which recorded 87.74 per cent reduction of ash weevil with minimum leaf damage of 8.37 per cent.
- The field demonstration of BIPM module against *Aleurodicus dispersus* on cassava indicated that whitefly population was reduced to the tune of 80.83 per cent as against the farmers practice which had 25.9 per cent reduction. The BIPM plots recorded a tuber yield of 32.84 t/ha whereas in farmer's practice the tuber harvested was 29.68 t/ha. The untreated plot had recorded 26.62 t/ha. The cost benefit ratio realised in BIPM module was 1:3.18 as against cost benefit ratio of 1:2.23 in farmers practice with insecticide sprays alone.
- Field evaluation of *Beauveria bassiana* (IIHR formulation) against tea mosquito bug showed that *B. bassiana* at 10g/litre of water had a maximum reduction of fruit damage (81.1%) closely followed by B. bassiana at 5g /l which reduced the fruit damage of 79.69 per cent over control. The insecticide spray of imidacloprid at 0.025% also had a reduction of 78.6 per cent fruit damage over control. The unsprayed tree recorded a fruit damage of 26.3 per cent during the same period of observation.
- BIPM module implemented in curry leaf could reduce the leaf roller population by 78.94 per cent and psyllid population upto 59 per cent, whereas the farmers practice recorded a reduction of 64.58 and 42.69 per cent leaf roller and psyllid population respectively. The leaf yield was high in BIPM plot 7.75 t/ha with the cost benefit ratio of 1:3.99, but in farmers practice, the leaf yield was 7.02 t/ha recording the cost benefit ratio of 1:2.98. The control plot realised the lowest leaf yield of 3.35t/ha.
- Application of *Beauveria bassiana* (NBAIR formulation) at 5g/ litre of water along with 6 releases of *Trichogramma chilonis* at 10 days interval from bud initiation stage was superior in checking the bud borer with minimum bud damage of 2.9 per cent and a reduction of 80.3 per cent bud damage in jasmine.

Establishment of mass production units

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:

Mass production and sale of biocontrol agents under Venture Capital scheme. Technologies were developed for mass production of predator *Dipha aphidivora* and parasitoid *Acerophagus papayae.*

Infrastructure and physical facilities developed in the last five years:

Mass production facility for *Goniozus nephantidis, Acerophagus papayae, Cryptolaemus* , *Chrysoperla* .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

The scientists working in the project provided training on IPM, Mass production of bio control agensts, field applications , identification of predatory and phytophagous mites , Entomopthogens for safe pest management, Non chemical methods of pest management for major Floriculture criops, Biological conntrol in vegetable crops, Biocontrol methods for entreprenuer development, to farmers, ooficers from State Department of Agriculture, horticulture and KVKs.

Publications

- Research articles published in journals - 86
- Research papers presented in symposium/workshops - 27
- Popular articles including extension folders - 5
- Book Chapetrs - 1

Observations of the QRT

- The centre had conducted all the research programmes allotted to them.
- Classical biological control of papaya mealybug through mass multiplication and release of parasitoids.
- BIPM package for sucking pests and fruit borer of cotton and other vegetables developed.
- BIPM strategies were dessiminated against major crop pests and diseases through large scale demonstrations

Recommendations of the QRT

- Economic analysis and documentation of impact of release of natural enemies should be done.

- Documentation of natural enemies of spiraling whitefly in Tamil Nadu.
- Parasitism to be measured as percentage parasitism (not as number of adults emerged / percent adult emergence).
- Status of pin worm *Tuta absoluta* in Tamilnadu to be re-checked in Erode and surrounding areas.

Overall assessment

The centre has successfully carried out all the trials covering 16 crops. Fifty eight trials were conducted Very good work was done on the monitoring of invasive pests, the papaya mealy bug and tomnato pinworm. BIPM packages were developed for pests of several vegetable crops. The centre has established good biocontrol laboratory and supplied biogents to farmers and other entreprenuers (Venture Capital Scheme). The centre has disseminated the technologies developed through HRD programmes and extension activities and has brought out good publications.

The performance of the centre is excellent and is graded "A+"

9.Assam Agricultural University, Jorhat

Brief achievements
BIOLOGICAL SUPPRESSION OF VEGETABLE PESTS

Developing bio intensive IPM package for the pests of Cole crops (2012-13)

Cabbage aphid, *Brevicoryne brassicae* and Lepidopteran pests , *Pieris brassicae* , *Plutella xylostella* The field experiment was carried out in farmers' field located at Allengmora, Jorhat covering an area of 200 sq.m. The IPM package included, release of *Chrysoperla zastrowi sillemi* @ 5 larvae /plant against *Brevicoryne brassicae*, three releases of *Trichogramma chilonis* , *T. brassicae* @ I,00,000/ha against. *P. xylostella* and *T. pieridis* @ 1,00,000/ha against *Pieris brassicae* at seven days interval when moths and eggs of the lepidopteran pests were seen in the field, The population of *P. brassicae* and *P. xylostella* significantly reduced from 2.45 to 1.34 and 4.85 to 1.94 where as in farmers practice they were 2.50 to 1.40 and 4.65 to 1.97, respectively after 55days of transplnting (third spray).. The yield of cabbage, was 169.9q /ha in IPM package compared to farmer's practice (163.7 q /ha)... The occurance of coccinellids was higher in IPM plot than farmers' practice.

Evaluation of local and NBAII entomopathogenic strains against soil insect in potato (2013-14 &2014-15)

Evaluation of local and NBAII entomopathogenic strain against soil insect in potato was carried out during *rabi* season in the farmers field. The treatments were *Metarhizium anisopliae* (AAU strain, Biometa) 15 kg/ha; *Beauveria bassiana* (, AAU strain, Biosona) 15 kg /ha; Imidacloprid 20 g a.i./ha as soil drenching; Malathion 5 % dust 40kg/ha as soil application; *Metarhizium anisopliae*(Ma4-NBAII strain)15 kg /ha; *Metarhizium anisopliae* (Ma35-NBAII strain)15 kg /ha; *Beauveria bassiana* (Bb5a-NBAII strain) 15 kg /ha; *Beauveria bassiana* (Bb23-NBAII strain) 15 kg /ha, and Untreated control. the application of imidacloprid @ 20 g ai/ha was found to be the best and could significantly reduce the infestation of soil insects of potato. Out of different bio insecticides of NBAII tested in the experiment, Ma-4 , *Bb*-23 and *Bb*-5a of NBAII strains showed good results in reducing the infestation of *D.orientalis* with 19.0, 19.25, 19.75 % infested tubers compared to the local strains of AAU(*M.a*,Biometa and *Bb*-Biosona)and *Ma*-35 NBAII strain, where the per cent infested tubers was 23.5 and 21.5 and 23.75, respectively. the highest yield (83.90 q/ha) was obtained in the plots with imidacloprid @20 g ai/ha followed by Bb5a- NBAII strain (83.12 q/ha), and malathion dust(79.37 q/ha) and the treatments were found to be at par with each other in their efficacies.

Development of bio control based IPM against pests of Okra (2012-13)

The *A. biguttula* and *B. tabaci* population/plant were 0.98 and 0.76 in IPM package whereas they were 1.03 and 0.74 was recorded in farmers' practice respectively, after third spray (fig.1 &2) . But in case of percent fruit damage, the minimum fruit damage of 8.17 was obtained in chemical control plots as against 9.06 in IPM plot, although they were on par

with each other. In case of untreated check fruit damage of 14.10 percent was significantly different from IPM package and farmers' practice.

Maximum yield (102.2q/ha) was registered in IPM package followed by farmer's practice with 98.57 q/ha, although they were statistically on par with each other

Evaluation of local and NBAII entomopathogenic strains against soil insect in potato (2013-14 & 2014-15)

There were 9 treatments including control. The treatments were *Metarhizium anisopliae* (AAU strain, Biometa) 15 kg/ha; *Beauveria bassiana* (, AAU strain, Biosona) 15 kg /ha; Imidacloprid 20 g a.i./ha as soil drenching; Malathion 5 % dust 40kg/ha as soil application; *Metarhizium anisopliae*(Ma4-NBAII strain)15 kg /ha; *Metarhizium anisopliae* (Ma35-NBAII strain)15 kg /ha; *Beauveria bassiana* (Bb5a-NBAII strain) 15 kg /ha; *Beauveria bassiana* (Bb23-NBAII strain) 15 kg /ha, and Untreated control.

The results indicated that the application of imidacloprid @ 20 g ai/ha was found to be the best The per cent infested tubers due to attack of *Dorylus orientalis* and *Agrotis ipsilon* of potato was 10.25 and 11.25 , respectively. Out of different bio insecticides of NBAII tested in the experiment, *Ma*-4 , *Bb*-23 and *Bb*-5a of NBAII strains showed good results in reducing the infestation of *D.orientalis* with 19.0, 19.25, 19.75 % infested tubers compared to the local strains of AAU.

Evaluation of fungal pathogens against sucking pest of Bhut Jolokia/ hot chill (*Capsicum sinensis*) (2014-15, 2015-16 &2016-17)

There were eight treatments including control and the treatments were,- *Metarhizium anisopliae* (Biometa, AAU strain) : ($1x10^8$ spores /g) @ 5g/ litre; *Beauveria bassiana (*Biosona, AAU strain*)* :(1x108 spores /g) @ 5g/ litre ; *Metarhizium anisopliae*(Ma-4) NBAIR strain:($1x10^8$ spores /g) @ 5g/ litre ; *Metarhizium anisopliae* (Ma-35) NBAIR strain :(1x108 spores /g) @ 5g/ litre ; *Beauveria bassiana* (Bb-5a)NBAIR strain:($1x10^8$ spores /g) @ 5g/ litre ; *Beauveria bassiana* (Bb-23)NBAIR strain :($1x10^8$ spores /g) @ 5g/ litre; Imidacloprid @ 20 g ai/ha, and Untreated control.

Demonstration of biointensive package for tomato (2014-15, 2015-16 & 2016-17)

The BIPM package comprise of the,- seedling root dip treatment with Pseudomonas 2% solution ; spray of NSKE @ 5 % against sucking pests; use of pheromone traps @ 15 /ha against *Helicoverpa armigera;* six releases of *Trichogramma chilonis* @ 1,00,000 /ha from flower initiation stage at weekly intervals, and rouging of leaf curl disease affected plants

The mean population of *H. armigera* per 10 plants was 2.70 whereas it was 4.10 in BIPM plots. Maximum number of larval population (16.20 /10 plants) was observed in untreated control plots. In chemical control plot the per cent fruit damage was 11.8 with higher yield of 153.82 q/ha as against 17.3 % in BIPM plot with 147.20 q /ha.

Development of Bio control base IPM module against *Leucinodes orbanalis* of brinjal (2015-16 & 2016-17)

The field experiment on the management of shoot and fruit borer (*Leucinodes orbanalis*) was conducted on variety "JC1" at farmer's field, Dangdhara, Titabor, Jorhat. The BIPM packagewas tested to compare with farmers practice (chemical control).

The results indicated that the per cent shoot (9.5) and fruit (17.7) damage was minimum in BIPM package as compared to farmers practice (chemical control) where the per cent shoot and fruit damage were 13.0 and 20.0, respectively.Four alternate sprayings of cypermethrin @ 50 g a.i /ha and profenofos @ 750 gm ai/ha at fortnightly interval found superior in reducing the fruit infestation (20.0%) and gave maximum yield (208.7q/ha) of marketable brinjal followed by BIPM package with 203.50 q/ha

Role of habitat manipulation on natural enemies of cabbage pests (2015-16 & 2016-17)

The following five modules were tested:**.,** T1 = Cabbage intercropped with mustard and cowpea**.,** T2 = Cabbage intercropped with mustard and sorghum as border crop**.,** T3 = cabbage intercropped with cowpea and sorghum as border crop**.,** T4 = cabbage with sorghum as border crop **and** T5 = cabbage as sole crop (untreated check).. Significantly, minimum larval population of *P. xylostella* (1.90/plant) was recorded in T1 (cabbage intercropped with mustard and cowpea) followed by T3 (cabbage intercropped with cowpea and sorghum as border crop) with 2.72 larva/plant and T2 (Cabbage intercropped with mustard and sorghum as border crop) with 2.79 larva/plant after 70 DAP, respectively.

