ANNUAL REPORT
2009 - 2010

NATIONAL BUREAU OF
AGRICULTURALLY IMPORTANT INSECTS
(Indian Council of Agricultural Research)
Bangalore

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Front cover

The Coconut leaf beetle *Brontispa longissima*, a quarantine pest

Cover design

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Hindi Text

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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

Indian agriculture continues to face the pressure of ever-increasing demand for food by the burgeoning human population. As we strive to enhance the food production, we face severe constraints, foremost being losses caused by pests, diseases and weeds. Loss of biodiversity of useful insects, mites and related arthropods like parasitoids, predators, honey bees, pollinators and soil builders due to indiscriminate use of chemical pesticides as well as habitat loss due to alien invasive weeds is becoming a huge concern. The Indian Council of Agricultural Research has responded to this situation by upgrading the Project Directorate of Biological Control to the **National Bureau of Agriculturally Important Insects** (NBAII) with effect from June, 2009. The mandate of this newly formed bureau shall be: "**Collection, characterisation, documentation, conservation, exchange and utilisation of agriculturally important insect resources (including mites, spiders and related arthropods) for sustainable agriculture**".

Since the time **Dr.S.Ayyappan,** a dynamic leader in agricultural research and education took charge as **Secretary, Department of Agricultural Research and Education** (DARE) and **Director General, Indian Council of Agricultural Research** (ICAR), the NBAII has become increasingly conscious of the strong support and encouragement from the ICAR. His constant affirmation of faith in the NBAII has enabled us to gain confidence in meeting the colossal challenge of harnessing the power of insects for the benefit of Indian Agriculture. The NBAII shall strive to enhance the preparedness for facing the threat posed by alien invasive pests. The staff of NBAII gratefully acknowledge the support of **Dr.S.Ayyappan**.

Dr.Swapan Kumar Datta, the **Deputy Director General**, ICAR, continues to guide us with his scientific excellence and leadership for which we shall ever remain grateful. His support to the bureau was crucial particularly as we went through the process of transformation and change. The NBAII enjoys the strong support of **Dr.T.P.Rajendran**, **Assistant Director General (Plant Protection)**, ICAR almost on a daily basis which we value very much.

We place on record our gratitude to **Shri Rajiv Mehrishi**, **Secretary, ICAR and Additional Secretary, DARE** for providing the much needed logistic support through his colleagues, **Shri J. Ravi**, Deputy Secretary (Personnel) and **Shri Sanjay Gupta**, Deputy Secretary (Administration). **Shri Sujit K. Mitra**, **Deputy Secretary (Crop Sciences)**, ICAR extended his help constantly. His timely actions on several administrative matters were very crucial to the smooth functioning of the NBAII. The support extended by **Mr. V. P. Kothiyal,** Director Works (ICAR) in carrying out the various civil works was remarkable.

I thank all my colleagues at the NBAII for their co-operation and earnest attempts to carry forward the vision and goals of the newly formed bureau. I acknowledge the research contributions of all the scientists of the NBAII as well as those in the different centres of the AICRP on biological control of crop pests, diseases and weeds during the year 2009-10.

I acknowledge the role of **Dr. B. S. Bhumannavar**, Principal Scientist (Entomology) and **Dr. K. Srinivasa Moorthy**, Senior Scientist (Entomology) in the preparation of this report.

The NBAII shall strive to forge partnerships and collaborations with all stake holders, both national and international, involved in conservation and utilisation of insects, mites and related arthropod resources for the benefit of the farming community.

R.J.Rabindra
Director
National Bureau of Agriculturally Important Insects and
Coordinator
AICRP on Biological Control of Crop Pests and Weeds

निष्पादित सारांश

25 जून, 2009 को पूर्वकालीन जैविक नियंत्रण परियोजना निदेशालय का उन्नयन करके राष्ट्रीय कृषि उपयोगी कीट ब्यूरो (रा.कृ.उ.की.ब्यू.) के रूप आयाम प्राप्त हुआ। नए रूप से बने ब्यूरो के अधिदेश के अन्तर्गत व्यापक अनुसंधान कार्यक्रम निष्पादित किये गये। रा.कृ.उ.की.ब्यू. पर परियोजना समन्वयन प्रकोष्ठ के अन्तर्गत पादप रोगाणुओं का जैविक नियंत्रण संबंधित सभी अनुसंधान कार्यक्रम निरंतर रूप से चलते रहे। सन् 2009-10 के दौरान रा.कृ.उ.की.ब्यू. के साथ-साथ जैविक नियंत्रण पर अ.भा.स.अनु.परि. के अन्तर्गत 14 राज्य कृषि विश्व विद्यालयों और भारतीय कृषि अनुसंधान परिषद (भा.कृ.अनु.प.) आधारित छः केन्द्रों के अतिरिक्त अनेक स्वैच्छिक केन्द्रों द्वारा प्राप्त की गई मुख्य उपलब्धियों को नीचे प्रस्तुत किया गया है। विविध फसल परिस्थितियों में कीट पीड़कों के प्रति जैव नियंत्रण नीतियों को अत्याधिक प्रभावशाली पाया गया।

मौलिक अनुसंधान

राष्ट्रीय कृषि उपयोगी कीट ब्यूरो

जैव-वर्गीकरण, जैव-विविधता और जैव सुरक्षा विभाग

जैव वर्गीकरण

भारत और पडौसी देशों के कीटों के गौण गणों के केटलोगिंग का कार्य आरम्भ किया तथा 15 गणों की चैकलिस्ट तैयार की गई। कोक्सीनेलिडे की नौ, *स्किमनोड्स* की सात और एपोलीनस की दो नई प्रजातियों को वर्णित किया गया। बेंगलोर, धारवाड, लुधियाना, कोयम्बटूर, बडौदा, दिल्ली, उदयपुर, सिरसा, गुन्टूर और श्रीगंगानगर से क्राईसोपरला कारनिआ (कार्निआ समूह) के दस कीट समूह सँख्याओं को कपास की फसल से एकत्र किया और उनका संसेर्गिक सिगनल को ध्वनिकी विश्लेषण के आधार पर *क्राईसोपरला जेस्ट्रोवी अरेबिया* हेनरी एटआल के रूप में विशेषता वर्णित की गई।

ट्राईकोग्रामा की निम्न तीन प्रजातियों – *ट्रा. रबिन्द्राई, ट्रा. पिएविडिस* और *ट्रा. गीरिएन्सिस* को वर्णित किया गया। भारत में पहली बार *ट्रा. किलोनिस* और *ट्रा. मानी* द्वारा क्राईसोपिडे (न्यूरोप्टेरा) के अण्ड़ों को परजीवित करते पाया। *ट्रा. एकीये* के लिए *यूरीमा ब्लान्डा* के अण्डों को अतिरिक्त परपोषक को रुप में पाया गया।

अण्ड परजीवी कीटों का कृषिगत पारिस्थितिकी और अकृषिगत पारिस्थितिकी दोनों स्थितियों में सर्वेक्षण किया गया। गन्ना, धान, गेहूं, मक्का, दलहनी, सब्जियों और फलों वाली फसलों पर असम, आन्ध्र प्रदेश, कर्नाटक, केरल, राजस्थान, तमिल नाडु और उत्तराखण्ड सात राज्यों से सीलिओनिड वेस्पों को अण्डों को एकत्र किया गया।

विभिन्न गणों जैसे हेटेरोप्टेरा (232), लेपिडोप्टेरा (66), अर्केनिडा (33), होमोप्टेरा (29), न्यूरोप्टेरा (क्राईसोपिडे और अस्केलेफिडे) (15), डिकटायोप्टेरा (13), डिप्टेरा (4) और कोयलोप्टेरा (2) के कीटों के 396 अण्ड समूहों से अण्ड परजीवी कीट एकत्र किए गए।

इस पाठयक्रम अध्ययन के दौरान, सीलिओनिडे के चौदह वंश जोकि तीन उपकूलों – सिलीओनिने, टेलीनोमिने और टेलीएसीने से संबन्धित थे, को अभिलेखित किया गया। ये चौदह वंश-एन्टिरोमोर्फा, बेरीकोनस, बाएयस, सीरटोबाएयस, डोडीएल्ला, फ्यूजीकोर्निआ, ओपिस्थोकान्था, सीलिओ, ओडोन्टेकोलस, सीलिओसेरडो, ग्रायोन, ट्राईमोरस, यूमिक्रोसोमा और ट्राईमोरस हैं। बेरीकोनस, बाएयस, सीरटोबाएयस, डोडीएल्ला, फ्यूजीकोर्निआ, ओपिस्थोकान्था और ओडोन्टेकोलस को कर्नाटक में पहली बार, जबकि यूमिक्रोसोमा जोकि केवल दिल्ली और हरियाणा से अभिलेखित है, वह दक्षिण भारत से पहली बार अभिलेखित किया गया।

धान के पीले तना बेधक के अण्ड समूहों को *ट्राईकोग्रामा* स्पे. (ट्राईकोग्रामेटिडे), *टेलीनोमस* स्पे. (सीलिओनिडे) और *टेट्रास्टिकस* स्पे. द्वारा परजीवित किया गया। टेलीनोमस स्पे. द्वारा अण्ड परजीवीकरण 25.5 से 86.2 प्रतिशत जबकि *टेट्रास्टिकस* स्पे. द्वारा अण्ड परजीवीकरण विस्तार 0-22.3 प्रतिशत पाया गया। *ट्राईकोग्रामा* द्वारा परजीवीकरण विस्तार 0-44.0 प्रतिशत पाया गया।

विभिन्न पर्यावरणिक परिस्थितिकी तन्त्र से एकत्र किए गए पीड़कों और प्राकृतिक शत्रु कीटों के अण्डों को सीलिओनिडे, युपेलमिडे, एन्सिर्टिडे और यूलोफिडे कूलों से संबन्धित परजीवी कीटों द्वारा परजीवित पाया गया। इस पाठयक्रम अध्ययन के दौरान कुल 3368 परजीवी कीटों को एकत्र किया गया।

कर्नाटक में विभिन्न पोषक पौधों के ग्रसन के लिए माईट की पाँच प्रजातियाँ *मिलानएफिस बेम्बुसे* (फुलावे), *ब्रेकीसीफोनिएल्ला मोन्टान* (वेन डेर गूट), *केपीटोफोरस माइटगोनी ईस्टोप, सीरेटोवेक्यूना पेरग्लेन्डूलोसा* बासु, घोष और रायचौधरी तथा एफिस कुरोसवाई ताकाहाशी को अभिलेखित किया गया। इन पाँच प्रजातियों में से, तीन प्रजातियों को दक्षिण भारत में पहली बार अभिलेखित किया गया।

बेंगलोर से कोक्सीड्स की 12 कूलों से संबन्धित 85 प्रजातियों को अभिलोखित किया गया। *कोनकेस्पिस कोकेरेल* (कूल कोनकेस्पिडिडे) और *केरुलेस्पिस* मेक गिलीवरे (कूल डाईएस्पिडिडे) प्रजातियों को भारत में पहली बार अभिलेखित किया गया। विभिन्न कूलों जैसे यूलोफिडे, एन्सिर्टिडे, एफिलिनीडे, सिग्निकोरिडे और टेरोमेलिडे से संबन्धित परजीवी कीटों की कुल 24 प्रजातियों को साफ्ट स्केल्स, डाईऐस्पिडिड्स और मीलीबगों सहित विभिन्न कोक्सीडस से एकत्र किया गया।

नारियल कीट *ब्रोन्टिस्पा* के संगरोध के लिए प्रत्याशित कार्रवाई

नारियल पत्ती की बीटल, न्टिस्पा *लोन्जिसिमा* दक्षिण पूर्व एशिया और दक्षिण प्रशान्त महाद्वीप के अनेक देशों में घुस गया है तथा इस कीट की हमारे देश में प्रवेश करने की आशंका है। कृषि / बागवानी विभागों के अधिकारियों, केन्द्रीय समेकित कीट प्रबंधन केन्द्रों के पादप संरक्षण कार्यकर्ताओं और कृषि विज्ञान केन्द्र के विषय विशेषज्ञों के लिए पाँच संवेदन ग्रहण कार्यशालाऐं आयोजित की गई, एक कार्यशाला ओ.यू.ए.टी., भुवनेश्वर, एक कार्यशाला अम्बाजीपेट्टा, आन्ध्र प्रदेश, दो कार्यशालायें रा.कृ.उ.की.ब्यू., बेंगलोर और एक कार्यशाला त.कृ.वि, तमिल नाडु में आयोजित की गयी। इस कीट के लिए ब्यूरो ने डी एन

ए बार कोड का विकास किया, जिससे कि इस कीट के देश में प्रवेश करने पर इसकी सहायता से तुरन्त पहचान की जा सकेगी । *ब्रो. लोन्जिसिमा* के कलासिकल जैविक नियंत्रण के लिए *एसीकोड्स हिस्पीनेरम* और *टेट्रास्टिकस ब्रोन्टिस्पे* संभाव्य जैविक नियंत्रण कारक हैं ।

पापीता मीलीबग *पेराकोकस मार्जिनेटस* पर अध्ययन

पपीते के मीलीबग ने अंकुरित आलूओं पर 30 से 35 दिनों में अपना जीवन चक्र पूर्ण किया । प्रत्येक गर्भित मादा /अण्डज 170.5 + 8.2 अण्डे (एन=20) देती है । अण्डे 4-6 दिनों में सेने योग्य हो जाते हैं और अण्डों से निम्म निकलकर पत्ती और तनों पर भक्षण आरम्भ कर देते है । पपीते के मीलीबग के प्राकृतिक शत्रु कीटों में तीन कोकसीनेलिड हैं जिनके नाम है – *मीनोकिलस सेक्समेकुलेटस, नीफस रेगुलेरिस* और *क्युरीनस कोएरुलीयस* । कपास की फसल में पपीता मीलीबग के ग्रसन के साथ *एपेर्टोक्रोइसा* स्पे. नियर के सीनेर्विस (न्यूरोप्टेराः क्रोईसोपिडे) को अभिलेखित किया गया । खेत में केवल स्पेल्जिस एपियस परभक्षी कीट को *पे. मार्जिनेटस* का निरंतर भक्षण करते पाया गया ।

प्राकृतिक शत्रु कीटों की जैव-विविधता

विभिन्न परजीवी कीट सँख्याओं में से तमिल नाडु के गोनिओजस निफेन्टिडिस को 32, 36 के उच्च तापक्र मों और 36-40^0 से.ग्रे. के परिवर्ती तापक्रमों पर प्यूपे बनने की प्रतिशत (62.6-80.5), परजीवीकरण दक्षता (6.2-8.5 लारवे/मादा) और प्रौढ़ दीर्घ काल (41.3-56.6 दिन) की दशाओं में सर्वश्रेष्ठ पाया गया ।

को. फलेविपस की विभिन्न कीट सँख्याओं ने फेनवेलीरेट और एन्डोसल्फान के प्रति परिवर्ती गुण प्रदर्शित किया । शिमला से एकत्र की गई कीट सँख्या में अत्यधिक एल सी$_{50}$ (2.77 पी पी एम) इसके बाद कोयम्बटूर (एल सी$_{50}$, 2.24 पी पी एम) और छिन्दवाडा (एल सी$_{50}$ = 1.98 पी पी एम) में पाई गई । एन्डोसल्फान के लिए बेंगलोर से एकत्र की गई कीट सँ'या में अत्यधिक एल सी$_{50}$ (56.24 पी पी एम) पाई गई ।

बागलकोट, बेंगलोर, देवागानाहल्ली, होसकोटे और मुलबागल (कर्नाटक) औरंगाबाद, छिन्दवाडा, दिल्ली, होशियारपुर, हैदराबाद और शिमला से एकत्र किए को. फ्लेविपस की कीट सँख्याओं के लिए आई टी एस-2 रिजन के पी सी आर अध्ययन में जीनोम के रिजन परीक्षण में बहुरुपता देखी गई । आई टी एस 2 के डी एन ए सीक्वेन्स विश्लेषण से अन्तः प्रजाति भिन्नता प्रदर्शित होती है । आर ए पी डी विश्लेषण द्वारा कीट सँख्याओं में भिन्नता प्रदर्शित होती है। शिमला से एकत्र कीट सँख्या में ढूँढने की क्षमता अच्छी पाई गई, इसके बाद डिन्डीगल से एकत्र कीट सँ'याओं में यह क्षमता पाई गई ।

कोयम्बटूर और शिमोगा से एकत्र किए गए *क्रिप्टोलीमस मोन्ट्रयूजिएरी* कीट सँख्याओं में 32-40^0 से.ग्रे. के परिवर्ती उच्चतम तापक्रम पर न्यूनतम (66.7 और 66.6 प्रतिशत) घातकता पाई गई, जबकि बेंगलोर, पुणे और प्रयोगशाला में पाली गई कीट सँख्या में 100 प्रतिशत घातकता पाई गई ।

जब *क्रि. मोन्ट्रयूजिएरी* के 10 दिन आयु के लारवों पर एसीफेट (0.67 ग्रा /ली) का छिड़काव किया गया तब बेंगलोंर (24 प्रतिशत) और पुणे (17 प्रतिशत) से एकत्र कीट सँ'याओं में बचने की अधिकतम प्रतिशतता पाई गई । इसी प्रकार के परिणाम पाये गये जब 20 दिन आयु के लारवों पर प्रयोग किया तब बेंगलोर और पुणे की कीट सँख्याओं में क्र मशः 37 प्रतिशत और 26 प्रतिशत बचने की प्रतिशतता पाई गई ।

कपास की फसल के चूषक कीटों के प्रति क्षेत्र में कीटनाशक सहिष्णु विभेद मूल्यांकन में पाया गया कि 15 दिन के अन्तराल पर क्राईसोपरला जास्ट्रोवी अरेबीका (सी जेड ए 8) कीटनाशी सहिष्णु विभेद को एसीफेट (0.67 ग्रा./ली.) के दो छिड़काव साथ साथ करने पर माहू (13.4), थ्रिप्स (1.87), श्वेत मक्खी (1.02) और पर्ण फुदके (3.13) की संख्या प्रति पौधा, न्यूनतम पाई गई और कपास के बीज की उपज अत्यधिक (1533 किग्रा/हे.) पाई गई। यह एसीफेट (0.67 ग्रा./ली.) के 4 छिड़कावों के समान पाया गया ।

जैव-संसाधन संरक्षण और उपयोजन विभाग

एन्थोकोरिड परभक्षी कीटों का मूल्यांकन

बऊहीनिया परपुरिआ पर *फेरीसिआ विरगेटा* कालोनियों से *एन्थोकोरिस* स्पे. एकत्र करके *फेनोकोकस सोलेनोप्सिस* और *फेरीसिआ विरगेटा* दोनों पर बहुगुणित किया गया । कपास के मीलीबग पर जैविक मापनों का अध्ययन किया गया । अण्डे से प्रौढ़ बनने तक का कुल विकास काल 21 दिन और जनन क्षमता 22.5 अण्डे पाई गई ।

रा.कृ.उ.की.ब्यू. के प्रक्षेत्र पर पोलीहाऊस सें माईट ग्रसित कार्नेशन के प्रति *ब्लाप्टोस्टेथस* पेलेसेन्स के मूल्यांकन के लिए किए गए परीक्षण के परिणाम दर्शाते हैं कि यह परभक्षी कीट माइट के ग्रसन को लगभग 28 प्रतिशत तक कम और फूलों की उपज को 20 प्रतिशत तक बढ़ा देता है ।

मिर्च की फसल (फें शनो चिली-सुप्रीम किस्म) में *ब्ला. पेलेसेन्स* को 10-20 प्रति पौधे की दर से पाँच बार छोड़ने के परिणाम स्वरुप थ्रिप्स द्वारा होने वाली क्षति को महत्वपूर्ण रुप से कम किया गया । जैव नियंत्रण उपचारित प्लाट में थ्रिप्स (फ्रेंकलिनिएल्ला स्कलटजेई) की सँखया का विस्तार 0.7 से 13 प्रति कली / फूल, जबकि अनोपचारित प्लाट में यह विस्तार 0.14 से 28.15 पाया गया, जोकि इस बात का सूचक है कि जैविक नियंत्रण प्लाट में थ्रिप्स की संख्या को महत्वपूर्ण रूप से कम किया गया । अनोपचारित प्लाट के मिर्च फलों की उपज, रासायनिक कीटनाशक के तुलना योग्य पाई गई ।

ओरीयस टेन्टिलस को *हेलीकोवर्पा आर्मीजेरा* के अण्डों को परागकणों के साथ मिलाकर फ्रोजन (बर्फ में जमाना) अण्डों पर प्रभावशाली रुप से पाला गया । फ्रोजन अण्डों पर भक्षण किये गए प्रौढ़ों की जननक्षमता *साईटोट्रोगा सीरीएलेल्ला* के अण्डों पर पाले गए से तुलनात्मक योग्य पाई गई ।

नेट हाउस में, टमाटर की स्पाईडर माइट के ग्रसन के प्रति ब्ला. पेलेसेन्स के मूल्यांकन पर किए गए अध्ययन में उपचारित पौधों में

माइट की सँख्या 50 प्रतिशत तक कम पाई गई । यद्यपि टमाटर के पौधों में ट्राईकोम्स की सघनता के कारण एन्थोकोरिड़ अत्याधिक मरे पाए गए । यह परीक्षण इस बात का सूचक है कि परभक्षी कीट *ब्ला. पेलेसेन्स* माइट *ट्रा. उर्टिके* का संभाव्य परभक्षी कीट है, तथापि परपोषी पौधे के रुप में उसकी विशिष्टता का परभक्षी कीट की कार्यक्षमता पर बुरा प्रभाव पड़ता है।

हेलीकोवर्पा आर्मीजेरा की फेरोमोन्स के प्रति अनुक्रिया

हे. आर्मीजेरा के श्रांगिकाओं (एन्टीनों) की कार्यिकी अध्ययन दर्शाता है कि नरों में *सेन्सिला ट्रायकोयडिआ* अधिक सँख्या में, जबकि मादाओं में *सेन्सिला बेसीकोनिका* अधिक सँख्या में होते हैं । नरों की विभिन्न कीट सँख्याओं का इलैकट्रोएन्टीनोग्राम अध्ययन के लिए जेड-11 हेकसाडेसीनल को 85:15, 88:12, 91:9, 94:6 और 97:3 अनुपात के ब्लेन्ड पर पाया गया कि जेड -11 हेकसाडेसीनल की तरफ नर अधिक आकर्षित होते है और जेड-9 हेकसाडेसीनल की तरफ कम आकर्षित होते हैं । अकेले जेड-11 हेकसाडेसीनल की अपेक्षा 85:15 अनुपात का ब्लेन्ड अत्याधिक आकर्षित करने के लिए प्रभावशाली पाया गया । अनेक कीट सँख्याओं के अध्ययनों में से 97:3 की अपेक्षा 85:15 अनुपात का ब्लेन्ड अत्यधिक प्रभावशाली पाया गया । यद्यपि रायचूर वाली कीट संख्या ने ब्लेन्डस अध्ययन में कोई सँख्यिकी अन्तर नहीं दर्शाया ।

फेरोमोन्स धीरे धीरे छोड़ने की नेनोप्रौद्योगिकी

फेरोमोन्स या फेरोमोन्स के मिश्रण से बनाई गई नेनोफाईबर्स नेटवर्क को कमरे के तापक्रम पर टिकाऊ व सही पाया गया और अधिक समय तक संग्रहण के लिए उचित पाया गया। नेनोफाईबर्स से फेरोमोन्स को छोडने की पद्यति को 10, 20 और 300 से.ग्रे. पर अध्ययन किया गया । फेरोमोन का धीरे-धीरे वाष्पीकरण देखा गया, जिससे कि इसकी दृढ़ता बढ़ाकर कृषि कीट प्रबन्धन के प्रयोग के लिए उपयोगी बनाया गया । फल मक्खी, बेक्ट्रोसीरा डोर्सेलिस के प्रबंधन के लिए फेरोमोन्स का नेनोनियमन बनाया गया और वाराणसी, उ.प्र. में अमरुद के बागीचे में सफलतापूर्वक क्षेत्रीय जाँच परीक्षण किया गया । हेलीकोवर्पा आर्मीजेरा और *स्किर्फोफेगा* इन्सर्टुलस फेरोमोन घटक जेड-9 हेक्साडेसीनल और जेड-11 हेकसाडेसीनल संश्लेषित किया गया । प्रोटीन न्यूक्लियर मेग्नेटिक रीजोनेन्स (एच एन एम आर) के साथ संरचना को सुनिश्चित किया गया । प्राकृतिक शत्रु कीटों के लिए केरोमोन्स के नेनो नियमन तैयार किए गए । स्किर्फोफेगा इन्सर्टुलस फेरोमोन के नेनोफाइबर्स की संग्रहण जीवन बढाने और आसानी से वितरण के लिए संश्लेषित किया गया ।

परागणकर्ता

कर्नाटक (गुलबर्गा) तथा महाराष्ट्र (परभनी) के परम्परागत रुप से और आन्ध्र प्रदेश (हैदराबाद) तथा तमिल नाडु (पुदुकोटाई) के गैर परम्परागत रुप से अरहर उगाने वाले क्षेत्रों का सर्वेक्षण किया गया । परंपरागत तरीके अपनाए गए क्षेत्रों में शहद की मक्खी (*एपिस फ्लोरीआ* और *ए. डोर्सेटा*) प्रमुखता से पाई गई और शहद तथा पराग एकत्र करते पाई गई । डंक रहित मक्खी, *ट्रायगोना* स्पे. इन्हीं क्षेत्रों में मितव्ययी पाई गई । किन्तु ये सभी गैर परम्परागत कृषि अपनाए जाने वाले अरहर के क्षेत्रों में नहीं पाई गई । फूल की कील पत्रकों को खोलकर अर्थात पुंकेसरों के एकदम पास के क्षेत्र से परागकण निष्कर्ष लिया । परम्परागत और गैर परम्परागत दोनों ही क्षेत्रों में बढ़ई मक्खी (*जाईलोकोपा* स्पे.) और पत्ती काटने वाली मक्खी (*मेगाचिले* स्पे.) और हेलीक्टिड मक्खियाँ पायी गई । बढ़ई मक्खी और पत्ती काटने वाली मक्खी पत्रकों पर बैठकर बाल और पिस्टन मशीन के समान व्यवस्थित करने के बाद पराग कणों को एकत्र करती हैं, जबकि हेलीक्टिड मक्खी शहद की मक्खी के समान कार्य करते हुए परागकणों को एकत्र करती हैं । ए. फ्लोरीआ तथा ए. डोर्सेटा की प्रति फूल आवाजाही दर का समय विस्तार क्रमशः 1-80 सैकेण्ड (माध्यः 15.8) और 1-27 सैकेण्ड (माध्यः 8.4) पाया गया, जबकि बढ़ई मक्खी और पत्ती काटने वाली मक्खी का आवाजाही समय विस्तार 1 से 16 सैकेण्ड पाया गया।

जैव-प्रौद्योगिकी और जैव सूचना विभाग

परजीवी कीटों और परभक्षी कीटों के उत्कृष्ट विभेदों का विकास

औरंगाबाद, बेंगलोर, डिन्डीगुल और मालूर (बेंगलोर के पास) से कोटेशिआ फ्लेविपस की संखयाओं में अंतः सहजीवन जीवाणुवीय कारक पाए गए जोकि परजीवी कीट की उपयुक्तता में योगदान करते हैं । बेंगलोर से एकत्र परजीवी कीट की 5 पीढ़ीयों के बाद मादाओं की 20 प्रतिशत संख्या बढ़ी पाई गई।

कृषि उपयोगी प्रमुख कीटों की अणुविक विशेषता

क्राईसोपरला जेस्ट्रोवी अरेबीका

क्राईसोपरला जेड अरेबीका का पी सी आर अभिवर्द्धन के माध्यम से साईटोक्रोम सी आँक्सीडेज (सी ओ आई) जीन जैसे सी जेड ए - 8 और सी जेड ए-6 की पहचान और उन्हे सीकवेन्स (524 बी पी) किया गया, जोकि क्रोईसोपिड परभक्षी कीटों की डी एन ए बार कोड के विकास के लिए उपयोगी होगा । सी जेड ए 8 के सी ओ आई जीन के सीक्रेन्स को जीन बैंक में जमा किया गया और उसका खाता संख्या जी यू 817334 (524 बी पी) है ।

ट्रायकोग्रामटिडे

कुछ ट्रायकोग्रामाटाँयडिए प्रजातियों के आई टी एस-2 आर डी एन ए पी सी आर उत्पादों के मूल जोडों के 800-900 बी पी तक भिन्न भिन्न पाए गए । एन-जे विधि में फाइलोजिनेटिक ट्री आधार पर पाँच प्लेट प्रजातियों के साथ और एक विशेष प्रजाति अपने सहयोगी से जुडी पाई गई । *ट्रा. किलोनिस* के आई टी एस-2 रिजन को क्षेत्र से एकत्र करके अभिर्द्धित और सीक्रेन्स किया गया । इन सीक्रेन्सों का विश्लेषण किया गया और सीक्रेन्स पहचान मैट्रिक्स तैयार किया गया । ये सँख्यायें आपस में 98.1 से 100.0 प्रतिशत तक मेल खाती हैं ।

वोल्बेशिआ की असंक्रमित प्रजातियों का ऊर्ध्वाधर प्रत्यार्पण अध्ययन में पाया गया कि जाँच की गई चार प्रजातियों के पैतृक में

मादा प्रतिशत केवल 45.0 से 56.0 प्रतिशत था। 20 पीढ़ीयों तक प्रत्यार्पण करने के बाद मादाओं का प्रतिशत 60.0 से 79.0 प्रतिशत पाया गया । *ट्रा. एकीये* (20 वीं. पीढ़ी में 45.0 से 79.0) और *ट्रा. जेपोनिकम* (20 वीं पीढ़ी में 50.0 से 72.0) के पैतृक कीट संख्या की मादाओं की संख्या बढने का माध्य प्रतिशत बहुत अधिक पाया गया जोकि इस बात का सूचक है कि शायद वोल्बेशिआ का प्रत्यार्पण हो गया होगा। संग्रमित प्रजातियों में बोल्बेशिआ को रीफेम्पिसीन एन्टीबायोटिक द्वारा उपचारित करने पर पाया कि *ट्रा. केकोएसीए* में मादा प्रतिशत 100 प्रतिशत रही जोकि इस बात का सूचक है कि बेक्टीरियम के कारण थेलीटोकी नही पाया गया । अन्य प्रजातियों में मादा प्रतिशत 23.2 – 98.1 प्रतिशत का विस्तार पाया गया और *ट्रा. कोर्बुडेन्सिस, ट्रा. ईवानेसेन्स* और *ट्रा. प्रेटिओजम* (फ्रांस) में जनन क्षमता माध्य घटी पाई, किन्तु *ट्रा. सेम्बलिडिस* और *ट्रा. प्रेटिओजम* (यु एस ए) में 20 पीढ़ीयों तक उपचार के बाद जनन क्षमता बढ़ी पाई गई ।

प्रयोगशाला में, ट्रायकोग्रामेटिडस को मीस्ट खिलाकर उपयुक्तता परीक्षण दर्शाता है कि *ट्रा. किलोनिस, ट्रा. जेपोनिकम, ट्रा. एकीये* और *ट्राय. बेक्टरे* कीटों की मादा प्रतिशत क्रमशः 45.0–80.0, 50.0–79.4, 45.0–64.5 और 56.0–79.0 बढी पाई गई । अनेक प्रजातियों की जनन क्षमता भी बढ़ी *ट्रा. किलोनिस* (35 से 54.0), *ट्रा. जेपोनिकम* (40.0 से 62.0) *ट्रा. एकीये* (35.0 से 56.0) और *ट्राय. बेक्टरे* (25.0 से 38.0) यद्यपि यह सीमांत बढोत्तरी थी ।

भारतीय कोक्सीनेलीड

बेंगलोर क्षेत्र से कोक्सीनेलिडों की चौदह प्रजातियों को एकत्र करके डी एन ए निष्कर्ष तैयार किया गया । कोक्सीनेलिडों की सी ओ आई रिजन के लिए प्राइमर्स जोडों का डिजाईन तैयार किया गया । चौदह प्रजातियोंं के सी ओ आई जीन का पी सी आर में अभिवर्धन करने के मानकीकरण करने की आंशिक जीन सीक्रेन्स सुनिश्चित की गई ।

कीटों और खरपतवारों के जैविक नियंत्रण पर अखिल भारतीय समन्वित अनुसंधान परियोजना

समन्वित प्रकोष्ठ – रा.कृ.उ.की.ब्यू.

