ANNUAL REPORT

2008–2009

PROJECT DIRECTORATE OF BIOLOGICAL CONTROL

(UPGRADED TO NATIONAL BUREAU OF AGRICULTURALLY IMPORTANT INSECTS)

(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)

BANGALORE

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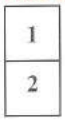
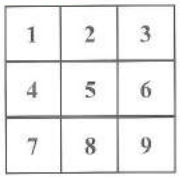
Front cover



1. Papaya mealybug, *Paracoccus marginatus* on papaya
2. *P. marginatus* on neem

Back cover



1. *P. marginatus* on papaya leaf
2. *P. marginatus* on papaya fruit
3. *P. marginatus* on bhendi
4. *P. marginatus* on teak
5. *P. marginatus* on cotton
6. *P. marginatus* along with pupae of *Spalgis epius* on mulberry stem
7. Grubs of *Spalgis epius*, predator of papaya mealybug
8. Adult, pupa and grubs of *S. epius*
9. Coccinellid feeding on papaya mealybug

Note

The reference to some trade name in this report is in no way an endorsement of or discrimination against these products by the Institute.

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CONTENTS

1. PREFACE

India's economic growth, the envy of the world, has benefitted millions of people in terms of access to better quality food. Raising healthy food crops without toxic pesticidal residues is a major challenge for the Indian farmers of today. The Indian Council of Agricultural Research (ICAR) under its dynamic leader and visionary **Dr. Mangala Rai, the Director General (ICAR) and Secretary (DARE)** has been extending unflinching of support to the **Project Directorate of Biological Control (PDBC)** for undertaking frontier areas of research for developing biological control strategies. The scientists of the institute along with their active partners in the All India Co-Ordinated Research Project on Biological Control (AICRP on BC) spread over the entire country undertook need-based and focused research to address the all important demand for raising crops in a sustainable and eco-friendly manner using biocontrol technologies.

The taking over by **Prof. Swapan Kumar Datta**, a world renowned scientist as the **Dy. Director General (Crop Sciences),** ICAR has injected fresh enthusiasm and encouragement in our minds. We value the committed involvement of **Dr. T. P. Rajendran the Asst. Director General (Plant Protection),** ICAR in the activities of the PDBC.

While we are proud of the achievements of the PDBC, we have accepted the mammoth task of steering the metamorphosis of the Project Directorate into the **National Bureau of Agriculturally Important Insects (NBAII)**. The major mandate of the Bureau would be harnessing the biodiversity of insects, mites and other arthropods of agricultural importance for enhancing the productivity of crops and thereby improving the livelihood of the farmers. I am grateful to **Dr. Mangala Rai** our Director General for trusting us with this great task.

I am grateful to all the scientists whose contributions find a place in this annual report. **Dr. B.S.Bhumannavar, Dr. Chandish R. Ballal** and **Dr. S. Sriram** made excellent contributions in compiling and editing this annual report.

We look forward to facing the challenges of ensuring the growth of the newly formed National Bureau of Agriculturally Important Insects, into a world class Bureau to serve the stake holders involved in the food production particularly the farmers of India. At this juncture we would like to place on record our appreciation for our senior colleagues of the PDBC like **Dr. S. P. Singh,** former **Project Director, Dr. P. L. Tandon, Dr. K. Narayanan, Dr. N. S. Rao, Dr. S. S. Hussaini and Mr. Biswas,** Principal scientists who have retired in the recent past for their research contributions in the field of biological control.

The **NBAII** would keep its door open for Collaboration, Linkages, Partnerships and Co-operation in the task of harnessing the power of insects for the growth of Indian Agriculture.

R. J. Rabindra
Project Director
Project Directorate of Biological Control
&
Coordinator
AICRP on Biological Control of Crop Pests and Weeds

निष्पादित सारांश

अखिल भारतीय समन्वयक परियोजना जैविक नियंत्रण पर (ए आई सी आर पी) के अन्तर्गत फसलों, सूत्रकृमियों और खरपतवारों के प्रमुख पीड़कों व रोगों के पर्यावरणिक प्रबंधन के लिए जैव नियंत्रण आधारित प्रौद्योगिकियाँ विकसित करने के लिए वर्ष 2008-2009 के दौरान राष्ट्रीय कृषि उपयोगी कीट ब्यूरो (पुराना नाम जैविक नियंत्रण परियोजना निदेशालय) के साथ-साथ 10 राज्य कृषि विश्वविद्यालयों और भारतीय कृषि अनुसंधान परिषद (भा कृ अनु प) आधारित छः केन्द्रों के अतिरिक्त अनेक स्वैच्छिक संगठनों के केन्द्रों पर व्यापक अनुसंधान कार्य किए गए। उत्पन्न समस्यायें जैसे बी टी कपास के पीड़कों, पपीते पर लगने वाले मिलीबग और जैविक खेती में जैविक नियंत्रण के समेकित करने वाले पर्यावरणिक प्रबंधनों को इन अनुसंधान कार्यक्रमों में शामिल किया गया । वर्ष 2008-09 मे किए गए मुख्यतः परीक्षणों को तकनीकी कार्यक्रम के तहत सफलतापूर्वक किया गया और उनके परिणामों को संक्षेप रूप से नीचे लिखा गया है ।

मौलिक अनुसंधान

जैविक नियंत्रण परियोजना निदेशालय, बेंगलोर

जैव-वर्गीकरण

विश्व की *साइनोना* पोप वंश को रीवाइज किया गया । भारत में प्रायः पाये जाने वाली कोक्सीनेलिड प्रजाति *सा. मिलेनोपेप्ला* (मूलसेन्ट) को सही प्रजाति पाया गया। *लेम्निआ(सायनिआ) मार्टिनी* लेबलोकोफ -कनजोरियन, *ले. मेलानोप्टेरा* लेबलोकोफ-कनजोरियन और *सा. रोउगेटी* (मूलसेन्ट) को *सा. मिलेनोपेप्ला* (मूलसेन्ट) का पर्याय पाया गया । ये प्रजातियाँ भारतीय उपमहाद्वीप में पायी जाती हैं जिनको गलत पहचान के कारण *सा. रोउगेटी* समझा गया वास्तव में यह एक नई प्रजाति थी जिसको *सा. ओब्सक्यूरा* पूरणी, स्लिपन्सकी और बूथ के रूप में पहचाना गया । *स्किमनोडस* ब्लैकबर्न, *एपोलिनस* पोप और लारेन्स, *रहाईन्कोर्टेलिआ* क्राच और *क्रिप्टोलीमस* मूलसेन्ट के इन चार वंशों को रीवाइज किया गया ।

केल्विया अल्बिडा बिएलावस्की को त्रिपुरा राज्य से अभिलेखित किया गया । पश्चिमी घाट क्षेत्र, केरल से *आर्टेलिया* की दो अपरिचित प्रजातियों को अभिलेखित किया गया। केरल राज्य से, *स्यूडोस्पडिमेरस इनफरकेटस* पूरणी को एकत्र किया गया जो कि इस प्रजाति के लिए नया विसरण के रुप में अभिलेखित किया गया । भारतीय क्षेत्र के स्टिकोलोटायडिने और स्किमनिने की उपकुल, जातियों और वंशों की कुंजी तैयार की गई । इस समय के दौरान कोक्सीनेलिडों की प्रायः पाए जाने वाली आम प्रजातियों के अनेक फोटोग्राफ लिए गए ।

एक अपरिचित लेपिडोप्टेरियन (तितली कूल के कीट) के अण्डों से एकत्रित *ट्राइकोग्रामा* स्पे. और क्राइसोपिड की एक नई प्रजाति जान पडती है । एक अपरिचित लेपिडोप्टेरियन से *ट्राइकोग्रामेटायडिआ* की दो कीट संख्या को एकत्र किया गया जो कि *ट्राइकोग्रामेटायडिआ रोबुस्टा* के समान प्रतीत होती है। इनको अन्तः प्रजनन में असफल पाया गया जो इस बात का सूचक है कि ये दोनों कीटों की संख्या आपस में पास की प्रजातियाँ हैं । प्रयोगशाला में *उस्कोना फीमेरोलिस* को *केलासोब्रूकस मेक्यूलेटस* के अण्डों पर सफलतापूर्वक संवर्धन किया गया और जब 25° सें.ग्रे. तापक्रम पर पाला गया तो इनके अधिकतम प्रौढ़ कीटों की प्राप्ति हुई ।

प्राकृतिक शत्रु कीटों का उपोदघात

यूकेलिप्टस पौधे की गाँठ मक्खी, *लेप्टोसाइबे इनवेसा* का जैविक नियंत्रण करने के लिए दो परजीवी कीटों, *क्लाड्रास्टिकस मैन्डेली* और *सेलीट्राईकोडस क्राईसेरी* को इजाईल से मंगाया गया । *स्पीलजिस एपिएस* एक लेपिडोप्टेरियन परभक्षी कीट को पपीते के मिलीबग *पेराकोकस मार्जिनेटस* का सक्रिय रुप से भक्षण और नियंत्रण करते पाया गया, यह मिलीबग तमिलनाडु में, पपीते, टीक, कपास, शहतूत और गुडहल पर बहुत ज्यादा प्रकोप फैला रहा है ।

प्राकृतिक शत्रु कीटो का पालन और मूल्यांकन

नेट हाउस के अन्दर किए गए मूल्यांकन में पाया कि मिर्च की माइट, *पोलीफेगोटार्सोनीमस लेटस* के प्रति *ब्लाप्टोस्टेथस पेलेसेन्स* को 20 निम्फ प्रति पौधे की दर से साप्ताहिक अन्तराल पर छोडने से पत्तियां मुडने की 81.8 से 6 प्रतिशत की कमी हुई।

नेट हाउस में गमलों में लगे बीन्स के पौधो पर *ब्लाप्टोस्टेथस पेलेसेन्स* को 20/पौधे की दर से साप्ताहिक अन्तराल पर छोडने के परिणामस्वरुप प्रौढों की 40 प्रतिशत कमी आई ।

कपास के मिलीबगों के प्रति *ब्लाप्टोस्टेथस पेलेसेन्स* के प्रौढों को 1:5 अनुपात में छोडने पर अधिकतम घातक (93.3 प्रतिशत) पाया गया ।

प्रयोगशाला में किए गए परीक्षण में जब बीन्स , परागकण और परपोषी *(साइटोट्रोगा)* के अण्डे उपयोग किए गए तब *ओरियस टेन्टिलस* की मादा ने अत्याधिक (45 प्रतिशत) संख्या में अण्डे दिए । दूसरे जाँच परीक्षण में डंठल सहित बीन्स के टुकडों के ऊपर *ओ. टेन्टिलस* की मादा ने अत्याधिक (47.6) संख्या में अण्डे दिए ।

गन्ने के वूली एफिड के परभक्षी कीट के क्षेत्रीय आँकडे दर्शाते हैं कि बेंगलोर और उसके आस पास के क्षेत्रों में *माइक्रोमस टिमिडस* का *मा. इगोरोटस* ने पूर्णतः स्थान ले लिया है किन्तु *मा. इगोरोटस* पुणे और कोयंबतूर में अभी भी प्रमुख कीट प्रजाति बना हुआ है । *मा. इगोरोटस* के लारवे *मा. टिमिडस* की अपेक्षा वूली एफिड का अधिक संख्या में भक्षण करते हैं।

मा. टिमिडस के अण्डों को अधिक मात्रा में एकत्र करने के लिए एक अण्डनिक्षेपण पिंजडे का विकास किया गया ।

साइटोट्रोगा सीरीएलेल्ला के अण्डो पर *ब्रुमायडस सुटुरेलिस* को पालने की विधि विकसित की गयी। मिलीबग पर पाली गई बीटल से कम संख्या में अण्डे (160.09 अण्डे प्रति मादा) जबकि *साइटोट्रोगा सीरीएलेल्ला* के अण्डों पर पाली गई बीटल से अधिक संख्या में अण्डे (204.62 अण्डे प्रति मादा) की प्राप्ति हुई । अण्ड परजीवी कीट, *ट्राइकोग्रामा* द्वारा परपोषी महत्व देने के विषय में परिणाम दर्शाते हैं कि *को. सीफ्लोनिका* के अण्डों को सर्वाधिक (परजीवीकरण माध्य 89.7 प्रतिशत), इसके बाद *काइलो पारटीलस* (परजीवीकरण माध्य 60.5 प्रतिशत) और सबसे कम रेशम कीट के अण्डों को प्राथमिकता दी । सभी परपोषी अण्डों के एकत्रित परजीवी कीट, ट्राइकोग्रामेटिडस *को. सीफेलोनिका* के अण्डों को परजीवीकरण करने की प्राथमिकता देते हैं ।

कीटभक्षी कीटों का अणु लक्षण

आठ *ट्राइकोग्रामेटिड* प्रजातियों के अध्ययन में आई टी एस-2, आर डी एन ए पी सी आर उत्पादो के आकार, आधार जोडों का अन्तर 550-600 बी पी तक पाए गए । आकार के अंतर आधार पर, तीन समूहों की पहचान की गई: समूह-। में 600 बी पी आधार जोडे के साथ *ट्रा. केकोइसीए* को शामिल किया गया, समूह- ।। में 575 बी पी आधार जोडे के साथ *ट्रा. सेम्बलीडिस* और *ट्रा. एम्ब्रियोफेगम* (जर्मनी) को शामिल किया गया और समूह-।।। में 550 बी पी आधार जोडे के साथ *ट्रा. कोर्बयूडेन्सिस, ट्रा. ईवेनेसेन्स, ट्रा. एम्ब्रियोफेगम, ट्रा. प्रेटिओजम, ट्रा. प्रेटिओजम* (यू एस ए) को शामिल किया गया ।

छः ट्रायकोग्रामेटिड प्रजातियों पर किए गए अध्ययन में डब्लू एस पी आर एफ टी एस जेड पी सी आर (बोल्वेशिया-स्पेसीफिक) उत्पादनों के आकार क्रमशः 550-600 बी पी और 700 - 750 बी पी पाये गये । यह निश्चित पाया गया कि *ट्रा. केकोएसीए* और *ट्रा. एम्ब्रियोफेगम* (जर्मनी) में बोल्वेशिया नही पाया गया ।

बोल्वेशिया से संक्रमित *ट्रा. केकोएसीए* को जैव प्रतिकारक रिफाम्पसिन और टेट्रासायकलिन से उपचार करने पर पाया गया कि पाँच संक्रमित प्रजातीयों में मादा प्रतिशत में 100 प्रतिशत से घट कर 23.3 से 70 प्रतिशत तक कम हो गई ।

प्राकृतिक शत्रु कीटों की जैव विविधता

दिल्ली, कोयम्बटूर, शिमोगा और पुणे से एकत्र किए गये *क्रिप्टोलीमस मोन्ट्रयूजिएरी* की संख्याओं में रासायनिक और तापक्रम के प्रति भिन्न भिन्न रुप में सहिष्णुता देखी गई ।

आन्ध्र प्रदेश (वेस्ट गोदावरी जिले) से एकत्र *गोनियोजस निफेन्टिडीस* (संख्या और प्रौढ़ निकलने कि दशा में क्रमशः 74.2 और 86.4 प्रतिशत) की तुलना में तमिलनाडु (इरोडे जिले) से एकत्रित संख्या (80.2 प्रतिशत) और प्रौढ़ निकलने (92.4 प्रतिशत) की दशा में उत्कृष्ट पाई गई ।

कर्नाटक, केरल और आन्ध्र प्रदेश में *गोनियोजस निफेन्टिडीस* संख्याओ के आई टी एस-2 रिजन का आंशिक श्रेणीबद्दता प्रदर्शित करती है कि दो जी सी 127 और 132 बी पी के बीच में तथा 462 और 467 बी पी के बीच में आता है ।

होशियारपुर से एकत्र किए गए *कोटेशिया फ्लेविपस* के कीट सर्वाधिक कोकुन (63.2) और प्रौढ़ (37.4) निकलते हैं इसके बाद डिन्डीगुल (तमिलनाडु) और देवागानाहल्ली (कर्नाटक) के कीट के कोकुन और प्रौढ़ निकलते हैं ।

आर ए पी डी आकलन द्वारा *कोटेशिया फ्लेविपस* की विभिन्न कीटों की आनुवंशिकी, विविधता और भौगोलिक दशाओं का अनुमानिक आकलन किया गया । औरंगाबाद और देवागानाहल्ली से एकत्र कीटो की सहसम्बधता एक समान 66 प्रतिशत जबकि दिल्ली और डिन्डिगल से एकत्र कीटो की

होमोलोजी क्रमशः 63 और 52 प्रतिशत पाई गई । बेंगलोर, बागलकोट और हैदराबाद से एकत्र कीटो की होमोलोजी सभी समूहों से क्रमशः बहुत कम 24, 26 और 36 प्रतिशत पाई गई ।

कवकीय प्रतिरोधकता

टाल्क आधारित *ट्राइकोडर्मा हरजिएनम* ठोस अवस्था फरमन्टेशन (एस एस एफ) से बनाए गए कोनेडिया को संग्रहित रुप से 10^6 रखने के लिए सामान्य पैकिंग करना 14 महीनो के लिए उपयुक्त पाया गया जबकि वेक्यूम पैकिंग करने पर 12 महीनो के लिए उपयुक्त पाया गया ।

ठोस अवस्था फरमन्टेशन वाले कोनेडिया आधारीत नियम नों के *ट्रा. हरजीएनम* के नियमनों को संग्रहित रखने की समय सीमा बढाने के लिए एक विधि विकसित की गई ।

टमाटर के पौधो को गमलों में उगाकर *आल्टरनेरिया सोलेनाई* के प्रति जीवाण्विक प्रतिरोधता का मूल्यांकन किया, *बेसीलस* स्पे. बी-23 प्रथक्करण के द्वारा ब्लाईट रोग की 26.2 प्रतिशत तक कमी पाई गई ।

टमाटर में *आ. सोलेनाई* के प्रति *ट्राईकोडर्मा* का क्षेत्रीय मूल्यांकन किया गया । *ट्रा. हरजीएनम* (टी एच - 7 प्रथक्करण) से उपचारित करने पर 18.4 जबकि पी डी आई अनोपचारित पौधो से तुलना करते है तो 62.6 प्रतिशत की कमी पाई गई ।

देशी *बेसीलस थूरिन्जीयन्सीस* विभेदों का पृथक्करण, चरित्रण और विषाक्तता

बी टी के आठ देशी पृथक्करणों का क्राई-1 और क्राई-4 यूनिवर्सल प्राइमर्स के साथ जाँचा गया। इन में से कोई भी क्राई-1 जीन के लिए विशेष नही पाया गया । यद्यपि क्राई-4 प्राइमर के साथ पृथक्करण-1 और 2 पी सी आर उत्पाद 230 बी पी दर्शाता है और तीसरा पृथक्करण पी सी आर उत्पाद 300 बी पी दर्शाता है । यह संभव है कि ये तीनों पृथक्करण क्राई - 4 जीन से संबंधित हों ।

पी डी बी सी विभेदों का पी सी आर विश्लेषण परिणाम दर्शाते हैं कि क्राई - ।।। ए जीन्स के उत्पादो का विस्तार 652 से 769 बी पी पाया गया । एक विभेद आशा के विपरीत 350 बी पी उत्पाद पैदा करता है जो कि ।।।ए जीन्स को आश्रय प्रदान करता है, की पहचान की गई ।

मोठी के फली बेधकों के प्रति बी टी पृथक्करणों के क्षेत्रीय मूल्याकंन में पी डी बी सी - बी टी 1 का 1.5 प्रतिशत छिडकाव फलियों की क्षति को महत्वपूर्ण रुप से कम करता है और स्वस्थ फलियों की संख्या बढी पाई गई ।

अन्तः भक्षी जीवाणु

अरहर के स्वस्थ पौधों से एन्डोफायटिक जीवाणु की चार प्रजातियों का पृथक्करण किया गया । इनमें से तीन ग्रामपोजेटीव व एक ग्रामनेगेटीव पाई गई । ट्रिपटिक सोया अगर पर इन विट्रो दशाओं के अन्तर्गत दो पृथक्करण *स्कलेरोशियम रोलफसाई* का 40-48 प्रतिशत तक अवरोधकता दर्शाता है ।

चने के बीजो का उपयोग करते हुए पेट्री प्लेट में बीजांकुर वृद्दि पर 30 जीवाणुवीय पृथक्करणो की जाँच की गई । जी आर-3 ए आर यू - बी पृथक्करण के प्रयोग से सर्वाधिक जड की लम्बाई 15 से.मी. और जी आर - 4 आर ए यू-ए पृथक्करण के प्रयोग से वायुवीय भाग की लम्बाई 10.5 से.मी. देखी गई । सी के -23 , सी के-4, एच-8, सी के -10, जी आर -4 आर ए यू -ए , एन डी-1, और जी आर-3 ए आर यू - बी पृथक्करणों ने अच्छी वृद्दि प्रदर्शित की ।

स्यूडोमोनास फ्लुओरेसेन्स (पी डी बी सी ए बी 2) का पोषक तत्वो के द्वारा सुधार किए गए पाउडर आधारित टाल्क नियमनों की संग्रहण करके रखने के अध्ययन में पाया कि 2 प्रतिशत पेप्टोन या 2 प्रतिशत ट्रायप्टोन के साथ संपूरक के रुप में 2 प्रतिशत ग्लिसरोल मिलाने पर *स्यूडोमोनास फ्लुओरेसेन्स* को उसकी अधिकतम सी एफ यू (7.48 सी एफ यू प्रति ग्राम) के साथ 180 दिनों तक बढा देता है ।

पादप भक्षी माईट के रोगाणु

लम्बे समय तक के संग्रहण अध्ययन दर्शाते हैं कि *हिर्सुटेल्ला थोम्पसोनाई* की पिलेटस को निर्जर्म पानी में रेफ्रीजरेटर में 3 वर्षों से अधिक तक सुरक्षित रखा जा सकता है । *हिर्सुटेल्ला थोम्पसोनाई* (माईसीलिआ) को 0.5 प्रतिशत ग्लिसरोल के साथ मिलाकर 15 दिनों के अन्तराल पर तीन छिड़काव करने पर फलियों की श्रेणीकरण इन्डेक्स न्यूनतम अर्थात 1.97 + 0.13 (1-10 प्रतिशत क्षति) कर देता है ।

पादप परजीवी सूत्रकृमियों का जैविक नियंत्रण

यह देखा गया कि कपास की काली मृदा के अतिरिक्त लेटेराईट, एल्यूवियल, बलुई दोमट और पीट मृदायें जड वृद्दि, सूत्रकृमि संक्रमण और *पेसीलोमाइकस लिलेसीनस* तथा

पोकोनिया क्लेमायडोस्पोरिया द्वारा अण्ड समूहों को प्रभावी रुप से परजीवीकरण करने के लिए उपयुक्त होती हैं ।

गमलों में किए गए अध्ययन में पाया गया कि उपचार के 45 दिनो के बाद टमाटर और कपास की तुलना में बैंगन (लम्बे बैंगनी) के पौधो में अत्यधिक जडें और जडों के रेशों में जडग्रंथि सूत्रकृमियों का अत्यधिक संक्रमण, अण्डों के समूह और अण्ड समूहों के कवकीय परजीवीकरण भी अत्यधिक पाये गए ।

पेसीलोमाइकस लिलेसीनस तथा *पोकोनिया क्लेमायडोस्पोरिया* को ठोस अवस्था फर्मन्टेशन से प्राप्त और टाल्क के साथ निर्मित नियमन संग्रहित (बीजाणु जीवक्षमता) रुप में रखने और ब्रोथ में उत्पादित की तुलना में जड ग्रंथि सूत्रकृमियों के प्रति (अण्ड समूहों की प्रभावशीलता) के लिए सर्वोत्तम पाया गया । *पो. क्लेमायडोस्पोरिया* द्वारा क्लेमायडोस्पोर का उत्पादन द्रवीय उत्पादन की अपेक्षा ठोस अवस्था उत्पादन में अत्यधिक पाया गया ।

चौकर पर *पे. लिलेसीनस* के क्लेमायडोस्पोर उत्पादन के लिए 50 प्रतिशत नमी और पानी की सक्रियता के संयोग को आदर्श पाया गया, जबकि चावल के दानों पर 20-23 प्रतिशत नमी तथा पानी की सक्रियता को आदर्श पाया गया । क्लेमायडोस्पोर के उत्पादन के लिए नमी और पानी की सक्रियता के उचित स्तर की अपेक्षा एक आदर्श यौगिक की पहचान बहुत कठिन है ।

डेन्किन्कोटाई, होसुर में पोली हाऊस में शिमला मिर्च और टमाटर की फसल पर प्रतिरोधक कवकों के टाल्क नियमनो (*पो. क्लेमायडोस्पोरिया* और *पे. लिलेसीनस*) को फसल-मृदा निर्जर्मीकरण (फोर्मल्डिहाईड) के साथ समेकित प्रयोग करने के परिणामस्वरुप अनोपचारित क्यारियों की अपेक्षा उपचारित क्यारियों में सूत्रकृमि-जड सडन रोग में 64 प्रतिशत तक कमी पाई गई ।

सी टी आर आई , हुन्सुर में नर्सरी क्यारियों में क्षेत्र परीक्षण दर्शाते हैं कि *पे. लिलेसीनस, ग्लो. फेसकीकुलेटम* और नीम की खली या *पे. लिलेसीनस, ग्लोमस फेसकीकुलेटम* और वर्मीकम्पोस्ट का प्रयोग करने पर स्वस्थ बीजांकुरों की प्राप्ति अधिक तथा गाँठे (जडों में संक्रमण) कम पाई गई ।

सफेद लट (व्हाइट ग्रब) के प्रति ई पी एन का प्रयोग

जी. वर्सिकोलर ग्रब के दूसरे और तीसरे निरुप के प्रति जैवदक्षता जाँचने के लिए *हेटेरोरहाब्डिटिज बेक्टेरिओफोरा, हे. इन्डिका* 13.3, *हे. इन्डिका* अशोका, *स्टेईनर्नेमा कार्पोकेप्से* एस सी 11 और *स्टे. ग्लेसेरी* कीट रोगाण्विक सूत्रकृमियों के 4 विभेदों के परीक्षण के लिए एक माध्यम के रुप में खाद प्रयोग किया गया और पाया कि इन सभी चारों सूत्रकृमियों के कारण 3 इन्च की गहराई तक 60-72 घन्टों में घातक सिद्व होती है । देवनहल्ली से एकत्र एक रोगी ग्रब से *स्टेईनर्नेमा* का एक नया पृथक्करण पाया गया ।

स्टे. कार्पोकेप्से, स्टे. राइओब्रेव, हे. इन्डिका 13.31 और *हे. इन्डिका* 6.71 के 1000 आई जे / 100 सी सी की मात्रा का द्रवीय नियमन स्केरेबिड और रहाईनोसेरस ग्रबों के लिए 72 और 96 घन्टों में 15 से. मी. की गहराई पर घातक साबित होता है ।

सफेद लट के प्रति ई पी एन के जैवदक्षता मूल्यांकन विभिन्न जैविक संशोधनों पर किया गया । *स्टे. कार्पोकेप्से, स्टे. राइओब्रेव, हे. इन्डिका* 13.31 और *हे. इन्डिका* 6.71 का द्रवीय निस्पंदन 1000 आई जे / 100 सी सी की दर से फार्म कम्पोस्ट, शहरी कम्पोस्ट, वर्मीकम्पोस्ट, वर्मिकुलाईट और नारियल की जूट रेशे पर प्रयोग किया गया जो कि स्केरेबिड और ओरिक्टस ग्रबों के लिए 15 सेमी. की गहराई पर प्रयोग करने पर 72 से 120 घन्टों में घातक सिद्व हुआ जबकि नारियल के जूट रेशों पर 96 से 120 घन्टों में घातक सिद्व हुआ ।

फसल पीडकों और खरपतवारों के जैविक नियन्त्रण पर ए आई सी आर पी

ट्राइकोडर्मा और *स्यूडोमोनाज* पर तापक्रम, पी एच और नमी का प्रभाव

ट्राइकोडर्मा हर्जिएनम के दस पृथक्करणों के अध्ययन में से 10^0 सें.ग्रे. पर टी एच 10, टी एच-4, टी एच-12 और टी एच - 31 तेजी से विकास करते हैं जबकि टी एच-43 और टी एच-28 भी विकास करते हैं । *स्यूडोमोनाज फ्लुरोसेन्स* के दस पृथक्करणों में से अन्य प्रथक्करणों की अपेक्षा पी एफ-31, पी एफ-28 और पी एफ-27, 30^0 से.ग्रे. पर उत्कृष्ट वृद्वि करते हैं । *ट्राइकोडर्मा* और *स्यूडोमोनाज* 7 पी एच पर तेजी से वृद्वि करते हैं । टी एच-38 पृथक्करण हवा में सूखाये 30 प्रतिशत नमी वाले गोबर की खाद पर वृद्वि और अधिक बीजाणु बनाते हैं । इसी प्रकार के परिणाम *स्यूडोमोनाज* के दस पृथक्करणों से प्राप्त हुए ।

पादप रोगों का जैविक नियंत्रण

मसूर की प्रजाति पी एल -5 पर विस्तृत क्षेत्रफल में ट्रा. हरजिएनम पी बी ए टी - 43 के नियमन और स्यू. *फ्लूओरेसेन्स* पी बी ए पी - 28 (10 ग्राम / किग्रा.) के मिश्रण से बीज उपचार करने के साथ पहले वर्मीकम्पोस्ट में (1 किग्रा. जैव कारक नियमन को 100 किग्रा. वर्मीकम्पोस्ट की दर से) संवर्धित करने के बाद उपयोग किया गया तब पाया कि यह जैव कारक जड़ और आर्द्र गलन को प्रभावी रुप से कम करता है तथा उपज भी अत्यधिक प्राप्त होती है । इसी प्रकार बडे क्षेत्रफल में बीज उपचार (10 ग्राम /किग्रा.), दो छिडकाव (10 ग्राम/ली.) और गोबर की खाद का प्रयोग करने पर अधिकतम नवोदभिद/मी.^{2} (32), जड सडन व आर्द्र गलन का न्यूनतम प्रकोप (25 प्रतिशत) और हरी मटर की फलियों की उपज अत्यधिक (87.5 किग्रा./हे.) प्राप्त हुई । (गो ब पं कृ एवं प्रौ वि)

तराई जैविक खेती किसान एसोसिएशन के 13 सदस्यों ने बी आई पी एम पैकेज (*ट्राइकोडर्मा हर्जिएनम* + *स्यूडोमोनाज फ्लुओरेसेन्स* को 5 से 10 टन / हे. की दर से गोबर की खाद में कालोनी बनाना) या (*स्यूडोमोनाज फ्लुओरेसेन्स* का 5 से 10 कुन्टल / हे. की दर से वर्मीकम्पोस्ट में कालोनियाँ बनाकर प्रयोग करना), *ट्रा. हर्जिएनम* + *स्यूडोमोनाज फ्लुओरेसेन्स* मिश्रण का 10 ग्रा. / किग्रा. की दर से बीज उपचार करना, शीथ ब्लाईट ग्रसित क्षेत्रों में *ट्रा. हर्जिएनम* + *स्यूडोमोनाज फ्लुओरेसेन्स* का 10 ग्रा. / ली. की दर से आवश्यकता अनुसार छिडकाव करने से जैविक धान के 600 एकड क्षेत्र में जीवाणुवीय पत्ती की ब्लाईट और ब्राउन प्लान्ट होपर को सफलतापूर्वक नियंत्रित किया गया । (गो ब पं कृ एवं प्रौ वि)

उत्तराखंड की पहाडियों में बी आई पी एम पैकेज अपनाने (नर्सरी मृदा का सौरीकरण, *ट्रा. हर्जिएनम* पी बी ए टी - 43 और स्यू. *फ्लूओरेसेन्स* के मिश्रण के नियमन को 10 ग्रा. / किग्रा. की दर से बीजोपचार करना, *ट्रा. हर्जिएनम* पी बी ए टी - 43 और स्यू. *फ्लूओरेसेन्स* पी बी ए पी-28 के 10 ग्रां / ली. की दर से बने मिश्रण में नवोदभिदों की जडें डुबाकर प्रयोग करना, *ट्रा. हर्जिएनम* पी बी ए टी-43 और स्यू. *फ्लूओरेसेन्स* पी बी ए पी - 28 को वर्मीकम्पोस्ट में कालोनियाँ बनाकर प्रयोग करना, *ट्रा. हर्जिएनम* पी बी ए टी-43 और स्यू. *फ्लूओरेसेन्स* पी बी ए पी - 28 को 10 ग्रा. / ली. की दर से घोल बनाकर 2-3 छिडकाव, सोलुनीम के 1-2 छिडकाव) पर पातगोभी, शिमला मिर्च, बैंगन और मटर के बीजांकुरण और उपज अत्यधिक प्राप्त हुई । (गो ब पं कृ एवं प्रौ वि)

ट्रा. हर्जिएनम द्वारा बीजोपचार + *ट्राइकोडर्मा* से भरपूर गोबर की खाद का प्रयोग करने पर चने में आर्द्र गलन और ब्लाइट रोगों के ग्रसन में महत्वपूर्ण कमी (5.40 प्रतिशत) देखी गई । अन्य उपचारों की अपेक्षा वर्णित उपचार से दानों की उपज भी अत्यधिक (1246.5 कि.ग्रा./हे.) पाई गई। (आ कृ वि, आनंद)

फल सड़न के रोगाणुओं का प्रबंधन

दशहरी आम में पृथक्करण I-4 (0.0 और 3.3 प्रतिशत), और बी टी 4 डी 4 (0.2 और 5.4 प्रतिशत) के प्रयोग करने से अनोपचारित की अपेक्षा 2 और 4 दिनों के बाद फलों की सतह सडन प्रतिशत कम पाई गई । चौसा आम में पृथक्करण I-2 (0.2 प्रतिशत) और बी टी 4 डी 4 (1.7 प्रतिशत) से उपचार करने के 2 दिनों के बाद फलों की सतह सडन कम पाई गई । पृथक्करण I-4 से भी दशहरी आम (0.0 प्रतिशत) और चौसा आम (4.2 प्रतिशत) उपचारित करने के 2 दिनों बाद फलों में संक्रमण प्रतिशत कम पाया गया । उसके बाद सर्वोत्तम पृथक्करण बी टी 4 डी 4 पाया गया जिससे दशहरी आम में 4.2 प्रतिशत संक्रमण पाया गया जबकि पृथक्करण I-2 से चौसा आम में 16.6 प्रतिशत संक्रमण पाया गया ।

पपीते में, *स्यूडोमोनाज* विभेद-27 द्वारा उत्कृष्ट परिणाम प्राप्त हुए उसके द्वारा उपचारित करने के 2 दिनों के बाद केवल 1 प्रतिशत क्षेत्र संक्रमित और उपचार के 10 दिनों के बाद संक्रमण केवल 12.2 प्रतिशत पाया गया । इसके पश्चात पपीते में *स्यूडोमोनाज* विभेद-3 अच्छा पाया गया इसके प्रयोग के 2 दिनों के उपचार के पश्चात फल क्षेत्र संक्रमण केवल 1.1 प्रतिशत पाया गया । (आ कृ वि, आनंद)

पादप परजीवी सूत्रकृमियों का जैविक नियंत्रण

आनंद में मोठी (बी डी एन-2 प्रजाति) में, धागाकार सूत्रकृमि *रोटीलेन्कुलस रेनिफोर्मिस* के प्रति प्रतिरोधक कवक के मूल्यांकन का क्षेत्रीय परीक्षण किया गया, जिसमें ज्ञात हुआ कि जिन प्लाट में *ट्रा. हर्जिएनम* और *पो. क्लेमायडोस्पोरिया* मिश्रण प्रयोग किया गया उनमें अत्यधिक उपज (1250 कि.ग्रा. / हे.) प्राप्त हुई । उन प्लाटो में जिनमें *ट्रा. हर्जिएनम* या *पो. क्लेमायडोस्पोरिया* किसी एक से उपचार किया गया

उनमें उपज के हिसाब से एक समान परिणाम प्राप्त हुए । (आ कृ वि, आनंद)

सन 2008 में खरीफ मोसम में, राहुरी में मोठी की फसल में (विपुल प्रजाति), धागाकार सूत्रकृमि के प्रति प्रतिरोधक कवक के मूल्यांकन का क्षेत्रीय परीक्षण किया गया, जिसमें ज्ञात हुआ कि *ट्रा. हर्जिएनम* को 5 कि. ग्रा./हे. और *पो. क्लेमायडोस्पोरिया* को 20 कि. ग्रा. /हे. की दर से मिलाकर प्रयोग करने के परिणामस्वरूप धागाकार सूत्रकृमियों की संख्या कम (15.6) करने और अरहर की उपज बढ़ाने (1750 कि. ग्रा./हे.) में अति प्रभावशाली पाये गए ।

टमाटर (पूसा रुबी जाति) जड़ ग्रन्थि सूत्रकृमि *मिलायडोगाईने इन्कोगिनेटा* के प्रति *पे. लिलेसिनस* और *पो. क्लेमायडोस्पोरिया* को 20 कि. ग्रा. / हे. के प्रयोग का क्षेत्रीय मूल्यांकन किया, जिसमें ज्ञात हुआ कि फसल रोपण के 45 दिनों के बाद उपचारित करने पर *पो. क्लेमायडोस्पोरिया* की अपेक्षा *पे. लिलेसिनस* द्वार उपचारित पौधों पर अण्ड समूहों का परजीवीकरण बहुत अधिक पाया गया, किन्तु फसल कटाई के समय दोनों उपचारों की दक्षता एक जैसी पाई गई । (आ कृ वि, आनंद)

छः साल की आयू वाले संतरों के पेड़ों पर 10^9 बीजाणु / ग्रा. वाले *पे. लिलेसिनस* के टाल्क नियमन को 20 कि. ग्रा. / हे. की दर से प्रयोग करने पर नींबू वर्ग सूत्रकृमि संख्याओं में कमी (41.3 प्रतिशत) और जडों में मादाओं की संख्या (34.6 प्रतिशत) तथा संतरों के फलों की उपज 19.56 प्रतिशत तक बढी । (म फु कृ विद्यापीठ, राहुरी)

अनार (सिन्दुरी प्रजाति) के बाग में 200 से.मी.^{3} मृदा और 5 ग्रा. जडों के नमूनों से 6 महीनों के बाद सूत्रकृमियों की संख्या प्राप्त की गई , जिसमें ज्ञात हुआ कि जिन पौधों को *पे. लिलेसिनस* + सरसों की खली से उपचारित किया गया उनमें सूत्रकृमियों की संख्या कम (14) पाई गई । *पे. लिलेसिनस* + सरसों की खली प्रयोग करने पर भी जडग्रन्थि इन्डेक्स सबसे कम (1.0) इसके पश्चात *प्रो. क्लेमायडोस्पोरिया* को सरसों की खली (1.1) के प्रयोग अभिलेखित किए गए । (आ कृ वि, आनंद)

फसल कीटों का जैविक दमन

गन्ना

गोलाघाट जिले के हलोवा गाँव में एक किसान के 10 हेक्टेयर क्षेत्र में गन्ने की को बी एल एन 9605 जाति में प्लासी बेधक के प्रति *ट्रा. किलोनिस* की प्रभावशीलता का क्षेत्रीय प्रदर्शन किया गया। सन 2008 में जुलाई के दूसरे सप्ताह से अक्टूबर के पहले सप्ताह तक *ट्रा. किलोनिस* को 50,000/ हे./प्रतिबार की दर से 10 दिनों के अन्तराल पर 9 बार छोडनें के परिणामस्वरूप गन्नों के ग्रसन के कमी और गन्नों की उपज अत्यधिक (84,450 कि.ग्रा./हे.) पाई गई । (अ कृ वि, जोरहाट)

पंजाब में गोहवार और छाछरारी गाँव में 100 हे. क्षेत्रफल पर *ट्रा. किलोनिस* को 50,000 /हे. की दर से 10 दिनों के अन्तराल पर 8 बार छोडने के परिणामस्वरूप अगेती कोंपल बेधको के ग्रसन को महत्वपूर्ण रुप से कम किया गया । *ट्रा. किलोनिस* छोडे गये प्लाट में *का. इनफसकेटेलस* के औसतन 51.2 प्रतिशत अण्डे परजीविकृत पाए गए । उपज महत्वपूर्ण रुप से अधिक पाई गई । (पं कृ वि)

पंजाब के रावलपिंडी गाँव में तापक्रम सहिष्णु विभेद *ट्रा. जेपोनिकम* 50,000 /हे. की दर से 10 दिनों के अन्तराल पर 8 बार छोडने के परिणामस्वरूप अगोला बेधको के ग्रसन को महत्वपूर्ण रुप से कम किया गया । *ट्रा. जेपोनिकम* छोडे गए प्लाट में *एस. एक्सर्पटेलीस* के औसतन 23.6 प्रतिशत अण्डे परजीविकृत पाए गए । उपज महत्वपूर्ण रुप से अधिक पाई गई । (पं कृ वि)

पंजाब के पाडी खालसा गाँव में 40 हे. क्षेत्रफल में *ट्रा. किलोनिस* के 10 दिनों के अन्तराल पर 12 बार छोडने के परिणामस्वरूप तना बेधको का ग्रसन 5.6 प्रतिशत तक कम किया गया । अनोपचारित (4.9 प्रतिशत) की अपेक्षा परजीवी कीट छोडे गए क्षेत्रों में परजीवीकरण प्रतिशत अत्यधिक (55.6) पाया गया । (पं कृ वि)

8 हे. क्षेत्रफल में को. 86032 जाति पर सितम्बर से नवम्बर के दौरान *ट्रा. किलोनिस* को 10 दिनों के अन्तराल पर 8 बार छोडने के परिणामस्वरूप पोरी बेधको का ग्रसन महत्वपूर्ण रुप से कम किया गया । अनोपचारित प्लाट की अपेक्षा परजीवी कीट छोडे गए प्लाट में महत्वपूर्ण रुप से उपज भी अत्यधिक (115200 कि.ग्रा./हे.) पाई गई । (त कृ वि)

गन्ने के पोरी बेधको के प्रति *ट्रा. किलोनिस* (टी टी एस और एस ए एस विभेदों) के क्षेत्रीय प्रदर्शन में परजीवी कीट को 1 लाख / हे. / प्रतिबार की दर से छोडने पर गन्ने पर कीट का ग्रसन और प्रकोप प्रभावी रुप से कम पाया गया । (म फु कृ विद्यापीठ)

पोरी बेधक के प्रति *ट्रा. किलोनिस* को 2.5 लाख / हे. दर से छोडने के क्षेत्रीय मूल्यांकन में पाया गया कि पोरी बेधक कीट का ग्रसन 52.4 प्रतिशत जबकि अनोपचारित प्लाट में 74.8 प्रतिशत पाया गया । अनोपचारित प्लाट की अपेक्षा परजीवी कीट छोडे गए प्लाट में 153400 कि. ग्रा. / हे. की दर से अत्याधिक उपज पाई गई और पोरी बेधक कीट का ग्रसन 29.95 प्रतिशत कम पाया गया तथा अनोपचारित प्लाट की अपेक्षा परजीवी कीट छोडे गए प्लाट में 13.29 प्रतिशत उपज बढी पाई गई। (ग प्र सं)

ट्रा. किलोनिस की दक्षता का मूल्यांकन करने के लिए किसान के खेत में 2 क्षेत्रीय परीक्षण किये गये, अनोपचारित और 6 बार परजीवी कीट छोडने की तुलना में, *ट्रा. किलोनिस* को लगातार छोडने के परिणाम स्वरूप पोरी बेधकों द्वारा क्षति (2.1 प्रतिशत), डेडहर्ट (8.9 प्रतिशत) कम और उपज अत्यधिक (2,02,060 कि. ग्रा. /हे.) प्राप्त हुई । (ग प्र सं)

कोटेशिआ फ्लेविपस (जुलाई से नवम्बर तक 7 दिनों के अन्तराल पर 500 गर्भित मादायें /हे. की दर से) या *टेट्रास्टिकस होवार्डी* (जुलाई से नवम्बर तक एक महीने के अन्तराल पर 5000 प्रौढ कीट /हे. की दर से) की तुलना में *ट्राइकोग्रामा किलोनिस* (जुलाई से अक्टूबर तक 50,000/ हे. की दर से 10 दिनों के अन्तराल पर) छोडे गए प्लाटों में पोरी बेधकों का ग्रसन न्यूनतम (5.6 प्रतिशत) पाया गया । किन्तु *को. फ्लेविपस* छोडे गए प्लाटों में कोंपल बेधकों का ग्रसन न्यूनतम (5.6 प्रतिशत) इसके बाद *ट्रा. होवार्डी* तथा *ट्रा. किलोनिस* द्वारा पाया गया । *ट्रा. किलोनिस* छोडे गए प्लाटों में अत्याधिक उपज (60,710 कि. ग्रा. /हे.) पाई गई । (भा ग अ सं)

तमिलनाडू, महाराष्ट्र और असम में क्षेत्रीय सर्वेक्षण में वर्ष 2008 के दौरान पाया गया कि गन्ने के वूली माँहू का ग्रसन बहुत नगण्य था । कीट को जैव कारकों द्वारा सफलतापूर्वक नियंत्रित किया गया।

बी टी कपास

आन्ध्र प्रदेश में किसान द्वारा अपनाई जाने वाली कृषि प्रक्रिया और स्थानीय प्रक्रियाओं की अपेक्षा बी आई पी एम प्रक्रियाओं के क्षेत्रीय परीक्षणों में पाया कि बी टी कपास में गूलरों की क्षति न्यूनतम और उपज अत्यधिक पायी गई । किसानों द्वारा अपनाई गई प्रक्रियाओं से लागतः लाभ अनुपात केवल 1:1.03 जबकि बी आई पी एम प्रक्रियाओं को अपनाने पर यह अनुपात 1:1.81 पाया गया । (आ एन जी रंगा कृ वि)

गुजरात में, किसानो द्वारा अपनाई जाने वाली कृषि प्रक्रियाओं की तुलना में बी आई पी एम पैकेज अपनाने के क्षेत्रीय परीक्षणों में माँहू, फूदकों और सफेद मक्खियों का ग्रसन न्यूनतम पाया गया । बी आई पी एम पैकेज अपनाने पर *इरियास* और गुलाबी सूंडी द्वारा कलियों, हरे गूलरों की क्षति प्रतिशत न्यूनतम जबकि किसानों द्वारा अपनाई गई प्रक्रिया में यह क्षति प्रतिशत अत्याधिक पाया गया । बी आई पी एम पैकेज अपनाने पर *क्रा. कारनिया*, कोक्सीनेलिड, *जिओकोरिस* बग और मकडियों की संख्या क्रमशः 17.3, 54.8, 12.0 और 16.0 प्रति 25 पौधे जबकि किसानों द्वारा अपनाई गई प्रक्रियाओ में यह संख्या क्रमशः 11.0, 37.8, 4.0 और 9.3 प्रति 25 पौधे पाई गई । किसानों द्वारा अपनाई गई प्रक्रियाओ की तुलना में कपास बीज का उत्पादन महत्वपूर्ण रूप से अत्याधिक पाया गया । किसानों द्वारा अपनाई गई प्रक्रियाओ की अपेक्षा बी आई पी एम पैकेज अपनाने से कपास बीज की उपज 32.17 प्रतिशत बढी पाई गई । (आ कृ वि, आनंद)

पंजाब में बी टी कपास पर बी आई पी एम पैकेज के क्षेत्रीय प्रदर्शन से ज्ञात हुआ कि किसानों द्वारा अपनाई गई प्रक्रियाओ की तुलना में बी आई पी एम पैकेज अपनाए गए क्षेत्र में परभक्षी कीटों की संख्या प्रति 3 पत्तियों पर अत्यधिक पाई गई, यद्यपि फूदकों की संख्याँयें किसान प्रक्रिया अपनाए गए क्षेत्र में अधिकतम पाई गई । बी आई पी एम पैकेज और किसान द्वारा अपनाई जाने वाली प्रकियायों के कपास बीज उपज में कोई विशेष अन्तर नही पाया गया । (पं कृ वि)