BIOLOGICAL SUPPRESSION OF PESTS IN HORTICULTURAL CROPS

Survey for mealy bugs and its natural enemies on horticultural crops – papaya, hibiscus, tapioca, brinjal, tomato, okra (2012-13)

Regular surveys were initiated in different districts (Kamrup, Jorhat, Golaghat, and Dibrugarh) of Assam to monitor the occurance of mealy bugs and their natural enemies on horticultural crops- like papaya, hibiscus, Guava, citus, brinjal, tomato and okra during June 2012 to February,2013. like hibiscus, okra, citrus and Guava were found to be free from mealy bug infestation. Minor infestation of mealy bugs was observed in citrus and guava leaves during the month of September and October'2012. Papaya mealy bugs on papaya fruits and leaves was first detected in Kamrup district and was identified as Papaya mealy bug, *Paracoccus marginatus*. Brinjal, and tomato crop were found to be free from infestation of any species of mealy bug during the survey period.

Survey and surveillance of Pinworm, *Tuta absoluta* on Tomato (2015-16 to 2016-17)

Results: Survey was conducted in different tomato growing pockets of Kamrup, Nagaon, Jorhat, Golaghat and Sivsagar districts. No Pinworm infestation was observed in those surveyed areas.

BIOLOGICAL SUPPRESSION OF TEA PESTS

Evaluation of *Beauveria bassiana* (IIHR isolate) against Tea mosquito bug in tea (2013-14 and 2014-15)

Beauveria bassiana (IIHR strain),*B.bassiana* (Commercial product) and botanical insecticides (Pestoneem) against tea mosquito bug (*Helopeltis theivora*), were evaluated in an organic tea garden area of 1 ha was selected at Kachagaral area of Jorhat. Thiamethoxam @30 gm ai/ha was found superior to *B. Bassiana* (IIHR strain) in reducing the *H. theivora* population (6.40 per 10 plants). No significant difference was noticed in reducing the *H. theivora* population with *B.bassiana* IIHR strain (15.75/10 plants) pestoneem (16.25/10 plants) and B.*bassiana* (17.25 /10 plants) of commercial formulation in their efficacies in reducing the *H. theivora* population. An egg parasitoid of *H. theivora* was detected in the laboratory and it was suspected to be *Telenomus* sp.

BIOLOGICAL SUPPRESSION OF STORAGE PESTS (2012-13 & 2013-14)

Evaluation of anthocorid predators against storage pests in rice

The following treatments were imposed T1: Release of 10 *Blaptostethus pallescens* nymphs, T2 : Release of 20 *Blaptostethus pallescens* nymphs, T3 : Release of 30 *Blaptostethus pallescens* nymphs, T4 : Release of 10 *Xylocoris flavis* nymphs, T5: Release of 20 *Xylocoris flavis* nymphs, T6: Release of 30 *Xylocoris flavis* nymphs and T7: Infested grain with no anthocorid predator

The inoculative release of *Xylocoris flavipes* @ 30 nymphs per kg of stored rice (18.00 moths/ container) was significantly superior to all other treatments in reducing the emergence of *corcyra* moths. However, *B pallescens*,@ 30 nymphs/container and *X. flavipes* @ 10 nymphs / container were on par with each other (32.5 and 36.0 moth emerged respectively) in infested stored rice.

BIOLOGICAL SUPPRESSION OF RICE PESTS

Seasonal abundance of predatory spiders in rice eco system (2012-13)

The diversity and fluctuation of predatory spiders, the samples were collected randomly from 10 quadrats (1x1m) from each field at weekly interval. Altogether 7 Nos. of predatory spiders *viz. Oxyopes javanus, Tetragnattha sp., Lycosa psedoannulata, Argiope catanulata, Uluborous* spp. *Tomisus* spp. *Neoscona* spp .were observed in rice ecosystem. The population of predatory spiders was maximum during September to mid of October. Among the different spiders *Oxyopes* spp. was recorded maximum followed by *Argiope spp, Tetragnatha spp* and *Lycosa spp.* ***Oxyopes*** spp. was the most dominant species during the cropping season.

Enabling large scale adoption of proven bio control technologies (2012-13, 2013-14, 2014-15,2015-16 & 2016-17)

Area covered: 50 hectares (2012-13), 30 hectares (2013 -14), 30 hectares (2014 -15), 20 hectares (2015 -16) and 30 hectares (2016 -17)

Large scale adoption of proven bio control based IPM package in rice was carried out in the farmer's field at village Pirakota of Jorhat district.The BIPM package consisted of seedling root dip treatment with *Pseudomonus fluorescens* @ 2 % solution, application of *Beauveria bassiana* @ 10^{13} spores/ha against sucking pests, erection of bird perches @ 10 no /ha, six releases of *T. japonicum* @ 1,00,000 laks /ha at weekly interval starting from 25-35 DAT against *Scirpophaga* spp. and *Cnaphalocrocis* spp, spray of Botanicals (Pestoneem @ 3ml/lit) against sucking pests and *Pseudomonus* @ 10g/lit against foliar diseases, respectively. The incidence of dead heart (2.75 %), WEH (3.00 %) and damaged leaves due to *Cnaphalocrocis* sp (2.78%) was significantly high in farmers' practice where as they were 1.41, 1.48 and 1.37 per cent in IPM plot after 65 DAT, respectively. Grain yield of 3364 kg /ha was registered in IPM package which was significantly superior to farmers' practice with 3160 kg/ha , higher number of spider population (1.40 /sq.m) was recorded in IPM plots as against farmers' practice at 65 DAT.

BIOLOGICAL SUPPRESSION OF SUGARCANE PESTS

Large scale adaptation of proven biocontrol technologies of Sugarcane (2012-13)

Target pest :. Large scale demonstration of *Trichogramma chilonis* against the plassey borer, *Chilo tumidicostalis* was carried out in the farmer's field located at Khanikor gaon in Golaghat district covering an area of 50 hectares with Farmer's practice (Chemical control).. In farmers' practice four rounds of profenofos 50 EC @ 0.05% was sprayed at 15 days interval. A total of eleven releases of *T. chilonis* @ 50,000/ha/release at 10 days . The per cent incidence of *C. tumidicostalis* in chemical control plot was 14.71 compared to 12.08 per cent in parasitoid released plot.. The cane yield attributed in parasitoid released and chemical plot was 73.2 t/ha and 71.39 t /ha, respectively. A net return of Rs.3720 was only achieved in cane yield of IPM plot compared to chemical control plot.

Biodiversity

Biodiversity of bio control agents from various agro –ecological zones (2012 -13 to 2015-16)

1. Trichogramma

Trichocards with the eggs of *Corcyra cephalonica* were placed in rice, maize, sugarcane, castor and tea plantation areas for parasitism by T*richogramma* in different geographical area and collected after two days from the fields, *Trichogramma chilonis* could be recovered from rice and sugarcane eco system from Jorhat and Golaghat district of Assam.

2. Chrysoperla 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 (5.2/2.5sq.cm leaf) during 2012-14 which was found only in few clumps of sugarcane area.

3. ***Cryptolaemus*** one *cryptolaemus* was rcovered from bhut Jolokia during 2015-16. predators like *Coccinella septempunctata*, and *Menochilus sexmaculatus* were very common.

4. Entomopathogens The cadavers of french bean leaf folder and Banana leaf and fruit scaring beetle infected by as *Numorea rileyi* and *Beauveria bassiana*.,

5. **Spiders** 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 sent to NBAIR Bangalore for identification.

6. Insect derived EPN: Soil samples from different areas of surveys have been collected to isolate local EPN. Insects (*Corcyra* larvae) suspected to be effected by EPN were isolated and placed in 50 cc soil in polythene bags and sent to NBAIR, Bangalore for identification.

7. Anthocorids No anthocorid predators could be detected from the unsprayed farmers fields.

Surveillance for alien invasive pests in vulnerable areas (2012-13 to 2016-17)

Surveillance for alien invasive pests (*Brontispa longissima, Aleurodicus dugesii, Phenacoccus manihoti, Phenacoccus madeirensis*) in vulnerable areas was made particularly in Jorhat, Golaghat, Shivsagar and Kamrup districts. The investigation revealed that there was no any population of mealy bugs recorded in fruit crops and vegetables.

Tribal Sub plan programme (2014-15)

Popularization of Bio-intensive IPM in vegetables.

Villages : 3, Number of farmers :8 in each village Area of demonstration: 0.5 ha per demonstration in each crop. **Crops dealt:** Major winter vegetables (Cabbage, Tomato, Brinjal and Frenchbean) and summer vegetables (Okra and Chilli).

Biocontrol/ IPM technologies implemented for pest and disease management:.

The technologies were as follows: 1. Use of resistant varieties., 2. Soil application of FYM/ vermicompost enriched microbial pesticticides 3. Release of *Trichogramma chilonis*/ *T. brassicae* @ 1 lakhs /ha at weekly interval., 4. Use of YST @ 15 traps / ha., 5.Use of pheromone trap @ 20 nos /ha..,6.Removal and destruction of infested fruits and shoots., 7.Rouging of disease infested plants., 8.Spray of *Beauveria bassiana* @ 2 X 10^7 per ml ., 9. Spray of neem products (NSKE 5%) and 10. Need based application of insecticides

Crop wise achievement of BIPM demonstration in tribal areas:

Sl no.	Crop	Transplanting/ sowing	Yield (q/ha)*
1.	Cabbage	October	184.5
2.	Tomato	October-November	186.8
3.	Brinjal	September	194.5
4.	French bean	October	63.5 (green pod)
5.	Chilli	March	62.8
6.	Okra	March	154.7

*Average yield of 3 villages

Impact of TSP project: The farmers under TSP programme were economically benefited.. The inputs provided to the farmers and the benefit derived from them significantly helped the farmers in creation of wealth of the areas.

LARGE SCALE ADOPTION OF BIOCONTROL TECHNOLOGIES IN RICE: A SUCCESS STORY OF ASSAM

Large scale adoption of biocontrol technologies conducted in about 1000 hectares in each cropping season consecutively for 5 years.. The BIPM package comprised of seedlings root dip treatment in 2% solution of *Pseudomonus fluresence*, application of *Beauveria bassiana* @ 10^{13} spores/ha against sucking pests, use of bird perches 10/ha, six releases of *Trichogramma japonicum* @ 50, 000 /ha/week, spray of *Pseudomonus flurescens* 10 g/lit against foliar diseases, and need based application of neem product (Azadiractin 1000ppm @ 5 ml/lit). The BIPM package was also introduced in the villages under different KVKs of AAU, Jorhat The "TRICOCARD" are being supplied as per demand to various KVK's of AAU, State department of Agriculture, Govt. of Assam and Govt. of Nagaland, private entrepreneurs and progressive farmers..

ESTABLISHMENT OF MASS PRODUCTION UNIT

The Centre has established a new Bio control Laboratory to produce biocontrol agents relevant to the technical programme of work.Following parasitoids are maintained in the laboratory *Trichogramma japonicum., T. chilonis., T. brassicae., T. mwanzai., T. pretiosum., T. pieridis*MITS (*T. chilonis*). Cultures of parasitoids have been supplied to different Regional Research stations of AAU, KVKs, Agricultural Officers Govt. of Assam, Govt. of Nagaland, NGO's for their field demonstration.

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 1000 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

- Training on IPM with special reference to use of bioagent/ biopesticides in vegetables *(Kharif & Rabi*) rice and sugarcane, imaprted to Extension officers, Plant Protection officeres, Agricultural officers of SAUs, KVKs.

Publications

- Research articles published in journals - 13
- Extension bulletins - 10
- Popular articles - 26
- Books - 7
- Book chapters - 3
- Leaf lets - 9
- Radio/ TV talks - 11

Observations of the QRT

- The centre had conducted all the experiments/ technical programmes allotted.
- Centre developed BIPM for suppression of vegetable,rice, sugarcane tea, and storage pests, and has successfully demonstrated these under farmers conditions.
- Extensive surveys were carried out to catalog the biodiversity of biocontrol agents from various regions of state.
- The BIPM package developed by the centre for rice pests was adopted on large scale through effective linkage with State Department of Agriculture, Govt of Assam and Govt of Nagaland, private entrepreneurs and progressive farmers.

Recommendations of the QRT

- Search for local isolates/strains of bio agents.

- Success story on biocontrol of cabbage diamond back moth and potato cut worm to be prepared in three months time and to be hosted on University and ICAR-NBAIR Websites.
- Centre to strengthen the mass production program for tricho-cards and other biocontrol agents.
- Networking with state Biocontrol labs and KVKs for mass production and dissemination of proven technologies.
- Identified duplicate specimens may be sent to ICAR-NBAIR museum.
- The centre should focus on supply of biocontrol agents to farmers.

Overall assessment

The centre had conducted all the experiments/ technical programmes allotted during the period under report. The centre has come out with BIPM packages for supression of vegetable,rice, sugarcane tea and storage pests, which were adapted by the farmers on large scale through linkages with State department of Agriculture of both Nagalanad and Assam. The centres sucess stories on management of diamond back moth and potato cut worm need to be documented and economic analysis done.