कवकीय प्रतिरोधी

ट्राईकोडर्मा हरजिएनम की अच्छी वृद्वि के लिए ठोस अवस्था किण्वन परीक्षण के दौरान छः अधोस्तरों में से ज्वार और रागी के दानों का उपयोग उत्कृष्ट पाया गया और इन आधोस्तर पर सी एफ यू 8.5 से 9.0 प्रति ग्राम पाया गया । जबकि अन्य अधोस्तर जैसे चावल के दाने, गेहूँ या चावल का बुरादा और चोकर पर सी एफ यू विस्तार 7.5 से 8.5 प्रति ग्राम के बीच पाया गया ।

ट्रा. हरजिएनम के गुणन उत्पादन के लिए सामान्यतः दानों को पूरी रात भर पानी में भिगोया जाता है । यद्यपि, जब रागी और ज्वार को विभिन्न समय के लिए भिगोया गया तब केवल चार घंटों के लिए भिगोये गये दानों से पार्याप्त मात्रा में उत्पादन हुआ, जो इस बात का प्रतीक है कि दानों को पूरी रात भर पानी में भिगोने की आवश्यकता नहीं है ।

ट्रा. हरजिएनम के बहोत्पादन के लिए स्पाँज और गन्ने की खोई के ठोस अवस्था अधोस्तर किण्वन में अंतः सहयोगी के रुप में परीक्षण किया गया । स्पाँज की तुलना में, खोई पर बीजाणुओं का उत्पादन कम और 1 सेमी ^{3} आकार के घनाकार स्पाँज पर 20 वे दिन बीजाणु के जीवाक्षम की संख्या 10^6 सी एफ यू तक नीचे तक आ जाती है । 10 दिनों के बाद बीजाणु उत्पादन अत्याधिक इसके बाद बीजाणु जीवाक्षम क्षमता घटना आरम्भ हो जाती है, जो इस बात का सूचक है कि बीजाणुओं को 10 वें दिन एकत्र कर लेना चाहिए ।

गन्ने की खोई ठोस अधोस्तर किण्वन के दौरान जल सक्रियता विस्तार 0.95 से 0.97 जबकि स्पाँज की अवस्था में लगभग यह विस्तार सीमा संतृप्त (0.98 से 0.99) पाई गई । गन्ने की खोई में 15 वें दिन तक तभी की मात्रा बढ़ती है और उसके बाद 20 वे दिन तक घट कर कम हो जाती है ।

कीटकवकीय रोगाणु

ब्यू. बेसीआना और *मे. एनाईसोप्लिए* के वायुवीय कोनिडिआ उत्पादन के लिए सात ठोस अघोस्तरों जैसे चावल, ज्वार, रागी, गेहूँ का चौकर, चावल का चौकर, लकडी का बुरादा और गन्ने की खोई पर मूल्यांकन किया गया । *ब्यू. बेसीआना* (ब्यू ब 5 ए पृथक्करण) और *मे. एनाईसोप्लिए* (मे.ए. 4) को 25^0 से.ग्रे. और 70 प्रतिशत आ. आर्द्रता पर 5, 10 और 15 दिनों पर कोनिडिअल उत्पादन का आकलन किया गया। जाँचे गए सभी सातों अधोस्तरों पर 15 वें दिन कोनिडिअल उत्पादन अधिक पाया गया । चावल के दानों पर ब्यू. बेसीआना (31.3 x 10^8 कोनिडिआ/ग्राम) का बीजाणुजनन अत्यधिक पाया गया ।

स्पाँज के 1 सेमी ^{3} आकार के घनाकार टुकडों को दो विधियों के माध्यम से सेबोरोड डेक्सट्रोज यीस्ट ब्रोथ (एस डी वाई बी) के साथ तैयार किया गया । पहली विधि में स्पाँज के टुकडों को एस डी वाई बी में तैयार करने के बाद निर्जर्मीकरण किया गया तथा ब्यूवेरीआ बेसीआना और मेटारहाईजियम एनाईसोप्लिए के साथ निवेशित किया गया । पहले से निर्जर्म किए गए स्पाँज घनाकारों में एस डी वाई बी मिलाने के बाद ब्यू. बेसीआना और मे. एनाईसोप्लिए के द्वारा निवेशित किया गया । जाँच की गई दोनों ही विधियों में ब्यू. बेसीआना का कोनिडिअल उत्पादन 1.3 x 10^8 कोनिडिआ /सेमी ^{3} पाया गया । *मे. एनाईसोप्लिए* के संबंध में पहली विधि में 1.3 x 10^8 कोनिडिआ / सेमी ^{3} और दूसरी विधि में 0.6 x 10^8 कोनिडिआ /सेमी ^{3} पाया गया ।

टमाटर और बैंगन में राल्सटोनिआ सोलेनेसीरम के कारण आर्द्र गलन रोग का प्रबंधन

बेसीलस स्पे. के जाँचे गए 100 पृथक्करणों में से 10 पृथक्करणों में जीवाणुवीय आर्द्र गलन रोगाणु राल्सटोनिआ सोलेनेसीरम के प्रति प्रतिरोधकता पाई गई । अधिकतम प्रतिरोघकता देवीकुलम पृथक्करण

(11.5 मिमी.) इसके बाद पम्पाडुम्पारा (9.4 मिमी.), एन बी ए आई आई (9.3 मिमी) और हेसरघट्टा (7.5 मिमी) पृथक्करणों में पाई गई । अन्य पृथक्करणों और अनोपचारित क्षेत्र की अपेक्षा प्रतिरोधक (देवीकुलम पृथक्करण)को बीजोपचार, जड़ोपचार और पत्तियों पर छिड़काव के मिलाकर प्रयोग करने से जड़ की लम्बाई (12 से मी) शाखा की लम्बाई (58.1 से मी), ताजा भार (23.2 ग्राम), शुष्क भार (5.3 ग्राम) बढ़ा और जीवाणुवीय आर्द्र गलन रोग को 79.14 प्रतिशत तक कम किया ।

टमाटर की पर्ण ब्लाईट, आल्टरनेरिआ का जैविक नियंत्रण

टमाटर की फसल में आल्टरनेरिआ स्पे. द्वारा पर्ण धब्बा रोग के प्रति ट्राइकोडर्मा स्पे. के 12 प्रमुख प्रथक्करण जोकि *ट्रा. वीरिडे, ट्रा. वाइरेन्स* और *ट्रा. हरजिएनम* से संबंधित थे और तीन जीवाणुवीय पृथक्करणों (स्यूडोमोनाज फलुओरेसेन्स, बेसीलस सबटीलिस और बे. मेगाटेरीअस) के मूल्यांकन के लिए 2009 में रबी मौसम के दौरान अट्टूर फार्म पर एक क्षेत्रीय परीक्षण किया गया ।

जाँचे गए 15 पृथक्करणों में से *ट्रा. वीरिडे* (टी वी –115 पृथक्करण) के प्रयोग करने पर रोग ग्रसन प्रतिशत न्युनतम (20.33) पाया गया, यद्यपि साँख्यिकी रूप में यह *ट्रा. हरजिएनम* (टी एच–7 और टी एच 10 पृथक्करण) और स्यूडोमोनाज फलुओरेसेन्स के समान रोग ग्रसन प्रतिशत क्रमशः 20.66, 22.16 और 21.36 पाया गया ।

देशी बेसीलस थ्युरिन्जीएन्सिस विभेदों का पृथक्करण और विशेषता

असम और राजस्थान से दो नये देशी पृथक्करणों को पृथक किया गया जो बाईपिरेमीडल क्रिस्टल रखते हैं और उनको एन बी ए आई आई–बी टी ए एस और एन बी ए आई आई–बी टी जी 4 का नाम दिया । एन बी ए आई आई–बी टी ए एस में पैतृक प्रोटीन सान्द्रता 3.2 मिग्रा/मिली पाई गई । *प्लुटेल्ला जाइलोस्टेल्ला* के दूसरे निरुप के लारवों के प्रति इन दोनों पृथक्करणों की 10^{-1} से 10^{-2} तनुता को 100 प्रतिशत घातक और अत्यधिक विषैला पाया गया । 10^{-3} से 10^{-4} तनुता संग्रहण में 95 प्रतिशत घातकता पाई गई । एन बी ए आई आई –बी टी ए एस में एल सी$_{50}$ 0.037 माईक्रो ग्राम/मिली और एन बी ए आई आई–बी टी जी 4 में 0.026 माईक्रो ग्राम/मिली मात्रा की गणना की गई ।

सभी देशी पृथक्करणों (पी डी बी सी – बी टी असम, पी डी बी सी – बी टी1, पी डी बी सी एच डी–1, एन बी ए आई आई – बी टी जी 4) को क्राई–1 जनरल प्राईमर्स के साथ अभिवर्द्न किया और क्राई–1 जीन के लिए इसे सकारात्मक पाया गया । सभी पृथक्करणों में लगभग 1.5 से 1.6 के बी की अभिवर्द्न देखा गया ।

देशी *बे. थ्युरिन्जीएन्सिस* पृथक्करणों के लिए बीजाणु क्रिस्टल प्रोटीन का एस डी एस – पी ए जी ई विश्लेषण किया गया और एच डी–1 मानक विभेद के साथ इनकी तुलना की गई । एन बी ए आई आई – बी टी जी 4 और पी डी बी सी बी टी–1 ने लगभग एक समान प्रोटीन प्रोफाईल दर्शाया, किन्तु एन बी ए आई आई – बी टी जी 4 पृथक्करण 15 के डी ए बेण्ड दर्शाता है जोकि पी डी बी सी –बी टी –1 पृथक्करण में यह नही पाया गया ।

बी. टी. नियमनों का क्षेत्रीय मूल्यांकन

मोठी की फसल में फली बेधक प्रति पी डी बी सी बी टी–1, पी डी बी सी–बी टी–2, बी एन जी टी –1, एच डी–1 और एन बी ए आई आई – बी टी ए एस पाँच देशी पृथक्करणों का क्षेत्रीय मूल्यांकन किया गया । अनोपचारित चेक क्षेत्र में फली की क्षति 28.1 प्रतिशत, जबकि एन बी ए आई आई – बी टी ए एस द्वारा उपचारित क्षेत्र में फली क्षति न्यूनतम 1.9 प्रतिशत पाई गई ।

अन्तःपादपी जीवाणु

स्वस्थ टमाटर के पौधों से सात अन्तःपादपी जीवाणुओं का प्रथक्करण किया गया और उन्में से पाँच को बायोलोग सिस्टम की सहायता से *एसीनेटोबेक्टर बाऊमानी, स्टेनोट्रोफोमोनाज माल्टोफिला, एन्टरोबेक्टर कलोएसी, ब्रेवुन्डीमोनाज वेसीकुलेरिस* और *बुरहोल्डेरिआ प्लेन्टेरी* के रूप में पहचाना गया । कपास, मूँगफली, टमाटर और अरहर से चार अत्तः पादपी जीवाणुओं को पृथक किया गया, उनकी पहचान सेलुलोसीमीक्रोबियम सेलुलेन्स, स्युडोमोनाज पुटिडा बायोटाईप ए (मूँगफली और टमाटर से दो पृथक्करण) और ब्रेवीबेक्टेरीयम ओटीडिस के रूप में की गई ।

माइट का जैविक नियंत्रण

नेट हाउस परीक्षण में, करेला, लौकी और तुरई पर एकीमोनियम स्पे. का 1 x 107 /मिली बीजाणु सान्द्रता की दर से प्रयोग करने पर टेट्रानिकस उर्टिके के ग्रसन को महत्वपूर्ण रुप से कम किया गया, इसके बाद लिकेनीसीलियम सेलीओटे का प्रयोग उचित पाया गया ।

ग्रीन हाउस में, *लि. सेलीओटे* को 1 x 10^7/मिली. बीजाणु सान्द्रता की दर से प्रयोग करने पर बैंगन में टे. उर्टिके के ग्रसन को महत्वपूर्ण रुप से कम किया गया, इसके बाद *लि. लेकेनाई* और *ब्यू. बेसीआना* का प्रयोग सफल पाया गया ।

क्षेत्रीय परीक्षण में, लि. सेलीओटे को 1 x 10^7/मिली. बीजाणु सान्द्रता की दर से प्रयोग करने पर बैंगन के टे. उर्टिके के ग्रसन को महत्वपूर्ण रुप से कम किया गया, इसके बाद लि. लेकेनाई और ब्यू. बेसीआना सफल पाए गए ।

कीटरोगणिवक सूत्रकृमियों का डी एन ए बार कोडिंग

12 ई पी एन प्रथक्करणों का डी एन ए बार कोडिंग आँकडे बनाने के लिए सी ओ आई जीन अभिवर्द्न और सीकवेन्स किया गया । पृथक्करण की पहचान करने के लिए सीक्वेन्स विश्लेषण (डी एन ए बार कोडिंग) की गई, जिनका उनमें समानता और असमानता का उनके कुछ कार्यिकी लक्षणों तथा मार्फोमेट्रिकस की सहायता से पता चलता है, यह एक एसा ठोस माध्यम है जिससे ई पी एन विविधता को केटालोग किया जा सके तथा ई पी एन नियमनों परल लगे लेबलों की सचाई का परीक्षण एवं जाँच करने में भी बहुत सहायक है ।

स्टेईनर्नेमा और हेटरोरहाब्डिटिस का इन वाइवों उत्पादन

गेलेरिआ मिलोनेल्ला की वृद्दि, जीवन चक्र काल, लारवा जैव भार और जनन क्षमता के लिए 28 और 300 से. ग्रे. के बीच तापक्रम व

50–80 प्रतिशत आपेक्षिक आर्द्रता उचित पाई गई । हेटरोरहाब्डिटिस इन्डिका और स्टेईनर्नेमा कार्पोकेप्से को गेलेरिआ लारवों पर इन वाइवों उत्पादन बढ़ाने के लिए लारवों का उत्पादन समकालीन और आहार में बदलाव किया गया ।

ई पी एन (हे. इन्डिका और स्टे. कार्पोकेप्से) को हे. आर्मीजेरा, स्पो. लिट्यूरा और *प्लु. जाइलोस्टेल्ला* के लारवों से प्राप्त सन्तति की तुलना में *गे. मिलोनेल्ला, को. सीफेलोनिका* और सफेदलट पर गुणित करना अधिक विषैला और लारवों के लिए अल्प समय (24 से 36 घन्टे) में ही अत्यन्त घातक (*गे. मिलोनेल्ला* और सफेद लट) साबित हुआ ।

इ पी एन के नए पृथक्करण

मडिकेरी से एकत्रित रोगी सफेद लटों से हे. इन्डिका का एक नया पृथक्करण और *हेटरोरहाब्डिटिस* स्पे. के दो नए पृथक्करण पृथक किए गए ।

सफेद लटों के प्रति ई पी एन की जैव क्षमता

बारह ई पी एन पृथक्करणों की जैव क्षमता के लिए सफेद लट के अण्डों के प्रति लियूकोफोलिस और एनोमाला प्रजातियों के साथ इन विद्वों के अन्तर्गत जाँच परीक्षण किया गया और सुनिश्चित पाया कि ई पी एन द्वारा अण्डों पर कोई भी ग्रसन/प्रवेश नही होता है ।

सफेद लट की तीन प्रजातियों (*एनोमाला, बेंगालेन्सिस, लियूकोफोलिस लेपिडिफोरा* और *लि. बर्मेस्ट्राई*) को 3 गहराईयों (10, 20 और 30 से. मी) पर ई पी एन की तीन प्रजातियों में से *हे. इन्डिका* इसके बाद *स्टे. राईओब्रेव* और *स्टे. कार्पोकेप्से* द्वारा एल डी और एल सी मात्रायें लगातार न्यूनतम पाई गई । ये अनुवीक्षण खेत में, ई पी एन की तीनों प्रजातियों की मात्रा तय करने और ई पी एन प्रयोग करने के बाद विभिन्न गहराईयों पर सफेद लट की घातकता के लिए समय आकलन में अत्यन्त महत्वपूर्ण पाई गई ।

सफेदलट के प्रति ई पी एन का क्षेत्रीय मूल्यांकन

सुल्या (कर्नाटक) में सुपारी के खेतों में *लियूकोफोलिस लेपिडिफोरा, एनोमाला बेंगलएन्सिस* और *लि. बर्मेस्ट्राई* को 6 से 8 दिनों में नियंत्रित करने के लिए तैयार किए गए ई पी एन कड़ावरो (*हे. इन्डिका* और *स्टे. कार्पोकेप्से*) का प्रयोग सफल रहा । उपचारित भूमि से 6 महीनों तक ई पी एन पुनः प्राप्त होते रहे, जो इस बात का सूचक है कि सफेद लट के साथ ई पी एन भूमि में सफलतापूर्वक स्थपित हो गए ।

सफेद लट के व्यवहार और ई पी एन द्वारा सफेद लट के नियंत्रण को सुनिश्चित करने के लिए उपचारित भूमि से कडावर की पुनः प्राप्ति के लिए इन सीटू में एक नई तकनीक विकसित की गई । अगस्त से अक्टुबर महीनों में आन्तरयिक बडे आकार की सफेद लट के साथ 1 से 2.5 सेमी. तक के आकार की 20 सेमी. के भू–स्तर पर अधिक प्रमुखता से, जबकि 2.5 सेमी से बडे आकर की सफेद लट अक्टुबर से जनवरी माह में 10 और 30 सेमी. की गहराई पर प्रमुखता से पाई गई ।

पादप परजीवी सूत्रकृमियों का जैविक नियंत्रण

व्यवसायिक पोलीहाऊस से रोगी अण्ड समूह और अण्डों के प्रतिदर्शो से प्रतिरोधी कवक, डेकटाईलेल्ला ओवीपेरासीटिका और ड्रेसलेरा स्पे. से दो नए पृथक्करण पृथक किए गए । पुत्तुर, दक्षिण कन्नडा, कर्नाटक की मृदा में जड़ ग्रंथि सूत्रकृमि अण्डों से पेसीलोमाइसस लिलेसीनस से अन्य 2 नए पृथक्करण पृथक किए गए ।

इन विट्रो और इन वाडवो दशाओं में जड़ ग्रंन्थि और धागाकर सूत्रकृमियों के प्रति इन पृथक्करणों द्वारा अण्ड समूहों और अण्डों के ग्रसन की प्रतिशतता अत्यधिक पाई गई। इन पृथक्करणों की कवक जाल वृद्वि के लिए 26 से 34^0 से.ग्रे. और बीजाणु अंकुरण के लिए 26 से 38^0 से.ग्रे. तापक्रम उचित पाया गया ।

पे. लिलेसीनस और पो. कलेमायडोस्पोरिआ के एमार्फस नियमन की विशिष्टताऐं

पे. लिलेसीनस और पो. क्लेमायडोस्पोरिआ नियमनों का पी एच 6.0 और 6.5 के बीच जबकि ई पी एन नियमन से 49.56 सेक न्यूनतम भीगेपन के साथ 15.23 प्रतिशत नमी वाले निस्पन्दन होते हैं।

आण्विक पहचान और पता करने की विधि

पी सी आर के आधार पर *पे. लिलेसीनस* और *पोकोनिआ क्लेमायडोस्पोरिआ* के एन बी आई आई पृथक्करणों की आण्विक पहचान और उनके पता करने की विधि तैयार की गई और रेस्ट्रीकशन एनजाईम (आर एफ एल पी) अध्ययनों के माध्यम से जड़ ग्रन्थि व धागाकार सूत्रकृमियों के प्रति इन पृथक्करणों की विषैलापन कारक/कार्य करने की प्रक्रिया की विशिष्टताकरण तैयार किया गया । इन विट्रो दशाओं में जड़ ग्रन्थि सूत्रकृमि के अण्डो और अण्ड समूहों के प्रति विषैलेपन के लिए उत्तरदायी सीरीन प्रोटीएज, कोलेजीनेज और काईटिनेज एन्जाईम का *पे. लिलेसीनस* और *पो. कलेमायडोस्पोरिआ* के पृथक्करणों का पता किया गया ।

कार्नेशन के जड़ ग्रन्थि सूत्रकृमियों का जैविक नियंत्रण

व्यवसायिक पोलीहाऊस में कार्नेशन उगाकर *पे. लिलेसीनस* और *पो. कलेमायडोस्पोरिआ* के टाल्क नियमन को गोबर की खाद के साथ 100 ग्राम (107 बीजाणु/ग्राम) प्रयोग कर एक हल्की सिंचाई का प्रयोग करने से जड़ ग्रन्थि सूत्रकृमि के ग्रसन को प्रभावी ढंग से नियंत्रित किया गया ।

कवकीय प्रतिरोधको द्वारा पादप रोगों का जैविक नियंत्रण (गो ब पं कृ एवं प्रौ वि)

धान में वृद्वि मापनो (जड़ और शाखा की वृद्वि, क्लोरोफिल की उपस्थिति, प्रति पौधा पत्तियों की सँख्या और एस पी ए डी मात्रायें) की जाँच में ट्राइकोडर्मा हरजिएनम के पृथक्करणों के मूल्यांकन की तुलना में अनोपचारित की अपेक्षा *ट्रा. हरजिएनम* के सभी पृथक्करणों को प्रभावी वृद्वि कारक पाया गया । ग्लास हाऊस दशाओं में इन सभी पृथक्करणों में से *ट्रा. हरजिएनम* के टी–14, टी एच–56 और टी एच –57 पृथक्करणों को धान (कालानमक–3131) के वृद्वि मापनों के लिए उचित पाया गया ।

पौधों को *स्यु. फ्लुओरेसेन्स* + *ट्रा. हरजिएनम* + *हाईमीडिआ* (न्यूट्रिएन्ट मिश्रण) द्वारा मृदा उपचार और पत्तियों पर छिड़काव करने पर धान की बाल की लम्बाई अत्यधिक 96.33 सेमी. लम्बी पाई गई जोकि अन्तर्राट्रीय बाजार में निर्यात मानक ग्रेड ए पाती है, शैल्फ लाईफ के सन्दर्भ में *स्यूडोमोनाज* + *ट्राइकोडर्मा* द्वारा पी डी ए एच पर उपचार करने पर शरीर क्रिया भार की कमी न्यूनतम (16.44) पाई गई। *स्युडोमोनाज* और *ट्राईकोर्डमा* का हाईमिडिआ न्यूट्रिएन्ट मिश्रण के अन्तः क्रिया के साथ उपचार करने पर शेल्फ लाईफ बढ़ना और उनका जैव रासायनिक मापनो जैसे पेरोकसीडेज, केटालेज, पोलीफीनाॅल आक्सीडेज, प्रोटीन्स, फीनोलस और चीनी में सकारात्मक सहसंबन्ध पाया गया ।

धान (कालानमक 3119 और 3131) की क्षेत्रीय दशाओं में वृद्दि और उपज मापनों के लिए *ट्रा. हरजिएनम* के 20 पृथक्करणों का मूल्यांकन किया गया । उपज मापनों जैसे भरे दानों और बिना भरे दानों की क्रमशः औसत 1206.00 और 302.33 के साथ टी-12 पृथक्करण की उत्कृष्ट उपलब्धि पाई गई, किन्तु अन्य वृद्दि और कुल उपज मापनों के लिए कालानमक-किस्म 3119 के समान अच्छा नहीं पाया गया । धान की जाँच की गई दोनों किस्मों (कालानमक-3119 और 3131) में शीथ ब्लाईट, शीध रोट, तना बेधक, ग्रास हाॅपर्स और पत्ती मोड़क कीट के प्रति टी-1 पृथक्करण की उपलब्धि अच्छी पाई गई।

सभी जाँचे गए मापनों में *ट्रा. हरजिएनम* के टी-39, टी-50 के साथ टी एच-60, टी एच-75 और टी एच - 60 को गेहूँ में अच्छा पाया, जबकि मसूर और चने में टी-14 इसके बाद टी एच-56 पृथक्करणों को उत्कृष्ट पाया गया ।

ट्रा. हरजिएनम के टी एच-56, टी एच-75, टी-14, टी एच-69, टी-19, टी-9, टी एच-55, टी एच-57, टी-1, और टी एच (रानीचौरी) के दस विभिन्न विभेदों के साथ ब्युवेरीआ बेसीआना (पी बी बी-04) का एक संभाव्य विभेद के अनुरुपता का अध्ययन किया गया । ब्यु. बेसीआना के विभेद पी बी बी -04 के साथ टी एच -56 और टी-19 विभेद बहुत अनुरुप पाए, जबकि टी-01, टी-09 और टी एच-75 को ब्यु. बेसीआना के विभेद पी बी बी-04 के अनुरूप नहीं पाया गया ।

पादप परजीवी सूत्रकृमियों का जैविक नियंत्रण

राहुरी में, खरीफ 2009 के दौरान मोठी (किस्म-विपुल) में धागाकर सूत्रकृमियों के प्रति प्रतिरोधक कवक के मूल्यांकन पर किए गए परीक्षण के परिणाम दर्शाते हैं कि *ट्रा. हरजिएनम* को 5 किग्रा./हे. और *पो. क्लेमायडोस्पोरिआ* को 20 किग्रा/हे. की दर से मिलाकर प्रयोग करने पर धागाकार सूत्रकृमि की मादा सँख्याओं को कम (38.5 प्रतिशत) और मोठी की उपज बढ़ाई (1440 किग्रा./हे.) के लिए अत्यन्त प्रभावी पाया गया (म फु कृ विद्या)।

छः वर्ष की आयु वाले संतरे के वृक्षों पर *पेसीलोमायसस लीलेसीनस* के टाल्क नियमन (108 बीजाणु/ग्राम) को 20 किग्रा./हे की दर से प्रयोग करने पर नींबू वर्ग के सूत्रकृमि सँख्या को कम (43.8 प्रतिशत), जडों में मादाओं की सँख्या कम (31.8 प्रतिशत) और संतरों की 1:8.85 आई सी बी आर के साथ उपज बढ़ाने में प्रभावी पाया गया । (म फु कृ विद्या, राहुरी)

अनार (किस्मः मृदुला) पर दो वर्ष के विश्लेषण के आँकडे दर्शाते हैं कि *स्यु. फलुओरेसेन्स* को 20 ग्राम /मी² की दर से भूमि उपचार करने से जड़ ग्रन्थि सूत्रकृमियों की सँख्या और जड़ ग्रन्थि सँख्या कम करने तथा 1:11.81 आई सी बी आर के साथ अनार की उपज बढ़ाने में अत्यन्त प्रभावी पाया गया । (म फु कृ विद्या)

क्षेत्र में अनार (सिन्धुरी-किस्म) पर *पो. क्लेमायडोस्पोरिआ* (100 ग्राम/वृक्ष) और सरसों की खली (2 टन/हे) दोनों को साथ में मिलाकर प्रयोग करने पर सूत्रकृमियों की सँख्या में अत्यधिक कमी (57.83 प्रतिशत) पाई, इसके बाद *पे. लिलेसीनस* (100 ग्राम/वृक्ष) + सरसों की खली का प्रयोग उचित पाया गया । (अ कृ वि, असम)

आन्नद में, मोठी (बी डी एन 2 किस्म) फसल में, धागाकार सूत्रकृमि रोटीलेन्कुलस रेनिफोर्मिस के प्रति प्रतिरोधक कवक के मूल्यांकन पर किए गए क्षेत्रीय परीक्षण के परिणाम दर्शाते हैं कि *ट्रा. हरजिएनम* (5 किग्रा./हे.) और पो. क्लेमायडोस्पोरिआ (20 किग्रा./हे.) को मिलाकर उपचारित किए गए प्लाटों से महत्वपूर्ण रुप से अत्यधिक उपज (1355 किग्रा./हे.) पाई गई । केवल ट्रा. हरजिएनम या पो. क्लेमायडोस्पोरिआ द्वारा उपचारित प्लाट में दानों की उपज की दशाओं में एक समान क्षमता के परिणाम पाए गए । (आ कृ वि, आनन्द)

फसल पीड़को का जैविक नियंत्रण, गन्ना

गोलाघाट जिले के डेरगाँव क्षेत्र में किसान के खेत (100 हे.) में ट्राइकोग्रामा किलोनिस को प्लासी बेधक के प्रति 50,000/बारी की दर से छोडने पर प्लासी बेधक के ग्रसन को 34.6 प्रतिशत तक महत्वपूर्ण रुप से कम किया गया । किसान द्वारा अपनाई जाने वाली प्रक्रियाओं में प्राप्त उपज (65,900 किग्रा/हे.) की अपेक्षा परजीवी कीट छोड़े गए प्लाट से गन्ने की उपज अत्यधिक (78,400 किग्रा./हे) प्राप्त हुई । ट्राइकोग्रामा छोड़े गए प्लाट से अत्यधिक लाभ प्राप्त हुआ। (अ कृ वि, जोरहट)

गन्ने में, *ट्रा. किलोनिस* की तापक्रम सहिष्णु विभेद को पोरी बेधक के प्रति छः बारी छोड़ने पर ग्रसन 5.9 प्रतिशत और ग्रसन तीव्रता 1.2 प्रतिशत के साथ प्रभावी पाया गया । (म फु कृ विद्या)

विस्तृत-स्तर पर किए गए प्रदर्शन में, अप्रैल से जून माह के दौरान अगोला बेधक के प्रति 10 दिन के अन्तराल पर *ट्रा. जेपोनिकम* को आठ बारी 50,000/हे. की दर से छोड़ने के परिणामस्वरुप अगोला बेधक का ग्रसन 54.5 प्रतिशत तक कम पाया गया । परजीवी छोड़े गए क्षेत्र में लगातः लाभ अनुपात अत्यधिक (1:22.4) जबकि रासायनिक नियंत्रण क्षेत्र में कम (1:8.5) पाया गया। (पं कृ वि)

गन्ने के ऊनी माहू को महाराष्ट्र के पश्चिमी भाग में पुणे और सतारा जिलों में देखा गया, किन्तु परभक्षी कीटों, डाइफा एफिड़िवोरा (1-3 लारवे/पत्ती) माइक्रोमस इगोरोटस (3-7 ग्रब/पत्ती) और सिरफिड (1-2 लारवे/पत्ती) और एनकार्सिआ फ्लेवोस्कुटेलस द्वारा परजीवीकरण पाए जाने के कारण पीड़कों की तीव्रता कम पाई गई। (म फु कृ विद्या)

सफेद लट के तीसरे निरुप के ग्रब पर *ब्यू. बेसीआना*, *ब्यू. ब्रोन्गनिआर्टी* और *मे. एनाईसोप्लिए* का मिलाकर प्रयोग करने के प्राथमिक जैव-निर्धारण में मरे हुए लारवों के सूक्ष्मदर्शी परीक्षण में *मे. एनाईसोप्लिए* के ऊपर *ब्यू. ब्रोन्गनिआर्टी* की प्रधानता पाई गई । (ग प्र सं)

गन्नों (सी ओ एल के 8102 किस्म) में दीमक के प्रति मेटारहाईजियम एनाईसोप्लिए के मूल्यांकन के लिए क्षेत्रीय परीक्षण आयोजित किया गया । मई माह के दौरान गन्ने में रासायनिक नियंत्रण (क्लोरपायरिपास 20 ई सी को 1 किग्रा ए.आई./हे. की दर से) द्वारा न्यूनतम (8.98 प्रतिशत) कवक उपचार द्वारा 10.73-12.86 प्रतिशत क्षति जबकि, अनोपचरित क्षेत्र में गन्ने की क्षति 29.29 प्रतिशत पाई गई । रासायनिक उपचारित क्षेत्रों में गन्ने की उपज अत्यधिक (48,110 किग्रा/हे.) जबकि *मे. एनाईसोप्लिए* द्वारा उपचारित क्षेत्र में उपज का विस्तार 40,510 - 45,030 किग्रा/हे. पाया गया। (भा ग अनु सं)

क्षेत्र में किए गए परीक्षण से यह निष्कर्ष निकला कि रोपण के समय ई पी एन (एन बी ए आई आई द्वारा भेजे गए *हे. इन्डिका* और *स्टे. कार्पोकेप्से*) के टाल्क आधारित नियमनों का प्रयोग करना दीमक के प्रति प्रभावी नहीं पाया गया । रासायनिक उपचार (क्लोरपायरीफास 20 ई सी को 1 किग्रा ए. आई./हे. की दर से) के परिणाण स्वरुप गन्ने की क्षति मई माह के दौरान, यहाँ तक कि कटाई के समय तक क्षति न्यूनतम पाई गई। (भा ग अनु सं)

कपास

एनासीअस बेन्बावेली का परजीवीकरण दर 25.65 प्रतिशत औसत के साथ 17.16 से 48.82 प्रतिशत तक भिन्न-भिन्न पाई गई । फसल वृद्धि की प्रारम्भिक अवस्था में परजीवीकरण न्यूनतम (17.16 प्रतिशत) पाया गया जोकि प्रत्येक सप्ताह बढ़ता गया और सितम्बर, 2009 के तीसरे सप्ताह तक अत्यधिक (30.37 प्रतिशत) पहुँच गया । पिंगलवाडा (कर्जन तह.) में, अक्टुबर, 2009 के दौरान परजीवीकरण अधिकतम (48.82 प्रतिशत) पाया गया। (अ कृ वि - असम)

प्रयोगशाला में, कपास के मीलीबग, *फेनोकोकस सोलेनोप्सिस* को अंकुरित आलूओं पर ब्हुगुणन करने की तकनीक विकसित की आई और बी टी कपास में कपास मीलीबग के प्रमुख प्रबल परजीवी कीट, ऐनासीअस बेन्बावेली को गुणन करने के लिए उपयोग किया गया । (अ कृ वि - असम)

बी आई पी एम प्रक्रिया अपनाने पर गूलर सूँडियों द्वारा हरे गूलर की क्षति केवल 2.80 प्रतिशत जबकि किसान द्वारा अपनाई गई प्रक्रिया में 7.33 प्रतिशत क्षति पाई गई । बी आई पी एम प्रक्रिया अपनाने पर लोक्यूल्स क्षति महत्वपूर्ण रुप से कम (3.54 प्रतिशत) जबकि किसान द्वारा अपनाई गई प्रक्रिया में अधिक (5.81 प्रतिशत) क्षति पाई गई । बी आई पी एम प्रक्रिया अपनाने पर कपास के बीज की उपज महत्वपूर्ण रुप से अत्यधिक (2,416 किग्रा/हे.) जबकि किसान द्वारा अपनाई गई प्रक्रिया में उपज कम (1,320 किग्रा/हे.) पाई गई । बी आई पी एम प्रक्रिया अपनाने पर कपास के बीज की उपज 83.03 प्रतिशत बढ़ी । (अ कृ वि - असम)

बी टी कपास बुआई होने के लगभग 50 दिनों के बाद मीलीबग का ग्रसन पाया गया । मीलीबग की प्रजाति *फे. सोलेनोप्सिस* मुख्यतः पाई गई जबकि मेकोनेलीकोकस हिर्सुटस भी थोडी सँ'या में पायी गयी । (आ एन जी रंगा कृ वि)

मीलीबग के अनेक कवक ग्रसित निम्फों से वर्टिसीलियम लेकेनाई पृथक किए गए । पुनः प्राप्ति प्रतिशत बहुत कम होने के परिणाम स्वरुप सिद्ध हुआ कि क्षेत्र में कपास मीलीबग के प्रति क्रिप्टोलीमस मोन्ट्र्यूजिएरी का छोड़ना प्रभावी नहीं है । यद्यपि, किसान द्वारा अपनाई प्रक्रिया और अनोपचारित प्लाट की अपेक्षा क्रिप्टोलीसस छोड़े गए और वर्टिसीलियम छिड़के गए प्लाटों में प्राकृतिक शत्रु कीटों की सक्रियता अधिक पाई गई । (आ एन जी रंगा कृ वि)

कपास में, मीलीबग *फे. सोलेनोप्सिस* का प्रकोप सितम्बर-अक्टुबर, 2009 में और फिर पछेती फसल में जनवरी से मार्च 2010 में पाया गया, किन्तु इनकी ग्रसन तीव्रता न्यूनतम पाई गई । मीलीबग कीट सँख्याओं (कालोनीज) में परजीवी कीट, ऐनासीअस बेन्बावेली और परभक्षी कीट, स्पेलजिअस एपिअस, कोक्सीनेल्ला, क्राईसोपरला और ब्रुमायडस पाए गए । (म फु कृ विद्या)

कपास की फसल में चूषक पीड़कों की सँख्या और गूलर क्षति को कम करने के लिए प्राकृतिकवास प्रबन्धन के अन्तर्गत जोडी लाईनों में लोबिया और गेंदा लगाने के साथ-साथ क्राईसोपरला और ट्राइकोग्रामा किलोनिस को छोड़ना अत्यन्त प्रभावी पाया गया । यह प्रबन्धन अपनाने से प्राकृतिक शत्रु कीटों (क्राईसोपिड्स और कोक्सीनेलिड्स) की सँख्या और 1:1.5 आई सी बी आर अनुपात के साथ कपास के बीज की उपज भी बढ़ी पाई गई । (म फु कृ विद्या)

बी टी कपास में बी आई पी एम पैकेज के अन्तर्गत ट्राइकोडर्मा से बीज उपचार, खेत की मेड पर मक्का को लाईन में उगाना, चिडिया डराने वाले पुतले खडे करना, वर्टिसीलियम लेकेनाई का छिड़काव करना, 5 प्रतिशत नीम बीज अर्क प्रयोग और ट्रायकोग्रामेटायडिआ बेक्टरे को छोड़ने से चूषक पीड़को के नियंत्रण और गूलर क्षति नियंत्रण करने के लिए प्रभावी पाया गया तथा 1:1.96 आई सी बी आर अनुपात के साथ कुल लाभ अधिक (25.35 प्रतिशत) पाया गया । (म फु कृ विद्या)

बी टी कपास में, किसान द्वारा अपनाई गई प्रक्रिया और बी आई पी एम पैकेज अपनाने से चूषक कीटों के ग्रसन में कोई विशेष अन्तर नहीं पाया गया, यद्यपि बी आई पी एम पैकेज अपनाए गए क्षेत्र में परभक्षी कीट सँख्या थोडी अधिक पाई गई । किसान द्वारा अपनाई गई और बी आई पी एम पैकेज अपनाई गई प्रक्रियाओं द्वारा कपास बीज की उपज में कोई विशेष अन्तर नहीं पाया गया । (पं कृ वि)

तम्बाकू

नर्सरी में बेसीलस थ्यूरिन्जिसन्सिस प्रजाति कुर्सटेकी के 7.00 पी एच वाले द्रवीय घोल का प्रयोग करने के 7 दिनों के बाद स्पोडोप्टेरा लिट्यूरा के लिए अधिकतम घातक पाया गया । (के त अनु सं)

हे. एन पी वी के जाँचे गए 6 विभेदों में से रा कृ उ की ब्यू वाला 1.08 x 105 पी आई बी सान्द्रता का हे. एन पी वी के परिणाम स्वरूप *हे. आर्मीजेरा* के लिए 80.1 प्रतिशत घातक पाया गया । (के त अनु सं)

पुनः सुनिश्चित पाया गया कि *ब्यू. बेसीआना* का 10^8 बीजाणु / मिली. या ग्राम की दर से बीज उपचार, छिड़काव, भूमि उपचार या सभी मिलाकर उपचार करने के परिणाम स्वरुप तना बेधक, स्क्रोबीपाल्पा हेलीओपा के ग्रसन को नियंत्रित करने के लिए प्रभावी नहीं है । (क. त अनु सं)

दलहन

अरहर में, हे. एन पी वी (1.5 x 1012 पी ओ बी /हे. + 0.5 प्रतिशत कच्ची चीनी + 0.1 प्रतिशत टीपाला की दर से) छिड़काव और दुसरे निरुप के लारवों को हाथ से एकत्र करने पर *हे. आर्मीजेरा* का ग्रसन महत्वपूर्ण रुप से कम (3.45 प्रतिशत) जबकि अनोपचारित प्लाँट में ग्रसन अधिक (8.83 प्रतिशत) पाया गया । यद्यपि यह उपचार प्लम मौथ और फली मक्खी द्वारा फलियों की क्षति को नियंत्रित करने में असफल रहा । अनोपचारित क्षेत्र की अपेक्षा हे. एन पी वी छिड़काव + *हे. आर्मीजेरा* के लारवों को हाथ से एकत्र करने के उपचार से दानों की उपज महत्वपूर्ण रुप से अत्यधिक (1274 किग्रा./ हे.) प्राप्त हुई । (अ कृ वि – असम)

अरहर की फसल में, सूरजमुखी को अन्तः फसल (9:1) के रुप में, साथ-साथ मक्का या ज्वार को खेत की मेड पर उगाने पर कटाई के समय *हे. आर्मीजेरा* द्वारा फली क्षति कम (6.5 प्रतिशत) जबकि अकेले अरहर उगाने पर फली क्षति अधिक (12.82 प्रतिशत फली क्षति) पाई गई। अकेले अरहर उगाने की अपेक्षा, अरहर के साथ सूरजमुखी को अन्त फसल के रुप में और खेत की मेड पर मक्का उगाने के उपचार अपनाए प्लाट में क्राईसोपा और कोकसीनेलिडो की महत्वपूर्ण रुप से अधिकतम सँख्या प्राप्त हुई । (अ.कृ.वि., असम)

जाँचे गए तीन फसल मोड़यूल्स में से, अरहर के साथ सूरजमुखी को अन्तः फसल के रुप में तथा ज्वार को खेत की मेड़ पर उगाने से *हे. आर्मीजेरा* के लारवों की सँख्या कम (23/10 पौधे), जबकि दुसरे मोडयूल में अरहर के साथ सूरजमुखी को अन्तः फसल के रुप में तथा मक्का को खेत की मेड़ पर उगाने से हे. आर्मीजेरा के लारवों की सँख्या अधिक (42/10 पौधे) एवं तीसरे मोड़यूल से केवल अरहर उगाने से *हे. आर्मीजेरा* के लारवों की संख्या अधिकतम (80/10 पौधे) पाई गई । अरहर के साथ सूरजमुखी को अन्तः फसल के रुप में तथा ज्वार को खेत की मेड़ पर उगाने से उपज भी अधिकतम (1,256 किग्रा/हे.) प्राप्त हुई जबकि अन्य दो मोड्यूल में कम (क्रमशः 1152 किग्रा/हे. और 911 किग्रा/हे.) प्राप्त हुई । (आ एन जी रंगा कृ वि)