तमिलनाडू में , बी आई पी एम पैकेज अपनाने पर कपास की फसल पर फूदकों, माँहू, थ्रिप्स और सफेद मक्खियों की संख्या प्रति 5 पौधे महत्वपूर्ण रुप से कम पाई गई । बी आई पी एम पैकेज अपनाने पर बी टी कपास पर *इरियास* और *हे. आर्मिजेरा* द्वारा गूलरों की क्षति भी कम पाई गई । बी आई पी एम पैकेज अपनाए गए क्षेत्र में लागत-लाभ अनुपात 1:1.9 के साथ कपास के बीज की अधिक उपज (2169 कि. ग्रा. / हे.) पाई गई जबकि किसान प्रक्रियायों द्वारा बी टी कपास की न्यूनतम उपज (1894 कि. ग्रा. /हे.) प्राप्त हुई । (त कृ वि)

महाराष्ट्र में विस्तृत स्तर पर किए गए क्षेत्रीय प्रदर्शन में ज्ञात हुआ कि किसान प्रक्रियायों की अपेक्षा बी आई पी एम पैकेज अपनाने पर माँहू, फूदकों, मिलीबग और थ्रिप्स की संख्या अधिकतम किन्तु गूलर क्षति कम पाई गई तथा कपास बीज की उपज महत्वपूर्ण रुप से अधिकतम (2420 कि. ग्रा. /हे.) प्राप्त हुई । *हे. आर्मिजेरा* और *पे. गोसिपिएल्ला* का ग्रसन बहुत कम पाया गया। (म फु कृ वि)

रायचूर में किये गए क्षेत्रीय प्रदर्शन से ज्ञात हुआ कि बी आई पी एम और किसान प्रक्रिया वाले प्लाट में चूसने वाले कीटों की संख्या अधिक या कम एक समान पाई गई। किसान प्रक्रिया की तुलना में बी आई पी एम प्लाट में उच्चतम लाभ (59925 रु./हे.) प्राप्त हुआ। (कृ वि वि, रायचूर)

महाराष्ट्र में अनेक स्थानों पर किए गए जाँच परीक्षणों से ज्ञात हुआ कि बी आई पी एम पैकेज के अंतर्गत गूलाबी सूँडी के प्रति *ट्रायकोग्रमेटायडिया बेक्टरे* को 3-4 बार छोडने पर औसतन गूलर क्षति कम पाई गई , जो कि किसान प्रक्रियायों की अपेक्षा न्यूनतम थी । बी आई पी एम पैकेज अपनाने पर कपास बीज की उपज अत्याधिक (1689 कि. ग्रा./हे.) जबकि किसान प्रक्रिया अपनाने पर कम उपज (1432 कि. ग्रा./हे.) तथा अनोपचारित क्षेत्र से न्यूनतम (987 कि. ग्रा./ हे.) उपज प्राप्त हुई।

गुजरात में किसान प्रक्रियायों और अनोपचारित प्लाटों कि तुलना में *ट्रा. बेक्टरे* छोडने पर गूलर क्षति होना कम पाया गया। बी आई पी एम पैकेज अपनाने पर अत्याधिक उपज (2022 कि. ग्रा./हे.) जबकि किसान प्रक्रिया द्वारा कम उपज (1789 कि. ग्रा. /हे.) तथा अनोपचारित क्षेत्र से न्यूनतम उपज (1508 कि.ग्रा. /हे.) प्राप्त हुई ।

महाराष्ट्र, पंजाब और गुजरात में बी आई पी एम पैकेज व किसान प्रक्रिया की अपेक्षा आश्रय प्रबंधन के अन्तर्गत कपास के साथ लोबिया और गेंदा की फसल उगाने पर वर्षा निर्भर क्षेत्रों में उपज अत्याधिक प्राप्त हुई । आश्रय प्रबंधन प्लाट में *क्रा. कारनिया,* कोक्सीनेलिड और मकडियों की संख्या अधिक प्राप्त हुई । बी आई पी एम और किसान प्रक्रियायों कि अपेक्षा आश्रय प्रबंधन के अन्तर्गत *ट्रा. किलोनिस* द्वारा प्राकृतिक परजीविकरण भी अत्याधिक पाया गया ।

क्रि. मोन्ट्रयूजिएरी की बीटलों को 15 दिनों के अन्तराल पर 1500 बीटल / हे. की दर से छोडने पर मिलीबग की संख्या को 153.4 से 80.4 प्रति 5 से.मी. शाखा पर कम कर देता है जोकि किसान द्वारा रासायनिक उपचार और अनोपचारित प्रयोग से उत्कृष्ट पाया गया ।

तम्बाकू

स्पो. एन पी वी का 7 पी एच निस्पंदन का छिडकाव करने के सात दिनों के बाद *स्पो. लिटयूरा* द्वारा नवोदभिदों की क्षति न्यूनतम पाई गई जोकि एन पी वी की उत्कृष्टता सिद्द करती है। *स्पो.* एन पी वी का 5 तथा 9 पी एच निस्पंदन प्रयोग करने पर नवोदभिद की क्षति अधिक दिखाई पडी जोकि एन पी वी की कम सक्रियता का सूचक है। नर्सरियों में *स्पोडोप्टेरा* के प्रबंधन के लिए *स्पो.* एन पी वी को 1.5 X 10^{12} पी आई बी / हे. की दर से प्रयोग करना बहुत प्रभावी पाया गया ।

राजमुन्द्री और जीलुगुमिली से एकत्र किए गए *स्पो.* एन पी वी विभेदों में अधिकतम विषाक्तता पाई गई इनके छिडकाव करने के 7 दिनो के बाद सूँडी की संख्या प्रति पौधा कम पाई गई । इन दोनों विभेदों के छिडकाव के 7 दिनों के बाद पत्तियों की क्षति प्रतिशतता कम पाई गई । *स्पो.* एन पी वी का राजमुन्द्री विभेद प्रयोग करने पर हरी पत्तियों की उपज अत्यधिक (15272 कि. ग्रा./हे.) इसके पश्चात जीलुगुमिली विभेद पाया गया । तम्बाकू के तना बेधक, *स्क्रोबीपालपा हेलीयोपा* के प्रति पी डी बी सी के बी टी विभेद का 1:10 अनुपात का घोल बहुत प्रभावी पाया गया ।

दलहनी फसलें

तमिलनाडू में अरहर पर किए गए क्षेत्रीय परीक्षणों से ज्ञात हुआ कि किसान प्रक्रियाओ की अपेक्षा बी आई पी एम पैकेज अपनाने पर *हे. आर्मिजेरा* और *मे. टेरस्टुलेलिस* द्वारा फलियों का क्षतिग्रस्तता व सूँडियों का प्रकोप कम, फलियों की उपज तथा लागत-लाभ अनुपात अत्यधिक पाया गया । अम्मापेटाई गाँव (इरोडे जिला) में किए गए एक अन्य क्षेत्रीय परीक्षण में भी इसी प्रकार के परिणाम मिले, जिसमें बी आई पी एम पैकेज में 1:1.79 जबकि किसान प्रक्रिया में 1:1.30 का लागत लाभ अनुपात प्राप्त हुआ । (त कृ वि)

आन्ध्र प्रदेश में अरहर की फसल में बी आई पी एम पैकेज प्रदर्शन में पाया कि किसान प्रक्रिया की अपेक्षा बी आई पी एम मोडयूल अपनाने पर फली बेधकों का ग्रसन न्यूनतम पाया गया तथा अत्यधिक उपज पाई गई। (आ एन जी रंगा कृ वि वि)

गुजरात में अरहर की बी डी एन-2 प्रजाति पर किए गए क्षेत्रीय प्रदर्शन से ज्ञात हुआ कि बी आई पी एम और किसान प्रक्रिया अपनाये गए क्षेत्रों के बीच में 5 शाखाओं के लिए खडे पौधे और उन पर *हे. आर्मिजेरा* की सूँडियों की संख्या में कोई विशेष अंतर नही पाया गया, यद्यपि बी आई पी एम प्रक्रिया अपनाये गये क्षेत्रों में *हे. आर्मिजेरा* द्वारा फलियों का न्यूनतम ग्रसन पाया गया । स्थानीय अनुशंसाओं और किसान प्रक्रियायों कि तुलना में बी आई पी एम पैकेज अपनाए गए क्षेत्रों में अत्यधिक उपज प्राप्त हुई। (आ कृ वि, आनंद)

गुजरात में अरहर की फसल पर *हे.* एन पी वी का 1.5 X 10^{12} पी ओ बी / हे. + 0.5 कच्ची चीनी + 0.1 प्रतिशत टी पाल की दर से क्षेत्र में प्रयोग करने के परीणाम स्वरुप प्रति 5 शाखाओ पर *हे. आर्मिजेरा* सूँडियों की संख्या और फली क्षतिग्रस्तता कम पायी गयी । (आ कृ वि, आनंद)

आन्ध्र प्रदेश में *डोलीकस* लेबलेब पर *हे.* एन पी वी का 0.375 X 10^{12} पी ओ बी / हे. की दर से प्रयोग करने पर *हे. आर्मिजेरा* की संख्या कम और उपज अधिकतम प्राप्त हुई । (आ एन जी रंगा कृ वि)

धान

केरल में 10 हे. क्षेत्रफल पर धान ज्योति प्रजाति में जैव प्रबलित पीडक प्रबंधन प्रक्रिया (*स्यू. फ्लूओरेसेन्स* द्वारा 8 ग्रा. / कि. ग्रा. बीज / को 10^{13} बीजाणु / हे. की दर से, पत्ती मोडक कीट या तना बेधक कीटों के ग्रसन पर *ट्रा. जेपोनिकम* को 1 लाख / हे. की दर से, पीडक के ग्रसन की निर्भरता के आधार पर बी टी का 2 कि. ग्रा. / हे. की दर से 2-4 छिडकाव, नीम आधारित या वनस्पति आधारित जैवकारको का बिन्दु प्रयोग और *स्यू. फ्लूओरेसेन्स* का पर्णरोग के प्रति छिडकाव) में ज्ञात हुआ कि बी आई पी एम पैकेज, किसान द्वारा अपनाई जाने वाली प्रक्रिया की अपेक्षा डेडहर्ट, सफेद बाली ग्रसन और पत्ती मोडक कीट द्वारा क्षति महत्वपूर्ण रुप से कम पाई गई । किसान प्रक्रिया की तुलना में बी आई पी एम पैकेज अपनाए गए प्लाटों में मकडियों और कोक्सीनेलिड्स की संख्या अधिक तथा दानों की उपज और लाभ अत्याधिक पाया गया ।

केरल में अनेक स्थानों पर जैव प्रबलित पीडक प्रबंधन (बी आई पी एम) प्रक्रिया (रोग प्रतिरोधी प्रजातियों का प्रयोग, *स्यू. फ्लूओरेसेन्स* द्वारा 8 ग्रा. / कि. ग्रा. की दर से बीज उपचार, गोबर की खाद 5 टन / हे. की दर से, चूसने वाले कीटों की अपेक्षा *ब्यू. बेसियाना* को 10^{13} बीजाणु / हे. की दर से प्रयोग, चिडिया डराने वाले दस पुतले / हे., कीटो के ग्रसन होने पर *ट्रा. जेपोनिकम* को एक लाख /हे. की दर से छोडना, पर्ण रोगों के प्रति *स्यू. फ्लूओरेसेन्स* का छिडकाव) का जैविक धान प्रदर्शन से ज्ञात हुआ की परंपरागत प्रक्रियाओ की तुलना में जैविक खेती में कोक्सीनेलीडस और मकडियों की संख्या अधिक पाई गई । खरीफ मौसम के दौरान डेड हर्ट के प्रकोप का कोई विशेष अंतर नही पाया गया, यद्यपि रबी मौसम के दौरान जैविक पैकेज में डेडहर्ट का प्रकोप कम पाया गया । (के कृ वि)

असम में 10 हे. क्षेत्रफल पर धान की महासुरी प्रजाति में किसान के खेत में बी आई पी एम के क्षेत्रीय प्रदर्शन में पाया कि किसान प्रक्रिया की तुलना में बी आई पी एम पैकेज अपनाने पर ग्रीन लीफ हापर की संख्या, तने बेधक और पत्ती मोडक कीट द्वारा क्षति न्यूनतम पायी गयी । किसान प्रक्रिया की तुलना में बी आई पी एम पैकेज अपनाने पर दानों की उपज अत्याधिक और किसान प्रक्रिया की तुलना में 8550 रु. का अधिक लाभ हुआ । असम में 10 हे. क्षेत्रफल में जैविक धान में बी आई पी एम प्रक्रिया अपनाने पर ग्रीन लीफ हापर्स, पत्ती मोडक कीट द्वारा क्षति और डेड हर्ट प्रकोप कम पाया गया । यद्यपि परंपरागत विधि में दानों की उपज अधिकतम, बी आई पी एम में 4506 रु. का अधिक लाभ पाया गया । (अ कृ वि, जोरहाट)

किसान के क्षेत्र में बी आई पी एम के क्षेत्रीय प्रदर्शन में ज्ञात हुआ कि बी आई पी एम और किसान प्रक्रिया अपनाये गये प्लाटों में पत्ती मोडक कीट द्वारा क्षति और डेडहर्ट के संदर्भ में कोई विशेष अंतर नही पाया गया । बी आई पी एम पैकेज को किसान द्वारा रासायनिक कीटनाशक प्रयोग के समान ही प्रभावी पाया गया । पंजाब में धान की फसल में बी आई पी एम प्रक्रिया अपनाने पर ज्ञात हुआ कि बी आई पी एम किसान प्रक्रियायों में पत्ती मोडक कीट द्वारा क्षति और डेडहर्ट के प्रकोप का कोई विशेष अंतर नही पाया गया । बी आई पी एम पैकेज को किसान द्वारा रासायनिक कीटनाशकों के प्रयोग के समान ही प्रभावी पाया गया । पंजाब में जैविक धान के दो क्षेत्रीय प्रदर्शनों में पाया गया कि उपज में कोई विशेष अंतर नही है यद्यपि किसान प्रक्रिया में केवल 98,188 रु. /हे. का लाभ हुआ जबकि बी आई पी एम पैकेज अपनाने पर 1,12,798 रु. का लाभ हुआ । (पं कृ वि)

मक्का

हेटरोरहाब्डिटिस इन्डिका को 2 बिलियन आई जे / हे. की दर से प्रयोग करने से क्षेत्रीय प्रदर्शन में पाया गया कि प्रति 10 पौधो पर *एग्रोटिस ईप्सिलोन* के लारवों की संख्या कम और पौधो की क्षति न्यूनतम प्रतिशत तथा दानों की उपज अत्यधिक प्राप्त हुई । (शे क कृ वि एवं प्रौ, जम्मू)

अरंडी

बी आई पी एम पैकेज (*एकीया जनेटा* और *डाईकोक्रोसिस पंकटिफेरालिस* के प्रति 100000/ हे. की दर से *टेलीनोमस रीमस, ट्रा. एकिये* को 100000 / हे., *स्पो.* एन पी वी 1.5 X10^{12} पी ओ बी / हे. + 0.5 प्रतिशत कच्ची चीनी, डाइपेल का 0.5 ली. / हे. की दर से छिडकाव) अपनाने पर *स्पो. लिटयूरा, ए. जनेटा* और *डा. पंकटिफेरालिस* का न्यूनतम ग्रसन पाया गया । किसानों द्वारा अपनाई जाने वाली प्रक्रिया की तुलना मे बी आई पी एम पैकेज अपनाने से कीट द्वारा क्षति कम तथा उपज अत्याधिक प्राप्त हुई । (आ एन जी रंगा कृ वि)

मूँगफली

तमिलनाडू में क्षेत्रीय प्रदर्शन में 10 दिनों के अंतराल पर *ट्रा. किलोनिस* को 100000/हे. की दर से 3-4 बार छोडना, बुआई के 60 और 75 दिनों के बाद बी टी का 1 कि. ग्रा. / हे. और नीम बीज अर्क के 5 प्रतिशत छिडकाव को एन्डोसल्फान के समान प्रभावी पाया गया तथा बी टी छिडकाव से पत्ती सुरंगी कीट के लारवों की संख्या और क्षति नियंत्रित करने के लिए तथा उपज बढाने के लिए उपयुक्त पाया गया । (त कृ वि)

नारियल

केरल में, *ओपिसीना एरेनोसेल्ला* की सूँडियों को नियंत्रित करने के लिए *गोनियोजस नीफेन्टिडीस* के 10 प्रौढ / ताड की दर से चार बार छोडना या *कार्डियास्टेथस एक्जिगुअस* को 50 / ताड की दर से क्रमवार या *ट्राइकोग्रामा एम्ब्रियोफेगम* को 1000 / ताड की दर से छोडना उत्तम पाया गया । (के कृ वि)

ओरीक्टस का प्रबंधन करने के लिए बेक्यूलोवायरस, *मे. एनाईसोप्लिए* और फेरोमोन प्रपंच का प्रयोग करने के परिणामस्वरुप पत्ती और पुष्पक्रम क्षति कम पायी गयी तथा गोबर गड्ढों को *मे. एनाईसोप्लिए* द्वारा उपचारित करना *ओ. रहाईनोसेरस* ग्रबों के लिए अत्यंत घातक पाया गया । (के कृ वि और के फ रो अ सं)

ई पी एन का प्रयोगशाला मूल्यांकन दर्शाता है कि *हे. बेक्टेरीओफोरा* की अपेक्षा *हे. इन्डिकस* का स्थानीय विभेद अधिक विषैला पाया गया । यह पाया गया कि *हे. बेक्टेरीओफोरा* और *हे. इन्डिकस* की 400 आई जे की मात्रा रेड पाम विविल ग्रब को 96 घन्टो के अन्दर 63 प्रतिशत तक घातक साबित होती हैं । (के फ रो अ सं)

ऊष्ण फल

आम के वृक्षों की डालों पर आफ सीजन में *मेटारहाईजियम एनाईसोप्लिए* का 1 X10^{7} बीजाणु / मि. ली. की दर से नवम्बर माह में छिडकाव और एक छिडकाव फूल आने के दौरान करने पर फूदकों के ग्रसन को कम किया गया । (भा बा अनु सं)

तमिलनाडू में आफ सीजन के दौरान *वर्टीसिलियम लेकेनाई* का 1 X10^{9} बीजाणु / मि. ली. की दर से वृक्षों की डाल पर छिडकाव और एक छिडकाव कोंपलों पर करने पर फूदकों का महत्वपूर्ण रुप से कम किया गया । (त कृ वि)

फल बेधक *डयूडोरिक्स आईसोक्रेटस* का जैविक नियंत्रण करने के लिए *ट्रा. किलोनिस* का जून माह से साप्ताहिक अंतराल पर 6 बार छोडने की सुधरी विधि को प्रभावी पाया गया । (शे क कृ वि और प्रौ वि)

अंगुर की बेल पर कीट प्रबंधन हेतु प्रयोग करने के लिए कुल 14 कवकनाशकों का अनुमोदन किया जिन्हें *क्रिप्टोलीमस मोन्ट्रयूजिएरी* के लिए सुरक्षित पाया गया । (रा अं अनु के, पुणे)

तमिलनाडू में पपीता, भिन्डी, कपास, टीक, नेरीयम, जंगली शहतुत, सूरजमुखी, मोठी, शकरकन्दी, जैट्रोपा, अमरुद, टमाटर, बेर, कोक्सीनीया, मिर्च, बैंगन और टेपिओका पर पपीता मिलीबग, *पेराकोकस मार्जिनेटस* पर विभिन्न प्रकार के प्राकृतिक शत्रु कीट अभिलेखित किए उनमें से परभक्षी कीट *क्रिप्टोलीमस मोन्ट्रयूजिएरी, स्पेलजिस एपिअस, स्किमनस कोक्सीवोरा, बुमायडस सुद्रेलिस* और परजीवी कीट *क्लेडिस्कोडस सेकेराई* प्रमुख पाये गये । (त कृ वि)

शीतोष्ण फल

मे. एनाईसोप्लिए का 10^{13} बीजाणु / मिली. और *ब्यू. बेसियाना* का $1x10^{8}$ बीजाणु / मिली. की दर से प्रयोग करने पर सेब के तना बेधक कीट (*एओलेस्थस सारटा*) का अच्छा नियंत्रण करने की उपलब्धि प्राप्त की । (शे क कृ वि और प्रौ वि)

सोलन में *ब्यू. बेसियाना* और *मे. एनाईसोप्लिए* का 10^{7} कोनिडिया /मिली. या *व. लेकेनाई* का $1x10^{7}$ कोनिडिया / मिली. की दर से प्रयोग करने पर क्षेत्रीय परीक्षण में सेब के वुली माँहु को नियंत्रण करने में असफल पाया गया । (डा. य. सिंह प उ और वा वि)

ट्रा. एम्ब्रियोफेगम को 4000 प्रौढ / वृक्ष की दर से दो बार छोडने (मई के दूसरे सप्ताह और जुलाई के अन्तिम सप्ताह) के परिणाम स्वरूप कोडलिंग मौथ द्वारा होने वाली क्षति को सेब में प्रभावपूर्ण ढंग से नियंत्रित करता है । (शे क कृ वि और प्रौ वि, श्रीनगर)

सब्जी वाली फसले

असम में, *ट्राईकोग्रामा ब्रेसीके* को 1 लाख / हे. की दर से 6 बार छोड़ने के परिणाम स्वरूप डायमण्ड बैक मौथ के ग्रसन में कमी और पातगोभी की उपज बढी । (अ कृ वि, जोरहाट)

तमिलनाडू में *ट्रा. ब्रेसीके* को साप्ताहिक अन्तराल पर 1 लाख / हे. की दर से छोड़ने के परिणामस्वरूप प्रति पौधा डायमण्ड बैक मौथ की सूँडी में कमी और फूलगोभी में लागत लाभ अनुपात 1:2.2 के साथ उपज बढी । (त कृ वि)

ट्रा. ब्रेसीके को साप्ताहिक अन्तराल पर 1 लाख / हे. की दर से 6 बार छोडने के परिणाम स्वरूप फूलगोभी में *प्लू. जाइलोस्टेल्ला* द्वारा क्षति से रोकने में महत्वपूर्ण, उपज अधिकतम मिलने के साथ लाभ अधिक प्राप्त हुआ । यह विधि किसान द्वारा अपनाई जाने वाली प्रक्रिया में 2-3 रासायनिक कीटनाशकों के छिडकाव से अधिक उत्कृष्ट पाया गया । (शे क कृ वि और प्रौ वि, जम्मू)

ट्रा. किलोनिस को 6 बार छोडने के परिणामस्वरूप *पीएरिस ब्रेसीके* के लारवों के घनत्व को 1.9 प्रति पौधा तक कम किया गया और अण्ड परजीविकरण अधिकतम 10.4 प्रतिशत तक पाया गया । (शे क कृ वि और प्रौ वि, जम्मू)

क्षेत्रीय परीक्षण में *ब्यू. बेसीयाना* को $1x10^{8}$ बीजाणु / मिली. की दर से प्रयोग करने पर *पी. ब्रेसीके* की 60 प्रतिशत सूंडी मृत पाई गई और यह *मे. एनाईसोप्लिए* (56.3 प्रतिशत) तथा तेल (63.3 प्रतिशत) के समान पाया गया । (शे क कृ वि और प्रौ वि)

प्लू. जाइलोरटेल्ला के जैविक नियंत्रण पैकेज जिसमें *ट्रा. ब्रेसीके* को 1 लाख / हे. की दर से (6 बार) छोडना, *ब्यू. बेसियाना* का 1×10^{9} बीजाणु / मिली., *स्टे. कार्पोकेप्से* को 1 बीलियन आइ जे / हे., नीम सोप 4 प्रतिशत, डाईपेल 1 मिली. / ली. और *मे. एनाईसोप्लिए* को 1×10^{9} बीजाणु / मिली. की दर से छिडकाव करना उतना ही प्रभावी पाया गया जितना कि इस्पिनोसेड का 0.7 मिली./ली. की दर से प्रयोग करना । (भा बा अनु सं)

पंजाब में, बैंगन के कोंपल और फल बेधक के प्रति विभिन्न जैविक नियंत्रण विधियों के परीक्षण में पाया गया कि बी टी का 2 कि. ग्रा. /हे. की दर से प्रयोग करने पर बहुत कम (20.3 प्रतिशत) फल क्षतिग्रस्त पाये गये जोकि ई पी एन की 2 बिलियन आई जे / हे. तथा ट्रायजोफोस प्रयोग करने से अच्छा पाया गया । बी टी का 2 कि. ग्रा. /हे. की दर से प्रयोग करने पर महत्वपूर्ण रुप से अधिकतम उपज प्राप्त हुई जो कि ट्रायजोफोस प्रयोग से अधिक पाई गई । (पं कृ वि)

असम में क्षेत्रीय परीक्षण में, ई पी एन को 2 बिलियन / हे. की दर से दो बार प्रयोग करने पर बैंगन की कोंपल और फल क्षति को कम (17.8 प्रतिशत) रखने के लिए अत्यन्त प्रभावी पाया गया जोकि बी टी और *ट्रा. किलोनिस* के प्रयोग से उत्कृष्ट पाया गया । ई पी एन का 2 बिलियन / हे. की दर से प्रयोग करने पर अत्यधिक उपज पाई गई तथा इसको एन्डोसल्फान के प्रयोग से उत्तम पाया गया। (अ कृ वि, जोरहाट)

भिण्डी (पंजाब-8 प्रजाति) में फल बेधक *इरिआस* स्पे. के प्रबंधन के क्षेत्रीय परीक्षण के परिणाम दर्शाते हैं कि बी टी को 2 कि.ग्रा. / हे. की दर से प्रयोग करने पर फल क्षति न्यूनतम तथा उपज अधिकतम प्राप्त हुई तथा इसको डीकामेथ्रीन के प्रयोग से उत्तम पाया गया ।

ए. क्रेक्सीवोरा के प्रति विभिन्न जैवनियंत्रण कारकों की दक्षता के क्षेत्रीय परीक्षण में ज्ञात हुआ कि *व. लेकेनाई* को 10^{10} कोनीडिया / ली. की दर से उपचारित पौधों पर माहूँ की संख्या न्यूनतम पाई गई और यह *फ्यू. पेलीडोरोसियम*,

ब्यू. बेसीयाना, मे. एनाईसोप्लिए और क्विनालफास उपचारों से उत्तम पाया गया । (के कृ वि)

श्वेत मक्खी के प्राकृतिक शत्रु कीट

सर्वेक्षण करने पर पाया गया कि ग्रीनहाउस श्वेत मक्खी का बिना पहचान किए गए *एनकार्सिआ* स्पे., *एनकार्सिआ सोफिया* (= *ए. ट्रान्सवेना*) और *एरीटमोसीरस डेल्हिएन्सिस* द्वारा परजीवीकरण पाया गया । बिना पहचान वाला *एनकार्सिआ* स्पे. परजीवी कीट केवल खीरे के पौधों पर पाया गया , जबकि *ए. सोफिया* और *एरीटमोसीरस* स्पे. को सेम, खीरा और टमाटर पर उसके परपोषी पर परजीवित पाया गया । (डा. य. सिंह प उ और वा वि)

आलू में सफेद लट का जैविक नियंत्रण

सफेद लट के प्रति *मे. एनाईसोप्लिए* का 6 ग्रा./मी.^{2} की दर से मृदा में प्रयोग करने के परिणामस्वरूप आलू कन्द कम (23.2 प्रतिशत) क्षतिग्रस्त पाए गए, उसके पश्चात समान मात्रा में *ब्यू. ब्रोन्गनीआर्टी* उपयोग करने पर (28.3 प्रतिशत) प्रभावी पाया गया और ये प्रयोग अनोपचारित (53.1 प्रतिशत) से श्रेष्ठ पाये गये ।

पोलीहाउस फसल कीट

पोलीहाउस में कार्नेशन पर 20 *ब्लाप्टोस्टेथस पेलेसेन्स* को प्रति पौधे की दर से साप्ताहिक अंतराल पर 5 बार छोडने पर *टेट्रानिकस उर्टिके* की संख्या को महत्वपूर्ण रूप से कम कर देता हैं। (म फु कृ वि)

खरपतवार नियंत्रण

केरल में, *सेसीडोकेरस कोनेक्सा* द्वारा क्रोमोलीना खरपतवार में गाँठें बनाने के कारण पौधो की ऊँचाई 18.0 प्रतिशत, शाखाओं की संख्या 5.8 प्रतिशत, पेनिकल्स की संख्या 12.9 प्रतिशत, केपीटुला की संख्या 5.1 प्रतिशत और बीज बनने में 6.3 प्रतिशत की कमी पाई गई । (के कृ वि)

3. EXECUTIVE SUMMARY

A comprehensive research programme undertaken at the National Bureau of Agriculturally Important Insects (Formerly Project Directorate of Biological Control) as well as 10 state Agricultural Universities (SAUs) and six Indian Council of Agricultural Research (ICAR)-based centres besides many voluntary centres under All-India Co-ordinated Research Project (AICRP) on Biological Control during the year 2008-09 to develop biocontrol-based technologies for the eco-friendly management of key pests, diseases of crops, nematodes and weeds. Emerging issues like eco-friendly management of mealy pests on Bt cotton, papaya mealy bug and integration of biological control in organic farming were included in the programme. Most of the experiments assigned under the technical programme drawn for the year 2008-09 have been carried out successfully and the results are summarized hereunder.

Basic research

Project Directorate of Biological Control, Bangalore

Biosystematics

The genus *Synona* Pope of the world was revised. The most commonly found coccinellid species in India, *Synona melanopepla* (Mulsant), was found to be a valid species. *Lemnia (Synia) martini* Iablokoff-Khnzorian, *L. melanoptera* Iablokoff-Khnzorian and *S. rougeti* (Mulsant) were synonymised with *S. melanopepla*. The species commonly found in peninsular India, which has been hitherto misidentified as *S. rougeti*, was found to be a new species and described as *S. obscura* Poorani, Slipinski & Booth. Four genera, namely, *Scymnodes* Blackburn, *Apolinus* Pope & Lawrence, *Rhynchortalia* Crotch and *Cryptolaemus* Mulsant, were revised.

Calvia albida Bielawski was recorded from Tripura. Two indeterminate species of *Ortalia* were recorded from Western ghats region, Kerala. *Pseudaspidimerus infuscatus* Poorani was collected from Kerala, which constitutes a new distribution record for this species. Keys were constructed for the subfamilies, tribes, and genera of Sticholotidinae and Scymninae (Coccinellidae) of the Indian region. Several digital photographs of common species of coccinellids were generated during this period.

Trichogramma spp. Collected from the eggs of an unidentified lepidopteran and chrysopid appears to be a new species. Two populations of *Trichogrammatoidea* collected from an unidentified lepidopteran looking similar to *Trichogrammatoidea robusta* failed to interbreed indicating that the two populations are closed related species. *Uscona femoralis* has been successfully cultured on the eggs of *Callasobruchus maculates* in the laboratory and maximum adult emergence was obtained when maintained at 25° C.

Introduction of natural enemies

For the biological suppression of *Leptocybe invasa*, an invasive species of gall wasp of eucalyptus, two parasitoids namely *Quadrastichus mendeli* and *Selitrichodes kryceri* were imported from Israel. *Spalgis epius*, a lepidopteran predator is actively feeding and checking the spread of the papaya mealy bug, *Paracoccus marginatus* which has become very serious on papaya, teak, cotton, okra, mulberry and hibiscus in Tamilnadu.

Rearing and evaluation of natural enemies

In a net house evaluation, the anthocorid *Blaptostethes pallescens* @ 20 nymphs per plant at weekly interval against chilli mite

Polyphagotarsonemus latus resulted in the reduction of per cent curled leaves from 81.8 to 6%. Release of *B. pallescens* @ 20/plant at weekly interval, four times on potted bean plants in net house, resulted in about 40% reduction of adults. Release of *B. pallescens* adults at a ratio of 1:5 against cotton mealybugs provided maximum mortality (93.3%).

In a laboratory experiment, females of *Orius tantillus* laid significantly highest (45%) number of eggs when beans, pollen and host (*Sitotroga*) eggs were provided. In a second trial *O. tantillus* females laid the highest percentage of eggs (47.7%) on bean pieces with stalk.

Field observations on sugarcane woolly aphid predators revealed that *Micromus timidus* has completely replaced *M. igorotus* in and around Bangalore but *M. igorotus* is still a dominant species in Pune and Coimbatore. *M. igorotus* larvae fed on significantly higher number of woolly aphids as compared to *M. timidus*. A new oviposition cage has been developed to maximize the harvest of eggs of *M. timidus*.

A rearing method for *Brumoides suturalis* on *Sitotroga cerealella* eggs was developed. The beetle produced significantly higher number of eggs (204.62 eggs per female) on *S. cerealella* eggs than on mealybugs (160.09 eggs per female).

The results on host preference by trichogramma egg parasitoids indicated that eggs of *C. cephalonica* was the most preferred (mean 89.7% parasitism), followed by *Chilo partellus* (mean 60.5% parasitism) and eri silk worm eggs were least preferred. Irrespective of host egg from which parasitoids were collected, trichogrammatids prefer to parasitise *C. cephalonica* eggs.

Molecular characterisation of entomophagous insects

The size of the ITS-2 rDNA PCR products varied from 550 – 600bp in the eight *Trichogramma* species used in the study. Based on this size variation, three groups could be distinguished: Group I included *T. cacoeciae* with base pair of 600bp; Group II included *T. semblidis* and *T. embryophagum* (Germany) with base pair of 575bp and Group III included *T. corbudensis*, *T. evanescens*, *T. embryophagum*, *T. pretiosum*, *T. pretiosum* (USA) with base pair of 550bp.

The size of the wsp and FtsZ PCR (Wolbachia-specific) products varied from 550– 600bp and 700-750bp, respectively in the six *Trichogramma* species used in the study. It was confirmed that *T. cacoeciae* and *T. embryophagum* (Germany) did not contain wolbachia.

Curing of wolbachia symbiont with antibiotic rifampsin and tetracycline revealed that in five infected species, the percent females were reduced to 23.3 - 70.0% from 100 per cent.

Bio-diversity of natural enemies

Populations of *Cryptolaemus montrouzieri* collected from Delhi, Coimbatore, Shimoga and Pune varied in their susceptibility to chemical pesticides and temperature.

Goniozus nephantidis population collected from Tamilnadu (Erode district) was superior in terms of pupation (80.2%) and adult emergence (92.4%) compared to Andhra Pradesh (West Godavari district) (74.2 and 86.4%, respectively).

Partial sequences of ITS-2 region in Karnataka, Kerala and Andhra Pradesh *G. nephantidis* populations revealed two GC repeats between 127 & 132 bp and between 462 & 467 bp.

The *Cotesia flavipes* population from Hoshiarpur had the highest number of cocoons formed (63.2) and number of adults emerged (37.4) followed by the population from Dindigul (Tamilnadu) and Devaganahalli (Karnataka). Aurangabad population was female-biased compared to others.

Estimation of genetic variability, diversity and geographic lineage between different populations of *C. flavipes* was assessed by RAPD assay. Aurangabad and Devaganahalli populations were grouped proximate with a high similarity coefficient of 66 per cent while the population from Delhi and Dindigul had 63% and 52% homology respectively. Bangalore, Bagalkot and Hyderabad populations

were grouped distinct from the others with a low similarity coefficient of 24, 26 and 36% homology respectively.

Fungal antagonists

The shelf life of talc-based *Trichoderma harzianum* conidia derived from Solid State Fermentation (SSF) was 14 months with recovery of CFUs above x 10^6 in normal packing while in vacuum packing it was 12 months.

A method of drying for extending the shelf life of conidia based formulations of *T. harzianum* derived from SSF up to 15 months has been developed. A method of prolonging the shelf life of liquid fermentation-derived talc-based formulations of *T. harzianum* has been developed.

In a pot culture evaluation of bacterial antagonists against *Alternaria solani* infection in tomato, *Bacillus* sp. B-23 isolate showed 26.2% reduction of blight disease.

In a field evaluation of *Trichoderma* isolates against *A. solani* infection in tomato, the lowest post treatment index of 18.4 was observed with *T. harzianum* (TH-7 isolate) which when compared with the PDI of control plants showed 62.6% reduction.

Isolation, characterization and toxicity of indigenous *Bacillus thuringiensis* strains

Eight indigenous isolates of Bt were probed with Cry1and Cry4 universal primers. None of them was specific to Cry1 gene. However with Cry4 primer, it was observed that isolate 1 and 2 showed PCR products of 230bp and the third isolate showed PCR products of 300bp. These 3 isolates could be related to cry 4 genes.

PCR analysis of PDBC strains resulted in products of the cry IIIA genes ranging from 652 to 769 bp. A strain that produced an unexpected 350 bp product which might harbour a unique cry IIIA gene has also been identified.

Field evaluation of Bt isolates against redgram pod borer revealed that 1.5% spray of PDBC-BT1 reduced the damage to pods significantly and increased the number of healthy pods.

Endophytic bacteria

Four species of endophytic bacteria were isolated from healthy pigeonpea plants. Three were Gram positive and one was Gram negative. Two of the isolates showed 40 to 48% inhibition of *Sclerotium rolfsii* under *in vitro* conditions on Tryptic Soya Agar.

Thirty bacterial isolates were tested for seedling growth promotion in Petri plates using Chickpea seeds. Highest root length of 15cm was observed with the isolate GR-3 ARU-B and the highest shoot length of 10.5cm was observed with the isolate GR-4 RAU-A. Good growth promotion was also exhibited by CK-23, CK-4, H-8, CK-10, GR-4 RAU-A, ND-1and GR-3 ARU-B.

Studies on shelf life of *Pseudomonas fluorescens* (PDBC-AB2) in powder-based talc formulations amended with nutrients revealed that addition of 2% peptone or 2% tryptone supplemented with 2% glycerol enhanced the shelf life of *P. fluorescens* to 180 days with highest population of log 7.48 cfu/gm.

Pathogens of phytophagous mites

Long term storage studies revealed that the pellets of *Hirsutella thompsonii* could be stored in sterile water under refrigerated condition for more than three years. Three sprays of *H. thompsonii* (mycelia) with adjuvant (Glycerol 0.5%) at 15 days interval resulted in lowest nut grading index of 1.97 ± 0.13 (1-10% damage)

Biocontrol of plant parasitic nematodes

It was observed that laterite, alluvial, loamy sand and peat soils except black cotton soil were suitable for root growth, nematode infection and effective parasitisation of the egg masses by *Paecilomyces lilacinus* and *Pochonia chlamydosporia*.

In pot culture studies it was revealed that brinjal (purple long) having higher root volume and root hair recorded higher root-knot nematode infection, egg

masses and fungal parasitisation of the egg masses as compared to tomato and cotton 45 days after the treatment.

Paecilomyces lilacinus and *P. chlamydosporia* obtained from solid state fermentation and formulated with talc exhibited better shelf life (spore viability) and bioefficacy (infectivity to egg masses) against root-knot nematodes compared to that produced in broth. Chlamydospore production by *P. chlamydosporia* was highest in solid state production than in liquid production.

A combination of 50% moisture content (mc) and a_w at saturation was ideal for conidiospore production in *P. lilacinus* on bran, while a MC of 20-23% and saturated a_w was ideal on rice grain. Identification of an ideal combination of MC and a_w were more critical than an optimum level of MC or a_w for conidiospore production.

Integrated use of talc formulations of antagonistic fungi (*P. chlamydosporia* and *P. lilacinus*) with crop-soil sterilization (formaldehyde) in capsicum and tomato in polyhouses at Denkinkotai, Hosur reduced the incidence of nematode-root wilt disease complex by 64% in treated beds compared to untreated beds.

A field experiment in nursery beds at CTRI, Hunsur, revealed that treatment with *P. lilacinus, G. fasciculatum* and neem cake or *P. lilacinus, Glomus fasciculatum* and vermicompost yielded healthier seedlings with significantly lower gall index (root infection).

EPN against white grubs

Screening of 4 isolates of entomopathogenic nematodes viz., *Heterorhabditis bacteriophora, H. indica* 13.3, *H. indica* Ashoka, *Steinernema carpocapsae* Sc11 and *S. glaseri* in manure as medium for efficacy against second and third instar *G. versicolor* grubs indicated that all the four nematodes caused mortality of grubs in 60-72 hrs up to a depth of 3 inches. A new isolate of *Steinernema* was obtained from diseased grub collected from Devanahalli.

At constant dose of 1000 IJs/100cc column, aqueous formulations of *S. carpocapsae, S. riobrave, H. indica* 13.31 and *H. indica* 6.71 caused mortality of scarabid and rhinoceros grubs in 72 and 96 hrs of application at a depth of 15 cm.

Evaluation of different organic amendments on bio-efficacy of EPN against white grubs *S. carpocapsae, S. riobrave, H. indica* 13.31 and *H. Indica* 6.71 in aqueous suspensions @ 1000 Ijs/100cc column) applied to farm compost, urban, compost, vermicompost, vermiculite and coir pith in column assay caused mortality of scarabaeid and *Oryctes* grubs in 72 to 120 hrs of application at a depth of 15 cm while in coir pith grub mortality was observed between 96 to 120 hrs.

AICRP on Biological Control of Crop Pests and Weeds

Effect of temperature, pH and moisture on *Trichoderma* and *Pseudomonas*

Out of ten isolates of *Trichoderma harzianum* studied, isolate Th-10, Th-4, Th-12, and Th-31 grew faster, however isolate Th-43 and Th-28 could grow even at 10°C. Out of ten isolates of *Pseudomonas fluorescens*, isolates Pf-31, Pf-28 andPf-27 had excellent growth at 30°C as compared to other isolates. All the isolates of *Trichoderma* and *Pseudomonas* could grow faster at pH 7. Isolate Th-38 was found to be the best in growth and sporulation and gave highest colony count of 20 x 10^4 CFU/g in air dried FYM with 30% moisture. Similar results were obtained with ten isolates of *Pseudomonas*.

Biological control of plant diseases

A large scale field demonstration on Lentil variety PL-5, seed treatment with mixed formulation of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28 (10 g/kg) along with the vermicompost pre-colonized with the same bioagent (1 kg of the formulated bioagent per 100 kg of vermicompost) was the most effective in controlling root rot and wilt and increasing the yield. In a similar large scale field demonstration, the seed treatment (10g/kg), two sprays (10g/l) and application of enriched FYM resulted in higher seedlings/m^2 (32), lower intensity of root rot and wilt (25%) and higher green pod yield (87.5 kg/ha) in green pea (GBPUA & T).

Thirteen members of the Tarai Organic Farmers Association adopted the BIPM package (FYM colonized with mixed formulation of *Trichoderma harzianum* + *Pseudomonas fluorescens* (@ 5 to 10 tons/ha) or use of vermicompost colonized with *Pseudomonas fluorescens* (@ 5 to 10 q/ha), Seed treatment/ biopriming with mixed formulation of TH + PsF (@ 10g/kg seed), Need-based spray of TH+PsF (@ 10 g/l) in patches infected with sheath blight) for successfully controlling bacterial leaf blight and brown plant hopper in organic rice in 600 acres (GBPUA & T).

Significantly highest seed germination and yield was recorded in BIPM package (solarization of nursery soil; seed treatment with mixed formulation of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28 @ 10g/kg seed; Seedling root dip in mixed formulation of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28 @ 10g/l; Use of vermicompost colonized with *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28; 2-3 sprays of mixed formulation of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28 @ 10g/l; 1-2 sprays of soluneem) in cabbage, capsicum, brinjal and pea under low input system in Uttarkhand hills (GBPUA & T).

Significantly least (5.40%) incidence of chickpea wilt and blight diseases was noticed in the treatment of seeds treated with *T. harzianum* + application of FYM enriched with *Trichoderma* over other treatments tried. The former treatment also produced significantly highest (1246.5 kg/ha) grain yield than the remaining treatments (AAU-Anand).

Pathogens for the management of fruit rot

In mango Dusheri, the lowest per cent fruit surface rotten 2 and 4 days after treatment was in isolate I-4 (0.0 and 3.3%), and Bt 4D4 (0.2 and 5.4%) which was significantly lower than the control. In mango Chausa, the lowest per cent fruit surface rotten 2 days after treatment was in isolate I-2 (0.2%) and Bt 4D4 (1.7 %). Isolate I-4 also resulted in lowest per cent fruit infection in mango Dusheri (0.0%) and Mango Chausa (4.2%) 2 days after treatment. The next best isolate was Bt 4D4 recording 4.2% fruit infection in mango Dusheri, whereas isolate I-2 recorded 16.6% fruit infection in mango Chausa (PAU).

In Papaya, *Pseudomonas* strain 27 performed excellent recording only 1% fruit area infected 2 days after treatment and the progressive fruit area infected 10 days after the treatment was only 12.2%. The next best treatment was *Pseudomonas* strain 3 recording 1.1 per cent fruit area infection 2 days after treatment in papaya (AAU-Anand).

Biological control of plant parasitic nematodes

Field experiment conducted to evaluate the antagonistic fungi against the reniform nematode *Rotylenchulus reniformis* in redgram (var. BDN2) at Anand revealed that significantly higher yield (1250 kg/ha) was recorded in plots treated with combination of *T. harzianum* and *P. chlamydosporia*. Plots treated with either *T. harzianum* or *P. chlamydosporia* alone performed equally in terms of grain yield (AAU-Anand).

Results of the experiment conducted to evaluate the antagonistic fungi against the reniform nematode in redgram (var. Vipula) in *Kharif* 2008 at Rahuri revealed that combined application of *T. harzianum* @ 5 kg/ha and *P. chlamydosporia* @ 20 kg/ha was the most effective in reducing the reniform nematode female population (15.6) and increased the yield of redgram 1750 kg/ha).

Field evaluation of *P. lilacinus* and *P. chlamydosporia* @ 20kg/ha each against the root knot nematode, *Meloidogyne incognita* in tomato (Cv. Pusa Ruby) revealed a significant difference in the plants treated with *P. lilacinus* which exhibited good impact on egg mass parasitisation compared to *P. chlamydosporia* after 45 DAP of crop, but at harvest both the treatments were found to be at par in their efficacy (AAU-Anand).

On six year old sweet orange plants, *P. lilacinus* @ 20kg/ha talc formulation containing 10^8 spores/g was found to be effective in reducing the citrus nematode population (41.3%) and number of females in roots (34.6%) and increased yield of sweet orange by 19.56% (MPKV-Rahuri).

In a pomegranate (var. Sinduri) orchard, nematode population extracted after 6 months from the samples of 200 cm^3 soil and 5g roots revealed least number of nematodes (14) in plants treated with *P. lilacinus* + mustard cake. Least Root Knot Index (RKI) was also recorded in *P. lilacinus* + mustard cake (1.0) followed by *P. chlamydosporia* along with mustard cake (1.1) (AAU-Anand).

Biological suppression of crop pests

Sugarcane

A field demonstration on the effectiveness of *T. chilonis* against the plassy borer was carried out in a farmer's field on Co BLN 9605 variety at Halowagaon in Golaghat district over an area of 10 ha. Nine releases of *T. chilonis* @ 50,000/ha/release at 10 days interval from July second week to October first week, 2008 resulted in significant reduction of infested cane and higher cane yield (84,450 kg/ha) (AAU-Jorhat).

The incidence of early shoot borer was significantly reduced by 8 releases of *T. chilonis* @ 50,000/ha at 10 days interval at village Gohawar and Chachrari in Punjab in 100 ha area. The mean parasitism of eggs of *C. infuscatellus* in *T. chilonis* release plot was 51.2%. The yield was enhanced significantly (PAU).

The incidence of top borer was significantly reduced by 8 releases of temperature-tolerant strain of *T. japonicum* @ 50,000/ha at 10 days interval in Rawalpindi village in Punjab. The mean parasitism of eggs of *S. excerptalis* in *T. japonicum* release plot was 23.6%. The yield was enhanced significantly (PAU).

Twelve releases of *T. chilonis* @ 50,000/ha at 10 days interval in 40 ha area at village Paddi Khalsa in Punjab reduced the stalk borer incidence to 5.6 per cent. The per cent parasitisation in release fields was high (55.6%) as compared to control (4.9 %) (PAU).