The overall performance of the centre is Very Good and is graded "A"

10. Mahatma Phule Krishi Vidyapeeth, Pune

Brief achievements

1. Biodiversity of bioagents studies revealed that sixteen bioagents (Parasitoids and Predators) and four entomopathogens recorded in fields and horticultural crops from ten districts of Maharashtra covering five Agro-climatic Zones.
2. The alien invasive pests *viz., Paracoccus marginatus, Phenacoccus solenopsis, Pseudococcus jackbeardsleyi and Tuta absoluta* were recorded.
3. The SWA incidence has been reduced from 25.45 to 1.41 per cent due to establishment of natural enemies' *viz., Dipha, Micromus* and *Encarsia flavoscutellum* in Maharashtra.
4. The Cotton mealy bug *P. solenopsis* incidence has been reduced due to *Anesius arizonensis* established in Maharashtra.
5. The incidence of PBW recorded severe for last two years in *Bt* cotton.
6. The *Bt* strain (NBAIR *Bt* G 4) provided by NBAIR, Bangalore found effective against *H. armigera* and *M. vitrata* in pigeon pea.
7. Besides, *Sl*NPV the MPKV strain of *N. rileyi* found effective in controlling *S.litura* on soybean.
8. The *M. anisopliae* found effective against safflower aphids, mango hoppers and onion thrips tested at this centre.
9. *Scymnus coccivora @* 10 grub /tree has been found effective and at par with *Cryptolaemus* against mealy bugs on custard apple.
10. *Acerophagus papayae* found successful and became classical example for biosupression of PMB. This parasitoids first time reported by Pune centre.
11. American Pin worm, *Tuta absoluta* was recorded on tomato in Pune region. Six releases of *Trichogramma achaeae* found effective against the pests.
12. The BIPM module (*T. chilonis* + NSKE + *Bt*) found effective against *Leucinodes orbonalis* in brinjal.
13. *Bt* strain Galleriae found effective against fruit borer, *Earias vittella* on okra.
14. Application of FYM enriched with *Paecilomyces lilacinus* found comparable with carbofuran 3 G against RKN in gerbera in polyhouse.
15. Four releases of predatory mites and three sprays of *Hirsutella thompsonii* found at par with abamectin spray against *T. urticae* on rose in polyhouse condition.
16. **Enabling large scale adoptions of technologies** :
    - Release of *T. chilonis* TTS against Early shoot borer in sugarcane.
    - Mass production and demonstration of *N. rileyi* MPKV isolate over 62 ha in soybean and potato fields against *S. litura.*
    - Technology developed and transferred: Mass production and field effectiveness of **six** bioagents demonstrated on farmer's field.
17. **Establishment of mass production unit**:
    Cultures of eleven species of parasitoids, four species of predators, four species of microbial agents and four laboratory hosts were mass cultured and utilize for experimentations, field demonstrations and supply to needy framers and Government agencies.
18. **TSP program:** TSP program has been executed for three consecutive years (2014-2017) in Tribal areas in Nasik district effectively. The tribal farmers are convinced for adoption of bioagents and biopesticides for management of pests.

Production, process, technologies developed

Establishment of mass production unit: Cultures of eleven species of parasitoids, four species of predators, four species of microbial agents and four laboratory hosts are maintained.

Biosuppression of mealybug by Cryptolaemus montrouzieri for grape growers, custard apple

Biosuppression of papaya mealybug *Paracoccus marginatus*

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.

Referral laboratory for testing quality parameters of biopesticides established with the help of DBT, GOI, and New Delhi

Facilities of controlled polyhouse and shade net were developed for mass prodcution and testing of bioagents in floriculture and vegetable taken in protected cultivation

Human resource development

Soft skill development programme for personality development were organised for staff members of the project.

Hands on Training conducted “Experimental learning Programme" on Production and Handling of Bioagents and Biopesticides" to 150 students during the last five years.

Sixteen training porogrammes were organised on biocontrol agents, biopesticdes. The trainees included extension officers, state department officers, farmers and tribals.

Trainings priovided to tribal farmers under Tribal sub plan projects on insect pest management in fuit iorchards, mango stem borers , cahsew bores, identification of natural enemies, application of Entomopthogenic fungi to conytrol mango hoppers and tea mosquito bug

Publications

- Research articles published in journals - 36
- Research papers presented in symposium/workshops - 18
- Popular articles including extension bulletins - 17
- Books./ bulletins/ Folfders - 2

Observations of the QRT

- The QRT appreciates the active role played by the centre in the classical biological control of papaya mealybug.
- The centre had conducted all the experiments during the period under report.
- The centre has contributed immensely on biological suppression of potato tuber moth, sugarcane woolly aphid, tomato, pinkbollwarm , phytophagous mites and oher alien invasive pests.
- Large scale adoption of these technologies was promoted through supply of cultures of natural enemies through a well established mass production unit.
- TSP program was successfully executed in tribal areas of Nasic district through supply of bioagents and biopesticides.

Recommendations of the QRT

- The centre should have tie up with biocontrol agent producers. Important to compare the local commercial products with the products formulated by the centre.
- Status paper on quality control of biopesticides to be prepared. A programme has to be launched to take up Quality analysis of commercial products without revealing the source of the products.

Overall assessment

The centre had conducted all the experiments/ technical programmes allotted during the period under report.The centre has contributed immensely on biological suppression of potato tuber moth, sugarcane woolly aphid, tomato, pinkbollwarm , phytophagous mites and oher alien invasive pests. Sixteen training porogrammes were organised on biocontrol agents, biopesticdes to extension officers, state department officers, farmers and tribals. The centre is recognised as Referral laboratory for testing quality parameters of biopesticides by the government with funding from DBT, GOI, and New Delhi. The publications in peer reviewed journals and local languages brought out by the centre is noteworthy.
The performance of the centre is Very Good and is graded "A"

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

Brief achievements

I. **Characterization of abiotic stress tolerant *Trichoderma* isolates for the production of hydrolytic enzymes:**
Among the six abiotic stress tolerant (drought and salinity) isolates of *Trichoderma harzianum* (Th-14, Th-15, Th-19, Th-55, Th-56 and Th-89), Th-14 was found best in

producing hydrolytic enzymes (chitinase, chitosanase, β1, 3 endoglucanase, cellobiase, amylase and protease).

II. **Evaluation of bioagents for their compatibility for the development of consortium to enhance their efficacy:**

Compatibility among biocontrol potential *Trichoderma-Pseudomonas* and *Trichoderma-Trichoderma* isolates was studied by dual culture, mixed formulations and using cell free cultures. All the combinations (14 no.) were found compatible with each other as no isolate inhibited the growth of one- another. In glasshouse studies all the combinations showed significantly better seed germination while some combinations viz. Th14+Psf173, TCMS36+Psf173, Th17+Th19, Th17+Psf2, Th17+TCMS36 and Th14 +Psf2 showed better plant vigour index (43.5 to 44.9%) as compared to their checks (28.8 to 41.5%).These guidelines could be used before developing bioagent consortium and evaluation in field for crop health management.

III. **Development of cost-effective WP/EC/Paste based *Trichoderma* (Th-14) formulations.**

A technique to get higher CFU ($3.1x10^{12}$ spores/ml) was standardized. Nine different formulations (3 WP based, 4 liquid and 2 paste based) were prepared which retained a CFU of $4x10^6$ up to 7 months at room temperature and 2-$3.8x10^6$ CFU/g or ml up to 11 months at 4^0C.

IV. **Selection and promotion of plant growth promoting crop specific *Trichoderma*.**

A total of 72 *Trichoderma* isolates were isolated from rhizosphere and rhizoplane of rice, wheat, and chickpea and evaluated for their growth promotion effects on their crop of origin. *In-vitro* and glasshouse studies revealed that native crop *Trichoderma* isolates were significantly more effective in increasing plant vigour in their respective crop and could be exploited in a better way for crop health management.

V. **Field evaluation of invert-emulsion/ talc formulation.**

The invert emulsion based *Trichoderma* formulation (IEF2) was found most effective in managing seed and seedling mortality, and getting higher yield (18.12 q/ha) of chickpea followed by talc-formulation (16.12 q/ha) as compared to check (10.12 q/ha).

VI. **Evaluation of potential isolates of *Trichoderma*, *Pseudomonas* and *Bacillus.***

Thirty isolates of *T. asperellum/harzianum*, two of *P. fluorescens*, one of *Bacillus* and one of the consortium [PBAT3- T. *asperellum* (Th14) + Ps. *fluorescence* (173)] were tested in different crops (rice, chickpea and lentil). For rice, Th-14, PBAT-3, TCMS-9 and TCMS-36; for chickpea, Th- 14, Th-3, PBAT-3 and Psf-173; for lentil, Th-14, Th-17, TCMS 5 and PBAT- 3; for pea (among four isolates of *T. asperellum/harzianum*, two of *P. fluorescens*, one of *Bacillus* and one of the consortium) TCMS-9, PBAT-3 and Psf-173 and for wheat (among 25 *T.*

asperellum/harzianum and 03 isolates of *P. fluorescens*) TCMS-16 and TCMS-65 were found most effective in managing crop health and yield. Overall, TH14 and PBAT-3 were found most effective in managing crop health in rice, chickpea and lentil.

VII. **Evaluation of yeast and *Trichoderma* based formulations against chilli anthracnose**.

T. harzianum (Th-3) was found best in reducing fruit rot incidence while *Pichiaguillier mondii* (Y-12) was best in reducing fruit rot incidence and increasing yield of Chilli.

VIII. **Evaluation of *Trichoderma, Pseudomonas* and *Bacillus* against Pre- and Post-emergence damping off.**

Four isolates of *T. asperellum/harzianum*, two of *P. fluorescens*, one of *Bacillus* and one consortium [PBAT3- T. *asperellum* (Th14) + P. *fluorescence* (173)] were tested in tomato, onion and chilli. For tomato, Psf-173, Psf-2 and PBAT 3; for onion, PBAT 3 and Psf-2 and for chilli, *Bacillus* and Th-14 were found most effective in reducing pre and post-emergence damping off and improving seedling vigour.

IX. Large scale field demonstrations at farmers' fields

a. Rice: Demonstrations using biocontrol technologies (PBAT-3) conducted over an area of 202.0 ha at the end of 196 farmers gave an average yield of 50.75q/ha as compared to 42.25 q/ha obtained with farmers' practices (conventional practices).

b. Pea: Demonstrations using biocontrol technologies (PBAT-3) conducted over an area of 43.0 ha at the end of 76 farmers gave an average yield of 91.25 q/ha as compared to 54.0 q/ha with farmers practices (conventional practices). Conventional farmers faced a comparative loss both monetarily in terms of cost of inputs and the seed quality, which deteriorated due to the impact of diseases. During 2017 large scale field demonstrations were conducted in basmati rice (189 ha), at the end of certified organic growers at districts Nainital and Udham Singh Nagar (Uttarakhand) for the validation. As per farmer's feedback and observations recorded, the consortium was found effective in reducing bacterial leaf blight, sheath blight and blast in rice by 50-70 per cent as compared to farmer's practices. Farmers obtained an average additional yield of 4.4 q/ha in rice as compared to the farmer's practices.

X. Promotion of Bio-intensive IPM under TSP

A total of 531 farmers from 04 blocks and 28 villages in district U.S. Nagar were adopted and trained to adopt a Common Minimum Programme (CMP) under IPM to reduce pesticide applications in vegetable cultivation. The CMP had four interventions viz., soil solarization, use of bioagents, use of vermicompost and value addition of vermicompost. The tribal farmers were greatly benefitted by this low-cost technology in producing quality vegetables.

Production, process and technologies developed

a. **Production of microbial pesticides (2012-2017)**
Produced six tons of Pant Bio-agent 3 (PBAT-3) and distributed to the farmers of Uttarakhand and Uttar Pradesh.

b. **Process and Technologies developed:**
Developed WP, Oil and Paste-based formulations
Developed an eco-friendly triple combination of low dose of copper based fungicide, copper hydroxide (500ppm); naturally occurring plant strengthener, Chitosan (500ppm) and copper tolerant bio control agent, *Trichoderma asperellum* (TCMS 36) for cost effective management of Oomycete pathogens (late blight diseases of potato and tomato) under the 2+2 Indo-German Project funded by DBT.

Infrastructure developed

Well established biocontrol laboratory for the production of disease antagonists, entomogathogenic fungi and other microbials.

Human resource development activities

Promoted a Common Minimum Programme under Bio-intensive IPM among small and marginal farmers developed under RKVY programme.