क्षेत्रीय परीक्षण में, बी टी का 1 किग्रा/हे. की दर से प्रयोग करने के परिणाम स्वरुप एडिसुरा एटकिनसोनी की सँख्या (11 लारवे/10 पौधे) और फली क्षति (1.35 प्रतिशत) न्यूनतम पाई गई, जबकि अनोपचारित क्षेत्र में एडिसुरा एटकिनसोनी की सँख्या (29 लारवे/10 पौधे) और फली क्षति (14.79 प्रतिशत) अधिक पाई गई । अन्य सभी उपचारों की तुलना में इस उपचार द्वारा अधिकतम उपज (3,650 किग्रा/हे.) प्राप्त हुई और यह उपज *मे. एनाईसोप्लिए* उपचारित प्लाट से प्राप्त उपज (3,750 किग्रा/हे.) के समान पाई गई । इसके बाद वर्टिसीलियम लेकेनाई उपचारित प्लाट में उपज अधिक (2,650 किग्रा/हे.) जबकि अनोपचारित प्लाँट में केवल 550 किग्रा/हे उपज प्राप्त हुई। (आ एन जी रंगा कृ वि)

सोयाबीन की फसल में, हेटरोरहाब्डिटिस इन्डिका (रा कृ उ की ब्यू विभेद) का 2 करोड संकं मित ज्यूवेनाईल्स/हे. की दर से द्रवीय नियमन प्रयोग करने पर क्राईसोडीएक्सिस एक्यूटा और स्पोडोप्टेरा लिट्यूरा के लारवों की सँख्या महत्वपूर्ण रुप से न्यूनतम और उपज अत्यधिक पाई गई । (ज ने कृ वि वि)

अरहर के साथ खेत की मेड पर मक्का या ज्वार की फसल उगाकर फसल व्यवहार विविधता के प्रभाव का अध्ययन किया गया । परिणामों से पता चलता है कि अकेले अरहर उगाने की तुलना में, अरहर के साथ खेत की मेड पर फसल उगाने पर प्राकृतिक शत्रु कीटों की सँख्या अधिक पाई गई । चार परभक्षी कीटों (कीलोमीनस सेकसमेकुलेटस, क्राईसोपरला समुह, ड्रेगन फ्लाई और मिट्टी वाली वास्प) सहित एक परजीवी कीट (कोटेशिआ स्पे.) के रुप में प्राकृतिक शत्रु कीट पाए गए /अरहर के साथ खेत की मेड़ पर मक्का उगाए गए प्लाट में दोनो प्राकृतिक शत्रु कीटों की संख्या अधिकतम पाई गई । (ज ने कृ वि वि)

धान

बी आई पी एम प्रक्रियाओं की पुष्टता के लिए तीन गाँवों में 300 हे. क्षेत्रफल पर प्रक्रिया की गई । किसान द्वारा अपनाई गई प्रक्रिया की तुलना में बी आई पी एम प्रक्रिया अपनाने पर हरे पर्ण कुदकों की सँख्या के साथ-साथ तने बेधक और पत्ती मोड़क कीट द्वारा क्षति बहुत कम पाई गई । किसान द्वारा अपनाई प्रक्रिया द्वारा प्राप्त दानों की उपज (2,968 किग्रा./हे.) की तुलना में बी आई पी एम प्रक्रिया अपनाने पर दानों की उपज अधिकतम (3210 किग्रा/हे.) प्राप्त हुई । किसान प्रक्रिया की तुलना में आई पी एम प्रक्रिया अपनाने पर डेड हर्ट, श्वेत बाली शीर्ष और पत्ती मोड़क कीटों का ग्रसन न्यूनतम (5 प्रतिशत) पाया गया । (अ कृ वि जोरहाट)

छः विभिन्न पंचायतों में, 295 हेक्टेयर क्षेत्रफल पर बी आई पी एम प्रौद्योगिकीयों को बडे स्तर पर अपनाया गया । किसान प्रक्रिया और बी आई पी एम प्रक्रिया के बीच डेड हर्ट और पत्ती मोड़क कीट के ग्रसन का कोई विशेष, अन्तर नहीं पाया गया । किसान प्रक्रया अपनाए गए प्लाँट की तुलना में बी आई पी एम प्रविया अपनाए गए प्लाट में प्राकृतिक शत्रु कीट जैसे – मकडी और कोक्सीनेलिडों की सँख्या महत्वपूर्ण रुप से अधिकतम पाई गई । बी आई पी एम प्रक्रिया अपनाए गए प्लाट में दानों की उपज 7925 किग्रा/हे. और किसान प्रक्रिया अपनाए प्लाट में 7757 किग्रा/हे. उपज प्राप्त हुई । जो इस बात का सूचक है कि दोनों प्रक्रियाओं के बीच कोई विशेष अन्तर नहीं है । (के कृ वि)

प्रयोगशाला दशाओं में, धान की पेनीकल माइट, स्टेनोटार्सोनमिस स्पिनकाई के प्रति कवकीय रोगाणुओं (*ब्यू. बेसीआना, मे. एनाईसोप्लिए, व. लेकेनाई* और *हि. थोम्पसोनाई*) का 2 x 07 कोनिडिआ/मिली. की दर से प्रयोग करना प्रभावी नहीं पाया गया । (आ एन जी रंगा कृ वि)

परिणाम दर्शाते हैं कि किसान द्वारा केवल रासायनिक कीटनाशी प्रयोग करने की तुलना में आई पी एम पैकेज अपनाकर कीट पीड़कों का अति प्रभावी रुप से नियंत्रण किया गया । किसान प्रक्रिया की तुलना में आई पी एम पैकेज अपनाने पर पीले तना बेधकों, हरे पर्ण फुदकों और अन्य पर्ण कीटों के ग्रसन को महत्वपूर्ण रुप से कम पाया गया । किसान प्रक्रिया की तुलना मे आई पी एम पैकेज अपनाने पर डेड हर्ट, श्वेत बाली, पत्ती मोड़क कीट, केस वोर्म, स्किपर और हरे पर्ण फुदकों की संख्याओं को महत्वपूर्ण रुप से न्यूनतम किया गया । एक असंगत या प्रतिकूल आक्षेप में, आई पी एम नही अपनाने वाली किसान प्रकिया में स्पाईडर और लेडी बर्ड बीटल की सँख्यायें महत्वपूर्ण रुप से अधिक और लाभ अत्यधिक प्राप्त हुआ। (ओ कृ एवं प्रौ वि)

तराओरी बासमती धान का 1000 हे. के बडे क्षेत्रफल पर विस्तृत स्तर के प्रदर्शन में 7 और स्यू. फलुओरेसेन्स के मिश्रित नियमन को गोबर की खाद, बीज उपचार और पर्ण छिड़काव के रुप में प्रयोग करने पर जैविक खेती के रुप में धान (पुसा 1121, तराओरी बासमती और पुसा–1) की जीवाणुवीय पछेती ब्लाईट और तना बेधकों के नियंत्रण के लिए प्रभावी पाया गया । जैविक खेती के रुप में पुसा–1121 की औसत उपज 3,250 किग्रा/हे., तराओरी बासमती की औसत उपज 2000 किग्रा/हे. तथा पुसा–1 की 4000 किग्रा/हे. औसत उपज के साथ क्रमशः 2,300 रुपये, 3,500 रुपये और 2,200 रुपये प्रति कुन्तल का मूल्य प्राप्त हुआ, जोकि परम्परागत विधि से उगाई फसल से औसतन 400.00 रुपये अधिक पाया गया । (गो ब पं कृ एवं प्रौ वि)

क्षेत्रीय सर्वेक्षण में, धान के गंधी कीट, लेप्टोकार्सिआ स्पे. के अण्डो के ट्राईसोलकस स्पे. (सेलीओनिडे) और ईनोसिरटस उटेथीसीए (रिसबेक) (एनसीर्टीडे) द्वारा परजीवित करते पाया गया । इन परजीवी कीटों की अधिकतम सकियता 39 वें और 41 वें जलावायुवीय सप्ताहों में तथा 40 वें सप्ताह में अधिकतम परजीवीकरण पाया गया । (त ना कृ वि)

गमले में किए गए परीक्षण में, ई पी एन (*स्टेईनर्नेमा* स्पे. (रुने) को 8 लाख/गमले की दर से प्रयोग करने पर *काईलो सपरेसेलिस* के लावों में 60.48 प्रतिशत और नेफेलोक्रोसिस *मेडीनेलिस* में 82.0 प्रतिशत घातक पाए गए । (के कृ वि, इम्फाल)

तिलहन

प्राकृतिक शत्रु कीटों के क्षेत्रीय सर्वेक्षण से ज्ञात हुआ कि ट्राइकोग्रामा किलोनिस (25.6 प्रतिशत) ट्राइकोग्रामेटायडिआ बेक्टरे (19.6 प्रतिशत) ट्राइकोग्रामा जेपोनिकस (15.2 प्रतिशत) और ट्राइकोग्रामा एकीये (14.7 प्रतिशत) द्वारा अरण्डी के केप्सूल बेधक कीट के अण्डे परजीवित पाए गए। (आ एन जी रंगा कृ वि)

बी आई पी एम पैकेज अपनाने के परिणामस्वरूप स्पोडोप्टेरा लिट्यूरा, एकीया जनेटा और पर्ण फुदकों का ग्रसन अरण्डी में न्यूनतम पाया गया । किसान प्रक्रिया (उपज 170 किग्रा/हे.) की तुलना में बी आई पी एम पैकेज अपनाने पर उपज भी अधिकतम (355 किग्रा/हे.) प्राप्त हुई । (आ एन जी रंगा कृ वि)

जैविक नियंत्रण पैकेज के अन्तर्गत क्राईसोपरला को दो बारी के छोडने पर कुसुम के पौधों पर माहू की संख्या को 50.0 प्रतिशत तक कम किया गया । जैविक नियंत्रण पैकेज अपनाने पर उपज 501 किग्रा/हे. जबकि अनोपचारित दशा में उपज केवल 323 किग्रा/हे. पाई गई, जिससे कुसुम के माहू के प्रबंधन में जैव कारकों की दक्षता सबित होती है । (आ एन जी रंगा कृ वि)

तमिल नाडु में, नीम बीज कर्नेल अर्क 5 प्रतिशत के छिड़काव या बी टी को 1 किग्रा/हे. की दर से प्रयोग उसके बाद *ट्रा. किलोनिस* को चार बारी छोड़ने पर मूंगफली के पत्ती सुरंगी कीट के प्रबंधन के लिए प्रभावशाली पाया गया । बी टी छिड़काव करने पर अधिकतम उपज (1,447 किग्रा/हे.) इसके बाद नीम बीज कर्नेल अर्क 5 प्रतिशत के छिड़काव करने पर उपज (1373 किग्रा/हे.) पाई गई । (त ना कृ वि)

नारियल

केरल के अलापुझा जिले में, 10 हे. क्षेत्रफल पर समेकित जैव नियंत्रण कारकों ओरीक्टस रहाईनोसेरस विषाणु, *मे. एनाईसोप्लिए* और *फेरोमोन* प्रपंच के द्वारा ओरीक्टस रहाईनोसेरस कीट के प्रबंधन के लिए क्षेत्रीय जाँच परीक्षण किए गए, जिससे ज्ञात हुआ कि उपचार से पूर्व समय की तुलना में पत्ती तथा नई कोंपलों की क्षति में क्रमशः 53.6 प्रतिशत और 74 प्रतिशत की कमी पाई गई । (के फ रो अनु सं)

रेड पाल्म वीविल्स की जीवन अवस्थाओं को क्षेत्रीय एकत्रीकरण में रोगाणुओं द्वारा कोई भी प्राकृतिक संक्रमण नही पाया गया । कीटरोगाग्विक सूत्रकृमियों के परीक्षण में से, हेटरोरहाब्डिटिज इन्डिकस के स्थानीय पृथक्करण को रेड पाल्म वीविल ग्रब में फिल्टर पेपर जैव निर्धारण को 1500 आई जे/ग्रब की दर से प्रयोग करने के लिए अधिक विषैले व ग्रब के लिए 92.5 प्रतिशत घातक पाया गया, जबकि *हे. बेक्टेरीओफोरा* को केवल 65 प्रतिशत घातक पाया गया। इसी सान्द्रता वाले स्टेईनर्नेमा कार्पोकेप्से और स्टे. अबासी को क्रमशः 20 प्रतिशत और 15 प्रतिशत घातक पाया गया । नारियल के पत्रक आधारित जैव – निर्धारण में *हे. इन्डिकस* के ई पी एन टाल्क आधारित नियमन को अत्यधिक घातक (70 प्रतिशत) जबकि पानी निस्यंदन – आधारित नियमन कम घातक (<10 प्रतिशत) पाए गए । (के फ रो अनु सं)

वेकुर (जिला कोट्टायाम, केरल) क्षेत्र में 61.4 प्रतिशत पत्ती क्षति तथा लारवों की संख्या 304/100 पत्रक के साथ ओपीसिना एरेनोसेल्ला की प्रचण्डता देखी गई, किसानों और केरल राज्य के कृषि विभाग अधिकारियों के सक्रिय योगदान के साथ परजीवी कीटों (गोनियोजस निफेन्टिडिस और ब्रेकोन ब्रेवीकोर्निस को 10 परजीवी कीट/ताड वृक्ष

की दर से) को छोड़कर इस कीट को नियंत्रित किया गया । परजीवी कीट छोड़ने के 8 महिनों के बाद कीट की संख्या घटने (91 प्रतिशत कमी) के स्पष्ट परिणाम दिखाई दिए । इसी समय के दौरान पत्ती क्षति 61.4 प्रतिशत से घटकर 39.4 प्रतिशत के परिणाम स्वरुप कीट ग्रसन भी कम पाया गया । (के फ रो अनु सं)

उष्ण कटिबन्धीय फल

आम के पर्ण फुदको या प्रभावशाली प्रबंधन करने के लिए फूल (बौर) आने के समय *मे. एनाईसोप्लिए* को 1 x 10^9 बीजाणु/मिली. की दर से तेल और स्टिकर के साथ छिड़काव करना 51 प्रतिशत घातक साबित हुआ । अल्ट्रा वायलेट संरक्षक मिलाने पर घातकता 64.61 प्रतिशत तक बढी पाई गई । दोनों ही उपचारों को यद्यपि एक समान तथा अनोपचार से महत्वपूर्ण रुप से उत्कृष्ट पाया गया । (भा. बा. अनु. सं).

पपीते का मीलीबग (पेराकोकस मार्जिनेटस) बेंगलोर के शहरी क्षेत्रों में घर आँगन में पपीतो पर फैलता जा रहा है । (भा बा अनु सं)

फल न आने के समय मे. एनाईसोप्लिए का 1 x 10^7 कोनिडिआ/ली. की दर से वृक्ष की शाखाओं पर तीन छिड़काव तथा फूल आने के समय तीन छिड़काव करना आम के फुदको को नियंत्रित करने के लिए प्रभावी पाया गया । (म फु कृ विद्या)

किसान के खेत में, जून, 2009 के समय *क्रिप्टोलीमस मोन्ट्रयूजिएरी* को प्लावित रुप से 2,500 बीटल/हे. की दर से छोड़ने पर शरीफे को बाजार योग्य उपज 40.2 प्रतिशत बढ़ने और मीलीबग की 78.6 प्रतिशत तक संख्या नियंत्रित करके प्रभावी पाया गया । (म फु कृ विद्या)

शीतोष्ण फल

तना बेधक डोरीस्थेनेस हुयूगेली के प्रति *ब्यूवेरिआ ब्रोन्गनीआर्टी* और *मे. एनाईसोप्लिए* को क्रमशः 36.6 से 63.6 प्रतिशत घातक पाया गया । (डा य सि प बा एवं वा वि)

माँगमोर, शानीगुण्ड और हरदास में, *ट्रा. एम्ब्रियोफेगम* को क्रमवार दो बारी छोड़ने पर कोडलिंग मौथ द्वारा फल क्षति और अनोपचारित की तुलना में फल क्षति प्रतिशत विस्तार को 23.6 से 36.1 तक कम करता है । (शे क कृ वि एवं प्रौ वि)

सब्जी वाली फसलें

बैगन के विषय में, बी आई पी एम पैकेज मोडयूल-1 (ट्रा. किलोनिस + बी टी) के प्रयोग से 17.2 प्रतिशत और बी आई पी एम मोडयूल-2 (ट्रा. किलोनिस + बी टी + खेत की मेडों पर मक्का उगाना) द्वारा 17.3 प्रतिशत जबकि रासायनिक उपचार द्वारा फल क्षति माध्य 21 प्रतिशत पाया गया । (भा बा अनु सं)

टमाटर की फसल में प्रतिरोपण के 45 दिनों के बाद ट्राईकोग्रामा प्रेटिओजम थेलीटोकस विभेद को 1 लाख प्रति हे. की दर से साप्ताहिक अन्तराल पर छः बारी छोड़ने पर हे. आर्मीजेरा के ग्रसन को कम और टमाटर फलों की बाजार योग्य उपज बढ़ाने में अत्यन्त प्रभावी पाया गया। (म फु कृ विद्या और ओ कृ एवं प्रौ वि)

आलू की फसल में, रोपण के 45 दिनों के बाद *कोपिडोसोमा कोईहेल्री* का प्लावित रुप में 1250 ममीज/हे. की दर से साप्ताहिक अन्तराल पर छिद्रोवाली प्लास्टिक की छोटी शीशी में 3-4 ममीज चार बारी छोड़ने पर आलू कन्द मौथ द्वारा क्षति का नियंत्रण और आलू कन्दों की उपज बढाने के लिए किसान द्वारा अपनाई जाने वाली प्रकि या की अपेक्षा महत्वपूर्ण रुप से प्रभावी पाया गया । (म फु कृ विद्या)

मे. एनाईसोप्लिए से परिपूर्ण गोबर की खाद (2 x 10^{10} कोनिडिआ /किग्रा) को मृदा में 20 किग्रा/प्लाट की दर से कन्दों को रोपण करते समय करने के परिणाम स्वरुप सफेद लट (*होलोट्रीशिआ कोन्सेनगुयीना*) की सँख्या को अत्यधिक कवकीय जाल के साथ करने और आलू कन्द की उपज बढ़ाने के लिए प्रभावी पाया गया । (म फु कृ विद्या)

उत्तराखण्ड राज्य के चमौली जिले में, 20 से अधिक किसानों के खेतों में, खरीफ मौसम, 2009 के दौरान विभिन्न सब्जियों वाली फसलों में आई पी एम पैकेज के क्षेत्रीय प्रदर्शन किए गए । आई पी एम पैकेज अपनाने पर पातगोभी की उपज 4.7 प्रतिशत बढ़ी पाई गई। (गो ब पं कृ एवं प्रौ वि)

नीओसीयुलस लोन्जिास्पाईनोसस का सेम पर बहुगुणन करने की विधि का आदर्श मानकीकरण किया गया और परभक्षी कीट एवं शिकार कीट का उचित अनुपात 1:30 पाया गया। *नी. लोन्जिस्पाईनोसस* (30 प्रतिशत पौधों में 20 माइट/पौधा) को साप्ताहिक अन्तराल पर क्र मवार छोड़ने पर दो धब्बेदार माइट के प्रबंधन के लिए, प्रोफेनोफास (0.15 प्रतिशत) के तीन छिड़काव के समान पाया गया । (डा य सि प बा एवं वा वि)

पोलीहाउस फसल पीडक

ब्लापटोस्टेथस पेलेसेन्स को 10 और 20 परभक्षी कीट की दर से पाँच बार छोड़ने पर गुलाब के पौधो में स्पाइडर माइटों की संख्या को 25.22/5 ऊपरी पत्तियों के रुप में महत्वपूर्ण रुप से कम किया जबकि अनोपचारित दशा में इनकी सँख्या 56.58 पाई गई । (शे क कृ वि एवं प्रौ वि)

पे. लिलेसीनस को 20 किग्रा. टाल्क नियमन/हे. की दर से भूमि में प्रयोग करने पर कार्नेशन में जड़ ग्रन्थि सूत्रकृमियों की सँख्या 41.1 और आर के आई 2.16 तक कम करने के लिए जड़ग्रन्थि सूत्रकृमि के प्रति अत्यन्त प्रभावी पाया गया । (म फु कृ विद्या)

एनथोकोरिड परभक्षी कीट, ब्लाप्टोस्टेथस पेलेसेन्स को 20 निम्फ प्रति पौधे की दर से साप्ताहिक अन्तराल पर चार बार छोड़ना, गुलाब की दो धब्बेदार माईट की सँख्या को कम करने के लिए प्रभावी पाया गया । (म फु कृ विद्या)

पोलीहाऊस में हिर्सुटेल्ला थोम्पसोनाई को 108 सी एफ यू/मिली. की दर से तीन छिड़काव करना टेट्रानिकस उर्टिके की संख्या नियंत्रण करने के लिए प्रभावी पाए गए । (म फु कृ विद्या)

खरपतवार नियंत्रण

क्रोमोलीना ओडोरेटा का नियंत्रण करने के लिए वेलानिकरा के आसपास के क्षेत्रों में सेसीडोकेरस कोनेकसा छोडे गए । क्षेत्र में कीट

छोडने के पश्चात निरिक्षण में गाँठे पाई गई जो इस बात का सूचक है कि केरल में गाँठ मक्खी स्थापित और फैल रही हैं। (के कृ वि)

भण्डारण कीट

ब्लापटोस्टेथस पेलेसेन्स की अपेक्षा जाईलोकोरिस फ्लेविपस को 30 निम्फ/10 किग्रा की दर से धान भण्डार में आप्लावित रुप से छोड़ना को. सीफेलोनिका के निकलना कम करने के लिए अत्यन्त प्रभावी पाया गया । (म फु कृ विद्या)

मानव संसाधन विकास

- डा. जे. पूरणी ने 23 फरवरी, 2010 को बेंगलोर में आयोजित जैव विविधता के लिए भारत में जैव वर्गीकरण का अग्रगामी विज्ञान पर एक दिवसीय राष्ट्रीय परामर्श कार्यशाला में भाग लिया ।
- डा. सी. आर. ब्राल ने 6 से 11 सितम्बर, 2009 तक मेडीटेरेनीअन एग्रोनोमिक इन्सटिटयूट में चानिया, इसले ऑफ क्रेटे, ग्रीस में सुरक्षित खेती पर आई ओ बी सी संगोष्ठी मे भाग लिए तथा एक शोध पत्र पुस्तुत किया ।
- डा. सी. आर ब्राल ने 22 नवम्बर 2009 को मद्रास विश्वविद्यालय, चेन्नई में कीट पादप अंतःक्रिया में आण्विक नितियाँ– परपोषी विशेषता में रासायनिक पारिस्थितविज्ञान की भूमिका पर उसकी दसवी वार्षिक संगोष्ठी में और एस.के.आर.ए.यू, दुर्गापुर में पर्यावरणिक तकनीकों और पारम्परिक खेती क्रियाओं के माध्यम से कृषि में पादप सुरक्षा विषय पर राष्ट्रीय कान्फें न्स में भाग लिया ।
- डा. वीणा कुमारी ने सीलीओनिडे के विभिन्न वंशों की पहचान के लिए डा. के. राजमोहन के माध्यम से पश्चिमी घाट के लिए जुओलोजिकल सर्वे ऑफ इन्डिया, कालीकट में 8 दिनों का प्रशिक्षण प्राप्त किया और भारतीय वन्य जीव संस्थान, देहरादून में, 8–10 मार्च 2010 तक विज्ञान और प्रौद्योगिकी विभाग द्वारा प्रायोजित वन्यजीव संरक्षण वाद–पद और चुनौती कार्यशाला में भाग लिया ।
- डा. जी. शिवकुमार ने भा कृ अनु सं नई दिल्ली में 10–13 नवम्बर 2009 तक पादप रोग विज्ञान पर आयोजित अंतर्राष्ट्रीय कान्फ्रेन्स में भाग लिया ।
- डा. आर. रंघेश्वरण ने इक्रिसेट (आई सी आर आई एस ए टी), पटानचेरु (आ. प्र.) में पीडकों के प्रबंधन के लिए वंशानुवीय रुपान्तरित जीवों और परम्परागत प्रौद्योगीकियों का जैव–सुरक्षा और पर्यावरणीय प्रभाव विषय पर 19–11–09 से 22–11–09 तक आयोजित सिम्पोजियम में भाग लिया ।
- डा. बी एस भुमन्नावर ने रा.प.पो.का.सं., बेंगलोर में 5–5–09 से 27–5–09 तक आयोजित सतर्कता अधिकारी प्रशिक्षण कार्यक म में भाग लिया ।
- श्री बी. अमरनाथ ने आई एस टी एम, नई दिल्ली में 26–8–2009 से 29–08–2009 तक कैट मामलों और कचहरी मामलों के प्रबंध पर प्रशिक्षण में भाग लिया और प्रशासनिक सतर्कता–ख प्रशिक्षण 5–10–09 से 9.10.2009 तक नई दिल्ली में प्रशिक्षण में भाग लिया ।
- डा. एम नागेश और आर टिप्पेस्वामी ने ई एस टी विश्लेषण और उनके अभ्युक्ति पर 20.10.2009 से 23.10.2009 तक भा. म. अनु. सं., कालीकट में प्रशिक्षण में भाग लिया ।
- डा. जी शिवकुमार ने इक्रिसेट (आई सी आर आई एस ए टी) में 12.12.09 से 16.12.09 तक फसल सिद्दान्त मोडलस पर एक अल्पकालीन पाठ्यक्रम में भाग लिया ।
- डा.टी. वेंकटेशन और डा. एम. नागेश ने एन बी एफ जी आर, लखनऊ में 3.12.09 से 12.12.09 तक मछली और समुद्रीय जीव डी एन ए बार कोडिंग का प्रशिक्षण प्राप्त किया ।
- डा. एस. के. जलाली , बी. रामानुजम, पी. श्रीराम कुमार, डा. आर. रंघेश्वरण ने भा कृ अनु सं, नई दिल्ली मे. 21.12.09 से 23.12.09 तक फसल विज्ञान में जैव–सूचना प्रयोगों पर प्रशिक्षण प्राप्त किया ।
- डा. वाई. ललिता ने रा.कृ.अनु.प्र.अका., हैदराबाद में 22.02.10 से 27.02.10 तक कृषि मे कन्सट्रोटिया आधारित अनुसंधान के लिए तकनीकी और प्रशासनिक सहायता विषय पर प्रशिक्षण में भाग लिया ।
- श्री पी. के. सोनकुसरे ने रा.कृ.अनु.प्र.अका., हैदरबाद में 2.2.10 से 3.2.10 तक नेटवर्किंग और वेब होस्टिंग विषय पर प्रशिक्षण में भाग लिया ।
- डा. एस. के जलाली ने एन बी पी जी आर, नई दिल्ली में 19.03.10 को बेब साईट के लिए एक समान दिशा निर्देश के बारे में एरिस (ए आर आई एस) प्रभारी की संवेदन ग्रहण विषय पर राष्ट्रीय कार्यशाला में भाग लिया ।
- श्री सतेन्द्र कुमार ने होटल संदेश द प्रिंस, मैसूर में राजभाषा विषय पर 2.2.10 से 3.2.2010 दुसरी आयोजित राष्ट्रीय रिहायसी फंकश्नल कार्यशाला में भाग लिया ।

राजस्व प्राप्ति

प्राकृतिक शत्रु कीटों की बिक्री, तकनीकी बुलेटिनों की बिक्री, प्रशिक्षण शुल्क, परामर्श प्रभार, गुणवन्ता जाँच शुल्क और स्नातकोत्तर विद्यार्थियों के परियोजना कार्यों के लिए एकत्र शुल्क से रा.कृ.उ.की.ब्यू., बेंगलोर द्वारा, सन् 2009–2010 के दौरान 10.93 लाख रुपयों का राजस्व प्राप्त किया ।

प्रकाशन

वैज्ञानिक जरनल्स में चौहत्तर शोध–पत्र, सिम्पोजिया/कार्यशाला, संगोष्ठियों में अड़तालीस शोध–पत्र प्रस्तुत किए गए । तीन पुस्तक अध्यायों और 14 लोकप्रिय लेख प्रकाशित किए गए ।

3. EXECUTIVE SUMMARY

The erstwhile Project Directorate of Biological Control has been upgraded as the **National Bureau of Agriculturally Important Insects** (**NBAII**) with effect from 25th June, 2009. A comprehensive research programme was undertaken to address the mandate of the newly formed bureau. All research programmes relating to biological control of plant pathogens continued under the project coordination cell functioning at the NBAII. The salient achievements of the NBAII as well as those of the AICRP on Biological Control operating in 14 state Agricultural Universities (SAUs) and six Indian Council of Agricultural Research (ICAR) – based centres besides many voluntary centres during the year 2009-10 are presented below They testify to the headway being made in the search for effective biocontrol strategies in our battle against pests in diverse crop situations.

Basic research

National Bureau of Agriculturally Important Insects

Division of biosystematics, biodiversity and biosafety

Biosystematics

Cataloguing of minor orders of insects of India and its neighboring countries was initiated and checklists were prepared for 15 orders. Nine new species of Coccinellidae - seven of *Scymnodes* and two of *Apolinus* were described. Ten populations of *Chrysoperla* (*carnea*-group) collected on cotton from Bangalore, Dharwad, Ludhiana, Coimbatore, Baroda, Delhi, Udaipur, Sirsa, Guntur, and Sriganganagar were characterized as *Chrysoperla zastrowi arabica* Henry *et al*. based on acoustic analysis of mating signals.

Three new species of *Trichogramma viz., T. rabindrai*, *T. pieridis* and *T. giriensis* have been described. For the first time in India *Trichogramma chilonis* and *T. manii* were found to parasitize the eggs of Chrysopidae (Neuroptera). Eggs of *Eurema blanda* has been found to be an additional host for *T. achaeae*.

Surveys for insect egg parasitoids were conducted in both agroecosystems and in non-crop ecosystems. Scelionid wasps were collected from eggs from seven states, *viz.,* Assam, Andhra Pradesh, Karnataka, Kerala, Rajasthan, Tamil Nadu and Uttarakand on sugarcane, rice, wheat, maize, pulses, vegetables and fruits.

Egg parasitoids were collected from 396 egg masses of different orders of insects such as Heteroptera (232), Lepidoptera (66), Homoptera (29), Neuroptera (Chrysopidae and Ascalaphidae) (15), Dictyoptera (13), Diptera (4) and Coleoptera (2) and Class Arachnida (33).

During the course of this study, fourteen genera of Scelionidae belonging to three subfamilies - Scelioninae, Telenominae and Teleasinae were recorded. The fourteen genera are *Anteromorpha, Baryconus, Baeus, Ceratobaeus, Doddiella, Fusicornia, Opisthocantha, Scelio, Odontacholus, Sceliocerdo, Gryon, Trimorus, Eumicrosoma* and *Telenomus. Baryconus, Baeus, Ceratobaeus, Doddiella, Fuscicornia, Opisthocantha* and *Odontocholus* are reported for the first time from Karnataka while *Eumicrosoma* which is reported only from Delhi and Harayana is reported for the first time from South India.

Egg masses of the yellow stem borer of rice were parasitized by *Trichogramma* sp. (Trichogrammatidae), *Telenomus* sp. (Scelionidae) and *Tetrastichus* sp. (Eulophidae). Egg parasitization by *Telenomus* sp. varied from 25.5 to 86.2 per cent while, the egg parasitisation by *Tetrastichus* sp. was in the range of 0- 22.3 per cent. The parasitization of *Trichogramma* ranged from 0-44.0 per cent.

Eggs of pest insects and natural enemies that were collected from various ecosystems were found to be parasitized by parasitoids belonging to different families such as Scelionidae, Eupelmidae, Encyrtidae and Eulophidae. A total of 3368 parasitoids were collected during the course of this study.

Five species of aphids viz., *Melanaphis bambusae* (Fullaway), *Brachysiphoniella montana* (van der Goot), *Capitophorus mitegoni* Eastop, *Ceratovacuna perglandulosa* Basu, Ghosh and Raychaudhuri and *Aphis kurosawai* Takahashi were recorded infesting different host plants from Karnataka. Out of these five species, three were recorded for the first time from South India.

Eighty five species of coccids belonging to 12 families were recorded from Bangalore. A species of *Conchaspis* Cockerell (Family Conchaspididae) and a species of *Carulaspis* MacGillivray (Family Diaspididae) were recorded for the first time from India. A total of 24 species of parasitoids belonging to the different families, Eulophidae, Encyrtidae, Aphelinidae, Signiphoridae and Pteromalidae were collected from different coccids including soft scales, diaspidids and mealybugs.

Anticipatory action for the quarantine coconut pest *Brontispa longissima*

The coconut leaf beetle, *Brontispa longissima* has invaded many of the south east Asian countries and South Pacific islands and there is a threat of this pest entering our country. Five sensitization workshops were conducted for officers of the Departments of Agriculture/Horticulture, Plant Protection Officers of the Central Integrated Pest Management Centres, Officers of the Coconut Development Board, Plant Protection Scientists of the Agricultural Universities and Subject Matter Specialists of the KVKs; one at OUAT, Bhubaneshwar, one at Ambajipetta, Andhra Pradesh, two in NBAII, Bangalore and one in TNAU, Tamil Nadu. The Bureau has developed DNA bar codes of this pest which will facilitate rapid identification of the pest in the event of its invasion. *Acecodes hispinarum* and *Tetrastichus brontispae* are potential parasitoids for the classical biological control of *B. longissima*.

Studies on the papaya mealy bug *Paracoccus marginatus*

The papaya mealy bug completed its life cycle on potato sprouts in 30 to 35 days. Each gravid female/ ovisac contained 170.5 ± 8.2 eggs (N=20). The eggs hatched in 4-6 days time and the nymphs started feeding on the leaf and also on the stem. The native natural enemies of the papaya mealybug were three coccinellids, namely, *Menochilus sexmaculatus*, *Nephus regularis* and *Curinus coeruleus*. *Apertochrysa* sp. nr. *crassinervis* (Neuroptera: Chrysopidae) was recorded in association with papaya mealybug infesting cotton. *Spalgis epius* was the only predator frequently found feeding on *P. marginatus* in the field.

Biodiversity of natural enemies

Among the different populations, *Goniozus nephantidis* from Tamilnadu was superior in terms of per cent pupation (62.6-80.5), parasitizing efficiency (6.2-8.5 larvae/female), and adult longevity (41.3-56.6 days) at higher temperatures of 32, 36 and variable temperatures of 36-40^{o}C.

Different populations of *Cotesia flavipes* showed variability in response to fenvalerate and endosulfan. The population collected from Shimla had the highest LC_{50} (2.77 ppm) followed by that from Coimbatore (LC_{50} = 2.24 ppm) and Chindwara (LC_{50} = 1.98 ppm). For endosulfan, maximum LC_{50} was recorded in population from Bangalore (56.24 ppm).

PCR of ITS-2 region for the Bagalkot, Bangalore, Devaganahalli, Gowribidanur, Hoskote and Mulbagal (Karnataka) Aurangabad, Chindwara, Delhi, Hoshiarpur, Hyderabad, and Shimla populations of *C. flavipes* showed polymorphism in the genome. DNA sequence analysis of the ITS-2 showed intra-species divergence. The RAPD analysis indicated variation among the populations. The searching efficiency of Shimla population was the best followed by Dindigal population.

Cryptolaemous montrouzieri populations from Coimbatore and Shimoga had lowest mortality (66.7% and 66.6%) to the variable higher temperature of 32-40 ºC, whereas the populations from Bangalore, Pune and Lab- reared population showed 100% mortality.

When 10 days old larvae of *C. montrouzieri* were topically sprayed with acephate (0.67g/lit), higher survival of Bangalore (24%) population was recorded. Similar observations were recorded when 20 days old larvae were exposed recording 37% survival for Bangalore populations.

Field evaluation of pesticide-tolerant strain against sucking pests of cotton revealed that two releases of pesticide tolerant strain of *Chrysoperla zastrowi arabica* (Cza-8) at 15 days interval in combination with two sprays of acephate (0.67g/li) recorded lowest population of aphids (13.4), thrips (1.87), white flies (1.02) and leaf hoppers (3.13) per plant and realized highest seed cotton yield (1533 kg/ha). This was on par with 4 sprays of acephate (0.67g/l).

Division of bio-resource conservation and utilization

Evalution of anthocorid predators

Anthocoris sp. collected from *Ferrisia virgata* colonies on *Bauhinia purpurea* could be multiplied on both *Phenacoccus solenopsis* and *Ferrisia virgata.* The biological parameters were studied on cotton mealybugs. The total developmental period from egg to adult was 21 days and the fecundity 22.5 eggs.

Results of an experiment taken up at the polyhouse in the NBAII farm to evaluate *Blaptostethus pallescens* against mites infesting carnation showed that the predators could reduce the mite infestation by about 28 per cent and increase the flower lyield by 20 per cent.