The incidence of internode borer was significantly reduced by eight releases of *T. chilonis* @ 1,00,000/ ha at 10 days interval during September to November on variety Co 86032 in 8 ha area. Significantly higher yield (1,15,200 kg/ha) was recorded in parasitoid release plots compared to control (TNAU).

Field demonstration of *T. chilonis* (TTS and SAS strains) against internode borer (INB) on sugarcane revealed that six releases @ 1 lakh/ha/release found effective in reducing the pest incidence and intensity in sugarcane (MPKV).

Field evaluation of *T. chilonis* @ 2.5 lakh/ha against internode borer revealed that the incidence of INB was 52.4% in release plot compared to 74.8% in control. The yield in released plot was significantly higher at 153400 kg/ha than control and there was 29.95% reduction in the INB incidence and 13.29% increase in yields in parasitoid-released plots compared to control plots (SBI).

In two field trials conducted in farmers fields to assess the efficacy of *T. chilonis*, continuous release of *T. chilonis* resulted in lowest intensity of damage by the INB (2.1%), dead hearts (8.9%) and highest yield (2,02,060 kg/ha) as compared to six releases and control (SBI).

Trichogramma chilonis release (@ 50,000 /ha from July to October at 10 days interval) plots recorded lowest internode borer incidence (5.6%) compared to *Cotesia flavipes* (@ 500 gravid females/ha from July to November at 7 days interval) or *Tetrastichus howardi* (5000 adults/ha at monthly interval from July to November). But *C. flavipes* release plots recorded lowest incidence of stalk borer (5.6%) followed by *T. howardi* and *T. chilonis*. Highest yield of 60,710 kg/ ha was recorded in *T. chilonis* release plots (IISR).

The field survey in Tamilnadu, Maharashtra and Assam revealed very negligible incidence of sugarcane woolly aphid during 2008. The pest had been successfully controlled by the biocontrol agents.

Bt cotton

In Andhra Pradesh, field experiments revealed that the mean square and boll damage was significantly less and the yield was higher in *Bt* cotton with BIPM practices as compared to farmers practice and local check. The cost:benefit ratio was 1:1.81 in BIPM

package compared to 1:1.03 in farmers' practice. Higher egg parasitism and higher coccinellids and spiders were recorded in BIPM package compared to farmers practice (ANGRAU).

In Gujarat, results of a field experiment revealed that incidence of aphids, leafhopper and whiteflies was relatively lower in BIPM package compared to farmers' practice. BIPM package recorded lower percentage of damage to buds, green bolls and locule by *Earias* and pink bollworm whereas these figures in farmers' practice were significantly higher. The number of *C. carnea*, coccinellids, *Geocoris* bugs and spiders per 25 plants in BIPM package were 17.3, 54.8, 12.0 and 16.0 whereas the corresponding figures in farmers' practice were 11.0, 37.8, 4.0 and 9.3. There was 32.17% increase in seed cotton yield in BIPM package over farmers' practice (AAU-Anand).

Field demonstration of BIPM package on Bt cotton in Punjab revealed that the number of predators on the cotton plants in BIPM package was higher than those in farmers' practice, however the number of leaf hoppers were higher in farmers practice. There was no significant difference in seed cotton yield in BIPM package and farmers' practice (PAU).

In Tamilnadu, BIPM package on *Bt* cotton recorded significantly low population of leafhoppers, aphids, thrips and whiteflies and the bollworms *Earias* and *H. armigera*. A higher seed cotton yield of 2169 kg/ha was recorded in *Bt*. BIPM field with a cost benefit ratio of 1 :1.9 whereas a significantly lower seed cotton yield (1894 kg/ha) was recorded in *Bt.* farmers practice field (TNAU).

A large scale field demonstration in Maharashtra revealed that the population of aphids, leaf hopper, mealy bug and thrips was higher in BIPM package than farmers practice, but the bollworm damage was lower and the seed cotton yield was significantly higher (2420 kg/ha). The infestation of *H. armigera* and *P. gossypiella* was very low (MPKV).

At Raichur, field demonstration indicated that sucking pest population was more or less similar in both BIPM and farmers practice plot. Highest net profit (Rs 59925/ha) was realized in BIPM plot compared to farmers practice plot (UAS-Raichur)

Multi-location trials in Maharashtra revealed that 3-4 releases of *Trichogrammatoidea bactrae* against the pink bollworm in BIPM package significantly reduced the boll damage over farmers practice. Significantly higher seed cotton yield (1689 kg/ha) was realized in BIPM package compared to farmers practice (1432 kg/ha) and control (987 kg/ha) (MPKV).

In Gujarat, release of *Tr. bactrae* resulted in lower boll and locule damage as compared to farmers' practice and untreated control. Significantly higher seed cotton yield (2022 kg/ha) was realized in BIPM package compared to farmers practice (1789 kg/ha) and control (1508 kg/ha).

In Maharashtra, Punjab and Gujarat, habitat manipulation by growing cowpea and marigold along with cotton in rainfed areas resulted in significantly higher yield as compared to farmers practice. Habitat management plot also recorded higher population of *C. carnea*, coccinellids and spiders. Natural parasitism by *T. chilonis* was also higher in habitat management as compared to in BIPM and farmers' practice.

Release of *C. montrouzieri* @ 1500 beetles /ha at 15 days interval beetles brought down the mealy bug population from 153.4 to 80.4 per 5 cm twig of cotton plants which was on par with farmers practice of chemical application.

Tobacco

Application of SlNPV suspension with pH 7 recorded the lowest seedling damage by *S. litura*, 7 days after application indicating greater NPV action. SlNPV with pH 5 and 9 recorded relatively more seedling damage indicating lesser NPV activity. Application of SlNPV @ 1.5 x 10^{12} PIB/ha was found very effective for the management of *Spodoptera* in nurseries.

SlNPV strains collected from Rajhamundry and Jeelugumilli were highly virulent recording lowest number of larvae/ plant as well as leaf damage, 7 days after the spray. The highest green leaf yield (15272 kg/ha) was realized in Rajahmundry strain of SlNPV followed by Jeelugumilli. PDBC strain of *Bt*

at 1:10 dilution was very effective against stem borer of tobacco, *Scrobipalpa heliopa*.

Pulses

In Tamilnadu, field trials on pigeonpea indicated lower incidence of pod borers, pod damage by *H. armigera* and *M. testulalis*, higher pod yield and higher CB ratio in BIPM package than the farmers practice. Similar results were obtained in another field trial conducted at Ammapettai village (Dt. Erode) and the cost benefit ratio in BIPM module was 1:1.79 and in farmers practice 1:1.30 (TNAU). Field demonstrations of BIPM package on pigeonpea in Andhra Pradesh revealed lower incidence of pod borers and higher yield in BIPM module than farmers' practice (ANGRAU).

In Gujarat, in a field trial on pigeonpea variety BDN-2, there was no significant difference in plant stand and number of *H. armigera* larvae between BIPM and farmers practice, However, signficantly lowest pod damage by *H. armigera* and higher grain yield were recorded in BIPM practice (AAU-Anand).

Field application of HaNPV @ 1.5 x 10^{12} POB/ha + 0.5% crude sugar + 0.1% teepol had significantly reduced the number of larvae per 5 twigs and also pod damage by *H. armigera* on pigeonpea in Gujarat. (AAU-Anand).

Application of HaNPV at 0.375 x 10^{12} POB/ha significantly reduced the population of *H. armigera* and realised higher yield of *Dolichos lablab* in Andhra Pradesh (ANGRAU).

Rice

Validation of biointensive pest management practice (seed treatment with *P. fluorescens* @ 8 g/kg of seeds/ seedling dip in 2% suspension of *P. fluorescens*, *B. bassiana* 10^{13} spores/ha against sucking pests; bird perches at 10/ha; *T. japonicum* @ 1 lakh/ha on occurrence of leaf folder or stem borer; *Bt* at 2 kg/ha, 2-4 sprays depending on pest occurrence; *P. fluorescens* spray against foliar diseases and need-based or spot application of botanicals) in 10 ha rice variety Jyothi in Kerala revealed that BIPM package registered significantly low incidence of dead heart, white earhead and leaf folder damage compared to farmers practice. The population of spiders and coccinellids as well as grain yield and net returns were significantly higher in BIPM plots as compared to farmers practice. In Kerala multi-location demonstrations on biointensive pest management (BIPM) practices (use of disease resistant variety; seed treatment with *P. fluorescens* @ 8g/kg seed ; FYM @ 5 t/ha; *B. bassiana* @ 10^{13} spores/ha against sucking pests; bird perches at 10/ha; release of *T. japonicum* @ 1 lakh/ha on occurrence of pests; spray of *P. fluorescens* against foliar diseases.) in organic rice revealed that the population of coccinellids and spiders were relatively higher in organic farming as compared to conventional practice. There was no significant difference in dead hearts incidence during *kharif*, however dead hearts were lower in organic package during *rabi* (KAU).

In Assam, the BIPM field demonstration on 10 ha plot of Mahsuri variety in the farmers' field revealed that the populations of GLH, damage by stem borer and leaf folder were much lower in the BIPM package compared to the farmers' practice. Higher grain yield was obtained in the BIPM package than the farmers practice and BIPM package realized net return of Rs. 8,550 over farmers' practice. Validation of BIPM practice on 10 ha organic rice resulted in lesser incidence of GLH, leaf folder damage and dead heart incidence in Assam. Even though the grain yield was highest in conventional method, the net return Rs. 4506 was higher in BIPM (AAU-Jorhat).

Validation of BIPM practice on rice in farmers field in Punjab revealed that there was no significant difference in leaf folder damage and dead hearts in BIPM plots and farmers practice. The BIPM package was as effective as farmer's practice of application of chemical pesticides. In Punjab two field demonstrations on the use of BIPM package on organic rice revealed no significant difference in yield, however higher net returns of Rs. 1,12,798/ ha was realized in BIPM package compared farmers practice (Rs. 98,188/ha) (PAU).

Maize

In a field trial application of *Heterorhabditis indica* @ 2 billion IJ/ha could result in significantly lowest larvae of *Agrotis ipsilon* per 10 plants and lowest per cent plant damage and highest grain yield (SKUAS&T – Jammu).

Castor

Validation of BIPM package (release of *Tetenomus remus* @ 1,00,000/ha, release of *T. achaeae* @ 1,00,000/ha, spray of SINPV@ 1.5 x 10^{12} POB/ha + 0.5% crude sugar, spray of Dipel @ 0.5 l/ha for *Achaeae janata* and *Dichocrocis punctiferalis*) revealed lower incidence of *S. litura*, *A. janata* and *D. punctiferalis* in BIPM package. Lesser insect damage and higher yield was recorded in BIPM package than farmers practice (ANGRAU).

Groundnut

In a field trial in Tamilnadu, 3-4 releases of *T. chilonis* @ 1,00,000/ha at 10 days interval, Bt @ 1 kg/ha at 60 and 75 DAS and NSKE 5 % spray were as effective as endosulfan and Bt spray in controlling the leaf-miner larval population and damage and increasing the yield (TNAU).

Coconut

Four releases of *Goniozus nephantidis* adults @ 10/palm or sequential release of *Cardiastethus exiguous*, 50 /palm or sequential release of *Trichogramma embryophagum* @ 1000/palm could control the larvae of *Opisina arenosella* in Kerala (KAU).

In a field demonstration, use of baculovirus, *M. anisopliae* and pheromone trap for the management of *Oryctes* resulted in reduction of leaf and spindle damage and cent mortality of *O. rhinoceros* grubs in cow dung pits treated with *M. anisopliae* (KAU & CPCRI).

Laboratory evaluation of EPN revealed that the local isolate of *H. indicus* was found to be more virulent than *H. bacteriophora*. It was observed that a dose of 400 IJ of *H. bacteriophora* and *H. indicus* produced 63% mortality of red palm weevil grubs in 96 hours (CPCRI).

Tropical fruits

Off-season spraying of *Metarhizium anisopliae* @ 1 x 10^7 spores/ml on the trunk during the month of November and one spray during flowering period reduced the hopper incidence on mango (IIHR). In Tamilnadu, application of *Verticillium lecanii* @ 1 x 10^9 spores/ml on tree trunk during off-season and one spray on shoots reduced hopper numbers significantly (TNAU).

Release of *T. chilonis* six times at weekly interval starting from June through improved method proved effective in suppression of the fruit borer *Deudorix isocrates* (SKUAS & T- Jammu).

A total of 14 fungicides approved for use in grape vine pest management were found safe to *Cryptolaemous montrouzieri* (NRC Grapes, Pune).

The papaya mealy bug *Paracoccus marginatus* was very serious on papaya, bhendi, cotton, teak, nerium, wild mulberry, sunflower, redgram, sweet potato, jatropa, guava, tomato, ber, coccinea, chillies, brinjal and tapioca in Tamil nadu. The different natural enemies recorded on papaya mealy bug were the predators *C. montrouzieri*, *Spalgis epius*, *Scymnus coccivora*, *Brumoides suturalis* and the parasitoid *Cladiscodes sacchari* (TNAU).

Temperate fruits

Good control of apple stem borer (*Aeolesthes sarta*) was achieved by the application of *M. anisopliae* @ 10^{13} spores/ml and *B. bassiana* @ 1x10^8 spores/ml (SKUAS & T).

In a field trial it was found that *B. bassiana* or *M. anisopliae* or *V. lecanii* @ 1x10^7 conidia/ml failed to control the apple woolly aphid at Solan (YUPUH & F).

Two releases of *T. embryophagum* (3rd week of May and last week of July) @ 4000 adults/tree could effectively reduce fruit damage in apple by the codling moth (SKUAST-Srinagar).

Vegetables crops

Six releases *Trichogramma brassicae* @ 1 lakh/ha resulted in reduction of diamond back moth incidence and increased the cabbage yield in Assam (AAU-Jorhat).

Three releases of *T. brassicae* @ 1 lakh/ha at weekly interval resulted in less larvae of diamond back moth per plant and increased the yield of cauliflower with cost benefit ratio of 1: 2.2 in Tamilnadu (TNAU).

Weekly releases of *T. brassicae* @ 1 lakh/ha six times resulted in significant protection of cauliflower from damage by *Plutella xyllostella* recording significantly higher yield and net return. It was better than the prevailing farmers' practices of 2-3 application of conventional insecticides (SKUAS & T- Jammu).

Six releases of *T. chilonis* resulted in lower *Pieris brassicae* larval density of 1.9 per plant and higher egg parasitisation of 10.4% (SKUAS & T-Jammu).

In a field experiment application of *B. bassiana* @ $1x10^8$ spores/ml resulted in 60.0 % larval mortality of *P. brassicae* and was on par with *M. anisopliae* (56.3%), and mineral oil (63.3%). (SKUAS & T).

A biocontrol package consisting of sprays of *T. brassicae* @1 lakh /ha/release (6 releases), sprays of *B. bassiana* @ 1 x 10^9 spores/ml, *S. carpocapsae* @ 1 billion Ij/ha, Neem soap 4% , Dipel @ 1 ml/l and *M. anisopliae* @ 1 x 10^9 spores/ml was as effective as spinosad @ 0.7ml/l against *P. xylostella* (IIHR).

In Punjab, validation of different biocontrol methods against the brinjal shoot and fruit borer, revealed that minimum fruit damage 20.3 % was recorded in Bt. @ 2.0 kg/ha which was on par with EPN @ 2 billion/ha and triazophos. Significantly higher yield was realized in Bt. @2.0 kg/ha which was on par with triazophos application (PAU).

In a field trial at Assam, application of EPN @ 2 billion/ha two times was most effective in reducing the brinjal shoot and fruit damage (17.8%) which was significantly superior to Bt and *T. chilonis*. Highest yield was recorded in EPN 2 billion/ha which was on par with endosulfan treatment (AAU-Jorhat).

Results of field experiment on okra (variety Punjab 8) on the management of fruit borer, *Earias* spp. revealed that significantly lowest fruit damage and highest yield was recorded in Bt. @ 2.0 kg/ha which was on par with application of decamethrin (PAU).

A field experiment on the effiacy of different biocontrol agents against *A. craccivora* revealed that lowest aphid count was recorded in *V. lecanii* (@10^{10} conidia/l) treated plant and it was on par with *F. pallidoroseum*, *B. bassiana*, *M. anisopliae* and quinalphos treatments. The highest yield was recorded in *F. pallidoroseum* treated plot followed by *B. bassiana* and *V. lecanii* (KAU).

Natural enemies of whiteflies

The survey revealed parasitisation of green house white fly by unidentified *Encarsia* sp., *Encarsia sophia* (= *E. transvena*) and *Eretmocerus delhiensis*. The unidentified *Encarsia* species was found only on cucumber plants, whereas *E. sophia* and *Eretmocerus* sp. were found parasitizing its host on bean, cucumber and tomato (YSPUH & F).

Biological control of white grubs in potato

Soil application of *M. anisopliae* @ 6g/m^2 against white grubs resulted in low potato tuber damage (23.2%) followed by *B. brongniartii* at same dosage (28.3%) which was better than control (53.1%)

Polyhouse crop pests

Five releases of *Blaptostethus pallescens* @20 per plant at weekly interval reduced *Tetranychus urticae* population significantly on carnation in polyhouse (MPKV).

Weed control

There was a reduction of 18.0% plant height, 5.8% number of branches, 12.9% number of panicles, 5.1% capitula and 6.3% seeds due to the formation of gall on chromolaena weed by *Cecidochares connexa* at Kerala (KAU).

Human resource development

Dr. R. J. Rabindra, Project Director attended a executive development programme in agricultural research management from 23.09.2008 to 27.09.2008 at NAARM, Hyderabad. Dr. Deepa Bhagat, Scientist (SS) attended a) nanotechnology based training and meetings/discussions from 03.04.2008 to 06.04.2008 at CIFE, Mumbai and b) Computer training programme on Rajbhasha from 18.08.2008 to 22.08.2008 at CPRI, Bangalore-560 003. Dr. K. Veenakumari & Dr. B. Ramanujam Principal Scientists attended training programme on "Mainstreaming Gender Concerns in Agriculture and allied Sectors from 05.08.2008 to 09.08.2008 at UAS, GKVK, Hebbal, Bangalore 560 024. Dr. B. Ramanujam, Dr. S. Sriram, Dr. K. Veenakumari attended ICAR-training-cum-workshop on IP and Technology Management from 30.10.2008 to 01.11.2008 at CTCRI, Trivandrum. Ms. R. Gandhi Gracy attended training programme on perspectives and current trends in bioinformatics from 09.02.2009 to 15.02.2009 at CCMB, Hyderabad & Application of GIS in plant biodiversity and horticulture from 5.02.2009 to 06.03.2009 at IISR, Calicut.

Dr. M. Nagesh, Dr. Prashanth Mohanraj, Dr. B. Ramanujam, Dr. G. Sivakumar and Dr. K. Veenakumari attended training programme on GPS/GIS/Open source software from 16.02.2009 to 22.02.2009 at AINP on Agriculture Ornithology, ANGRAU, Hyderabad. Dr. T. Venkatesan attended training programme on Management of intellectual property rights in biotechnology from 08.01.2009 to 09.01.2009 at Hotel Atria, Palace Road, Bangalore 560 001. Dr. R. Rangeshwaran attended training programme on MDP on PME of agricultural research and development projects from 09.03.2009 to 13.03.2009 at NAARM, Hyderabad.

B. Amarnath, Assistant Administrative Officer attended a training on a)"Records management for Right to Information from 28.07.2008 to 31.07.2008 at ISTM, New Delhi, b) National residential convention on reservation policy of Govt. of India for Liaison Officers for Sc/St/OBC from 08.09.2008 to 10.09.2008 at Hotel Parkview, Sector-24, Chandigarh, c)Technical and Administrative support for consortia based research in Agriculture from 17.11.2008 to 26.11.2008 at MANAGE, Hyderabad and d) Training on Knowledge management from 02.03.2009 to 03.03.2009 at ISTM, New Delhi.

Revenue generation

Revenue of Rs. 12.33 lakh was generated during 2008-09 by the project directorate, which included sale of natural enemies, sale of technical bulletins, training fee, consultancy charges, quality testing fee, project work for PG students, registration for biocontrol work group meeting and rental charges for hostel.

Publications

Sixty six research papers were published in scientific journals, six papers were presented during symposia/ seminars/ workshops, one book chapter and seven popular articles/ technical and extension bulletins were published.

4. INTRODUCTION

Brief History

The All India Co-ordinated Research Project on Biological Control of Crop Pests and Weeds was initiated in 1977 under the aegis of the Indian Council of Agricultural Research, New Delhi, with funds from the Department of Science and Technology, Government of India. Within two years (1979), the ICAR included the project under its research activities with full financial support. Recognition of the importance of biological control came during the VIII plan with the up-gradation of the centre to the present Project Directorate of Biological Control with headquarters at Bangalore. The Project Directorate started functioning on 19th October 1993. The AICRP started with 13 centres initially and has now 16 centres, all functioning under the Project Directorate.

Past achievements

Basic Research

- Ninety-one exotic natural enemies (NEs) have been studied for utilization against alien pests, out of which 59 could be successfully multiplied in the laboratory, 51 species have been recovered from the field, four are providing partial control, five substantial control and six are providing economic benefits worth millions of rupees. Twelve are augmented in the same way as indigenous natural enemies.
- The encyrtid parasitoid, *Leptomastix dactylopii*, introduced from West Indies in 1983, has successfully established on mealybugs infesting citrus and many other crops in South India.
- Two aphelinid parasitoids of South American origin were fortuitously introduced against *Aleurodicus dispersus*. *Encarsia guadeloupae*, introduced from Lakshadweep has colonized in peninsular India, displacing the earlier introduced *Encarsia* sp. nr. *meritoria*.
- *Trichogramma brassicae*, an egg parasitoid, introduced from Canada was successfully quarantined and found suitable for biological control of *Plutella xylostella* on cole crops.
- *Curinus coeruleus* (origin: South America), the coccinellid predator introduced from Thailand in 1988, colonized successfully on subabul psyllid, *Heteropsylla cubana*.
- *Cyrtobagous salviniae* (Origin: Argentina) was introduced in 1982 and colonized on water fern, *Salvinia molesta*, in 1983. Weevil releases have resulted in savings of Rs.68 lakhs / annum on labour alone in Kuttanad district, Kerala.
- The weevils, *Neochetina bruchi* and *N. eichhorniae*, and the hydrophilic mite, *Orthogalumma terebrantis* (Origin: Argentina), introduced in 1982 and colonized in 1983 on stands of water hyacinth, have established in 15 states. Savings on labour alone is Rs. 1120 per ha of weed mat.
- The chrysomelid beetle, *Zygogramma bicolorata* (Origin: Mexico), introduced and colonized in 1983 on stands of parthenium, has established in all the states and Union Territories suppressing parthenium growth during rainy season.
- The stem gallfly, *Cecidochares connexa*, was introduced from Indonesia in 2002 and successfully field released and established on *Chromolaena odorata* in Karnataka, Assam, Tamil Nadu and Kerala and is suppressing the growth of *C. odorataa* and is spreading from the release spot.

- *Puccinia spegazzinii*, the rust fungus specific to *Mikania micrantha* imported from CABI, UK in 2003 was successfully quarantined in NBPGR, New Delhi and open field releases were made in Kerala and Assam where the establishment is being monitored.
- Biosystematic studies were carried out on 275 predatory coccinellids. A website on Indian Coccinellidae featuring image galleries of common species and their natural enemies has been constructed and hosted.
- A computer-aided dichotomous key to 10 common Indian species of *Chilocorus* is hosted on the internet.
- *Aphids of Karnataka*. URL: www.aphidweb.com (compendium on the aphid fauna of Karnataka covering 67 species, covering diagnostic and other information such as host plants and natural enemies with photographs and other illustrations).
- Aphids of Karnataka - Web photo album on Picasaweb (the largest of its kind with 1160 digital photographs of aphids of Karnataka). URL: http://picasaweb.google.com/home
- Biological control of sugarcane pyrilla has been achieved within the country by the redistribution of *Epiricania melanoleuca*, a parasite of *Pyrilla perpusilla*.
- Breeding techniques for 46 host insects standardized including rearing on semi-synthetic diet and cost of production has been worked out.
- Improved laboratory techniques were developed for the multiplication of 26 egg parasitoids, seven egg-larval parasitoids, 39 larval/nymphal parasitoids, 25 predators and seven species of weed insects.
- A technique for shipping *Telenomus* cards in ventilated plastic boxes fixed with polystyrene strips (with slits) has been standardized.
- *Sitotroga cerealella* eggs proved to be the most suitable for rearing *Orius tantillus* and *Corcyra cephalonica* eggs for *Blaptostethus pallescens*.
- A beef liver-based semi-synthetic diet has been evolved for *Chrysoperla carnea* to facilitate its large-scale production and use.
- Toddy palm leaf powder-based artificial diet was developed for rearing *Opisina arenosella*
- The Coccinellid predators, *Cryptolaemus montrouzieri*, *Cheilomenes sexmaculata* and *Chilocorus nigrita* were successfully mass-produced on semi-synthetic diets.
- A new multi-cellular acrylic larval rearing unit devised for efficient and economic mass production of *Helicoverpa armigera* and *Spodoptera litura* for commercial production of host-specific parasitoids and NPV.
- The sugarcane woolly aphid, *Ceratovacuna lanigera* was successfully controlled by the release of predators, *Micromus igorotus* and *Dipha aphidivora*, and parasitoid, *Encarsia flavoscutellum* in Karnataka, Anndhra Pradesh, Maharashtra and Tamil Nadu.
- A novel technique of modified atmosphere packing of *Corcyra cephalonica* eggs followed by low temperature storage at 8±1°C has been developed to extend the shelf life.
- Tritrophic interaction studies between the egg parasitoid, *Trichogramma chilonis*, bollworm *H. armigera* and cotton, chickpea, pigeonpea, sunflower and tomato genotypes have helped in identifying biocontrol-friendly genotypes.
- Suitable low temperatures for short-term storage of trichogrammatids, *Eucelatoria bryani*, *Carcelia illota*, *Allorhogas pyralophagus*, *Copidosoma koehleri*, *Hyposoter didymator*, *Cotesia marginiventris*, *Leptomastix dactylopii*, *Sturmiopsis inferens*, and *Pareuchaetes pseudoinsulata* have been determined.
- An endosulfan-tolerant strain of *Trichogramma chilonis* (Endogram) developed for the first time in the world. Technology transferred to private sector for large-scale production.
- Strains of *T. chilonis* tolerant to multiple-insecticides and high temperature and a strain

having high host searching ability have been developed for use against lepidopterous pests.

- Pesticide tolerant strain of *T. chilonis* had higher amount of glutathion-s-transferase activity than the susceptible strain.
- Different pesticides have been screened against 37 natural enemies for identifying the relatively safe ones to be used in a biological control-based integrated approach.
- Kairomones from scale extracts of *H. armigera* and *C. cephalonica* increased the predatory potential of chrysopids.
- Acid hydrolyzed L-tryptophan increased the oviposition by *C. carnea* on cotton.
- Two fungal (*Trichoderma harzianum*-PDBCTH 10 and *T. viride*-PDBCTH 23), and two bacterial antagonists (*Pseudomonas fluorescens*-PDBCAB 2, 29 & 30 and *Pseudomonas putida*-PDBCAB 19) of plant pathogens have been released for commercial production after intensive studies.
- Bacterial antagonists, particularly *Pseudomonas cepacia* (starin N 24), suppressed successfully *Sclerotium rolfsii* in sunflower rhizosphere as seed inocula.
- New species and strains of entomopathogenic nematodes (EPN), namely, *Steinernema abbasi, S. tami, S. carpocapsae, S.bicornutum* and *Heterorhabditis indica* have been recorded.
- Suitable media for mass multiplication of EPN were identified. *S. carpocapsae* @ 1.25-5 billion/ha proved effective against the brinjal shoot and fruit borer, *Leucinodes orbonalis*. Talc-based and alginate-capsule formulations of *S. carpocapsae* and *H. indica* were effective against *S. litura* in tobacco. A sponge formulation was found suitable for transport retaining 90% viability of *Steinernema* spp. for 3-4 months and 85% viability of *Heterorhabditis* spp. for 2 months.
- An easy and rapid technique to screen antagonistic fungi against plant parasitic nematodes has been devised to identify efficient strains. The antagonistic fungus, *Paecilomyces lilacinus* was found effective against *Meloidogyne incognita* and *Rotylenchulus reniformis* in red laterite soils and *Pochonia chlamydosporia* was effective in sandy loam soil.
- Molecular identity of native isolates of *P. chlamydosporia* at PDBC was established through sequencing the β-tubulin gene (1 to 233 bases) and registered in the Genbank, NCBI, Maryland, USA.
- *Bacillus thuringiensis* isolate PDBC-BT1 caused 100% mortality of first instars of *Plutella xylostella*, *Chilo partellus* and *Sesamia inferens*. *B. thuringiensis* isolate PDBC-BNGBT 1 caused complete mortality of *Helicoverpa armigera*.
- 'PDBC-INFOBASE' giving information about bioagents, their use and availability in public and private sector in the country; and 'BIOCOT", giving information about biocontrol measures for cotton pests and a CD version of the software "Helico-info" were developed.
- The software on "Vegetable crop pests," has been developed in MS-Access. It gives the users information on important pests and their natural enemy complex, distribution and IPM options of vegetable crops like Brinjal, Beans, Cabbage, Cow pea, Tomato and Potato.

Applied Research

- Eight releases of *T. chilonis* (@ 50,000/ha at 10 days interval) during April-June and six releases of *T. japonicum* (@ 50,000/ha at 10 days interval) during May-June have proved effective in suppressing sugarcane tissue borers.
- *Beauveria bassiana, B. brongniarti* and *Metarhizium anisopliae* were mass cultured and utilized effectively against sugarcane white grubs.
- *Encarsia flavoscutellum, Micromus igorotus* and *Dipha aphidivora* effectively controlled the sugarcane woolly aphid.

- Application of *Heterorhabditis indica* @ 2.0 billion IJs/ha resulted in minimum population of white grubs in sugarcane.
- *Trichogramma chilonis* has proved effective against maize stem borer, *Chilo partellus.*
- Biocontrol-based IPM modules consisting of use of moderately resistant variety, *T. viride* as seed treatment, release of *T. japonicum* @ 50,000/ ha/week (6 releases), spray of *Pseudomonas fluorescens,* need-based insecticidal application and use of bird perches (10/ha) controlled the rice stem borer and increased the grain and net profit.
- IPM module comprising of need-based use of oxydemeton methyl (0.03%), releases of *C. carnea, T. chilonis* and spray of *Ha*NPV controlled the sucking pests and boll worms and increased the yields of seed cotton and conserved natural enemies.
- BIPM package recorded significantly lower bud and boll damage, lower population of sucking pests and higher seed yield than the package with chemical agents in Bt cotton.
- *Bt* and *Ha*NPV were important components of BIPM of pod borers in pigeonpea and chickpea resulting in increased grain yield.
- Release of *Telenomus remus* @ 100,000/ha and three sprays of *Sl*NPV @ 1.5 x 10^{12} POBs/ha along with 0.5% crude sugar as adjuvant against *S. litura* in soybean resulted in 17% higher yield than in chemical control.
- Integration of *T. remus* and NSKE for the management of *S. litura* and *C. carnea* and *Nomuraea rileyi* (@ 10^{13} spores/ha) for the management of *Helicoverpa armigera* on tobacco were effective. The cost-benefit ratio for BIPM was better (1:2.74) than that for chemical control (1:1.52).
- *Ischiodon scutellaris* @ 1000 adults/ha or 50,000 larvae/ha reduced *Lipaphis erysimi* population on mustard and gave higher yield.
- Inundative releases of parasitoids *Goniozus nephantidis* and *Brachymeria nosatoi,* against *Opisina arenosella* on coconut, coinciding the first release with the appearance of the pest, have proved effective.
- Adult release of *G. nephantidis* on trunk was as good as release on crown for the control of *O. arenosella* on coconut
- *Oryctes* baculovirus has been highly successful in reducing *Oryctes rhinoceros* populations in Kerala, Lakshadweep and Andaman Islands.
- *Cryptolaemus montrouzieri* has effectively suppressed *Planococcus citri* on citrus and grapes, *Pulvinaria psidii, Ferrisia virgata* on guava, *Maconellicoccus hirsutus* on grapes and *Rastrococcus iceryoides* on mango.
- Efficacy of *Trichogramma, Cryptolaemus, C. carnea, Ha*NPV and *Sl*NPV has been successfully demonstrated in Punjab, Andhra Pradesh, Karnataka, Maharashtra, Gujarat and Tamil Nadu.
- *Aphelinus mali* and several coccinellid predators were found effective against the apple woolly aphid.
- San Jose scale parasitoids, *Encarsia perniciosi* and *Aphytis* sp., were well established in Jammu & Kashmir and Himachal Pradesh.
- *Trichogramma brassicae* and *Bt* were found effective against *Plutella xylostella.*
- Tomato fruit borer, *H. armigera* was effectively controlled by releases of *T. pretiosum* and *Ha*NPV.
- *Copidosoma koehleri* and *Bt* were found effective against potato tuber moth in country stores.

Mandate

Project Directorate of Biological Control, Bangalore

Harness the natural resources to develop and promote biological control strategies for sustainable and eco-friendly pest management in agriculture and horticulture to enhance the profitability and welfare of the farming community.

AICRP on biological control of crop pests and weeds

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

Organisational set-up

With a view to fulfil the mandate effectively and efficiently, the Project Directorate is functioning with specialized laboratories for Biosystematics, Introduction and Quarantine, Mass Production, Pathology, Entomophagous Insect Behaviour studies, Biotechnology and a Co-ordination, Documentation and Training Cell (Fig. 1).

Financial statement (2008-09) (Rs.in lakhs)

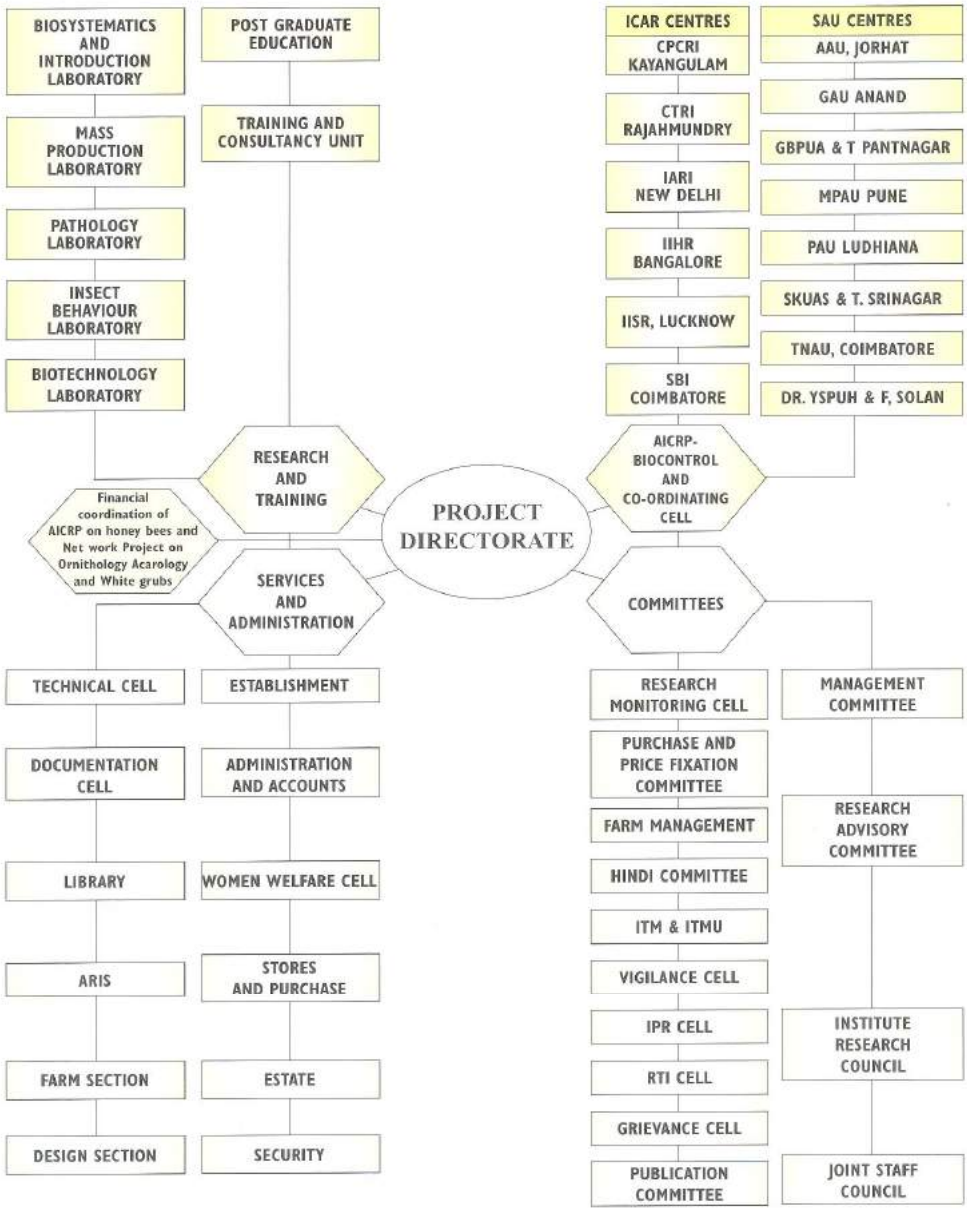
Project Directorate of Biological Control, Bangalore

Head	Plan	Non-plan	Total
Pay & allowances	00.00	265.00	265.00
TA	05.00	04.00	09.00
Other charges including equipment-Lib.	159.95	30.75	190.70
Information Technology	01.00	-	1.00
Vehicle	5.80	05.80	11.60
Works/petty works	76.75	16.00	92.75
HRD	02.00	-	02.00
OTA	-	0.03	0.03
Total	**250.50**	**321.58**	**572.08**

AICRP Centres (ICAR share only) expenditure (2008-09)

Name of the centre	Expenditure (Rs. in lakhs)
AAU, Anand	33.00
AAU, Jorhat	27.60
ANGRAU, Hyderabad	23.70
Dr.YSPUH&F, Nauni, Solan	21.45
GBPUA&T, Pantnagar	17.12
KAU, Thrissur	24.40
MPKV, Pune	27.60
PAU, Ludhiana	27.20
SKUAS&T, Srinagar	25.55
TNAU, Coimbatore	27.06
PC Cell, Bangalore	88.79
Total	**343.57**

ICAR Institute-based centres (CPCRI, Kayangulam; CTRI, Rajahmundry; IARI, New Delhi; IIHR, Bangalore; IISR, Lucknow and SBI, Coimbatore) did not maintain separate budget accounts since the Project has been merged with Non-Plan



Fir. 1. The Organisation Chart of PDBC

5. RESEARCH ACHIEVEMENTS

5.1. Project Directorate of Biological Control, Bangalore

5.1.1. Biosystematics

5.1.1.1. Taxonomic studies on lesser known coccinellidae of the Indian subcontinent

(a) Taxonomic revisions and new taxa described

The male genitalia of *Stictobura melanaria* and *Synonychimorpha immaculata* Poorani were recorded for the first time. The genus *Synona* Pope of the world was revised. The most commonly found species in India, *S. melanopepla* (Mulsant), was found to be a valid species. *Lemnia (Synia) martini* Iablokoff-Khnzorian, *L. melanoptera* Iablokoff-Khnzorian and *S. rougeti* (Mulsant) were synonymised with *S. melanopepla* (Fig.2.). The species commonly found in peninsular India, which has been hitherto misidentified as *S. rougeti*, was found to be a new species and described as *S. obscura* Poorani, Slipinski & Booth. Two species, *Synona philippinensis* Poorani *et al.* from the Philippines and *S. consanguinea* Poorani *et al.* from China and Vietnam were described as new. The type species of *Synona, S. melanaria* (Mulsant), was based on a female specimen and hence, its identity was uncertain. The locality of the type species was clarified and a lectotype was designated for the type species. *Synona seminigra* (Weise), *Coccinella cassidoides* Montrouzier and *Harmonia anthracina* Iablokoff-Khnzorian were synonymised with *S. melanaria* and *Coelophora vidua* Mulsant was synonymised with *C. inaequalis* (F.). Four genera, namely, *Scymnodes* Blackburn, *Apolinus* Pope & Lawrence, *Rhynchortalia* Crotch and *Cryptolaemus* Mulsant were revised.

(b) Updation of checklist with nomenclatural changes and new records

Distribution and biological data for the species of the Indian subcontinent were updated. *Calvia albida* Bielawski was recorded from Tripura. Two indeterminate species of *Ortalia* were recorded from Western ghats region in Kerala. *Pseudaspidimerus*

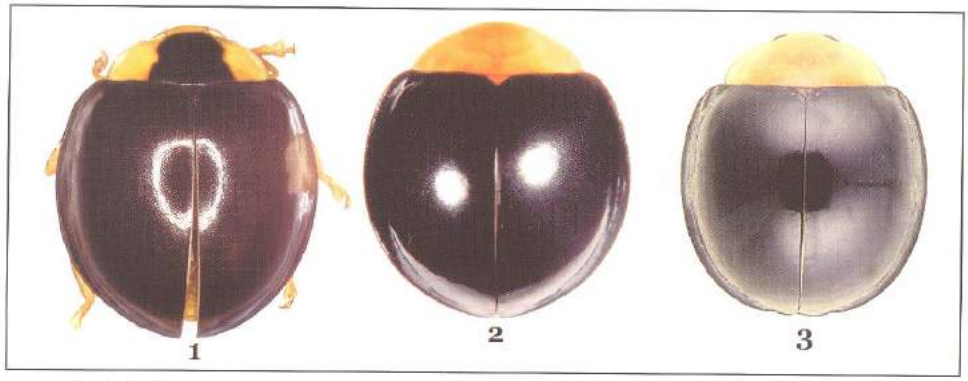


Fig. 2. Indian species of *Synona*: 1, 2. *S. melanopepla* (Mulsant); 3. *S. obscura* Poorani *et al.*

infuscatus Poorani was collected from Kerala, which constitutes a new distribution record for this species. *Coccinella nepalensis* was removed from the checklist of the fauna of the Indian subcontinent as it is based on a wrong locality label and a junior synonym.

(c) Studies on coccinellids in other collections

Primary type material and other specimens of coccinellids in the Australian National Insect Collection (ANIC), CSIRO Entomology, Canberra, were studied, with particular reference to the fauna of the Australasian region.

(d) Development of interactive keys to the genera of Coccinellidae of the Indian region

Keys were constructed for the subfamilies, tribes, and genera of Sticholotidinae and Scymninae (Coccinellidae) of the Indian region.

(e) Maintenance of website on Coccinellidae of the Indian region

The website on the Coccinellidae of the Indian subcontinent which is being regularly updated gets 15-75 hits per day. The website, "Aphids of Karnataka" (URL: www.aphidweb.com),is regularly updated. Factsheets on important aphidophagous coccinellids were included in the website with diagnostic characters and other details, besides colour photographs to facilitate easy field identification.

5.1.1.2. Biosystematics studies on egg parasitoids

Trichogramma spp. *Uscana* spp. were collected from lepidopterous eggs and bruchid eggs. Seventeen species of *Trichogramma* and two species of *Uscana* are currently being maintained. Crossing experiments between morphologically similar populations of *Trichogrammatoidea robusta* indicate that they are two species. Egg parasitoids were collected from insect eggs belonging to different insect orders. Maximum occurrence of parasitism was from orders Heteroptera and Lepidoptera followed by Dictyoptera and Arachnida.

5.1.2. Introduction and studies on natural enemies of some new exotic insect pests and weeds

The Chromolaena gallfly, *Cecidochares connexa* has established on chromolaena weed at GKVK campus and at Tataguni village near Bangalore and has dispersed to over more than 2 km. *Ormyrus* sp., a species of parasitoid is found attacking the gallfly and the parasitism ranged from 38.0 to 41.4% from February to April and less than 10% during other months. The summer burning of the weed greatly impacted the gallfly emergence.

For the biological suppression of *Leptocybe invasa*, an invasive species of gall wasp of eucalyptus, two parasitoids namely *Quadrastichus mendeli* and *Selitrichodes kryceri* were imported from Israel and being quarantine screened. *Spalgis epius*, a lepidopteran predator is actively feeding and checking the spread of papaya mealy bug, *Paracoccus marginatus* which has become a very serious pest on papaya, teak, cotton, okra, mulberry and hibiscus.

5.1.3. Biology and mass production of predators

(a) Studies on anthocorids

(i) Production of anthocorid predators

In *Orius tantillus*, maximum fecundity was recorded when bean pieces with stalks were provided as oviposition substrates (Fig. 3) and additionally pollen and *Sitotroga* eggs are also provided in the ovipositional containers.

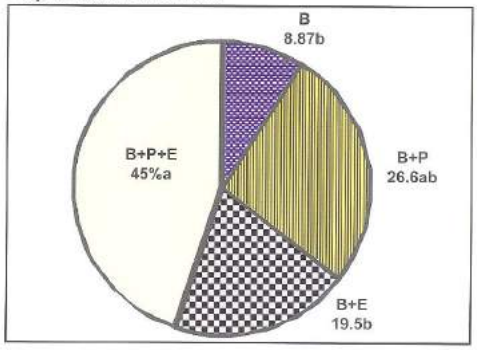


Fig. 3. Ovipositional preference of *O. tantillus* (B: Bean; P: Pollen; E: Eggs)

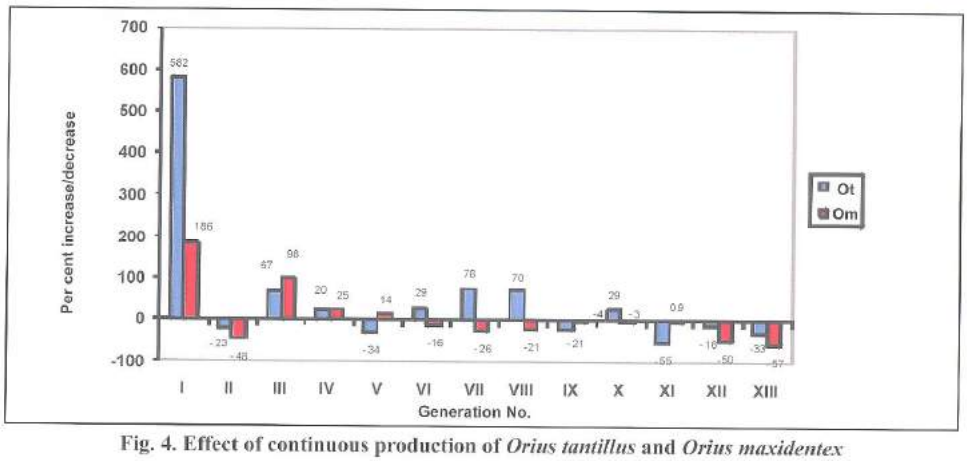


Fig. 4. Effect of continuous production of *Orius tantillus* and *Orius maxidentex*

(ii) Effect of continuous production of *Orius tantillus* and *Orius maxidentex*

Field collected *O. tantillus* and *O. maxidentex* were continuously reared in the laboratory on *Sitotroga cerealella* eggs and the generation wise increase/ decrease in progeny production was recorded. The increase in the first generation was very high in the case of both anthocorids. In progeny production, there was reduction in the second generation due to the sudden change from the field to the laboratory conditions and the alternate prey provided (Fig. 4). In *O. tantillus*, there was a reduction in progeny production from the XIth generation. While in the case of *O. maxidentex*, from the VIth generation itself there was a continuous decrease till the XIIIth generation (except for a slight increase in the XIth generation). The number of progeny per female was observed to be 4/female in the case of field collected *O. maxidentex*, while the corresponding figure for *O. tantillus* was 8.28. This experiment indicated that *O. tantillus* is more amenable to laboratory multiplication.