Publications

- Research Papers : 32
- Book Chapters : 02
- Laboratory Manuals : 02
- Booklets : 04
- Folders : 02
- Lectures in Proceedings : 29
- Abstracts : 27
- Ph.D. Theses : 06
- M.Sc. Theses : 06

Observations of the QRT

- The centre has extensively evaluated abiotic stress tolerant *Trichoderma* isolates for the management of diseases and has made significant contributions in identifying and developing formulations of *T. harzianum* and *P. fluorescens*. A cost effective WP/EC/Paste based *Trichoderma* was developed.
- Large scale demonstration of BIPM in rice and Pea pests under farmers field conditions was carried out successfully.
- Plant bioagent (PBAT-3) was produced on a large scale and supplied to the farmers of Uttarakhand and Uttar Pradesh.
- The centre has given adequate attention to transfer of relevant technologies particularly on organic farming which is being practiced.

Recommendations of the QRT

- To aim towards commercialization/registration of the potential isolates of the centre, to generate toxicology data for the potential isolates through applying for lateral funding. The potential isolates to be shared with other AICRP/Institutes for generation of field efficacy data under different agroecological zones.
- To prepare success stories for the potential isolates PBAT-3 and 14 in English and local languages and put up on website of University and NBAIR.

Overall assessment

The centre has carried out all the trials during the period under report. Extensive work was carried out on the management of diseases by abiotic stress tolerant *Trichoderma* isolates. A cost effective WP/EC/Paste based *Trichoderma* was developed by the centre. Plant bioagent (PBAT-3) was produced on a large scale and supplied to the farmers of Uttarakhand and Uttar Pradesh. The transfer of technologies particularly on organic farming through large scale demonstrations is appreciated. Good punblications have been brought out by the centre. Success stories on the adaption of technologies and economics need to be documented.

The overall performance is Good and is graded "B"

12. **University of Agricultural Sciences, Raichur**

The following trials were conducted:

1. Diversity of biocontrol agents from various Agro-ecological zones
2. Surveillance for alien invasives pests, *Aleyrodicus digessi, Phenococcus manthoti, Paracoccus marginatus, P.madeirensis* and others,
3. Monitoring the sugarcane wooly aphid incidence and impact assessment of natural enemies on its biosupression,
4. Monitoring mealybug and other sucking pests and their natural enemies in Bt. cotton
5. Evaluation of NBAII liquid formulation (PDBC-BT1 and NBAII BT (G4) and IARI Bt against pigeonpea pod borer and legume pod borer
6. Survey and collection of *Trichogramma, Chrysoperla* and *Cryptolaemus.*
7. Identification and evaluation of predatory mite potential on *Tetranychus* spp, in tomato under green house conditions.
8. Incidence of natural enemies fo cotton mealy bug and to work out the species rtichness fo natural enemies.
9. Demonstration of NBAII liquid formulation (PDBC BT1 and NBAII BYTG 4 against pigeon pea podborer *Helicoverpa armigera*
10. Survey and surveillance of natural enemies of tomato pin worm *Tuta absoluta*
11. Biological suppression of American pin worm *Tuta absoluta*
12. Biological suppression of sap sucking pests of cotton
13. Monitoruing and biological suppression of pink bollworm *Pectinophora gossypiella*
14. Tribal sub plan

Brief Achievements:

a. For the management of pigeon pea pod borer, *Helicoverpa armigera* (Fab.) NBAII *Bt* strain (NBAII BTG 4) was evaluated for two years (2012-13 and 2013-14) which gave consistent results and the same was proposed for University package of practices (2015-16). Large scale demonstrations were made over an area of 20 ha.
b. Tribal sub plan (TSP) was implemented Vaddepalli village of Raichur taluk ten beneficiaries were identified and created awareness on benefits of biocontrol through trainings (02). Established ten vermipits and till today the beneficiaries are producing vrmicompost (2014-15).
c. The new invasive pest, tomato pinworm, *Tuta absoluta* (Meyrick) was noticed in and around Raichur taluk. To create the awareness on pinworm a training programme was organised in farmer's field which was witnessed by the project coordinator and team of scientist from NBAIR (2015-16).

d. During 2015-16 biocontrol agents like *Trichogramma* (500 cards), *Metarhizium anisopliae* (350 Kg) and *Beauveria bassiana* (300 Kg) were produced and demonstrated in sugarcane and rice ecosystem (NBAIR, Bengaluru).
e. In collaboration with KSDA, Ballari successfully demonstrated and managed the root grub in sugarcane (210 acre) in Hampsagar by using *M. anisopliae* (2016-17). Similarly, following biocontrol agents like *Trichogramma* (1000 cards), *Metarhizium anisopliae* (300 Kg) and *Beauveria bassiana* (3750 Kg) were produced.

a. **Production, process and technologies developed**

In pigeon pea ecosystem NAII BTG 4 Bt Technology was proposed for POP.

Entomopathogenic fungi were produced : *Metarhizium anisolpliae, Beauveria bassiana, Lecanicileium lecanii*

Infrastructure developed

The Biocontrol laboratory established with 7 rooms and atraining hall

Green House with facilities established.

The following equipments were procured for the laboratory : Autoclave, Laminar flow, Spectrophotometer, Microphotography, Centrifuge, PCR machine, Gel Doc, Electrphoresis unit, Hot air oven, Gel rocker, Corcyra rearing units, Growth chambvers, Multiple mixer, water bath, Incubator.

Human resource development activities

Biocontrol labortaory lab established in main campus to facilitate training

Farmers awareness training organised on new invasive pest, tomato pin worm and sugarcane wooly aphid

Publications

- Research Papers : 5
- Book chapters : 4

Observations of the QRT

- The centre has carried out surveillance for alien invasives pests, *Aleyrodicus digessi, Phenococcus manthoti, Paracoccus marginatus, P.madeirensis, tuta absoluta* and others.

- Established laboratory for the production of *Trichograma*, *Chrysoperla* and *Cryptolamines.*
- Biological suppression of pinkbollworm and sucking pests of cotton have been well addressed.
- QRT appreciates useful information generated by the centre on biological control of pests.

Recommendations of the QRT

- Continuous monitoring of treated fields during successive seasons.
- Quantified data to be prepared on area covered with bio-agents, number of farmers benefited, economic benefits and impact analysis.

Overall Assessment

The centre has carried out work on surveillance for alien invasives pests and , biological suppression of pinkbollworm and sucking pests of cotton. Biocontrol laboratory has been setup and training programmes on biological control have been organised for farmers and students. The centre has done good work since its inception during 2015.

The performance of the centre is graded "A" (Very Good)

13. Maharana Pratap University of Agriculture & Technology, Udaipur

Brief achievements

Evaluation of influence of crop habitat

Pigeon pea intercropped with maize with sunflower as border crop harboured lowest population of podborer

BIPM of termites in Maize

Soil application of FYM enriched with *Metarhizium anisopliae* 5 x 10^{13} spores/ha effectively increased germination upto 95% and least plant mortality of 4.6% with yield of 39.42 q/ha.

Effectiveness of bioagents and botanicals against aphid *Lipaphis erysmi* infesting mustard.

Two sprays of NSKE 5% was equally effective as two sprays of *Verticilium*. Percent reduction in pest population was 54.82 and 52.58, respectively.

Validation of BIPM of major pests of tomato

Releases of *Trichogramma pretiosum* @1.5 lakh/ha six times initiating first relaese at flowering stage resulted in lowest fruit damage (15.2%)

Validation of IPM module in Soybean

Two sprays of NSKE 5% was effective in reducing major pests of soybean. Soil application of FYM enriched *Metarhizium anisopliae* was effective in reducing the plant mortality (4.24%) due to soil pests with a grain yeild of 16.5 q/ha

BIPM against *H.armigera* in tomato

Bt.K @1 kg/ha and HaNPV @ 250 LE/ha resulted in higher fruit yield of 164.5 and 155.9 q/ha respectively.

Management of major insect pests of brinjal

NSKE 5% and six releases of *Trichogramma chilonis* in brimnjal significantly reduced fruit damage with yeld of 192 q/ha.

Demonstration of *Trichogramma chilonis* against maize stem borer / Maize IPM

Four releases of *T,chilonis* @q,50,000/ha at 10 days interval starting from 35 days after germination was m,ost effective against maize stem borer and resulted in 2.58% dead hearts with 48.5% egg parasitism.

Validation of IPM modules in rainfed maize

Validation was taken up by way of supply of critical inputs (seeds, fertilizers, egg parasitouids and HaNPV) to farmers.

Validation of IPM module in pulses (blackgram in kharif, greengram in summer)

The module comprised of early sowing , installation of pheromone traps, two sprays of 5% NSKE at vegetable stage, two sprays of HaNPV, four releases of egg parasitoid starting from flowering stage of the crop.

Biological suppression of mustard aphid *Lipahis erysmi*

The spray of *Lecanicilium lecani* $2x10^8$ spores/g @5 g/litre and *L. lecanii* + *Metarhizium anisolpliae* @ $2x10^8$ spores/g @ 5g/litre were found to effective in reducing the aphid populations.

Production, process, technologies developed:

BIPM package for mustard aphid, pod borers of tomato, pulses, brinjal and stem borer of maize was developed.

Infrastructure and physical facilities developed:

Established biocontrol laboratory for mass production of natural enemies.

Human resource development efforts

Farmers field schools were conducted for 105 farmers

Publications

- Research papers : 5
- Papers presented in symposia : 2

Observations of the QRT

- Limited funding was provided to the centre**.**
- BIPM package for mustard aphid, pod borers of tomato, pulses, brinjal and stem borer of maize was developed and these were validated under farmers field conditions.

Recommendations of the QRT

- To prioritize crop/pest/ bioagents for future work.
- To focus on production of specific bioagents, the area covered and farmers involvement.

Overall assessment

The centre has carried out all the trials. BIPM packages for vegetable pests. maize and pulses have been developed. The centre needs to focus on specific bioagents and their utilisation by the farmers. The centre has made good progress with the limited funding provided and with the existing infrastructure facilities.

The performance of the centre is good and is graded "B" (Good)

14. Central Agricultural University, Pasighat

The following experiments were carried out durring the period under report

1. Biodiversity of Biocontrol agents from various agro ecological zones
2. Collection of spider fauna from the rice ecosystem.
3. Bio-efficacy of EPNs against Citrus trunk borer, *Anoplophora versteegi.*
4. Evaluation of IPM for upland rice pest and diseases.
5. Evaluation of microbial pesticides against diamond back moth, *Plutella xylostella.*
6. Management of bacterial wilt with an isolate of *Pseudomonas florescence.*
7. Demonstration on "Management of insect pests of cabbage with bio- control based IPM" under TSP.

Brief achievements

Biodiversity of Biocontrol agents from various agro ecological zones

Ninety six isolates of *Pseudomonas fluorescens* were isolated from soil samples collected from different places of East Siang District, Arunachal Pradesh. 51 are found to be *Pseudomonas fluorescens* and the screened isolates were characterized for their potentiality as Plant growth promoting rhizobacteria (PGPR).

Fifgteen species of lady bird beetles were also collected from the different parts of East Siang District of Arunachal Pradesh.

Collection of spider fauna from the rice ecosystem.

Ten species of spider of spiders has been collected from different rice eco- systems of rice and they are preserved in 95% ethyl alcohol.and sent to the NBAIR for molecular characterization and identification .

Management of bacterial wilt an isolate of *Pseudomonas florescence.*

Seedling root dip + soil drenching with CHF*Pf*-1 it was significant different from other treatments. Soil drenching with CHF*Pf*-1 (16.50%) was comparable or at par with soil drenching with streptomycin (15.28% wilted plants). Soil application with mustard oil cake (17.25% wilted plants), soil drenching with bleaching powder (18.26% wilted plants) and seedling root dip with CHF*Pf*-1 (20.65% wilted plants) was found at par with each other. Intercropping with marigold recorded a 35.32% wilted plants.

Bio-efficacy of EPNs against Citrus trunk borer, *Anoplophora versteegi*.

Field evaluation for bio-efficacy of EPNs against citrus trunk borer, *Anoplophora versteegi* were carried out at two locations *viz.* Pasighat and Ringging of Arunachal Pradesh.. Stem injection with dichlorvos gave the highest reduction of 89.53 and 89.71 per cent at Pasighat and rengging, respectively. Among the EPN treatments, CAU-1 stem injection (37.22 % reduction) was observed as the best treatment

Evaluation of IPM for upland rice pest and diseases.

The IPM practice includes- seed treatment with *Pseudomonas florescense* (Su-mona, Pest Control India Limited, Mumbai) @ 5gm/ kg of seed; installation of yellow stem borer trap from 40 days after transplanting (DAT) @ 15 traps / ha; spraying of entomopathogenic nematode (EPN) (CAU-1) at 40,50, 60 and 70 DAT and installation of fermented snail trap from 85 DAT @ 20 traps/ ha area. Farmer's Practice includes seed treatment with carbendazim @ 2gm/ kg of seed, spraying of 0.05% profenophos/ monocrotophos at 40, 55, 70 and 85DAT.