Five releases of *B. pallescens* @10-20 per plant significantly reduced the thrips damage on chilli (Freshno chilli- var. Supreme). The number of thrips (*Frankliniella schultzei*) per bud/flower in the biocontrol plot ranged from 0.7 to 13, whereas in the control it was 0.14 to 28.15, indicating a significant reduction of thrips population in the bio-control plot. Yield of fruits in biocontrol plots was comparable with that of chemical insecticide.

Orius tantillus could be effectively reared using frozen eggs of *Helicoverpa armigera* mixed with pollen. The fecundity of the adults fed on frozen eggs was comparable with that recorded on *Sitogroga cerealella* eggs.

In a net house study conducted to evaluate the efficacy of *B. pallescens* against spider mites infesting tomato it was seen that there was a 50% reduction in the mite population in the treated plants. However, there was heavy mortality of the anthocorid on tomato plants due to the dense trichomes. This experiment indicated that though *B. pallescens* is a potential predator of *T. urticae,* the host plant characteristics can adversely affect the performance of the predator.

Response of *Helicoverpa armigera* to pheromones

Morphological studies on the antenna of *H. armigera* revealed the presence of more number of *sensilla trichoidea* in males, while the females possessed more of *sensilla basiconica*. Electroantennogram studies of males of different populations with blends of Z-11 hexadecenal and Z-9 hexadecenal @ ratios of 85:15; 88:12; 91:9; 94:6 and 97:3 indicated that males were more responsive to Z-11-hexadecenal and least responsive to Z-9 hexadecenal. The blends 85:15 elicited higher response than Z-11 hexadecenal alone. Most of the populations showed significantly higher response to the blend of 85:15 than to 97:3. However, the Raichur population showed no statistical difference between the blends studied.

Nanotechnology for slow release of pheromones

The nanofibers network formed by the pheromones or a mixture of the pheromones was found to be stable at room temperature and showed increased shelf-life. The release pattern of the pheromone from the nanofibers was studied at 10, 20 and 30° C. A slow evaporation rate of the pheromone was seen thus making the assembly useful for agricultural pest management applications with increased persistence. Synthesized the nanoformulations of pheromones for management of the fruit fly *Bactrocera dorsalis*, and conducted field trials successfully in a guava orchard at Varanasi, Uttar Pradesh. Synthesized the *Helicoverpa armigera* and *Scirphophaga incertulas* pheromone components Z-9-hexadecenal and Z11-hexadecenal. The structure was confirmed with proton nuclear magnetic resonance (^{1}HNMR). Synthesized nano formulations for kairomones for natural enemies. Synthesized nanofibers of *Scirphophaga incertulas* pheromone to enhance shelf life and ease of dispensation.

Pollinators

Surveys were undertaken in traditional pigeonpea belt of Karnataka (Gulbarga) and Maharastra (Parbhani) regions and nontraditional pigeonpea areas of Andhra Pradesh (Hyderabad) and Tamil Nadu (Pudukottai). In the traditional areas, honey bees (*Apis florea* and *A. dorsata*) were predominant visitors and collected both nectar and pollen. The sting less bee, *Trigona* sp. was observed sparingly in the same regions. But, those were totally absent in nontraditional pigeonpea areas. Pollen grains were extracted by opening the keel petals exactly at the region of anthers. In both traditional and nontraditional areas, carpenter bees (*Xylocopa* spp.) and leaf cutter bees (*Megachile* spp.) and halictid bees were observed. Carpenter bees and leaf cutter bees alight on wing petals and set the ball and piston mechanism in operation to collect pollen grains, whereas halictid bees collect pollen grains just like honey bees. The visitation time/flower for *A. florea* and *A. dorsata* ranged from 1-80 seconds (mean: 15.8) and 1-27 seconds (mean: 8.4) respectively, whereas visitation time for carpenter bees and leaf cutter bees ranged from 1-16 seconds

Division of biotechnology and bioinformatics

Development of superior strains of parasitoids and predators

Bacterial endosymbionts in the populations of *Cotesia flavipes* from Aurangabad, Bangalore, Dindigul and Malur (near Bangalore) contributed to the fitness of the parasitoid. There was about 20% increase in females over 5 generations in the population from Bangalore.

Molecular characterization of agriculturally important insects

Chrysoperla zastrowi arabica

PCR amplification of cytochrome c oxidase (COI) gene of *Chrysoperla z. arabica viz.*, Cza-8 and Cza-6 was done and sequenced (524 bp) which will be useful for the development of DNA barcode of chrysopid predators. Sequence of COI gene of Cza-8 was submitted to GenBank and the Acc. No. is GU817334 (524 bp)

Trichogrammatidae

The size of the base pairs of the ITS-2 rDNA PCR products of some *Trichogrammatoidea* species varied from 800-900bp. Phylogenetic tree based on N-J method showed five plates with species and ones near to particular species aligning with their counterparts. ITS2 region of *T. chilonis* collected from the field were amplified and sequenced. The sequences were analyzed and sequence identity matrix was generated. The populations matched to the tune of 98.1 to 100.0% amongst themselves.

Horizontal transmission studies of wolbachia with non-infected species revealed that % females in parent was only 45.0 to 56.0% in four species tested. After transmission for 20 generations, %females obtained was 60.0 to 79.0%. The mean %females from parent population increased drastically in *T. achaeae* (from 45.0 to 79.0 in 20th generation) and *T. japonicum* (from 50.0 to 72.0 in 20th generation) indicating the possibility of wolbachia getting transmitted. Curing of wolbachia in infected species with antibiotic rifampicin revealed that % females remained 100.0% in *T. cacoeciae* indicating that thelytoky was not due to the bacterium. In other species, %females ranged from 23.3-98.1% and mean fecundity decreased in *T. corbudensis*, *T. embryophagum*, *T. evanescens* and *T. pretiosum* (France) but fecundity increased in *T. semblidis* and *T. pretiosum* (USA) after 20 generations of curing.

The fitness experiment carried out with laboratory-reared trichogrammatids by feeding yeast revealed that the per cent females in *T. chilonis*, *T. japonicum*, *T. achaeae* and *Tr. bactrae* increased to 45.0 – 80.0, 50.0 – 79.4, 45.0 – 64.5 and 56.0 –

79.0%, respectively. The fecundity also increased, though marginally, in *T. chilonis* (from 35.0 to 54.0), *T. japonicum* (from 40.0 to 62.0), *T. achaeae* (from 35.0 to 56.0) and in *Tr. bactrae* (from 25.0 to 38.0)

Indian Coccinellidae

DNA was extracted from fourteen species of coccinellids collected from Bangalore region. Primer pairs were designed for the COI region of the coccinellids. Protocol for standardization of PCR to amplify the COI gene was done for the fourteen species. Partial gene sequence of COI region was determined for eight species.

All India Coordinated Research Project on Biological Control of pests and weeds

Co-ordinating Cell- NBAII

Fungal antagonists

Among the six substrates tested, sorghum and finger millet grains were found to support good growth of *Trichoderma harzianum* during Solid State Fermentation (SSF) and the log of CFUs was 8.5 to 9.0 per gram of substrate. While in other substrates like rice grain, saw dust and brans from wheat or rice, the viability ranged between 7.5 to 8.5 Log CFUs g^{-1}.

Overnight soaking of the grains is generally followed for the mass production of *T. harzianum*. However, when finger millet and sorghum were soaked for different periods, the saturation was obtained within four hours of soaking indicating that there is no need for overnight soaking.

Suitability of sponges and sugarcane baggase as inert-support culture in solid state fermentation for the mass production of *T. hariznaum* was tested. Compared to sponge, production of spores on baggase was less and by 20th day, viable propagule count came down to 10^6 CFUs per sponge cube of 1 cm^3 size. The spore production was maximum on 10th day after which the spore viability started declining, indicating that spores are to be harvested by 10th day.

In baggase, the water activity during SSF ranged from 0.95 to 0.97 while in sponges it was almost saturation (0.98 to 0.99) during SSF. In baggase, the moisture content increased up to 15th day and then declined by 20th day.

Entomofungal pathogens

Seven solid substrates like, rice, sorghum, ragi, wheat bran, rice bran, saw dust and sugarcane bagasse were evaluated for production of aerial conidia of *B. bassiana* and *M. anisopliae*. The conidial production of *B. bassiana* (Bb-5a isolate) and *M. anisopliae* (Ma-4) was estimated after 5, 10 and 15 days of incubation at 25^0C and 70% RH. Conidial production was highest on 15th day in all 7 substrates tested. Rice grains supported the highest sporulation of *B. bassiana* (31.3x10^8 conidia/g) and *M. anisopliae* (28.3x10^8 conidia/g).

Sponge cubes of 1cm^3 were cut and impregnated with Sabouraud dextrose yeast broth (SDYB) by two methods. In the first method, sponge cubes were impregnated with SDYB followed by sterilization and inoculation with *Beauveria bassiana* and *Metarhizium anisopliae*. In the second method, SDYB was added to the pre-sterilized sponge cubes followed by inoculation with *B. bassiana* and *M. anisopliae.* Conidial production was highest on 15th day in the two methods tested. Conidial production of 1.3x10^8 conidia/cm^3 of *B. bassiana* was observed in both methods. With regard to *M. anisopliae*, 1.0x10^8 conidia/cm3 was observed in the first method and 0.6x10^8 conidia/cm3 in the second method.

Management of tomato and brinjal wilts caused by *Ralstonia solanacearum*

Among the 100 isolates of *Bacillus* spp. screened, ten were found to be inhibitory to the bacterial wilt pathogen *R. solanacearum*. Highest inhibition was found in the case of Devikulam isolate (11.5mm) followed by isolate 7 from Pampadumpara (9.4mm), isolate 33 from NBAII (9.3mm) and isolate 56 from Hesserghatta (7.4mm) isolates. Application of the antagonist (Devikulam isolate) as seed treatment, root dipping and foliar spray in combination increased the root length (12cm), shoot length (58.1cm), fresh weight (23.2 g), dry weight (5.3g) and reduced the bacterial wilt up to 79.15 per cent as compared to other isolates and control.

Biological control of *Alternaria* leaf blight of tomato

A field experiment was carried out in Attur Farm during rabi season of 2009 to evaluate twelve promising isolates of *Trichoderma* spp. belonging to *T. viride*, *T. virens* and *T. harzianum* and three bacterial isolates (*Pseudomonas fluorescens*, *Bacillus subtilis* and *B. megaterium)* against leaf blight disease of tomato caused by *Alternaria* spp.

Among the 15 isolates of antagonists tested, the lowest PDI of 20.33 was observed with *T. viride* (TV-115 isolate), however it was statistically on par with *T. harzianum* (Th-7 and Th-10 isolates) and *Pseudomonas fluorescens* which showed PDI of 20.66, 22.16, and 21.36 respectively.

Isolation and characterization of indigenous *Bacillus thuringiensis* strains

Two new indigenous Bt isolates having bipyramidal crystals were isolated from Assam and Rajasthan and designated as NBAII-BTAS and NBAII-BTG4. The native protein concentration in NBAII-BTAS was 3.2mg/ml. Both the isolates were highly toxic and 100% mortality of second instar larvae of *Plutella xylostella* was recorded at $10^{-1}$to 10^{-2} dilutions. The minimum mortality of 95% was recorded at 10^{-3} to 10^{-4} dilution. The calculated LC_{50} value was 0.037 µg/ml for NBAII-BTAS and 0.026µg/ml for NBAII-BTG4.

All the indigenous Bt isolates (PDBC BT-ASSAM, PDBC BT-1, PDBC HD-1, NBAII-BT G4) were amplified with cry1 general primers and found to be positive for cry1 gene. Amplification of a family band of about 1.5 to 1.6kb was observed in all the isolates.

SDS-PAGE analysis of the spore crystal protein was done for the indigenous *B. thuringiensis* isolates and compared with the standard HD-1 strain. NBAII-BTG4 and PDBC-BT1 showed almost similar protein profile but the NBAII-BTG4 isolate showed a 15kDa band that was missing in the PDBC-BT-1 isolate.

Field evaluation of Bt isolates

Field evaluation of five indigenous Bt isolates namely PDBC-BT1, PDBC-BT2, BNGT1, HD-1 and NBAII-BTAS was done against redgram pod borer. NBAII-BTAS recorded the lowest pod damage of 1.9 per cent as against 28.1 in untreated check.

Endophytic bacteria

Seven endophytic bacteria were isolated from healthy tomato plants and five of them were identified by Biolog system as *Acinetobacter baumanii, Stenotrophomonas maltophila, Enterobacter cloacae, Brevundimonas vesicularis* and *Burholderia plantarii*. Four endophytic bacteria were isolated from cotton, groundnut, tomato and pigeonpea. They were identified as *Cellulosimicrobium cellulans*, *Pseudomonas putida, Pseudomonas putida* biotype A (2 isolates from groundnut and tomato) and *Brevibacterium otidis*.

Biological control of mites

In a net-house trial, application of *Acremonium* sp. at a spore concentration of 1 x 10^7/ml, significantly brought down the incidence of *Tetranychus urticae* on bitter gourd, bottle gourd and ridge gourd.

In a green house experiment application of *L. psalliotae* at a spore strength of 1 x 10^7/ml significantly reduced the incidence of *T. urticae* on brinjal.

In a field trial, three time application of *L. psalliotae* at a spore strength of 1 x 10^7/ml significantly reduced *T. uritace* incidence on brinjal.

DNA bar coding of entomopathogenic nematodes

COI gene amplification and sequencing has been done for 12 EPN isolates to generate data for DNA bar coding. The sequence analysis (DNA bar coding) strongly supported 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 the label claims in EPN formulations.

In vivo production of *Steinernema* and *Heterorhabditis*

The optimal temperature for growth, duration of life cycle, larval biomass and fecundity of *Galleria mellonella* ranged between 28 and 30°C at a relative humidity of 50-80%. *In vivo* production of *Heterorhabditis indica* and *Steinernema carpocapsae* on *Galleria* larvae was enhanced by synchronizing the larval production and diet modification for the larvae.

The EPN (*H. indica* and *S. carpocapsae*) multiplied on *G. mellonella, C. cephalonica* and root grubs were more virulent and caused larval mortality (*G. mellonella* and root grub) in shorter duration (24-36h) compared to the progeny obtained from larvae of *H. armigera, S. litura* and *P. xylostella.*

New isolates of EPN

A new isolate of *H. indica* and two new isolates of *Heterorhabditis* spp. were isolated from diseased white grubs collected from Madikeri.

Bioefficacy of EPN against root grubs

Replicated screening of twelve EPN isolates for their bioefficacy against eggs of root grubs under *in vitro* with *Leucopholis* and *Anomala* species confirmed that there was no infection/penetration of eggs by the EPN.

Among the three EPN species, *H. indica* followed by *S. riobrave* and *S. carpocapsae* consistently recorded lower LD and LT values for the 3 white grub species (*Anomala bengalensis, Leucopholis lepidophora* and *L. burmestrii)* at 3 depths (10,20 and 30cm). These observations aid us in fixing the EPN doses for field application for the three species and to estimate the probable time of grub mortality at different depths after application of the EPN.

Field evaluation of EPN against root grubs

Applications of cadaver preparations of EPN (*H. indica* and *S. carpocapsae*) successfully controlled *Leucopholis lepidophora, Anomala bengalensis* and *L. burmestrii* in 6 to 8 days in arecanut fields at Sulya (Karnataka). EPN were recovered from the treated soils up to a period of 6 months indicating successful establishment of EPN in root grub endemic soils.

A new technique to observe *in situ* the behaviour of root grubs and recover the cadavers in treated soil to confirm EPN as cause of root grub control was developed. Root grubs of different sizes 1cm to 2.5cm were predominant in top 20cm soil from August to October with intermittent large sized grubs, while, grubs of more than 2.5cm were predominant between 10 and 30 cm from Oct to January.

Biological control of plant parasitic nematodes

Two new isolates of antagonistic fungi, *Dactylella oviparasitica* and *Dreschlera* species have been isolated from diseased egg masses and eggs sampled from commercial polyhouses. Another 2 new isolates of *Paecilomyces lilacinus* were isolated from the infected root-knot nematode egg masses collected from soils of Puttur, Dakshina Kannada, Karnataka

These isolates exhibited high percentage infection of egg masses and eggs under *in vitro* and *in vivo* against root-knot and reniform nematodes. The optimum temperature for mycelial growth was 26 to 34^{o}C and spore germination was 26 to 38^{o}C for these isolates.

Features of amorphous formulations of *Paecilomyces lilacinus* and *Pochonia chlamydosporia*

The pH of *P. lilacinus* and *P. chlamydosporia* formulations was between 6.0 and 6.5, while the suspensibility was 4.63 and 4.73, wettability 31.85 min. and 35.06 min. at a moisture content of 1.1%.

Molecular identification and detection technique

Molecular identification and detection of NBAII isolates of *P. lilacinus* and *P. chlamydosporia* were developed based on PCR and restriction enzyme (RFLP) studies for further characterization of virulence factors/mode of action of the isolates against root-knot and reniform nematodes. Serine protease, collagenase and chitinase enzymes responsible for virulence against root-knot nematode eggs and egg masses, were detected in the isolates of *P. lilacinus* and *P. chlamydosporia* under *in vitro.*

Biological control of root-knot nematode in carnation

Root-knot nematode infection of carnation grown in commercial polyhouses was effectively controlled by application of talc preparations of *P. lilacinus* or

P. chlamydosporia with FYM at planting of cuttings at 100 g (10^7 spores/g) followed by a light irrigation.

All India Coordinated Research Project on Biological Control of Crop Pests and Weeds

Biological Suppression of Plant Diseases with fungal antagonists (GBPUAT)

All the isolates of *Trichoderma harzianum* evaluated were effective growth promoters in rice in all the growth parameters tested as compared to check (root and shoot growth, chlorophyll content, average no. of leaves per plant and SPAD values). Overall *T. harzianum* isolates T-14, Th-56, and T-57 were found to be the best growth promoters of rice (Kalanamak-3131) under glass house conditions.

Plants treated with *Pseudomonas fluorescens* + *T. harzianum* + Himedia (Nutrient mixture) both as soil and foliar spray recorded the highest spike length of 96.33 cm which meet the export standard grade A in the international market, whereas with regard to shelf life, the lowest physiological weight loss (16.44) was recorded in the treatment with *Pseudomonas* + *Trichoderma* at 4 DAH. The biochemical parameters like peroxidase, catalase, polyphenol oxidase, proteins, phenols and sugars also revealed a positive correlation with increased shelf life in the treatment with *Pseudomonas* and *Trichoderma* and in interaction with Himedia nutrient mixture.

Twenty isolates of *T. harzianum* were evaluated for growth and yield parameters under field conditions on rice (Kalanamak-3119 and 3131). Isolate T12 gave the best performance on the yield parameters like average filled and unfilled grains with 1206.00 and 302.33; respectively but other growth and total yield parameters were not as good as Kalanamak-variety 3119. Isolate T-1 performed well against sheath blight, sheath rot, stem borer, grass hopper and leaf folder on both the rice varieties tested (Kalanamak 3119 and 3131).

Overall, *T. harzianum* isolates T-39, T-50 along with Th-60, Th-75 and Th-60 were found to be good in wheat whereas in case of lentil and chickpea, T-14 followed by Th-56 were the best isolates in all the tested parameters.

Compatibility of ten different isolates of *T. harzianum viz.,* Th-56, Th-75, T-14, Th-69, T-19, T-9, Th-55, Th-57, T-1 and TH (Ranichauri) with one potential isolate of *Beauveria bassiana* (PBB-04) was studied. Isolate Th-56 and T-19 were most compatible with PBB-04 isolate of *B. bassiana* while T-01, T-09 and Th-75 were not found compatible with PBB-04 isolate of *B. bassiana*.

Biological control of plant parasitic nematodes

Results of the experiment conducted to evaluate the antagonistic fungi against the reniform nematode in redgram (var. Vipula) in *Kharif* 2009 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 (38.5%) and increasing the yield of redgram (1840 kg/ha) (MPKV).

On six year old sweet orange plants, *Paecilomyces lilacinus* @ 20kg/ha of talc formulation containing 10^8 spores/g was found to be effective in reducing the citrus nematode population (43.8%) and number of females in roots (31.8%) and increasing the yield of sweet orange by with 1:8.85 ICBR (MPKV-Rahuri).

In pomegranate (var. Mrudula), pooled analysis of two years data showed that the treatment with soil application of *P. fluorescens* @ 20 g/m^2 was most effective in reducing the root knot nematode population and number of root galls and increasing the yield of pomegranate with 1:11.8 ICBR (MPKV).

In a field experiment on pomegranate (var. Sindhuri), combined application of *P. chlamydosporia* (100g/plant) and mustard cake (2 t/ha) resulted in maximum reduction (57.83%) of nematode counts followed by *P. lilacinus* (100g/plant) + mustard cake (AAU-A).

Results of a 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 (1355 kg/ha) was recorded in plots treated with combination of *T. harzianum* (5 kg/ha) and *P. chlamydosporia* (20 kg/ha). Plots treated with either *T. harzianum* or *P. chlamydosporia* alone performed equally in terms of grain yield (AAU- Anand).

Biological suppression of crop pests

Sugarcane

Eleven releases of *Trichogramma chilonis* @50,000/release in a farmer's field (100ha) located at Dergaon area in Golaghat district significantly reduced the incidence of Plassey borer by 34.6 %. Maximum sugarcane yield was recorded in the parasitoid-released plot (78,400 kg/ha) as against farmers practice (65,900 kg/ha). The highest net return was obtained in the *Trichogramma* released plot (AAU-J).

Six releases of temperature-tolerant strain of *T. chilonis* were found effective against internode borer on sugarcane (MPKV).

In a large-scale demonstration, eight releases of *T. japonicum* at 10 days interval during April to June @ 50,000/ha resulted in reduction of top borer incidence by 54.5 per cent. The cost benefit ratio in release field (1:22.4) was higher than chemical control (1:8.5) (PAU).

Sugarcane woolly aphids were noticed in Pune and Satara districts of western Maharashtra, but the pest intensity was low owing to the occurrence of predators *Dipha aphidivora* (1-3 larvae/leaf), *Micromus igorotus* (3-7 grubs/leaf) and syrphids (1-2 larvae/leaf) and parasitism by *Encarsia flavoscutellum* (MPKV).

In the preliminary assay with III instar white grubs on the combinations of *B. bassiana, B. brongniartii* and *M. anisopliae*, microscopic examinations of dead larvae revealed the dominance of *B. brongniartii* over *M. anisopliae* (SBI).

A field experiment was conducted to evaluate *Metarhizium anisopliae* against termites in sugarcane (variety CoLk 8102). Cane damage during May was lower (8.98%) in chemical treatment (chlorpyriphos 20EC @1 kg.a.i/ha) as compared to fungus treatment (10.73-12.86%) and control (29.20%). The maximum cane yield (48,110 kg//ha) was observed in chemical treatment whereas the yield ranged from 40,510 - 45,030 kg/ha in *M. anisopliae* treatment (IISR).

In a field experiment it was concluded that application of talc-based formulations of EPNs (*H. indica* and *S. carpocapsae* supplied by NBAII) at the time of planting was not effective against termites. Cane damage during May as well as at harvest was minimum in chemical treatment (chlorpyriphos 20EC @1 kg.a.i/ha) (IISR).

Cotton

The parasitism rate of *Phenococcus solenopsis* by *Aenasius banbawalei* varied from 17.16 to 48.82 % with an average of 25.65 %. Minimum (17.16%) parasitism was found during early phase of crop growth which increased in subsequent weeks and reached a peak (30.37%) during the third week of September 2009. Maximum parasitism (48.82 %) was recorded at Pingalwada (Ta. Karjan) during October 2009 (AAU-A).

Laboratory techniques for the mass production of cotton mealy bug *P. solenopsis* using sprouted potatoes has been developed for the multiplication of *A. banbawalei*, a dominant parasitoid of the cotton mealybug in Bt cotton (AAU-A).

BIPM module exhibited 2.80% green boll damage due to bollworms as against 7.33% in Farmers' Practice. The damage to locules was significantly low (3.54%) in BIPM module in comparison to farmers' practice (5.81%). Significantly higher seed cotton yield was recorded in BIPM module (2,416 kg/ha) compared to farmers practice (1,320 kg/ha). Increase in seed cotton yield owing to adoption of BIPM practices was found to be 83.03% (AAU-A).

The incidence of mealy bugs was noticed at around 50 days after sowing of Bt cotton. The dominant mealybug species was *P. solenopsis*, however *Maconellicoccus hirsutus* was also seen in small numbers (ANGRAU).

Verticillium lecanii was isolated from many of the mycosed mealybug numphs. Field release of *Cryptolaemus montrouzierii* againt the cotton mealybug was not effective and this was evidenced by its poor recovery percentage. However, more natural enemy activity was found in plots where *Cryptolaemus* was released and *Verticillium* sprayed plots compared to farmers' practice and untreated control (ANGRAU).

The mealy bug *P. solenopsis* incidence was recorded on cotton in September-October, 2009 and again from January to March, 2010 on late sown crop, but at low intensity. The parasite *A. bambawalei* and the predators, *Coccinella*, *Brumoides, Chrysoperla* and *Spalgis epius,* were observed in the mealy bug colonies (MPKV).

Habitat management consisting of paired row planting interspersed with cowpea and marigold and release of *Chrysoperla* and *T. chilonis* were very effective in reducing the sucking pest population and bollworm damage on cotton. This also increased the populations of natural enemies (chrysopids and coccinellids) and yield of seed cotton with 1:1.55 ICBR (MPKV).

The BIPM package for *Bt*-cotton consisting of seed treatment with *Trichoderma*, border rows of maize, erection of bird perches, spraying of *V. lecanii,* NSE 5% and release of *Trichogrammatoidea bactrae* was found to be effective in the suppression of sucking pests and bollworm damage, and increasing the net returns (25.35%) with 1: 1.96 ICBR (MPKV).

There was no significant difference in the incidence of sucking pests in BIPM package and farmers' practice in Bt cotton, however the predator population was slightly higher in BIPM package. There was no significant difference in seed cotton yield in BIPM package and farmers' practice (PAU).

Tobacco

Application of *Bacillus thuringiensis* var. *kurstaki* in aqueous suspension with pH 7.00, resulted in highest mortality of *Spodoptera litura* larvae, 7 days after the treatment in the nursery (CTRI).

Among six strains of HaNPV tested, the NBAII strain of HaNPV at a concentration of 1.08 x 10^5 PIB and resulted in 80.1% larval mortality of *H. armigera* (CTRI).

It has been reconfirmed that application of *B. bassiana* @ 10^8 spores per ml or g, as seed dressing, spray, soil application or all the treatments combined is not effective in suppressing the stem borer, *Scrobipalpa heliopa* infestation (CTRI).

Pulses

Application of HaNPV sprays (@ 1.5 X 10^{12} POB/ha + 0.5% crude sugar + 0.1% Teepol) and hand collection of second instar larvae recorded significantly less (3.45%) incidence of *H. armigera* in pigeonpea compared to control plot (8.83%). However, this treatment failed to suppress the pod damage due to plume moth and podfly. Significantly higher (1,274 kg/ha) grain yield was recorded in the treatment of HaNPV spray + hand picking of *H. armigera* larvae over untreated check (AAU-A).

Pigeonpea when intercropped with sunflower (9:1) with border crop of maize or soghum recorded less pod damage by *H. armigera* at harvest (6.5%) compared to sole crop (12.82% pod damage). Significantly higher number of *Chrysoperla* and coccinellids were registered in pigeonpea plots intercropped with sunflower and border crop of maize over the treatment of pigeonpea grown as sole crop (AAU-A).

Among the three crop modules tested, pigeonpea intercropped with sunflower and border crop of sorghum recorded least population of *H. armigera* larvae (23/10 plants) compared to the pigeonpea intercropped with sunflower and border crop of maize (42/10 plants) and the sole pigeonpea module (80/10 plants). Yield was also higher in the pigeonpea intercropped with sunflower with border crop of sorghum (1,256kg/ha) than the other two modules (1,152kg/ha) and 911kg/ha) respectively (ANGRAU).

In a field trial, application of Bt @ 1 kg/ha recorded lesser populations of *Adisura atkinsoni* (11 larvae/10 plants), and pod damage (1.35%) compared to untreated control (29 larvae/10 plants and 14.79% pod damage). It also recorded better yield (3,650 kg/ha) compared to all other treatments and was on par with *M. anisopliae* (3,750 kg/ha). *V. lecanii* recorded next best yield (2,650 kg/ha) while control plot recorded yield of only 550 kg/ha (ANGRAU).

Application of *Heterohabditis indica* (NBAII isolate) aqueous formulation @ 2 billion infective juveniles/ ha recorded significantly lowest population of larvae of *Chrysodeixis acuta* and *Spodoptera* *litura* and registered highest grain yield of soybean (JNKVV).

Influence of crop habitat diversity was studied by growing pigeonpea with border crop of maize or sorghum. The results revealed that the population of natural enemies was more on pigeonpea when grown along with border crops compared to sole crop. The natural enemies recorded included four predators (*Cheilomenes sexmaculatus*, *Chrysoperla* group, dragon fly and mud wasps) and one parasitoid (*Cotesia* sp). Maximum population of both the natural enemies was observed on pigeonpea crop bordered with maize (JNKVV).

Rice

Validation of BIPM practice carried out in an area of 300ha in three villages. The populations of GLH as well as 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 (3,210 kg/ha) than the farmers practice (2,968 kg/ha). The incidence of dead heart, white ear head and leaf folder were lower (< 5%) in IPM plot as compared to farmers' practice (AAU-J).

The large scale adoption of BIPM technologies was carried out in an area of 295 hectares in six different panchayats in Trichur district. There was no significant difference in leaf folder and dead heart incidence between the BIPM practice and farmers practice. The population of natural enemies like spiders and coccinellids was significantly higher in BIPM plots when compared to farmers plots. The grain yield was 7,925 kg/ha in BIPM plot and 7,757 kg/ha in farmers practice plot indicating that there is no significant difference between them (KAU).

The fungal pathogens (*B. bassiana, M. anisopliae, V. lecanii and Hirsutella thompsonii*) at @ 2 X 10^7 conidia/ml were not effective against the rice panicle mite, *Stenotarsonemus spinkii* under laboratory conditions (ANGRAU).

The results indicated that the IPM package was more effective in managing the insect pests of rice in comparison to the farmers' practice of only chemical pesticide application. The incidence of YSB, GLH and other foliar pests were significantly less in IPM package with significant increase in yield over the farmers' practice. In IPM package, the dead heart, white ear, leafolder, case worm, skipper and GLH population were significantly lower than that of the farmers' practice. On the contrary, the spider and ladybird populations were significantly higher fetching higher net return over non IPM farmers' practice (OUAT).

In a large scale demonstration covering an area of 1000ha of Taraori basmati rice, application of mixed formulation of *T. harzianum* and *P. fluorescens* through FYM, seed treatment and foliar spray effectively suppressed both bacterial late blight and stem borers in organically cultivated rice (Pusa-1121, Taraori basmati and Pusa-1). The average yield of organically cultivated Pusa-1121 was 3,250 kg/ha and Taraori basmati was 2,000 kg/ha and Pusa-1 was 4,000 kg/ha fetching a price of Rs. 2,300 and Rs. 3,500 and Rs. 2,200 per quintal respectively which on an average is Rs.400.0 higher than conventionally grown crop (GBPUAT).

In a field survey, *Trissolcus* sp. (Scelionidae) and *Oenocyrtus utethesiae* (Risbec) (Encyrtidae) were found parasitising the eggs of the rice gundhi bug, *Leptocorisa* sp. The activity of these parasitoids was high between the 39th and 41st meteorological weeks with peak parasitism (25%) being in the 40th meteorological week (NAU).

In a pot culture experiment, application of EPN (*Steinernema* sp. (Runne) @ 8 lakh/pot resulted in the mortality of 60.48% in larvae of *Chilo suppressalis* and 82.0% in *Cnaphalocrocis medinalis* (CAU-Imphal).

Oilseeds

Field survey for natural enemies revealed that the eggs of castor capsule borer were parasitized by *Trichogramma chilonis* (25.6%), *Trichogrammatoidea bactrae* (19.6%), *Trichogramma japonicum* (15.2%) and *Trichogramma achaeae* (14.7 %) (ANGRAU).

BIPM package in castor resulted in lower incidence of *Spodoptera litura, Achaea janata* and leaf hopper. Yield was also higher in the BIPM package (355 kg/

ha) compared to the Farmers' practice (170 kg/ha) (ANGRAU).

Biocontrol package involving two releases of *Chrysoperla* recorded a 50.0 per cent reduction in the population of aphids on non-spiny safflower plants. Yield in biocontrol package was 501 kg/ha while it was 323 kg/ha in untreated control proving the efficacy of bioagents in managing the safflower aphid (ANGRAU).

Groundnut leaf miner could be effectively managed by spraying of NSKE 5% or Bt @ 1 kg/ha followed by four releases of *T. chilonis* in Tamilnadu. Highest yield was obtained in Bt spray (1,447 kg/ha) followed by NSKE 5% spray (1,373 kg/ha) (TNAU).

Coconut

A field demonstration in 10 ha area undertaken at Alappuzha district, Kerala for management of *Oryctes rhinoceros* by integrating biocontrol agents, *viz*., *Oryctes rhinoceros* virus, *Metarhizium anisopliae* and pheromone trap revealed a reduction of 53.6 and 74% in leaf and fresh spindle damage, respectively over the pre treatment period (CPCRI).

Field collection of red palm weevil life stages did not reveal any natural infection by pathogens. Among the entomopathogenic nematodes tested, the local isolate of *Heterorhabditis indicus* was found to be more virulent inducing 92.5% mortality of red palm weevil grubs in filter paper bioassay @ 1500 IJ/grub while *H. bacteriophora* caused only 65% mortality. At the same concentration *Steinernema carpocapsae* and *S. abbasi* caused mortality only to the tune of 20% and 15%, respectively. Talc-based EPN formulation of *H. indicus* elicited higher mortality (70%) than water suspension-based formulation (<10%) on coconut petiole based bioassay (CPCRI).

An outbreak of *Opisina arenosella* noticed in Vechoor (Kottayam district, Kerala) with leaf damage to the tune of 61.4% and larval population of 304/ 100 leaflets was brought under control by releases of parasitoids (*Goniozus nephantidis* and *Bracon brevicornis* @10 parasitoids/ palm) at monthly intervals with active participation of farmers and officials of Dept. of Agriculture, Kerala. Population of the pest showed a sharp decline (91 % reduction) after release of parasitoids over a period of 8 months. The pest incidence also showed reduction of leaf damage from 61.4% to 39.4% during this period (CPCRI).

Tropical fruits

The mango leaf hoppers could be effectively managed by spraying *M. anisopliae* @ $1x10^9$ spores/ ml with oil and sticker which caused a mean of 51 % mortality during flowering season. The mortality was enhanced to 64.61% by the addition of UV protectant. Both the treatments however were at par and significantly superior to control (IIHR).

The exotic pest, papaya mealybug (*Paracoccus marginatus*) is spreading to urban areas of Bangalore on backyard papaya (IIHR).

Three sprays of *M. anisopliae* @ $1x10^7$ conidia/ lit on tree trunk during off season and three sprays during flowering were found to be effective in the suppression of mango hoppers (MPKV).

Inoculative release of *Cryptolaemus montrouzieri* @ 2,500 beetles/ha in June, 2009 in farmer's field was found to be effective in suppressing mealy bug population to the extent of 78.6 % with 40.2% increase in yield of marketable custard apples (MPKV).

Temperate fruits

Beauveria brongniartii and *M. anisopliae* were ineffective against the apple stem borer *Dorysthenes hugelii* recording mortality of 36.6 to 63.3 per cent, respectively (YSPUHF).

Two sequential releases of *T. embryophagum,* significantly reduced the fruit damage by codling moth and per cent reduction in fruit damage over control ranged from 23.6-36.1 at Mangmore, Shanigund and Hardas (SKAUS&T).

Vegetable crops

In the case of brinjal, BIPM module -1 (*T. chilonis* + bt) recorded a fruit damage of 17.2 % and BIPM Module-2 (*T. chilonis* + bt+ Maize as border crop) 17.3 % as compared to chemical treatment, which recorded 21.0 % mean fruit damage (IIHR).

Six releases of *Trichogramma pretiosum* thelytokous strain @ 1 lakh/ha at weekly interval starting from 45 days after transplanting were found to be more effective in reducing the infestation of *H. armigera* and increasing the yield of marketable tomato fruits (MPKV and OUAT).

Inundative releases of *Copidosoma koehleri* @ 1,250 mummies/ha by placing 3-4 mummies in each perforated plastic vial four times, at weekly interval, starting from 45 days after planting were found to be significantly more effective than farmer's practice in suppressing PTM damage and increased the tuber yield of potato (MPKV).

Soil application of *M. anisopliae* enriched FYM (2 x 10^{10} conidia/kg) @ 20 kg/plot at the time of planting of tubers was found to be effective in reducing the white grub (*Holotrichia consanguinea*) population with higher mycosis and increasing the potato tuber yield (MPKV).

In Kharif 2009, field demonstrations were conducted in more than 20 farmers' fields on IPM package on different vegetables crops in district Chamoli of Uttarakhand. IPM packages resulted in 32.79% increase in tomato yield, 21.46% increase in chilli yield and 13.97% increase in capsicum yield. There was 4.7% increase in yield of cabbage due to IPM package (GBPUAT).