(iii) Cost of production of *Cardiastethus exiguus*

The cost of production of *Cardiastethus exiguus* was worked out to be Rs. 8 for 100 nymphs (@ Rs 26/- per cc of *C. cephalonica* eggs and including cost of other facilities).

(iv) Evaluation of anthocorids

Releases of *Blaptostethes pallescens* @ 20 nymphs per plant at weekly intervals for 13 weeks against chilli mite *Polyphagotarsonemus latus* resulted in 72% reduction in total drying of plants in comparison to control plants.

Four releases of *B. pallescens* nymphs @ 20/plant against spider mites on bean plants resulted in 56 % reduction in the mite population per leaf in treated plants in comparison to control. However, even in the treated plants mite population was as high as 63 per leaf indicating that releases should be initiated earlier.

(v) Evaluation of anthocorids against cotton mealy bug

In a laboratory trial, 45.5 crawlers emerged from one cotton mealy bug ovisac (Table 1.). When *B. pallescens* nymph or adult was released against the ovisac, 10.5 and 3.67 crawlers respectively emerged. *B. pallescens* nymphs and adults and 1: 5 and 1: 10 predator (nymph): pest ratio and 1.5 in case of adult anthocorid appeared to be the optimum ratio for obtaining maximum pest mortality (Table 2.). The experiment clearly indicated that *B. pallescens* nymphs and adults are potential predators of cotton mealy bug ovisacs and crawlers.

Table 1. Evaluation of *B. pallescens* against cotton mealybug ovisacs/neonates

No	Treatments	No. of crawlers emerged
1	Release of *B. pallescens* nymph	10.50[a]
2	Release of *B. pallescens* adult	3.67[a]
3	Control	45.50[b]
CD at 5%		27.77

Table 2. Evaluation of *B. pallescens* against cotton mealybug crawlers

Treatments	Predator: pest ratios	Per cent mortality
B. pallescens nymph	1:5	86.67[ab]
	1:10	80.00[ab]
	1:15	52.00[bc]
	1:20	44.52[c]
B. pallescens adult	1:5	93.30[a]
	1:10	70.00[b]
	1:15	68.86[b]
	1:20	51.67[bc]
Control	-	29.87[d]
CD at 5%		19.25

(vi) Field evaluation of anthocorid against onion thrips.

A field experiment was undertaken at Attur Farm for the evaluation of *B. pallescens* against *Thrips tabaci* infesting onion var. Arka kalyan. Pre-release thrips population per plant was almost similar in the control and treatment. *B. pallescens* nymphs were released @ 10 per plant at 10 days' intervals on the treatment plants. After two releases there was a significant reduction in the thrips population in the treated plants (Fig. 5). On an average, 2 anthocorids were observed per plant in the released plot. The yield obtained from the treatment plot was 1.11 kg/sqm, while in the control it was 0.85 kg/sqm.

(b) Studies on *Micromus igorotus* and *M. timidus*

(i) Life table studies

Regular field surveys have indicated that *M. timidus* has completely replaced *M. igorotus* as a predator of sugarcane woolly aphids in and around Bangalore, while *M. igorotus* is still a dominant species in Pune and Coimbatore.

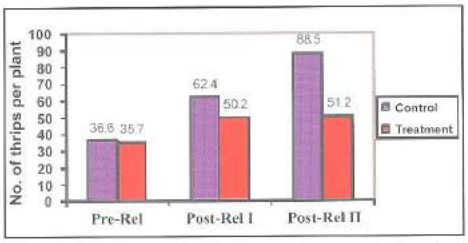


Fig. 5. Evaluation of *B. pallescens* against onion thrips

Both *M. igorotus* and *M. timidus* adults fed on significantly higher number of *A. craccivora* as compared to *C. lanigera*. *M. timidus* fed on significantly higher number of *A. craccivora* than *M. igorotus*, while *M. igorotus* fed on significantly higher number of *C. lanigera* than *M. timidus*. *M. timidus* survived for significantly longer duration on *A. craccivora* as compared to *M. igorotus*, also fecundity of *M. timidus* was higher on *A. craccivora* as compared to *M. igorotus* (Table 3).

The fecundity parameters like gross reproductive rate, net reproductive rate and mean length of generation were higher in *M. timidus*, while the innate capacity and finite rate of increase were higher in *M. igorotus* (Table 4.). Life table studies indicated that the immature stage mortality in *M. timidus* was 49 per cent. Survival index was maximum in case of third instar larva and life expectancy value decreased with the age indicating type III survivorship curve.

(ii) Mass production of *Micromus timidus*

An oviposition cage was designed and it was possible to harvest 28,866 *M. timidus* eggs per oviposition cage per month. A total of 2,02,062 eggs could be harvested per month if seven oviposition cages with 20 pairs in each are maintained.

(c) Production of *Cryptolaemus montrouzieri*

A total of 19 generations of *C. montrouzieri* were reared on *S. cerealella* eggs with a larval survival of 46.66 per cent. When adults were reared on *S.*

Table 3. Feeding potential and reproductive parameters of *M. igorotus* and *M. timidus* on *Ceratovacuna lanigera* and *Aphis craccivora*

Parameter	*Micromus igorotus*		*Micromus timidus*	
	C. lanigera	*A. craccivora*	*C. lanigera*	*A. craccivora*
Feeding potential (No./adult)	649.00	1695.30	598.89	1919.82
Pre-oviposition period (days)	4.30	5.20	5.10	5.13
Adult longevity (days)	39.06	47.00	26.98	59.01
Fecundity (Eggs/female)	964.20	1028.40	922.10	1443.30
Feeding potential of different instars				
1st instar	41.60	63.80	29.23	68.61
2nd instar	115.00	112.70	106.02	129.81
3rd instar	354.70	283.00	316.07	332.08
Total feeding by all the instars	511.30	459.50	451.30	530.50

Table 4. Growth rate statistics of *Micromus igorotus* and *Micromus timidus* on *Aphis craccivora*

	Micromus igorotus	*Micromus timidus*
Gross reproductive rate	106.13	124.61
Net reproductive rate	66.52	88.40
Mean length of generation	33.89	39.45
Innate capacity for increase	0.124	0.119
Finite rate of increase	1.33	1.29
Weekly multiplication of population	7.36	6.15
Hypothetical F_2 females	4424.51	7815.09
Doubling time	2.43	2.66

cerealella eggs, the average fecundity was 119.20 eggs per female.

(d) Production of *Brumoides suturalis* on *S. cerealella* eggs

The adult longevity of *Brumoides suturalis* was significantly shorter (38.60 days) on *S. cerealella* eggs as compared with that on mealy bugs (49.00 days), while the fecundity was significantly higher (204.62 eggs per female) than that on mealybugs (160.09 eggs per female) (Table 5). The per cent mortality of eggs, larvae and pupae of *B. suturalis* when reared on *S. cerealella* eggs was 18.36, 17.50 and 18.18, respectively.

Table 5. Biological parameters of *Brumoides suturalis* on *Sitotroga* eggs and mealybugs

Parameter	*Sitotroga* eggs	Mealybugs
Larval period (days)	14.64	11.68
Pupal period (days)	6.03	6.28
Adult longevity (days)	38.60	49.00
Fecundity (eggs/female)	204.62	160.09

Table 6. Effect on fresh and UV radiated eggs of *Sitotroga cerealella* on survival of immature stages and fecundity of two predators

Mortality/Fecundity	*Cryptolaemus montrouzieri*		*Brumoides suturalis*	
	Fresh eggs	UV radiated eggs	Fresh eggs	UV radiated eggs
Larval mortality	23.33	28.57	15.19	17.50
Pupal mortality	13.04	26.00	18.18	50.00
Total mortality	33.33	52.85	31.02	58.75
Fecundity	162.60	102.00	204.62	92.13

(e) Effect of UV radiated eggs of *S. cerealella* on survival of different stages of *B. suturalis* and *C. montrouzieri.*

There was higher mortality of immature stages of *C. montrouzieri* and *B. suturalis* when UV radiated eggs of *S. cerealella* were provided as feeding (Table 6).

5.1.4. Behavioural studies

(a) Effect of extracts of different rice varieties on the parasitization efficiency of *Trichogramma chilonis* and *T. japonicum.*

Maximum parasitism by *Trichogramma chilonis* was recorded in the treatment with methanol extract of rice variety Kadamba (66.57 %) followed by Jaya (54.40%), MTU-1010 (49.80%), KMT-148 (48.53%), KCP-1 (46.71%) and Basmati-370 (44.97%).

Highest percentage parasitization by *Trichogramma japonicum* was in the treatment with methanol extract of rice variety CTH-1 (48.52%) followed by rice variety 9 (48.24%), VIT -5204 (45.18 %), CTH-3 (43.63%), Vilirajamundi (43.5%) and IR-30864 (40.57%)

(b) Electroantennogram studies

Highest response of *Oxya nitidula*, was recorded in the treatment with honey and chloroform extract of rice *var.* TN1, of *Leptocorisa acuta* and *Ischnojoppa luleator* with hexane extract of the same variety and of cricket with chloroform extract of the same variety. Acetone extract of variety PTB recorded lowest response from *L. acuta* and methnol extract of same variety recorded lower response from cricket while acetone extract of TN1 and methanol extract of Triguna elicited minimum response from *O. nitidula* and *I. luleator*, respectively.

5.1.5. Biological and molecular characterization of inter and intra specific variation in Trichogrammatids

(a) Host preference of *Trichogramma* spp. collected from different crops

Maximum parasitism by *Trichogramma chilonis* populations collected from rice, tomato, cabbage, capsicum and sugarcane was observed on eggs of *C. cephalonica* (mean 89.7%), followed by those of *C. partellus* (mean 60.5%), while eri silk worm eggs were least preferred (2.9%).

Generally *T. chilonis* collected on rice prefers to parasites more eggs on rice. Irrespective of crops on which *T. chilonis* was collected, parasitism was highest on *C. cephalonica* eggs on sugarcane (30.8%) followed by rice (24.6%) and cotton (23.3%), while least parasitism was recorded on cabbage (14.0%).

(b) Molecular characterization of various species and strains of trichogrammatids.

DNA was extracted from eight isofemale lines of *T. cacoeciae*, *T. corbudensis*, *T. evanescens*, *T. embryophagum*, *T. pretiosum*, *T. semblidis* (thelytokus species obtained from France), *T. pretiosum* (from USA), and *T. embryophagum* (from Germany). Based on the size of the ITS-2 rDNA PCR products, base pairs varied from 550bp – 600bp (Fig. 6). Based on this size variation, three groups

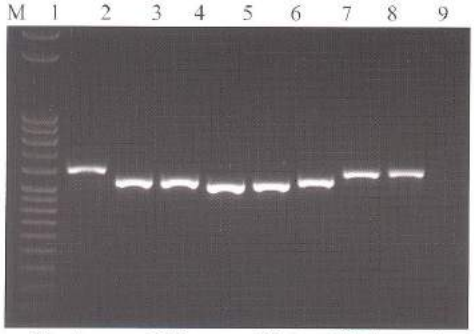


Fig. 6. PCR amplified ITS-2 regions different trichogrammatids (Lanes: M, 50bp DNA perfect ladder (Novagen); 1: *T. cacoeciae* (France); 2: *T. corbudensis* (France); 3: *T. evanescens* (France); 4: T. *embryophagum* (France) ; 5: *T. pretiosum* (France); 6: *T. pretiosum* (USA); 7: *T. semblidis* (France); 8: *T. embryophagum* (Germany); 9: Negative

could be distinguished: Group I included *T. cacoeciae* with base pair of 600bp; Group II included *T. semblidis* and *T. embryophagum* (Germany) with base pair of 575bp and Group III included *T. corbudensis*, *T. evanescens*, *T. embryophagum*, *T. pretiosum* and *T. pretiosum* (USA) with base pair of 550bp.

(c) Studies on wolbachia symbiont association with trichogrammatids

Freshly emerged adults of *T. cacoeciae*; *T. corbudensis*; *T. evanescens*; *T. embryophagum*; *T. pretiosum*; *T. pretiosum*; *T. semblidis* and *T. embryophagum* (Germany) were used for the DNA extraction. Based on the size of the wsp and FtsZ PCR products, base pairs varied from 550bp – 600bp and 700-750bp, respectively in the eight trichogrammatid species used in the study (Fig. 7 and 8). It was confirmed that all these species except for *T. cacoeciae* and *T. embryophagum* (Germany) contained wolbachia.

(d) Horizontal transmission of wolbachia

Studies on horizontal transmission, carried out between wolbachia giver (*T. brasiliense*) and taker (*T. achaeae* and *T. japonicum*) indicated that per cent females in the parent was only 31.0 and 52.0% in *T. achaeae* and *T. japonicum*, respectively. After

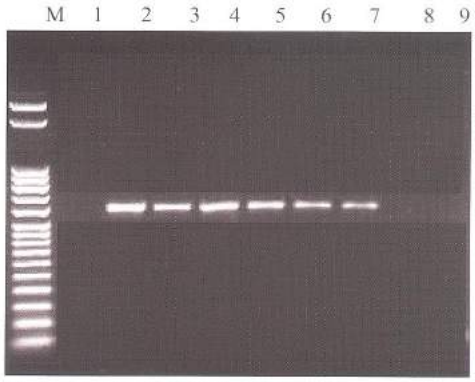


Fig. 7. PCR amplified WSP regions different trichogrammatids (Lanes: M, 50bp DNA perfect ladder (Novagen); 1: *T. cacoeciae* (France); 2: *T. corbudensis* (France); 3: *T. evanescens* (France); 4: T. *embryophagum* (France) ; 5: *T. pretiosum* (France); 6: *T. pretiosum* (USA); 7: *T. semblidis* (France); 8: *T. embryophagum* (Germany); 9: Negative

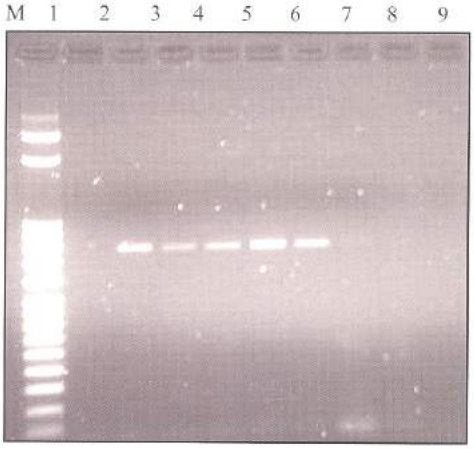


Fig. 8. PCR amplified FTS Z regions different trichogrammatids (Lanes: M, 50bp DNA perfect ladder (Novagen); 1: *T. cacoeciae* (France); 2: *T. corbudensis* (France); 3: *T. evanescens* (France); 4: T. *embryophagum* (France) ; 5: *T. pretiosum* (France); 6: *T. pretiosum* (USA); 7: *T. semblidis* (France); 8: *T. embryophagum* (Germany); 9: Negative

Table 7. Wolbachia transmission studies with trichogrammatids

Generation	% female in parent generation		% females after in transmission	
	T. achaeae	*T. japonicum*	*T. achaeae*	*T. japonicum*
F1	31.0	52.0	31.0	53.0
F5	35.0	55.0	65.0	55.0
F10	32.0	52.0	68.0	55.0
F15	30.0	50.0	75.0	68.0
F20	35.0	53.0	79.0	72.0
Mean	**32.6**	**52.4**	**63.6**	**60.6**

transmission studies for 20 generations, per cent females obtained was 79.0 and 72.0%, respectively indicating the possibility of wolbachia getting transmitted (Table 7).

(e) Curing of wolbachia

Curing of wolbachia infected species was carried out with two antibiotics *viz*. rifampsin and tetracycline on six species of *Trichogramma*. Studies carried out with rifampsin revealed that % females remained 100.0% in *T. cacoeciae*, while in other species, % females ranged from 35.4 to 66.4 in different species after 20 generations. Mean fecundity decreased in all species except in *T. semblidis* and *T. pretiosum* (France) and remained almost the same in *T. pretiosum* (USA) after 20 generations of curing.

Studies carried out with tetracycline too revealed that % females remained 100.0% in *T. cacoeciae*, while in other species it ranged from 52.1 to 83.2. Mean fecundity decreased in all species while it increased in *T. semblidis* (France) and remained almost the same in *T. pretiosum* (USA) after 20 generations of curing (Table 8).

(f) Identification of yeast strain by ITS sequence analysis

ITS sequence analysis and a BLAST search revealed that yeast isolated from sesamum and rose had sequence similarities with their corresponding type strains *Pichia anomala* (GenBank Accession No. AY349442), those from tomato with those of the type strain of *Candida apicola* (GenBank Accession

Table 8. Curing of wolbachia infection with different antibiotics in various trichogrammatids

Species	Parent		Refampsin				Tetracycline			
			F_5		F_{20}		F_5		F_{20}	
	%♀	MF	%♀	MF	%♀	MF	%♀	MF	%♀	MF
T. cacoeciae	100.0	36.2	100.0	27.9	100.0	23.0	100.0	27.6	100.0	31.2
T. corbudensis	98.1	55.3	52.0	28.5	35.4	20.6	84.7	24.3	78.5	33.2
T. embryophagum	100.0	64.2	51.3	36.9	50.5	38.6	100.0	36.8	70.5	38.6
T. evanescens	90.0	83.3	67.3	23.1	60.5	30.5	62.1	33.6	60.5	40.5
T. pretiosum (France)	88.7	28.4	71.1	31.4	48.9	49.9	86.9	41.9	83.2	36.3
T. semblidis	98.6	36.5	66.6	27.3	66.4	48.4	66.6	30.7	59.6	48.6
T. pretiosum (USA)	100.0	37.2	56.0	35.8	35.6	23.9	74.0	36.9	52.1	37.8

F5-F20 = generations; %♀ = per cent females; MF = mean fecundity

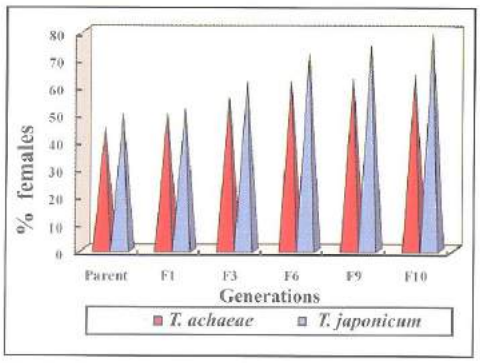


Fig. 9. Per cent females after feeding yeast for 10 generations to *T. achaeae* and *T. japonicum*

Nos. EU926481). The endosymbiotic yeast associated with *T. chilonis* obtained from sesamum, rose and tomato were identified as *Pichia anomala* Tcy1 strain (GenBank Accession No. FJ224365), *P. anomala* Tcy2 strain (GenBank Accession No. FJ599744) and *Candida apicola* Tcy3 strain (GenBank Accession No. FJ713025) respectively.

(g) Fitness

When laboratory reared *T. achaeae* and *T. japonicum* were fed with yeast extract mixed with honey there was a significant increase in female progeny production (Fig. 9).

5.1.6. Selection of superior strains of *C. carnea* and *C. montrouzieri* from different agro-ecosystems and their molecular characterization.

(a) Selection of superior strains of *C. carnea* from different agro-ecosystems

Chrysoperla carnea populations from Sirsa showed highest tolerance (LC_{50}=9983.7 ppm), followed by Delhi (4006.7 ppm) and Coimbatore (1233.47 ppm) populations to imidacloprid (Fig.10).

Maximum tolerance to high temperature (32° C) was observed in Sri Ganganagar population (63.2%) followed by Nagpur (14.0%) and Sirsa (12.0%) populations. Delhi and Coimbatore populations showed highest host searching efficiency (Fig. 11).

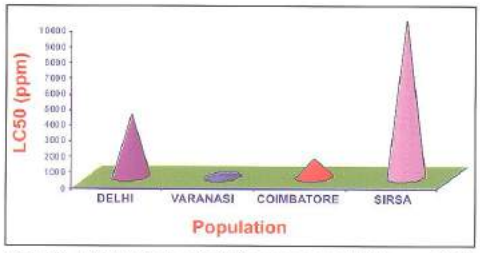


Fig.10. Tolerance of different populations of *C. carnea* to imidacloprid

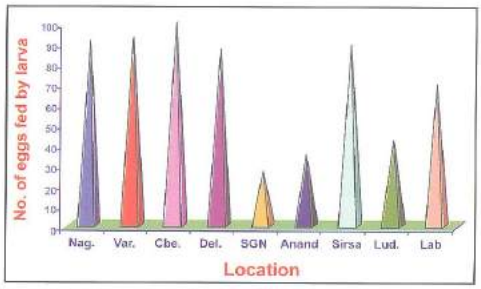


Fig 11. Host searching efficiency of *C. carnea* collected from different locations in India

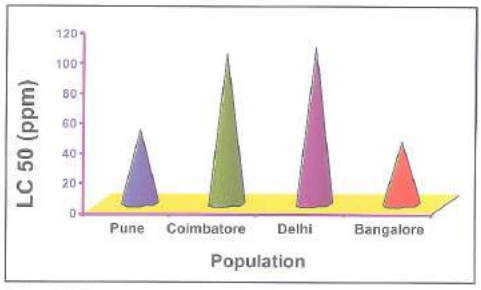


Fig. 12 Susceptibility of different populations of *C. montrouzieri* to imidacloprid

(b) Selection of superior strains of *Cryptolaemus montrouzieri* from different agro-ecosystems

Cryptolaemus montrouzieri populations collected from Delhi was observed to be superior with respect to its response to imadacloprid and based on the highest LC_{50} value (Fig.12). Predatory efficiency was observed to be superior in Bangalore population of *C. montrouzieri*.

Table 9. Aetylcholine esterase (AchE), esterase and GST activity in different populations of *C. carnea* adult

Name of the strain	AChE activity (µmol min^{-1} mg^{-1} protein)	Esterase activity (n mol of *p*-nitro phenol formed min^{-1} individual $^{-1}$)	GST activity (µmol CDNB) min^{-1} mg^{-1} protein
SIRSA	2.100441	38	3.3
Gujarat	2.121949	32	2.2
Punjab	2.138787	35	2.3
PDBC	2.400368	23	1.5

(c) Isozyme studies in *C. carnea* (group) populations

Isozyme studies revealed that there is a variation in the activity of AchE, esterase as GST activity in the different *C. carnea* populations. ITA-2 region of Guntur and Sriganganagar populations were characterized as the base pairs were 527 bp and 537 bp, respectively (Table 9. & Fig. 13).

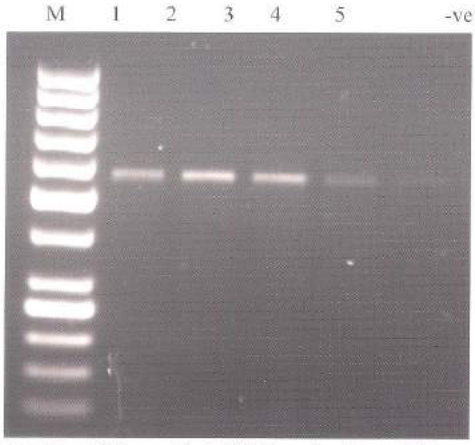


Fig 13. PCR amplified ITS-2 region from different *Chrysoperla* populations {Lanes: M, 50bp DNA perfect ladder (Fermentos)}

5.1.7. Selection of superior strains of certain parasitoids and their characterization

(a) Selection of superior strains of *Goniozus nephantidis*

The Tamilnadu population of *G. nephantidis* was superior in terms of pupation (80.2%) and adult emergence (92.4%) compared to Andhra Pradesh population (74.2 and 86.4%, respectively).

The biological parameters of Karnataka populations of *G. nephantidis* were evaluated at 26° C, 32° C and 36° C for over twelve generations and 32°C was observed to be the most congenial temperature (Table 10).

Table 10. Biological attributes of *Goniozus nephantidis* (Karnataka population) at higher temperatures

Biological parameters	26± 1°C	32± 1°C	36± 1°C
Fecundity (No. of eggs/female)	47.2	54.6	35.2
Parasitising efficiency (%) (No. of larvae parasitised / female)	7.2	8.1	5.2
Percentage pupation (cocoons formed)	74.2	83.4	62.4
Percent adult emergence	70.2	82..8	56.2
Adult longevity	45.1	52.6	35.2
Sex ratio (Male: Female)	1:2.2	1:2.5	1:0.5
Total Developmental period (days)	12.8	11.2	10.2

* Mean of 12 generations – Karnataka population.

(b) Molecular characterization of *G. nephantidis* based on ITS sequence and RAPD

PCR of ITS-2 region for the Andhra Pradesh, Kerala and Karnataka populations of *G. nephantidis* showed polymorphism in the region of the genome. DNA sequence analysis of the ITS-2 showed intra-species divergence. Intra species variations among the Karnataka and Kerala populations were minimal (Fig. 14). The sequences for the ITS-2 region for Karnataka, Kerala and Andhra Pradesh populations were submitted to GenBank with Accession numbers EU016231, EU719071 and EU719072.

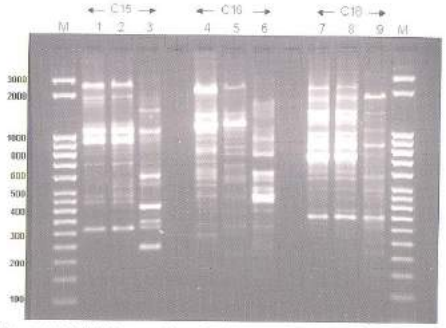


Fig. 14. RAPD profile of *G. nephantidis* populations using 11 random primers. In each gel, three primers C15, C16, C18 for each of the three populations are shown, along with a size standard. (Lanes: M, 100bp DNA ladder); 1, 4 & 7 - Karnataka; 2, 5 & 8 - Kerala; 3, 6 & 9 - Andhra Pradesh.

(c) Evaluation of Biological attributes of *Cotesia flavipes*

Nine geographical populations of *Cotesia flavipes* were studied. The biological attributes of *C. flavipes* population from Hoshiarpur was observed to be superior with respect to cocoon production and adult emergence. The Aurangabad population was superior with respect to female progeny production.

(d) Molecular characterization and genetic variability of *Cotesia flavipes*

Using the PCR, partial sequences of the COI for the different populations of *C. flavipes* were amplified to assess the homology or otherwise. PCR using COI-F and COI-R primers amplified a product of approximately 550 bp, which was similar for all the four populations (Fig. 15). The multiple alignment performed for four populations and one population from GenBank Accession number DQ 538818 revealed a size range from 402 bp (Bangalore) to 420 bp (DQ538818) of the partial COI gene sequences analyzed for the five different populations. RAPD assays and cluster analysis indicated that populations from Aurangabad and Devanahalli had similarity coefficient of 66%, Delhi and Dindigul 63%, while those from Bagalkot and Hyderabad were distinct.

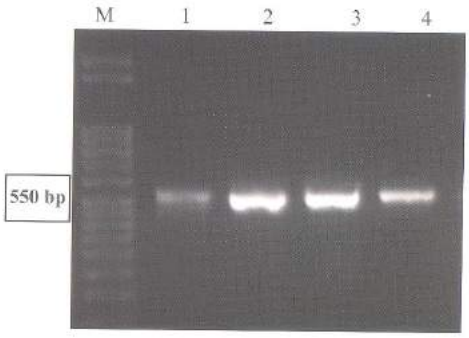


Fig. 15. Amplified PCR product of COI gene. Lane 1. 1 kb DNA ladder, *C. flavipes* from (lane 2, Bangalore; lane 3, Hyderabad; lane 4, Delhi; lane 5, Shimla)

5.1.8. Studies on insect pathogens

5.1.8.1. Efficient formulations of *Trichoderma* sp. and entomofungal pathogens with prolonged shelf life

(a) Extended shelf life of SSF based formulations of *Trichoderma harzianum*

The shelf life of talc formulations of *T. harzianum* derived from Solid State Fermentation (SSF) was 14 months with recovery of CFUs above x 10^6 in normal packing and in vacuum packing it was 12 months (Fig.16).

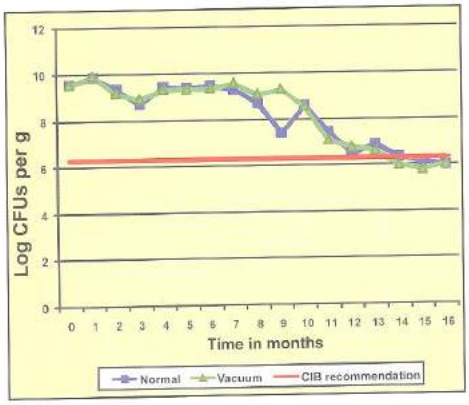


Fig.16. Shelf life of *T. harzianum* in SSF based formulations (Log of CFUs/g)

(b) Effect of different methods of drying on shelf life of *T. harzianum* derived from SSF

Shelf life of conidia based formulations of *T. harzianum* derived from SSF could be extended by selected drying methods up to 15 months after which the recovery of CFUs per g was less than 10^6. The bioefficacy of these formulations were tested using fusarium wilt of tomato as the host-pathogen system. With the *Fusarium lycopersici* inoculation alone the % tomato fusarial wilt incidence was 69% while in *T. harzianum* treated plants it was ranging from 13.11% to 65% (Table 11). In formulations with modified packing process, forced drying increased the shelf life up to 18 months, after which the population was less than 10^6 CFUs g^{-1}.

(c) Effect of combinations of different treatments like addition of chitin and glycerol with heat shock on the shelf life of *T. harzianum*

Addition of 0.2% colloidal chitin along with 6% glycerol resulted in prolonged shelf life of liquid ferementation derived talc-based formulations of *T. harzianum* compared to addition of glycerol alone at 6% concentration. The CFUs recovery was above 10^6 even at 17th month in these formulations derived from liquid medium amended with 6%

Table 11. Growth parameters and per cent wilt infection in plants treated with talc formulations of *T. harzianum* (derived from SSF and subjected to different drying processes) in bioefficacy test with pathogen (*Fusarium lycopersici*) inoculation

Treatments	Shoot length	Root length	Shoot weight	Root weight	% wilt infection
Pathogen	15.64	3.29	0.40	0.8g	69.14
RTE 1 Nor	17.40	7.24	48g	14g	13.11
RTE 2 Nor	14.20	5.62	19g	3g	43.70
RTE 3 Nor	12.15	3.34	19g	4g	13.11
RTE 4 Nor	12.08	3.24	9g	2g	56.81
RTE 5 Nor	12.05	4.55	19g	3g	30.59
RTE 1 Vac	18.92	8.25	42g	7g	30.59
RTE 2 Vac	21.16	5.17	48g	6g	26.22
RTE 3 Vac	16.39	5.47	32g	4g	30.59
RTE 4 Vac	13.42	3.48	12g	2g	48.07
RTE 5 Vac	10.05	3.95	3g	1g	65.55

(Nor- Normal packing; Vac- Vacuum packing)

Table 12. Growth parameters and % of wilt infection in plants treated with talc formulations of *T. harzianum* (derived with different combination of amendments in production medium) in bioefficacy test with pathogen (*Fusarium lycopersici*) inoculation.

Treatments	Intervention in fermentation	Shoot length	Root length	Shoot weight	Root weight	% wilt infection
PATHOGEN		15.64	3.29	8.00	0.40	72.11
CTE1	C	19.08	8.36	35.00	1.00	17.48
CTE2	C +HS	16.30	6.80	31.00	1.00	0.00
CTE3	3%G	18.30	6.14	36.00	1.00	4.37
CTE4	3%G +HS	19.07	7.90	39.00	2.00	17.48
CTE5	6%G	15.88	5.63	20.00	5.00	8.74
CTE6	6%G +HS	16.22	4.97	16.00	2.00	17.48
CTE7	3%G +CC	18.81	11.00	54.00	14.00	4.37
CTE8	3%G +HS +CC	14.40	5.55	18.00	2.00	21.85
CTE9	6%G +CC	17.17	5.55	20.00	5.00	30.59
CTE10	6%G +HS +CC	14.35	4.21	10.00	2.00	34.96
CTE11	CC	23.13	6.82	30.00	4.00	8.74
CTE12	CC +HS	15.10	6.57	20.00	2.00	30.59

glycerol and 0.2% colloidal chitin with or without heat shock.

In bioefficacy tests, in *Fusarium lycopersici* inoculated plants, the wilt incidence was 72% while in treated plants (*T. harzianum* talc-based formulation derived by addition of colloidal chitin with 6% glycerol) it varied from 0 to 30.59% (Table 12).

5.1.8.2. Entomofungal pathogens

(a) Effect of humectant, polyvinyl pyrrolidone (PVP) on shelf life of *B. bassiana, M. anisopliae and V. lecanii*

Shelf life of talc formulations of *B. bassiana, M. anisopliae* and *V. lecanii* prepared by adding polyvinyl pyrrolidine (PVP), a humectant to the production medium ranged from 5-6 months and was on par with the shelf life of the talc formulations prepared from the biomass devoid of humectant.

(b) Biological control of *Alternaria* leaf blight of tomato

(i) Evaluation of bacterial antagonists against *A. solani* in tomato seedlings (Pot culture studies)

Pseudomonas fluroscens (Pf-19), *Bacillus subtilis* and *Bacillus* isolates isolated from phylloplane of tomato plants (B-3, B-4, B-10, B-14, B-15, B-16, B-20 and B-23) were tested against leaf blight of tomato caused by *Alternaria solani* under glasshouse conditions. Bacterial suspensions of the test isolates at the dose of $2x10^9$/CFUs L^{-1} and the spore suspensions of *A. solani* at spore dose of $1x10^4$spores/ml were sprayed on the foliage of tomato seedlings simultaneously. Mancozeb (as Indofil M 45) at 3.0 g L^{-1} along with *A. solani* spray served as fungicidal check and control plants were sprayed with sterile distilled water along with *A. solani* spray. The lowest post-treatment disease index (PDI) of 33.8 was recorded in *Bacillus* sp. B-23 whereas *P. fluroscens-*

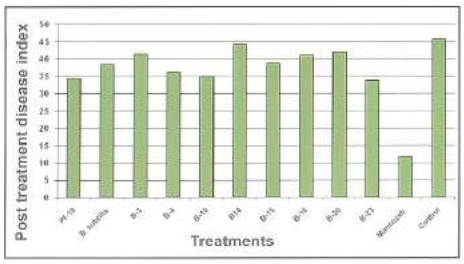


Fig. 17. Efficacy of bacterial antagonists on the infection of *A. solani* in tomato seedlings

Pf-19 and *Bacillus* sp.B-10 record next lowest PDI of 34.3 and 34.8 respectively (Fig. 17). The highest PDI of 45.8 was observed in the control plants.

(ii) Evaluation of *Trichoderma* isolates against *A. solani* in tomato (Field trials)

A field experiment was conducted to evaluate four promising isolates of *Trichoderma* sp. against leaf blight disease of tomato caused by *A. solani* at Chinthamani during kharif season of 2008. Talc formulations of *Trichoderma* isolates were prepared containing $2x10^6$ CFUs $g^{-1}$and applied as seedling dip during transplantation and foliar sprays after 15, 30 and 45 days after transplantation. Mancozeb (as Indofil M 45) at 3.0 gL^{-1}served as fungicidal check and applied as seedling dip during transplantation and foliar sprays after 15, 30 and 45 days after transplantation. In control plot, seedlings were dipped in water during transplantation and water sprays were given after 15, 30 and 45 days after transplantation.

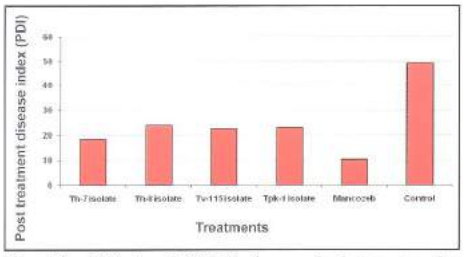


Fig. 18. Effect of *Trichoderma* isolates on the incidence of leaf blight of *A. solani* on tomato

Among the four isolates of *Trichoderma* sp. tested, the lowest PDI of 18.4 was observed with *T. harzianum* (TH-7 isolate) which when compared with the PDI of control plants showed 62.6% reduction. *T. viride* (TV-115 isolate), *T. pseudokoningii* (Tpk) and *T. harzianum* (Th-8 isolate) showed next lowest PDI of 22.7, 23.1 and 23.8, respectively (Fig. 18).

5.1.8.3. Isolation, characterization and toxicity test of indigenous *Bacillus thuringiensis* strains against lepidopterous pests

(a) Molecular characterization of indigenous Bt

Eight indigenous isolates of Bt were probed with Cry1and Cry4 universal primers. None of them were specific to Cry1 gene. However with Cry4 primer, isolates 1 and 2 showed PCR product of 230bp and the third isolate showed PCR product of 300bp. These 3 isolates could be related to cry 4 genes.

Three Bt isolates toxic to *Plutella xylostella* were probed with CRY1 universal primer but none of them were positive for cry1 gene. Three isolates were subsequently probed with cry4 specific primer and one isolate showed band corresponding to 300bp which could be harbouring cry4 gene.

PCR analysis with the samples PDBC-BT-1,PDBC-BT-2, PDBC-BNGT-3,CK-4,CK-12,VK-1,HD-1 for amplification of Cry I gene with the standard molecular weight molecular weight marker was performed. Cry IIIA primer pairs were used to detect the strains. The expected size of PCR products of the cry IIIA genes range from 652 to 769 bp. In this analysis rapid cell lysates were used as the DNA samples this allowed us to analyze several sample at the same time and reduced the possibility of sample contamination. We identified a strain that produced an unexpected 350 bp (shown in Fig 19) product when it was assayed with the primer mixture, suggesting that this strain may harbour a unique Cry IIIA gene.

b) SDS-PAGE analysis of crystal protein

SDS-PAGE analysis was done for the protein in samples from Bt isolates and the molecular weights

Fig.19. Molecular Characterization by PCR analysis of *Bacillus thuringiensis* strains by using *cry III* primers.

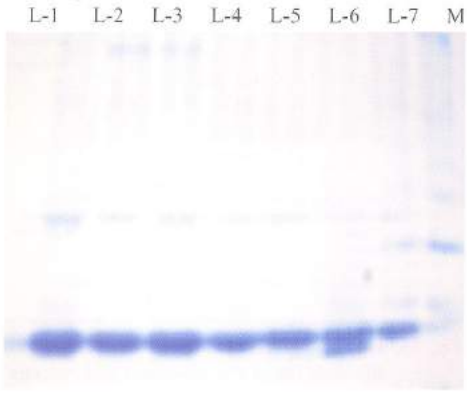


Fig. 20. Protein profile for the crystal protein of Bt isolates by SDS-PAGE

of protein bands were estimated for different isolates (Table 13 and Fig. 20).

(c) Evaluation of formulation of PDBC-BT1 and BNGT1.

Field evaluation of three indigenous Bt isolates namely PDBC-BT1, PDBC-BT2 and PDBC-BNGT1 was done against redgram pod borer. The isolates were compared with HD-1 standard and insecticide spray. The protein concentrations in the test organisms ranged between 400 to 800 µg/ml and

Table 13. Molecular weights of proteins resolved by SDS-PAGE from different isolates

Bt Isolates	Molecular weights determined by SDS-PAGE
PDBC-BT-1 (L-7)	116, 44,38,35 and 23 Kda
PDBC-BT-2(L-6)	116, 54,50,38,25 Kda
BNGT-3 (L-5)	54, 38, 37,25Kda
CK-4(L-4)	40,38,35,28 Kda
CK-12(L-3)	95, 63, 41,38,35,33 Kda
VK-1(L-2)	116, 48,38,35,28 Kda
HD-1(L-1)	66, 38,36,32,13 Kda

these were tested with four different concentrations of 0.5, 1.0. 1.5 and 2.0%. Ten replications were used to assess the treatments. Three sprays of the diluted liquid cultures were given at pod initiation, pod emergence and pod bearing stages at 15 day intervals. The highest pod number per plant (98.7) was recorded in plants having 1.5% spray of PDBC-BT1 and the lowest (46.5) was in treatment with 1% spray of PDBC-BT1.

The per cent pod damage was also estimated based on the mean number of pods damaged. The highest pod damage of 44.18% was recorded in untreated control and the lowest (3.5%) in plants treated with 2% HD-1 spray (Fig. 21). Low pod damage was also observed in other treatments *viz.*, 4.25% (PDBC-BT2), 4.41% (PDBC-BT1) and 4.91% (BNGT1). The results showed that 2% spray of the tested Bt strains could significantly reduce pod damage (Fig. 21).

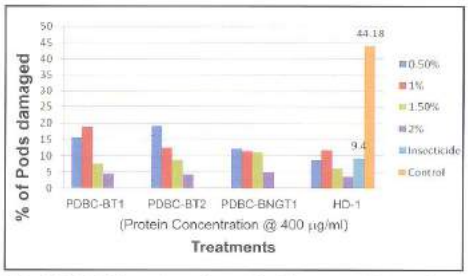


Fig. 21. Field evaluation of indigenous Bt strains against redgram pod borer

Fig.22. Healthy redgram pods in HD-1 treatment

5.1.8.4. Isolation and characterization of plant growth promoting endophytic bacteria and development of improved formulations

(a) Culture collection of plant beneficial bacteria at PDBC

Four endophytic bacteria were isolated from healthy pigeon pea plants. Three were Gram positive and one was Gram negative. Ninety four *Pseudomonas* isolates (from rhizosphere) were added to the culture collection of PDBC. The four endophytes were tested for inhibition of *Sclerotium rolfsii in vitro* on Tryptic Soya Agar. Two of the isolates showed 40 to 48% inhibition. The isolates are being identified through Biolog identification system.

(b) Plant growth promotion and rhizosphere competence of endophytic/rhizospheric bacteria

Thirty bacterial isolates were tested for seedling growth promotion in Petri plates using chickpea seeds. Among the tested isolates twenty showed growth promoting ability in terms of root and shoot length. Highest root length of 15cm was observed with the isolate GR-3 RAU-B and the highest shoot length of 10.5cm was observed with the isolate GR-4 RAU-A. Good growth promotion was also exhibited by CK-23, CK-4, H-8, CK-10, GR-4 RAU-A, ND-1and GR-3 RAU-B. All the twenty isolates showed growth promotion of more than 20% in terms of root and shoot length when seedling growth was observed 7 days after germination.

(c) Shelf life studies of powder based formulations of Gram negative bacteria.

Studies on shelf life of *Pseudomonas fluorescens* (PDBC-AB2) in powder based talc formulations amended with nutrients was conducted for 240 days. At 180 days highest population of log 7.48 CFUs g^{-1} was observed with formulations amended 2% peptone + 2% glycerol and at 240 days the population declined. High CFU of log 4.10 to 4.20 CFUs g^{-1} was observed in treatments amended with 2% tryptone or 2% peptone supplemented with 2% glycerol. It was concluded that 2% peptone or 2% tryptone supplemented with 2% glycerol enhanced the shelf life of *P. fluorescens)* (Fig. 23).

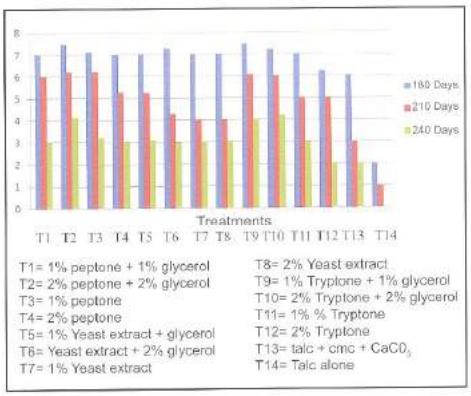


Fig. 23. Effect of different nutrient amendments on the shelf life of *Pseudomonas flulorescens*

(d) Shelf life studies of powder based formulations of Gram positive bacteria.

The shelf life of Gram positive spore forming *Bacillus* sp. (MTCC 6535) was evaluated in powder based formulations that were amended with nutrients. At 180 days highest population of log 9.90 CFU g^{-1} was observed with 1 or 2% yeast extract + 1 or 2% glycerol. Equal population was also noticed in treatments having 2% tryptone + 2% glycerol. At 210 days population remained stable and again highest population of log 9.90 cfu/gm was observed again in 2% yeast extract + 2% glycerol the same population was also seen in treatments having 1 or 2% yeast

extract + 1 or 2% glycerol and 1 or 2% tryptone + 1 or 2% glycerol. At 240 days there was slow decline in population in all treatments and high cfu of 9.30 to 9.38 per gm was noticed in yeast extract or tryptone treatments. It was concluded that yeast extract or tryptone supplemented with glycerol enhanced shelf life of *Bacillus* sp.

5.1.8.5. Identification of pathogens of phytophagous mites and assessment of their potential in microbial control

(a) Storage of *Hirsutella thompsonii* pellets

Long term storage studies revealed that the pellets of *Hirsutella thompsonii* could be stored in sterile water under refrigerated condition for more than three years.

(b) Evaluation of *Hirsutella thompsonii* along with adjuvants against coconut mite

Field evaluation of *H. thompsonii* against coconut mite was undertaken at Huskuru farm in Karnataka. Three sprays of *H. thompsonii* (mycelia) with adjuvant (glycerol 0.5%) at 15 days interval resulted in lowest nut grading index of 1.97 ± 0.13 (1-10% damage) (Table 14). The fungal formulations applied with or without glycerol brought about significant reduction in the pre-harvest nut damage through timely killing of the post-treatment population of the coconut mite. All the fungal treatments were on par with the chemical and superior to control in the tagged bunch 1 ($F = 14.31$; df = 5, 66; $P < 0.0001$), tagged bunch 2 ($F = 11.54$; df = 5, 66; $P < 0.0001$) as well as in the mean of the two tagged bunches ($F = 25.46$; df = 5, 66; $P < 0.0001$)

All the fungal treatments outperformed the chemical (Triazophos) in terms of reducing the nut damage at the pre-harvest stage. Among all, the mycelial formulation of *H. thompsonii* in combination with glycerol (0.5%) was the best with a mean score of 1.97, which was less than half of the control score (4.09)

(c) Endophytic fungi/bacteria associated with *Mikania micrantha*

More than 20 sporulating species of phylloplane mycoflora from leaf tissues of *M. micrantha*, were found to be capable of causing disease-like symptoms when re-inoculated. The genera, *Alternaria*, *Cercospora*, *Colletotrichum* and *Phoma* from symptomatic tissues of greenhouse-grown

Table 14. Pre-harvest nut damage grades from the second-round field evaluation of new formulations of *H. thompsonii* [MF(Ag)66 ex Kerala] against *A. guerreronis* on coconut at Huskuru, Bangalore Rural district, Karnataka

Treatments	Pre-harvest nut damage grades		
	Tagged bunch 1 (2nd bunch)	Tagged bunch 2 (3rd bunch)	Mean
H. thompsonii (Mycelia) (1%) + glycerol (0.5%)	1.91 ± 0.20[a]	2.03 ± 0.24[a]	1.97 ± 0.13[a]
H. thompsonii (Mycelia) (1%)	2.23 ± 0.23[a]	1.99 ± 0.20[a]	2.11 ± 0.13[a]
H. thompsonii (Mycelia + conidia) (1%) + glycerol (0.5%)	1.93 ± 0.20[a]	2.08 ± 0.28[a]	2.00 ± 0.17[a]
H. thompsonii (Mycelia + conidia) (1%)	2.10 ± 0.24[a]	2.16 ± 0.25[a]	2.13 ± 0.21[a]
Triazophos (Trifos 40) (0.2%)	2.48 ± 0.23[a]	2.19 ± 0.30[a]	2.34 ± 0.17[a]
Control	4.05 ± 0.19[b]	4.12 ± 0.16[b]	4.09 ± 0.14[b]

Means in each column followed by the same letter did not differ significantly at $P < 0.05$, Tukey's HSD.

M. micrantha from Andaman and Nicobar Islands produced characteristic, original symptoms while proving Koch's postulates. The field-collected Karnataka population of *M. micrantha* was found to be susceptible to foliage diseases by species under the genera *Alternaria*, *Cercospora*, *Colletotrichum*, *Dreschslera* and *Phoma*. In stems and roots, species of *Aspergillus*, *Penicillium*, *Fusarium*, *Lasiodiplodia*, *Phoma* and *Rhizoctonia* were found to have domination over several other genera. These results suggest that the endophyte composition of *M. micrantha* is heterogeneous on several levels.