Infestation of stem borers in the IPM field at Pasighat was significantly lower than the untreated control was recorded from 65 DAT (days after transplanting) onward. Similar with the observation at Pasighat, significantly lower incidence of stem borers in the IPM field than the untreated control was recorded from 65 DAT onward at Mebo.

Evaluation of microbial pesticides against diamond back moth, *Plutella xylostella.*

Two fungal species *viz. Metarrhizium anisopliae* (Metagreen, Green Harvest Bio-tech Pvt. Ltd. , Mumbai) and *Beauveria bassiana* (Beauvegreen, Green Harvest Bio-tech Pvt. Ltd. , Mumbai); two entomopathogenic nematods (EPNs) *viz. Steinernema* sp. (CAU-1) and *Heterorhabditis* sp. (CAUH-1) and a *Bacillus thuringiensis* strain received from NBAII, Bangalore (Bt-NBAII) were evaluated

Among the entomopathogenic microbes, Bt (NBAII) recorded the lowest population (0.22larvae/leaf). The two EPNs *viz.* CAU-I and CAUH-1 recorded 0.40 and 0.42 laevae/leaf, respectively. *Metarrhizium anisopliae* were found as least effective microbes with a population of 0.70 larvae/leaf. The population of *P. xylostella* in the untreated control was 0.93 larvae/leaf which were significantly higher than the other treatments after the second round of spray.

Demonstration on "Management of insect pests of cabbage with bio- control based IPM" under TSP.

The IPM module, comprised of intercropping with mustard (pair rows of mustard for every 15 rows of cauliflower), mechanical collection of egg mass and early instars larvae, release of *Trichogramma brassicae* at weekly interval from 30DAT to 65DAT (6 releases @1, 00,000/ha) pheromone traps of *Spodoptera litura* was installed @ 15 traps /ha. Farmer's practice comprised of spraying profenophos @0.05% was sprayed at 30 DAT, 45 DAT and 60 DAT. Biocontrol based IPM recorded significantly lower incidence (0.67, 0.68 and 0.65 larvae/ leaf) of the pest than untreated control (0.89, 0.93, 0.89 larvae/ leaf) at Jampani, Ruksin and Pasighat respectively. The incidence of *P. xylostella* gradually decreased with the increased in the number of *T. brassicae* releases.

The total 149 farmers family was benefited due to demonstration of different practice under TSP. The benefited farmer family 54, 46 and 49 was observed at Jampani, Ruksin and Pasighat respectively.

Production, process, technologies developed: Nil

Infrastructure and physical facilities developed:

Established EPN production laboratory

Established *Trichogramma* production laboratory

Human resource development

Pasighat center worked as volunteer center and P.I of this project attended several workshops/ conferences/ symposiums to get first hand information and knowledge in the area of their research.

Publications:

- Research papers : 2
- Book Chapters : 2
- Popular articles : 2

Observations of the QRT

- Limited funding was provided.
- BIPM for upland rice pests and diamond black moth was developed and evaluated both under farmers field conditions and TSP.
- The centre has demonstrated the efficacy of EPN's against Citrus trunk borer, *Anoplophora versteegi*.

Recom**mendation of the QRT**

- Experiments on rice may be stopped as pest incidence for last 3-4 years is much below ETL level, and work on *Pseudomonas* may be continued for rice blast disease.
- Since the PI is having Nematology background, it was suggested that PI should propose experiments on nematology work in one month's time and this should be incorporated in AICRP-BC technical programme for 2017-18 & 2018-19 e.g. Management of Root-Knot nematodes in vegetables.
- More emphasis should be on documentation of diversity that includes both insect pests and natural enemies.
- Unidentified species of natural enemies including spiders to be sent to ICAR-NBAIR for identification.
- Identified duplicate specimens to be sent to ICAR-NBAIR museum

Overall assessment

The centre has carried out all the experiments assigned. The work on management of Citrus trunk borer, *Anoplophora versteegi* utilisng EPN and BIPM for rice and cabbage pests is

noteworthy. Field demonstrations on biological control of pests was imparted to tribal farmers. The centre has established an EPN laboratory. Diversity of natural enemies and spider fauna need to be documented. A voulnteer centre has done good work. **The performance of the centre is graded "B (Good)**

15. Orissa University of Agriculture & Technology, Bhubaneshwar

Brief achievements

1. Application of Bt @1kg/ha twice at 15 days interval was found at par with chemical control in reducing major pests of groundnut and attaining higher yield(18.979/ha) as against higher pest incidence and lowest yield (7.979/ha) in untreated control.
2. The release of Antrocorid predator, *Blaptostethus pallescens* @ 30/plant proved effective in controlling the mite (*Tetranychus urticae*) population in brinjal and okra and found next to chemical control.
3. Application of *Metarrhizium anisopliae* @ 2×10^8 cfu at 15 and 30 DAG followed by Bt spray @ 1kg/ha at 40 and 55 DAG in okra (*Arka Anamica*) proved to be the best BIPM package in reducing the sucking and fruit borer pests and producing higher yield (8.38t/ha) next to insecticidal check.
4. Application of *Metarrhizium anisopliae* (2×10^8 spores/gm) + *Lecanicillium lecanii* (2×10^8 spores/gm) @ 5ml/l three times at 15 days interval starting from initial appearance of aphids in mustard (NRCHB-101) proved to be the best BIPM package in reducing the aphid incidence and producing the highest yield (8.23q/ha) with the highest B:C ratio (1.55).
5. BIPM demonstrations in paddy, sugarcane and brinjal were carried out in the farmers field @ 100 ac/crop/annum and compared with the farmers own practice.
6. Survey studies on the host range of *Phenacoccus solenopsis* and their natural enemies, spider fauna in paddy eco-system and chrysopid fauna were also carried out.
7. TSP activities on BIPM demonstrations in paddy and brinjal were also carried out in tribal districts (Kandhamal, Sonepura and Keonjhar).

Production, process, technologies developed: Nil

Infrastructure and physical facilities developed:

Bio-control laboratory with the production facility of the following bio-agents:

Trichigramma spp. *Chrysoperla zastrowi sillemi Bracon hebetor*, *Goniozus nephantidis Cryptolaemus montrouzieri Blaptostethus pallescens*, *Xylocoris flavipes Trichoderma* spp. and *Chelonus blackburni*

Human resource development

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

Publications : -

Observations of the QRT

- Limited funding is provided.
- Large scale demonstrations on the biocontrol agents have not been carried out.

Recommendations of the QRT

- Adequate funding support to be provided by the University for the AICRP-BC work.
- Experiments on plant disease management with *Trichoderm*a and other biocontrol agents may be taken up. Strains from NBAIR to be evaluated.
- A new PI for the biocontrol project to be identified at the earliest as the current PI is due for retirement.
- Centre to focus on few bioagents with larger coverage area to be followed up with proper monitoring.

Overall assessment

The centre though carried out the experiments assigned, has not addressed the issues in proper manner, particularly those on plant disease management. Adequate funding and support from the University is the constraint. the centre. BIPM demonstrations in paddy, sugarcane and brinjal were carried out in the farmers field. The area covered under bioagents needs to be documented. Publications , HRD programmes and extension activities / linkages have not been reported**.**

The performance of the centre is satisfactory and is graded "C" (Satisfactory)

Project Coordinating Unit, ICAR-NBAIR, Bangalore

The present Project Coordinating Unit functioning at NBAIR, 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 Biocontrol Workers Group Meetings of AICRP on Biological Control of Crop Pests, Diseases and Weeds were organized in ANGRAU, Hyderabad on 22-23rd May 2012, at NBAII, Bangalore on 24-25th May 2013, -27-28th June 2014 at OUAT, Bhubaneshwar, 2-3rd June 2015 at TNAU, Coiimbatore, 17-18th May 2016 at ANGRAU, Vishakapatnam and 17-18th May 2018 at KAU, Thrissur.
2. UAS, Raichur was added as a new centre during 2014 with limited contingency funding.
3. XII plan EFC document was prepared and submitted.
4. Compilation of combined annual report of AICRP on Biological Control and NBAIR, Bangalore every year.
5. Monitoring of implementation of technical programme by AICRP centres from time to time.uFund allocation to different centres through NBAIR, Bangalore and monitoring of expenditure.
6. Development of linkages with other projects, agencies, institutions, etc.

Comments and recommendations of the QRT

1. The Director of NBAIR who is also the Project Coordinator is presently looking after the monitoring of the technical programme as well as fund allocation.

2. The QRT is satisfied regarding the functioning of the Project under the Project Coordinator of this AICRP considering the matching mandate of NBAIR and

importance of biological control and non chemical methods of pest management at national level.

Structure and organization

Centres and Scientist	Scientist	Technical	Supporting staff	Total
National Bureau of Agricultural Insect Resources, Bangalore Dr. Abraham Verghese/ Dr Chandish R Ballal, Project Coordinator	**35**	**15**	**3**	**53**
Anand Agricultural University, Anand Dr. D. M. Mehta Principal Res. Scientist Dr.P. H. Godhani Asso. Res. Scientist Dr. B.L. Raghunandan Asso. Res. Scientist	3	5	-	8
Acharya N. G. Ranga Agricultural University, RARS, Anakapalle Dr. M. Visalakshi Sr. Scientist (Ent.)	1	2	-	3
Assam Agricultural University, Jorhat Dr. D. K.Saikia Principal Scientist (Ent.) Dr.Rudranarayana Borkakati Scientist (Ent.)	2	2	-	4
Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar Dr. Anand Kumar Tewari Professor, Pl. Pathology	1	1	1	3
Kerala Agricultural University, Thrissur Dr.(Mrs.) K.R.Lyla Professor (Ent.) Dr. Madhu Subramanian Asst. Professor (Ent.)	2	4	-	6
Mahatma Phule Krishi Vidyapeeth, Pune Dr. R.V Nakat Associate	2	2	-	4

Entomologist Aug. 2007 upto Aug2016 Dr. S.M. Galande Asst. Entomologist				
Professor Jayashankar Telangana State Agricultural University, (PJTSAU) Hyderabad Dr. S.J Rehman Professor & Head	1	2	-	3
Punjab Agricultural University, Ludhiana Dr.K.S. Sangha Entomologist Dr Neelam Joshi Microbiologist Dr Rabinder Kaur Asstt. Entomologist Sh. Sudhendu Sharma Asstt. Entomologist Dr Parminder Singh Shera Asstt. Entomologist	4	3	1	8
Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar Dr. Jamal Ahmed Associate Professor Mr. Sajad Mohi-ud-din Assistant Professor	2	2	-	4
Tamil Nadu Agricultural University, Coimbatore Dr. S. Sridharan Professor Entomology Dr. P.A. Saravanan Assistant Professor Ent.	2	2	-	4
Dr. Y.S. Parmar University of Horticulture and Forestry, Solan Dr. Usha Chauhan Sr. Entomologist Dr. P. L. Sharma Principal Scientist (Ent.)	2	2	-	4
Voluntary centres				
Central Agricultural University, Pasighat	1	-	-	1

Dr. Raghubir Kumar Patidar Asso. Prof. (Ent.)				
Orissa University of Agriculture & Technology, Bhubaneshwar Dr. Bhagaban Patro Prof. (Ent.)	1	-	-	1
University of Agriculture Sciences, Raichur (Voluntary Centre) Dr. Arunkumar Hosmani Asso. Prof. (Ent.)	1	-	-	1
Total	**26**	**27**	**2**	**55**

v. Management practices

Budget and Finance

XII Plan Budget (2012-2017)

Sl.No.	NAME OF THE CENTER	PAY	T.A.	R.C.	TSP	TOTAL
1	AAU, Anand	227.30	5.77	16.11	6.90	256.08
2	AAU, Jorhat	134.77	2.89	6.42	0.90	144.98
3	ANGRAU, Anakapalle	126.50	3.80	8.51	8.00	146.81
4	PJSTAU, Hyderabad	50.03	1.56	2.75	0.00	54.34
5	DR.YSPUH&F, Solan	159.06	4.57	10.84	4.60	179.07
6	GPUAT, Pantnagar	62.74	3.18	5.74	0.90	72.56
7	KAU, Thrissur	147.20	6.07	11.19	0.00	164.46
8	MPKV, Pune	158.07	3.54	12.34	2.90	176.85
9	PAU, Ludhiana	292.20	9.14	19.99	0.00	321.33
10	SKUAT, Srinagar	123.16	4.52	10.49	2.95	141.12
11	TNAU, Coimbatore	160.20	4.87	12.22	5.15	182.44
12	MPUAT, Udaipur	0.00	2.92	6.55	1.00	10.47
13	OUAT, Bubanneshwar	0.00	1.75	9.48	0.90	12.13
14	CAU, Pasighat	0.00	0.87	5.56	0.90	7.33
15	UAS, Raichur	0.00	1.49	3.81	0.90	6.20
16	P.C.CELL, Bangalore	0.00	13.45	34.67	0.00	48.12
	TOTAL	**1,641.23**	**70.39**	**176.67**	**36.00**	**1,924.29**