Mass multiplication of *Neoseiulus longispinosus* on bean was standardized and an optimum predator prey ratio of 1: 30 was worked out. Three sequential releases of *N. longispinosus* (20 mites/plant in 30% plants) at weekly interval were as effective as three sprays of profenophos (0.15%) for the management of two spotted spider mite (YSPUHF).

Biological control of white grubs

Soil application of *B. bassiana, M. anisopliae, H. indica* and *Steinernema carpocapsae* resulted in low potato tuber damage by the white grubs (28.4-37.4%) as compared to control (55.7%) (YSPUHF).

Polyhouse crop pests

Five releases of *Blaptostethus pallescens* @ 10 and 20 predators significantly reduced the population of spider mites to 25.22/ 5 top leaves of rose plants as compared to 56.58 in untreated check (SKAUS&T).

Soil application of *P. lilacinus* @ 20 kg talc formulation /ha was found to be more effective against root-knot nematode, with 41.1% decline in population and 2.16 RKI in carnation (MPKV).

Four releases of the anthocorid predator *B. pallescens* @ 20 nymphs per plant at weekly interval was found to be effective in reducing the two spotted mite population on rose (MPKV).

Three sprays of *Hirsutella thompsonii* @ 10^8 CFU/ml, followed by *Verticillium lecanii* @ 10^8 CFU/ml were effective in suppressing the population of *Tetranychus urticae* on carnation in polyhouse (MPKV).

Weed control

Cecidochares connexa was released in areas near Vellanikkara for the control of *Chromolaena odorata*. Post release observations showed the presence of galls indicating that the gallfly was establishing and spreading in Kerala (KAU).

Storage pests

Inoculative releases of *Xylocoris flavipes* @ 30 nymphs/ 10 kg in stored rice was more effective in reducing the emergence of *C. cephalonica* than *B. pallescens* (MPKV).

Human resource development

- **Dr. J. Poorani** attended a one-day National Consultation workshop on "Advancing the Science of Taxonomy in India for Biodiversity Conservation" in Bangalore on February 23, 2010".
- **Dr. C. R. Ballal** attended The IOBC meeting on protected cultivation at the Mediterranean Agronomic Institute at Chania, Isle of Crete, Greece and presented a research paper; 6th to 11th September, 2009
- **Dr. C. R. Ballal** attended the Xth Annual Discussion Meeting on Molecular strategies in Insect Plant Interactions: Role of Chemical

Ecology in Host Specialisation at University of Madras, Chennai on 22nd Nov, 2009 and The National Conference on Plant Protection in Agriculture through Eco-friendly techniques and traditional farming practices at SKRAU, Durgapura.

- **Dr. Veenakumari** attended a training for 8 days on the identification of different genera of Scelionidae under Dr. K. Rajmohana, Zoological Survey of India for Western Ghats, Calicut and Wildlife Conservation: Issues and Challenges' sponsored by Department of Science and technology in the Wildlife Institute of India, Dehradun from 8-12 March, 2010.
- **Dr. G. Sivakumar** attended the International conference on Plant Pathology held at IARI, New Delhi from 10-13, November, 2009.
- **Dr. R. Rangeshwaran** attended the symposium on, 'Bio-safety and Environmental Impact of Genetically Modified Organisms and Conventional Technologies for Pest Management' at ICRISAT – Patancheru, (AP) from 19-11-09 to 22-11-09.
- **Dr. B.S.Bhumannavar** attended the vigilance officer training programme from 5.05.2009 to 27.05.2009 at NIANP, Bangalore.
- **Mr. B. Amarnath** attended training on handling of CAT cases & court cases from 26.08.2009 to 29.08.2009 at ISTM, New Delhi and Administrative Vigilance-I training from 05.10.2009 to 09.10.2009 and Administrative vigilance – II from 09.11.2009 to 20.11.2009 at ISTM, New Delhi.
- **Dr. M. Nagesh** and **R. Thippeswamy** attended training on recent advance in EST analysis & their annotation from 20.10.2009 to 23.10.2009 at IISR, Calicut.
- **G. Sivakumar** attended a short course on cropping system models from 12.12.2009 to 16.12.2009 at ICRISAT, Hyderabad.
- **Dr. T. Venkatesan** and **Dr. M. Nagesh** attended the training on DNA bar coding of fish and marine life from 3.12.2009 to 12.12.2009 at NBFGR, Lucknow.
- **Dr. S.K.Jalali**, **Dr. B. Ramanujam, Dr. Sreerama Kumar** and **Dr. R. Rangeswaran** attended the training on bioinformatics applications in crop science from 21.12.2009 to 23.12.2009 at IARI, Pusa, New Delhi.
- **Dr. Y. Lalitha** attended the training on technical and administrative support for consortia-based research in agriculture from 22.02.2010 to 27.02.2010 at NAARM, Hyderabad.
- **Mr. P.K.Sonkusare** attended a training on networking and web hosting from 02.02.2010 to 03.02.2010 at NAARM, Hyderabad.
- **Dr. S. K. Jalali** attended the national workshop for the sensitization of the ARIS Incharge about the uniformity guidelines for websites on 19.03.2010 at NBPGR, New Delhi.
- **Mr. Satendra Kumar** attended the second national residential functional workshop on official languages from 02.02.2010 to 03.02.2010 at Hotel Sandesh The Prince, Mysore

Revenue generation

A revenue of Rs.10.93 lakh was generated during the year 2009-10 by the NBAII, which included sale of natural enemies, sale of technical bulletins, training fee, consultancy charges, quality testing fee and project work for PG students.

Publications

Seventy four research papers were published in scientific journals, forty eight papers were presented in symposia/ workshop, seminars. Three book chapters and 14 popular articles were published.

4. INTRODUCTION

Brief History

The All India Co-ordinated Research Project on Biological Control of Crop Pests and Weeds was initiated in the year 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 period with the up-gradation of the centre to Project Directorate of Biological Control (PDBC) with headquarters at Bangalore with effect from 19th October 1993. In the XI plan, the PDBC has been reoriented into **National Bureau of Agriculturally Important Insects (NBAII)** on the 25th June, 2009. The AICRP has 16 centres along with 4 voluntary centres, all functioning under the Bureau.

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 defoliating parthenium growth during rainy season.
- The stem gallfly, *Cecidochares connexa*, introduced from Indonesia in 2002 has successfully established on *Chromolaena odorata* in Karnataka, Assam, Tamil Nadu and Kerala and is suppressing the growth of *C. odorataa*.
- 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 - Web photo album on Picasaweb (the largest of its kind with 1160 digital photographs of aphids of Karnataka was hosted). 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.*
- 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.
- 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 *Helicoverpa 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. The technology was 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.
- Kairomones from scale extracts of *H. armigera* and *C. cephalonica* increased the predatory potential of chrysopids.
- Acid hydrolyzed L-tryptophan increased the oviposition by *Chrysoperla zastrovi arabica* on cotton.
- Two fungal (*Trichoderma harzianum*-PDBC-TH 10 and *T. viride*-PDBC-TH 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*. *Bacillus 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 (BIPM) modules consisting of use of moderately resistant variety, *Trichoderma 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 yield 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. zastrovi arabica* 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, *Pulvinaria psidii, Ferrisia virgata* on guava, *Maconellicoccus hirsutus* on grapes and *Rastrococcus iceryoides* on mango.
- Efficacy of *Trichogramma, Cryptolaemus, C. zastrovi arabica, 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 the potato tuber moth in country stores.

Mandate

National Bureau of Agriculturally Important Insects

To act as a nodal agency for collection, characterization, documentation, conservation, exchange and utilization of agriculturally important insect resources (including mites and spiders) for sustainable agriculture.

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

Financial statement (2009-10) (Rs.in lakhs)

National Bureau of Agriculturally Important Insects, Bangalore

Head	Plan	Non-plan	Total
Pay & allowances	00.00	441.69	441.69
TA	06.00	03.58	09.58
Other charges including equipment-Lib.	198.78	38.55	237.33
Information Technology	01.00	-	1.00
Vehicle	0.00	00.00	0.00
Works/petty works	33.22	6.93	40.15
HRD	02.00	-	02.00
OTA	-	0.00	0.00
Total	**241.00**	**490.75**	**731.75**

AICRP Centres (ICAR share only) expenditure (2009-10)

Name of the centre	Expenditure (Rs. in lakhs)
AAU, Anand	32.87
AAU, Jorhat	10.97
ANGRAU, Hyderabad	16.20
Dr.YSPUH&F, Nauni, Solan	10.05
GBPUA&T, Pantnagar	0.00
KAU, Thrissur	0.00
MPKV, Pune	0.00
PAU, Ludhiana	15.15
SKUAS&T, Srinagar	0.00
TNAU, Coimbatore	11.23
PC Cell, Bangalore	32.65
MPUAT, Udaipur	01.28
JNKVV, Jabalpur	01.28
OUAT, Bhubaneshwar	01.28
CAU, Manipur	11.28
Total	**144.24**

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 budget of the institutes.

Organisational set-up

With a view to fulfil the mandate effectively and efficiently, the NBAII is being reorganized into three divisions viz. Division of biosystematics, biodiversity and biosafety, Division of bio-resource conservation and utilization and Division of bioinformatics and genomics. Research on microbial biocontrol is being addressed under the coordinating cell of the AICRP on Biological Control (Fig. 1).

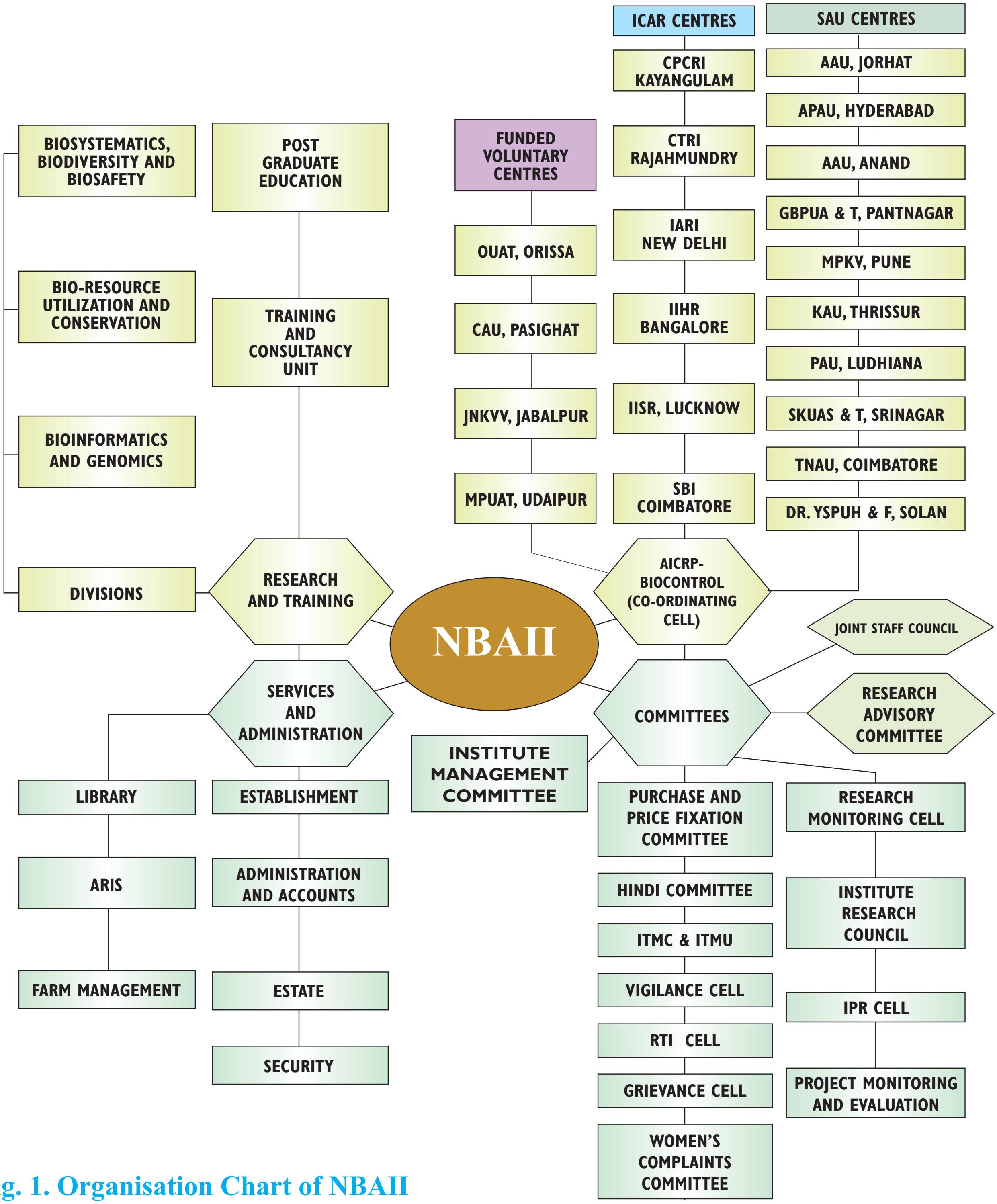


Fig. 1. Organisation Chart of NBAII

5. RESEARCH ACHIEVEMENTS

5.1. National Bureau of Agriculturally Important Insects

5.1.1. Division of biosystematics, biodiversity and biosafety

Identification services

Several species of coccinellids, parasitic Hymenoptera, and other insects numbering 68 were identified for 37 institutions including various AICRP centres, state agricultural universities, other universities, partners under the Network Project on Insect Biosystematics and students and institutions from overseas, including the Department of Agriculture, Sri Lanka, and Iran.

Cataloguing of insect fauna of India, with emphasis on minor orders

Checklists of minor orders of insects including Protura, Odonata, Ephemeroptera, Isoptera, Plecoptera, Psocoptera, Mantodea, Blattodea, Phasmatodea, Embioptera, Thysanopera, Orthoptera, Neuroptera, Mecoptera, Trichoptera, and Anoplura were prepared, with reference to the fauna of India and its neighbouring countries. For all these orders, the latest world / regional catalogues were taken as the starting point and subsequent additions were made on the basis of abstracts in Zoological Record. The checklists were loaded in the software Playtpus® (ABRS), used for biodiversity documentation. The lists will be shortly hosted in the website of NBAII.

Biosystematic studies on *Trichogramma*

A new species of *Trichogramma, viz., T. danaidiphaga* has been described. It was collected from the eggs of *Danaus chrysippus* on *Calotropis gigantea*. *Trichogramma embryophagum* was collected on trap/sentinel cards from a tea plantation in Assam. *Trichogramma pretiosum*, an exotic species imported and released in India in the late 1960s and early 1970s was for the first time recovered on trap cards from Anakapalli in Andhra Pradesh. The newly described *Trichogramma rabindrai* was collected from a new sphingid host *Cephanodes* sp. on *Mitragyna parviflora* along the Dharwar - Sirsi highway.

Thus far *Trichogramma* have been collected only on lepidopteran hosts from India. For the first time they were collected from the eggs of Neuroptera from Chickaballapur, Karnataka. *Trichogramma chilonis* were found parasitizing these eggs. In addition, a species closely resembling *T. manii* has also been collected and is being studied. *Eurema blanda* was found to be an additional host of *Trichogramma acheae.* It was collected from Bharatpur in Rajasthan.

In a study of 226 egg masses of *Scirpophaga incertulas* collected from various localities it was found that *Trichogramma* only parasitized 11 per cent of the egg masses in some localities while in others they were less than 2 per cent. Parasitisation by *Telenomus* was as high as 48 per cent while that by *Tetrastichus* was about 8 per cent. While egg masses were parasitized by a combination of *Trichogramma/ Telenomus* and *Telenomus /Tetrastichus,* none was found to be parasitized by both *Trichogramma* and *Tetrastichus.*

Introduction of exotic natural enemies of some crop pests and weeds

The chromolaena gall fly *Cecidochares connexa* had spread to a distance of 5 km from the initial release site at Tataguni village in a span of three years. Vertical spread was also increasing resulting in 15-18 galls per plant. The parasitisation by indigenous parasitoid ranged from 2 to 4% during March and 7-8% during November months.

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

Surveys for insect eggs were conducted in both agroecosystems and in non-crop ecosystems for insect eggs. Scelionid wasps were collected from insect eggs occurring on sugarcane, rice, wheat, maize, pulses vegetables, fruits in addition to forest and uncultivated fields in seven states viz. Assam, Andhra Pradesh, Karnataka, Kerala, Rajasthan, Tamil Nadu and Uttarakand.

Egg parasitoids were collected from 396 egg masses of different orders of insects such as Heteroptera (232), Lepidoptera (66), Homoptera (29), Neuroptera (Chrysopidae and Ascalaphidae) (15) Dictyoptea (13), Diptera (4) Coleoptera (2) and Class Arachnida (33).

Fourteen genera of Scelionidae belonging to three subfamilies- Scelioninae, Telenominae and Teleasinae were recorded. The fourteen genera are *Anteromorpha, Baryconus* (fig. 2)*, Baeus, Ceratobaeus, Doddiella, Fusicornia, Opisthocantha* (fig. 3)*, Scelio* (fig.4)*, Odontacholus, Sceliocerdo, Gryon, Trimorus, Eumicrosoma* and *Telenomus. Baryconus*, *Baeus*, *Ceratobaeus, Fuscicornia* and *Opisthocantha* are reported for the first time from Karnataka. *Eumicrosoma* (reported from Delhi and Haryana) and *Doddiella* (reported from Uttarkhand) are reported from South India for the first time. *Odontocholus* is reported for the first time from India.

Egg masses of yellow stem borer of rice were parasitized by *Trichogramma* sp. (Trichogrammatidae), *Telenomus* sp. (Scelionidae) and *Tetrastichus* sp. (Eulophidae) were found parasitizing these eggs. Egg parasitization by *Telenomus* sp. varied from 25.5 to 86.23 per cent while, the egg parasitisation by *Tetrastichus* sp. was upto 22.3 per cent. The per cent parasitization of *Trichogramma* was upto 44.0 per cent.

Egg masses of *Pyrilla perpusilla* (Hemiptera: Fulgoridae) collected on sugarcane were parasitized by Eulophid parasitoid (?*Parachrysocharis javensis*). The average number of parasitoids per egg mass was 19 and the per cent parasitisation was 73.26 per cent.

Eggs of a noctuid moth *Diacrisia* sp. collected on ornamental palm trees in Calicut were parasitized by *Telenomus* sp. This species of *Telenomus* readily parasitized the eggs of *Spodoptera* in the laboratory. They successfully completed 12 generations in the laboratory and the 13th generation is going on in the laboratory. The mean total life cycle ranged from 9.2 to 15.4 days while the adult longevity ranged from 2-28 days.

Eggs of insect pests and their natural enemies collected from various ecosystems were found to be parasitized by species belonging to different families such as Scelionidae, Euplemidae, Encyrtidae and Eulophidae. A total of 3368 parasitoids were collected during the course of study.

Variations in insecticide susceptibility in *Cotesia flavipes*

Different populations of *C.flavipes* showed variability in response to fenvalerate and endosulfan. The population collected from Shimla had the highest LC_{50} (2.77 ppm) followed by that from

Fig. 2. *Baryconus* sp.

Fig. 3. *Odontacholus* sp.

Fig. 4. *Scelio* sp.

Coimbatore (LC_{50} = 2.24 ppm) and Chindwara (LC_{50} = 1.98 ppm). For endosulfan, maximum LC_{50} was recorded in population from Bangalore (56.24 ppm) (Fig. 5). However, the populations from Bangalore, Devaganahalli and Malur did not differ in their level of tolerance to both the insecticides.

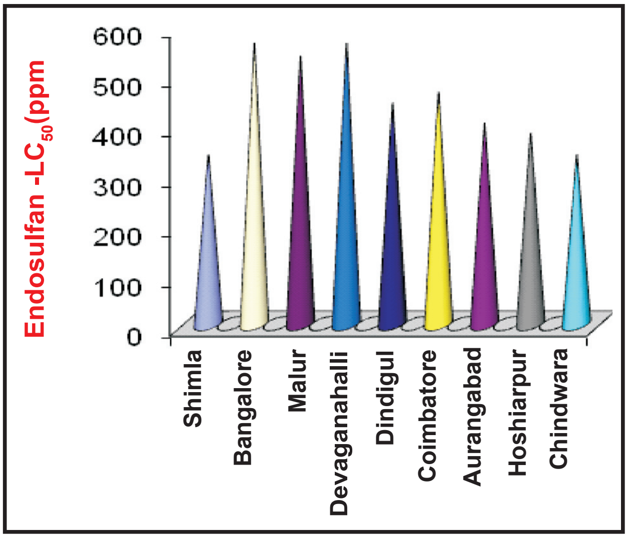


Fig 5. Variability in response to endosulfan in *C. flavipes* populations from different locations

Field evaluation of pesticide-tolerant strain of *C. flavipes*

Four releases of *C. flavipes* @ 2000 cocoons/ ha (@500 at weekly intervals) resulted in the highest parasitism (52.6 cocoons /larvae) and better yield (4019 kg/ha) of maize (Table 1). Releases of parasitoid followed by spray application was better than releases made after insecticidal spray.

Selection of superior strains of *Goniozus nephantidis*

Among the different populations of *G. nephantidis* the Tamilnadu population was superior in terms of per cent pupation (62.6 - 80.5), parasitizing efficiency (6.2- 8.5 larvae/female), and adult longevity (41.3- 56.6 days) at higher temperatures of 36 and variable temperatures of 36-40°C. The population from Kerala ranked second in terms of the above parameters, while the population from Gujarat recorded the minimum among all. The study revealed that in all the populations the response at 32°C was optimum and recorded comparatively higher attributes than other temperature regimes.

Selection of superior strains of *C. montrouzieri* from different agro-ecosystems

Cryptolaemous montrouzieri populations from Coimbatore and Shimoga were more tolerant to the variable higher temperature of 32-40ºC than those from Bangalore and Pune (Fig. 6).

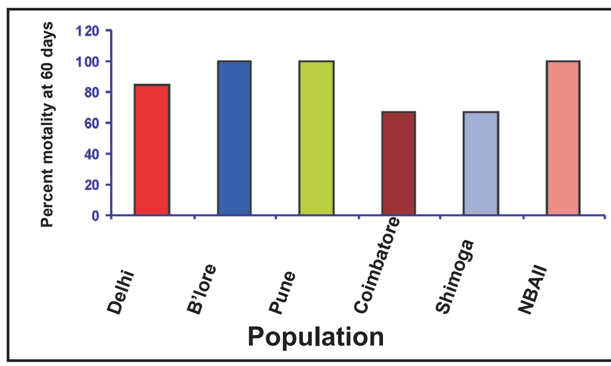


Fig. 6. Survival of different populations of *C. montrouzieri* adults at variable temperature (32-40ºC)

When 10 days old larvae of *C. montrouzieri* were topically sprayed with acephate (0.67g/l), higher survival of Bangalore (24%) and Pune (17%) populations was recorded. Similar observations were recorded when 20 days old larvae were exposed recording 37% and 26% survival for Bangalore and Pune populations.

Table 1. Field evaluation of tolerant strain of *C. flavipes*

Treatment	Per cent dead hearts	Leaf damage Rating *	Parasitism (No. cocoons/ larvae)	Yield (kg/ha)
Four sprays of Fenvalerate	5.7	1.5	---	4,280
Four releases of *C. flavipes* (@ 2000 cocoons/ha., @ 500 at weekly intervals)	27.5	4.8	52.6	4,019
Two sprays of Fenvalerate + two releases of *C. flavipes*	18.6	3.4	28.3	3,768
Two releases of *C. flavipes* + two sprays of Fenvalerate	32.6	5.6	40.8	3,809
Untreated check (Control)	80.0	7.8	10.6	2,448

* Damage rating scale: 1= <10%, 2 =11-20%, 3 =21-30%, 4 =31-40%, 5 =41=50%, 6 = 51-60, 7 = 61-70%, 8 = 71-80%, 9 = >90%.

Field evaluation of pesticide tolerant *Chrysoperla zastrowi arabica* from different agro-ecosystems

Field evaluation of pesticide tolerant strain against sucking pests of cotton revealed that two releases of Pesticide Tolerant Strain of *Chrysoperla zastrowi arabica* (Cza-8) at 15 days interval in combination with two sprays of acephate (0.67g/l) recorded lowest population of aphids (13.4), thrips (1.87), white flies (1.02) and leaf hoppers (3.13) per plant and realized highest cotton yield (1,533 kg/ha). This was significantly superior to releases of susceptible population of *C. z. arabica* and on par with four sprays of acephate (0.67g/l).

5.1.2. Division of bio-resource conservation and utilization

Biology of *Anthocoris* sp.

The new anthocorid predator *Anthocoris* sp. (fig. 7) collected from *Ferrisia virgata* colonies on *Bauhinia purpurea,* could be multiplied on both cotton mealybug *Phenacoccus solenopsis* and *Ferrisia virgata.* When fed on cotton mealybug, the incubation period was 4.7 days, nymphal period 16.3 days and total developmental period from egg to adult 21 days and the fecundity was 22.5 eggs. The morphometrics of the different stages were studied. Eggs are inserted into bean pods which were provided as oviposition substrates. The length, width and diameter of the operculum of the egg is 0.546, 0.255 and 0.13 mm, respectively; the length and width of the 7 day old nymph 0.87 and 0.44 mm, respectively; of adult male 0.72 and 0.15 mm, respectively and of adult female 2.34 and 0.75 mm, respectively.

Fig. 7. *Anthocoris* sp.feeding on cotton mealybug

Evaluation of *Blaptostethus pallescens* against red spider mites infesting carnation in polyhouse conditions

In a polyhouse experiment, *Blaptostethus pallescens* nymphs were released @ 5 to 10 per plant on carnation (variety Dona) and 22 releases were made. Significantly more number of flowers were harvested from the released plot compared to non-release plot. In all, 36% flowers from the treatment and 50% of the flowers from the control were mite infested.

Evaluation of *B. pallescens* against *Frankliniella schultzei* attacking chilli

Five releases of *B. pallescens* @ 20 per plant reduced the thrips damage on chilli significantly (Freshno chilli- var. Supreme) at a polyhouse belonging to Namdhari. The number of thrips (*Frankliniella schultzei*) per bud/flower in the biocontrol plot was 13, whereas in the chemical control (with eleven chemical applications) it was 28.15, indicating a significant reduction of thrips population in the bio-control plot. The yield and the quality of the produce from the biocontrol plot were as good as the chemical control plot.

Rearing of *Orius tantillus* on other hosts

Orius tantillus could be successfully reared on frozen *Helicoverpa armigera* eggs mixed with pollen. The fecundity of the adults fed on frozen *H. armigera* eggs was comparable with that recorded on *S. cerealella* eggs. When fed on frozen *H. armigera* eggs, the mean number of eggs recorded per day was 10.5, while when fed on *S. cerealella* it was 13.5. On frozen *H. armigera* eggs the fecundity per female was 64.25.

Evaluation of *B. pallescens* against spider mites on tomato plants

In a net house experiment, four releases of *B. pallescens* @ 50 per plant reduced the population of *Tetranychus urticae* and infestation of leaves significantly. After the release period, the number of mites per leaf was 270 in the control plants, while in the treatment it was 30.5. Though the population of red spider mites reduced significantly on the treated plants in comparison to control, the control was not adequate to reduce the damage caused by the mites. Very high mortality of *B. pallescens* was observed due to the trichomes on the tomato plants. This study indicated that though *B. pallescens* is a potential predator of *T. urticae,* the host plant characteristics can affect the performance of the predator.

Biological studies on *Pharoscymnus flexibilis* Mulsant on *Aonidiella* sp.

The incubation period of *Pharoscymnus flexibilis* (fig. 8) eggs varied from six to seven days. The larval period and pupal period were 15-17 and 4-5 days, respectively. Total egg to adult period was 25-29 days. The pre-copulation period, pre-oviposition period and adult longevity were 3-4, 6-8 and 45-69 days, respectively. The average fecundity was 58.85 eggs/female.

Fig. 8. *Pharoscymnus flexibilis*

First record of coccids from India

A species of *Conchaspis* Cockerell (Family Conchaspididae) and a species of *Carulaspis* MacGillivray (Family Diaspididae) was recorded for the first time from India.

Host searching ability of *C. flavipes*

The host searching efficiency of the population from Shimla was higher than that of Dindigal population.

Pollinators in different crop-ecosystems

Survey was undertaken in traditional pigeonpea belt of Karnataka (Gulbarga) and Maharastra (Parbhani) regions and nontraditional pigeonpea areas of Andhra Pradesh (Hyderabad) and Tamil Nadu (Pudukottai). In the traditional areas, honey bees (*Apis florea* and *A. dorsata*) were predominant visitors and collected both nectar and pollen grains. Stingless bee, *Trigona* sp. was also observed sparingly in the same regions. But, those were totally absent in nontraditional pigeonpea areas. Pollen grains were extracted by opening the keel petals exactly at the region of anthers. In both traditional and nontraditional areas, carpenter bees (*Xylocopa* spp.) and leaf cutter bees (*Megachile* spp.) and halictid bees were observed. Carpenter bees and leaf cutter bees alight on wing petals and set the ball and piston mechanism in operation to collect pollen grains, whereas halictid bees collect pollen grains just like honey bees. *Apis florea* spent more time on the pigeonpea flowers compared to other pollinators (Table 2.)

Table 2. Visitation of bees to pigeonpea flowers observed at Gulbarga

Name of bees	Visitation rate / flower(seconds)		No of bees / sq.m observed (range)
	Mean± S.E	Range	
Apis florea	15.8± 4.6	1-80	3-7
A.dorsata	8.4± 2.1	1-27	2-3
Xylocoids/ Megachiles	3.1± 1.0	1-16	0-2

Rungia parviflora (Acanthaceae) is a common species of weed which was found to support the population of pollinators in oilseed/pulse ecosystem.

Polymorphism in pheromone reception in *Helicoverpa armigera*

Morphological studies on the antennae of *H. armigera* revealed the presence of more number of *sensilla trichoidea* (fig. 9) in the case of males, while the females showed more of *sensila basiconica* (fig. 10). Electroantennogram studies were conducted on the males of different populations with the blends of Z-11 hexadecenal and Z 9 hexadecenal @ ratios of 85:15; 88:12; 91:9; 94:6 and 97:3. The males showed more response to Z-11-hexadecenal and least response to Z-9 hexadecenal. The blends 85:15 elicited higher response than Z-11 hexadecenal alone (fig. 11). Among the various populations studied, most of the populations showed significantly more response to the blend of 85:15 than 97:3. However, the Raichur population showed no statistical difference between the blends studied. Wind tunnel studies confirmed higher response of laboratory population of *H. armigera* males to 85:15 than 91:9 blend.

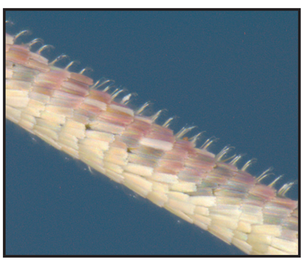


Fig. 9. *Sensilla trichoidea* of male *H. armigera*

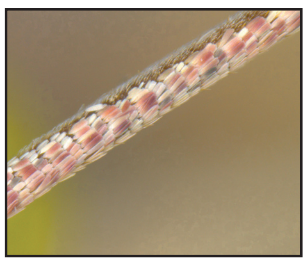


Fig.10. *Sensila basiconica* of female *H. armigera*

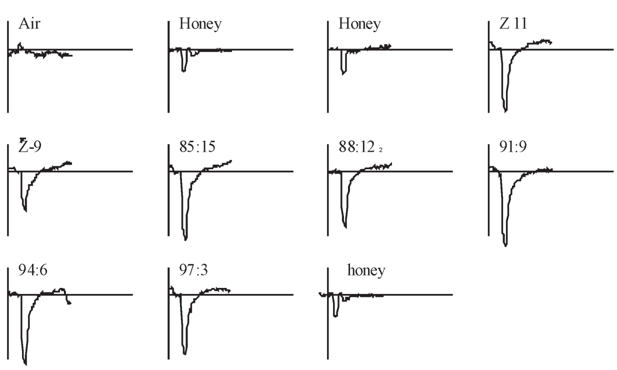


Fig.11. Electroantenogram response of male of *H. armigera* (GUNTUR population) to different blends of Z-11 & Z-9 hexadecenal

GCMS studies of pheromone gland extract of females of Guntur population showed a different proportion than 85:15 (Fig.12).

Enhancement of Shelf-life of Methyl Eugenol

The methyl eugenol pheromone immobilized by the interaction with a polymer giving rise to the formation of a composite by aromatic π-π

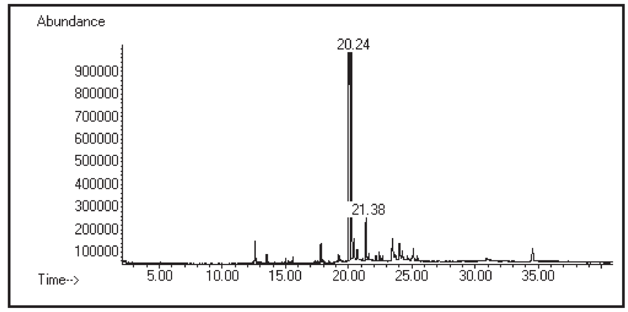


Fig. 12. Volatile profile of pheromone gland extract of Guntur population of *H. armigera*

stacking interaction. A convenient and solvent free method have been undertaken for the preparation of the composite of methyl eugenol (ME) and the hydrocarbon polymer without having the chemical cross linking between them. The composite showed the presence of nanofibers and found to be stable at room temperature which increased the shelf-life of the pheromone. The newly formed composite was found to be water insoluble and also the swelling and shrinking of the composite were not observed. The composite would be useful for trapping of *Bactrocera dorsalis* during rainy season.

Synthesis of *Helicoverpa armigera* pheromone

Nanofibre of *Helicoverpa armigera* pheromone blends was synthesized. Electrophysiological response of *H. armigera* revealed that the nanofibre pheromone blends are at par with unformulated pheromone blends and was active for185 days.

5.1.3. Division of Bioinformatics and Genomics

ITS-2 PCR and sequencing of *Trichogramma* spp.

Studies were made by extracting DNA using chelex (5%) from six isofemale lines of *Trichogrammatoidea armigera*, and *Tr. bactrae*, *Tr.* nr *armigera, Tr. fulva*, *Tr.* nr. *fulva* and *Tr. robusta.* Based on the size of the ITS-2 rDNA PCR products, it was found that the base pairs varied from 800-900bp in various species. Phylogenetic tree based on N-J method showed five plates with species and corresponding species near to particular species aligning with their counterparts. Intra-specific variation in the field-collected populations of *T. chilonis* was studied by using RAPD primers. The sequences were analysed using Bioedit software and sequence identity matrix was generated. Most of the populations matched to the tune of 98.1 to 100.0% amongst themselves.

Study with wolbachia symbiont

The horizontal transmission results indicated that %females in parent were 45.0 to 56.0% in four species tested. After transmission of wolbachia for 20 generations, %females obtained increased from 60.0 to 79.0%. The mean %females from parent population increased drastically in *T. achaeae* (from 45.0 to 79.0 in 20th generation) and *T. japonicum* (from 50.0 to 72.0 in 20th generation) indicating possibility of wolbachia getting transmitted in these two species. Curing of wolbachia infected species with rifampisin revealed that % females remained 100.0% in *T. cacoeciae* and this may be of different group as curing did not give any males. In other species, percentage females ranged from 23.3-100.0%. Mean fecundity decreased in *T. cacoeciae*, *T. corbudensis*, *T. embryophagum*, *T. evanescens* and *T. pretiosum* (France) but fecundity increased in *T. semblidis* and *T. pretiosum* (USA) after 20 generations of curing. In the experiment to detect *Wolbachia* via PCR amplification, a very faint band was observed after curing indicating lower microorganism titer, but once the treatment was withdrawn, the microorganism titer increased again resulting in a prominent band again at 10th generation after withdrawal.

Association of other micro-organisms with field-collected Trichogrammatids

Trichogrammatids collected from tomato ecosystem showed the presence of yeast, which was used as feed for laboratory reared adults to know its effect on fitness of the population. The per cent females in *T. chilonis*, *T. japonicum*, *T. achaeae* and *Tr. bactrae* was enhanced to 45.0 to 80.0, 50.0 to 79.4, 45.0 to 64.5 and 56.0 to 79.0%, respectively . The fecundity of various species increased though marginally in *T. chilonis* (35.0 to 54.0), *T. japonicum* (40.0 to 62.0), *T. achaeae* (35.0 to 56.0) and in *Tr. bactrae* (25.0 to 38.0).

ITS sequence and RAPD of *Cotesia flavipes*

PCR of ITS-2 region for the Bagalkot, Bangalore, Devaganahalli, Gowribidanur, Hoskote and Mulbagal (Karnataka) Aurangabad, Chindwara, Delhi, Hoshiarpur, Hyderabad, and Shimla populations of *C. flavipes* showed polymorphism in the region of the genome. DNA sequence analysis of the ITS-2 showed intra-species divergence. The RAPD analysis indicated variation among the populations. Primers OPK6 (350bp) and OPAA17 (450 bp) yielded intense and unambiguous bands and were promising in distinguishing the variants (Fig. 13).