5.1.8.6. Nematode-derived fungi and bacteria for exploitation in agriculture.

(a) Suitability of soil types on the pathogenicity of *P. lilacinus* and *P. chlamydosporia* against root-knot nematode of tomato

It was observed that laterite, alluvial, loamy sand and mountain soils except black cotton soil were suitable for root growth, nematode infection and effective parasitization of the egg masses by *P. lilacinus* and *P. chlamydosporia*. Mountain soils recorded highest fungal propagules followed by red laterite soils and least was in black cotton soils (Table 15). *P. lilacinus* recorded higher cfus, root colonization and egg mass parasitization in soils with comparatively higher organic carbon at all the pH categories.

(b) Effect of plant root density on the nematode infection_

In pot culture studies it was revealed that brinjal (purple long) having higher root volume and root hair recorded higher root-knot nematode infection, egg masses and fungal parasitisation of the egg masses as compared to tomato and cotton 45 days after the treatment (Table 16).

(c) Improvisation of mass production, formulation and delivery systems of *Paecilomyces lilacinus* and *P. chlamydosporia*

(i) Influence of production media and method

Paecilomyces lilacinus and *P. chlamydosporia* obtained from solid state fermentation and formulated on talc exhibited better shelf life (spore viability) and

Table 15. Effect of soil types on the pathogenicity of antagonistic fungi (*P. lilacinus* and *P. chlamydosporia*) against root-knot nematode on tomato in glass house

Soil type	Organic carbon (%)	pH	Tomato (60 days old)			Egg mass parasitization (%)		Fungal propagules/ 10g soil	
			Healthy root wt (g)	RKI*	RKI**	PL	PC	PL	PC
Red laterite	0.62	6.8	6.8	3.2	2.4	52	46	1226	688
Alluvial	0.65	6.7	7.4	3.6	2.5	54	44	1112	744
Loamy sand	0.58	7.6	5.4	3.4	3.0	38	51	998	692
Black cotton soil	0.55	8.7	4.4	2.5	2.5	8	3	238	146
Sulya mountain soil	3.6	4.6	8.6	3.6	2.0	62	58	1486	922
F-test	-	-	-	-	-	HS	HS	HS	HS
CD(P=0.01)	-	-	-	-	-	4.4	6.2	45.4	33.6

*RKI-Root-knot index in untreated root-knot nematode infected plants;
** RKI-Root-knot index in root-knot nematode infected plants treated with PL or VC.

Table 16. Effect of host root pattern on nematode infection of roots and pathogenicity of *P. lilacinus* against root-knot nematodes

	Tomato			Egg plant			Cotton		
	Root weight	J2/g root	RGI	Root weight	J2/g root	RGI	Root weight	J2/g root	RGI
3.0 - 3.3	4.8	22	0.6	4.9	32	0.8	3.0	14	0.2
4.0 - 4.5	6.5	38	1.4	7.2	52	1.8	4.6	28	0.8
5.0 - 5.4	7.8	62	2.5	8.6	78	3.0	6.4	44	1.4
6.0 - 6.3	9.1	84	3.0	10.0	98	3.6	8.2	62	2.0
7.0 - 7.2	10.4	96	3.8	12.2	122	4.0	9.4	76	2.5
F-test	-	HS	HS	HS	HS	HS	-	HS	Hs
CD (P=0.01)	-	2.80	0.053	1.60	3.6	0.072	-	3.99	0.058
	-	5.721	0.164	5.02	9.242	0.214	-	11.221	0.168

bioefficacy (infectivity to egg masses) against root-knot nematodes compared to that produced in broth. Chlamydospore production by *P. chlamydosporia* was highest in solid state production than in liquid production.

(ii) Influence of initial moisture content of solid substrates on conidial biomass of *Paecilomyces lilacinus* (Thom) Samson for solid state mass production and down-stream processing

The interrelationships between initial water content (WC), moisture content (MC) and water activity (a_w) and the effect of initial proportion of water in the solid substrates (maize, rice and wheat bran and rice grain) and conidial biomass and quality of conidia of *Paecilomyces lilacinus* PDBC PL55 were examined. With the increase in initial proportion of water content in bran, the MC and a_w recorded an increase. At a water proportion of 0.75:1.00 (v/w) and above in maize, rice and wheat bran, the water activity recorded saturation (1.00), while MC ranged between 41.90-47.55%. An initial proportion of water at 1.00:1.00, the MC was observed to be 49.19 to 50.58 %. Mycelial growth and conidiospore production at initial moisture content of upto 0.50:1.00 in maize, wheat and rice bran were very low and non significant. An increment of WC in rice bran to 0.75:1.00 significantly increased the conidiospore production to $>10^8$ g^{-1} substrate and to 10^9-10^{10} conidiospores g^{-1} bran at a WC of 1.00:1.00 (Fig. 24). There was a sharp decline in *P. lilacinus* spore production in all the 3 bran at a WC of 1.25:1.00. Increase in substrate WC recorded an increase in MC and a_w of conidiospores on all substrates but did not affect the spore viability. A combination of MC at 49-50% and a_w at saturation (1.00) was ideal

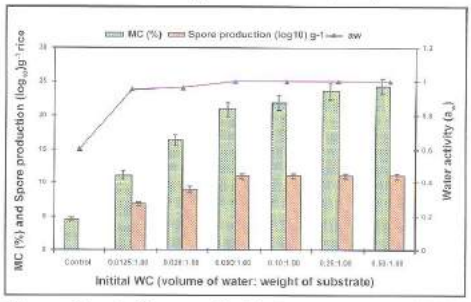


Figure 24. Influence of initial water content (WC) on moisture content (MC), water activity (a_w) and spore production of *P. lilacinus* PDBC PL55 g^{-1} on rice grain.

Table 17. Evaluation of antagonistic fungi against root-knot nematode on FCV tobacco (Pooled data of 2006-07 and 2007-08).

Treatments		Total healthy transplants count	Root knot Index (0 - 5 scale) At 60 DAS	No. of egg mass /g root	Total cured leaf yield (kg/h)
T1	*Glomus fasciculatum* (VAM) @ 10 g / m^2	483.0	2.72	17.4	1306.5
T2	*Paecilomyces lilacinus* (PDBC strain) @ 100 g / m^2	598.1	2.09	13.5	1279.8
T3	Carbofuran @ 50 g / m^2	611.0	2.05	11.7	1295.2
T4	Neem Cake @ 1 kg / m^2	532.5	2.30	15.5	1273.2
T5	Vermicompost @ 1 kg / m^2	500.7	2.36	16.2	1297.8
T6	T1 + T4	551.2	2.39	15.5	1315.1
T7	T1 + T5	524.7	2.51	16.0	1288.0
T8	T2 + T4	612.7	1.89	12.1	1287.2
T9	T2 + T5	614.0	1.89	12.2	1285.7
T10	T1 + T2 + T4	613.0	1.87	12.4	1328.7
T11	T1 + T2 + T5	595.5	1.92	12.7	1275.7
T12	Un Treated Check	455.7	3.86	19.7	1270.0
	S.E.M	3.44	0.03	0.28	23.43
	CD at 5%	9.54	0.08	0.77	NS
	CV %	1.75	3.52	5.38	4.46

for conidiospore production of *P. lilacinus* on bran, while a MC of 20-23% and saturated a_w was ideal on rice grain. Identification of an ideal combination of MC and a_w was more critical than an optimum level of MC or a_w for conidiospore production.

(d) Field evaluation of talc formulations of *Paecilomyces lilacinus* and *P. chlamydosporia*.

Integrated use of talc formulations of antagonistic fungi with crop-soil sterilization (formaldehyde) in capsicum and tomato in polyhouses at Denkinkotai, Hosur reduced the incidence of nematode-root wilt disease complex by 64% in treated beds compared to untreated beds. Infection of egg masses in treated beds was 56% and infective juveniles were recorded to be in the range of 78 to 134 per 100cc soil in treated beds.

(e) Biological control of root knot nematode in FCV tobacco nurseries

In a field experiment in nursery beds at CTRS, Hunsur, it was revealed that the treatments *P. lilacinus, G. fasciculatum* and neem cake or *P. lilacinus, G. fasciculatum* and vermicompost yielded healthier seedlings with significantly lower gall index (root infection). Seedlings that received treatments exhibited no significant leaf yield differences over untreated seedlings except seedling mortality in nursery (Table 17).

(f) EPN against white grubs

Surveys for white grubs and associated EPN in potato and groundnut cropped areas and in dung pits resulted in recording *Oryctes rhinoceros* and *Gametis versicolor* in chickballapur area. Screening of 4 isolates of EPN, viz., *H. indica* 13.3, *H. indica* Ashoka, *S. carpocapsae* Sc11 and *S. glaseri* (in

manure as medium) for efficacy against second and third instar grubs indicated that all the four nematodes caused mortality to grubs in 60-72 h up to a depth of 3 inches. A new isolate of *Steinernema* was obtained from a diseased grub collected from Devanahalli.

Surveys for white grub associated EPN in potato, cabbage, cauliflower, and groundnut areas and in dung pits resulted in *Anomala* and rhinoceros species of white grubs. Preliminary screening of 4 isolates of EPN viz., *Heterorhabditis indica* (13.31), *H. indica* (6.71) *Steinernema carpocapsae* (Sc 11) and *S. riobrave* using soil method for efficacy against late instars of rhinoceros grubs, resulted in grub mortality due to *S. riobrave* in 7-10 days up to a depth of 6 inches.

(g) Bar coding of PDBC isolates of EPN

ITS and ribosomal genes of 10 EPN isolates were amplified using specific primers and RFLP and RAPD of genomic DNA from these EPN isolates were carried out using REs and random primers. A comparison of the nucleotide sequences of the COI gene (DNA bar coding) revealed that the sequences of *Heterorhabitis* and *Steinernema* apparently differed between the two reproductive forms, and a high homology within each reproductive form. These genetic characterizations (DNA bar coding) strongly support the similarities and dissimilarities revealed by some morphological characters and morphometrics in correspondent isolates, making them a reliable tool to catalogue the EPN diversity and also to examine check the label claims in EPN formulations.

(h) Performance of PDBC isolates of EPN

(i) Influence of depth of compost on infectivity of EPN to scarabid and *Oryctess* grubs

At a constant dose of 1000 IJs/100cc column aqueous formulations of *S. carpocapsae, S. riobrave, H. indica* 13.31 and *H. indica* 6.71 caused mortality to scarabaeid and rhinoceros grubs in 72 and 96 hrs of application at a depth of 15 cm, while *H. indica* 13.31 and *H. indica* 6.71 caused grub mortality in 96 to 120 hrs at same depth.

(ii) Evaluation of different organic amendments on bioefficacy of EPN against whitegrubs

Steinernema carpocapsae, S. riobrave, H. indica 13.31 and *H. Indica* 6.71 in aqueous suspensions @ 1000 Ijs/100cc column) applied to farm compost, urban compost, vermicompost, vermiculite and coir pith in column assay caused mortality to scarabid and *Oryctes* grubs in 72 to 120 hrs of application at a depth of 15 cm while in coir pith grub mortality was observed between 96 to 120 hrs.

(iii) Screening of EPN isolates in soil columns for efficacy against white grubs

Preliminary screening of 4 isolates of EPN viz., *H. indica* (13.31), *H. indica* (6.71) *S. carpocapsae* (Sc 11) and *S. riobrave* using soil column method for efficacy against 2nd and 3rd instar grubs indicated that all the four nematodes caused mortality to scarabaeid grubs of *G. versicolor* in 60-72 hrs up to a depth of 3 inches, while grub mortality in late instar Rhinoceros beetle was recorded due to *S. riobrave* in 7 days up to a depth of 6 inches at 100 IJs/100cc soil, and 10 days due the other three nematodes.

(iv) Dose response assay of *S. carpocapsae, S. riobrave, H. indica* 13.31 and *H. indica* 6.71 against *G. versicolor* grubs at 48 hrs

LD_{50} values of 1.2 cm scarabid grubs in 100cc of manure mix (Manure + soil at 1:1 v/v) in aqueous formulation were 1820, 1980, 1860 and 1660, respectively, for the four nematodes.

5.2. AICRP ON BIOLOGICAL CONTROL OF CROP PESTS AND WEEDS

5.2.1. Biological control of plant diseases and nematodes using antagonistic organisms

GBPUAT

(a) Temperature effect on isolates of *Trichoderma* and *Pseudomonas*

Antagonistic activity of ten isolates of *Trichoderma* from rhizosphere of different plant species at different

altitudes was evaluated at different temperature ranging from 10 to 40°C. Out of ten isolates, isolate Th-10, Th-4,Th-12, and Th-31 grew faster at 30°C, however isolate Th-43 and Th-28 could grow even at 10°C, Th-4 and Th-31 at 15°C. At 35 and 40°C growth of several isolates was reduced. Out of ten isolates of *Pseudomonas fluorescens*, isolates Pf-31, Pf-28 and Pf-27 had excellent growth at 30°C as compared to other isolates.

(b) pH effect on isolates of *Trichoderma* and *Pseudomonas*

Ten isolates of *Trichoderma* were grown in PDA media and *Pseudomonas* isolates in Kings B media with pH ranging from 4 to 10. All the isolates of *Trichoderma* and *Pseudomonas* could grow faster at pH 7, but pH from 4-5 or 8-10 could not promote better growth of these isolates.

(c) Moisture effect on growth of *Trichoderma* and *Pseudomonas* in oven-dried cow dung

Ten isolates of *Trichoderma* and *Pseudomonas* were grown in oven-dried cow dung with moisture levels ranging from 10 to 70 per cent. Most of the isolates had excellent growth at 30 per cent moisture level. Isolate Th-38 was found to be the best in growth and sporulation and gave highest colony count of 20 x 10^6 CFU/g of air dried FYM followed by isolates Th-43 and Th-12 at 30 % moisture level. Similar results were obtained with ten isolates of *Pseudomonas*. isolates Pf-3, Pf-4 and Pf-28 had maximum growth and gave highest colony count of 24 x 10^6 CFU/g of air dried FYM followed by isolate Pf-31 and Pf-18 at 30 % moisture level.

(d) Biochemical characterization of 30 *Trichoderma* isolates

All isolates differed significantly in terms of utilization of cellulose and chitin. Isolate PB-11 used maximum cellulose (69.4%) with formation of clear zone followed by PB-29 (54.4%), whereas minimum cellulose was utilized by isolate PB-23 (24.3%) with no clear zone formation. Chitin was utilized maximum by PB-2 (75.4%) with clear zone formation. Isolate PB-29 was found to be best for utilization of both cellulose and chitin. Only one isolate (PB-6) was found to be the weakest for utilization of cellulose and chitin.

5.2.2. Large scale field demonstration of biocontrol technologies in plant disease management

(a) Lentil: GBPUAT

A large scale field demonstration was conducted on Lentil var. PL-5 in the organic farming block of Seed Production Center of GBPUA&T, Pantnagar. Bioagents were applied as seed treatment (10g/kg) and spray (10g/l). Two sprays were applied during the cropping season. For enrichment of vermicompost, 1 kg of the formulated bioagent was used per 100 kg of vermicompost. The experiment was conducted in a randomized block design with three replications under natural infection conditions in plots which had a history of wilt and root rot. The size of the plot was 5x6 m^2.

The results revealed that seed treatment with formulated product of the mixed formulation of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28 along with the vermicompost pre-colonized with the same bioagents was the best treatment in terms of disease control followed by seed treatment with mixed formulation of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28 and its spray. The least effective treatment in terms of disease control was seed treatment with *T. harzianum* PBAT-43 along with soluneem. Highest yield (876.6 kg/ha) was recorded with treatment which seed treatment with formulated product of the mixed formulation of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28 along with the vermicompost pre-colonized with the same bioagent which was significantly more than control (253.1 kg/ha) followed by seed treatment with *T. harzianum* PBAT-43 along with vermicompost added with the same bioagent.

(b) Pea: GBPUAT

Large scale field demonstration of biocontrol technologies was conducted on pea variety Arkil during Rabi 2008, at four farmer's fields covering an area of eight acres. The bioagent treatments included seed treatment with mixed formulation of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-27 @ 10 g/kg seed along with use of the same bioagents colonized FYM at the recommended dose followed by two sprays with mixed formulation of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-27@

10g/l of bioagent. In control plots farmers practice was followed which included seed treatment with Bavistin @2 g/kg of seed and normal FYM at the recommended dose followed by need based sprays of Bavistin at the recommended doses. The rust incidence was negligible in overall pea crop but *Rhizoctonia* root rot and wilt was quite significant.

Seed treatment with bioagents resulted in considerably higher germination, reduced disease severity and higher green pod yield (Table 18). Although overall disease incidence was high in all the fields, it was significantly lower in bioagents treated plots. Farmers applying biocontrol strategies could sell their produce @ Rs. 67,500 per ha as compared to conventional farmers who could sell their produce @ Rs.45,000/ ha.

Table 18: Large scale demonstration of effect of biocontrol agents on pea (Arkel) at farmers' fields under organic cultivation

Treatments	Mean seedlings/m²	Mean disease severity (%)	Green Pod Yield (kg/ha)
Biocontrol technology	32	25	87.5
Control (Farmers' practices)	15	90	27.5

(c) Rice: GBPUAT

Large scale evaluation of biocontrol agents was done on organically cultivated rice cultivar Pusa-1121, Taraori basmati and Pusa basmati-1. Thirteen members of the Tarai Organic Farmers Association along with several other farmers including members of *Swatantrata Sangram Sainani Jaivik Krishi Samiti* and members of *Rishi Parashar Jaivik Krishi Shodh Samiti* from district Udham Singh Nagar have been using the following treatments for the management of diseases in organic rice in more than 600 acre area:

1. FYM colonized with mixed formulation of *T. harzianum* + *P. fluorescens* (@ 5 to 10 t/ha) or use of vermicompost colonized with *P. fluorescens* (@ 5 to 10 q/ha).
2. Seed treatment/ biopriming with mixed formulation of TH + PsF (@ 10g/kg seed)
3. Need-based spray of TH+PsF (@ 10 g/l) in patches infected with sheath blight

Above interventions suppressed most of the diseases under field conditions. During 2008, the incidence of sheath blight was negligible but there was an outbreak of bacterial leaf blight (BLB) and brown plant hopper (BPH) which caused heavy damage to the rice crop. The above treatments of bioagents followed by the farmers along with need based application of neem oil (@1.5 l/ac) and cow urine (@20 l/ac) effectively suppressed both BLB and BPH in organically cultivated rice. During 2008, the average yield of organically cultivated Pusa-1121 was 20.0 q/ha and Taraori basmati was 17.5 q/ha and fetched a price of Rs 2800 and 3400 per quintal, respectively.

(d) Chickpea: AAU-A

Large scale field demonstration was conducted in chickpea and the following treatments were applied:

T1 : a. Seed treatment with *T. harzianum* (10^8 spores/g of formulation) @ 8 g/kg seed.

b. Use of FYM colonized with *T. harzianum* (10^8 spores/g of formulation) @ $2X10^{12}$ spores/ha. (Dose 5 t/ha)

T2 : a. Seed treatment with *T. harzianum* (10^8 spores/g of formulation) @ 8 g/kg seed.

b. Use of vermicompost colonized with *P. fluorescens* @ 1.5 t/ha

T3 : Farmer's practices (Control)

The results revealed that there was no significant difference in per seed germination and percent pod borer damage between the treatments. Significantly least (5.40%) incidence of wilt and blight diseases was revealed in the treatment of seeds treated with *T. harzianum* + application of FYM enriched with *Trichoderma* over other treatments tried. The former

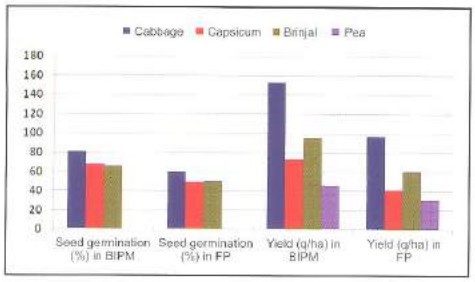


Fig. 25. Impact of BIPM package on germination and yield of vegetables in Uttarakhand hills

treatment also produced significantly highest (1246.5 kg/ha) grain yield than the remaining treatments (Table 19). All the parameters recorded during both the years exhibited a similar trend indicating the effectiveness of the treatments.

(e) Vegetables: GBPUAT

Large scale field demonstrations on biocontrol technologies under low input system in Uttarakhand hills was conducted. The BIPM package included: a) solarization of nursery soil; b) seed treatment with mixed formulation of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28 @ 10g/kg seed; c) seedling dip in mixed formulation of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28 @ 10g/l; d) use of vermicompost colonized with *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28; e) 2-3 sprays of mixed formulation of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28 @ 10g/l; 1-2 sprays of soluneem which was compared with farmers' practice. Significantly highest seed germination and highest yield was recorded in the BIPM package in cabbage, capsicum, brinjal and pea (Fig. 25).

5.2.3. Management of fruit rots in mango, papaya and guava

(a) Mango: PAU

Two isolates I-2 and I-4 obtained from PDBC along with local isolate J-3 along with control were evaluated for their efficacy against post harvest pathogen in mango. Observations were recorded from 2nd to 12th day at two days interval. The percent fruit infected by post harvest pathogen and surface area per cent rotten were recorded.

In mango Dusheri, the lowest per cent fruit surface rotten 2 and 4 days after treatment was in isolate I-4 (0.0 and 3.3%). In mango Chausa, the lowest per cent fruit surface rot 2 days after treatment was observed in isolate I-2 (0.2%).

Isolate I-4 also resulted in the lowest per cent fruit infection in mango Dusheri (0.0%) and Mango Chausa (4.2%) 2 days after treatment. Isolate I-2 recorded 16.6% fruit infection in mango Chausa.

(b) Papaya: AAU-A

Fresh fruits were dipped in the suspension of two strains each of *Trichoderma* and *Pseudomonas* @ 2 X 10^6 CFUs /ml and shade dried during the first year while sprays of respective treatments were made on the trees in orchard and the fruits were picked one day after the spray and brought to the laboratory for storage studies. Fruits were stored in cartons with holes and paddy straw lining inside. The pathogens that cause the infection were identified. Per cent fruits infected by post harvest pathogens were worked out. Per cent area of fruit surface infected by the pathogen (visual observations) was recorded. Number of fruits that have been infected in each

Table 19. Evaluation of biocontrol agents against pod borers and diseases of chickpea (2007 and 2008 pooled data)

Treatments	Seed germination (%)	Pod borer damage (%)	Disease incidence (%)		Yield (kg/ha)
			Wilt	Blight	
T1	77.0[a]	2.3[a]	5.4[c]	5.4[c]	1,246.5[a]
T2	77.3[a]	2.5[a]	6.7[b]	6.3[b]	1,125.5[b]
T3	76.3[a]	3.6[a]	11.9a	12.6[a]	927.5[c]

Figures followed by the same letter in table are not significantly different from each other by DMRT (P=0.05)

category were recorded. Average fruit surface area infected was calculated.

The results revealed that *Pseudomonas* strain 27 performed excellent recording only 1% fruit area infected 2 days after treatment and the progressive fruit area infected 10 days after the treatment was only 12.2%. The next best treatment was *Pseudomonas* strain 3 recording 1.1 per cent fruit area infection 2 days after treatment.

5.2.4. Biological control of plant parasitic nematodes

(a) Redgram

(i) AAU, Anand

A field experiment was conducted on pigeonpea variety BDN2 on the biological control of plant parasitic cyst nematodes at farmers' field at Jambusar (Dist-Bhuruch) during *Kharif* 2008. One kg of talc formulation of fungus was mixed with 100kg of completely decomposed dry FYM. Water was sprinkled on the mixture to provide sufficient moisture. FYM was covered with tarpaulin and left for 15 days with intermittent mixing. Presence of green coloured conidial growth on FYM was observed. Such FYM was used for the soil application. Agronomical and plant protection measures were followed as per University recommendation.

There was no difference with respect to plant height between the treatments. Combined application of *T. harzianum* + *P. chlamydosporia* exhibited significantly higher number of unhealthy (parasitized/ diseased) cysts in comparison to the rest of the treatments evaluated. Individual application of *T. harzianum* and *P. chlamydosporia* was equally effective and found to be statistically at par with each other, but significantly inferior to combined application of *T. harzianum* + *P. chlamydosporia*. Significantly higher yield was recorded in plots treated with combination of *T. harzianum* and *P. chlamydosporia*. Plots treated with either *T. harzianum* or *P. chlamydosporia* performed equally well in terms of grain yield (Table 20.).

Table 20. Effect of biocontrol agents and organic manures on *Heterodera cajani* in pigeonpea

Treatments	Plant Height (m)	Cyst Population (*H. cajani*/ 250 cc soil)	Eggs/ juveniles/ cyst	Parasitised/ diseased/ unhealthy cysts	Grain Yield (kg/ha)
T. harzianum @ 5.0 kg/ha talc formulation (10^8 spores/g)	0.8^a	14^b	15^b	51^{bc}	1078.70^{ab}
P. chlamydosporia @ 20kg/ha talc formulation (10^8 spores/g)	0.7^a	17^b	15^b	52^{bc}	1110.80^a
T. harzianum + *P. chlamydosporia*	0.8^a	14^b	11^b	72^a	1250.30^a
Carbofuran @ 2.0 kg a.i./ha (100 g/m^2)	0.7^a	17^b	16^b	45^c	911.00^{bcd}
Vermicompost (VC) @ 1 t/ha (50 g/m^2)	1.1^a	16^b	15^b	51^{bc}	916.00^{bc}
Neem cake (NC) @ ½ t/ha	0.6^a	17^b	16^b	59^{ab}	918.00^{bc}
VC+ Carbosulfan seed treatment @ 3% (W/W)	0.5^a	17^b	16^b	51^{bc}	917.00^{bc}
NC+ Carbosulfan seed treatment @ 3% (W/W)	0.7^a	17^b	15^b	53^{bc}	916.00^{bc}
Carbosulfan seed treatment @ 3% (W/W)	0.5^a	18^b	15^b	55^{bc}	912.30^{bc}
Control	0.9^a	118^a	19^b	13^d	757.00^c

Figures followed by the same letter in table are not significantly different from each other by DMRT (P=0.05)

(ii) MPKV, Rahuri

Results of the experiment conducted to evaluate the antagonistic fungi against the reniform nematode *Rotylenchulus reniformis* in redgram (var. Vipula) in *Kharif* 2008 at Rahuri revealed that combined application of *T. harzianum* @ 5 kg/ha and *P. chlamydosporia* @ 20 kg/ha was the most effective in reducing the reniform nematode population (number of females) and increased the yield of pigeonpea (Table 21). The ICBR of the combined treatment worked out be 1: 1.92.

Table 21. Efficacy of bioagents against the reniform nematode in pigeonpea

Treatment	Nematode population/ 200 cm³ soil	No. of females/ 5 g roots	Yield (kg/ ha)
T. harzianum	310.4[b]	19.8[b]	1,630[b]
P. chlamydosporia	273.1[a]	17.4[a]	1,680[a]
T. harzianum + *P. chlamydosporia*	220.9[a]	15.6[a]	1,750[a]
Carbofuran 3G	282.0[a]	18.6[b]	1,650[a]
Untreated control	560.0[c]	25.6[c]	1,290[c]

(b) Tomato: AAU- Anand

A field study was carried out to evaluate *P. lilacinus* and *P. chlamydosporia* @ 20 kg/ha each against the root knot nematode, *Meloidogyne incognita* in Tomato (Cv. Pusa Ruby) with Carbofuran @ 2kg ai/ ha as check. The average initial juvenile nematode population per 250 cc soil was 281.0 in the field.

The results revealed a significant difference in the plants treated with *P. lilacinus* which exhibited good impact on egg mass parasitization compared to *P. chlamydosporia* after 45 DAP of crop, but at harvest both the treatments were found to be at par in their efficacy (Table 22).

(c) Citrus: MPKV, Rahuri

The experiment was conducted at MPKV, Rahuri during *Kharif* 2008 on a 6 year old sweet orange with 6 x 6 m spacing. The bioagents *P. lilacinus* @ 20 kg/ ha talc formulation (10^8 spores/g), *P. chlamydosporia* @ 20 kg/ha talc formulation (10^8 spores/g) and carbofuran 3G @ 1 kg ai/ha were applied in soil along with FYM and a basal dose of fertilizers.

P. lilacinus @ 20kg/ha talc formulation containing 10^8 spores/g was found to be effective in reducing the citrus nematode population (41.3%) and number of females in roots (34.6%) and increased 19.56% yield of sweet orange with 1:9.53 ICBR (Table 23).

(d) Pomegranate: AAU-Anand

A field experiment was conducted in pomegranate (var. Sinduri) orchard in farmers field to evaluate the biocontrol agents against cyst nematode. Plant

Table 23. Efficacy of bioagents on the citrus nematode

Treatment	Nematode population/ 200 cm³ soil	females/ 5 g roots	Yield (kg/ ha)	ICBR
P. lilacinus	364.0[a]	12.0[a]	1600[a]	1: 9.53
P. chlamydosporia	404.0[a]	13.6[a]	1500[a]	1: 5.85
Carbofuran 3G	392.0[a]	13.4[a]	1570[b]	1: 6.48
Untreated control	700.0[b]	24.2[b]	1340[d]	-

In a column means followed by similar letter are not different statistically (P=0.05) by D.M.R.T.

Table 22. Efficacy of biotic agents against *Meloidogyne incognita* on tomato.

Treatments	Egg mass/ root system	Parasitized egg mass/ root system (45 DAP)	Egg mass/ root system at harvest	Parasitized egg mass/ root system at harvest	Final nematode population at harvest
P. lilacinus @ 20 kg/ha	19.20	9.80	54.80	17.62	161.40
P. chlamydosporia @ 20kg/ha	26.80	11.80	72.00	18.80	185.00
Carbofuran 2kg ai/ha	9.00	0.00	32.80	0.00	116.00
Control	59.40	0.00	134.80	0.00	390.20

Table 24. Effect of Biocontrol agents and organic manures on plant growth parameters and Root Knot nematode population in pomegranate

Treatment	Nematode count / 200 cm^3 soil+ 5 g roots*	Saprozooic Count / 200 cm^3 soil+ 5 g roots*	Root knot index
P. lilacinus @ 100g/Plant (T1)	1,698 [d]	2,512 [d]	1.67 [bc]
P. chlamydosporia @ 100g/Plant (T2)	316 [e]	1,778 [g]	1.9 [abc]
Mustard Cake alone @ 2.0 T/ha (may vary with the crop age) (T3)	26 [f]	10,965 [a]	1.3 [bc]
FYM alone @ 2.5 T/ha (may vary with the crop age) (T4)	1950 [cd]	2,570 [e]	1.8 [bc]
T1 + T3	14 [h]	1,950 [f]	1.0 [c]
T2 + T3	18 [g]	1,585 [h]	1.1 [cd]
T1 + T4	4,571 [a]	2,692 [b]	2.0 [b]
T2 + T4	1,905 [cd]	1,778 [g]	3.2 [a]
Carbofuran 2.0 kg ai/ha	3,802 [a]	1,023 [j]	1.6 [bcd]
Phorate 10 G	2,754 [b]	1,349 [i]	1.9 [bc]
Control	2,399 [bc]	2,042 [e]	3.2 [a]

height and plant canopy measured before impose of treatments revealed non-significant results suggesting homogeneity in different plots. Nematode population extracted after 6 months from the samples of 200 cm^3 soil and 5g roots revealed least number of nematodes was found in plants treated with *P. lilacinus* + mustard cake. Least Root Knot Index (RKI) was also recorded in *P. lilacinus* + mustard cake followed by *P. chlamydosporia* along with mustard cake (Table 24).

5.2.5. Biological suppression of sugarcane pests

(i) Demonstration of *Trichogramma chilonis* against the plassey borer *Chilo tumidicostalis*

AAU-Jorhat

Large scale demonstration of effectiveness of *T. chilonis* against the plassy borer was carried out in a farmer's field on Co BLN 9605 variety at Halowagaon in Golaghat district over an area of 10 ha. Nine releases of *T. chilonis* were made @ 50,000/ ha/release at 10 days interval from July second week to October first week, 2008. The release of *T. chilonis* resulted in significantly reduced infested cane and higher cane yield (84,450 kg/ha) than in farmers' practice. (fig.26)

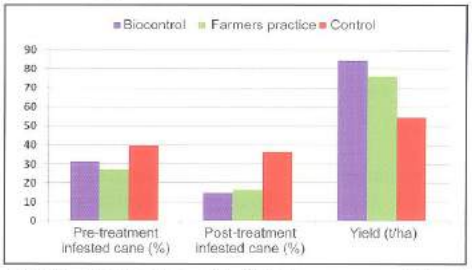


Fig. 26. Evaluation of *Trichogramma chilonis* against plassey borer

(ii) Demonstration on the use of *T. chilonis* (temperature-tolerant strain) against the early shoot.

PAU

Large scale field demonstration of *T. chilonis* against the early shoot borer *C. infuscatellus* was carried out at villages Gohawar (Distt. Jalandhar) and Chachrari (Distt. Kapurthala) and the results compared with chemical control. The plot size was 100 ha and the parasitoid, *T. chilonis* was

released 8 times at 10 days interval during April to June @ 50,000 per ha. In chemical control, cartap hydrochloride (Padan 4G) @ 25 kg/ha was applied 45 days after planting.

The incidence of early shoot borer was significantly reduced by *T. chilonis* release (Table 25). The mean parasitism of eggs of *C. infuscatellus* in *T. chilonis* release plot was 51.2%. The yield was significantly higher with a cost:benefit ratio of 1:13.8.

Table 25. Demonstration of *T. chilonis* (temperature-tolerant strain) against *C. infuscatellus* at village Nangal Khera (Distt. Jalandhar) and Paddi Khalsa (Distt. Kapurthala) during 2007.

Treatments	Incidence of *C. infuscatellus* (%)	Parasitism (%)	Yield (kg/ha)	Cost: Benefit ratio
T. chilonis (temperature tolerant strain)	4.6 a	51.2a	69,000[a]	1: 13.8
Chemical control (Padan @25kg/ha)	4.5[a]	4.2[a]	70,150[a]	1: 6.2
Control	12.4[b]	7.7[b]	64,000[b]	

Means followed by the same letter in a column are not significantly different (P=0.05)

SBI

Evaluation of *T. chilonis* against shoot borers showed that the dead heart incidence was significantly reduced after the release of the parasitoid resulting in more number of healthy shoots. The per cent parasitism and parasitoid emergence showed that effective dispersal up to 10 m in 48 hrs and 25 m in 72 h could be achieved. Beyond 72 hrs there was seldom any movement in cards beyond 10m in any direction. Dispersal did not vary with the direction.

(iii) Demonstration on the use of temperature tolerant strain of *T. japonicum* against top borer

PAU

Large scale field demonstration of temperature tolerant strain of *T. japonicum* against the top borer, *Scirpophaga excerptalis* was carried out at villages Rawalpindi (Distt. Kapurthala) and Mehli (Distt. Jalandhar) and the results compared with chemical control. The parasitoid, *T. japonicum* was released 8 times at 10 days interval during April to June @ 50,000 per ha. In chemical control, phorate (Thimet 10G) @ 30 kg/ha was applied during the last week of June.

When *T. japonicum* was released, the incidence of top borer was significantly reduced, the mean parasitism was 23.6% and the yield was enhanced significantly with a cost:benefit ratio of 1:10.7 (Table 26).

Table 26. Demonstration of *T. japonicum* (temperature-tolerant strain) against *S. excerptalis* at village Rawalpindi (Distt. Kapurthala) and Mehli (Distt. Jalandhar) during 2008.

Treatments	Incidence of *S. excerptalis* (%)	Parasitism (%)	Yield (kg/ha)	Cost: Benefit ratio
T japonicum (temperature tolerant strain)	7.4[a]	23.6[a]	72,230[a]	1: 10.7
Chemical control (Thimet 10G @ 30 kg/ha)	6.9[a]	2.4[b]	73,100[a]	1: 3.7
Control	15.6[b]	2.6[b]	68,330[b]	

(iv) Demonstration of *T. chilonis* against stalk borer

PAU

A large scale field demonstration on efficacy of *T. chilonis* for the management of *Chilo auricilius* was conducted over an area of 40 ha at village Paddi Khalsa (Dist. Kapurthala). *T. chilonis* was released 12 times at 10 days interval during July to October @ 50,000 per ha. The incidence of stalk borer was significantly lower (5.6%) in the release field in comparison to control (12.8%). The percent parasitisation was significantly higher in release fields (55.6%) as compared to control (4.9 %).

(v) Demonstration on the use of *T. chilonis* against internode borer (INB)

TNAU

Large scale field demonstration of *T. chilonis* against the internode borer was carried out at four locations on variety Co 86032 in 8 ha area and the results compared with control. The parasitoid, *T. chilonis* was released 8 times at 10 days interval during September to November @ 1,00,000 per ha. The incidence of internode borer was significantly reduced by *T. chilonis* release. The mean incidence of inernode borer in parasitoid release plot was 12.1% and the intensity of damage was 2.9% which was significantly lower as compared to control (22.0% and 10.0%, respectively). Significantly higher yield (1,15,200 kg/ha) was recorded in parasitoid release plots compared to control.

MPKV

Field demonstration of *T. chilonis* (TTS and SAS strains) against internode borer on sugarcane revealed that six releases @ 1 lakh/ha/release found effective in reducing the pest incidence and intensity in sugarcane.

SBI

Field evaluation of *T. chilonis* against internode borer was done in combination with INB Pheromone. *T. chilonis* was released @ 12.5 cc per hectare. Release of *T. chilonis* either alone or in combination of pheromone significantly reduced INB incidence and increased the yields compared to control (Table 27).

Field evaluation of *T. chilonis* @ 12.5 cc per hectare against internode borer revealed that the incidence of INB was 52.4% in release plot compared to 74.8% in control. The yield in released plot was significantly higher (1,53,400 kg/ha) than control and there was a 29.95% reduction in the INB incidence and 13.29% increase in yields in parasitoid released plots compared to control plots.

Two field trials were conducted in farmers fields to compare the effect of six releases and continuous release of *T. chilonis*. Continuous release of *T. chilonis* has resulted in lowest incidence (41.3%), intensity of damage (2.1%), dead hearts (8.9%) and highest yield (2,02,060 kg/ha) as compared to six releases and control.

Table 27. Evaluation of *T. chilonis* in combination with pheromone against internode borer

Treatment	Incidence of INB (%)	Intensity of INB (%)	Yield (kg/ha)
T. chilonis	43.68[a]	2.34[a]	1,38,100[a]
Pheromone	52.2[a]	2.68[a]	1,27,900[b]
T. chilonis + pheromone	44.4[a]	2.42[a]	1,35,300[a]
Control	63.23[b]	4.15[b]	1,21,620[c]

(vi) Bio-intensive management of stalk borer, *Chilo auricilius* and internode borer, *Chilo sacchariphagus indicus*

IISR

A field trial was conducted at IISR research farm on sugarcane variety CoLk8102. The treatments were: a) release of *T. chilonis* @ 50,000 /ha from July to October at 10 days interval, b) release of *Cotesia flavipes* @ 500 gravid females/ha from July to November at 7 days interval and c) release of *Tetrastichus howardi* @ 5000 adults/ha at monthly interval from July to November.

Table 28. Evaluation of six and continuous releases of *T. chilonis* against internode borer

Treatment	Incidence of INB (%)	Incidence of stalk borer (%)	Yield (kg/ha)
T. chilonis-	5.6[a]	13.4[b]	60,710[a]
Cotesia flavipes	7.5a	5.6[a]	51,440[b]
Tetrastichus howardi	9.7[b]	10.9[b]	46,990[cd]
Removal of dry leaves, late shoots and water shoots	7.8[b]	13.4[c]	50,110[bc]
T. c + *C. f* + *T. h.* + removal of dry leaves, late shoots and water shoots	7.6[b]	11.0[b]	48,840[bc]
Control	12.7[d]	17.3[d]	43,840[d]

T. chilonis release plots recorded lowest internode borer incidence (5.6%) compared to *C. flavipes* or *T. howardi* released fields, but *C. flavipes* release plots recorded lowest incidence of stalk borer (5.6%) followed by *T. howardi* and *T. chilonis*. Highest yield was recorded in *T. chilonis* release plots (Table 28).

(vii) Survey for sugarcane woolly aphid (SWA) and its natural enemies

TNAU

The field survey in 17 districts of Tamilnadu revealed a drastic reduction (below 3%) in the incidence of SWA during 2008-09. This low incidence of SWA was attributed to the activity of *Dipha*, *Micromus* and Syrphids.

MPKV

The survey was conducted in eight districts of Western Maharashtra and two districts of marathwada region. The incidence of SWA was below 1.85% during 2008-09.

SBI

Seven major sugar mills conducted the field survey and it was revelaed that the incidence of SWA was either nil or negligible.

AAU- Jorhat

The field survey during 2008-09 in Assam revealed that the maximum incidence of SWA was during September (4.9%) and nil in February. The highest population of *D. aphidivora* (8.5/leaf), *Micromus* (7.2/leaf) and syrphids (4.9/leaf) was recorded during September.

(viii) Biological control of termites

IISR

(a) Evaluation of *Metarhizium anisopliae* against termites

A field experiment was conducted at IISR research farm on variety CoLk 8102. *Metarhizium anisopliae* strains (1,2,3,4) supplied by PDBC Bangalore was mixed with soil and applied in furrows at the time of planting. The strain 4 of *M. anisopliae* recorded germination of 18.2% which was superior to control (13.8%) and inferior to chemical treatment (23.33%).

(b) Evaluation of entomopathogenic nematode (EPN) against termite

On var. CoLk 8102, the talk-based formulations of entomopathogenic nematodes applied in furrow at time of planting. The germination was recorded in each row after 45 days of planting. Soil application of *Heterorhabditis indica* PDBC-EN 13.31 @ 2.5 b/ ha resulted in a germination percentage of 21.3%, which was superior to control (17.3%) and inferior to chlorpyriphos (25.1%).

5.2.6. Biological suppression of cotton pests

(i) Demonstration of bio-Intensive Pest Management in *Bt* cotton

Multi-location demonstrations were conducted during the year 2008-09 to evaluate the biocontrol based-IPM (BIPM) package for the management of pests and disease in Bt cotton. Two modules were tested – Bt cotton with BIPM module and Bt cotton with farmers' practice.

PAU

The experiment on demonstration of BIPM of *Bt* cotton was conducted at Vander Jatana (Distt. Faridkot) on RCH 134 *Bt* cotton over an area of 10 acres during 2008. It was compared with farmers' practice (Two sprays of imidacloprid @ 100 ml/ ha and endosulfan @ 2.5 l/ ha).

The number of predators per three leaves was higher in BIPM package while the leaf hoppers were lower in BIPM in comparison to farmers' practice. Seed cotton yield in BIPM package and farmers' practice were on par (Table 29).

Table 29. Impact of BIPM in *Bt* cotton (Vander Jatana, Punjab)

Treatments	Sucking pests / 3 leaves		Predators/ 3 leaves	Seed cotton yield (kg/ha)
	Leaf hopper	Whitefly	Buds	
BIPM	1.3[b]	3.9[b]	0.4	2,380
Farmer's practice	1.5[a]	3.5[a]	0.3	2,400

Means followed by the same alphabet in a column are not significantly different (P=0.05)

AAU (Anand)

The experiment was laid out in a farmer's field at Shardapura village on one hectare Ankur 155 *Bt* cotton during *Kharif* 2008. Incidence of aphids, leafhopper and whiteflies and percentage damage to buds, green bolls and locule by *Earias* and pink bollworm were lower in BIPM module compared to farmers' practice (Table 30). The seed cotton yield was significantly higher compared to farmers' practice. There was 32.17% increase in seed cotton yield and an increase in predatory population in BIPM package in comparison to farmers' practice.

ANGRAU

Data from the experiment laid out in a farmers' field at Kothapalli Village during *Kharif* 2008 showed that the mean square and boll damage was significantly less and the yield was higher in *Bt* cotton with BIPM module as compared to farmers practice and local check (Table 31). The cost:benefit ratio was 1:1.81 in BIPM package compared to 1:1.03 in farmers' practice. Higher egg parasitism and coccinellid and spider population were recorded in BIPM package compared to farmers practice.

TNAU

BIPM package on *Bt* cotton recorded significantly low population of leafhoppers, aphids, thrips and whiteflies, low bollworm damage by *Earias* sp. and *H. armigera* and higher seed cotton yield with a cost benefit ratio of 1 :1.9 in *Bt* in comparison to farmers' practice (Table 32).

Table 31. Impact of BIPM module on *Bt* cotton (Kothapalli, Andhra Pradesh)

Parameters	Bt cotton + BIPM	Bt cotton + Farmer's practice	Check
Aphids/ 3 leaves	5.7[a]	7.2[b]	9.3[c]
Thrips/3 leaves	12.3[a]	16.7[b]	21.4[c]
Leaf hoppers/3 leaves	12.2[a]	17.2[b]	21.1[c]
White flies/3 leaves	0.2	0.3	0.2
Mean square damage (%)	0.5	0.72	0.6
Mean bolls damage (%)	0.81	0.62	0.8
Seed cottonl yield (kg/ha)	1,823[a]	1,757[a]	1,053[b]
CBR	1:1.81	1:1.27	1:1.09
Egg parasitism (%)	3.1[a]	1.6[b]	3.4[a]
Coccinellids/50 plants	12.8[a]	2.6[c]	12.1[b]
Spiders/50 plants	3.4[b]	2.0[c]	5.2[a]

MPKV

A large scale field demonstration was conducted in a farmers' field at village Ambapur, Dist. Dhule at

Table 30. Impact of BIPM in Bt cotton (Shardapura, Andhra Pradesh)

Treatments	Sucking pests / 15 leaves			Damage by bollworms (%)				Seed cotton yield (kg/ha)
	Aphid	Leaf hopper	Whitefly	Buds	Green bolls	Locules		
						Earias	BW	
BIPM	7.9[b]	2.1[b]	1.0[b]	3.0[b]	2.3[b]	2.5[b]	1.4[b]	3,114[a]
Farmer's practice	19.8[a]	3.6[a]	1.9[a]	5.5[a]	5.1[a]	3.9[a]	2.5[a]	2,356[b]

Means followed by the same alphabet in a column are not significantly different (P=0.05)

Table 32. Impact of BIPM in *Bt* Cotton during 2008 (Chinnakanur, Tamilnadu)

Treatments	Population of Sucking pests /5 plants				Boll damage (%)		Seed cotton yield (kg/ha)
	Leaf hoppers (60 days)	Aphids (75 days)	Thrips (90 days)	Whiteflies (105 days)	*Earias* sp.	*H. armigera*	
BIPM	22.1[a]	3.3[a]	3.0[a]	4.6[a]	1.1[a]	1.9[a]	2,169[a]
Farmer's practice	38.6[b]	21.2[b]	11.4[b]	11.8[b]	3.4[b]	3.9[b]	1,894[b]

Means followed by the same alphabet in a column are not significantly different (P=0.05)

Table 33. Impact of BIPM on *Bt* cotton (Ambapur, Maharashtra)

Treatment	Sucking pests population / 3 leaves					Bollworm damage (%) (*E. vitella*)	Seed cotton yield (kg/ ha)
	Aphid	Leaf hopper	Thrip	Whitefly	Mealy bug		
BIPM package	12.0	19.0	1.8	1.7	12.0	0.4	2,420
Farmers' practice	4.0	8.2	0.3	2.2	1.8	1.0	2,030

Maharashtra over 4 ha on Bt cotton Rashi 2. Though the population of aphids, leaf hopper, mealy bug and thirps was higher in BIPM package than farmers practice, the bollworm damage was lower and the seed cotton yield was significantly higher (Table 33).

UAS- Raichur

Demonstration of Bio intensive Pest Management in Bt cotton was conducted at Dinni village of Raichur taluk over an area of 10 ha in farmers field during 2008-09 *Kharif* season. The results clearly indicated that sucking pest population was on par in BIPM and farmers practice plot. Highest net profit (Rs 59,925/ ha) was realised in BIPM plot compared to farmers practice plot.