Comments and suggestions of QRT

- Contingency amount should be increased by 2.5 times to enable centres to meet increasing fuel prices, for surveys, conduct large scale field experiments and other project related activities.
- Budget for the project should be considerably increased

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

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 (Dharmapuri, Salem, 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., Kerala Cente for Pest Management, Moncombu, 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. The project activities focused more towards research and extension on biological control of crop pests. The farming communities have expressed their happiness and appreciation at various places about the biocontrol technologies and their benefits. The mass multiplication and supply of biological control agents should receive greater attention and the outcome should be in terms of supply. Considering the number of centres and the area covered under biocontrol should be considerably increased. During the period under report 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 expressed their views that these facilities should be fully utilized for the mass production and utilization of biological control agents on a large scale . Additionally all the centres should facilitate human resource development and capacity building in their respective regions/states to facilitate greater adoption of the biocontrol programmes

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

- **ANGRAU,** Anakapalle was actively involved in the management of sugarcane borers. Trash mulching + *T. chilonis* release @ 50,000/ha from 30 DAP for 6 times and 2 releases after node formation and Trash mulching + *T. chilonis* release @ 75,000/ha from 30 DAP for 6 times and 2 releases after node formation are effective in managing shoot borers in sugarcane with high incremental benefit cost ratio.
- **CAU, Pasighat** reported that sStem injection of CAU-1 strain of EPN with 30.5 % reduction in damage of citrus trunk borer. The stem injections of the EPNs were found more effective than their respective cadaver treatments.
- **AAU, Jorhat, was** actively involved in the management of plassey borer *Chilo tumidicostalis* and effcetively managed by eleven releases of *T. chilonis* @ 50,000/ha at 10 days intervals from June to November. Reduction in damage to the tune fo 13.5% was obtained with increased cane yield 70.4 -73.3 t/ha
- **AAU, Anand,** reported that **a**pplication of *Beauveria bassiana* or *Verticillium lecanii* @ 40 g/ 10 liter was effective in reducing the incidence of jassid, whitefly, aphid and thrips population per leaf in cotton and yield was on par with the chemical treatment.The mustard aphid was effectively suppressed with treatment of *B. bassiana + L. lecanii* @ 5g/ liter (1.88) with highest seed yield (9.66 q/ha) followed by *L. lecanii + M. anisopliae* @ 5g/ liter (9.24 q/ha.
- **Dr.YSPUH & F, Solan** was actively involved in the management of white grubs and repiorted that **s**oil application of *B. bassiana, M. anisopliae, H. indica* and *Steinernema carpocapsae* resulted in low potato tuber damage by the white grubs (31.4-38.0%) as compared to control (59.2%).Entomopathogenic fungi and EPNs suppressed the Apple

root borer, *Dorysthenes hugelii*.. Grub mortality of 74.4% was achived with the application of *Metarhizium anisopliae* (10^6 conidia/cm^2).,

- **SKUAS&T, Kashmir** reported that **r**oot dip treatment of tomato seedlings with *Paecilomyces lilacinus* @ 2.0 x 10^8 spores/ litre of water 15 minutes before transplantation significantly decreased the soil population of root-knot nematodes, *Meloidogyne hapla* by 85% and increased the yield up to 84%
- **KAU, Thrissur, was actively involved in the management of rice pests through BIPM.** The IPM practices (*Pseudomonas fluorescens* @ 10 g/kg of seed, followed by five releases of *Trichogramma japonicum* @ 1 lakh/ha starting from 20 days after transplanting or 40 days after sowing) recorded higher incidence of natural enemies and resulted in reduction in stem borer population in rice by 37%.
- **MPKV, Pune** was actively involved in the management of sucking pests and reported that three sprays of *M. anisopliae* @ 10^8 cfu/ml or six releases of *Blastothecus. pallescens* @ 20 nymphs/m row reduced the thrips, *Thrips tabaci* population in onion .Spraying of *M. anisopliae* @ $1x10^9$ spores/ml during offseason reduced the population of mango hoppers (10.4-12.0) and increased the fruit set (11.8-12.0 per inflorescence).
- **OUAT, Bhubaneshwar** has come out with a strategy to reduce mites on vegetable crops. Reported that releases of anthocorid predator, *Blaptostethus pallescens* @ 30/plant both in brinjal and okra effectively reduced the mite, *Tetranichus urticae* population in brinjal.
- **PAU, Ludhiana** was involved in the management of sugarcane pests. Sequential release of Tricho cards of *T. chilonis* (tts) @ 50,000/ha during July- October resulted in reduction of 57.4% of stalk borer, *Chilo auricilius* incidence in sugarcane.
- **MPUAT, Udaipur** reported effective management of *Spodoptera litura* with application of *Bacillus thuringiensis kurstaki* @ 1 kg /ha, followed by spray of *Nomuraea rileyi* @ 1.5 x 10^{13} conidia/ha with a second spray of SlNPV @ $1.5x10^{12}$ POBs/ha in sunflower.
- **TNAU, Coimbatore** has come out with a strategy to manage two spotted spider mite. Reported that eleases of coccinellid beetle,*Tethorus pauperculus* and predatory mite, *Amblyseius* sp @ 10 and 5 mites/ plant were effective in reducing two spotted spider mite, *Tetranychus urticae.*
- **PJTSAU, Hyderabad** was actively involved in the management of maize stem borer borer *Chilo partellus* and reported that releases of *Trichogramma chilonis* @ 75,000 and 1,00,000 parasitoids per ha) at 15d after seedling emergence , three times at weekly interval was effective in reducing maize stem damage with higher cob yields.
- **GBPUAT, Pantnagar** mentioned that the invert emulsion based *Trichoderma* formulation (IEF2) was found most effective in managing seed and seedling mortality in chickpea due to wilt. disease.
- **UAS, Raichur reported a**pplication of NBAII *Bt* strain (NBAII BTG 4) @ 2% effectively suppressed pigeon pea pod borer, *Helicoverpa armigera*.

Success stories

ANGRAU, Anakapalle

Tribal Farmers of Arakuvalley and Chinthapalli, with small land holdings of half an acre to one acre were benefited from ICAR-Tribal sub Plan Programme implemented by AICRP Biological Control centre at ANGRAU RARS, for improving the livelihood of tribal farmers through organic farming cultivation in paddy, rajmah and ginger. The production of *Trichogramma chilonis* for releases was demonstrated.

About 50 farmers successfully cultivated paddy and obtained good yields due to adoption of organic farming practices in paddy. Supplied the paddy variety 2 kg per each farmer; issued *Pseudomonas flourescens* @ 250 g/ 30 kg seeds/acre Conducted method demonstration on seed treatment with *P. flourescens* for @ 5 g/kg seed during first and second week of July, 2015. Issued Liquid Biofertilizers – *Azospirillum* and *Phosphobacteria* @ 500 ml each per farmer. Trichocards (*Trichogramma chilonis*) for 4 releases @ 40,000 egg parasitoids per acre were also supplied. Field demostrations and monitoring teh implementation resulted in adoption of the technology and fetched high returns.
Enhancement of yield levels by 93% with improved quality benefitting 45 paddy farmers covering 43 acres. Organic farming FLD farmers recorded higher yields (4262.5 kg/ ha) compared to 2200 kg / ha in farmers practice of without using fertilizer application and plant protection. Additional yield recorded by organic rice farmers was 2062.5kg/ha with additional income of Rs. 21,993.00 and incremental benefit cost ratio of 1 :5.02 compared to farmers practice of no fertilizer and no plant protection.

KAU, Thrissur

The large scale validation of BIPM technologies in rice was carried out in an area of 905 hectares in Thrissur district, Kerala. The IPM practices comprised of (*Pseudomonas fluorescens* @ 10 g/kg of seed, followed by five releases of *Trichogramma japonicum* @ 1 lakh/ha starting from 20 days after transplanting or 40 days after sowing).

The yield obtained from IPM plots was 37% more than that obtained from non IPM plots. The cost of cultivation also was 16 per cent lower in the former. The increased yield as well as reduced cost resulted in an increase in profit by Rs 52,960/ha. The cost benefit ratio, at 2.97 was almost double for IPM fields as compared to 1.45 for non IPM fields. The appreciable increase in yields combined with reduction in cost of plant protection has confirmed not only the ecological soundness of the approach but also its economic viability.

TNAU, coimbatore

The implementation of classical biological control of papaya mealybug, *Paracoccus marginatus* with mass multiplication and release of parasitoid, *Acerophagus papayae* in large areas cultivated with papaya, tapioca and mulberry saved crop loss of Rs.435 crores and input cost on pesticides to the tune of Rs.244.5 crores annually in Tamil Nadu.

PAU, Ludhiana

Successful mangement of sugarcane borers, maize stem borer and stem borers in organic basmathi rice through BIPM practices over the years (2012-17) under farmers field conditions in large areas (50-150ha) was carried out.

Bio-suppression of maize stem borer, *C.partellus* using egg parasitoid, *T. chilonis* at farmers' fields in maize at farmer's fields over an area of 20, 10, 81, 130 and 142 hectares during 2012-13, 2013-14, 2014-15, 2015-16 and 2016-17, respectively
Biocontrol based pest management technologies using bioagents, *T. chilonis* and *T. japonicum* for the management of leaffolder, *Cnaphalocrocis medinalis* and yellow stem borer *Scirpophaga incertulas* over an area of 20, 20, 60 and 66 hectares during 2013-14, 2014-15, 2015 and 2016-17, respectively at farmers' fields in organic basmati rice provided for higher yields and net returns .

Quantity of biocontrol agrents produced and area covered

Sl No	AICRP centre	Macrobial		Microbial	Area covered (ha)	Crops
		Tricho cards	Other Predators (Nos)	Biopesticides (Kgs)		
1	AAU, Anand	2581	--	5480	814	Paddy, Pigeon pea, *Bt* cotton, Vegetable crops, Ground nut, Banana, Maize
2	AAU, Jorhat	10213	----	--	361.69	Sugarcane,Rice,Cabbage, Okra,Tomato,Brinjal
3	ANGRAU, Anakapalle	3532	---	420	988	Sugarcane
4	PJTSAU, Hyderabad	2815	--	600	1360	Cotton,Tomato,Cabbage, Castor,Paddy,Sugarcane, Vegetables
5	YSPUH&F, Solan	705	---	405	36.65	Tomato,Apple,Carnation
6	GBPUAT, Pantnagar	---	---	3750	334	Rice, Pea, Tomato, Chickpea, Lentil, chilli, capsicum, brinjal, cucurbits
7	KAU, Thrissur	2254	36502	103051	20702	Rice,Vegetables and Banana
8	MPKV, Pune	1651		2830	803	Sugarcane,Paddy,Cotton,Tomato,Grape,Custard apple,Soybean
9	PAU, Ludhaiana	39102	539400	---	15738	Sugarcane, Maize,Basmati rice
10	SKUAST, Srinagar	400	250000	---	35.75	Apple,Knol-Khol, Cabbage,Saffron
11	TNAU, Coimbatore	1055	514,4444	---	3900	Papaya, Mulberry Tapoica,Rice,Brinjal,Sugarcane,coconut,Guava, Hibiscus

12	UAS, Raichur	--	--	975	740	Cotton, Cowpea, Soybean, Paddy, Mango and Sweet Orange
13	OUAT, Bubaneshwar	11142	66255	--	2363	Rice,Sugarcane,Brinjal, Coconut
14	CAU, Pasighat	--	---	---	---	Rice, vegetables
	Total	**75450**	**1406601**	**117511**	**48176.09**	

E. CONSOLIDATED RECOMMENDATIONS

ANGRAU, Anakapalle

- tSugarcane community fund – under sugar mills can be explored for the activities related to biological control of sugarcane pests.
- Data to be generated on resources supplied to to be obtained from farmers, area of adoption, benefits obtained and economics.
- Important to map the visibility of bioagents – the spread and adoption rates to be quantified to indicate the impact of the technologies.

AAU, Anand

- Vice Chancellor AAU expressed interest in providing funds for generating toxicological data for the NBAIR isolates. To explore the possibility of preparing a joint MOU between AAU and NBAIR for the same.
- Standard chemical check to be included in all experiments.
- Quantification of spider diversity and its predatory potential and relationship with pest incidence are to be included.
- Production of macrobials to be intensified.