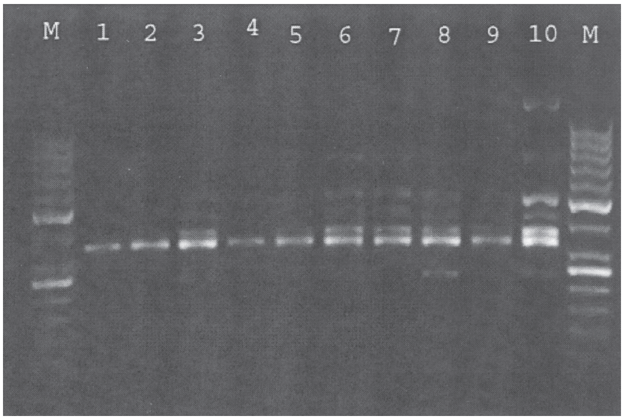
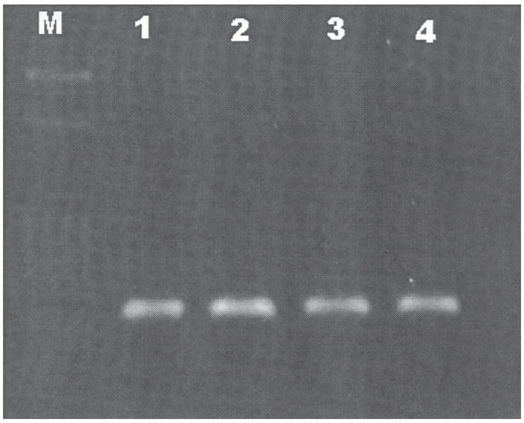


Fig.13. Gel electrophoresis of RAPD of *C. flavipes* (Lane M, 50 kb DNA ladder; lane 1, Aurangabad; lane 2, Bagalkot; lane 3,Chindwara; lane 4, Dindigul; lane 5, Devaganahalli; lane 6, Gowribidanur; lane 7, Hoskote; lane 8,Harohalli; lane 9, Hoshiarpur; lane 10, Mulbagal, generated by PCR amplification using the primer OPK6)

Molecular characterization of symbionts associated with *C. flavipes*

A 1.5kb product of 16s rDNA gene was amplified from bacteria isolated from field- collected population of *C. flavipes*. The amplification products were purified with the QIAquick PCR purification kit (Qiagen, Hilden, Germany). DNA fragments were extracted from the gel using the Qia Quick Gel extraction kit (Qiagen, Hilden, Germany). The DNA fragments were sequenced using an ABI prism 310 DNA sequencer using Big Dye Terminator reaction. A 550bp sequence length was obtained after the sequencing. Bacterial species was identified by searching databases using the BLAST sequence analysis tool. The 16sRDNA region sequence was compared with sequences acquired from GenBank using nucleotide–nucleotide BLAST (blastn). Species identification was determined from the lowest expect value of the BLAST output (fig. 14).



1500 bp

Fig. 14. Bacterial DNA amplified PCR product of 16s gene. Lane M, 50 kb DNA ladder, *C. plutellae* (lane 1), *C. flavipes* from (lane 2, Gowribidanur; lane 3, Hoskote; lane 4 Mulbagal).

Molecular characterization of *Chrysoperla zastrowi arabica* (ITS & COI region)

PCR amplification of cytochrome-c-oxidase (COI) gene of *C. zastrowi arabica viz.*, Cza-8 and Cza-6 was done and sequenced (524 bp) which will be useful for the development of DNA barcode of chrysopid predators. Sequence of COI gene of Cza-8 (524 bp) was submitted to GenBank (Acc. No. GU817334). ITS-2 regions of different populations of *C. z. arabica* were amplified and given for sequencing.

Molecular characterization of Indian coccinellids

Standardized the protocol for DNA extraction from coccinellid adults belonging to fourteen species of coccinellids from Bangalore region. DNA was extracted from old and freshly collected beetles. It was observed that the quantity and quality of the DNA from the fresh sample was better than that of the DNA extracted from the preserved coccinellids.

Cytochrome oxidase-I gene (COI) amplification

The following primer pair was used to standardize the PCR protocol for COI gene amplification, forward primer: 5`-GGTCAACAAATCATAAAGA-TATTGG-3` and reverse primer: 5`-TAAACTTCAG-GGTGACCAAAAAATCA -3`. The thermal cycling condition for PCR consisted of 30 cycles (Den: 94°C for 1 min, Ann: 48.7°C for 1 min, Ext: 72°C for 2 min, with an initial denaturation 95°C for 5 min and final extension at 72°C for 10 minutes). PCR products were electrophoresed on 1.5% agarose gel (ACROS) and visualized by ethidium bromide staining.

Among the species of coccinellids tested, the primer pair forward primer: 5`-AGGAGCTGGAA-CAGGTTGAA-3`, and reverse primer: 5`-TAAAAT-TGGATCACCCCCTC-3` amplified the COI gene around 550bp for five coccinellid species *viz*., *Coccinella septempunctata*, *C. transversalis*, *Cheilomenes sexmaculata* , *Chilocorus nigrita* and *Cryptolaemus montrouzieri* (Fig.15).

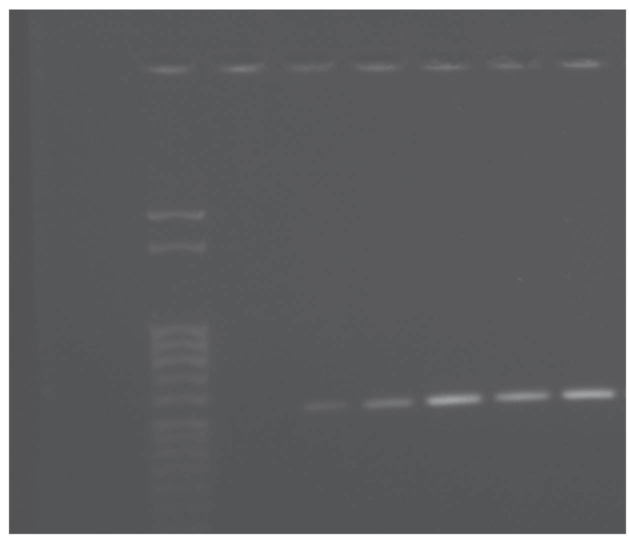


Fig.15. PCR product of COI gene (550bp) for five species of coccinellids, *Coccinella septempunctata*, *C. transversalis*, *Cheilomenes sexmaculata* , *Chilocorus nigrita* and *Cryptolaemus montrouzieri*

Another primer pair, forward primer: 5`-GGT-CAACAAATCATAAAGATATTGG-3` and reverse primer: 5`-TAAACTTCAGGGTGACCAAAAAAT-CA -3` amplified the COI gene around 556 bp for four coccinellids *Curinus coeruleus*, *Illeis cincta* (Fab), *Hyperaspis maindroni* and *Scymnus coccivora*.

Gene sequencing in coccinellids

The PCR products of the coccinellids were purified using Quigen Gel Elution Kit. The purified

DNA fragments were subjected for gene sequencing and the following are the partial sequence of COI gene.

1. *Coccinella septumpunctata*

TAAATAATATAAGCACCTTTGAGGACCA-CCAGCGTTTGACATTATTGATCTCTAGAAG-ATTAGTTGAAATAGGAGCAGGGACTGGAT-GAACAGTATACCCCCCTCTCTCTTCAAATT-TAGCTCATAATGGACCTTCGGTTGAC-CTAGTAATTTTTAGATTACATTTAGCAGGT-ATTTCCTCAATTTTAGGCGCAATTAATTTT-ATTTCAACTATTATAAATATACGACCTATAG-GAATGTCTATAGAAAAAACCCCTTTAT-TCGTTTGATCTGTACTAATTACAGCAATTCT-TCTCTTATTATCTCTACCCGTATTAGCAGGAG-CAATTACTATATTATTAACTGATCGAAACT-TAAATACATCCTTTTTTGTCCTATAGGAG-GAGGAGATCCAATTCTATACCAACACTT-ATTTTGATTTTTTGGACACCCAGAAGTTTAT-ATTTTAAT

2 *Cheilomenes sexmaculatus*

GGGCATCTCCCCCTCCTCAGTG-TAAAAAAAGAAGTGATAAACTATTAC-GATCTGTTAATAATATAGTACATTGCCCCG-GCTAATACAGGTAATGATAATAAAAG-TAAAATAGCAGTAATTAGTACTGATCAAA-CAAAAAGAGGTGTACTTGATACAAGGTT-TATGCCAAATGGTCGTATATTTATAATAGTT-GAAATAAAATTTACGGCTCCTAAAATAGAT-GAGATACCTGCTAAGTGTAAACTAAAAAT-TACTAAATCTACTGAAGGCCCATTAT-GAGCTAAGTTAGAGGATAAAGGAGGGTA-GACAGTTCATCCAGTTCCTGCACCTATTTC-TACTAATCTTCTAATAATAAGTAAGGT-TAAGGCAGGTGGGAGTAGTCAAAATCTTAT-ATTATTTAATCGAGGGAAAGCTATGCAGGT-GCTCCAATTATTAAG

3. *Cryptolaemus montrouzieri*

ATCCCAGAGGAGGCGGCGC-CCCGTTTTTCTCTCATAACTATAAAGCTAGT-CAATTTTCATAACATTATCGAGGTCGATTTT-GTCCATTCCTTTCTTCTTCTTCTTGTCGA-CATTAATTTGTGTCTGAGTATGTTTATTAC-CATAAAAAAGTTCACAATAATTTATAC-CTGCATATAAATTTTAACATCATTATTT-TAATTAACGAGGATTTTATCTACTTTATG-GACGATTTACTTCAGATTTTTATCGATT-TAGATGTCTTCCGGGAGATACTCGATT-TAATCTTCTATTTCCACCTATCTGACAAGT-TGGTCAAGGACGAGGAGAAAGATGT-TAACTTGAATATTAATTATTTCAATTCCGTC-CTCCTTCTTCAGTTTTAGAATATAATAAT-TCAGCTCCCTTCCGATATAGTCCCCGAGGT-TAATAATTTCCTTG

4. *Illeis cincta*

CTAATACTAGGGGCTCCGGATTTG-GCTTTCCCACGATTGAATAATATAAGATCT-TGACTTCTTCCCCCACCTTTAACATTAT-TAATTTTTAGAAGAATAGTAGAAATAG-GGGCAGGGACAGGATGAACTGTATAC-CCCCCTTTATCTTCAGATGTTGCACACA-GAGGAGCTTCTGTAGATTTAGTAATTTT-TAGTCTCGATTTAGCTGGAAATTCTTCT-ATTTTAGGTGCAGTAAATTTTATTTCTACT-ATTATAAATATACGCCCCTTTGGGATAAACT-TAGATAAAACTCCATTATATGTTTGATCAGT-ATTAATTACTGCAATTTTATTATTACTTTCAT-TACCAGTTTTAGCAGGAGCTATTACAAT-ATTATTGACTGACCGTAATATCAATAC-CTCTTTTTTTGACGCTATAGGAGGAGGA-GACCCCATTTTATATCAACATCTTTTTT-GATTTTTTGGACATCCA

5. *Hyperaspis maindroni*

GTAATTATTGGAGCACCTGACATAG-CATTACCTCGACTTAATAATATAAGATAAT-GATTACTACCTCCTTCTTATACTATAT-TAATTTTCAGAACTTTAGTAGAAATAGGT-GCTGGAACAGGCTGAACAGTTTATCCTC-CTTTATCGTCATATTTAGCTCATAATGCTC-CATCAGTAGATTTAGTAATTTTTAGAC-TACATCTAGCAGGAATTTCATGAAATT-TAGGAGCTGTAAATTTTATCTCAACTAT-TATAAATATACGTCCTTTGGAATAAAC-CTTGATAAAACCCCTCTATTTGTTTCAT-CAGTTCTAATTACAGCAATTTTATTACTTC-TATCTTTACCTGTATTAGCAGGGGCAAT-TACTATACTATTAACTGACCGAAATATT-TATACTTCTAATTTTGACCCAATAGGAGGT-GGAGATCCTATTCTTTACCAACATTTATTTT-GAAAATTTGGTCATCCA

6. *Chilocorus nigrita*

TTAATTTAAGCAGCGCCAGATATAG-CATTTCCTCGTTTAAATAAAATAAGATTTT-GACTTTTACTTCCTCCTTTAACTCTC-

CTAATTTTAAGAAGTTTAGTTGAAAGAGC-CCCAGGAACAGGATGAACAGTTAATCCA-CCTTTATCTTCAAATTTAGCTCATGTGG-GATCTTCAGTTGATTTAGCTATTTTCAGTCTT-TATATAGCTGGAATTTCTTCAATTTAAA-GAGCTGTATATTTTATTACAACAAATAT-TAATATACGACCAAAAGGAATAACTTTAGA-GAAAACTCGTACATTTGTATGATCAATAT-TAATTACTGCAATTTTATTACTCCTTTCTT-TACCTGTTAAAGCACCAGCAATTACTATATT-ATTAACTGACCGAAATATCAATACTTCATTT-TAACATCCTTCAGCTGGAGGAGATCCTAT-TCTATACCAACATTTATTTTGATTCTTCG-CATATCCA

7. *Coccinella transversalis*

CCGTCTCTTTCTCTCTNNTCTTTTTCTCAT-GCACAGCATTCGCTTGCCGCCTCGGGGTT-GGCATACCAGGATGAAGCTAGTTTCNC-CCACTCTTTCCTCTTACACAATATCAGT-CATCATAATGGATCTCTTCTCGTGAGAAA-CAATAGTAAATATCAAGAATATACATTAA-CAGCAAGAGCAATTAACCATCATAATT-TAAAGAGAAGCAGATAAAACAATAAATAGT-CAAAAAACAAATACAAAATAAAAACGA-GACCAAAAAGGGGAGAAAACAAATAAAA-GAAATAAAAACCCAAAAAACGAAAAA-GAAAACAGAAAACAATCAAAAAAAT-CAAAAAAAAAAACAAA

8. *Scymnus coccivora*

TACAATAATTATTGCTGAACCTACTGG-GATTAAGAAATTTTCTTGATTACGAACTT-TACATCCAGTACAATTTAATTATAGTC-CTTCTCTTTTATGAACCCTAGGATTTTT-ATTTTTAAATACAATTGGGGGCCTTACAG-GAGTAATTTTAGCTAATTCTTCTATTGA-TAGGATTCTTCATGATACTTATTATGTAG-TAGCTCATTTTCACTATGTTTTATCAATAG-GAGCTGTCTTTGCAATTATAGCAGGAAT-TGTTCAATGATTCCCTTTATTTACAGGATT-TAATTTAAACAATAAATATCTTCAAATTGTAT-CAATTATAATATTTATTGGAGTAAATATAA-CATTTTTTCCTCAACATTTCTTAGACTTGC-CGGTATACCTCGGCGATACTCTGATTACCCA-GATGCTTATATATTATGAAATAAAATTTCCTC-TATTGGATCCTTTATTTCTACTTTAAGAATTT-TAATATTTATAATAATTTTATGAGAAAGATTT-TATTCAATACGTCTTTCTAATCAAACAC-TAAGTAT

5.1.4. Basic work on Pathology at NBAII (Under the Project Co-ordination cell of AICRP on Biological Control of Crop Pests & Weeds)

Standardization of Solid State Fermentation (SSF) conditions for the mass production of *Trichoderma* spp., *Metarhizium anisopliae* and *Beauveria bassiana*

Trichoderma

Identification of suitable substrate as support as well as nutrition base

Among the six substrates tested, sorghum and ragi grains were found to support good growth of *T. harzianum* during SSF and the log of CFUs was 8.5 to 9.0 per gram of substrate (Fig. 16). While in other substrates like rice grain, saw dust and brans from wheat or rice, the viability ranged between 7.5 to 8.5 Log CFUs g^{-1}. Sorghum grains recorded lower moisture content (23%) while saw dust, wheat bran and rice bran recorded high moisture content (54-66%) without the addition of crude sugar solution and 51-74% with the addition of jaggery solution (Fig.16.). Addition of crude sugar solution to facilitate the quick growth of the antagonist organism did not make any significant changes in the growth of *T. hariznaum* on all the substrates. With or without the addition of crude sugar solution, sorghum and ragi grains were found to be better substrates as compared to other substrates.

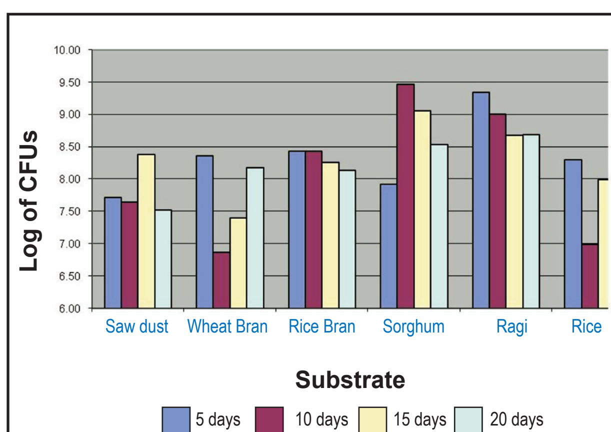


Fig.16. Viable propagules of *Trichoderma harzianum* on different substrate along with crude sugar

Optimum soaking time of the grains

Overnight soaking of the grains is generally followed for the mass production of *T. harzianum*. However, when finger millet and sorghum were soaked for different periods, the saturation was obtained within four hours of soaking indicating that there is no need for overnight soaking. Soaking for short periods also provided the opportunity to get the lower moisture content in the substrates. The viability in terms of Log CFUs g-^{1} at 5 days interval was recorded for all the six treatments. There was no significant differences among the treatment till the second observation while on the 15th and 20th days of solid state fermentation (SSF), the viability in treatments with grains soaked for shorter period (1 or 2h), was lower (10^{8} CFUs g^{-1}). The optimum time for incubation was 15 days, since after 15 days the viable population started coming down in all the treatments.

Inert Support Culture

Suitability of sponges as inert-support culture in solid state fermentation for the mass production of *T. hariznaum* was tested. Two methods of inoculations were tested. In the first method, 1 cm^{3} sponges were impregnated with molasses yeast extract medium and sterilized followed by inoculation with conidial suspension. In the second method, to the pre-sterilized sponge cubes, molasses yeast extract medium along with conidia suspended in it was added. In both methods good growth of the fungus could be observed (9.26 x 10^{8} and 6.1 x 10^{8} CFUs per sponge cube of 1 cm^{3} size) on 15th day of fermentation. Sugarcane baggase also was tested for its suitability as inert support for comparison. Compared to sponge, production of spores on baggase was less and by 20th day, viable propagule count came down to 10^{6} CFUs per sponge cube of 1 cm^{3} size (Fig. 17) The spore production was maximum on 10th day after which the spore viability started declining, indicating that spores are to be harvested by 10th day.

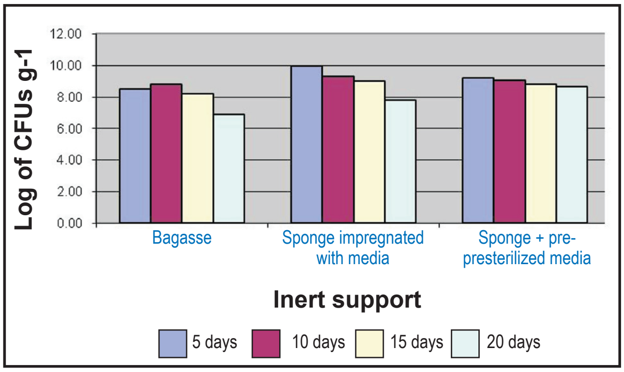


Fig. 17. Viable propagule of *T. harzianum* on inert supports during SSF

Entomofungal pathogens

Solid substrates for production of aerial conidia of *B. bassiana* and *M. anisopliae*

Seven solid substrates like, rice, sorghum, ragi, wheat bran, rice bran, saw dust and sugarcane bagasse were evaluated for production of aerial conidia of *B. bassiana* and *M. anisopliae*. The conidial production of *B. bassiana* (Bb-5a isolate) and *M. anisopliae* (Ma-4) was estimated after 5, 10 and 15 days of incubation at 25^{0}C and 70% RH. Conidial production was highest on 15th day in all seven substrates tested. Rice grains supported the highest sporulation of *B. bassiana* (31.3x10^{8} conidia/g) and *M. anisopliae* (28.3x10^{8} conidia/g).

Suitability of sponge as inert-support culture for production of aerial conidia of *B. bassiana* and *M. anisopliae*

Sponge cubes of 1cm^{3} were cut and impregnated with Sabouraud dextrose yeast broth (SDYB) by two methods. In the first method, sponge cubes were impregnated with SDYB followed by sterilization and inoculation with *B. bassiana* and *M. anisopliae*. In the second method, SDYB was added to the pre-sterilized sponge cubes followed by inoculation with *B. bassiana* and *M. anisopliae.* The inoculated sponge cubes were incubated at 25^{0}C and 70% RH for 15 days and thee conidial production of *B. bassiana* and *M. anisopliae* was estimated after 5, 10 and 15 days of incubation. Good conidial production of *B. bassiana* (Bb-5a isolate) and *M. anisopliae* (Ma-4) was observed on sponges in both methods tested. Conidial production was highest on 15th day in the two methods tested. Conidial production of 1.3x10^{8} conidia/1cm^{3} of *B. bassiana* was observed in both methods. With regard to *M. anisopliae*, 1.0x10^{8} conidia/1cm3 was observed in the first method and 0.6x10^{8} conidia/1cm3 in the second method.

Biological control of *Alternaria* leaf blight of tomato

Development of oil-based formulations of promising antagonistic organisms suitable for foliar application

Oil-based formulations of *Trichoderma* species were developed. The invert-emulsion formulations were made for the isolates of *T. viride* (4 isolates, TV-11, TV-23, TV-97 and TV-115), *T. virens* (4 isolates, TVs-1, TVs-9, TVs-12 and TVs-P-12) and *T. harzianum* (4 isolates, TH-10, TH-K and TH-P-26, Th-7). These isolates were grown on solid substrate using ragi for 15 days and dry spores were extracted and used for the invert-emulsion formulation. The emulsion formulations were prepared using different oils, emulsifiers and stabilizers. The formulations obtained were having 2 x 10^6 CFUs ml^{-1} of the formulation. The shelf-life of these formulations was studied at room temperature (20-32^{0}C). The formulations had shelf life of approximately 8 months. These formulations were used in the field trials against *Alternaria* leaf blight in tomato at the rate of 10 ml per litre of the spray liquid.

Evaluation of *Trichoderma* and bacterial isolates against *Alternaria* leaf blight of tomato (Field trials)

Field experiment was carried out in Attur Farm of the NBAII during rabi season of 2009 to evaluate twelve promising isolates of *T. viride* (4 isolates, TV-11, TV-23, TV-97 and TV-115), *T. virens* (4 isolates, TVs-1, TVs-9, TVs-12 and TVs-P-12) and *T. harzianum* (4 isolates, TH-10, TH-K and TH-P-26, Th-7) and three bacterial isolates (*Pseudomonas fluorescens*, *Bacillus subtilis* and *B. megaterium)* against leaf blight disease of tomato caused by *Alternaria* spp. Invert oil formulations of twelve isolates of *Trichoderma* were prepared containing 10^6cfu/ml and applied as seedling dip during transplantation and foliar sprays after 30, 60 and 90 days after transplantation. Talc formulations of three isolates of bacteria were prepared containing 10^8/g and applied similarly as seedling dip and foliar sprays. Mancozeb (as Indofil M 45) at 3.0g/l served as fungicidal check and applied as seedling dip during transplantation and foliar sprays after 30, 45, 60 and 90 days after transplantation. In control plot, seedlings were dipped in water during transplantation and water sprays were given after 30, 60 and 90 days after transplantation.

Taking in to consideration of the mean post treatment diseases index, the highest PDI of 53.13 was observed in the control plants and the lowest PDI was observed in fungicidal spray (17.26). Among the 15 isolates of antagonists tested, the lowest PDI of 20.33 was observed with *T. viride* (TV-115 isolate), however it was statistically on par with *T. harzianum* (Th-7 and Th-10 isolates) and *Pseudomonas fluorescens* which showed PDI of 20.66, 22.16, and 21.36 respectively. A 51.28-61.74% reduction in diseases was observed in the plots treated with these four antagonists (TV-115, Th-7, Th-10 & *P. fluorescens*) compared to the PDI observed in control plot (Un-treated) (Fig. 18).

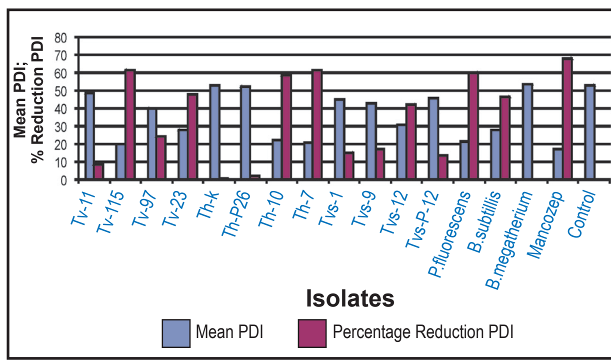


Fig. 18. Effect of fifteen antagonists on the diseases index (PDI) of Alternaria leaf blight of tomato

Highest yield of 181.6 kgs/30 m^2 was observed in the mancozeb treated plots, however it is statistically on par with the yield recorded in the plots treated with TV-115, Th-10, Th-7, and *P.fluorescens* (179.75, 176.5, 174.35 and 177.75 kgs/30m^2 respectively). The lowest yield of 131.6 kgs/30m^2 was recorded in control plot (Un-treated).

Management of bacterial wilts of Tomato and Brinjal caused by *Ralstonia solanacearum* through *Bacillus* spp.

Among the different isolates of *Bacillus* spp. collected from different places, isolate No.63 (from Devikulam of Kerala) had highest inhibition zone of 11.5 mm against *R. solanacearum* which causes wilts on tomato and brinjal. In a pot culture experiment, seed treatment, root dipping, foliar spray and soil drenching five times (40 ml/pot) after transplanting at 20 days interval with isolate no. 63 had reduced the bacterial wilt disease upto 79.15 % and increased the shoot and root growth of tomato seedlings (Fig. 19). Among the ten isolates of *Bacillus* spp., the Devikulam isolate survived and established better in the tomato rhizosphere with a population of 22x10^7 cfu g^{-1} at 20 days after transplanting and increasing up to 66.7x10^7 cfu g^{-1} soil at 100 days after transplanting.

Fig. 19. Effect of *Bacillus* spp. isolate 63 on growth of tomato plants

Isolation, characterization and toxicity tests of indigenous *Bacillus thuringiensis* strains against lepidopterous pests

New Indigenous strains of *B. thuringiensis* against *Plutella xylostella*

Two new indigenous Bt isolates having bipyramidal crystals were purified from Assam and Rajasthan and designated as NBAII-BTAS and NBAII-BTG4 (Fig. 20). The native protein concentration in NBAII-BTAS was 3.2mg/ml. NBAII-BTAS isolate was highly toxic and 100% mortality of second instar larvae of *Plutella xylostella* was recorded at $10^{-1}$to 10^{-2} dilutions. The minimum mortality of 95% was recorded at 10^{-3} to 10^{-4} dilution. The LC_{50} value was 0.037 µg/ml. The native protein concentration in NBAII-BT G4 was 2.9 mg/ml. The isolate was highly toxic and 100% mortality of first instar larvae of *Plutella xylostella* was recorded at 10^{-1} to 10^{-2} dilutions. The minimum mortality of 95% was recorded at 10^{-3} to 10^{-4} dilution. The lowest mortality 85% was recorded at 10^{-5} to 10^{-6} dilution. The LC_{50} value was worked out as 0.026µg/ml. The native protein concentration in HD-1 was 3.1mg/ml. The Isolate was toxic and 100% mortality was recorded at $10^{-1}$to 10^{-2} dilutions. The minimum mortality of 75% was recorded at 10^{-3} dilution. The lowest mortality of 42.5% was recorded at 10^{-4} to 10^{-5} dilution. The calculated LC_{50} value was worked out as 0.062µg/ml. No mortality was recorded in the control/distilled water. The results showed that the two indigenous *Bt* isolates (NBAII-BTAS, NBAII-BTG4) were highly toxic to the agriculturally important pest *P. xylostella* and that they were more toxic than the standard HD-1 strain. The above results clearly indicated the superiority of the two indigenous *Bt* isolates (NBAII-BTAS, NBAII-BTG4) over HD-1 strain against *P. xylostella*.

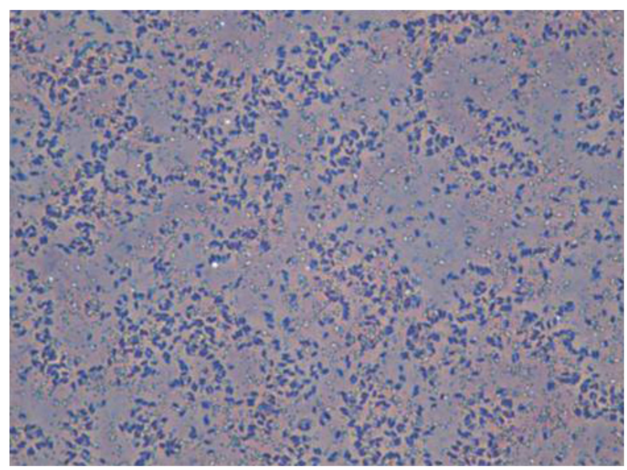


Fig. 20. Bipyramidal crystals of Bt isolate NBAII-BTG4

Molecular characterization of indigenous Bt

All the indigenous Bt isolates (PDBC BT-ASSAM, PDBC BT-1, PDBC HD-1, NBAII-BT G4) were amplified with cry1 general primers. All the isolates are found to be positive for cry1 gene presence. Amplification of a family band of about 1.5 to 1.6 kb was observed in all the isolates (Fig. 21).

SDS-PAGE analysis of the spore crystal protein was done for the indigenous *B. thuringiensis* isolates and compared with the standard HD-1 strain. It was observed that the isolates NBAII-BTG4 and PDBC-BT1 showed almost similar protein profile but the NBAII-BTG4 isolate showed a 15kDa band that was missing in the PDBC-BT-1 isolate. The other indigenous Bt isolate NBAII-BTAS showed closer resemblance to the standard HD-1 strain however the

NBAII-BTAS isolate extra protein bands of 70kDa, 65kDa, 38kDa and 42kDa were seen which implies that it was genetically different from that of HD-1 strain (Fig.21).

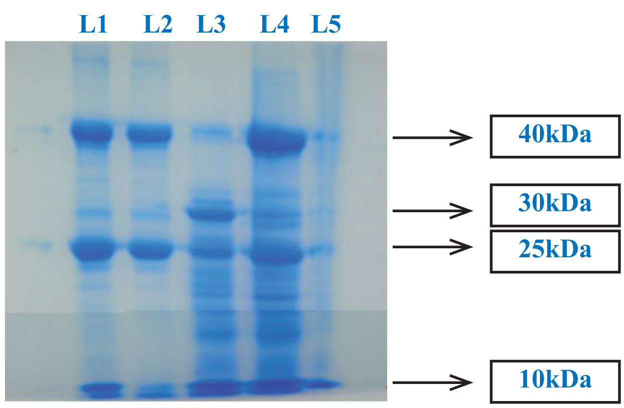


Fig. 21. SDS-PAGE analysis of indigenous *Bacillus thuringiensis* isolates.

L1=NBAIIBTG4; L2= PDBCBT1, L3=HD-1, L4=NBAII-BTAS, L5=Marker

Field evaluation of Bt formulations

Field evaluation of five indigenous Bt isolates namely PDBC-BT1, PDBC-BT2, BNGT1, HD-1 and NBAII-BTAS was done against redgram pod borer. Liquid formulation (10% a.i.) of the above *Bt* isolates was standardized. The formulation was used as spray (2%) for control of pod borers on redgram.

The highest pod damage of 28.05 per cent was in untreated control and the lowest (1.85%) in plants treated with 2% NBAII-BTAS. Low pod damage was also observed in other treatments viz., HD-1, BNGT1 and PDBC-BT1 (Fig. 22).

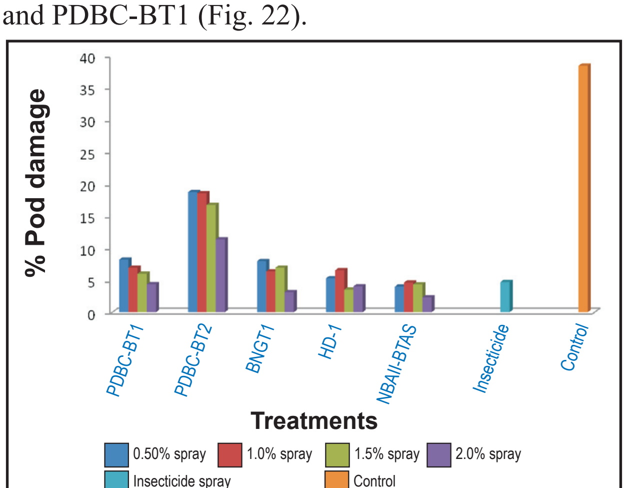


Fig. 22. Field evaluation of Bt isolates against Helicoverpa armigera against pigeonpea

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

Culture collection of plant beneficial bacteria at NBAII

Seven endophytic bacteria were isolated from healthy tomato plants and five of them were identified by Biolog system as *Acinetobacter baumanii, Stenotrophomonas maltophila, Enterobacter cloacae, Brevundimonas vesicularis* and *Burholderia plantarii*. Four endophytic bacteria were isolated from cotton, groundnut, tomato and pigeonpea. They were identified as *Cellulosimicrobium cellulans*, *Pseudomonas putida, Pseudomonas putida* biotype A (2 isolates from groundnut and tomato) and *Brevibacterium otitidis*.

Plant growth promotion and rhizosphere competence of endophytic / rhizospheric bacteria

Of the four endophytes isolated from cotton, maximum shoot length (5.60 cm) and root length (2.19 cm) was observed in *C. cellulans*-treated plants, however maximum vigour index of 686.7 was recorded in *Pseudomonas putida*-treated plants. All the endophytes had positive effect on plant growth. In pigeonpea, maximum shoot length (11.08 cm), root length (3.56 cm) and highest vigour index (1464.0) was observed in *P. putida* biotype A-treated plants (Table 3). All the endophytes had positive effect on plant growth when compared with control.

Table 3. Effect endophytic bacteria on growth and vigour of cotton and pigeonpea

Treatments	Cotton		Pigeonpea	
	Shoot length (cm)	Vigour index	Shoot length (cm)	Vigour index
Cellulosimicrobium cellulans	5.60	726.8	10.06	1247.4
Pseudomonas putida biotype A	5.44	604.8	11.08	1464.0
Pseudomonas putida	5.55	711.8	11.00	1441.0
Brevibacterium otitidis	5.63	620.0	10.16	1077.6
Control	4.63	420.1	8.25	817.3
$CD_{P=0.05}$	0.58	32.30	0.69	42.30

These four endophytes when applied on cotton and pigeonpea plants enhanced the activity of phenol and Phenylalanine ammonia-lyase (PAL), however by four days after the treatment phenol and Phenylalanine concentration was reduced.

Shelf life of powder based formulations of Gram negative bacteria and 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 2% tryptone and 2% glycerol. At 240 days highest population of 1.6×10^4 cfu/gm was obtained. The spore forming bacterium *Bacillus* sp. survived well throughout the study period. It was concluded that yeast extract or tryptone supplemented with glycerol enhanced shelf life of talc-based formulation of *Bacillus* sp.

Phytophagous mites as a source of microbes for harnessing in pest management

Field collection of fungi associated with different phytophagous mites

Surveys were made in vegetables and other crops for the collection of phytophagous mites and their associated pathogenic fungi (Table 4).

Table 4. Pathogenic fungi associated with different mites

Mite species	Associated pathogenic fungi
Tetranychus urticae	*Acremonium* sp., *Metarhizium* sp., *Neozygites floridana, Paecilomyces* sp., *Fusarium* sp., *Lecanicillium* sp., *Beauveria* sp., *Cladosporium* sp.
Oligonychus coffeae	*Acremonium* sp. 2, *Hirsutella* sp. 1, *Lecanicillium* sp. 3, *Neozygites* sp.
Acalitus adoratus	*Acremonium* sp., *Hirsutella* sp., *Paecilomyces* sp.
Phyllocoptruta oleivora	*Acremonium* sp., *Beauveria* sp., *Lecanicillium* sp., *Paecilomyces* sp.
Aceria litchii	*Acremonium* sp., *Fusarium* sp. 1, *Fusarium* sp. 2, *Fusarium* sp. 3, *Hirsutella* sp., *Lecanicillium* sp.
Rhombacus eucalypti	*Fusarium* sp. 1, *Hirsutella* sp.

Bioefficacy of fungi against *Tetranychus urticae*

In a green house trial, application of *Acremonium* sp. at a spore concentration of 1×10^7/ml, was the most effective in bringing down the population of *T. urticae* on bitter gourd, bottle gourd and ridge gourd, followed by *Lecanicillum psalliotae* (Table 5).