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

Multi-location trials were conducted to evaluate the efficacy of *Trichogrammatoidea bactrae* against the pink bollworm (PBW) *P. gossypiella*. The parasitoids were released 3-4 times @ 1,50,000 adults/ha per week synchronizing with appearance of pink bollworms.

ANGRAU

The experiment was conducted during *Kharif*, 2008 at College farm, Rajendranagar. The pink bollworm population and boll damage were lower in BIPM plot compared to farmers' practice plot and untreated control. Seed cotton yield was significantly higher in BIPM package (1689 kg/ha) compared to farmers practice (1432 kg/ha) and control (987 kg/ ha).

AAU (Anand)

The experiment was conducted at Anand during *Kharif*, 2008 on H-10 cotton. Significantly lower pink bollworm larval population, lower boll and locule damage were recorded in BIPM package plots over the untreated control (Fig. 27). Significantly higher seed cotton yield (2,022 kg/ha) was realized in BIPM package compared to farmers practice (1,789 kg/ha) and control (1,508 kg/ha).

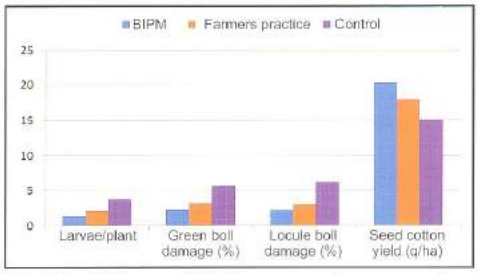


Fig. 27. Efficacy of *Trichogramma bactrae* against pink boll worm

TNAU

The experiment was conducted on Bt cotton at Coimbatore. Release of *Tr. bactrae* @ 1.5 lakhs/ ha four times at weekly interval starting from 80 days after germination was found effective in reducing the larval population of PBW, its damage to bolls and locules and in increasing the seed cotton yield (Table 34).

Table 34. Efficacy of *T. bactrae* on incidence of PBW in *Bt* cotton in Coimbatore

Treatment	Larvae/ plant	% Damage to		Seed cotton yield (kg/ha)
		Bolls	Locules	
Release of *T. bactrae* + BIPM	5.4[a]	14.1[a]	8.6[a]	1,721[a]
Farmer's practice	9.4[b]	20.2[b]	14.4[b]	1,563[b]
Untreated control	14.3[c]	25.7[c]	19.9[c]	1,319[c]

Means followed by the same alphabet in a column are not significantly different (P=0.05)

MPKV

The experiment was conducted on RCH-2 cotton at Rahuri. Release of *Tr. bactrae* @ 1.5 lakhs/ ha three times at weekly intervals starting from 80 days after germination, was found effective in reducing the larval population of PBW and its damage to bolls and locules and increasing the seed cotton yield (Table 35).

Table 35. Efficacy of *T. bactrae* on incidence of PBW in *Bt* cotton (Rahuri, Maharashtra)

Treatment	Larvae/ plant	% Damage to		Seed cotton yield (kg/ha)
		Bolls	Locules	
Release of *Tr. bactrae* + BIPM	1.5[a]	15.4[a]	16.6[a]	1,730[a]
Farmer's practice	2.1[b]	12.8[a]	15.6[a]	1,930[a]
Untreated control	4.8[c]	25.4[b]	33.2[b]	1,080[b]

Means followed by the same alphabet in a column are not significantly different (P=0.05)

(iii) Enhancement of natural enemy population in cotton by habitat manipulation

Rainfed cotton

Multi-location experiments were conducted during the year 2007-08 to enhance the natural enemy population by habitat manipulation in rainfed cotton. The following modules were tested in PAU and ANGRAU:

M_1: **Habitat Management**: Four paired rows of cotton interspersed with one paired row consisting of one row of cowpea and one row of marigold; one paired row of sorghum grown all-round the plot as border crop. Eight releases of *T. chilonis* @1,50,000/ha made at weekly intervals from July to October.

M_2: **BIPM practice**: Twelve releases of *T. chilonis* @1,50,000/ha at weekly intervals from July to October. Need based NPV sprays against *H. armigera* and *S. litura*.

M_3: **Insecticidal control**: One spray of imidacloprid 200SL @100ml/ha for the control of cotton leaf hoppers, one spray of deltamethrin 2.8EC @ 11.2 g a.i./ha and second of endosulfan 35 EC @ 87.5 g a.i./ha against spotted bollworm (*Earias* sp.).

ANGRAU

Results of the experiment at College farm, Rajendranagar during *Kharif* 2008-09 showed that the population of aphids, leaf hoppers and whitefly and square and boll damage were lower in habitat managed plots compared to BIPM and Insecticidal spray plots. Habitat management plot recorded significantly higher natural enemy population and yield as compared to BIPM and farmers practice (Table 36).

AAU (Anand)

The experiment was conducted in the agronomy farm, Anand during Kharif, 2008 on H-10 cotton with. The following three modules were tested:

M_1: Treatment of cotton seeds with *Trichoderma* @ 5 g/kg seeds + cotton interspersed with *Cassia occidentalis* (6:1) + planting of maize and zinnia @ 10 % plants + one release of *T. chilonis* @ 1.5 lakh/ha with the oviposition by *Catopsilia pyranthe* on *C. occidentalis* + one release of 5000 larvae of *C. carnea* coinciding with the appearance of aphids.

Table 36. Impact of habitat manipulation on cotton pest complex (Warangal, Andhra Pradesh)

Crop Module	Sucking pests/3 leaves			% Damage by boll worms			Seed cotton yield (kg/h)
	Aphids	Leaf hoppers	White fly	Square	Boll	Locule	
Habitat management	6.1[a]	13.7[a]	0.7	0.61	0.93	0.63	1,253[a]
BIPM	8.3[b]	18.5[b]	0.5	0.83	0.76	0.87	1,052[b]
Insecticidal spray	10.7[c]	23.8[c]	0.4	0.78	0.89	0.89	1,158[a]

Means followed by the same alphabet in a column are not significantly different (P=0.05)

Table 37. Impact of habitat manipulation on insect pests and yield of cotton at Anand

Treatments	Sucking pests / 15 leaves			Damage by bollworms (%)				Seed cotton yield(kg/ha)
	Aphid	Leafhopper	Whitefly	Buds	Green bolls	Locules		
						Earias	BW	
M_1	4.0 ^{c}	2.0 ^{c}	1.0 ^{c}	3.7 ^{c}	2.1 ^{c}	2.6 ^{c}	1.3 ^{c}	2,458 ^{a}
M_2	5.1 ^{b}	2.9 ^{b}	1.2 ^{bc}	4.6 ^{c}	3.7 ^{b}	2.8 ^{bc}	1.6 ^{c}	2,236 ^{a}
M_3	4.9 ^{b}	2.9 ^{b}	1.3 ^{b}	5.0 ^{b}	3.6 ^{b}	3.9 ^{ab}	2.4 ^{b}	2,055 ^{ab}
M_4	7.1 ^{a}	4.5 ^{a}	2.1 ^{a}	7.3 ^{a}	5.4 ^{a}	4.1 ^{a}	4.6 ^{a}	1,777 ^{b}

Means followed by the same alphabet in a column are not significantly different (P=0.05)

M_2: Treatment of cotton seeds with *Trichoderma* @ 5 g/kg seeds + cotton interspersed with *C. occidentalis* (6:1) + sowing/ planting of maize and zinnia @ 10 % plants.

M_3: Insecticidal Control (University recommended insecticides)

M_4: Untreated Control

The results revealed that the lowest number of aphids, leaf hoppers and whitefly, lower damage to buds, green bolls and locules and highest yield of seed cotton was recorded in M1 module (Table 37). The habitat manipulation plot also recorded a higher predatory population and parasitism by *T. chilonis*.

PAU

The experiment on enhancement of natural enemy population in Bt cotton (LH 2076) by habitat manipulation was conducted at the Entomological Farm, PAU, Ludhiana. Leaf hopper and whitefly populations and spotted bollworm incidence were significantly lower in the insecticidal control plot as compared to habitat management and BIPM plots. Habitat managed plot recorded a yield which was on par with that of BIPM plots (Table 38).

MPKV

The trial was laid out on the research farm of the Agricultural College, Pune on Kanaka cotton. The following three modules were tested.

M_1: Four paired rows of cotton interspersed with one paired row of cowpea (var. C-9) and one row of marigold, paired row of maize as border crop around the plot, release of *C. carnea* @ 5,000 larvae/ ha synchronizing with appearance of sucking pests, release of *T. chilonis* @ 1.5 lakh adults/ ha /week coinciding with egg laying of boll worm

M_2: Cotton without intercrop/ border crop (with BIPM practice)

M_3: Farmers' practice

The treatments with intercrops and BIPM practices were significantly more effective than farmers' practice in reducing the sucking pest population, boll worm damage and increasing natural enemy population and yield of seed cotton. In M_1 besides seed cotton yield additional returns were obtained from cowpea and marigold (Tables 39). The habitat manipulated plot recorded higher population of chrysopids and coccinellids and the ICBR worked out be 1: 1.46.

Table 38. Enhancement of natural enemy population in cotton by habitat manipulation in Punjab during 2008.

Treatments	Leaf hoppers / 3 leaves	White fly / 3 leaves	Fruiting bodies damage by *Earias* sp. (%)	Green boll damage (%)	Natural enemies** per plant	Seed cotton yield (kg/ha)
Habitat Management	1.1 ^{b}	1.5 ^{b}	9.8 ^{c}	6.6 ^{b}	1.5	990 ^{b}
BIPM	1.5 ^{c}	1.4 ^{ab}	7.1 ^{b}	6.2 ^{b}	1.2	940 ^{b}
Insecticidal control	0.9 ^{a}	1.2 ^{a}	3.4 ^{a}	0.5 ^{a}	0.2	1,120 ^{a}

Means followed by the same alphabet in a column are not significantly different (P=0.05)

**Natural enemies included *Chrysoperla* sp., *Zelus* sp., *Geocoris* sp. and spiders

Table 39. Impact of crop habitat manipulation on sucking pest complex and yield of cotton (Pune)

Module	Pest population / 3 leaves				Green boll damage (%)	Locule damage (%)	Seed cotton yield (kg/ha)
	Aphid	Leaf hopper	Thrip	Whitefly	*E. vitella*		
M_1	26.9[a]	4.2[a]	17.5[a]	2.7[a]	4.4[a]	5.3[a]	1,750[a]
M_2	25.7[a]	3.8[a]	22.7[b]	2.5[a]	5.4[b]	6.8[b]	1,810[a]
M_3	35.3[b]	5.8[b]	28.0[c]	4.3[b]	8.7[c]	8.4[c]	1,510[b]

Means followed by the same alphabet in a column are not significantly different (P=0.05)

(iv) Identification of natural enemies of mealybugs on cotton and evaluation of potential natural enemies

TNAU

A field trial was conducted at a farmers' field in Puthur village. Two releases of *C. montrouzieri* beetles were made @ 1500/ha at 15 days interval. Release of *C. montrouzieri* beetles brought down the mealybug population from 153.4 to 80.4 per 5 cm twig which was on par with farmers practice of chemical application and significantly superior to untreated control.

5.2.7. Biological suppression of tobacco pests

(i) Studies on the influence of water quality on the efficacy of entomopathogens against tobacco pests

CTRI

*Sl*NPV suspension with pH 7 recorded the lowest seedling damage by *S. litura* 7 days after application indicating greater NPV action. *Sl*NPV with pH 5 and 9 recorded relatively more seedling damage indicating lesser NPV activity. Seventy two hours after application, the mortality of larvae was highest in *Sl*NPV with pH 7, 6 and 8. Lowest mortality was noticed in control (water spray) followed by *Sl*NPV applied at pH 5 (Table 40).

Table 40. Effect of water quality (pH) on SlNPV

pH	Seedlings damage after 7 days (%)	Larval mortality days after	
		3	7
5	14.12[b]	48.25[b]	100
6	10.12[ab]	61.25[a]	100
7	9.12[a]	66.25[a]	100
8	11.62[ab]	58.75[ab]	100
9	19.50[c]	48.75[b]	100
Control (water spray)	31.00[d]		

Means followed by the same letter in a column are not significantly different (P=0.05%)

It was concluded that to obtain satisfactory control of *S. litura* in tobacco nurseries using SlNPV, the optimum pH of spray solution is 7. The pH below 6 or above 8 is detrimental to the performance of SlNPV under field conditions.

(ii) Comparative study of virulence of different isolates of SlNPV in tobacco, soybean and chilly ecosystem.

CTRI

Spodoptera litura cultures from tobacco nurseries were obtained from Jeelugumilli (West Godavari), Guntur, Rajahmundry (East Godavari), Nandyal (Kurnool) and Jeddangi (East Godavari) and NPV extracted from the diseased larvae from different populations. The different NPV isolates were tested on *S. litura* infesting tobacco transplanted crop.

Sl NPV strain collected from Rajhamundry and Jeelugumilli were highly virulent recording lowest number of larvae/ plant, lowest leaf damage and highest green leaf yield (Table 41).

(iii) Studies on Biological control options for suppression of tobacco stem borer *Scrobipalpa heliopa* (Lepidoptera: Gelichidae)

CTRI

A laboratory experiment was conducted to evaluate the efficacy of *B. thuringiensis* against the stem borer, *S. heliopa* on tobacoo. On stem,

Table 41. Efficacy of different isolates of SlNPV on *Spodoptera litura*.

Treatments (*Sl*NPV Strains)	Number of larvae/plant after 7 days	Leaf damage (%) After 7 days	Green leaf yield (kg/ha)
Jeelugumilli	3.40[a]	4.16[a]	14,714.3[a]
Guntur	6.25[c]	8.44[b]	13,040.8[a]
Rajahmundry	2.50[a]	4.10[a]	15,272.1[a]
Nandyal	6.50[c]	11.65[b]	13,040.8[a]
Jeddangi	4.25[b]	6.75[a]	14,850.3[a]
Control (water spray)	6.15[c]	18.67[c]	10,462.6[b]

Means followed by the same letter in a column are not significantly different (P=0.05%)

highest larval mortality was observed at dilutions 1:10 followed by $1:10^2$ and 10^3. Least mortality was observed in treatments $1:10^4$ to $1:10^6$ but they were superior to control (Table 42). On veins, significantly highest larval mortality was obtained in case of dilutions 1:10 followed by $1:10^2$ and 10^3. Lowest mortality was observed at dilutions 10^4, 10^5, 10^6 and control (water spray). It was concluded that 1:10 is the best dilution for Bt against stem borer.

Table 42. Effect of *Bt* (PDBC) on tobacco stemborer.

Treatments (*Bt* dilution)	Larval mortality (%)	
	On stem	On veins
1:10	67.08[a]	36.66[a]
1:100	46.66[b]	26.66[b]
$1:10^3$	35.55[c]	16.66[c]
$1:10^4$	22.21[d]	13.33[cd]
$1:10^5$	18.88[d]	6.66[de]
$1:10^6$	13.33[d]	4.44[e]
Control (water spray)	9.99[c]	6.66[de]

Means followed by the same letter in a column are not significantly different (P=0.05%)

5.2.8. Biological suppression of pulse crop pests

(i) Demonstration of biocontrol of pests and diseases of pigeonpea

The BIPM package included: a) Seed treatment with *Trichoderma* @ 6g/kg of seeds; b) soil application of *Pochonia chlamydosporia* @ 20kg/ha and *Trichoderma harzianum* 5 kg/ha (10^8 spores/g of formulation) at the time of sowing; c) NSKE 5% spray based on appearance of blister beetle or borers at flowering stage; d) application of *Ha*NPV @ $1.5x\ 10^{12}$ POB/ha along with 0.5 % crude sugar and 0.1% Teepol if *Helicoverpa armigera* is seen in early larval instars stages. Sprays may be repeated as per need. Hand-picking and destruction of full-grown larvae; e) monitoring for other borers like the blue butterflies, plume moths and *Maruca testulalis*. Repeat spray of NSKE 5% or Bt formulation @ 2 kg/ha as per need and f) maize as intercrop (one in 10 rows of pigeonpea as bird perches).

TNAU

Field trial was conducted in one hectare area in farmers' field at Nathegoundenpudur village and in the BIPM package lower incidence of pod borers,pod damage by *H. armigera* and *M. testulalis*, higher pod yield and higher CB ratio was recorded (Table 43). Similar results were obtained in another In a field trial conducted at Ammapettai village (Dt. Erode) BIPM module proved to be superior with a cost benefit ratio of 1:1.79 while in farmers practice it was 1:1.30.

ANGRAU

Field demonstration of BIPM package for pests and diseases of pigeonpea was conducted during *kharif* 2008 at Sangamukurdu village. Lower incidence of pod borers and higher yield were recorded in BIPM module in comparison to farmers' practice (Fig. 28).

Table 43. Efficacy BIPM module against pod borer complex in pigeon pea in Tamil Nadu

Observations		BIPM package	Farmers practice
Pre treatment larval population /10 plants)	*H. armigera*	22.4	29.2
	M. testulalis	10.1	9.2
Post treatment larval population /10 plants) (167 DAS)	*H. armigera*	6.2[a]	18.5[b]
	M. testulalis	3.0[a]	8.9[b]
Pod damage (%)		7.7[a]	16.1[b]
Yield (kg/ha)		714[a]	543[b]
Cost Benefit Ratio		1:1.98	1:1.27

Means followed by the same letter in a column are not significantly different (P=0.05%)

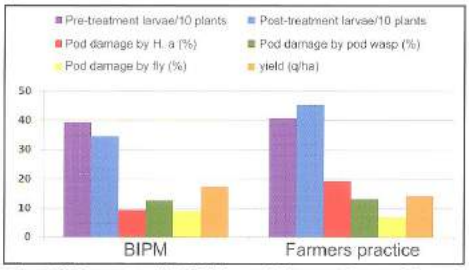


Fig. 28 Impact of BIPM module on the pod borer complex in pigeonpea in AP

AAU- Anand

A field trial was conducted in model farm, Baroda during kharif 2008 on pigeonpea variety BDN-2. Local recommendation included seed treatment with *T. viride* @ 1.0 kg/12 kg seeds, three sprays of 5% NSKE and farmers practice included seed treatement with carbendazium @ 0.1% w/w and application of endosulfan (0.07%) and monocrotophos (0.04%).

There was no significant difference in plant stand and number of *H. armigera* larvae per 5 twigs. However, signficantly lowest pod damage by *H. armigera* was recorded in BIPM practice as also higher yield compared to local recommendation and farmers practice (Table 44).

Table 44. Impact of BIPM practices on pest and diseases of pigeonpea in Anand

Observations		BIPM	Local recommendation	Farmers practice
Plant stand/10 sq.m		25.6[a]	24.6[a]	25.6[a]
Number of *H. armigera* larvae/5 twigs		1.6[a]	2.1[a]	2.5[a]
Pod damage by *H. armigera* (%)		4.4[c]	6.7[b]	12.6[a]
No. of blue butterfly larve/5 twigs		3.0[a]	3.4[a]	3.8[a]
Incidence of wilt (%)		1.1[a]	1.3[a]	1.4[b]
Pod damage (%)	*H. armigera*	5.6[c]	7.8[b]	10.1[a]
	E. atmosa	4.2[a]	3.9[a]	4.1[a]
	M. obtusa	13.6[a]	13.8[a]	13.9[a]
Grain yield (kg/ha)		1,189[a]	1,042[b]	911[c]

Means followed by the same letter in a column are not significantly different (P=0.05%)

(ii) Evauation of HaNPV against *Helicoverpa armigera* on pigeonpea

AAU- Anand

A field trial was conducted at the Agronomy farm, Anand during *Kharif* 2008. The treatment included spraying of *Ha*NPV @ 1.5 x 10^{12} POB/ha + 0.5% crude sugar + 0.1% teepol which was compared with untreated control. Application of *Ha*NPV had significantly reduced the number of larvae per 5 twigs and also pod damage by *H. armigera* (Table 45).

Table 45. Impact of BIPM practices on pest and diseases of pigeonpea in Anand

Observations		NPV	Control
Number of *H. armigera* larvae/5 twigs		1.7[a]	2.8[b]
Pod damage by *H. armigera* (%)		5.8[a]	147[b]
No. of pod fly *M. obtusa* larve/100 pods		27.4[a]	28.0[a]
Pod damage by pod fly *M. obtusa* (%)		40.0[a]	42.0[b]
Pod damage (%)	*H. armigera*	5.9[c]	10.6[b]
	E. atomosa	4.6[a]	4.5[a]
	M. obtusa	13.5[a]	14.4[a]
Grain yield (kg/ha)		1,313[a]	982[b]

Means followed by the same letter in a column are not significantly different (P=0.05%)

(iii) Microbial control of *H. armigera*, *Adisura atkinsoni* on *Dolichos lablab*

ANGRAU

A field trial was conducted at the College farm Hyderabad during *Rabi*, 2008-09 on local variety of lablab. The treatments included HaNPV at 0.375 x 10^{12} POB, 0.75 x 10^{12} POB and 1.5 x 10^{12} POB per hectare, Bt @ 1.0 kg/ha, NSKE 5%, *Nomuraea rileyi* @ 1.5 x 10^{13} conidia/ha with insecticidal check. The results revealed that the plots treated with *Ha* NPV @ 1.5 X 10^{12} POBs/ha fared well both in terms of reduction in the pest population and extent of damage. The yield obtained was comparable with the insecticidal treatment indicating that application of *Ha* NPV @ 1.5 X 10^{12} POBs/ha is a viable alternative to insecticides in field bean.

(iv) Evaluation of EPN (*Heterorhabditis* sp.) against lepidopteran pod borers of pigeonpea

ANGRAU

EPN (*Heterorhabditis* sp.) was evaluated during *Kharif* 2008-09 at College farm, Rajendranagar at dosages of 0.5, 1 and 1.5 billion nematodes/ha. The results revealed that spray application of 1.0 and 1.5 billion nematodes/ha resulted in better suppression of pod borer complex. However the yield differences were not significant (Table 46).

Table 46. Effect of *Heterorhabditis* on the incidence of *H. armigera* and yield of pigeonpea in AP

EPN dosages (billion/ha)	Larvae/ plant	Pod damage (%)	Yield* (kg/ha)
0.5	9.8[b]	16.60[b]	1,501
1.0	3.80[a]	11.00[a]	1,511
1.5	3.80[a]	11.00[a]	1,692
Control	19.00[c]	22.20[c]	1,249

Means followed by the same letter in a column are not significantly different (P=0.05)
*Differences between the means not significant

5.2.9. Biological suppression of rice pests

(i) Large-scale demonstration of IPM for rice pests and diseases in the farmers' field

Large-scale demonstration trials on IPM for rice were laid out. The IPM package included (a) seed treatment with *P. fluorescens* @ 8 g/kg of seeds/ seedling dip in 2% solution (b) *B. bassiana* @ 10^{13} spores/ha against sucking pests, (c) bird perches at 10/ha (d) *T. japonicum* @ 1 lakh/ha on occurrence of leaf folder or stem borer (e) *Bt* @ 2 kg/ha, 2-4 sprays depending on pest occurrence (f) *P. fluorescens* spray against foliar diseases and (g) need-based or spot application of botanicals.

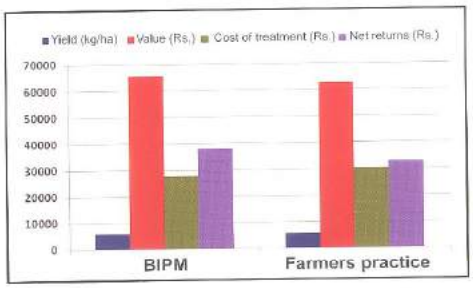


Fig. 29. Impact of IPM on rice pests and diseases (Koorkkenchery, Kerala)

KAU

The demonstration was laid out on 10 ha area at Koorkkenchery Panchayat on variety Jyothi during *Rabi* 2008. BIPM package registered significantly low incidence of dead heart, white earhead and leaf folder damage compared to farmers practice. The populations of spiders and coccinellids, grain yield and net returns were significantly higher in BIPM package compared to farmers practice (Fig. 29).

AAU-Jorhat

The demonstration was conducted on a 10 ha plot of Mahsuri rice variety in the farmers' field at Barokuri gaon, Teok, (Dist: Jorhat) during *Kharif* 2008. The results revealed that the population of GLH and damage by stem borer and leaf folder were much lower in the BIPM package compared to the farmers' practice. Higher grain yield and net returns were recorded in the BIPM package in comparison to farmers' practice (Table 47).

PAU

A demonstration of biocontrol-based IPM of rice was carried out at three locations viz., Machaki Mal

Table 47. Demonstration of IPM in farmers' rice fields (*Kharif*, 2008) (Barokuri, Jorhat)

Treatment	GLH/hill (7 DAT)	Dead Heart (%) (60 DAT)	White ear (%)	Leaf folder damage (%)	Grain yield (kg/ha)	Net return over farmers practice (Rs./ha)
IPM Package	4.13	5.00	4.43	4.21	3,247	8,550
Farmers' practice	6.04	6.55	7.38	6.31	2,990	

Singh, Vander Jatana and Chail on variety *Basmati* – 1121 over an area of 5 acres each. In farmers' practice two applications of cartap hydrochloride (Padan 4G) were given @ 25kg/ha, at 40 and 60 DAT.

The data revealed that there was no significant difference in leaf folder damage and dead hearts of BIPM and farmers' practice plots. The BIPM package was as effective as application of chemical pesticides (Table 48).

Table 48. Efficacy of BIPM on pests of rice (Basmati 1121) in farmers' field during 2008. (Punjab)

Treatments	Leaf folder damage (%)	Dead hearts (%)	White ears (%)	Yield (kg/ ha)
BIPM	0.6	0.3	2.2	4,370
Farmers practice	0.4	0.2	1.4	4,420

(ii) Validation of BIPM practices in organic rice production

Multi-locational demonstrations on BIPM practices in organic rice were conducted during 2008-09. The BIPM package consisted of (a) use of disease resistant variety (b) seed treatment with *P. fluorescens* @ 8g/kg seed (c) FYM @ 5 t/ha (d) *B. bassiana* @ 10^{13} spores/ha against sucking pests (e) bird perches at 10/ha (f) release of *T. japonicum* @ 1 lakh/ha on occurrence of pests (g) spray of *P. fluorescens* against foliar diseases.

KAU

Biointensive pest management package was demonstrated over an area of 2 ha of organic rice (variety Jyothi) during *kharif* and *rabi* of 2008-09 at agricultural farm, Mannuthy. BIPM package was followed. Organic farming treatment included green manuring with *Dhaincha* (*Sesbania aculeata*), 7 releases of *T. chilonis* and *T. japonicum* each @ 1 lkah/ha/week starting from 30 DAT. Recommended package consisted application of inorganic fertilizers, one spray of monocrotophos and 4 releases of *T. chilonis* and *T. japonicum* @1 lakh/ha/week starting from 30 DAT.

The results revealed that the population of coccinellids and spiders were relatively higher in organic farming as compared to the conventional practice. There was no significant difference in dead hearts incidence during *kharif*, however dead hearts were low in organic package during *rabi*. Damage due to earhead bug was significantly lower in organic practice during *kharif*. The grain yield was significantly higher in conventional practice compared to organic practice during *rabi* (Table 49). The net return in organic rice was significantly higher at Rs. 23,000 compared to conventional practice (Rs. 16,606).

AAU-Jorhat

The field experiment was conducted on 10 ha plot in the farmers field during *kharif*, 2008 on the rice variety was Mahsuri. The BIPM practice was compared with conventional and farmers practice.

The incidence of GLH, leaf folder damage and dead heart incidence were lower in BIPM as well as conventional method compared to farmer's practice. Grain yield was highest in

Table 49. Impact of organic farming on the pests of rice (cv.Jyothi) in Thrissur, Kerala

Parameter	*Kharif*		*Rabi*	
	Organic	Conventional	Organic	Conventional
Dead hearts (%)	2.2	2.2	2.3	2.8
Leaf folder incidence (%)	1.3	1.0	1.4	1.4
Leaf hopper/hill	1.7	1.4	1.0	0.7
Coccinellids/hill	0.2	0.02	0.4	0.04
Spiders/hill	0.5	0.1	0.6	0.08
Ear bug damaged earheads/sq. m	2.4	4.9	0.9	0.4
Organic carbon content (%)	0.9	0.5	0.5	0.4
Grain yield (kg/ha)	3,299	3,203	3,723	4,089

Table 50. Validation of BIPM package in organic rice (Cv.Mahsuri) in Assam

Parameter	Package		
	BIPM/ Organic	Conven-tional	Farmers practice
GLH/hill	3.11[c]	4.49[b]	7.45[a]
Leaf folder damage (&)	4.85[b]	4.64[c]	7.07[a]
Dead hearts (%)	5.26[b]	4.15[c]	8.65[a]
Yield of grain (kg/ha)	3,145[b]	3,368[a]	2,789[c]
Net return (Rs/ha)	9,350	4,800	

Means followed by similar letter in horizontal column are not statistically different (P=0.05) by L.S.D.

conventional method, while net return was higher in BIPM (Table 50).

PAU

The experiment was carried out at Fatehpur village on organic rice production on *Basmati* rice var. 1121. In organic farming, application of FYM @ 5 t/ha was done. Bird perches were erected @10 perches/ha. Hopper population was negligible and so *B. bassiana* was not applied. *T. chilonis* and *T. japonicum* were released each @1, 00,000/ha/week, 6 times starting 30 DAT. In the conventional practices nutritional requirement was met with inorganic recommended fertilizers and one application each of cartap hydrochloride 4G @ 25 kg/ha and imidacloprid 17.8 @ 100 ml/ha to curtail the insect menace.

In both the treatments, the incidence of leaf folder and stem borers was less than 2% indicating that both the methods were effective. There was no significant difference in yield in organic practice and farmers practice, however higher net returns was realized in organic package (Table 51).

Table 51. Validation of BIPM package in organic rice in Punjab

Treatments	Leaf folder (%)	Dead hearts (%)	White ears (%)	Yield (kg/ ha)
Organic practices	0.7	0.6	2.0	4,190
Farmers practice	0.1	0.4	1.3	4,260

5.2.10. Biological suppression of pests of maize

Evaluation of Entomopathogenic nematodes (EPN) against *Agrotis ipsilon* on maize

SKUAST- Jammu

A field trial was conducted for the evaluation EPN for the biological control of *A. ipsilon* on maize during 2008. *Steinernema carposapsae* and *Heterorhabditis indica* were applied at 1 and 2 billion juveniles per hectare and compared with control. The results revealed that application of *H. indica* resulted in significant reduction in *A. ipsilon* larval population and plant damage and highest grain yield (Fig. 30).

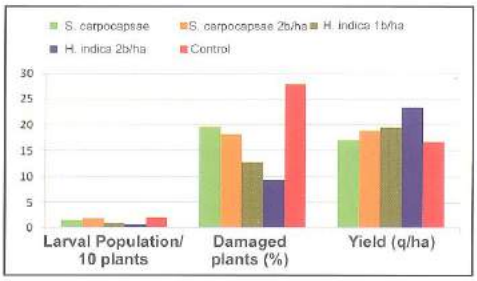


Fig. 30. Impact of EPN against *Agrotis ipsilon* on maize

5.2.11. Biological suppression of oilseed crop pests

(i) Evaluation of BIPM package for castor pests

ANGRAU

BIPM package was evaluated for management of pests of castor during 2008-09 at Mahaboobnagar. The BIPM package consisted of release of *Telenomus remus* @ 1,00,000/ha, release of *T. achaeae* @ 1,00,000/ha, spray of SlNPV@ 1.5 x 10^{12} POB/ha + 0.5% crude sugar and spray of Dipel @ 0.5 l/ha for *Achaeae janata* and *Dichocrocis punctiferalis*. The results revealed lower incidence of *S. litura*, *A. janata* and *D. punctiferalis*, lesser insect damage and higher yield in BIPM package in comparison to farmers practice.

(ii) Biological suppression of *Uroleucon carthami* in non-spiny safflower

ANGRAU

A field trial was conducted during *rabi* 2008 at the College farm, Rajendranagar on non-spiny safflower variety. The treatments included two release of *Chrysoperla carnea* @ 6000/ha, NSKE 5%, *V. lecani* @ 1x 10^{13} conidia/ha , *B. bassiana* @ 1x 10^{13} conidia/ha, *M. anisopliae* @ 1x 10^{13} conidia/ha, Bt @ 1.0 kg/ha, chemical check and untreated control.

The results indicated that there was no significant difference between the treatments with respect to aphid population after treatment imposition. This can be attributed to heavy incidence of aphids during the season. Yield data showed that *Bt* treated plots recorded higher yields but were on par with NSKE (Table 52).

Table 52. Biological suppression of *Uroleucon carthami* in non-spiny safflower varieties

Treatment	Mean aphid population/10 plants		Yield (kg/ha)
	Pre-treatment count	Post-treatment count	
Chrysoperla carnea @ 6000/ha –releases	3,371.67	2,344.67	211.64^{c}
NSKE 5% spray	3,466.33	2,707.30	444.44^{ab}
Verticillium lecanii @ 1X 10^{13} conidia/ha	3,138.33	1,971.30	222.22^{c}
Beauveria bassiana @ 1X 10^{13} conidia/ha	4,673.33	2,320.67	222.22^{c}
Metarrhizium anisopliae @ 1X 10^{13} conidia/ha	4,255.00	2,196.67	306.88^{bc}
B t @ 1.0 kg/ha	4,563.33	2,171.67	592.60^{a}
Insecticidal check	3,050.00	1,998.33	306.88^{c}
Untreated check	3,917.33	2,649.00	243.39^{e}
CD	NS	NS	176.72

(iii) Biological control of groundnut leaf miner

TNAU

A field trial was conducted in farmers' field at Nathegoundenpudur on variety TMV 7. The treatments included 3-4 release of *T. chilonis* @ 1,00,000/ha at 10 days interval, Bt @ 1 kg/ha at 60 and 75 DAS, NSKE 5 %, chemical check and untreated control. The results indicated that though the leaf-miner larval population and per cent damage was lower in endosulfan and Bt spray, there were no significant difference in the yield (Fig. 31).

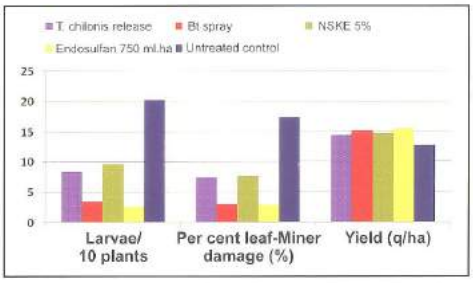


Fig. 31. Effect of *T. chilonis*, Bt and NSKE against groundnut leaf-miner at Tamil Nadu

(iv) Laboratory evaluation of trichogrammatids against the mustard sawfly

AAU- Jorhat

The laboratory experiment indicated that trichogrammatids were ineffective against mustard sawfly.

5.2.12. Biological suppression of coconut pests

(a) Large scale validation on biocontrol of coconut leaf caterpillar *O. arenosella*

KAU

The experiment was carried out at Ganesamungalam area in Thrissur district. The treatments included: (a) four releases of *Goniozus nephantidis* adults @ 10/palm (b) sequential release of *C. exiguus* & *G. nephantidis*. (c) sequential release of *T. embryophagum* and *G. nephantidis* and (d) three release of *Cardiastethus exiguus* nymphs @ 50/palm and (e) two releases of *T. embryophagum* adults @ 1000/palm at 5 days interval

The natural parasitism was above 10% in all the treatments including control before the treatments were imposed. Incidence of *O. arenosella* was very

low, however least number of larvae was recorded on *G. nephantidis* released palms (Table 53).

Table 53. Impact of parasitoid release on *Opisina arenosella*

Treatments	Larvae/ 10 leaf lets
G. nephantidis adults @ 10/palm	0.04[c]
Sequential release of *C. exiguus* & *G. nephantidis*	0.1[bc]
Sequential release of *T. embryophagum* & *G. nephantidis*	0.1[bc]
C. exiguus numphs @ 50/palm	0.3[bc]
T. embryophagum adults @ 1000/palm	0.3[b]
Untreated control	0.5[a]

(b) Large area demonstration of *Oryctes rhinoceros* management using *Metarhizium anisopliae* var. *major* and baculovirus

KAU

The demonstration was carried out by applying *M. anisopliae* (at a spore concentration of 5×10^{11}) in cowdung pits at three locations in Ollukkara village in Thrissur district. There was cent per cent mortality of *O. rhinoceros* grubs in cow dung pits treated with *M. anisopliae* (Fig. 32 and Table 54).

Table 54. Efficacy of *Metarrhizium anisopliae* var. major on *Oryctes rhinoceros*.

Locations	Post-treatment number of diseased grubs + pupae per m^3 in pits		
	1	2	3
Location I	8	9	6
Location II	14	7	3
Location III	4	8	4

Oryctes baculovirus-treated beetles were released in the field @ 10/ha. Observations were recorded on rhinoceros beetle damage from 15 palms before the release of OBV treated beetles and at six months intervals after the release. The incidence of rhinoceros beetle was negligible after the treatment imposition.

Fig.32. *Metarhizium* infected grubs of *Oryctes* at KAU

(c) Management of *Oryctes* through integration of Green muscardine fungus (GMF), *Oryctes* Baculovirus (OBV) and attractant-baited pheromone traps

CPCRI

Large area field management of *Oryctes rhinoceros* through integrated biocontrol methods was conducted in 10 ha plot at Kattanam. Pre-treatment observations on incidence and site occupancy of the pest were recorded during April, 2008. Two pheromone traps were installed and beetle catches were recorded at regular intervals. Four breeding sites in the experimental area were treated with *M. anisopliae* @ 5×10^{11} spores/m^2. A total of 48 virus infected beetles were released in the area. Post-treatment observations showed a reduction of 36.3% in leaf damage, 42% reduction in pest incidence and 72.2% reduction in spindle damage over a period of 10 months. The breeding sites treated with *M. anisopliae* were free of pest stages during post-treatment period. An average, 25-30 beetles/trap/month were collected during peak adult emergence period of May-August.

(d) Studies on natural enemies of red palm weevil

CPCRI

Field survey on grubs, pupae and adult red palm weevil revealed that no pathogen was associated with these stages in nature. Laboratory evaluation of EPN against red palm weevil revealed that the local isolate of *H. indicus* was more virulent than *H.*

bacteriophora and *H. indicus*. It was observed that at least 400 IJs of *H. bacteriophora* and *H. indicus* are required to induce 63% mortality of red palm weevil grubs in 96 hours.

5.2.13. Biological suppression of pests of tropical fruits

(i) Evaluation of biological control agents against mango hoppers

IIHR

Field evaluation of entomopathogens was carried out against mango hoppers on variety Alphonso. The treatments included: Off-season spraying of T-1 *M. anisopliae* @ 1 x 10^9 spores/ml; T-2 *M. anisopliae* @ 1 x 10^7 spores/ml; T-3 *Verticilium lecanii* @ 1x10^9 spores / ml; T-4 Imidacloprid 0.3 ml/l and T-5 Untreated control. Two sprays were applied at weekly intervals on the trunk during off-season (November). Mango hoppers were not found during off-season on the tree trunk. However, observations on the incidence of mango hoppers at flowering indicated lowest hopper number per panicle in insecticidal spray followed by *M. anisopliae* treatment (Fig. 33)

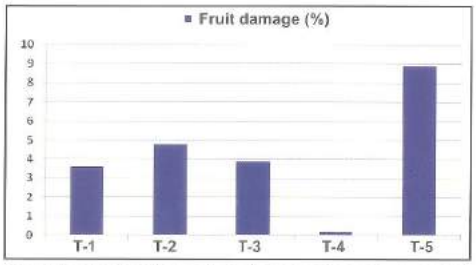


Fig. 33. Evaluation of entomopathogens against mango hoppers at IIHR

TNAU

A field experiment was laid out in Paiyur in Dharmapuri district on Neelum mango in a 7 year old plantation. Among the biocontrol agents tested, application of *M. anisopliae* @ 1x10^7 or *V. lecani* @ 1x10^9 spores/ml on tree trunk during off season and at flowering recorded the lowest mango hopper population which was superior to control (Table 55). However, one spray of imidacloprid @ 0.3 ml/l during off season followed by one spray at flowering period recorded the lowest hopper population, which was significantly superior to biocontrol agents.

Table 55. Efficacy of entomofungal pathogens against the mango leaf hopper (Unjavelampatti, Tamil Nadu)

Treatments	Mango hopper/ inflorescence	
	Pre-treatment	Post-treatment
M. anisopliae @ 1x10^7 on tree trunk during off season + at flowering	41.2	18.8^b
M. anisopliae @ 1x10^7 on tree trunk during off season	39.8	23.4^c
V. lecanii @ 1x10^9 on tree trunk during off season + at flowering	42.5	18.7^b
V. lecanii @ 1x10^9 on tree trunk during off season	33.9	22.9^c
One spray of imidacloprid @ 0.3 ml/lit during off season	33.9	17.6^b
One spray of imidacloprid @ 0.3 ml/lit during off season + 1 Spray at flowering period	46.5	10.3^a
Control	40.4	33.1^d

Means followed by a common letter in a column are not significantly different by DMRT

(ii) Biological suppression of anar butterfly on wild pomegranate

SKUAS&T (Jammu)

The experiment was conducted on wild pomegranate. Six releases of *Trichogramma chilonis* starting from end June at weekly intervals was effective in suppression of anar butterfly and reduction in fruit damage (Fig. 34).

(iii) Relative toxicity of some chemical insecticides to *Cryptolaemus montrouzieri*

NRC Grapes, Pune

A total of 14 fungicides were tested for their relative toxicity to *C. montrouzieri*. The fungicides

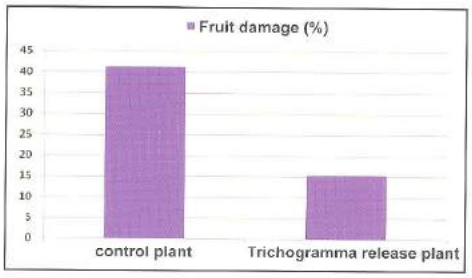


Fig. 34. Effectofimprovedreleaseof*Trichogramma chilonis* on pomegranate fruit borer

tested were Propineb (Antracol), Copper hydroxide (Kocide 101), Cymoxanil + Mancozeb (Curzate), Dimethomorph (Acrobat), Penconazole (Topas), azoxystrobin (Amistar), Potassium bi carbonate, kitazine, fenamidone + mancozeb (Secure), myclobutanil (Systhane), Iprodion (Rovral), flusilazole (Nustar), Fenarimol (Rubigan) and Difenconazole (Score). All the tested fungicides were non-toxic to *C. montrouzieri*.

(iv) Survey and record of natural enemies of pests of papaya mealy bug and mango thrips

(a) Papaya: TNAU

The papaya mealy bug *Paracoccus marginatus* was very serious on papaya, bhendi, cotton, teak, nerium, wild mulberry, sunflower, redgram, sweet potato, jatropa, guava, tomato, ber, coccinea, chillies, brinjal and tapioca in Tamil nadu. The different natural enemies recorded on papaya mealy bug were *C. montrouzieri*, *Spalgis epius*, *Scymnus coccivora*, *Cladiscodes sacchari* and *Brumoides suturalis*.

(b) Mango: NAU

The field survey revealed that incidence of mango thrips, *Scirtothrips mangiferae* was noticed throughout the observation period except from 31st std. week (30 July-5 Aug.) to 41st std. week (8-14 Oct.). The thrips population was more active during flowering and fruit formation stages i.e. from 48th std. week (26 Nov.-2 Dec.) to 13th std. week (26 Mar.-1April). The population reached its peak of 15.1 thrips/ twig during 13th std. week followed by 10.7 thrips/ twig during 6th std. week. *Chrysoperla* sp. was the only predator recorded during the thrips infestation period.

5.2.14. Biological suppression pests of temperate fruits

(i) Evaluation of some microbial pesticides against the apple stem borer (*Aeolesthes sarta*)

SKUAS&T (Srinagar)

The experiment was carried out in the apple orchard at Shalimar during 2008. The treatments evaluated were *B. bassiana* @ $1x10^8$ spores/ml, *M. anisopliae* @ 10^{13} spores/ml, neem, and dichlorvos. The results revealed that higher mortality was obtained in *B. bassiana* treatment followed by *M. anisopliae*, however both were inferior to dichlorvos (Table 56).

Table 56. Evaluation of microbial pesticides against the apple stem borer (*Aeolesthes sarta*)

Treatment	Mean mortality (%) (21 DAT)
B. bassiana @ $1x10^8$ spore/ml	50.0^c
M. anisopliae @ 10^{13} spores/ml	44.0^d
Neem (1.0%)	60.2^b
Dichlorvos	88.0^a
Control	0.0^e

Means followed by a common letter in a column are not significantly different by DMRT

(ii) Evaluation of microbial pathogens against the woolly apple aphid, *Eriosoma lanigerum*

YSPUH & F

A field trial was conducted in an apple orchard during 2008. The treatments evaluated were *B. bassiana* @ $1x10^7$ conidia/ml, *M. anisopliae* @ 10^7 conidia/ml, *V.lecanii* @10^7 conidia/ml, Chlorpyriphos 0.04% and control. The treatments were repeated 20 days after the first application. There was no significant differences in the aphid colony size in the treatments and control, indicating that the fungal pathogens are not effective in the suppression of the woolly apple aphid.

(iii) Field evaluation of *Trichogramma embryophagum* against codling moth

SKUAST-Srinagar

A field trial was conducted during May to September, 2008 in four apple orchards located at Mangmore, Karkichoo, Hardass and Shanigund at Kargil. *T. embryophagum* was released twice @ 4000 adults/tree. Post- release observations revealed that there was a significant reduction in fruit damage in all the treated plots compared to control plot (Table 57).

Table 57. Impact of *T. embryophagum* on apple fruit damage

Location	Fruit damage (%)
Mangmore	39.8[a]
Kirkichoo	43.6[ab]
Hardass	37.1[a]
Untreated control (Shanigund)	60.7[c]

5.2.15. Biological suppression of pests of vegetables

(i) Field evaluation of *Trichogramma brassicae* against *Plutella xylostella* on cabbage/cauliflower

Multi-location trials were conducted to evaluate *T. brassicae* against *P. xylostella* on cabbage/ cauliflower. The treatments consisted of (a) 6 releases of *T. brassicae* @ 1 lakh/ha (b) 6 releases of *T. chilonis* @ 1 lakh/ha (c) farmers practice (chemical spray).

AAU (Jorhat)

The experiment was conducted in a farmers' field (Fig. 35). Maximum yield was recorded in *T. brassicae* treated plot compared to *T. chilonis* treated plot. Farmers practice recorded lowest yield. (Fig. 36).

TNAU

An experiment was carried out at Iruttupallam near Thondamuthur for the management of *P. xylostella* on cauliflower. The parasitoids were released thrice at weekly intervals, following

Fig. 35. *Trichogramma brassicae* released plot at Jorhat

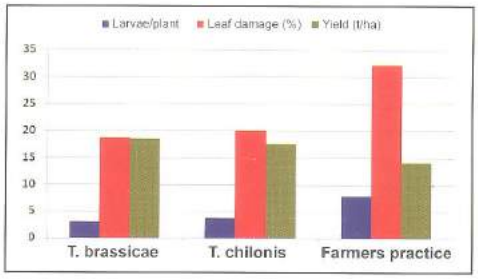


Fig. 36. Efficacy of *Trichogramma brassicae* against *Plutella xylostella* on cabbage

which one round of *Bt* @ 1 kg /ha and neem oil 3.0% were applied at weekly intervals as common sprays except in plots receiving chemical insecticides (Farmers' practice). Data on larval population and yield indicated that both the parasitoids were equally effective in controlling the pest (Table 58). However, *T. brassicae* treatment had a higher cost-benefit ratio based on the marginally higher yield.