AAU, Jorhat

- Search for local isolates/strains of bio agents.
- Success story on biocontrol of cabbage diamond back moth and potato cut worm to be prepared in three months' time and to be hosted on University and ICAR- NBAIR websites.
- Centre to strengthen the mass production program for tricho-cards and other biocontrol agents.
- Networking with state Biocontrol labs and KVKs for mass production and dissemination of proven technologies.
- Identified duplicate specimens may be sent to ICAR-NBAIR museum.
- The centre should focus on supply of biocontrol agents to farmers.

PJTSAU, Hyderabad

- Spider fauna recorded may be identified in collaboration with NBAIR.

- The trials on maize with biocontrol agents may be dropped/deleted as there is no pest incidence.
- Local strains of *Metarhizium* and *Lecanicillium lecanii* may be provided by the centre for evaluation by other centres.
- Monitoring of the programmes must be ensured based on the requirements if the farmers are and the recommendations made under package of practices by the University.

PAU, Ludhiana

- Success stories on Organic Basmathi, Maize and Sugarcane to be disseminated through booklets and website
- White fly genetic groups to be checked and to be related with early and late sown crops.
- Parasitisation of white flies to be studied in detail.

MPKV, Pune

- The centre should have tie up with biocontrol agent producers. Important to compare the local commercial products with the products formulated by the centre.
- Status paper on quality control of biopesticides to be prepared. A programme has to be launched to take up Quality analysis of commercial products without revealing the source of the products.

TNAU, Coimbatore

- Parasitism to be measured as percentage parasitism (not as number of adults emerged / percent adult emergence).
- Status of pin worm *Tuta absoluta* in Tamilnadu to be re-checked in Erode and surrounding areas.

GBPUA & T, Pantnagar

- To aim towards commercialisation registration the centre to generate toxicology data for the potential isolates through applying for lateral funding. The potential isolates to be shared with other AICRP/Institutes for generation of field efficiency data in different agroecological zones.
- To prepare success struggles for the potential isolates PBAT-3 and the fourteen in Englishand local languages and put up on website of University and NBAIR

KAU, Thrissur

- Promosing microbials may be supplied/distributed to farmers on a non commercial basis (free of cost).

- Attempts to be made to obtain licence for supplied bio-agents.
- Technical bulletins/brochures to be brought out in local languages for wider dissemination of the value of bio-control agents.
- Enough budget provision to be made for meeting the registration costs for biopesticides. Financial support for popularizing providing biocontrol agents may be sought from funding agencies viz. RKVY and MOEF.

SKUAS & T

- Strengthen mass production of EPN and supply to farmers.
- A complete comprehensive management protocol for codling moth.
- Success story for Codling moth to brought out in three months time and put up on University/NBAIR website.
- The technology for predatory mite proved developed at YSPUHF to be adopted at SKUAST.
- Unidentified species of natural enemies including spider to be sent to NBAIR for identification.
- Identification duplicate specimens may be sent to NBAIR museum.
- Attempts to be made to publish/patent the refind production structure for *Corcyra* developed by the centre with supporting data.

YSPUH & T, Solan

- Search for local isolates/strains of bioagents.
- Success story to be prepared on apple root borer in three months time.
- Metarhizium and predatory miles to strengthen mass production program.
- Not working with state Biocontrol labs and KVKs for mass production anddissemination of proved technologies.
- It was recommended that the pathology/nematology component can be included for the centre for specific crops without any financial commitment.
- The centre should focus on supply of metarhizium and miles to farmers.

OUAT, Bhubaneshwar

- Adequate funding support to be provided by the University for the AICRP-BC work.
- Experiments on plant disease management with *Trichodermitalics* and other biocontrol agents may be taken up. Strains from NBAIR to be evaluated.
- A new PI for the biocontrol project to be identified at the earliest as the current PI is due for retirement.
- Centre to focus on few bioagents with large coverage area to be followed up with proper monitoring.

MPUAT, Udaipur

- To prioritize crop/pest/ bioagents for future work.
- To focus on production of specific bioagents, maximum area coverage and farmers involvement.

UAS,Raichur

- Continuous monitoring of treated fields during successive seasons**.**
- Quantified data to be prepared on area covered with bio-agents, number of farmers benefitted, economic benefits and impact analysis.

CAU, Pasighat, Arunachal Pradesh

- Experiments on rice may be stopped as pest incidence for last 3-4 years is much below ETL level, and work on *Pseudomonas* may be continued for rice blast disease.
- Since the PI is Nematology background, it was suggested that PI should propose experiments on nematology work in one month time and should be incorporated in AICRP-BC technical programme for 2017-18 & 2018-19 e.g. Management of Root-Knot nematodes in vegetables.
- More study should be on documentation of diversity that includes both insect pests and natural enemies.
- Unidentified species of natural enemies including spiders to be sent to ICAR-NBAIR for identification.

General Recommendations

- Accountability for contingencies to be provided for AICRP centres.
- Safety precautions to be followed by all workers while handling bio-agents/pesticides.
- Digitization of data and submission by all co-ordinating centres.
- Production of macrobials and microbials and area coverage to be committed as fixed targets to commensurate with the contingency funding.
- All centres should contribute towards the NBAIR museum in terms of specimens/digitized materials.
- When required, Young Professionals may be hired as per ICAR norms for SAU centres.
- Success stories English, Hindi and local languages to be sent to ICAR-NBAIR and University for putting up on the websites.
- Attempts to be made to include all proven technologies brought out by the respective AICRP centre in the University package and practices.
- Attempts to be made to register/commercialise the proven isolates/technologies.
- All centres should document the quantum of bioagents production, supplied to farmers and area covered under biocontrol. Farmer feedback on impact should also be documented. This information should be presented in all reports.
- Cost benefit not only in terms of economics but also based on environment safety since, North Eastern region mainly focusing on organic farming.
- Success stories English and Hindi to be sent to NBAIR and University. .
- Attempts to be made to communicate the proven isolates/technologies.
- Approved pesticides by the Registration Committee should be selected for all comparative efficacy trials with biopesticides.

Specific Recommedations:

1. Travel grant should be enhanced
2. Funding iof AICRP centres should be linked to performance
3. Contingency grant must be enhanced
4. entres should establish effective linkages with other departments/ institutions/organisations
5. **AICRP -BC to be retained**

Justification for continuation of AICRP-BC

- The AICRP project activities involves research and extension about biological control of pests of crops. The co-ordinated project provides appropriate platform for research ,exchange of live materials for introduction, efficacious use and integrated efforts on the monitoring and management of invasive pests.

- These activities are achieved through mass multiplication and supply of biological control agents, large scale field demonstrations and validations under farmers field conditions. The adoption of the technologies is promoted through intensive extension activities and linkages with other departments/organizations.

- The AICRP is the only biocontrol based project in the country which is highly relevant considering the current thrusts on sustainable agriculture, an alternate way for bio-suppression of crop pests to produce residue free crop without ecological hazards.

- Biological control has been the remedy for successful management of pests viz., sugarcane woolly aphid, eucalyptus gall wasp, papaya mealybug, rugose whitefly etc., wherein chemical interventions have been futile

- Efficient methods of mass multiplication of parasitoids, predators and pathogens against insect pests and antagonists against plant pathogens and plant parasitic nematodes requires greater expertise and sustenance for effective utilization. The life stage specificity of the parasitoids and transit time are crucial for their effective utilization, therefore, a single window system with merger of institutes would hamper the modus operandi in disseminating the resource.

- Large scale multiplication of these natural enemies specific to the crop pests and location can only be done through the net work of centres across the country.

Hence, the QRT strongly recommends to maintain the status quo of AICRP-BC

F. LIST OF ANNEXURES

Annexure	**I**	-	Terms of reference for QRT
Annexure	**II**	-	QRT observations to the terms of reference
Annexure	**III**	-	Evaluation proforma for the centres
Annexure	**IV**	–	Overall performance of centres

ANNEXURE I

TERMS OF REFERENCE FOR QRT

- To analyse growth of manpower, number of co-operating centres both in terms of funds as well as staff resources.
- 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

- 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

- 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.
- 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?
- 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?
- How much operating funds does each scientist get under co-ordinated projects? Is it at least Rs. 60,000/- per scientist per year?
- 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)

- 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?
- 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?
- 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

SNo.		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 existing in centres is to be monitored. Contingency and travel grant can be increased based on the performance of the centre
To critically examine and evaluate achievements of the AICRPs in research with reference to:			
2	i	Focus on national programmes	All the AICRP centres co-ordinated by NBAIR are involved in national programmes.
	ii	Multi-location testing	Multi-location testing is done through AINP centres.
	iii	Evaluation of pests and diseases	The centres have addressed the major pest and diseases causing economic losses and have evaluated the . management strategies adequately. Focus has also been on documentation of diversity of insect pests, biocontrol agents and invasive pests.
	iv	Exchange of scientific information	NBAIR emerged as centre of excellence for insect repository, insect molecular taxonomy including DNA barcoding and documentation of dicersity of bioagents. The bureau as a co-ordinating unit, exchanges the scientific information generated with all the AICRP-BC centres, SAUs and KVKs.
	v	Inter-institutional and interdiscplinary linkages:	All the AICRP centres have inter institutional and interdisciplinary linkages with SAUs, ICAR institutes, KVKs and other institutes such as CSR & TI, Mysore, ITC, Bangalore and other private entreprenuers.
	vi	Development of strategic plans:	The strategic plans developed by NBAIR as co-ordinating unit, for the biological control of crop pests and invasives invasives is implemented through the net work of AICRP -BC centres. Statregic plans have been developed for the management of sugarcane wooly aphid, papaya mealybug, eucalyptus gall wasp,

			rice pests, tomato pinworm, Rugose spiralling whitefly
	vii	Linkages with international programmes	The NBAIR/AICRP on BC has linkages with international institutes like USDA, CABI and AVRDC.
	viii	Information on technology base	The NBAIR has developed several technologies for the management of pests. Information on the these technologies is made available to all the AICRP centres. Successful commercialization of technologies on EPN, liquid formulation of Bt., powder based formulations of *Pseudomonas* and *Bacillus megaterium* and other biocontrol based technologies have been done. The databases developed provides information on pest management strategies
	ix	Encouragement and guidance by the PC	Director of NBAIR is the Project Coordinator (PC) for the AICRP on BC. Encourgement and guidance is provided by the PC. The technical programme for the centres and monitoring the progress is done by the PC. The expertise on insect systematics and mass production of biocontrol agents at NBAIR, is the source of strength and encouragement for many scientists of the AICRP centres in executing the research work.
	x	Off-season nursery facilities:	Not applicable
	xi	Healthy competition in Annual Workshops and professional challenge	The Annual Biocontrol Workers Group Meeting/ Workshop are regularly conducted in the beginning of the season (May-June of each year). All the research experiments, technical programme are reviewed and suitably modified. Healthy competition and professional challenge among the workers is promoted. Good performances are encouraged.
	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 AICRP-BC. The proceedings are brought out and action

			taken on the recommendations is reviewed periodically.
	xiii	Whether research is of routine nature on trodden path or they are breaking new grounds:	Research is of breaking new grounds. The management of papaya mealybug, sugarcane woolly aphid, eucalyptus gall wasp, tomato pinworm and rugose whitefly are some of the examples. Break through has been done in areas like molecular taxonomy of insects, DNA barcoding and development of nanoformulations of biopesticides.
	xiv	Whether there is individual initiative	Personal initiative by the Director, ICAR-NBAIR and the co-ordination extended to the AICRP centres, break through has been observed in the management of several notorious pests through non chemical means.
	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. There is no regimentation/ rigidity observed
	xvi	Whether the resources including manpower are optimally utilized	Most of the AICRP on BC centres have optimally utilized the resources in terms of contingency granted and man power. In cases where the man power is not optimally utilized, the number could be reduced and managed with contractual staff.
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.	The QRT recommends for adequate funding under contingency. Several AICRP centres could not undertake surveys due to shortage of contingency grant for hiring vehicles.