In a another green house experiment application of *L. psalliatae* at a spore strength of 1×10^7/ml

Table 5. Efficacy of four pathogenic fungi against *Tetranychus urticae* on three cucurbits in the green house

Treatment	No. of live mites (± SE)/315 mm² area of the lower leaf surface					
	Bitter gourd		Bottle gourd		Ridge gourd	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Acremonium sp.*	37.5 ± 0.74	14.6 ± 0.41^b	38.1 ± 0.95	15.6 ± 0.42^b	32.6 ± 0.69	14.3 ± 0.58^b
*Beauveria bassiana**	36.7 ± 0.90	22.9 ± 0.81^d	37.6 ± 1.04	23.3 ± 0.42^d	31.6 ± 0.63	20.6 ± 0.65^d
*Lecanicillium lecanii**	37.6 ± 0.86	22.6 ± 0.55^d	38.4 ± 0.60	22.6 ± 0.30^d	32.5 ±0.67	20.6 ± 0.32^d
*Lecanicillium psalliotae**	37.0 ± 0.99	17.6 ± 0.34^c	38.2 ± 0.86	17.8 ±0.35^c	31.6 ± 0.55	16.6 ± 0.26^c
Dicofol (0.05%)	38.0 ± 0.56	4.8 ± 0.42^a	38.1 ± 0.56	4.7 ± 0.44^a	31.8 ±0.62	3.2 ± 0.20^a
Control 1@	37.6 ± 0.45	35.6 ± 0.34^e	38.5 ± 0.45	36.1 ± 0.27^e	32.2 ± 0.44	30.1 ± 0.32^e
Control 2#	38.9 ± 0.67	38.8 ± 0.52^e	38.5 ± 0.88	37.9 ± 0.30^e	32.6 ± 0.47	32.6 ± 0.41^e

Note: All the suspensions, except chemical, were made in 0.2% Tween 80
*10^7 conidia/ml + glycerol 1%
@ Glycerol 1%
# Water (0.2% Tween 80)
Data in each column were subjected to one-way ANOVA. Means in each column followed by the same letter did not differ significantly at $P < 0.05$, Tukey's HSD.

significantly reduced the incidence of *T. urticae* on brinjal followed by *Lecanicillium lecanii* and *Beauveria bassiana* (Table 6).

Table 6. Efficacy of three fungal pathogens against *Tetranychus urticae* on brinjal in the greenhouse

Treatment	Pre-treatment count in 315 mm² leaf area	Mean mite population 12 days after treatment in 315 mm² leaf area	
		No. of mites	% reduction
*Beauveria bassiana**	36.3 ± 0.46	23.6± 0.69[c]	35.0
*Lecanicillium lecanii**	36.1 ± 0.58	22.1± 0.56[c]	38.8
*Lecanicillium psalliotae**	37.1 ± 0.47	16.1± 0.73[b]	56.6
Control 1[@]	36.8 ± 0.56	34.4 ± 0.72[d]	6.5
Control 2[#]	37.2 ± 0.33	37.8 ± 0.70[e]	(+) 1.6
Chemical	37.0 ± 0.37	7.3 ± 0.36[a]	80.3

Note: All mite counts (± SE) were per 20-mm diameter area.
*10^7 conidia/ml + CMC 0.1%
@CMC 0.1%
#Water (0.2% Tween 80)
Data in each column were subjected to one-way ANOVA. Means in each column followed by the same letter did not differ significantly at $P < 0.05$, Tukey's HSD.

DNA bar coding of PDBC isolates of entomopathogenic nematodes

COI gene amplification and sequencing has been done for 12 EPN isolates to generate data for DNA bar coding (Fig. 23.). The sequence analysis (DNA bar coding) strongly supported 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 check the label claims in EPN formulations.

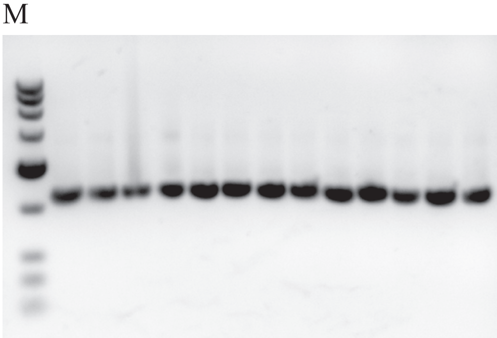


Fig. 23. Amplification of COI gene in natural populations of entomopathogenic nematodes catalogued at NBAII.

In a field trial, three-time application of *L. psalliotae* at a spore strength of 1 x 10^7/ml significantly reduced *T. uritace* incidence on brinjal followed by *L. lecanii* and *B. bassiana* (Table 7).

Table 7. Field efficacy of three fungal pathogens against *Tetranychus urticae* on brinjal in the field

Treatment	Pre-treatment count in 315 mm² leaf area	Mean mite population 12 days after third treatment in 315 mm² leaf area	
		No. of mites	% reduction
*Beauveria bassiana**	35.6 ± 0.48	20.9 ± 0.70[d]	13.3
*Lecanicillium lecanii**	35.4 ± 0.47	16.4 ± 0.78[c]	18.0
*Lecanicillium psalliotae**	37.0 ± 0.45	10.2 ± 0.57[b]	23.9
Control 1[@]	37.0 ± 0.45	31.3 ± 0.22[e]	1.6
Control 2[#]	37.3 ± 0.52	38.3 ± 0.18[f]	2.5
Chemical	36.9 ± 0.44	4.1 ± 0.40[a]	29.3

Note: All mite counts (± SE) were per 20-mm diameter area.
*10^7 conidia/ml + CMC 0.1%
@CMC 0.1%
#Water (0.2% Tween 80)
Data in each column were subjected to one-way ANOVA. Means in each column followed by the same letter did not differ significantly at $P < 0.05$, Tukey's HSD.

In vivo production of both *Steinernema* and *Heterorhabditis* on *Galleria mellonella*

The optimal temperature for growth, duration of life cycle, larval biomass and fecundity of *G. mellonella* ranged between 28 and 30°C at a relative humidity of 60-80%. *In vivo* production of *Heterorhabditis indica* and *Steinernema carpocapsae* on *Galleria* larvae was enhanced by synchronizing the larval production and diet modification for the larvae.

New isolates of EPN from whitegrub endemic fields

A new isolate of *H. indica* and two new isolates of *Heterorhabditis* spp. were obtained from diseased grubs collected from coffee plantations of Madikeri.

Influence of laboratory host insect on EPN production

The EPN (*H. indica* and *S. carpocapsae*) multiplied on *G. mellonella, C. cephalonica* and root grubs were more virulent and caused larval mortality (*G. mellonella* and root grub) in shorter duration (24-36h) compared to the progeny obtained from larvae of *H. armigera, S. litura* and *P. xylostella.*

Bioefficacy of EPN against root grubs

Replicated screening of twelve EPN isolates for their bioefficacy against eggs of root grubs *Leucopholis* and *Anomala* species under *in vitro* confirmed that there was no infection/penetration of eggs by the EPN screened. Eggs of root grubs were found to be resistant to EPN infection

Among the 3 nematodes, *H. indica* followed by *S. riobrave* and *S. carpocapsae* consistently recorded lower LD_{50} and LT_{50} values for the 3 white grub species (*Anomala bengalensis, Leucopholis lepidophora* and *L. burmestrii)* at 3 depths (10, 20 and 30cm). These observations aid us in fixing the EPN doses for field application for the three species and to estimate the probable time of grub mortality at different depths after application of the EPN.

Field evaluation of EPN against root grubs

Applications of talc or cadaver preparations of EPN (*H. indica* and *S. carpocapsae*) successfully controlled *Leucopholis lepidophora, Anomala bengalensis* and *L. burmestrii* in 6 to 8 days in arecanut fields at Sulya (Karnataka). EPN was recovered from the treated soils up to a period of 6 months indicating successful establishment of EPN in root grub endemic soils. (Fig. 24).

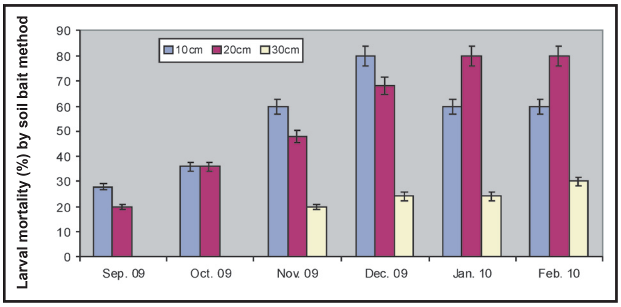


Fig. 24. Persistence of EPN at different depths-mortality of *G. mellonella* larvae

A new technique was developed to observe the behaviour of root grubs and recover the cadavers in treated soil to confirm EPN as the cause of root grub control *in situ*. Root grubs of different sizes (1 to 2.5 cm) were predominant in top 20 cm from August to October with intermittent large sized grubs, while, grubs of more than 2.5 cm were predominant between 10 and 30 cm from Oct to January in arecanut in Sulya.

Nematode- derived fungi and bacteria for exploitation in agriculture

Two new isolates of antagonistic fungi, *Dactylella oviparasitica* and *Dreschlera* sp. (Fig. 25) have been isolated from diseased egg masses and eggs sampled from commercial polyhouses. Another two new isolates of *Paecilomyces lilacinus* were isolated from the infected root-knot nematode eggmasses collected from soils of Puttur, Dakshina Kannada, Karnataka (Fig. 26).

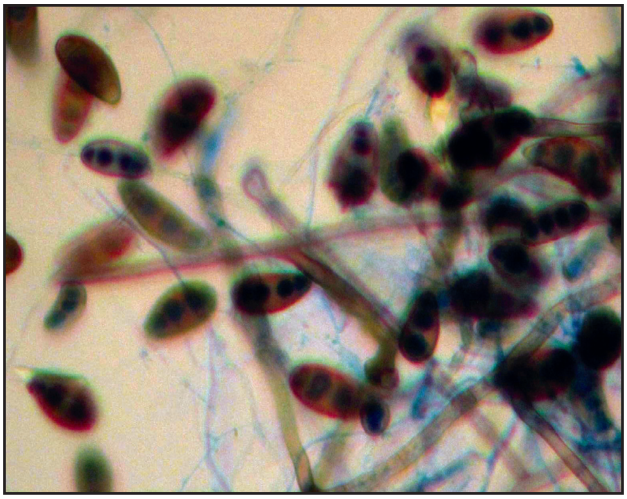


Fig. 25. Spores (40x) of *Dreschlera* sp.,

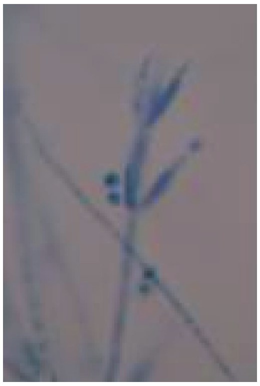


Fig. 26. Conidiophores (40x) of *P. lilacinus*

These isolates exhibited high percentage of infection of egg masses and eggs under *in vitro* and *in vivo* against root-knot and reniform nematodes. The optimum temperature for mycelial growth was 26 to 34°C and spore germination was 26 to 38°C for these isolates.

Features of amorphous formulations of *P. lilacinus* and *Pochonia chlamydosporia*

The pH of *P. lilacinus* and *P. chlamydosporia* formulations were between 6.0 and 6.5, while the wetttability and moisture content were 35.06 min and 1.08%, 31.85 min and 1.11% respectively.

Molecular identification and detection technique

Techniques for molecular identification and detection of NBAII isolates of *P. lilacinus* and *Pochonia chlamydosporia* were developed based on PCR (Figs. 27 and 28) and restriction enzyme (RFLP) studies for further characterization of virulence factors/mode of action of the isolates against root-knot and reniform nematodes. Serine protease, collagenase and chitinase enzymes responsible for virulence against root-knot nematode eggs and egg masses, were detected in the isolates of *P. lilacinus* and *P. chlamydosporia* under *in vitro.*

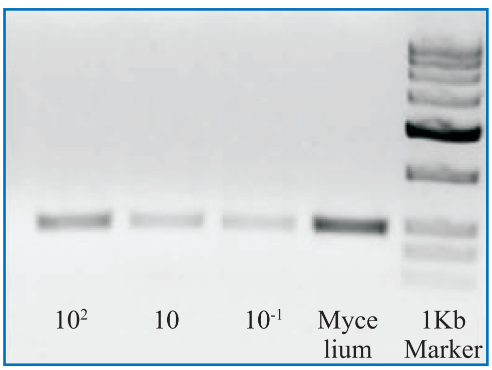


Fig.27. Detection of *P. chlamydosporia* isolates at different concentrations of spores per g of soil.

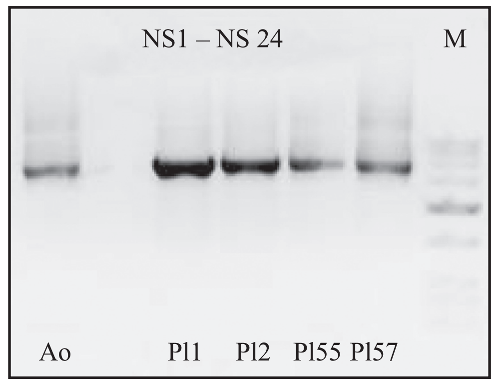


Fig. 28. PCR amplification of ITS gene in *A. oligospora* and *P. lilacinus* isolates.

Biological suppression of root-knot nematodes in polyhouses in combination with crop rotation (marigold)

Application of 10^7 spores of *P. lilacinus* and *A. oligospora* /m^2 in carnation followed by rotation with marigold effectively controlled root-knot infection which persisted for 1 year (Table 8).

Table 8. Effect of *P. lilacinus* and *P. chlamydosporia* on root-knot nematodes and flower yield in carnation in a commercial polyhouse with an organic carbon status of 3.8% and soil type of laterite with pH 6.4.

Treatment	RGI (0-5)	Nematode multiplication rate*	Root infection (%)	Egg mass/ juvenile parasitisation (%)	Cfus/g soil after 1 year	**Flower yield/m²
P. lilacinus	2.8	1.6	48.5	54	99.8	42
A. oligospora	2.6	2.1	36.2	59	33.8	46
Marigold	2.6	1.6	24.4	-	-	46
P. lilacinus + Marigold	1.4	0.8	21.8	48	86.2	47
A. oligospora + Marigold	1.6	1.1	18.6	44	36.9	46
Untreated check	3.8	2.4	68.2	-	-	36
CD(P=0.05)	0.36	0.24	1.68	5.88	8.22	5.11

*Nematode multiplication rate= nematode population in 100cc soil at harvest/initial nematode population in 100cc soil;**Flower yield- number of healthy long spiked flowers per m^2.

Effect of crop rotation and biological control using *P. lilacinus* on root-knot nematodes in tomato under field conditions

Crop rotation of tomato with radish or maize with or without application of talc formulation of *P. lilacinus* resulted in significantly low root galling, root infection, number of females and egg masses compared to crop rotation with brinjal and marigold (Fig.29.). However, these parameters were minimum in *P. lilacinus*-treated radish or maize plots.

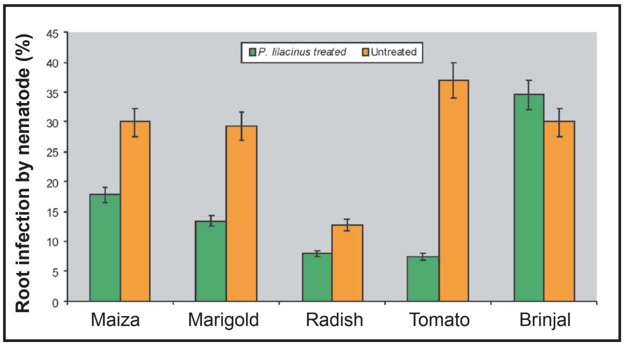


Fig. 29. Effect of use of *P. lilacinus* and crop rotation on root-knot nematode infection after rotation1.

5.2. All India Co-ordinated Research Project on Biological Control of Crop Pests & Weeds (AICRP on Biological Control).

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

GBPUAT

Effect of temperature on isolates of *Trichoderma*

Antagonistic activity of 93 isolates of *Trichoderma* from different farming situations in Uttarakhand hills and plains was evaluated at different temperature ranging from 10 to 40°C. All the isolates grew well from 20 to 30 °C. At 10°C, T-13 and T-14 grew well. At 35°C, isolates T-3, T-4, T-5, T-11, T-13, T-14, T-33, T-34, T-39, T-50 and T-57 showed optimum biomass production. Isolate T-50 and T-68 grew well at even 40°C.

Effect of pH on isolates of *Trichoderma*

All the 93 isolates grew well at pH 6 and 7. At low pH of 4 and 5, these isolates grew fast attaining the full growth of 8.5 cm within 96 hours. At pH range of 9 and 10, the isolates showed optimum biomass production with radius of 5.2 to 8.2 cm after 120 hours.

Effect of salinitly on colony growth of *Trichoderma*

When tested at different salinity concentrations (6, 7, 9 dSm/1 of NaCl, Na2CO3 and K2SO4 at 2:1:1), all the 93 isolates were able to grow from 2 to 4 dSm/1. Isolates T-1, T-4, T-5, T-9, T-12, T-13, T-14, T-19, T-33, T-39, T-50, T-55, T-56, T-57, T-60, T-61, T-62, T-66, T-67-70, T-75, T-68, T-69, T 82 and T-89 grew well reaching a radius of 7.0-8.5 after 120 hr at 6-7ds/m. Isolates T-1, T-4, T-5, T-9, T-14, T-33, T-50 and Th-56, T-57, Th-60, Th-61, Th-69, Th-70 and Th-82 grew up to the radius of 6.5-6.8 after 120 hr at 9ds/m.

Effect of moisture levels on colony growth of *Trichoderma*

All the 93 isolates were tested for their growth in oven-dried cow dung at different moisture levels (10%, 20%, 70%, and 90%). At 90%, no significant growth was found. Growth of *Trichoderma* was reasonably good from 10 to 70 % moisture levels. Isolates T-1, T-5, T-9, T-11, T-13, T-14, T-19, T-33, T-36, T-39, T-50, T-56, T-57 were comparatively better colonizers at different moisture levels at 10^8 dilutions. Cfu and sporulation was reduced with increase in the moisture percentage at 70-90 %.

Plant growth promotion activity of selected *Trichoderma* isolates on rice (Kalanamak-3131) in glass house

All the 32 isolates of *T. harzianum* evaluated were effective growth promoters in rice in all the growth parameters tested as compared to check. Highest root growth was recorded in isolate T-14 (22.96 cm), T-5 (21.9 cm) and Th-56 (18.2 cm). Significantly higher shoot growth was recorded in isolate Th-56 (79.5 cm), T-5 (77.23 cm), T-57 (76.96 cm) and Th-75 (72.6 cm). Maximum chlorophyll content was recorded in isolate T-57 (2.77mg/g), T-1 (2.61 mg/g) and Th-56 (1.7 mg/g). Highest average number of leaves per plant was recorded in isolate Th-56 (8.4), T-5 (7.3) and T-9 (7.3. Maximum SPAD value was recorded in isolate T-57 (44.82), T-1 (44.62) and Th-56 (40.0). Overall *T. harzianum* isolates T-14, Th-56, and T-57 were found to be the best growth promoters of rice (Kalanamak-3131) under glass house conditions.

Evaluation of selected isolates of *Trichoderma* on rice (Kalanamak-3119 and Kalanamak-3131)

A field experiment was laid at the organic farming block of Seed Production Center of GBPUA&T, Pantnagar to evaluate the potential 20 isolates of *Trichoderma* on rice (cv Kalanamak-3119 and Kalanamak-3131). The results indicated that Isolate T-9 recorded highest plant height (119.1 cm), Isolate T-16 recorded highest panicle length (26.23 cm), Isolate T-13 recorded higher number of tillers per hill ((12.53) and higher number of panicles/hill (11.73), However average higher yield per plant was recorded by Isolate T-19 (440.0 g) in Kalanamak-3119 rice. On another variety, Kalanamak-3131, Isolate T-13 recorded highest plant height (127.2 cm), Isolate T-14 recorded highest panicle length (29.4 cm), Isolate T-13 recorded higher number of tillers per hill ((11.47), isolate T-11 recorded higher panicles per hill (10.6). Maximum yield per plant was recorded by isolate T-7 (466.7 g). Isolate T-1 recorded less incidence of sheath blight, sheath rot, stem borers, grass hopper and leaf folder in both the Kalanamak 3119 and Kalanamak 3131 rice.

Evaluation of selected isolates of *Trichoderma* on wheat, lentil and chickpea

To evaluate the efficacy of 20 potential isolates of *T. harzianum* on Wheat (RR-21), Lentil (PL-5) and Chickpea (Pusa-362) under field conditions, a field experiment was conducted in rabi 2009-10 in the organic farming block of Seed Production Center of GBPUA&T, Pantnagar. On wheat, isolate T-39 recorded higher plant height (90.9 cm), spike length (18.1 cm), higher number of tillers/plant (4.8) and higher grain yield (14,500 kg/ha). On Lentil isolate T-14 recorded maximum plant height (41.36 cm) and grain yield (12,050 kg/ha). On chickpea isolate T-14 recorded the maximum plant height (50.1 cm) and grain yield (23,260 kg/ha).

Evaluation of *Pseudomonas fluorescens* and *Trichoderma harzianum* on yield and quality of gladiolus

Plants treated with *P. fluorescens* (PBAP-27)+ *T. harzianum* (PBAT-43)+ Himedia both as soil and foliar spray recorded the highest spike length of 96.33 cm which meets the export standard grade A in the international market, whereas with regard to shelf life, the lowest physiological weight loss (16.44) was recorded in the treatment with *P. fluorescens* + *T. harzianum* four days after harvest. The analysis of biochemical parameters like peroxidase, catalase, polyphenol oxidase, proteins, phenols and sugars also revealed a positive correlation with increased shelf life in the treatment with *P. fluorescens* and *T. harzianum* and in interaction with Himedia nutrient mixture. Also the microbial analysis for CFU /ml of *Pseudomonas* and *Trichoderma* revealed higher colony development in the treatments having *P. fluorescens* and *T. harzianum* alone or in combination with Himedia.

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

(GBPUA & T)

(i) Pea

Large scale demonstrations were conducted at farmer's fields in Bajpur area of District Udham Singh Nagar on Arkil variety of pea (vegetable) covering a total of 11 acres. The bioagent treatments included: seed treatment (@ 10g/g) with mixed formulation of *T. harzianum* PBAT-43 (TH-43) and *P. fluorescens* PBAP-27 (PsF), seed treatment with Rhizobium culture, use of FYM colonized with the same bioagents at the recommended dose, two sprays with mixed formulation of *T. harzianum* PBAT-43 (TH-43) and *P. fluorescens* PBAP-27 (PsF) (@ 10g/l) and spray of a commercial formulation of sea weed extract. 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 two sprays of Bavistin and Dithane M-45 at the recommended doses. The major diseases encountered were *Rhizoctonia* root rot and wilt complex.

The results indicated that the number of seedlings per square meter, and the grain yield was higher in plots where the biocontrol agents were applied compared to farmers practice (Table 9).

(ii) Rice

Large scale demonstrations of biocontrol technologies was conducted on organically cultivated rice cultivars, Pusa-1121, Taraori Basmati and Pusa Basmati -1 in thirteen Tarai farmers fields. The biocontrol treatments included FYM colonized with mixed formulation of *T. harzianum* + *P. fluorescens* (@ 5 to 10 tons/ha) or use of vermicompost colonized with *P. fluorescens* (@ 5 to 10 q/ha), seed treatment/ biopriming with mixed formulation of TH + PsF (@ 10g/kg seed) and need-based spray of TH+PsF (@ 10 g/l) in fields affected with sheath blight.

The results indicated that though the yields were slightly lower in biocontrol plots as compared to farmers practice, the rice produced in biocontrol plots fetched higher price due to better grain quality (Table 10).

(iii) Vegetables

Large scale field demonstrations on biocontrol technologies under low input system in Uttarkhand 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; and f) 1-2 sprays of soluneem. Farmers' practice was the control. Significantly highest seed germination and highest yield was recorded in the BIPM package in cabbage, capsicum, brinjal, chilli and tomoto (Fig. 30).

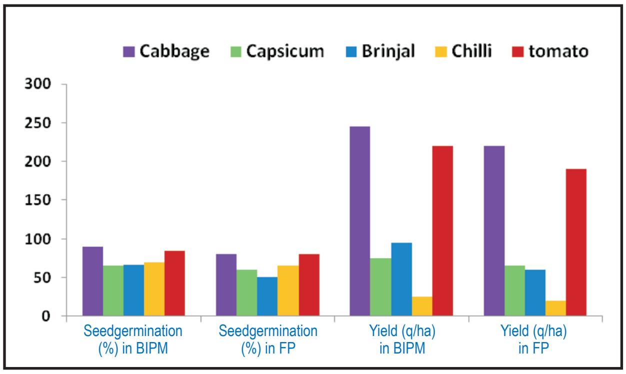


Fig. 30. Impact of BIPM package on germination and yield of vegetables in Uttarakhand hills

Table 9. Large scale demonstration of biocontrol on pea (Arkil) at farmers' fields under organic cultivation

Treatments	Seedlings /m²	Disease severity (%)	Yield (green pod/ha)	Additional yield over control (kg/ha)	Value of Yield (Rs/100kg)	Profit (Rs.) Lakh/ha
Biocontrol	39	18	12,250	5,500	1,700.00	2.08
Farmers' practices (Control)	21	82	6,750	-	1,400.00	0.95

Table 10. Large scale demonstration of biocontrol agents on organically cultivated rice

Rice	Yield (kg/ha)	Difference in yield over farmer's practice (kg/ha)	Value of yield (Rs/100 kg)	Value of yield (Rs/ha)
Organic Pusa-1121	3,250	- 250	2300.0	74,750
Organic Taraori Basmati	2,000	0	3500.0	70,000
Organic Pusa-1	4,000	- 750	2200.0	88,000
Farmers practice (Pusa-1121)	3,500	-	1900.0	66,500
Farmers practice Taraori basmati	2,000	-	3100.0	62,000
Farmers practice (Pusa-1)	4,750	-	1800.0	85,500

5.2.3. Biological control of plant parasitic nematodes

(a) Redgram

i) MPKV, Rahuri

Pooled analysis of results of the experiment conducted for two years to evaluate the antagonistic fungi against the reniform nematode *Rotylenchulus reniformis* in redgram (var. Vipula) in *Kharif* 2009 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 increasing the yield of pigeonpea (Table 11). The ICBR of the combined treatment was 1: 1.64.

Table 11. Efficacy of bioagents against the reniform nematode in pigeonpea (Rahuri)

Treatment	Nematode population/ 200 cm³ soil	No. of females/ 5 g roots	Yield (kg/ha)
T. harzianum	257.2 ^{b}	20.2 ^{b}	1,640 ^{c}
P. chlamydosporia	230.6 ^{a}	17.8 ^{a}	1,740 ^{b}
T. harzianum + *P. chlamydosporia*	194.5 ^{a}	16.0 ^{a}	1,840 ^{a}
Carbofuran 3G	241.0 ^{a}	19.1 ^{b}	1,700 ^{b}
Untreated control	500.0 ^{c}	26.0 ^{c}	1,370 ^{d}

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

ii) 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* 2009. One kg of talc formulation of fungus was mixed with 100kg of completely decomposed dry FYM. Water was sprinkled on the mixture to give sufficient moisture. FYM was then covered with tarpaulin and left for 15 days with intermittent mixing. Presence of green colour due to conidial growth on FYM was observed. Such FYM was used for the soil application. Biocontrol agents were applied as per details in table 12. Agronomical and plant protection measures were followed as per University recommendation.

There was no difference with respect to plant stand (%) 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 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*. (Table 12).

Table 12. Effect of biocontrol agents and organic manures on *Heterodera cajani* in pigeonpea

Treatment	Plant Stand (%)	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)	42.1 ^{bc}	15.3 ^{b}	13.0 ^{bc}	51 ^{bc}	1094 ^{b}
P. chlamydosporia @ 20kg/ha talc formulation (10^8 spores/g)	42.7 ^{ab}	15.4 ^{b}	11.8 ^{cde}	52 ^{bc}	1126 ^{b}
T. harzianum + *P. chlamydosporia*	43.1 ^{a}	13.0 ^{c}	15.0 ^{a}	72 ^{a}	1285 ^{a}
Carbofuran @ 2.0 kg a.i./ha (100 g/m²)	42.4 ^{abc}	15.9 ^{b}	10.7 ^{ef}	45 ^{c}	918 ^{c}
Vermicompost (VC) @ 1 t/ha (50 g/m²)	42.7 ^{ab}	15.1 ^{b}	13.8 ^{ab}	51 ^{bc}	925 ^{c}
Neem cake (NC) @ ½ t/ha	42.9 ^{ab}	16.2 ^{b}	12.0 ^{cd}	59 ^{ab}	927 ^{c}
VC+ Carbosulfan seed treatment @ 3% (W/W)	42.2 ^{abc}	16.1 ^{b}	11.6 ^{de}	53 ^{bc}	927 ^{c}
NC+ Carbosulfan seed treatment @ 3% (W/W)	42.7 ^{ab}	16.6 ^{b}	12.4 ^{cd}	55 ^{bc}	920 ^{c}
Carbosulfan seed treatment @ 3% (W/W)	42.2 ^{abc}	16.5 ^{b}	12.5 ^{bcd}	13 ^{d}	918 ^{c}
Control	41.7 ^{c}	19.3 ^{a}	10.0 ^{f}	51 ^{bc}	726 ^{d}

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

(b) Citrus: MPKV, Rahuri

The experiment was conducted at MPKV, Rahuri during *Kharif* 2009 on 6 year old sweet orange (Nuceler Mosambi) 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 @ 2 kg ai/ha were applied in soil along with FYM and basal dose of fertilizers.

Pooled analysis of data from two years revealed that *P. lilacinus* @20kg/ha talc formulation containing 10^8 spores/g was found to be effective in reducing the citrus nematode population (43.8%) and number of females in roots (31.8%) and increased 18.6% yield of sweet orange with 1:8.85 ICBR (Table 13).

Table 13. Efficacy of bioagents on the citrus nematode

Treatment	Nematode population/ 200 cm³ soil	females/ 5 g roots	Yield (kg/ ha)	ICBR
P. lilacinus @20 kg/ha	356.0 [a]	12.6 [a]	1600 [a]	1: 8.85
P. chlamydosporia @20 kg/ha	406.0 [a]	14.4 [a]	1500 [c]	1: 6.50
Carbofuran 3G 2 kg a.i./ha	406.0 [a]	14.6 [b]	1560 [b]	1: 6.38
Untreated control	736.0 [b]	23.8 [c]	1340 [d]	-

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

(c) Pomegranate

i) MPKV

A field experiment was conducted in pomegranate (var. Mrudula) orchard in farmers field to evaluate the biocontrol agents against the cyst nematode. Plant height and plant canopy measured before imposing the treatments revealed non-significant results suggesting homogeneity in different plots. Pooled analysis of two years data showed that treatment with soil application of *P. fluorescens* @ 20 g/m² was most effective in reducing the root knot nematode population (34.5%) and number of root galls /5 g roots (26.7%) and increased the yield of pomegranate by 19.4% with 1: 11.8 ICBR. It was followed by *T. viride* @ 20 g/m² and carbofuran 3G @ 0.3 g a.i./m² (Tables 14).

Table 14. Effect of Biocontrol agents on root knot nematode population and yield in pomegranate

Treatment	Nematode population/ 200 cm³ soil	females/ 5 g roots	Yield (kg/ ha)	ICBR
P. fluorescens @ 20g/m²	305.0 [a]	14.16 [a]	1750 [a]	1: 11.8
T. viride @ 20g/m²	335.0 [a]	18.0 [b]	1730 [a]	1: 10.7
Cartap hydrochloride 4G	342.0 [b]	18.5 [b]	1690 [a]	
Carbofuran 3G	315.0 [a]	14.6 [a]	1710 [a]	1:12.0
Control	720.0 [c]	32.5 [c]	1470 [b]	

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

ii) AAU-Anand

A field experiment was conducted in pomegranate (var. Sinduri) orchard in farmers field to evaluate the biocontrol agents against cyst nematode. Pooled analysis of two years data revealed least number of nematodes in plants treated with *P. lilacinus* + mustard cake. Significantly higher reduction of Root Knot Index (RKI) was also recorded in *P. lilacinus* + mustard cake followed by *P. chlamydosporia* along with mustard cake (Table 15). Significantly highest (2966 kg/ ha) yield of fruits was harvested from the plants treated with *P. chlamydosporia* + mustard cake and *P. lilacinus* + mustard cake over rest of the treatments.

Table 15. Biocontrol of Root Knot nematode in pomegranate

Treatment	Per cent decrease in nematode count / 200 cm³ soil+ 5 g roots*	Per cent decrease in Root knot index	Fruit yield (kg/ ha)
P. lilacinus @ 100g/ Plant (T1)	2.9 [b]	45.9 [cd]	1943 [b]
P. chlamydosporia @ 100g/Plant (T2)	14.3 [b]	40.4 [d]	2122 [b]
Mustard Cake alone @ 2.0 T/ha (T3)	50.5 [a]	53.5 [b]	1966 [b]
T1 + T3	69.8 [a]	66.5 [a]	2833 [a]
T2 + T3	66.1 [a]	62.2 [a]	2966 [a]
Carbofuran 2.0 kg ai/ha	0.5 [b]	54.1 [b]	1156 [b]
Control	-2.1	19.2 [e]	982 [d]

Figures followed by the same letter in a column are not significantly different from each other by DMRT

5.2.4. Biological Control of fruit rot (GBPUA & T)

Mango

In mango Lakhnawi, the lowest per cent fruit surface rotten 2 and 4 days after treatment was in *Candida tropicalis* isolate I-4 (0.3 and 4.7%). Isolate I-4 also resulted in the lowest per cent fruit infection in mango Lakhnawi (6.6%) 2 days after treatment. The percent fruit infection did not vary significantly among various treatments 10 days after the treatment indicating that none of the antagonistic organisms are effective.

Papaya and Guava

Fresh fruits were dipped in the suspension of three strains of *T. harzianum* (Th-9, Th-55 and Rani-2) @ 10g/l and carbendazim @ 0.1% and shade dried and the impact on post harvest fruit rot was studied.

The results revealed that all the treatments were ineffective in controlling post harvest decay in papaya and guava. Although fruits treated with carbendazim recorded minimum infected fruit surface it was not significantly different than other treatments.

Litchi (var. rose scented)

Fresh fruits were dipped in the suspension of one strain each of *T. harzianum* (PBAT-43) and *P. fluorescens* (PBAP-28) and mixture of both @ 2 x 10^6 cfu/ml and carbendazim @ 0.1% and shade dried. The results revealed that all the treatments were ineffective in controlling post harvest decay in litchi.

5.2.5. Biological suppression of sugarcane pests

(i) Survey on sugarcane woolly aphids and their natural enemies

MPKV

Surveys was conducted to assess the intensity of incidence of the sugarcane woolly aphids (SWA) in eight districts of Western Maharashtra and two districts of Marathwada region. The incidence of SWA was observed in August, 2009 at Pawananagar, Dist. Pune and around Marde village in Satara district but at low intensity. It was followed by the occurrence of predators like *Dipha aphidivora* (1-3 larvae/leaf), *Micromus igorotus* (3-7 grubs/leaf) and syrphid, *Eupodes confrator* (1-2 larvae/leaf) in September-October, 2009. The parasitoid, *Encarsia flavoscutellum* was observed on the research farm of CSRS, Padegaon, Dist. Satara.

TNAU

Monthly surveys conducted at Coimbatore, Erode, Salem, Dharmapuri, Madurai, Trichy and Tirunelveli districts revealed that the population of the sugarcane woolly aphids (SWA) was negligible during 2009-10 (Fig. 31). This was due to the action of natural enemies *viz. Dipha aphidivora*, *Micromus igorotus* and *Encarsia flavoscutellum*.

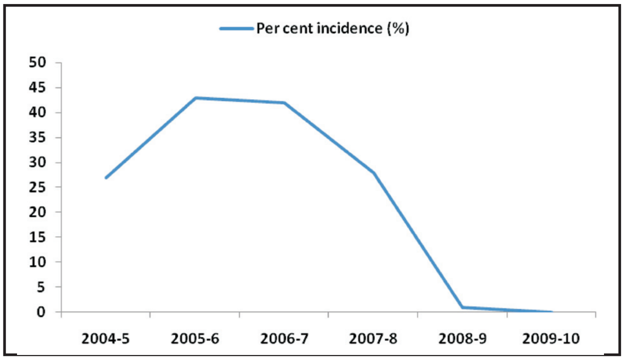


Fig. 31. Incidence of Sugarcane Woolly aphid from 2004-2010 in Tamilnadu

(ii) 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 Dhansiri variety at Dergaon area in Golaghat district covering an area of 100 ha. Eleven releases of *T. chilonis* @ 50,000/ha/release at 10 days interval from July second week to October first week, 2009 resulted in significantly reduced infested cane and higher cane yield (78,400 kg/ha) (fig.32).