Table 58. Comparative efficacy of *T. chilonis* and *T. brassicae* against DBM in cauliflower (Iruttupallam, Tamil Nadu)

Treatment	Larvae/ plant	Parasitism through retrieval (%)	Yield of marketable heads (kg/ ha)	Cost: benefit Ratio
T. brassicae	1.6[a]	22.4[a]	19,200[b]	1:2.2
T. chilonis	1.4[a]	13.1[b]	18,000[b]	1:1.9
Farmer's Practice	4.1[b]	0.0[c]	15,300[b]	

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

Table 59. Field evaluation of *T. brassicae* and *T. chilonis* against *Plutella xylostella* on cauliflower (Jammu)

Treatment	No. of larvae/ plant	Leaf infestation/ m^2	Egg parasitism (%)	Yield (kg/ha)	Net Profit (Rs/ha)	Profit over control (Rs/ha)	C:B ratio
T. brassicae	4.9^{a}	21.2^{a}	42.6^{c}	$24,120^{a}$	1,23,500	15,500	1:9.50
T. chilonis	6.1^{ab}	27.0^{b}	31.3^{b}	$23,130^{b}$	1,14,500	10,550	1:4.75
Farmers' Practice	8.5^{b}	34.3^{b}	2.47^{a}	$22,540^{b}$	1,09,000	7,600	1:1.25
Control	16.4^{c}	46.5^{c}	5.25^{a}	$21,020^{c}$	1,04,000		

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

SKUAS&T -Jammu

Six weekly releases of *T. brassicae* @ 1 lakh/ ha on cauliflower resulted in a significant reduction in damage by *P xylostella* recording significantly higher yield and net return with a C:B ratio of 1:9.50. This treatment was superior to the prevailing farmers' practices of 2-3 applications of conventional insecticides (Table 59).

(ii) Bio-suppression of *Pieris brassicae*

(a) Evaluation of *Trichogramma brassicae* against *Pieris brassicae*

SKUAS&T-Srinagar

Laboratory evaluation of *T. chilonis*, *T. brassicae* and *T. kashmirica* (local strain) against eggs of *P. brassicae* revealed that the percent parasitism by *T. chilonis* was 18.5 ± 11.8, 10.9 ± 8.0 by *T. brassicae* and nil parasitism in the case of *T. kashmirica*.

A field trial was conducted to evaluate *T. chilonis* against *P. brassicae*. Six releases of *T. chilonis* resulted in a lower larval population of 1.9 per plant and a higher egg parasitisation of 10.4% at the end of six releases.

(b) Effectiveness of various microbial pesticides and a summer oil against *P. brassicae* on Knol khol

SKUAS&T-Srinagar

The field experiment on evaluation of various microbials and oils against *P. brassicae* on knol khol was carried out in the farm of Division of Entomology, SKUAST-K during 2008. The treatments consisted of *B. bassiana* @ $1x10^{8}$ spore/ml, *M. anisopliae* @ 10^{8} spores/ha, D.C.Tron Plus @ 0.75%, and an insecticide dichlorvos @ 0.05% and untreated control (Check). Application of *B. bassiana* resulted in 60.0 % larval mortality and this treatment was on par with *M. anisopliae* (56.3%), and oil (63.3%) treatments. However, D.C.Tron Plus proved to be phytotoxic. A cost benefit ratio was 1: 6 (dichlorvos), 1:5.9 (D.C.Trion), 1: 4.78(*B. Bassiana*) and 1:4.68 (*M. anisopliae*).

(iii) Evaluation of *T. brassicae* and *Bt* against DBM infesting cabbage

IIHR

A field experiment was carried out at Bangalore to evaluate the efficacy of various biological control agents in controlling DBM on cabbage var. Unnati during 2008-09. The treatments consisted of (a) *T. brassicae* @1 lakh /ha/release (6 releases) (b) *B. bassiana* @ 1 x 10^{9} spores/ml (c) *S. carpocapsae* @ 1 billion Ij/ha (d) Neem soap 4% (e) Dipel @ 1 ml/l and *M. anisopliae* @ 1 x 10^{9} spores/ml (f) spinosad @ 0.7ml/l and an untreated check was maintained.

The results indicated that there was no significant difference in the number of larvae per plant eight weeks after the treatment. However the yield in *T. brassicae* treatment plot was 64,800 kg/ha compared to control 27,570 kg/ha.

MPUAT-Udaipur

A field experiment was laid out to test the efficacy of bicontrol agents against *P. xylostella* infesting cabbage. The biopesticides were applied at weekly interval after 20 DAP. Lowest numbers of larvae were recorded in DOR *Bt* treatment, which was superior to release of *T. brassicae* and spray of *B. bassiana*. Among the biocontrol agents, *Bt* treatment recorded the highest yield and highest net returns (Table 60).

Table 60. Evaluation of bioagents against lepidopteran pests of cabbage (Udaipur)

Treatments	No. of larvae/plant	Yield (kg /ha)	Value of yield/ha (Rs)	Cost of treatments (Rs/ha)	Net return (Rs/ha)	C:B ratio
T. brassicae @ 1 lakh/ha/ release (6 releases)	1.43 ^{c}	51,280^{d}	2,06,400	1,320	2,05,080	1:1.3
B. bassiana (1x10^{8} spores/ml)	1.59 ^{d}	39,510^{c}	1,97,550	2,040	1,95,510	1:1.24
DOR *Bt* 1 kg/ha	1.05 ^{b}	65,750^{f}	3,28,750	7,440	3,21,310	1:2.04
NSP 4%	1.43 ^{c}	60,210^{e}	3,01,050	2,640	2,98,410	1:1.89
Spinosad 0.75 ml/l	0.75 ^{a}	71,810^{g}	3,59,050	22,000	3,37,050	1:2.28
S. carpocapsae	1.57 ^{d}	35,260^{b}	1,76,300	2,440	1,73,860	1:1.12
Control	2.73^{e}	31,550^{a}	1,57,750	-	1,57,750	

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

(iv) Evaluation of *Trichogramma chilonis*, EPN and *Bt* against fruit borer of brinjal and Okra

(a) Brinjal

PAU

A field trial was conducted at entomological farm, PAU, Ludhiana on brinjal to evaluate the efficacy of biocontrol agents against shoot and fruit borer. Fruit damage was maximum (20.3%) in Halt treatment (@ 2.0 kg/ha) which was on par with EPN @ 2 billion ijs/ha and triazophos. Significantly higher yield was also recorded in the treatment with Halt, which was on par with triazophos application (Table 61).

Table 61. Effect of biocontrol agents on brinjal fruit borer, *Leucinodes orbonalis* (Punjab)

Treatments	Fruit damage (%)	Yield (kg/ha)
Halt @ 2.0 kg/ha	20.3 ^{a}	35,300^{a}
Halt @ 1.5 kg/ha	23.4^{ab}	33,820^{ab}
T. chilonis @ 50,000/ha	29.5^{c}	30,140^{c}
EPN @ 2 billion ijs/ha	24.2^{ab}	32,350^{bc}
EPN @ 1 billion ijs/ha	29.0^{c}	32,350^{bc}
Triazophos 40 EC @ 1250 ml/ha	20.3^{a}	35,600^{a}
Control	38.9^{d}	26,470^{d}

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

AAU- Jorhat

A field experiment was conducted in a farmers' field at Alengmora village to evaluate EPN and other biocontrol agents against brinjal shoot and fruit borer. Two sprays of Bt and EPN were applied at 10 days intervals, six releases of *T. chilonis* were made at weekly intervals and three sprays of endosulfan at 15 days intervals. Application of EPN @ 2 billion ijs/ ha. was most effective in reducing the fruit damage (17.8%), which was significantly superior to Bt and *T. chilonis* treatments. Highest yield was recorded in the treatment with EPN @ 2 billion ijs/h, which on par with endosulfan treatment (Table 62).

Table 62. Effect of biocontrol agents on brinjal fruit borer, *Leucinodes orbonalis* (Assam)

Treatments	Fruit damage (%)	Yield (kg/ha)
Bt @ 2.0 kg/ha	19.9^{b}	11,750^{a}
EPN @ 1 billion ijs/ha	22.8^{a}	11,050^{c}
EPN @ 2 billion ijs/ha	17.8^{c}	12,625^{a}
T. chilonis @ 50,000/ha	22.8^{a}	11,700^{b}
Endosulfan 5 EC @ 300 a.i./ha	14.2^{d}	12,775^{a}
Control	34.9^{e}	6,132^{d}

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

(b) Okra

PAU

The field experiment was conducted on okra variety Punjab 8 for the management of fruit borer, *Earias* spp. Significantly lowest fruit damage and highest yield were recorded in Halt @ 2.0 kg/ha which was on par with application of

Decis (Table 63). In all the treatments, significantly higher yield was recorded in comparison to control. However, the biocontrol treatments were inferior to Halt @ 2 kg/ha treatment.

Table 63. Effect of biocontrol agents on fruit borer, *Earias* spp in okra (Punjab)

Treatments	Fruit damage (%)	Marketable yield (kg/ha)
Halt @ 2.0 kg/ha	9.9[a]	13,150[ab]
Halt @ 1.5 kg/ha	14.4[b]	12,500[bc]
T. chilonis @ 50,000/ha	17.9[c]	10,010[d]
EPN @ 2 billion ijs/ha	14.9[b]	12,150[c]
EPN @ 1 billion/ ijsha	18.0[c]	9,450[d]
Decis 2.8 EC (Deltamethrin @ 400 ml/ha	9.2[a]	13,550[a]
Control	27.6[d]	7,750[e]

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

(v) Evaluation of entomofungal pathogens against *Aphis craccivora* in cowpea

KAU

Laboratory evaluation of different dilutions of *Hirsutella thompsonii* and *Metarhizium anisopliae* was done against *A. craccivora*. *H. thompsonii* caused higher aphid mortality ranging from 24.0 to 100% at different dilutions of 10^3 to 10^8. LC_{50} value for *H. thompsonii* (2.18×10^4) was lesser than the LC_{50} value of *M. anisopliae* (7.5×10^6).

Field evaluation of different entomopathogenic fungi was conducted against *A. craccivora* on cowpea variety Kanakamony at College farm Vellanikkara. Lowest aphid count was recorded in *V. lecanii* treatment, which was on par with *F. pallidoroseum*, *B. bassiana*, *M. anisopliae* and quinalphos treatments. The highest yield was recorded in *F. pallidoroseum* treated plot followed by *B. bassiana* and *V. lecanii* (Table 64).

Table 64. Effect of entomopathogenic fungi against *Aphis craccivora* on cowpea (KAU)

Treatments	Pre-treatment aphid number	Post-treatment aphid number	Yield (kg/ha)
Fumoroseus pallidoroseum (6.5×10^6 spores/ml)	49.0	0.8[bc]	4,516[a]
B. bassiana (10^{10} conidia/l)	37.5	0.8[bc]	4,359[a]
Verticillium lecanii (10^{10} conidia/l)	36.7	0.1[c]	4,194[a]
M. anisopliae (10^{10} conidia/l)	50.9	0.2[c]	4,097[a]
H. thompsonii (10g/l)	23.0	1.3[bc]	3,778[a]
Quinalphos (0.05%)	43.7	2.2[b]	3,134[a]
Control	28.3	42.5[a]	1,185[b]

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

(vi) Survey of natural enemies of greenhouse whiteflies (GHWF)

YSPUH&F

The survey revealed parasitisation of green house white fly by unidentified *Encarsia* sp., *Encarsia sophia* (= *E. transvena*) and *Eretmocerus delhiensis*. The unidentified *Encarsia* sp. was found only on cucumber plants, whereas *E. sophia* and *Eretmocerus* sp. were found parasitizing GHWF on bean, cucumber and tomato.

5.2.16. Biological suppression of white grubs in potato

YSPUH&F

Efficacy of *M. anisopliae*, *B. bassiana* and *B. brongniartii* each at 10^7, 10^8 and 10^9 conidia/ml and EPNs- *S. feltiae* and *H. bacteriophora* at 4×10^9 IJs/ha were tested against third instar of *Brahmina coriacea*. Maximum mortality was obtained with *B. brongniartii* (22.2%) and *S. feltiae* (33.3%).

A field trial was laid out at the Agriculture Department Potato Farm, Kedadhar (Sirmaur district). The treatments were *B. brongniartii* and *M. anisopliae* formulations at 10^9 conidia/g. Each formulation was evaluated at 2,4 and 6 g/m^2 and compared with chemical check (2g/m^2 Phorate 10G) and untreated control.

Tuber damage (on weight basis) was least in the treatment with *M. anisopliae* @ 6 g/m^2 (23.2%) followed by *B. brongniartii* at the same dosage (28.3%), which were superior to control (53.1%), but inferior to Phorate (9.3%) (Table 65).

Table 65. Efficacy of entomofungi against white grubs of potato at Keradhar, Sirmaur

Treatments	Tuber damage (%)	
	Number basis	Weight basis
M anisopliae 2g/m²	33.8^{c}	34.0^{c}
M anisopliae 4g/m²	32.7^{c}	33.9^{c}
M anisopliae 6g/m²	23.1^{b}	23.2^{b}
B. brongniartii 2g/m²	35.2^{c}	37.0^{c}
B. brongniartii 4g/m²	32.6^{c}	35.4^{c}
B. brongniartii 6g/m²	26.4^{bc}	28.3^{bc}
Phorate 10G	10.2^{a}	9.3^{a}
Control	50.4^{d}	53.1^{d}

5.2.17. Biological suppression of polyhouse crop pests

Evaluation of anthocorid predator, *Blaptostethus pallescens* against spider mites on carnation in polyhouses

MPKV

A trial was laid out at commercial Hi-Tech Floriculture Project, Agricultural College, Pune on carnation cv. Gold strike. Five releases of *B. pallescens* were made @10 and 20 adults/plant. Five releases of anthocorid predators @ 20 per plant at weekly intervals reduced the mite population significantly. This treatment was superior to control, but inferior to Abamectin treatment (Table 66).

Table 66. Effectiveness of anthocorid predator *B. pallescens* against spider mites on carnation in polyhouse in Maharashtra

Treatment	Mites number per 3 leaves 7 days after release
Release of 10 anthocorids/plant	61.80^{c}
Release of 20 anthocorids/plant	44.52^{b}
Abamectin 0.5 ml/lit spray	24.96^{a}
Untreated control	130.96^{d}

5.2.18. Biological suppression of weeds

Biocontrol of *Chromolaena odorata* utilising *Cecidochares connexa*

KAU

The gall fly received from PDBC, Bangalore was field released. The plants on which the gall fly oviposited was tagged and considered as treated and other plants as control. The height, number of branches, panicles, capitula and seeds on galled and non-galled plants were recorded. Plant height was reduced to an extent of 30.4% on the galled plants. There was also a reduction of 5.8% branches, 12.9% panicles per plant, 5.1% capitula per panicle and 6.3% seeds per capitula, due to gall formation (Table 67).

Table 67. Impact of gall formation on the growth parameters of *Chromolaena* plant

Growth parameter	Control plant	Galled plant	Per cent decrease over control
Plant height (mm) 30 days after oviposition	2.3	1.6	30.4
Plant height (mm) 60 days after oviposition	2.9	2.4	18.0
Mean number of branches	8.6	8.1	5.8
Mean number of panicles per plant	14.7	12.8	12.9
Mean number of capitula per panicle	23.6	22.4	5.1
Mean number of seeds per capitula	26.1	24.4	6.3

6. TECHNOLOGY ASSESSED, TRANSFERRED AND MATERIALS DEVELOPED

Technology developed and transferred

PAU, Ludhiana - The incidence of early shoot borer and top borer was significantly reduced by 8 releases of *T. chilonis* @ 50,000/ha at 10 days interval at village Gohawar and Chachrari in Punjab in 100 ha area. The mean parasitism of eggs of *C. infuscatellus* in *T. chilonis* release plot was 51.2% and the yield was enhanced significantly with a cost:benefit ratio of 1:13.8.

TNAU, Coimbatore - BIPM package on *Bt* cotton recorded significantly low population of leafhoppers, aphids, thrips and whiteflies. The bollworm damage by *Earias* and *H. armigera* was also low in BIPM package on *Bt* cotton. A higher seed cotton yield of 2,169 kg / ha. was recorded in *Bt.* BIPM field with a cost benefit ratio of 1 :1.9, whereas a significantly lower seed cotton yield (1,894 kg/ha) was recorded in *Bt* farmers practice field.

CTRI, Rajhamundry - *Sl*NPV suspension with pH 7 recorded the lowest seedling damage by *S. litura*, 7 days after application indicating greater NPV action. *Sl*NPV with pH 5 and 9 recorded relatively more seedling damage indicating lesser NPV activity. Application of *Sl*NPV @ 1.5 x 10^{12} PIB/ha was found very effective for the management of *Spodoptera* in nurseries.

KAU, Thrissur - Validation of biointensive pest management practice (seed treatment with *P. fluorescens* @ 8 g/kg of seeds/ seedling dip in 2% solution; *B. bassiana* @10^{13} spores/ha against sucking pests; bird perches at 10/ha; *T. japonicum* @ 1 lakh/ ha on occurrence of leaf folder or stem borer; *Bt* at 2 kg/ha- 2-4 sprays depending on pest occurrence; *P. fluorescens* spray against foliar diseases and need-based or spot application of botanicals) in 10 ha rice variety Jyothi in Kerala revealed that BIPM package registered significantly low incidence of dead heart, white earhead and leaf folder damage compared to farmers practice. The population of spiders and coccinellids, grain yield and net returns were higher in BIPM package compared to farmers practice.

DNA sequences generated and deposited

Jalali, S. K., Venkatesan, T., Sriram, S. and Rajeshwari, R. 2008. *Pichia anomala* strain Tcy1 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete sequence; and 28S ribosomal RNA gene, partial sequence, 579bp. GenBank Accession No. FJ224365.

Jalali, S. K., Venkatesan, T., Sriram, S., Rajeshwari, R. and Mahiba Helen, S. 2008. *Pichia anomala* strain Tcy2 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete sequence; and 28S ribosomal RNA gene, partial sequence, 573bp. GenBank Accession No. FJ599744.

Jalali, S. K., Rajeshwari, R., Sriram, S., Venkatesan, T. and Mahiba Helen, S. 2009. *Candida cf. apicola* Tcy3 internal transcribed spacer 1, partial sequence; 5.8S ribosomal RNA gene and internal transcribed spacer 2, complete sequence; and 28S ribosomal

RNA gene, partial sequence. 443bp. GenBank Accession No. FJ713025.

Khushboo, S., Venkatesan, T., Rajeshwari, R., Jalali, S.K., Murthy, K.S., Ashok kumar, G. and Joshi, S. 2008. *Cheilomenes sexmaculata* cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial (517 bp). GenBank Acc. No. FJ154102.

Srinivasa Murthy, S. K. Jalali, T. Venkatesan. 2008. Sequences of ITS-2 region from Karnataka, Kerala and Andhra Pradesh submitted to Gen Bank with Accession Number EU 016231, 719071 and 719072, respectively.

Venkatesan,T., Jalali, S. K., Sriram,S., Srinivasa Murthy, K., Rajeshwari, R., Lalitha,Y. and Mahiba Helen, S. *Pichia anomala* isolate Csy1 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1 and 5.8S ribosomal RNA gene, complete sequence; and internal transcribed spacer 2, partial sequence GenBank Acc. No. FJ605112).

7. EDUCATION AND TRAINING

Name	Training programme	Duration	Place
Deepa Bhagat	Nanotechnology based training and meetings/discussions	03.04.2008 to 06.04.2008	CIFE, Mumbai
B. Amarnath	Training on "Records management for Right to Information"	28.07.2008 to 31.07.2008	ISTM, New Delhi
K. Veenakumari B. Ramanujam	Training programme on "Mainstreaming Gender Concerns in Agriculture and allied Sectors	05.08.2008 to 09.08.2008	UAS, GKVK, Hebbal, Bangalore 560 024.
Deepa Bhagat	Computer training programme on Rajbhasha	18.08.2008 to 22.08.2008	CPRI, Bangalore-560 003.
B. Amarnath	National residential convention on reservation policy of Govt. of India for Liaison Officers for Sc/St/OBC	08.09.2008 to 10.09.2008	Hotel Parkview, Sector-24, Chandigarh
R.J.Rabindra	Executive development programme in agricultural research management	23.09.2008 to 27.09.2008	NAARM, Hyderabad
B. Ramanujam R. Sriram K. Veenakumari	ICAR-training-cum-workshop on IP and Technology Management	30.10.2008 to 01.11.2008	CTCRI, Trivandrum
B. Amarnath	Technical and Administrative support for consortia based research in Agriculture	17.11.2008 to 26.11.2008	MANAGE, Hyderabad
Ms. R.Gandhi Gracy	Perspectives and current trends in bioinformatics	09.02.2009 to 15.02.2009	CCMB, Hyderabad
Ms. R.Gandhi Gracy	Application of GIS in plant biodiversity and horticulture	25.02.2009 to 06.03.2009	IISR, Calicut
M. Nagesh Prashanth Mohanraj B. Ramanujam G. Sivakumar K. Veenakumari	Training programme on GPS/GIS/Open source software	16.02.2009 to 22.02.2009	AINP on Agriculture Ornithology, ANGRAU, Hyderabad
T. Venkatesan	Management of intellectual property rights in biotechnology	08.01.2009 to 09.01.2009	Hotel Atria, Palace Road, Bangalore 560 001.
B. Amarnath	Training on Knowledge management	02.03.2009 to 03.03.2009	ISTM, New Delhi
R. Rangeshwaran	MDP on PME of agricultural research and development projects	09.03.2009 to 13.03.2009	NAARM, Hyderabad

8. AWARDS AND RECOGNITIONS

PDBC: Bangalore

Dr R.J.Rabindra

- ICAR representative on the Board of Management of University of Agricultural Sciences, Bangalore 2006-09.
- Nominated as nominee of DG, ICAR as the expert member on the Assessment Committee for DPC of scientists under Career Advancement Scheme in the discipline of Entomology of NRC for Sorghum, Rajendranagar, Hyderabad.
- Assessment Committee Member at ASRB New Delhi in the discipline of Agricultural Entomology as per ASRB letter No.2(1)/2008-Assess.Cell dated 18th September, 2008.
- Member of the Selection Committee at UAS, Bangalore for the post of Director of Instructions (Agri.), Agricultural College, Mandya.
- Nominated as a Chairman of the Assessment Committee for interviewing the screened-in scientists at Bangalore on 21st and 22nd November, 2008 at The Central Silk Board.

Dr A. N.Shylesha

- Secretary , Society for Biocontrol Advancement, Bangalore.

Dr.S.K.Jalali

- Chief Editor, Journal of Biological Control.

Dr.K.Srinivasa Murthy

- Treasurer, Society for Biocontrol Advancement, Bangalore.

Dr. T. Venkatesan

- Recognised as a guide for PG studies by Mysore University

ANGRAU

Dr.S. J. Rahman

- Received "**Meritorious Research Scientist Award**" from the hands of His Excellency Sri N.D.Tiwari, Governor of Andhra Pradesh during the Annual Convocation held on 5.6.2008.

GBPUA&T, Pantnagar

- Dr. J. Kumar selected as Vice-President of Indian Society of Plant Pathologists for 2009-2011.

IIHR, Bangalore

Dr. A. Krishnamoorthy

- Referee for the Indian Journal of Agricultural Sciences.
- External referee to evaluate two DBT project proposals.
- Secretary for Association for Pest Management in Horticultural Crop Ecosystems (AAPMHE) till 16th June 2008.
- President for Association for Pest Management in Horticultural Crop Ecosystems (AAPMHE) from 17th June 2008 onwards.
- Chief Editor of Journal of Horticultural Sciences, Society for Promotion of Horticulture, Bangalore.
- Acted as Chairman, Price Fixation Committee from 1/4/2008 to 31/3/2009.

Dr,Ganga Visalakshy

- Referee for the Journals: Journal of Biological Control, Biopesticides International, Biocontrol Science and Technology, Review of projects related to Biological control, Dept. of Sericulture, Karnataka.
- Joint secretary for Association for Pest Management in Horticultural Crop Ecosystems (AAPMHE) from 17th June 2008.

9. LINKAGES AND COLLABORATION IN INDIA AND ABROAD INCLUDING EXTERNAL PROJECTS

Research Projects funded by lateral sources operating at Project Directorate of Biological Control, Bangalore

NAIP

Effect of abiotic stresses on the natural enemies of crop pests: *Trichogramma*, *Chrysoperla*, *Trichoderma* and *Pseudomonas* and mechanism of tolerance to these stresses (Collaborating centres - DOR, CRIDA, Vittal Mallya Science Research Foundation, Bangalore and Mysore University).

DBT

Development of invert-emulsion formulation of *Trichoderma harzianum* and prolonged shelf- life and enhanced biocontrol potential.

Development of a strain of *Trichogramma chilonis* tolerant to newer insecticides and high temperature.

ICAR Cess-Fund

Network project of biosystematics.

Development, validation, utilization and/or commercialization of biopesticides and bioinoculants.

AMAAS (ICAR)

Microbial control of insect pests – II.

10. AICRP / COORDINATION UNIT / NATIONAL CENTRES

With a view to fulfill the mandate under PDBC and AICRP on BC effectively and efficiently, the Project Directorate is functioning with the following ICAR Institute-based and State Agricultural University-based centres.

Headquarters

Project Directorate of Biological Control, Bangalore	Basic research

ICAR Institute-based centers

Central Tobacco Research Institute, Rajahmundry	Tobacco, soybean
CPCRI Regional Centre, Kayangulam	Coconut
Indian Agricultural Research Institute, New Delhi	Basic research
Indian Institute of Horticultural Research, Bangalore	Fruits and vegetables
Indian Institute of Sugarcane Research, Lucknow	Sugarcane
Sugarcane Breeding Institute, Coimbatore	Sugarcane

State Agricultural University-based centres

Acharya N.G. Ranga Agricultural University, Hyderabad	Sugarcane, cotton and vegetables
Anand Agricultural University, Anand	Cotton, pulses, oilseeds, vegetables and weeds
Assam Agricultural University, Jorhat	Sugarcane, pulses, rice and weeds
Dr. Y. S. Parmar University of Horticulture and Forestry, Solan	Fruits, vegetables and weeds
Govind Ballabh Pant University of Agriculture and Technology, Pantnagar	Plant disease antagonists
Kerala Agricultural University, Thrissur	Rice, coconut, weeds, fruits and coconut
Mahatma Phule Krishi Vidyapeeth, Pune	Sugarcane, cotton, soybean and guava
Punjab Agricultural University, Ludhiana	Sugarcane, cotton, oilseeds, tomato, rice and weeds

Sher-E-Kashmir University of Agricultural Sciences & Technology, Srinagar	Temperate fruits and vegetables
Tamil Nadu Agricultural University, Coimbatore	Sugarcane, cotton, pulses and tomato

Voluntary centres

Chaudhary Charan Singh Haryana Agricultural University, Hisar	Sugarcane
College of Agriculture, Kolhapur	White grubs, Weeds
Mahatma Phule University of Agriculture and Technology	Vegetables
National Research Centre for Soybean, Indore	Soybean
National Research Centre for weed Science, Jabalpur	Weeds
Navasari Agricultural University	Sugarcane, Coconut
S.D. Agricultural University	Vegetables
University of Agricultural Sciences, Bangalore	Cotton, pigeonpea
University of Agricultural Sciences, Dharwad	Cotton, chickpea
Vasantdada Sugar Institute, Pune	Sugarcane

11. LIST OF PUBLICATIONS

Research papers published in refereed scientific journals

PDBC, Bangalore

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IIHR, Bangalore

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IISR, Lucknow

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KAU, Thrissur

Lyla K. R., Sheena and Bhaskar, H. 2008. Biology and feeding preference of the coccinellid predator *Coccinella transversalis* Fab. *Insect Environment*, **14**(2): 75-76.

MPKV, Pune

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TNAU, Coimbatore

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PDBC, Bangalore

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YSPUAH&F, Solan

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12. LIST OF APPROVED ONGOING PROJECTS/ EXPERIMENTS

I BASIC RESEARCH

Project Directorate of Biological Control, Bangalore

1. Taxonomic studies on lesser known Coccinellidae of the Indian Subcontinent
2. Biosystematics of *Trichogramma* and *Trichogrammatoidea*
3. Introduction and studies on natural enemies of some new exotic insect pests and weeds
4. Interaction within the natural enemy guilds of *Ceratovacuna langera* and *Maconellicoccus hirsutus*
5. Development of production protocols and evaluation of anthocorid predators
6. Mass production and field evaluation of *Micromus* sp.
7. Development of novel mass production, storage, and packaging techniques for *C. montrouzieri*
8. Conservation of natural enemies of Rice pests through habitat manipulation techniques
9. Attractants for natural enemies of rice pests for use in the conservation of natural enemies
10. Selection of superior strain of *Chrysoperla carnea* and *Cryptolaemus montrouzieri* from different agro-ecosystems and their molecular characterization
11. Selection of superior strains of certain parasitoids and their characterization
12. *In vitro* cloning of NPV for genetic improvement
13. Inter and Intra specific variation in egg parasitoids, storage and their molecular characterization
14. Identification of pathogens of phytophagous mites and assessment of their potential in microbial control
15. Identification of *Trichoderma* isolates with enhanced biocontrol potential
16. Efficient formulations of *Trichoderma* sp. and entomofungal pathogens with prolonged shelf-life
17. Isolation, characterization and toxicity of indigenous *Bacillus thuringiensis* strains against lepidopterous pests
18. Isolation and characterization of plant growth promoting endophytic bacteria and development of improved formulations
19. Biological control of *Alternaria* leaf blight of tomato
20. Long term management of red hairy caterpillar (*Amsacta albistriga*) by creating Epizootics of Nuclear polyhedrosis virus
21. Effect of different edaphic factors on EPN activity and refinement of packaging for EPN formulations
22. Data base on entomopathogenic nematodes

Indian Agricultural Research Institute, New Delhi

1. Isolation, characterisation and evaluation of potential *Bt* isolates

II BIOLOGICAL CONTROL OF PLANT DISEASES AND NEMATODES USING ANTAGONISTIC ORGANISMS

1. *In vitro* and Green house testing, screening of available isolates of antagonists for their tolerance to abiotic stresses (i.e. cold, drought, salinity) under *invitro* conditions and their performance under rain-fed conditions of hills and plains (normal & *Usar* soils) (GBPUAT)
2. Field evaluation of promising strains under rain-fed conditions (GBPUA&T)
3. Management of wilt disease complex in tomato (TNAU)
4. Large scale field demonstration of biocontrol technologies in field (GBPUA&T, PAU, AAU-A)
5. Development of non-chemical methods based management strategy for minimizing post harvest losses in mango, litchi and guava (GBPUA&T)
6. To evaluate the potential of selected agents in the management of fruit rot in mango, papaya and guava (PAU, AAU-A, GBPUA & T, ANGRAU, MPKV)

   A. Isolation and identification of the potential biocontrol agents (especially yeasts) for the management of post harvest losses.

      (GBPUA&T : with *Trichoderma* and *Pseudomonas*, not yeast, (on papaya, mango, guava); AAU-A (on papaya); PAU (on mango), ANGRAU (on mango); MPKV (on mango)

   B. Evaluation of the biocontrol potential of selected bioagents

7. Biological control of plant parasitic namatodes

   (A linkage programme with AICRP on plant parasitic nematodes)

   A Biological control of pigeonpea cyst nematodes and disease complex in redgram (AAU-A, TNAU, CS Azad UAT, Kanpur; MPKV, Rahuri)

   B. Biological control of plant parasitic nematodes on vegetables and fruits (tomato & pomegranate)

      Tomato: AAU-J, CSKHPKVV, Palampur; BCKVV, Kalyani, CCSHAU, Hisar, UAS, Bangalore. Pomegranate: UAS, Bangalore, AAU-A; Citrus: MPKV, Rahuri

   C. Biological control of nematodes infesting carnation in polyhouses (UAS, Bangalore)

III. BIOLOGICAL SUPPRESSION OF SUGARCANE PESTS

1. Demonstration of *Trichogramma chilonis* against the Plassey borer *Chilo tumidicostalis* (AAU-J)
2. Demonstration on the use of *T. chilonis* (temperature tolerant strain) against early shoot borer (PAU, CCSHAU)
3. Large scale demonstration of *T. chilonis* against stalk borer in collaboration with sugar mills of the state. (PAU, CCSHAU)
4. Demonstration on the use of temperature tolerant strain of *T. japonicum* against top borer (PAU, IISR)
5. Evaluation of *T. chilonis* against sugarcane internode borer (TNAU, Coimbatore and Cuddalore), Sugarcane Research Station, Sankeshwar, UAS-B, UAS-D, MPKV, SBI, VSI)
6. To study the influence of plant structural complexity on the behavior of *T. chilonis* (SBI)
7. Field evaluation of *T. chilonis* in combination with pheromones for stalk borer, *Chilo auricilius* management (CCSHAU)
8. To standardize group rearing of the host for mass production of GV of *C. infuscatellus* (SBI)
9. To collect GV isolates from different factory zones and assess the virulence of GV isolates on *Chilo infuscatellus* (SBI)
10. Survey and surveillance of sugarcane woolly aphid and its major natural enemies (SBI,

ANGRAU, MPKV, UAS-D, Raichur, UAS-B, Sugarcane Federation, Chengalpattu)

11. Studies on *Encarsia flavoscutellulm* (SBI, AAU-J, TNAU, VSI, MPKV & NAU)
12. Bio-intensive management of stalk borer,*Chilo auricilius* Dudgeon and internode borer,*Chilo sacchariphagus indicus* (Kapur) (IISR)
13. Evaluation of *Metarhizium anisopliae* and EPNs against termites (IISR, SBI and VSI & CCSHAU)
14. Termite control with Entomopathogenic Nematodes (IISR, PDBC,VSI)

IV. BIOLOGICAL SUPPRESSION OF COTTON PESTS

1. Demonstration of bio-Intensive Pest Management (BIPM) in *Bt* cotton (ANGRAU, AAU-A , PAU, MPKV, TNAU, UAS-D, Raichur)
2. Bio-intensive pest management of pink boll worm, *Pectinophora gossypiella* on cotton (MPKV, ANGRAU, TNAU, AAU-A)
3. Enhancement of natural enemies population in cotton by habitat manipulation in rainfed cotton (PAU, ANGRAU, AAU-A, MPKV)
4. Identification of natural enemies of mealy bugs on cotton and evaluation of potential natural enemies (AAU-A, ANGRAU, MPKV, TNAU)

V. BIOLOGICAL SUPPRESSION OF TOBACCO PESTS

1. Studies on the influence of water quality on the efficacy of entomopathogens against tobacco pests. (CTRI)
2. Comparative study of virulence of different isolates of *Spodoptera litura* NPV in tobacco, soybean and chilly ecosystem. (CTRI)
3. Studies on Biological control options for suppression of tobacco stem borer *Scrobipalpa heliopa* Low (Lepidoptera, Gelichidae) (CTRI)
4. Standardization of mass multiplication of *Spodoptera exigua* and *Se*NPV (CTRI)
5. Bio-efficacy of some microbial insecticides against *Spodoptera litura* in tobacco nursery. (AAU, Anand)
6. Popularization of Biocontrol Techniques in farmers fields (CTRI).

VI. BIOLOGICAL SUPPRESSION RICE PESTS

1. Large-scale demonstration of IPM for rice pests and diseases in the farmer's field (KAU, AAU-J, PAU)
2. Validation of biointensive pest management practices in organic rice production (PAU, KAU, AAU-J)

VII. BIOLOGICAL SUPPRESSION OF PESTS OF MAIZE

1. Control of cutworm *Agrotis ipsilon* on maize with EPN (SKUAS & T-J)

VIII. BIOLOGICAL SUPPRESSION OF PULSE CROP PESTS

1. Demonstration of biocontrol of pests and diseases of Pigeonpea (TNAU, ANGRAU & AAU-A)
2. Demonstration of biological control of seed/ soil borne disease of chickpea and *H. armigera* (PAU)
3. Fixing economic threshold level for NPV application for the control of *Helicoverpa armigera* on chickpea (TNAU, PAU, AAU-A)
4. Impact of bio-suppression of *H. armigera* on the incidence of other lepidopteran and borer species of pigeonpea (AAU-A)
5. Survey for natural enemies of pigeonpea pod wasp, *Tanaostigmodes cajaninae* and pod fly, *Melanagromyza obtusa* (ANGRAU)
6. Evaluation of EPN (*Heterorhabditis* sp.) against lepidopteran pod borers (ANGRAU)
7. Microbial control of *H. armigera* and *Adisura atkinsoni* on *Dolichos lablab* (ANGRAU)

8. Large scale demonstration of BIPM on chickpea (NCIPM)

VIII. BIOLOGICAL SUPPRESSION OF OILSEED CROP PESTS

1. Evaluation of BIPM package for castor pests (ANGRAU)
2. Laboratory evaluation of Trichogrammatids against castor capsule borer (ANGRAU)
3. Biological suppression of Uroleucon carthami in non spiny safflower varieties (ANGRAU)
4. Biological control of groundnut leaf miner (TNAU)
5. Evaluation of Trichogrammatids against the mustard sawfly (AAU-J)

IX. BIOLOGICAL SUPPRESSION OF COCONUT & CASHEW PESTS

1. Monitoring the incidence of *Opisina* in Kerala and collection of geographic populations of braconid parasitoids of coconut black headed caterpillar and evaluation of efficiency (CPCRI)
2. Large scale validation on biocontrol of coconut leaf caterpillar *Opisina arenosella* in Kerala (KAU)
3. Large area demonstration of *Oryctes rhinoceros* management using *Metarrhizium anisopliae* var. *major* and baculovirus in Kerala (KAU, CPCRI)
4. Large area demonstration of integrated biocontrol technology against *Oryctes rhinoceros* (CPCRI)
5. Studies on natural enemies of red palm weevil (CPCRI)

X. BIOLOGICAL SUPPRESSION OF PESTS IN TROPICAL FRUITS

1. Evaluation of biological control agents against mango hoppers (IIHR, MPKV, TNAU)
2. Demonstration on biological suppression of pink mealy bugs, *M. hirsutus* on custard apple, grapes (MPKV)
3. Survey and record of natural enemies of thrips on pomegranate, grapes (MPKV) and mango (NAU)
4. Effect of off-season release of *Cryptolaemus montrouzieri* to suppress the mealy bug in the main season on custard apple (ANGRAU)

XI. BIOLOGICAL SUPPRESSION OF PESTS OF TEMPERATE FRUITS

1. Survey for identification of suitable natural enemies of codling moth (SKUAS & T -S)
2. Field evaluation of *Trichogramma embryophagum* against the codling moth, *Cydia pomonella* on apple (SKUAS&T- S)
3. Evaluation of some microbial pesticides against tree stem borer (*Aeolesthes sata*) (SKUAS&T, YSPUH & F)
4. Evaluation of fungal pathogens against the apple woolly aphid (*Eriosoma lanigerum*) on apple (YSPUH & F).
5. Laboratory evaluation of some bioagents against the root borer *Dorysthenes hugelii* as pest of apple (YSPUH&F)
6. Studies on the predators of phytophagous mites on apple and beans (YSPUH&F)

XII. BIOLOGICAL SUPPRESSION OF PESTS OF VEGETABLE CROPS

1. Field evaluation of *Trichogramma brassicae* against *Plutella xylostella* on cabbage/cauliflower (AAU-J, MPKV, TNAU, SKUAS&T)
2. Laboratory evaluation of different species of *Trichogramma* against *Pieris brassicae* on cabbage/cauliflower (SKUAS&T)
3. Field evaluation of *Trichogramma chilonis* (local strain) against *Pieris brassicae* on cabbage/ cauliflower (SKUAS & T-S)
4. Demonstration of biocontrol based IPM module against cabbage pests (SDAU)
5. Evaluation of *Trichogramma brassicae, B. bassiana* and *S. carpocapsae* against lepidopteran

pests of cruciferous crops (cabbage) (IIHR, MPUAT)

6. Evaluation of *Trichogramma chilonis*, EPN and *Bt.* against fruit borer of brinjal and Okra (PAU, AAU-J and MPUAT)
7. Evaluation of *T. chilonis*, EPN and Bt against fruit borer of okra (UAS-D, Raichur)
8. Demonstration of Biological Control of Tomato fruit borer *Helicoverpa armigera* (PAU)
9. Adaptive trials on IPM in tomato (GBPUA & T)
10. Biocontrol of *Aphis craccivora* in cowpea using entomofungal pathogens. (KAU)
11. Demonstration of Potato Tuber Moth suppression by releasing *Copidosoma koehleri* (MPKV, AAU-J)
12. Effectiveness of various microbial pesticides and a summer oil against *Pieris brassicae* on kale / Knol khol. (SKUAS & T)
13. Biological control of cabbage aphids (*Brevicoryne brassicae*) (SKUAS & T-Srinagar)
14. Study on natural enemies of the serpentine leaf miner, *Liriomyza trifolii* on tomato and their possible exploitation for its suppression (YSPUH&F)
15. Demonstration of bio-intensive package for the pests of cole crops (YSPUH & F)
16. Biocontrol of greenhouse whiteflies (GHWF) on beans/cucumber/tomato (YSPUH&F)
17. Mass multiplication and evaluation of predatory mite against okra mite (UAS-D, Raichur)

XIII. BIOLOGICAL SUPPRESSION OF WHITE GRUBS

1. Biological suppression of white grubs

a) Potato and tomato (GBPUA&T, Ranichauri Centre)

b) Potato (YSPUH&F, MPKV)

c) Sugarcane

i) *Leucopholis* (COA, Kolhapur)

ii) *Holotrichia* (VSI, MPKV)

2. Mass Production of *B. brongniartii* and *B. bassiana* using adult white grubs (MPKV, Kolhapur)
3. Suppression of Cardamom root grub, *Basilepta fulvicorne* with Entomopathogenic Nematodes (Cardamom Researchs Station, Idukki)

XIV. BIOLOGICAL SUPPRESSION OF PESTS IN POLYHOUSES

1. Evaluation of biological control agents against sucking pests of vegetables and ornamentals under polyhouse conditions (MPKV: Rose)
2. Evaluation of anthocorid predator, *Blaptostethus pallescens* against spider mites on carnation in polyhouses (KAU, MPKV, NBAII)

XV. BIOLOGICAL SUPPRESSION OF WEEDS

1. A) Survey of natural enemies of *Cyperus rotundus* (AAU-J)

B) Biocontrol of *Cyperus rotundus* (KAU)

2. Biocontrol of *Chromolaena odorata* using *Cecidochares connexa* (KAU, AAU-J)
3. Monitoring of populations of *Cyrtobagous salviniae* released in the Kolhapur lake (College of Agriculture, Kolhapur)
4. Investigations on the differential performance of *Cyrtobagous salviniae* against *Salvinia* (KAU)

XVI. ESTABLISHMENT OF MASS PRODUCTION UNITS (AT ALL THE AICRP CENTRES)

13. CONSULTANCY, PATENTS AND COMMERCIALISATION OF TECHNOLOGY

PDBC

- Quality testing of several biopesticides
- EAG and GC-MS analysis for samples received from various organizations
- Bioassay of *Bt* proteins against lepidopteran pests
- Mass production and supply of trichogrammatids and coccinellids for biological control of various pests
- Mass production and supply of *Trichoderma*, *Pseudomonas*, etc for management of plant diseases
- Mass production and large scale supply of host insects like *Corcyra cephalonica*, *Spodoptera litura*, *Helicoverpa armigera* for research and commercial units
- Mass production and supply of *Goniozus nephantidis* and *Cardiastethus exiquus* for the biological control of *Opisina arenosella* on coconut

14. MEETINGS HELD AND SIGNIFICANT DECISION MADE

XIIth Research Advisory Committee Meeting held on 18th August, 2008

The twelfth Research Advisory Committee Meeting was held in the conference hall of the Project Directorate of Biological Control, Bangalore on 18th August 2008 under the chairmanship of Dr. A. N. Mukhopadhyaya. The other members who attended the meeting was Dr. T. P. Rajendran (ADG (PP)); Dr. B. S. Parmar; Dr. C. Manoharachary; Dr. D. J. Patel; Dr. C. A. Viraktamath; Dr. R. J. Rabindra

Dr. R. J. Rabindra, Project Director welcomed the Chairman and the Members of the RAC and briefed them about the institute activities. He stressed the need for orienting the research programmes with a specific objective of bringing out the effective biocontrol agents/technologies for adoption by stake holders particularly the farmers. Emphasis was laid upon the need for harnessing the natural enemies and providing biocontrol inputs to the farmers' field for sustainable agriculture. He summarized the salient achievements of research work done during 2007-08, especially the large scale village level adoption of biocontrol of rice pests by the Adat Panchayat in Thrissur (Kerala) and the successful control of sugarcane woolly aphid in the states of Maharashtra, Karnataka and Tamil Nadu.

Dr. A. N. Mukhopadhyay, Chairman RAC indicated that India, being one of the twelve mega-biodiversity countries has rich reservoir of microbes and arthropods. Harnessing of natural enemies is crucial to develop and promote sustainable Bio-Intensive Pest Management (BIPM) methods to increase the food production and to reduce the usage of chemical pesticides in the country. He emphasized on the need for availability of quality biocontrol products at low cost so that the farmers can afford it. Further he stressed the need for bio-village concept. The entire village can be adopted for demonstrating the BIPM methodologies. He complimented the PDBC scientists for quality research work in the field of biological control of crop pests and weeds. He advised the PDBC scientists to be focused and to bring out useful technologies for the welfare of the farmers.

The Chairman reviewed the action taken report on various recommendations made during the previous RAC held on 14th July, 2006. Then the laboratory chiefs made detailed presentations on the progress of work under the individual institute projects in the respective laboratories for the year 2007-08. The following recommendations emerged out of detailed discussions in several projects:

General remarks

1. The presentations in future should be supplemented with photographs of lab/pot/ net house experiments
2. PDBC may make attempts to document the feedback information from other institutes regarding the biocontrol agents received by them from PDBC.
3. Proposals for training of PDBC scientists in international laboratories may be proposed to the ICAR.
4. Innovative approaches with an accountability of outcome may be adopted in the research projects.
5. In future RACs research achievements under externally funded projects may also be presented by the PIs. If necessary the RAC may be held for two days.

6. Whenever biocontrol agents are exchanged, a material transfer agreement should be in place.
7. The experiments, where the results cannot be taken to the field may be discontinued
8. A data base has to be created regarding the number of cultures maintained at PDBC.
9. Scientists should ensure that there is no duplication of their research work in other institutes (both ICAR and SAUs)
10. Evaluation through MTA (Material Transfer Agreement)
11. While formulating the projects, scientists should give importance to the emerging IPR issues
12. A summary of all the projects may be provided to each RAC member

Specific comments

1. A *Trichoderma harzianum* formulation with two years of shelf life has been developed by the Division of Plant Pathology of IARI, New Delhi. PDBC may obtain the sample and validate the same.
2. The scientists working with microbial formulations should compare the efficacy of products made by solid-state fermentation with those of liquid fermentation.
3. Storage studies with *Trichoderma* formulation should be accompanied by a protocol for assessing the bioefficacy of the formulations.
4. *Bt* cry genes may be characterized using PCR technique with cry specific primers, a status paper on molecular characterization of *Bt* may be prepared
5. Studies on the possibilities of biological control of bacterial diseases of pomegranate may be initiated. Antagonistic activities of biocontrol organisms like *Paecilomyces lilacinus, Penicillium lilacium, Psudomonas putida, Trichoderma virens* and *Bacillus* spp. against *Xanthomonas malvacearum punicae* may be investigated.
6. *Steinernema riobrevi* may be tried against root grubs
7. An identification key for the entomopathogenic nematodes may be prepared
8. While assessing the efficacy of entomopathogenic nematodes against soil insects, soil factors like temperature, humidity, soil type, soil organic matter, soil poracity etc. may also be recorded.

Institute Research Council Meeting held on 19th August, 2008

The Institute Research Council Meeting of PDBC, Bangalore was held on 19th August, 2008 under the Chairmanship of Dr. R. J. Rabindra, Project Director, PDBC. Dr. T. P. Rajendran, ADG (PP), ICAR New Delhi stressed on the need for new research approaches in the XI plan as the Project Directorate of Biological Control (PDBC) was being upgraded to the National Bureau of Agriculturally Important Insects (NBAII). He advised the scientists to continue the research work in the existing projects and to reorient their research to fit into the new mandates of NBAII. He emphasized that research should be initiated on new thrust areas such as soil dwelling insects, pollinators, aquatic insects and their respective roles in agriculture and vectors of plant diseases and plant vector relationship. The action taken report was reviewed and found satisfactory.