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.	AICRP-BC works both on the strategic and basic research related to the biological control of crop pests and diseases though the major focus is on mass production and field evaluation of

			biocontrol agents. Interdisciplinary and integration of research among the AICRP centres derives full support.
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?	The technical programme for the centres is thoroughly discussed during the annual workshops to avoid distortions/ duplication and overlapping of the work in different coordinating centres. Monitoring of the programme is done through visit of the PC to the centre and assessing the progress of work.
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 are planned for the coordinating centres keeping in view the major crops grown by the state where the centre is located and also on major pest and disease problems encountered in each state. Sustainability of prodcution system developed is maintained
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 and the budgetary provision is accordingly allotted.
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 elevan coordinating centres are located from the SAUs and four voluntary centres located in SAUs (contingency funded), where no staff has been provided. No additional fund for travel is given.
Annual Workshops (Group Meetings)			
9	i	i) How the Annual Workshop is organized?	The Annual workshop of Biological control workers is conducted with group meeting of scientists from the ICAR institutes, SAUs, State agricultural departments and private industries. After thorough discussions and interactions, the strategic problems are identified and technical programme is drawn for the ensuing year,
	ii	Is it serving as a focus of generation of	Yes

		new ideas?	
	iii	Do the senior officials from the Departments of Agriculture and Extension attend workshops?	The senior officials from State Department of Agriculture/ Extension are invited to attend the workshops. However, all do not participate.
	iv	Do scientists from private sector participate?	Yes, has there is an increasing interest in biocontrol from the private sector. The scientists from private industry also participate.
10	i	Is a policy brief prepared after the workshop for use by policy-makers and planners?	The recommendations on policy issues often emerge, which are conveyed to ICAR.
	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 co-ordinating unit has 22 databases on biological control
11.		How is the HRD programme organized for the young scientists working in the Project and also other staff working in the project?	The Project Coordinator promotes organizing of HRD programmes for the PI's under the project and technical staff involved, at regular intervals which are need based. Capacity building of the staff involved is also organized through linkages with SAU's and other scientific institutes.

ANNEXURE – III

EVALUATION PROFORMA FOR THE CENTRES

Centre : 1. Acharya NG Ranga Agricultural University, Anakapalle

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks Assigned
1	Staff position and vacancy		10	7
2	Research achievements in terms of technical programme		10	9
3	Quality of work output		10	9
4	Quantity of work in relation to staff in position		10	8
5	Technologies developed		10	8
6	Technologies adopted		10	7
7	Infrastructure and facilities developed		10	8
8	HRD		05	5
9	Extension activities		10	8
10	Publications		05	5
11	Utilization of budget		10	8
		Total	**100**	**82**

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

Overall assessment and remarks on continuation of the centre: Very Good

: Graded "A"

Date: **Signature of the QRT Chairman**

Centre : 2. Anand Agrcultural University , Anand, Gujarat

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks Assigned
1	Staff position and vacancy		10	8
2	Research achievements in terms of technical programme		10	8
3	Quality of work output		10	8
4	Quantity of work in relation to staff in position		10	8
5	Technologies developed		10	8
6	Technologies adopted		10	6
7	Infrastructure and facilities developed		10	8
8	HRD		05	5
9	Extension activities		10	7
10	Publications		05	5
11	Utilization of budget		10	8
		Total	**100**	**79**

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

Overall assessment and remarks on continuation of the centre: Very Good

: Graded "A"

Date: **Signature of the QRT Chairman**

Centre : 3. Assam Agrcultural University , Jorhat, Gujarat

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks Assigned
1	Staff position and vacancy		10	8
2	Research achievements in terms of technical programme		10	8
3	Quality of work output		10	8
4	Quantity of work in relation to staff in position		10	8
5	Technologies developed		10	8
6	Technologies adopted		10	6
7	Infrastructure and facilities developed		10	6
8	HRD		05	5
9	Extension activities		10	7
10	Publications		05	4
11	Utilization of budget		10	8
		Total	**100**	**76**

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

Overall assessment and remarks on continuation of the centre: Very Good

: Graded "A"

Date: **Signature of the QRT Chairman**

Centre : 4. Prof. Jayashankar Telanagana Agricultural University, Hyderabad

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks Assigned
1	Staff position and vacancy		10	8
2	Research achievements in terms of technical programme		10	8
3	Quality of work output		10	7
4	Quantity of work in relation to staff in position		10	8
5	Technologies developed		10	7
6	Technologies adopted		10	7
7	Infrastructure and facilities developed		10	7
8	HRD		05	5
9	Extension activities		10	7
10	Publications		05	3
11	Utilization of budget		10	7
		Total	**100**	**74**

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

Overall assessment and remarks on continuation of the centre: Good

: Graded "B"

Date: **Signature of the QRT Chairman**

Centre : 5. Punjab Agricultural University, Ludhiana

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks Assigned
1	Staff position and vacancy		10	8
2	Research achievements in terms of technical programme		10	9
3	Quality of work output		10	9
4	Quantity of work in relation to staff in position		10	9
5	Technologies developed		10	8
6	Technologies adopted		10	8
7	Infrastructure and facilities developed		10	9
8	HRD		05	5
9	Extension activities		10	9
10	Publications		05	5
11	Utilization of budget		10	8
		Total	**100**	**87**

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

Overall assessment and remarks on continuation of the centre: Excellent

: Graded "A + "

Date: **Signature of the QRT Chairman**

Centre : 6. Mahatma Phule Krishi Vidyapeeth, Pune.

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks Assigned
1	Staff position and vacancy		10	8
2	Research achievements in terms of technical programme		10	8
3	Quality of work output		10	8
4	Quantity of work in relation to staff in position		10	7
5	Technologies developed		10	8
6	Technologies adopted		10	8
7	Infrastructure and facilities developed		10	9
8	HRD		05	5
9	Extension activities		10	8
10	Publications		05	5
11	Utilization of budget		10	8
		Total	**100**	**82**

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

Overall assessment and remarks on continuation of the centre: Very Good

: Graded "A "

Date: **Signature of the QRT Chairman**

Centre : 7. Tamilnadu Agricultural Unuiversity, Coimbatore.

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks Assigned
1	Staff position and vacancy		10	8
2	Research achievements in terms of technical programme		10	9
3	Quality of work output		10	9
4	Quantity of work in relation to staff in position		10	9
5	Technologies developed		10	9
6	Technologies adopted		10	8
7	Infrastructure and facilities developed		10	9
8	HRD		05	5
9	Extension activities		10	9
10	Publications		05	5
11	Utilization of budget		10	9
		Total	**100**	**88**

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

Overall assessment and remarks on continuation of the centre: Excellent

: Graded "A+ "

Date: **Signature of the QRT Chairman**

Centre : 8. Dr Y S Parmar University of Horticulture & Forestry, Solan.

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks Assigned
1	Staff position and vacancy		10	7
2	Research achievements in terms of technical programme		10	7
3	Quality of work output		10	7
4	Quantity of work in relation to staff in position		10	7
5	Technologies developed		10	6
6	Technologies adopted		10	4
7	Infrastructure and facilities developed		10	7
8	HRD		05	4
9	Extension activities		10	7
10	Publications		05	4
11	Utilization of budget		10	8
		Total	**100**	**68**

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

Overall assessment and remarks on continuation of the centre: Good

: Graded "B "

Date: **Signature of the QRT Chairman**

Centre : 9. G B Pant University of Agrtciulture & Technology, Pantnagar.

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks Assigned
1	Staff position and vacancy		10	7
2	Research achievements in terms of technical programme		10	7
3	Quality of work output		10	7
4	Quantity of work in relation to staff in position		10	7
5	Technologies developed		10	7
6	Technologies adopted		10	5
7	Infrastructure and facilities developed		10	7
8	HRD		05	5
9	Extension activities		10	8
10	Publications		05	4
11	Utilization of budget		10	8
		Total	**100**	**72**

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

Overall assessment and remarks on continuation of the centre: Good

: Graded "B "

Date: **Signature of the QRT Chairman**

Centre : 10. Kerala Agrixcultural University, Thrissur

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks Assigned
1	Staff position and vacancy		10	7
2	Research achievements in terms of technical programme		10	9
3	Quality of work output		10	8
4	Quantity of work in relation to staff in position		10	8
5	Technologies developed		10	8
6	Technologies adopted		10	7
7	Infrastructure and facilities developed		10	9
8	HRD		05	5
9	Extension activities		10	8
10	Publications		05	4
11	Utilization of budget		10	8
		Total	**100**	**81**

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

Overall assessment and remarks on continuation of the centre: Very Good

: Graded "A "

Date: **Signature of the QRT Chairman**

Centre : 11. Sher E-Kashmir University of Agrcultural Sciences and Technology, Srinagar

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks Assigned
1	Staff position and vacancy		10	7
2	Research achievements in terms of technical programme		10	8
3	Quality of work output		10	8
4	Quantity of work in relation to staff in position		10	8
5	Technologies developed		10	8
6	Technologies adopted		10	7
7	Infrastructure and facilities developed		10	7
8	HRD		05	4
9	Extension activities		10	7
10	Publications		05	3
11	Utilization of budget		10	7
		Total	**100**	**70**

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

Overall assessment and remarks on continuation of the centre: Good

: Graded "B "

Date: **Signature of the QRT Chairman**

Centre : 12. Maha Rana Prathap University of Agrculture and Technology, Udaipur

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks Assigned
1	Staff position and vacancy		10	7
2	Research achievements in terms of technical programme		10	6
3	Quality of work output		10	7
4	Quantity of work in relation to staff in position		10	7
5	Technologies developed		10	7
6	Technologies adopted		10	6
7	Infrastructure and facilities developed		10	6
8	HRD		05	4
9	Extension activities		10	7
10	Publications		05	3
11	Utilization of budget		10	8
		Total	**100**	**68**

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

Overall assessment and remarks on continuation of the centre: Good

: Graded "B "

Date: **Signature of the QRT Chairman**

Centre : 13. Orissa University of Agrculture and Technology, Bubaneshwar

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks Assigned
1	Staff position and vacancy		10	7
2	Research achievements in terms of technical programme		10	6
3	Quality of work output		10	6
4	Quantity of work in relation to staff in position		10	5
5	Technologies developed		10	5
6	Technologies adopted		10	3
7	Infrastructure and facilities developed		10	6
8	HRD		05	3
9	Extension activities		10	6
10	Publications		05	2
11	Utilization of budget		10	7
		Total	**100**	**56**

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

Overall assessment and remarks on continuation of the centre: Satisfactory

: Graded "C "

Date: **Signature of the QRT Chairman**

Centre : 14. University of Agrcultural Sciences, Raichur

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks Assigned
1	Staff position and vacancy		10	8
2	Research achievements in terms of technical programme		10	8
3	Quality of work output		10	8
4	Quantity of work in relation to staff in position		10	8
5	Technologies developed		10	7
6	Technologies adopted		10	5
7	Infrastructure and facilities developed		10	8
8	HRD		05	5
9	Extension activities		10	8
10	Publications		05	3
11	Utilization of budget		10	8
		Total	**100**	**76**

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

Overall assessment and remarks on continuation of the centre: Very Good

: Graded "A "

Date: **Signature of the QRT Chairman**

Centre : 15. Central Agricultural University, Pasighat

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks Assigned
1	Staff position and vacancy		10	7
2	Research achievements in terms of technical programme		10	6
3	Quality of work output		10	7
4	Quantity of work in relation to staff in position		10	6
5	Technologies developed		10	5
6	Technologies adopted		10	3
7	Infrastructure and facilities developed		10	7
8	HRD		05	4
9	Extension activities		10	7
10	Publications		05	3
11	Utilization of budget		10	8
		Total	**100**	**62**

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

Overall assessment and remarks on continuation of the centre: Good

: Graded "B"

Date: **Signature of the QRT Chairman**

ANNEXURE - IV

OVERALL PERFORMANCE OF CENTRES

SNo.	Centres	Overall performance
State Agricultural University-based centres		
1	Anand Agricultural University, Anand	**Very Good**
2	Kerala Agricultural University, Thrissur	**Very Good**
3	Punjab Agricultural University, Ludhiana	**Excellent**
4	Sher-e-Kashmir University of Agricultural Sciences & Technology,Srinagar	**Good**
5	Acharya N G Ranga Agricultural University, Anakapalle	**Very good**
6	Professor Jayashankar Telangana State Agricultural University, Hyderabad	**Good**
7	Dr.YS Parmar University of Horticulture & Forestry, Nauni, Solan	**Good**
8	Tamil Nadu Agricultural University, Coimbatore	**Excellent**
9	Assam Agricultural University, Jorhat	**Very Good**
10	Mahatma Phule Krishi Vidyapeeth, College of Agriculture, Pune	**Very Good**
11	Govind Ballabh Pant University of Agriculture and Technology, Pantnagar	**Good**
Voluntary centres (Contingency funded)		
12	Maharana Pratap University of Agriculture & Technology, Udaipur	**Good**
13	Central Agricultural University, Pasighat, Arunachal Pradesh	**Good**
14	Orissa University of Agriculture & Technology, Odisha	**Satifactory**
15	University of Agricutural Sciences, Raichur	**Very Good**

Date: **Signature of the QRT Chairman**