After detailed discussions on the presentations on the achievements as per the targets given in their respective projects following points emerged out as recommendations.

- Work has to be intensified in the taxonomy of trichogramma and core competence in the taxonomy of Trichogrammatids is expected to have been developed since it is more than two years after the start of the project.
- Efforts should be renewed for the import of natural enemies of the mealy bugs, *Phenococcus solenopsis*, *Paracoccus marginatus* and the psyllid *Heteropsylla spinulosa*, for the control of *Mimosa diplotricha*.
- A model for scaling up of production of *B. pallescens* may be developed.
- The studies on *Micromus timidus* has to be completed.
- The studies on rearing of *C. montrouzieri* on *Sitotroga* should be completed by March, 2009 and RPF III to be submitted.

- The EPN project 'Effect of different edaphic factors on EPN activity and refinement of packaging for EPN formulations' should be concluded with suitable end use formulations for field adaption and RPF III be submitted. It was suggested that an efficient mass production technology for EPN should be developed in a new project.
- The project 'Identification of pathogens of phytophagous mites and assessment of their potential in microbial control' has to be closed on 30.6.2008 and RPF III to be submitted. RPF I for a new project.
- The work on isolation, characterization and toxicity of indigenous *Bacillus thuringiensis* strains against lepidopteran pests should be strengthened. Performance of superior isolates should be validated in initial evaluation trials (IET) in other centres of the AICRP. Samples to be supplied along with bioassay protocols.
- The scientists should re-submit RPF-I incorporating the suggestions given by the Project Monitoring and Evaluation Cell

Institute Management Committee Meetings

XIV IMC meeting

The XIV IMC meeting was held on 23rd June, 2008 at PDBC under the chairmanship of Dr. R. J. Rabindra, Project Director. The other members who attended the meeting were Dr. K. P. Jayanth, Dr. K. Prabhudas, Dr. M. Edward Raja, Dr. S. Prabhukumar and Mr. B. Amarnath.

The committee recommended the following:

The institute screening committee can recommend the scientists applications for overseas International Conferences/training under HRD. Replacement of equipments like BOD incubator international; Cold light source (as a part of leica stereozoom); SLR camera Minolta 35 mm as a part of compound microscope Leica; Hewlett Packard scanjet 6300 cc 1200 dpi flat bal. scanner; Hewlett Packard colour laserjet (600x600 dpi) Model No.4500; SWPC 486 laser printer – Lasetjet 4+; Magnetic stirrer; Cordless keyboard Logitech, Computer with H. P. 2000 C Printer (Part of Electrophoresis unit); Computer monitor compact digital; One network electronic typewriter to be replaced by a computer as electronic typewriters are now obsolate. Approval for the extension of the authorized medical attendants Dr. P. V. Mahalakshmi and Dr. Vishwanath Patil for a further period of one year i.e. upto 31.03.2009. Approved a part-time medical officer (PTMO) in Hebbal campus of PDBC for one hour daily during the office hours as PDBC is having guest house and hostel facility where a lot of VIPs and students/research scholars are staying. Approved payment of consultancy charges under the project "Studies on Baseline Susceptibility of Corn Pests to Cry1AB *Bacillus thuringiensis*".

XV IMC Meeting

The XV meeting was held on 10th February, 2009. The IMC recommended the proposal for payment of honorarium for the consultancy services undertaken by the staff members of the Institute under the following projects. a) "Bioefficacy with MON89034" sponsored by Monsanto India Ltd; b) Baseline susceptibility of *Chilo partellus* and *Helicoverpa armigera* to Bt proteins- Kharif 2008" sponsored by Monsanto India Ltd; c) "Baseline susceptibility and bio-efficacy with wide strike" sponsored by DOW Agro Sciences

The committee approved the proposal of entrusting the following works with UAS, Bangalore with 5% administrative charges.

Name of the work	Amount(Rs. in lakhs)
Live repository laboratories	62.67
Bitumen topping on main roads at farm	15.00
Staff rest room	10.02
Pavement for farm office, lab, net houses, polyhouses etc with pavers blocks	10.00
Chain linked fencing	10.00
Lighted sign board for NBAII, monogram etc	5.00
Worker toilet at farm	5.00
Borewells	5.00
Kerbing of dividers on main road	4.40
Insectaries (AICRP Co-ordinating unit at NBAII)	58.00
Total	185.09

The committee further mentioned that due to lack of sufficient space (particularly after losing some of the land to Bruhat Bangalore Mahanagara Palike (BBMP) for road widening), the Live Repository Laboratories can be constructed at the Attur Farm campus of PDBC.

The committee ratified the import of Millipore Water Purification System for Rs.6.21 lakh from France under Non-Plan during November 2008.

The Committee also approved the proposal for the procurement of imported items under XI Plan after following LC procedures. The committee recommended that for all the costlier/ imported items, the Institute should go for AMC after the expiry of warranty period. The committee also advised that the equipment purchased should be of use for all the Scientists of the Institute and sister units. A circular in this regard may be sent to all the neighboring ICAR institutes as well as UAS, GKVK campus for making the best use of the equipment.

The committee approved the proposal to condemn the two Matador vehicles KA-04-4891 and KA-04-4881 and the same to be replaced with Tavera/ Cheverolet (Jeep category).

The committee approved the extension of the authorized medical attendants Dr. P. V. Mahalakshmi and Dr. Vishwanath Patil for a further period of one year i.e. up to 31.03.2010 as the staff of PDBC need to avail medical facilities from time to time.

The committee approved the proposal for purchase of the following items of equipment costing less than Rs.5.00 lakh under the plan funds.

Name	Approx. Unit cost Rs. in lakh *	Quantity
Phase Contrast Microscopes	3.00	2
Stereozoom Microscope	2.00	3
Thermal cycler	3.00	2
Portable field data processing unit with acces.	0.55	11
Digital camera	0.40	9
Video camera	0.50	3
TLC unit	1.00	1
Tissue grinder	1.00	2
Insect pins	0.60	Assorted sizes
Hydbridization oven	1.00	2
Stereo zoom microscope with digital camera, software & accessories	3.50	1
Deep Freezer	0.50	1
Gel doc system	4.75	1
SSCP gel electrophoresis unit with power pack	3.50	1
Environmental shaker with temperature control	3.00	1
Vacuum flash evaporator	2.00	2
Laminar flow (vertical model)	1.50	1
Automatic autoclave	2.00	1
Incubator shaker	4.50	3
Low speed shaker	1.00	1
BOD incubator	1.00	11
Electrophoresis unit(vertical and horizontal) with power pack	1.00	3
Pre-freezer for lyophilizer	4.80	1
Precision electronic balance	0.80	6
Laminar flow (horizontal model)	0.80	4
Moisture analyzer	1.50	2
Ice flaking machine	1.50	1
Transilluminators	1.10	2
Centrilutor	0.50	1
Microfuge	0.65	1
Gel rocker with double platform	0.70	1
Refrigerated table top Centrifuge	4.75	1
Horizontal & vertical gel electrophoresis with 2D System	3.00	1

The committee approved the proposal for demolition of the old corcyra laboratory which is currently unfit for insect rearing or for scientific research. In view of the additional laboratory space required for the expanded mandate of the newly proposed Bureau, the committee approved the proposal for construction of a new Insectary building in the site of the old Corcyra laboratory building.

XVI IMC Meeting

The meeting was held on 21st March, 2009. The IMC recommended the following civil works to be executed costing more than 25 lakhs. The estimates were provided by the CPWD and the vetting of the proposal by the Director (W) has been obtained. As per the ICAR guidelines on works, the estimates amounting to more than Rs.50.00 lakhs and up to Rs.75.00 lakhs need the ratification from IMC. Considering the fact that both the estimate of works

listed at Sl.No.1 and 2 below have been technically vetted by Director (Works) and are approved items of works in the Institute's EFC document, both are ratified by the IMC.

Name of the work	Approved in EFC	Now proposed and vetted by Council
Repository building at Hebbal campus of NBAII	Rs.62.67 lakhs	Rs.72.28 lakhs
Insectory building at Attur campus at NBAII	Rs.58.00 lakhs	Rs.74.31 lakhs

Approval of change of equipment under Plan funds of XI plan EFC

Equipment originally proposed		Equipment now proposed	
Name of the equipment	Cost of the equipment	Name of the equipment	Cost of the equipment
Dehumidi-fier	Rs.5.00 lakh	Microscope	Rs.15.00 lakh
Arthropod collection equipment kit	Rs.20.00 lakh	Arthropod collection equipment kit	Rs.10.00 lakh
Total	Rs.25.00 lakh	Total	Rs.25.00 lakh

The IMC recommended the substitution of equipments listed at i) and ii) above in view of justification furnished by the Institute and the close functional relationship (lab equipments) between the approved equipment in the EFC and proposed substituted equipment. Further, there is no additional liability of funds due to substitution of the originally proposed equipment with a new one.

15. PARTICIPATION OF SCIENTISTS IN CONFERENCES, MEETINGS, WORKSHOPS, SYMPOSIA, ETC. IN INDIA AND ABROAD

Project Directorate of Biological Control, Bangalore

Dr R.J.Rabindra attended

- Executive Development Programme at NAARM, Hyderabad from 23rd to 27th September, 2008.
- Workshop on AICRP on white grubs at Regional Agricultural Research Station, Jaipur on 15th and 16th October, 2008.
- Launch Workshop of NAIP to be organized at CRIDA, Hyderabad on 28th and 29th November, 2008.
- International Workshop on DNA Barcoding organized by National Bureau of Fish Genetic Resources at NASC complex, New Delhi on 4th December, 2008.
- AICRP on Honeybee Research & Training workshop at Pusa Samastipur, Patna on 18th and 19th February, 2009.
- National symposium on Non chemical insect pest management held on 5th February, 2009 at Loyola College, Chennai and presented a paper on climate change and biological control.
- Directors' Conference At NASC Complex, New Delhi on 15th and 16th January, 2009.
- National Conference on "Biotechnological Approaches for Eco-Friendly Insect Pest Management and delivered a lecture entitled Endophytes in biological control" during the conference on 27th February, 2007 at Madras University, Chennai.
- DPC meeting as one of the members at NRCS, Hyderabad on 5th May, 2008 as a nominee of DG, ICAR.
- QRT meeting of the IIVR, Varanasi and drafted the QRT recommendations on 6th and 7th May, 2008.
- Discussion meeting on the biological control of gall insect of eucalyptus *Leptocybe* organized by the IPMA, Hyderabad on 13th May, 2008.
- Screening committee meeting at NAIP, New Delhi to screen the NAIP projects under basic and strategic research on 14th July, 2008.
- Selection committee meeting at Acharya N. G. Ranga Agricultural University, Rajendranagar, Hyderabad on 12th August, 2008.
- Research Coordination Committee Meeting of the Central Silk Board, Bangalore on 1st September, 2008.
- EFC meeting On 10th September, 2008 chaired by the DG, ICAR.
- Screening committee meeting at NAIP, New Delhi to screen the NAIP projects on IPM on 16th September, 2008.
- Institute Management Committee Meeting on 18th September, 2008 of NCIPM, New Delhi.
- Discussion meeting on management of aiien invasive species at the Centre for Advanced Studies, Madras University on 13th December, 2008.
- CIBRC meeting at Krishi Bhawan, New Delhi on 17th December, 2008.
- Interactive meeting on 22nd December, 2008with the Director and scientists of Institute of Forest Genetics and Tree Breeding, Coimbatore on the management of eucalyptus gall wasp.

- Discussions with the entomologists of Sugarcane Breeding Institute on 23rd December, 2008 on the biological control of internode borer and preparation of status paper on the current status of sugarcane woolly aphid.
- Discussion with the Member Secretary, Central Silk Board and Director, Central Sericultural Research and Training Institute campus at the Regional Station of Central Silk Board, Kolkata on 27th January, 2009 on the problem of papaya mealy bug on mulberry and possibility of developing a collaborative project for funding from Central Silk Board on the classical biological control of the mealy bug.
- Meeting for discussion on eucalyptus gall wasp at the Institute of Forest Genetics and Tree Breeding at Coimbatore on 25th and 26th February, 2009 to finalise the list of host plants for host specificity testing of gall wasp parasitoids.

Dr. J. Poorani attended

- The review meeting of the Network Project on Insect Biosystematics held at MPUAT, Udaipur, on 19-20th February, 2008 and presented the report for PDBC centre.
- The Biocontrol Workers group meeting held in Solan, YSPUHF, in May 2008 and presented the report on basic research carried out at PDBC on parasitoids and predators.

Dr. K. Srinivasamurthy attended

- The Launch Workshop of NAIP Project " Effect of abiotic stresses on the natural enemies of crop pests: *Trichogramma, Chrysoperla, Trichoderma, Pseudomonas* and mechanism of tolerance to these stresses" held on 28th November, at CRIDA, Hyderabad.
- The Consortium Advisory Committee meeting of the NAIP Project " Effect of abiotic stresses on the natural enemies of crop pests: *Trichogramma, Chrysoperla, Trichoderma, Pseudomonas* and mechanism of tolerance to these stresses" held on 29th November, at CRIDA, Hyderabad.

Dr. Chandish R. Ballal attended

- QRT meeting at PDBC 23rd to 24th April, 2008.
- XVII Biocontrol Workers Group Meeting held on 29th to 30th May, 2008 at YSPUH&F, Solan, Chairperson of Documentation Committee; Presented the basic work done at PDBC; Acted as Rapporteur for the finalisation of Technical Programme and plenary session.
- National Conference: Applied Entomology – Impact of global Warming on the incidence and management of insect pests in Agriculture at MPUA&T, Udaipur 5th to 7th March, 2009.

Dr. R. Rangeshwaran attended

- The workshop on "Project Management and Evaluation in Agriculture and Livelihood Projects" held at National Institute of Rural Development, Hyderabad from 9th to 13th March 2009.
- The launch workshop organized by NAIP for the PDBC project titled "Effect of abiotic stresses on the natural enemies of crop pests: *Trichogramma, Chrysoperla, Trichoderma* and *Pseudomonas* and mechanism of tolerance to these stresses" held at Hyderabad from 28th to 29th November 2008.
- The Consortium Implementation Committee Meeting for the NAIP project titled "Effect of abiotic stresses on the natural enemies of crop pests: *Trichogramma, Chrysoperla, Trichoderma* and *Pseudomonas* and mechanism of tolerance to these stresses", held at PDBC on 6th January 2009.
- Attended the Consortium Implementation Committee Meeting for the NAIP project titled "Effect of abiotic stresses on the natural enemies of crop pests: *Trichogramma, Chrysoperla, Trichoderma* and *Pseudomonas* and mechanism of tolerance to these stresses", held at PDBC on 20.09. 2009.

Dr. M. Nagesh attended

- And presented the progress in biological control of plant parasitic nematodes and a technical program for multi-location trials (The Annual Group Meeting of AICRP on Plant Parasitic Nematodes with integrated approach for their control) at RCA, MPUAT, Udaipur on 16th December, 2008.

- The AINP training on GPS/GIS at ANGRAU, Hyderabad, between 16.2.09 and 22.2.09.

Dr. Deepa Bhagat attended

- The second "Bangalore Nano- Nanotechnology in india's Future" at Hotel Ashoka from 11.12.2008 to 13.12.2008.

Dr. B. Ramanujam

- Geographical indications (GI) Road Show on 03.12.2008 at Hotel Atria, Palace road, Bangalore on 03.12.2008.

Dr. A.N.Shyleasha attended

- The two day workshop "Indo-US AKI workshop on SPS issues related to agriculture trade in Plant based commodities at NASC Complex, New Delhi-12 from 22-23 July, 2008.

AAU, Anand

Dr. D. M. Korat

- Expert in Krushi Darshan Phone in live program (Doordarshan Ahmedabad). (Two programmes).
- Gave radio talk on Biocontrol in Pulse crops.
- Provided technical guidance regarding Biological Control of crop pests was provided through lectures to the extension officers and farmers in various training programs organized by Directorate of Extension Education, AAU, Anand, State Department of Agriculture, Govt. of Gujarat and NGOs.
- Gave lectures on role of Biocontrol agents in Insect Pest Management and IPM in Cereals, Pulses and Oilseeds crops.
- Gave lecture on role of biological control of insect pests in Bt cotton (Surat).

Dr. B. H. Patel

- Gave T.V. talks through ETV Gujarati.
- Was subject matter specialist in Video Conference Programs organized by SSK, AAU, Anand.
- Participated in an exhibition in the Krishi mela organized by Uma Friends organization (UFO) at Umiyadham, Ganthila , Ta. Vanthali Di. Junagadh (from 18 -4-08 to 20-4-08).
- Participated in an exhibition at Godhra (9-5-08) and Devgadh baria (19-6-08) on the occasion of Bhoomi Pujan under Vanbandhu Project.

AAU, Jorhat

Dr. A. Basit

- Provided advance course on Biological Control to P.G. students.
- Attended XVI Biocontrol workers Group Meeting held at ANGRAU, Hyderabad on 18th & 19th May 2007.
- Imparted training to the Agricultural Officers, State Department of Agriculture Govt. of Assam.
- Organised a Field day on the impact of Biocontrol in organic farming in the management of rice pests was conducted at Burakuri Gaon, Teok, (Dist:Jorhat) on 21st November 2008. About 50 farmers participated in the field day.

ANGRAU, Hyderabad

Dr S.J.Rahman

- Guided B.Sc.(Ag.), M.Sc.(Ag.) and Ph.D. students of College of Agriculture, Rajendranagar.

CTRI, Rajahmundry

Dr Gunneswara Rao

- Imparted training to input dealers of Manage on 8-2-2009 at CTRI, Rajahmundry on IPM.
- Imparted training to tobacco farmers on IPM at Vadisaleru Village on 25-11-08.

GPUA&T, Pantnagar

Dr. J. Kumar

- Organized a 21 days national training on *'Recent Advances in Biological Control of Plant Diseases'* from March 20 to April 09, 2009 wherein 20 scientists from various Universities covering 11 states of India participated.
- Organized a National Conference on Increasing Production and Productivity of Medicinal and Aromatic Plants through Traditional Practices from 18 -20 September 2008 at G. B. Pant

University of Agriculture and Technology, Pantnagar.

Dr. N. W. Zaidi

- Visited the International Rice Research Institute (IRRI) Philippines, to serve as consultant at Dhaka, Bangladesh, to give her input on Biological seed treatment for development of a training module for the course on rice seed production for the farmers and seed producers which will be used for training of scientists, extension workers, governmental and non-governmental organizations and farmers in South Asia including India.

IIHR, Bangalore

Dr. A. Krishnamoorthy

- Gave lecture during the Special training course for officers of Department of Agriculture, Government of Kerala under National Horticultural Mission on Vegetable production Technology – Gave lecture on use of Biopesticides and biocontrol agents in the management of pests and diseases in vegetable crops on 23/06/2008 at IIHR, Bangalore.
- Gave lecture during the Special Training Programme being organized for the Officers of Department of Horticulture, Govt. of Haryana on Advances in Production Technologies in Horticultural Crops held from 15th to 21st July 2008.
- Gave lecture during the Special Training course for Programme Executive of Prasar Bharathi representing various states of the country on Advances in Production Technology of Horticultural Crops, held from 23rd – 30th July 2008.
- Gave lecture during the Special Training Programme for programme executives (2nd batch) of Prasar Bharathi representing various states of the country on Advances in Production Technology of Horticultural Crops, held from 19 – 26 August 2008.
- Gave lecture during the Model Training course for Agri- Horticultural Officers, sponsored by Directorate of Extension, Ministry of Agriculture, GOI on Integrated Pest Management in Horticultural Crops (16/ 9/ 2008 to 23/9/2008) on16th September and gave lecture on Advances in Biocontrol of pests in Horticultural crops.
- Gave lecture during the Model Training course for Agri- Horticultural Officers, sponsored by Directorate of Extension, Ministry of Agriculture, GOI on Advances in protection technology in Horticultural crops (18/ 11/ 2008 to 25/11/2008) on 21 November and gave lecture on Advances in Biocontrol of pests in Horticultural crops.
- Gave lecture during the Special Training course for Horticultural Officers, sponsored by dept of Horticulture, Govt. of Andhara Pradesh on Integrated Pest and Disease management in Horticultural crops (10/ 02/ 2009 to 17/02/2009) on 16 Feb and gave lecture on Biological control of insect pests in Horticultural Crops.
- Gave lecture during the Special Training course for Farmers of Chikkaballapura district sponsored by the dept. agriculture, Govt. of Karnataka on advances in Production technology of Horticultural Crops (11/ 03/ 2009 to 18/03/2009) on 17 March and gave lecture on Biological control of insect pests in Horticultural Crops
- Attended XVII Biocontrol workers' group meeting on biological control of crop pests and weeds at Dr. Y. S. Parmar University of Horticulture and Forestry, Solan, HP, 29 -30 May 2008.
- Attended a group meeting on Bioinformatics in Plant Protection on 7th November 2008 at IIHR.
- Attended National Conference on Biotechnological approaches for eco-friendly insect pest management held at University of Madras, Guindy campus, Chennai from Feb 27 – 28, 2009.

Dr. P.N. Ganga Visalakshy

- Gave a lecture on use of Biopesticides and biocontrol agents in the management of pests and diseases in vegetable crops on 23/06/2008 at IIHR, Bangalore during the Special training course for officers of Department of Agriculture, Govt. of Kerala under National Horticultural Mission on Vegetable production Technology.

- Was a resource person in the panel discussion on Integrated pest management in fruits, vegetables and ornamental crops in Advances in production of horticultural crops from 5-3-2009 to 7-3-2009.
- Presented the report for 2007-08 on biological control of weeds, polyhouse pests and white grubs during the XVII Biocontorl workers group meeting on biological control of crop pests and weeds at Dr.Y.S.Parmar University of Horticulture and Forestry, Solan, H.P from 29 to 30-5-2008.
- Attended the National conference on Biotechnological approaches for ecofriendly insect pest management, Feb. 27-28,2009, University of Madras.
- Presented the progress report of the DBT funded project Development of biocontrol technology for mango hoppers in the sixth task force meeting on biopesticides of DBT. held at IICT, Hyderabad on June 26-27, 2008.
- Presented the project Developing an invert emulsion formulation of *Metarhizium anisopliae*, for thrips of horticultural importance during the 7th task force meeting on bopesticides held by DBT on 29 to 30-12-2008 at Delhi for DBT funding.
- Attended a group meeting on Bioinformatics in Plant Protection on 7th November 2008 at IIHR.

KAU, Thrissur

Dr Babu Philip

- Provided one day training for the final year B.Sc (Ag.) students (Entomology Elective) of College of Horticulture, Vellanikkara on Mass production of biocontrol agents.
- Guided PG students of Dept. of Entomology, College of Horticulture, Vellanikkara.
- Arranged classes on the B. Sc zoology students of St. Josephs College, Alappuzha on 14th October, 2008 and M. Sc students of BCM College, Kottayam on 29th October, 08.
- Arranged classes on the students of Govt. V.H.S.S., Nadavarambu and Ramavarmapuram on 14th November, 08 and 11th December, 08 respectively.

Dr Lyla

- Provided one day training for the final year B.Sc (Ag.) students (Entomology Elective) of College of Horticulture, Vellanikkara on Mass production of biocontrol agents.
- Guided PG students of Dept. of Entomology, College of Horticulture, Vellanikkara
- Arranged classes on the B. Sc zoology students of St. Josephs College, Alappuzha on 14th October, 2008 and M. Sc students of BCM College, Kottayam on 29th October, 08.
- Arranged classes on the students of Govt. V.H.S.S., Nadavarambu and Ramavarmapuram on 14th November, 08 and 11th December, 08 respectively.
- Attended XVII Biocontrol workers group meeting held at Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan on 29th and 30th May, 2008.

Dr. Pathummal Beevi

- Attended XVII Biocontrol Workers Group Meeting held at Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan on 29th and 30th May, 2008.

MPKV, Pune

Dr. D.S. Pokharkar

- PG course ENTO. 509, Biological Control during 2008-09.
- Evaluated three theses submitted to Marathwada Agricultural University, Parbhani and one from Anand Agricultural University, Anand, Gujarat for award of M. Sc. (Agri.) degree.
- Was examiner for UAS, Dharwad for setting question paper of course No. AET. 401, Crop Pests and Their Management and evaluated the answer papers.
- Provided lecture on 'Biological suppression of pests of grape and mass production of *Cryptolaemus montrouzieri*' to 30 trainees at MRDBS, Manjari, Pune on 12/7/2008.
- Provided lectures on 'Biological control of insect pests' to 30 trainees from Department of Agriculture, Maharashtra State, Pune on11/11/2008.

- Provided lecture on 'Mass production and use of bioagents for the control of crop pests in organic farming' to a team of 18 farmers accompanied with Dr. Diliprao Deshmukh, Vice Precident, Maharashtra Organic farming Federation (MOFF), Pune and Shri. Ramesh Deshmukh, Regional Head, Dist. Buldhana on 06/12/2008.
- Exhibits of bioagents displayed through RAEC in KISAN 2008, the International Agricultural Exhibition arranged at Moshi, Dist. Pune during December 17-21, 2008.
- Provided lecture on 'Biological control of insect and mite pests' to 35 trainees of State Dept. of Agriculture, Maharashtra State, RAMETI Training Centre, Pune on 19/03/2009.
- Attended the Research Review Committee Meeting in Plant Protection- Agril. Entomology held at MPKV, Rahuri on 10th April 2008 and presented a research report as well as two recommendations on biological control.
- Research Finding Release Committee Meeting on 22nd April, 2008 and one recommendation on development of mass production technique of *Dipha aphidivora*, a predator on sugarcane woolly aphids in shade net was approved.
- Attended the XVII Biocontrol Workers Group Meeting at Dr. YSPUH & F, Nauni, Solan (HP) on May 29-30, 2008.
- Attended the DBT Ad-hoc project on '*In vitro* production of NPV through insect cell culture'.
- Attended the 'Fourth Meeting on Strategies for the "Management Mealy bugs in Grapes" held at NRC for Grapes, Pune on 8th July 2008 and presented the research and extension work carried out by this centre.
- Attended the 'Seminar on Roadmap of Biotechnological Research in Maharashtra' held on 27th September 2008 at MPKV, Rahuri.
- Attended the Research Programme Planning Meeting held at MPKV, Rahuri on 3rd and 4th February 2009 and presented the research programme for the year 2009-10.

Dr. R.V. Nakat

- Conducted PG course ENTO 510 – Techniqwues in Bioagents Production during 2008-9.
- Conducted the Thesis viva-voce examination of PG student at Department of Entomology, MPKV, Rahuri on 21st October 2008.
- Provided Lecture on 'Mass production and use of bioagents for the control crop pests in organic farming' to a team of 18 farmers accompanied with Dr. Diliprao Deshmukh, Vice Precident, Maharashtra Organic farming Federation (MOFF), Pune and Shri. Ramesh Deshmukh, Regional Head, Dist. Buldhana on 06/12/2008.
- Attended the Research Review Committee Meeting in Plant Protection- Agril. Entomology held at MPKV, Rahuri on 10th April 2008 and presented a research report as well as two recommendations on biological control.
- Attended the VI DBT Task Force Meeting on Biopesticides held at IICT, Hyderabad during 25-26th June, 2008.
- Attended the Fourth Meeting on Strategies for the Management Mealy bugs in Grapes' held at NRC for Grapes, Pune on 8th July 2008 and presented the research and extension work carried out by this centre.
- Attended the Research Programme Planning Meeting held at MPKV, Rahuri on 3rd and 4th February 2009 and presented the research programme for the year 2009-10.
- Attended the Central Zone Workshop on Mealy bugs on Cotton' organized by NCIPM, New Delhi at Dr. PDKV, Akola on 24th February 2009.

IISR, Lucknow

Dr Arun Baitha

- Provided information on "Bio-Control of Insect-Pests of Sugarcane" to Sugarcane Development Personnel on 19 th July, 2008 at IISR, Lucknow.
- Attended the XVII Bio-control Worker's Group Meeting on Biological Control of Crop Pests and Weeds at Y.S.Parmar University of Horticulture and Forestry, Solan (H.P.) from 29.-30th May 2008.
- Attended the Seminar on "Awareness about intellectual property rights and its protection on 03.03.2009 at IISR, Lucknow, sponsored by Council of Science and Technology, U.P.

SBI, Coimbatore

Dr N.Geetha

- Served as a resource person for one batch of M.Sc (Sugarcane production) students (Contact classes) in 2008 and took classes for B.Sc (Ag) students.
- Served as a resource person (Topic: "Recent advances in pest management in sugarcane") in the training course on "Modern trends in pest management" during 13 to 15.2.09 conducted by Tamil Nadu Agricultural University.

CTRI, Rajahmundry

S. Gunneswara Rao

- Attended IRC meetings of CTRI, Rajahmundry during June 2008.
- Participated in Rythu sadassu on 8-06-2008 at Devarapalli village organized by Dept. of Agriculture, Govt. of Andhra Pradesh.

TNAU, Coimbatore

Dr. M. Kalyanasundaram

- Attended National Symposium on Non Chemical Insect Pest Management" at the Entomology Research Institute, Chennai on 5-6, February, 2009.

PAU, Ludhiana

Dr M S Mahal

- Attended the Research and Extension Specialists Workshop for *Rabi* crops August 11-12, 2008 at PAU, Ludhiana.
- Attended the *Kisan Mela* at PAU, Ludhiana on March 19 –20, 2009.
- Attended the course on "Recent techniques for taxonomic treatment of the order Lepidoptera" held in the Department of Entomology, PAU, Ludhiana from December 15-19, 2008.

Dr Jaspal Singh Virk

- Attended the Research and Extension Specialists Workshop for *Rabi* crops August 11-12, 2008 at PAU, Ludhiana.
- Attended the XVII All India Biocontrol Worker's group meeting held at Y S Parmar University of Horticulture & Forestry, Nauni (Solan) from May 28-29, 2008.
- Attended the *Kisan Mela* at PAU, Ludhiana on March 19 –20, 2009.
- Attended the course on "Recent techniques for taxonomic treatment of the order Lepidoptera" held at the Department of Entomology, PAU, Ludhiana from December 15-19, 2008.
- Attended the "Advances in Design and Analysis of Agricultural Experiments" held at IASRI, Pusa Institute, New Delhi from January 14 to February 3, 2009.

Dr Neelam Joshi

- Attended the Research and Extension Specialists Workshop for *Rabi* crops August 11-12, 2008 at PAU, Ludhiana.
- Attended the XVII All India Biocontrol Worker's group meeting held at Y S Parmar University of Horticulture & Forestry, Nauni (Solan) from May 28-29, 2008.
- Attended the *Kisan Mela* at PAU, Ludhiana on March 19 –20, 2009.
- Attended the course on "Recent techniques for taxonomic treatment of the order Lepidoptera" held at the Department of Entomology, PAU, Ludhiana from December 15-19, 2008.
- Attended the Winter School on "Immunological and Molecular techniques for Diagnosis of Infectious Diseases of Domestic animals and Poultry" from December 2-22, 2008 at Department of Microbiology, GADVASU, Ludhiana.
- Attended the 12th Punjab Science Congress at PAU, Ludhiana on February 7-9, 2009.

Dr Naveen Aggarwal

- Attended the Research and Extension Specialists Workshop for *Rabi* crops August 11-12, 2008 at PAU, Ludhiana.
- Attended the *Kisan Mela* at PAU, Ludhiana on March 19 –20, 2009.
- Attended the course on "Recent techniques for taxonomic treatment of the order Lepidoptera" held at the Department of Entomology, PAU, Ludhiana from December 15-19, 2008.

- Attended the Golden Jubilee Celebration of Indo-German Cooperation in Higher Education-Symposium on Education and Research in Sustainability at IIT, Madras on September 8-9, 2008.
- Attended the National Conference on Ecofriendly Approaches in Sustainable Agriculture and Horticulture Production at Amity University, Lucknow on November 28-30, 2008.

Dr Vikas Jindal

- Attended the Research and Extension Specialists Workshop for *Rabi* crops August 11-12, 2008 at PAU, Ludhiana.
- Attended the course on "Recent techniques for taxonomic treatment of the order Lepidoptera" held at the Department of Entomology, PAU, Ludhiana from December 15-19, 2008.
- Attended the "Advances in Design and Analysis of Agricultural Experiments" held at IASRI, Pusa Institute, New Delhi from January 14 to February 3, 2009.
- Attended the Workshop of All India Co-ordinated Cotton Improvement Project at PAU, Ludhiana during April 9-11, 2008.
- Participated in XXIII International Congress of Entomology held at Durban, South Africa during July 6-12, 2008.
- Attended the Young Scientist Award Programme of Indian Science Congress Association at NEHU, Shillong, Meghalaya on October 17, 2008.

Dr Rabinder Kaur

- Attended the Research and Extension Specialists Workshop for *Rabi* crops August 11-12, 2008 at PAU, Ludhiana.
- Attended the XVII All India Biocontrol Worker's group meeting held at Y S Parmar University of Horticulture & Forestry, Nauni (Solan) from May 28-29, 2008.
- Attended the *Kisan Mela* at PAU, Ludhiana on March 19 –20, 2009.
- Attended the course on"Recent techniques for taxonomic treatment of the order Lepidoptera" held at the Department of Entomology, PAU, Ludhiana from December 15-19, 2008.
- Attended the "Recent Advances in Pest Population Dynamics and its Monitoring Techniques" at Chowdhary Charan Singh Haryana Agricultural University, Hisar from February 17- March 9, 2009.

YSPUH&F, Solan

Dr P.R.Gupta & and Dr Sharma

- Attended the VIII National Symposium on Emerging Trends of Researches in Insect Pest Management and Environment Safety, September 24-26, 2008, Haridwar, by The Uttar Pradesh Zoological Society, Muzaffarnagar; research paper authored by Sharma, A., U. Chauhan, P. R. Gupta & K. C. Sharma entitled "Effect of botanicals on two spotted spider mite, *Tetranychus urticae* (Koch) (Acari: Tetranychidae) on Sweet pepper, *Capsicum annum*" was presented by senior author. Abstract No. 65, pp. 43.
- Attended the XVII Biocontrol Workers' Group Meeting, held on May 29-30, 2008 at Dr. Y. S. Parmar University of Horticulture & Forestry, Nauni, Solan: Attended by Dr. P. R Gupta, Dr. Usha Chauhan and Dr. P. L. Sharma of the Department.
- Attended the National Seminar-cum-Exhibition on Apple, September 26-28, 2008, organized by UHF, Nauni, Apple Growers Association of India and National Horticulture Board, Gurgaon, held at Dr. Y. S. Parmar University of Horticulture & Forestry, Nauni, Solan.

16. WORKSHOPS, SEMINARS, SUMMER INSTITUTES, TRAINING, ETC.

Trainings conducted at PDBC

- Mass production of *Spodoptera litura* from 27-06-2008 to 28-06-2008- for one person
- Mass production of entomofungi, *Bt*, NPV, and *S. litura* and *H. armigera* from 19-06-2008 to 23-06-2008 for one person.
- Isolation, purification by column chromatography and structure elucidation from 20-06-2008 to 20-07-2008 for one person.
- Mass Production of Quality NPV from 22-09-2008 to 30-09-2008 for two persons.
- Mass production of egg parasitoids, predators, NPV, *Trichoderma* and *Pseudomonas* from 20-10-2008 to 25-10-2008 for 12 farmers sponsored by ATMA, Vellore.
- Mass production of Ttrichogramma egg parasitoids, predators like lady bird beetle and chrysoperla, NPV, entomopathogenic fungi like *Beauveria*, antagonistic fungi like *Trichoderma*, *B.t.* from 17-11-2008 to 25-11-2008 for three persons.
- Mass production of NPV, *Trichoderma* spp., *Metarhizium* spp., *Verticillium* spp. and *Pseudomonas flouorescens* from 09-02-2009 to 12-02-2009 for two persons.
- Mass production and quality control of *Sl* NPV from 04-03-2009 to 05-03-2009 for 11 persons from Agri. Dept. Maharashtra.
- Mass production and quality aspects of *Trichogramma*, *Trichoderma*, NPV, *Pseudomonas fluorescens*,*Beauveria bassiana* including *Nomuraea*" from 16-03-2009 to 21-03-2009 for four persons from Agri. Dept., Karnataka.

Organized

- Hindi Pakhwada 16-30 September, 2008.
- Vigilance awareness week from 3-7 November, 2008.

17. DISTINGUISHED VISITORS

PDBC, Bangalore

Mr. B.A.Coutinho, Additional Secretary and Financial Advisor, Department of Agricultural Research and Education, ICAR, Krishi Bhavan, New Delhi on 7.6.2008.

Dr. V. V. Sadamate, Advisor (Agriculture), Planning Commission, Govt. of India, Yojana Bhawan, New Delhi-110 001 along with Sandeepa Kanitkar Chairman and Managing Director of Kanbiosy and E.M.Koshy 29/101 EE Apartments, AOFG India Delhi-110096 on 9.9.2008..

Dr. Abdullah Al Shagag, Dr. Mansour Al Baqshy, Dr. Sarni Al Sarouj, Dr. Yaseen All Abbad and Dr. Saud Alayeid from Date Palm Centre, Saudi Arabia visited PDBC on 25.10.2008.

AAU, Anand

D. M. Paranjape, Dept. of Agriculture, Goa on 7.7.2008.

P.G. Majither, Deputy Director of Agriculture on 18.8.2208.

Tejal Manvar, NIOH, Ahmedabad on 13.10.2008.

Dr. V. J. Jadhav, BVC, Parel, Mumbai on 13.10.2008.

Prof. B. V. Deore, Asstt. Residue Analyst, RPQS, Mumbai on 13.10.2008.

H. D. Vaghela, Deputy Director of Agriculture(T.) FTC, on 16.12.2008.

Rem Raj, Asst. Director of Agriculture, Jaipur on 16.2.2009.

AAU, Jorhat

Dr. B. Mallik, Project Coordinator Acarology Bangalore.

Dr. Basudev Rao,Project Coordinator Ornithology Haydarabad.

Dr. M.P. Singh, Prof. & Head Manipur University, CAU.

Dr. B. Senapati, Professor. Uttar Bangla KrishiVigayan Kendra.

ANGRAU, Hyderabad

Dr. P. Raghava Reddy. Hon'ble Vice Chancellor, ANGRAU on 11.6.2006.

Scientists' Team on Bio Pesticides Training on 18.3.2009.

GBPUA&T, Pantnagar

Maj. Gen. (Retd) B. C. Khanduri Honourable Chief Minister of Uttarakhand, visited and inaugurated the new building of the Biocontrol lab in December 2008.

Dr. A.N. Mukhopadhyay, Ex-Vice-Chancellor, Assam Agriculture University, Jorhat.

Dr. Akhtar Haseeb, Chairman, Department of Plant Protection, Faculty of Agricultural Sciences, Aligarh Muslim Univervsity of Aligarh.

Dr. O.M. Bambawale, Director, National Centre for Integrated Pest Management, (NCIPM), New Delhi-110 012.

MPKV, Pune

The Peer Review Committee members comprising – Dr. Raghuvardhan Reddy, Chairman & Former Vice Chancellor, ANGRAU, Hyderabad.

Dr. A. N. Mathur, Member and Ex-Dean, Rajasthan Agril. Univ., Udaipur and Dr. R. K. Mittal, Secretary and Asstt. Director General, ICAR, New Delhi visited this Bio-control centre on 22/5/2008.

Dr. Dilip Deshmukh Baradkar, Vice President, Maharashtra Organic Farming Federation (MOFF), Pune and Shri Ramesh Deshmukh, District Incharge, MOFF, Buldhana along with 18 trainees of organic farming visited this Biocontrol laboratory on 06/12/2008.

Dr. Mangala Rai, Secretary, DARE, Govt. of India & DG, ICAR, New Delhi.

Dr. R. B. Deshmukh, Vice Chancellor, MPKV, Rahuri.

Dr. A. S. Jadhav, Dean & Director of Instruction, MPKV, Rahuri.

Dr. K. D. Kokate, Director of Extension Education, MPKV, Rahuri.

Prof. G. B. Gutal, University Engineer, MPKV, Rahuri.

Dr. B. R. Ulmek, Associate Dean, College of Agriculture, Pune on 16/12/2008 to review the research work carried out by this centre especially on sugarcane woolly aphids.

A team of foreign delegates- Mr. Johu Edema, Mr. Ariku David, Mr. Andrew Ebayu and Mr. Awoko Walter, Sugar Corporation of Uganda, P. B. 1, Lugazi, UGANDA on 06/01/2009 and took review of the work on Sugarcane woolly aphids.

PAU, Ludhiana

Kenneth Shapiro, Associate Dean and John Peters, UW Soil Scientist, UW College of Agricultural and Life Sciences, University of Wisconsin-Madison, USA, on March 18, 2009.

18. PERSONNEL

Project Directorate of Biological Control, Bangalore

Dr. R. J. Rabindra	Project Director	Dr. S. K. Jalali	Senior Scientist
Dr. S. S. Hussaini	Principal Scientist	Dr. T. Venkatesan	Senior Scientist
Dr. B. S. Bhumannavar	Principal Scientist	Dr. P. Sreerama Kumar	Senior Scientist
Dr. D. Sundararaju	Principal Scientist	Dr. K. Srinivasa Murthy	Senior Scientist
Dr. N. Bakthavatsalam	Principal Scientist	Dr. S. Sriram	Senior Scientist
Dr. B. Ramanujam	Principal Scientist	Dr. Sunil Joshi	Senior Scientist
Dr. Prashanth Mohanraj	Principal Scientis	Dr. R. Rangeshwaran	Senior Scientist
Dr. (Ms.) Veena Kumari	Principal Scientist	Dr. G. Sivakumar	Senior Scientist
Dr. (Ms.) J. Poorani	Principal Scientist	Ms. M. Pratheepa	Scientist (SS)
Dr. (Ms.) Chandish R. Ballal	Principal Scientist	Dr. (Ms.) Deepa Bhagat	Scientist (SS)
Dr. M. Nagesh	Principal Scientist	Ms. Gandhi Gracy	Scientist
Dr. A. N. Shylesha	Principal Scientist		

Anand Agricultural University, Anand

Dr. D. M. Korat	Principal Research Scientist
Dr. Babubhai H. Patel	Associate Research Scientist
Dr. J. J. Jani	Assistant Research Scientist

Achrya N. G. Ranga Agricultural University, Hyderabad

Dr. N. Hariprasada Rao	Principal Scientist
Dr. S. J. Rahman	Principal Scientist

Assam Agricultural University, Jorhat

Dr. A. Basit	Principal Scientist
Dr. D. K. Saikia	Senior Scientist

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

Dr. P. R. Gupta	Senior Entomologist
Dr. Usha Chauhan	Entomologist

Govind Ballabh Pant University of Agricultural Science & Technology, Pantnagar

Dr. J. Kumar	Professor & Head
Dr. (Ms.) Nijam Waris Zaidi	Assistant Professor

Kerala Agricultural University, Thrissur

Dr. Babu M. Philip	Professor
Dr. (Ms.) K. R. Lyla	Associate Professor

Mahatma Phule Krishi Vidyapeeth, Pune

Dr. D. S. Pokharkar	Entomologist
Dr. R. V. Nakat	Assistant Entomologist

Punjab Agricultural University, Ludhiana

Dr. Naveen Aggarwal	Entomologist
Dr. (Ms.) Neelam Joshi	Microbiologist
Ms. Ramandeep Kaur	Assistant Entomologist
Dr. (Ms.) Rabinder Kaur	Assistant Entomologist
Dr. Vikas Jindal	Assistant Entomologist
Sh. Sudhendu Sharma	Assistant Entomologist

Sher-e-Kashmir University of Agriculture and Technology, Srinagar

Dr. M. Jamal Ahmad	Associate Professor
Dr. Sajad Mohi-ud-din	Assistant Professor

Tamil Nadu Agricultural University, Coimbatore

Dr. P. Karuppuchamy	Professor
Dr. M. Kalyanasundaram	Professor

19. INFRASTRUCTURE DEVELOPMENT

PDBC

Equipment

The laboratories were further strengthened with the acquisition of several equipments like nano-drop spectrophotometer, real time PCR, Temperature gradient chamber, Co_2 incubators, fermentors, SS CP gel electrophoresis, gradient PCR, Refrigerted centrifuge, Colour multicopier, Phase-contrast microscope and High resolution compound microscopes

Library

The library has a collection of 1,869 books, 1,421 volumes of journals, 59 bulletins and several miscellaneous publications including several reprints on various aspects of biological control. Seventeen foreign and 17 Indian journals were subscribed for. CD-ROM - abstracts upgraded up to February 2009.

ARIS Cell

Computer systems have been upgraded with Windows XP operating system in ARIS Cell. The software Corel DRAW X3 Graphics Suite and MS-Office 2007 has been procured. Database on entomopathogenic nematodes was developed at PDBC and is available in CD. Project Directorate of Biological Control domain name has been registered with ERNET India, New Delhi. PDBC web site had been hoisted with web site address : www.pdbc.res.in. The mail server has been configured in the ARIS Cell and the official E-mail id is: pdbc@mail.pdbc.res.in

National Insect Reference Collection

The PDBC has 4,225 authentically identified species belonging to 235 families under 18 orders. The collection includes representatives of the orders Hymenoptera, Coleoptera, Hemiptera, Orthoptera, Strepsiptera, Thysanoptera, Neuroptera, Diptera, Lepidoptera, etc., encompassing crop pests, parasitoids and predators. A sizeable reference collection of Thysanoptera with 1000 slides has been added. PDBC's reference collection of insects has been electronically catalogued in a retrievable form.

Land and buildings

The following civil and other works were taken up. Sanitary connection & Kaveri water connection; retaining wall & SIRA stone wall cladding formation of road to trainees hostel; MS Grill fencing for protecting electrical air conditioning equipments installed outside the quarantine lab; staff rest room; and Providing aluminum partitions with pre-laminated board & glass pane at Biotech lab.

Farm development

Construction of farm house/ lab & implement shed; kerbing of dividers of main road; compound wall; insectaries laboratory; pavement of farm office laboratory with pavers and live repository lab at PDBC Farmat Attur.

20. EMPOWERMENT OF WOMEN

During 2008-09, the participation of women in different training programmes was as follows:

Mass production of trichogramma egg parasitoids, predators like lady bird beetle and *Chrysoperla*, NPV, entomopathogenic fungi like *Beauveria*, antagonistic fungi like *Trichoderma*, *Bt* (17-11-2008 to 25-11-2008).

Dr. Z. Sailaja Rani, M.Sc (Ag.), Assistant Manager (Ag.), K.C.P.Sugars & Industries Corporation Ltd., Vuyyuru, Krishna (Dist.), Andhra Pradesh.

Mass production of NPV, *Trichoderma* spp., *Metarhizium* spp., *Verticillium* spp. and *Pseudomonas flouorescens* (09-02-2009 to 12-02-2009).

Ms. Amruta B. Sorte, Production Manager, Ellora Biotech and Agro Services Pvt. Ltd., Aurangabad.

Mrs. Sunanda D. Sitole, Agricultural Officer, Biocontrol Laboratory, Dharwad.

Mass production and quality control of *Sl* NPV (04-03-2009 to 05-03-2009)

Ms. Pallavi Suryawanshi, Agriculture Assistant, Biocontrol laboratory, Aurangabad.

Ms. D. K. Gaikwad, Agriculture Assistant Biocontrol laboratory, Ahamednagar.

Mass production and quality aspects of *Trichogramma*, *Trichoderma*, NPV, *Pseudomonas fluorescens*, *Beauveria bassiana* and *Nomuraea*" (16-03-2009 to 21-03-2009).

Ms. M. Kavitha, Agricultural Officer, Parasite Laboratory, Mandya.


Spalgis epius
Pupa
Larva