(iii) Demonstration of *Cotesia flavipes* against the plassey borer *Chilo tumidicostalis*

AAU-Jorhat

Field demonstration of effectiveness of *Cotesia flavipes* against the plassy borer was carried out

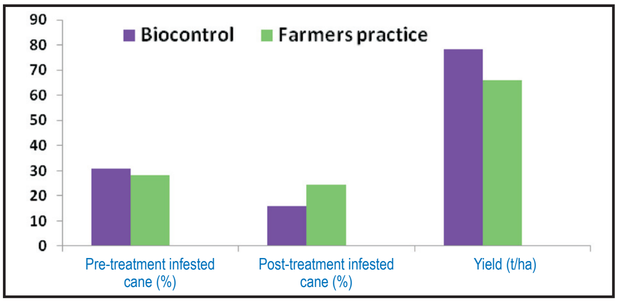


Fig. 32. Evaluation of *Trichogramma chilonis* against plassey borer

in a farmer's field on Dhansiri variety at Halowa Gaon,Golaghat district covering an area of one hectare. Four releases of *C. flavipes* were made @ 500/ha/release in mid July, August, September and October 2009. The pre-treatment and post-treatment infested cane was 28.3 and 22.5 per cent in the parasite release plot and it was 32.6 and 24.9 in farmers practice plot. The cane yield was slightly higher in the released plot (69,300 kg/ha) compared to farmers' practice (63,400 kg/ha).

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

PAU

Large scale field demonstration of *T. chilonis* against the early shoot borer *C. infuscatellus* was carried out at villages Jasso Majara (Distt. Jalandhar) and Paddi Khalsa (Distt. Kapurthala) and the results compared with chemical control. The plot size was 20 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 16). The mean per cent reduction of shoot borer incidence over control was 58.9%. The yield was significantly higher with a cost:benefit ratio of 1:21.9.

(v) Demonstration of *T. chilonis* against stalk borer of sugarcane

PAU

A field demonstration on efficacy of *T. chilonis* for the management of *Chilo auricilius* was conducted over an area of 40 ha at village Chachrari (Distt. 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 (4.8%) in the release field in comparison to control (10.8%). The per cent parasitisation was significantly higher in release fields (54.8%) as compared to control (4.6 %).

Large scale demonstration of effectiveness of *T. chilonis* against stalk borer over an area of 4500 acres was carried out in collaboration with three sugar mills of the state i.e. Doaba Co- operative Sugar Mills Ltd. Nawanshahar, Morinda Co- operative Sugar Mills Ltd. Morinda and Nahar Sugar Mills Amloh. The egg parasitoid, *T. chilonis* was released from July to October in all the three mill areas at 10 days interval @ 50,000/ha. The incidence of *C. auricilius* in IPM fields ranged from 0.7 to 9.3 per cent whereas in control it ranged from 1.7 to 27.5%. The reduction in cane damage over control in these three mills ranged from 54.4 to 66.2 per cent.

(vi) Demonstration with 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,

Table 16. Demonstration of *T. chilonis* (temperature-tolerant strain) against *C. infuscatellus* at village Jasso Majara (Distt. Jalandhar) and Paddi Khalsa (Distt. Kapurthala) during 2009.

Treatments	Incidence of *C. infuscatellus* (%)	Per cent reduction over control	Yield (kg/ha)	Cost:Benefit ratio
T. chilonis (temperature tolerant strain)	5.3[a]	58.9[a]	71,850[a]	1: 21.9
Chemical control (Padan @25kg/ha)	5.1[a]	60.1[a]	72,850[a]	1: 8.5
Control	12.7[b]	7.7[b]	64,500[b]	

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

Table 17. Demonstration of *T. japonicum* (temperature-tolerant strain) against *S. excerptalis* at village Jasso Majara and Mehli (Distt Jalandhar) during 2009.

Treatments	Incidence of *S. excerptalis* (%)	Parasitism (%)	Yield (kg/ha)	Cost: Benefit ratio
T. japonicum (temperature tolerant strain) 50,000/ha	5.7 [a]	29.9[a]	71,090 [a]	1: 22.4
Chemical control (Thimet 10G @ 30 kg/ha)	5.3 [a]	2.3 [b]	71,840 [a]	1: 7.1
Control	12.6 [b]	2.9 [b]	63,610 [b]	

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

Scirpophaga excerptalis was carried out at Jasso Majara 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 17).

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

MPKV

Field demonstration of *T. chilonis* (TTS and SAS strains) against internode borer on sugarcane revealed that six releases @ 1 lakh/ha/release were effective in reducing the pest incidence and increasing the cane yield (Table 18).

Table 18. Efficacy of *Trichogramma chilonis* against INB on sugarcane

Treatment	INB Incidence		Yield (kg/50 canes)
	Pre-release	Post-release	
T. chilonis TTS @ 1 lakh/ha	3.6 [a]	5.9 [a]	82.0 [a]
T. chilonis SAS @ 1 lakh/ha	3.8 [a]	13.2 [b]	75.2 [b]
Untreated control	3.6 [a]	24.2 [c]	71.7 [b]
CV (%)	7.8	6.4	8.3

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

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. Cultures of *M. 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 1 of *M. anisopliae* recorded 23.9% cane damage at harvest which was superior to control (32.3%) but inferior to chemical treatment (19.7%). The strain 4 recorded cane yield of 45,000 kg/ha which was superior to control (34,900 kg/ha) but inferior to chemical control (48,100 kg/ha).

b) Evaluation of entomopathogenic nematode (EPN) against termites

On var. CoLk 8102, the talk-based formulations of entomopathogenic nematodes was applied in furrow at time of planting. The germination was recorded in each row after 45 days of planting. Soil application of *Steinernema carpocapsae* PDBC EN 11@5b/ha resulted in cane damage of 25.7% at harvest which was superior to control (32.2%) but inferior to chlorpyriphos (22.4%). However, there was no significant difference in the cane yield in chemical and EPN treatment plots.

SBI

(i) Influence of egg and adult moth washings of Internode borer (INB) and Shoot borers (SB) against *T. chilonis*

The washings of INB and SB eggs were not attractive to *T. chilonis* parasitoids, however the washings of INB moths were more attractive to the parasitoid than SB moths.

When different host densities were tested for parasitization by *T. chilonis* in the laboratory, there was a type II functional response of the parasitoid to the host density at lower densities initially which turned to a type III response at higher densities. Similar tests with differing parasitoid density showed density independent parasitization levels.

(ii) Comparative virulence of GV isolates of *Chilo infuscutellus*

Bioassays revealed that the GV isolates (Karnal, KCP sugars, Sakthi, Coimbatore, Dharani, Saraswathi and Harinagar) recorded overlapping fiducial limits of the low LC_{50} values indicating uniform high virulence against II and III instar larvae. However there were marked differences in the virulence of the isolates when tested against IV instar in the mortality as well as sub-lethal effects.

(iii) The natural incidence of GV

The recovery of the granulo virus of shoot borer was possible throughout the year varying from 6.4 % to 31.2% with the highest incidence in February 2010. The fungal species *B. bassiana* and *M. anisopliae* were recovered during Sept 2009-Jan 2010 samples while *Sturmiopsis* was recorded in Sept. and Oct. 2009 samples.

5.2.6. Biological suppression of cotton pests

Monitoring the biodiversity and outbreaks of invasive mealybugs and their natural enemies

AAU-A

A regular survey in cotton fields revealed that *Aenasius bambawalei* was a dominant parasitoid of the cotton mealybug and the extent of parasitism varied from 17.16 to 48.82 % with an average of 25.65 %. Minimum (17.16%) parasitism was found during early phase of the crop which increased in subsequent weeks and reached at peak level (30.37%) during third week of September 2009. The samples collected from Pingalwada (Ta. Karjan) showed less (17.97 %) emergence of *A. bambawalei*, but registered maximum (48.82 %) parasitism during mid-October 2009.

ANGRAU

Populations of mealy bugs were monitored on *Bt* cotton crop and their bio-diversity was studied. The dominant species was *Phenococcus solenopsis* and *Maconellicoccus hirsutus* was also found.

MPKV

The survey revealed that the cotton (early and late sown), soybean, sunflower, ornamentals- rose, hibiscus, hollyhock, acalifa, and Parthenium were found attacked by the cotton mealy bug, *P. solenopsis*. In cotton, the mealybug was noticed in September-October, 2009 and in January-February, 2010 and with high intensity (27.2 mealy bugs/ 5 cm shoot) during March-April, 2010. It was primarily parasitised by *A. bambawalei* and also predated by coccinellids, chrysopids and Brumoides. In pigeonpea, outbreak of mealy bugs, *Ceccidohystrix insolita* was noticed on perennial varieties. The orchard crops like grape, guava and custard apple were attacked by *M. hirsutus* and *Ferrisia virgata,* while pomegranate, citrus and sapota were infested by *Planococcus* sp.

Natural parasitism by *A. bambawalei* and predators viz., *Spalgis epius*, *Coccinella*, *Brumoides suturalis*, *Chrysoperla zastrowi arabica* and spiders were found feeding on the mealy bugs during March-April, 2010.

PAU

In the field survey, *A. bambawalei* was prevalent in most of the districts of Punjab and the per cent parasitization ranged from 10-90%.

TNAU

The dominant mealybug species found on cotton was P. *solenopsis* which was gradually replaced by *Paracoccus marginatus* (papaymealybug) in Coimbatore, Erode and Tiruppur districts. The level of incidence was as high as 60 per cent on many crops. For, *P. solenopsis*, the hosts were cotton, sunflower, vegetable (brinjal, tomato, bhendi cucurbits), pulses and parthenium.

Phenacoccus solenopsis population was maximum (35 insects/5 cm) during June and decreased slowly during September and there was no incidence during February 2009. Multiple correlation studies with weather parameters and natural enemy activities indicated that there was a significant positive correlation with minimum temperature and significantly negative correlation with relative humidity. For every one unit increase of minimum temperature, there was an increase of 0.77 unit of the pest population and likewise unit increase in morning relative humidity resulted in decrease in pest population by 0.75 units.

Evaluation of coccinellid predators against the cotton mealybug

ANGRAU

A field experiment was laid out in Rajendranagar campus to study the efficacy of coccinellids predators on cotton mealybug. The treatments included release of *Cryptolaemus montrouzieri* @ 2-4/ infested plant at 15 days interval, release of *B. suturalis* at the same rate after 15 days and release of *Scymnus coccivora* @ 4-8/ infested plant at 15 days intervals, spraying endosulfan @ 700 g a.i./ha and untreated control.

Results indicated that among the three predators used, *C. montrouzieri* recorded lesser per cent infestation by mealy bug (graded as low) and lesser per cent infested bolls (15.3%) compared to the other two predators, *B. suturalis* and *Scymnus coccivora* which recorded higher per cent infestation (graded as medium) and higher per cent infested bolls (25.3% and 28.3% respectively) (Table 19).

Table 19. Efficacy of coccinellid predators against cotton mealybugs

Treatments	Post-release mealybug incidence (%)	Mealybug infested bolls (%)	Yield of seed cotton (kg/ha)
Release of *C. montrouzieri*	L	15.3	1612
Release of *B. suturalis*	M	25.3	1412
Release of *S. coccivora*	M	28.3	1396
Endosulfan	L	5.3	1756
Untreated control	M	40.4	1269

L: Low ; M: Medium

TNAU

Results of a similar field experiment in Coimbatore revealed that post-release mealybug incidence was lowest (10.1%) in *B. suturalis*, whereas mealybug infested bolls was lowest in *S. coccivora* release plot. The *S. coccivora* release plot also recorded highest seed cotton yield which was superior to control and inferior to farmers practice (Table 20).

Table 20. Efficacy of coccinellid predators against cotton mealybugs

Treatments	Post-release mealybug incidence (%)	Mealybug infested bolls (%)	Seed Cotton Yield (kg/ha)
Release of *C. montrouzieri*	21.3[c]	46.6	1240
Release of *B. suturalis*	10.1[a]	38.9	1335
Release of *S. coccivora*	15.2[b]	35.6	1420
Farmers' practice Dimethoate 2 ml/lit + Imidacloprid 0.5 ml/lit + Azadirachitn 3 ml/lit	11.9[a]	23.1	1530
Untreated control	50.3[d]	69.5	880

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

5.2.7. Biological suppression of tobacco pests

CTRI

(i) Studies on the influence of water quality on the efficacy of *Bt* against *Spodoptera litura*

Bacillus thuringensis var. kurstaki was applied to tobacco nursery with water with different pH. Seven days after spraying, there was no significant difference in the damage to tobacco seedlings caused by *S. litura* in different treatments. However control recorded the highest seedling damage (23.3%). Highest larval mortality of *S. litura* was recorded when *B.t.k* was applied in suspension at pH-7 (21.1%) (Table 21).

(ii) Laboratory evaluation of different isolates of HaNPV against *Helicoverpa armigera*.

Ha NPV isolates were obtained from AAU, Anand; NBAII, Bangalore; PCI, Bangalore; CTRI, Rajahmundry; Jeelugumilli and Jeddangi. The early third instar larvae of *H. armigera* were fed with diet contaminated with different isolates of NPV at five concentrations.

Table 21. Effect of water pH on the efficacy of *B. thuringensis* on *Spodoptera litura* larvae

pH	Seedlings damage after 7 days (%)	Larval mortality %
5	17.4	10.4
6	17.3	16.6
7	12.7	21.1
8	16.7	16.2
9	19.9	4.3
Control (water spray)	23.3	4.3
S.Em	0.72	2.68
CV%	7.21	36.28
P=0.05%	2.22	8.25

The results revealed that the NBAII isolate of HaNPV recorded the highest mortality of *H. armigera* larvae at all the concentrations (Table 22).

Table 22: Comparative efficacy of different Ha NPV isolates against *H. armigera*

Treatments POB/ml	Larval mortality (%)					
	Jml	PCI	AAU	NBAII	CTRI	Jdg
1.08×10^{5}	63.4	61.1	55.7	80.1	65.6	46.7
5.40×10^{4}	53.3	49.9	43.3	76.7	55.6	35.6
2.70×10^{4}	46.7	39.9	41.1	66.7	46.7	30.1
1.35×10^{4}	39.9	36.7	36.7	56.7	49.9	26.7
0.68×10^{4}	31.2	29.9	26.7	49.9	31.1	19.9
Control	9.9	6.6	7.8	4.4	4.4	5.6
S.Em	1.68	2.21	1.49	2.44	1.89	1.75
CV%	7.17	10.25	12.27	7.60	8.08	10.86
P = 0.05%	5.31	6.97	7.85	7.71	5.96	5.41

(iii) Efficacy of *Beauveria bassiana* against the tobacco stem borer

A laboratory experiment was conducted to evaluate *B. bassiana* as seed treatment, aerial spray and soil drench @ 10^{8} spores/ml against the stem borer. The results indicated that *B. bassiana* @ 10^{8} spores/ml as seed treatment, soil drench and spray was not effective in reducing the stem borer, *Scrobipalpa heliopa* incidence on tobacco.

5.2.8. Biological suppression of rice pests

Evaluation of EPN against Yellow stem borer, striped borer and leaf folder

CAU-Imphal

A Pot culture experiment was carried out to evaluate the bio-efficacy of EPNs against larvae of *Chilo suppressalis* and *Cnaphalocrocis medinalis*. Five collections of *Steinernema* from different locations of Arunachal Pradesh viz. *Steinernema* sp. (Runne) @ 8 lakh/pot, *Steinernema* sp . (Oyan) @ 8 lakh/pot, *Steinernema* sp . (2-1) @ 8 lakh/pot, *Steinernema* sp . (2-4) @ 8 lakh/pot and *Steinernema* sp. (4-2) @ 8 lakh/pot were evaluated. Chemical pesticide, profenophos @0.05% was used for comparison. The results revealed that among the EPN strains, *Steinernema* sp. (Runne) recorded the highest mortality of *C. supressalis* (60.5%) and *C. medinalis* (82.0%) whereas profenophos recorded 77.6% mortality of *C. suppressalis* and 94.0% mortality of *C. medinalis* (Table 23).

Table.23 Efficacy of *Steinernema* spp. against striped borer, *Chilo suppressalis* and leaf folder, *Cnaphalocrocis medinalis* during *kharif*, 2009

Treatments	Per cent mortality of *C. suppressalis*	Per cent mortality of *C. medinalis*
Steinernema sp. (Runne)	60.48^{b}	82.00^{b}
Steinernema sp . (Oyan)	48.98^{c}	78.00^{b}
Steinernema sp . (2-1)	46.61^{c}	74.00^{bc}
Steinernema sp . (2-4)	45.38^{c}	60.00^{c}
Steinernema sp. (4-2)	40.13^{c}	64.00^{c}
Profenophos 0.05%	77.57^{a}	94.00^{a}
Untreated control	0.00^{d}	0.00^{d}

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

KAU

Results of the pot culture experiment to evaluate the efficacy of *S. riobrave* and *S. feltiae* @ 8 lakh ijs/ pot against the yellow stem borer and leaf folder revealed that the EPN were unable to control the stem borer and the leaf folder.

OUAT-Orissa

The EPN (*S. riobrave, S. feltiae*) were applied as talc-based powder formulation and also as aqueous suspension @ 8 lakh/pot. The results indicated that the aqueous formulations of EPN are more effective than the powder formulations in recording lower incidence of dead hearts and leaf folder damage (Table 24).

Table 24. Efficacy of powder and aqueous formulations of EPN against stem borer and leaf folder

Treatments	Dead heart incidence (%)	Leaf folder damage (%)
S.riobrave aqueous formulation	12.3[a]	9.2[ab]
S. feltiae aqueous formulation	14.5[ab]	9.7[ab]
S. riobrave powder formulation	18.1[bc]	12.2[bc]
S. feltiae powder formulation	22.4[c]	14.8[c]
Carbofuran 3% G @ 33kg/ha	10.2[a]	6.2[a]
Control	29.6[d]	27.2[d]

PAU

A net house experiment was conducted to evaluate the efficacy of aqueous and powder formulations of *S. riobrave* and *S. feltiae* against the stem borer and leaf folder of rice (var. PAU 201). The EPN were applied @ 8 lakhs/ pot. The results indicated that the aqueous formulation *S. feltiae* recorded the highest mortality of 50.6 and 43.3 per cent of stem borer and leaf folder respectively. Powder formulation were interior to aqueous formulation (Table 25).

Table 25. Efficacy of EPN formulations against stem borer and leaf folder of rice

Treatments	Per cent mortality of stem borer (%)	Per cent mortality of leaf folder (%)
S. riobrave aqueous formulation	43.9[bc]	29.9[c]
S. feltiae aqueous formulation	50.6[b]	43.3[b]
S. biobrave powder formulation	29.9[d]	19.9[cd]
S. feltiae powder formulation	36.6[cd]	23.3[cd]
Chlorpyriphos 20 EC	100.0[a]	100.0[a]
Control	0.0[e]	0.0[e]

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

Survey for identification of natural enemies of gundhi bug, *Leptocorisa acuta*

NAU

In a field survey, *Trissolcus* sp. (Scelionidae) and *Oenocyrtus utethesiae* (Risbec) (Encyrtidae) were found parasitising the eggs of the rice gundhi bug, *Leptocorisa* sp. The activity of these parasitoids was high between the 39th and 41st meteorological weeks with peak parasitism (25%) being in the 40th meteorological week.

AAU-J

An unidentified egg parasitoid has been collected on the eggs of gundhi bug at Assam.

Large scale demonstration of IPM for rice pests and diseases in the farmers' field

OUAT

Large scale field demonstration was conducted on rice variety Lalat. The IPM package included (a) seedling root dip in 2% *P. fluorescens* (b) two sprays of *B. Bassiana* at 21 and 35 DAT (c) Bird perches @10/ha (d) six releases of *T. japonicum* @ 1,00,000/ ha at 10 days interval from 15 DAT (e) spraying of Bt @ 2 kg/ha, two times (f) spraying of *P. fluorescens* @ 2 kg/ha (g) spraying of neemazol @ 2.5 lit/ha and (h) auto confusion pheromone placement. The farmers' practice included 5 times spray of monocrotophos or triazophos or bufrofezin or spinosad or chloropyriphos or chloropyriphos+ and also fungicide sprays.

The results indicated that the IPM package was more effective in managing the insect pests of rice in comparison to the farmers' practice of only chemical pesticide application. The incidence of YSB, GLH and other foliar pests were significantly less in IPM package with significant increase in grain yield over the farmers' practice. In IPM package, the dead heart, white ear, Leaf folder, Case worm, Skipper and GLH population were significantly lower than that of the farmers' practice (Table 26).

AAU-J

Validation of BIPM practice carried out in an area of 300ha in three villages. The populations of GLH

Table 26. Demonstration of IPM in farmers' rice fields (OUAT, Orissa)

Treatment	GLH/hill	Dead heart (%)	White ear (%)	Leaf folder damage (%)	Grain yield (kg/ha)	Net returns over farmers practice (Rs./ha)
IPM package	4.1	5.7	6.7	5.2	4077	8384
Farmers practice	10.5	11.2	16.0	10.1	3029	

Table 27. Demonstration of IPM in farmers' rice fields in Assam

Treatment	GLH/hill	Dead heart (%)	White ear (%)	Leaf folder damage (%)	Grain yield (kg/ha)	Net returns over farmers practice (Rs./ha)
IPM package	3.6	4.6	4.6	3.5	3165	8346
Farmers practice	6.9	7.4	7.9	6.6	2865	

as well as 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 (3,165 kg/ha) than the farmers practice (2,865 kg/ha). The incidence of dead heart, white ear head and leaf folder were lower (< 5%) in IPM plot as compared to farmers' practice (Table 27).

KAU

The large scale adoption of BIPM technologies was facilitated in an area of 295 hectares in six different panchayats. There was no significant difference in leaf folder and dead heart incidence between the BIPM practice and farmers practice. However, the population of natural enemies like spiders and coccinellids was significantly higher in BIPM plots when compared to farmers plots. The grain yield was 7,925 kg/ha in BIPM plot and 7,757 kg/ha in farmers practice plot indicating that there is no significant difference between them (Fig. 33).

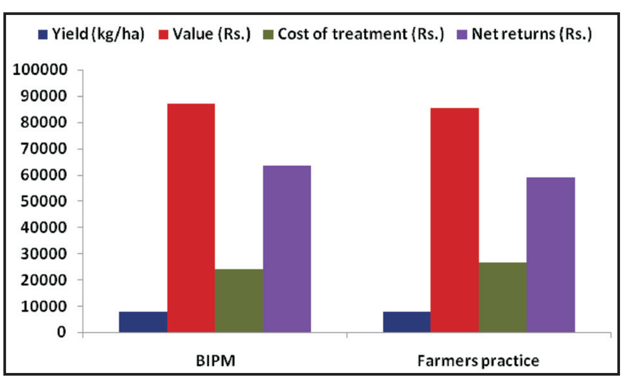


Fig. 33. Impact of IPM on rice pests and diseases (Kerala)

GBPUA & T

In a large scale demonstration covering an area of 1000 ha of Taraori basmati rice, application of a mixed formulation of *T. harzianum* and *P. fluorescens* through FYM, seed treatment and foliar spray effectively suppressed both bacterial leaf blight and stem borers in organically cultivated rice (Pusa-1121, Taraori basmati and Pusa-1). The average yield of organically cultivated Pusa-1121 was 3,250 kg/ha and that of Taraori basmati was 2,000 kg/ha and that of Pusa-1 was 4,000 kg/ha fetching a price of Rs. 2,300 and Rs. 3,500 and Rs. 2,200 per quintal respectively which was higher than conventionally grown crop.

5.2.9. Biological suppression of pulse crop pests

(i) Influence of crop habitat diversity on biodiversity of pests of pigeonpea and their natural enemies

The influence of crop habitat diversity on biodiversity of pests of pigeonpea and their natural enemies was studied. The treatments included (a) Pigeonpea intercropped with sunflower and maize as border crop (b) pigeonpea intercropped with sunflower and sorghum as border crop and (c) pigeopea as sole crop.

TNAU

The results indicated that there was no significant difference in the larval population of *H. armigera* on pigeonpea grown as either mixed and sole crop. However, significantly less (2.4) larvae of *Maruca testulalis* were recorded on pigeonpea intercropped with sunflower and border crop of maize compared to sole crop of pigeonpea (5.9). The natural enemy population was high (42), Pre-harvest pod damage also was less (18.7) and yield per 10 plants was high (6.2) on pigeonpea intercropped with sunflower with maize as border crop (Table 28).

ANGRAU

Pigeonpea intercropped with sunflower and border crop of sorghum recorded the least population of *H. armigera* larvae (23/10 plants) compared to pigeonpea intercropped with sunflower and border

Table 28. Effect of crop habitat diversity on biodiversity of pests of pigeonpea

Treatments	Larvae/10 plants		Pod damage (%)	Natural enemy population/10 plants	Grain yield kg/10 plants
	H. armigera	*M. testulalis*			
P+S+M	5.4[a]	2.4[a]	18.7[a]	42	6.2[a]
P+S+So	6.8[a]	3.3[a]	19.0[a]	29	5.9[a]
P	6.1[a]	5.9[b]	23.8[b]	6	5.0[b]

P-Pigeonpea; S-Sunflower; M-Maize; So-Sorghum
Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

crop of maize (42/10 plants) and the sole pigeonpea module (80/10 plants). Yield was also higher in the pigeonpea intercropped with sunflower with border crop of sorghum (1,256kg/ha) than the other two modules (Fig. 34).

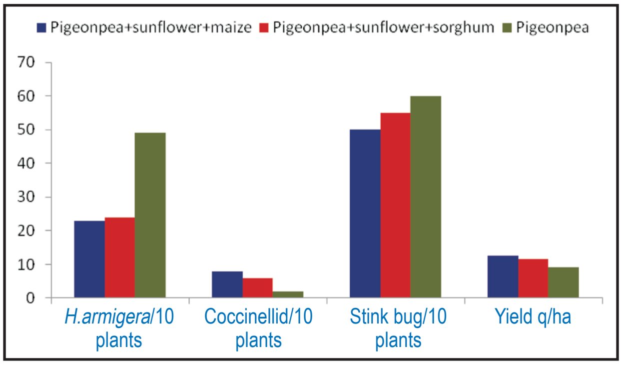


Fig. 34. Influence of crop habitat on the pests and natural enemies of pigeonpea

Pigeonpea when intercropped with sunflower (9:1) and border crop of maize recorded less pod damage by *H. armigera* at harvest compared to sole crop. Significantly higher number of *Chrysoperla* and coccinellids were registered in pigeonpea plots intercropped with sunflower and border crop of maize over the treatment of pigeonpea grown as sole crop (Table 29).

JNKVV

Population of natural enemies was more on pigeonpea when grown along with border crops compared to sole crop. The natural enemies recorded included four predators (*Cheilomenes sexmaculatus*, *Chrysoperla* group, dragon fly and mud wasps) and one parasitoid (*Cotesia* sp). Maximum population of both the natural enemies was observed on pigeonpea crop bordered with maize. Higher grain yield was recorded in pigeonpea intercropped with sunflower and maize as border crop (Table 30).

Table 30. Crop habitat influence on the incidence of pests and yield of pigeonpea in Jabalpur

Treatments	Per cent grain damage by				Grain yield (kg/5 plants)
	Pod fly	*H. armigera*	Plume moth	Pod bug	
P+S+M	13.0	3.5	4.1	4.1	0.26
P+S+So	6.1	1.7	2.3	2.0	0.21
P	7.7	2.6	2.8	2.2	0.15

Table 29. Influence of crop habitat on the pests and their natural enemies on pigeonpea in Anand

Treatments	*H. armigera* larvae/5 twigs	Pod damage (%)	Natural enemy population/ plant		Grain yield (kg/ha)
			Chrysopids	Coccinellids	
P+S+M	0.5	6.5	0.5	0.6	1225
P+S+So	0.6	7.4	0.3	0.2	1207
P	0.8	12.8	0.1	0.04	1037
S.Em±	0.03	0.52	0.02	0.05	28.73
CD at 5%	0.07	1.52	0.05	0.18	83.71
CV (%)	8.81	9.13	7.09	6.44	7.45

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

AAU- Anand

Application of HaNPV sprays @ 1.5 X 10^{12} POB/ha+0.5% crude sugar+ 0.1% Teepol and hand collection of second instar larvae recorded significantly less (3.45%) incidence of *H. armigera* in pigeonpea compared to control plot (8.83%). However, this treatment failed to suppress the pod damage due to plume moth and podfly. Significantly higher (1,274 kg/ha) grain yield was recorded in the treatment of HaNPV spray + hand picking of *H. armigera* larvae over untreated check (Table 31).

Table 31. Impact of HaNPV on pod borer complex of pigeonpea in Anand

Observations		NPV	Control
Number of *H. armigera* larvae/5 twigs		0.2[a]	0.5[b]
Pod damage by *H. armigera* (%)		4.5[a]	11.3[b]
No. of pod fly *M. obtusa* larve/100 pods		29.3	31.0
Pod damage by pod fly *M. obtusa* (%)		34.9	36.2
Pod damage (%)	*H. armigera*	3.5[a]	8.8[b]
	E. atomosa	3.5	3.7
	M. obtusa	9.0	9.8
Grain yield (kg/ha)		1,274[a]	922[b]

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

(iii) Evaluation of entomopathogens against the pod borer complex of pigeonpea

JNKVV

A field experiment was conducted for evaluating *B. bassiana* against the pod borer complex of pigeonpea. The treatments included *B. bassiana* @250 and 300 mg/l, *B. bassiana* WP @ 1.0 and 1.5 kg/ha, Bt @ 1.5 kg/ha, Spinosyn 45% SC @ 73 g a.i./ha.(Spinosyn A 50%+Spinosyn B 50%). The results revealed that *B. bassiana* WP @ 1.5 kg/ha recorded significantly less grain damage by *H. armigera* and *E. atmosa* and also recorded higher grain yield compared to *B. bassiana* SC formulation or Bt but was inferior to Spinosad (Table 32).

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

ANGRAU

A field trial was conducted at the College farm at Hyderabad during *Rabi*, 2009-10 on local variety of lablab. The treatments included *M. anisopliae*, *V. lecanii* and *B. bassiana* all @ 1X 10^8 CFUs/g, *Bt* @ 1.0 kg/ha, NSKE 5%, *Nomuraea rileyi* @ 1.5 x 10^{13} conidia/ha, Insecticidal check (Endosulfan @ 2ml/L) and Control.

Results showed that Bt @ 1 kg/ha recorded lower populations of *Adisura atkinsoni* and lesser pod damage and better yield compared to untreated control and also with all other treatments. Bt also recorded better yield compared to all other treatments and was on par with *M. anisopliae* (Table 33).

Table 32. Impact of entomopathogens on the pod borer complex of pigeonpea

Treatments	Grain Damage (%)		Grain yield (kg/ha)
	H. armigera	*E. atomosa*	
B. bassiana @ 250 mg/l	1.89[d]	2.42[d]	1,251[e]
B. bassiana @ 300 mg/l	1.43[c]	1.82[c]	1,504[d]
B. bassiana WP@1 kg/ha	0.24[a]	0.75[b]	2,200[b]
B. bassiana WP @ 1.5 kg/ha	0.23[a]	0.73[b]	2,237[b]
Bt @ 1.5 kg/ha	0.40[b]	0.97[b]	2,140[c]
Spinosad 45% SC W/W 73 g a.i./ha	0.00[a]	0.00[a]	2,943[a]
Control	3.80[e]	3.58[e]	924[f]

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

Table 33. Evaluation of microbials against *Adisura atkinsoni* on *Dolichos lablab*

Treatments	*Adisura* larvae/10 plants	Pod damage (%)	Grain yield (kg/ha)
M. anisopliae @ 1X 10^8 CFUs/g	27.67[c]	3.75[b]	3,750[a]
V. lecanii @ 1X 10^8 CFUs/g	27.33[c]	7.55[c]	2,650[b]
B. bassiana @ 1X 10^8 CFUs/g	12.00[ab]	3.59[b]	2,025[c]
Bt @ 1.0 kg/ha	11.00[a]	1.35[a]	3,650[a]
NSKE 5%s	13.67[b]	7.28[c]	1,700[c]
Nomuraea rileyi @ 1.5 x 10^{13} conidia/ha	28.00[c]	14.04[d]	825[d]
Endosulfan @ 2ml/l	28.33[c]	13.93[d]	550[d]
Control	23.30[c]	14.79[d]	550[d]

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

5.2.10. Biological suppression of oilseed crop pests

(i) Survey for natural enemies of castor pests

ANGRAU

Eggs of castor capsule borer were parasitized by *Trichogramma chilonis* (25.6%), *Trichogrammatoidea bactrae* (19.6%), *Trichogramma japonicum* (15.2%) and *Trichogramma achaeae* (14.7 %).

(ii) Evaluation of BIPM package for castor pests

ANGRAU

The BIPM package consisting of release of *Trichogramma achaeae* @ 100,000/ha, spray of *Sl*NPV @ 1.5 x 10^{12} POB/ha + 0.5% crude sugar and spray of Dipel @ 0.5 l/ha. resulted in lower incidence of *Spodoptera litura (25/10 plants), Achaea janata (23 larvae/10 plants)* and leaf hopper (233/10 plants). Yield was also higher in the BIPM package (355 kg/ha) compared to the Farmers' practice (170 kg/ha).

(iii) Biological suppression of *Spodoptera litura* and *Uroleucon carthami* in non-spiny safflower

ANGRAU

A field trial was conducted during *rabi* 2009 at the College farm, Rajendranagar on non-spiny safflower variety. The treatments included two releases of *Chrysoperla* sp. @ 6000/ha, NSKE 5%, *Sl* NPV @ 1.5 X 10^{12} POBs/ha, *Sl* NPV @ 0.75 X 10^{12} POBs/ha, *Sl* NPV @ 0.375 X 10^{12} POB/ha, *Bt* @ 1.0 kg/ha, *N. rileyi* @ 1.5 x 10^{13} conidia/ha, insecticidal check and untreated Control

The results indicated that the BIPM package did not reduce the aphid population significantly. Yield in biocontrol package was 501 kg/ha while it was 323 kg/ha in untreated control proving the efficacy of bioagents in managing the safflower aphid (Table 34).

Table 34. Biological suppression of *Uroleucon carthami* in non-spiny safflower varieties

Treatment	Aphid population (per 10 plants)		Yield (kg/ha)
	After fist application of package	After second application of package	
Biocontrol package	536	496	501
Farmers' package	255	308	604
Untreated control	1014	1217	323

(iv) Biological control of groundnut leaf miner

TNAU

A field trial was conducted in farmers' field at Aliyarnagar 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 %, a chemical check and an 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. 35).

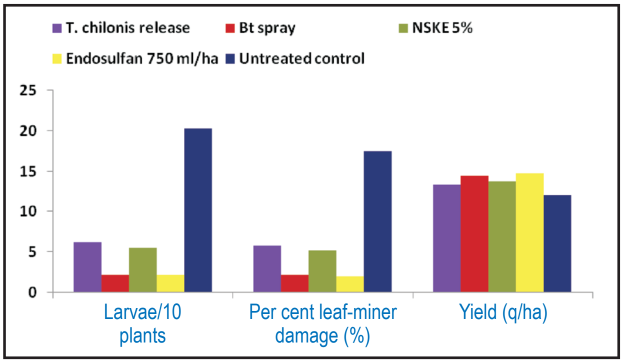


Fig. 35. Effect of *T. chilonis*, Bt and NSKE against groundnut leaf-miner at Aliyarnagar

Evalution of entomopathogens against soybean defoliators

JNKVV

A field experiment was carried out in Kharif 2009-10 to evaluate entomopathogens against soybean (var. JS-335) defoliators (*Spodoptera litura*, *Chrysodeixis acuta* and *Trichoplusia orichalcea*). The treatments included application of *B. bassiana*, *M. anisopliae* and *V. lecanii* each @ 10^{13} spores/ha + 0.2% sunflower oil + 0.01% tween-80, Dipel @ 1 kg/ha, spinosad 45% SC @ 73 g a.i./ha and untreated control.

The results revealed that B.t.k. sprayed plots recorded lowest larval number of *C. acuta* (4.3),

Table 35. Efficacy of entomopathogens against soybean defoliators

Treatments	Post-treatment larval population/ meter row		Incidence of stem fly (%)	Grain yield (Kg/ ha)
	C. acuta	*S. litura*		
B. bassiana @ 10^{13} spores/ha	5.1[b]	3.9[b]	53.3	2404[ab]
M. anisopliae @ 10^{13} spores/ha	6.1[c]	4.5[c]	66.7	2092[bc]
V. lecanii @ 10^{13} spores/ha	8.3[e]	6.3[f]	70.0	1606[e]
B.t.k. @ 10^{13} spores/ha	4.3[a]	3.6[a]	73.3	2697[a]
Dipel	7.6[d]	5.8[e]	50.0	2072[cd]
Spinosad 45% SC @ 73 g a.i./ha	6.4[c]	4.7[d]	60.0	2083[c]
Control	9.3[f]	8.0[g]	43.3	1488[e]
			NS	

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

S. litura (3.6) and highest grain yield (2697 kg/ha). Sprays of *B. bassiana* was as effective as B.t. sprays with reference to yield of grain (Table 35).

Evaluation of EPN against defoliators on on soybean

JNKVV

A field experiment was conducted to evaluate the efficacy of EPN on soybean defoliators during Kharif 2009-10 on variety JS-335. The treatments included *H. indica* talc formulation, *S. carpocapsae* talc formulation, *H. indica* aqueous formulation, *S. carposapsae* aqueous formulation each @ 2 billion IJs/ha, SlNPV @ 1.5 x 10^{12} POB/ha, Spinosad 45%SC and control.

The results revealed that lowest larval population of *C. acuta* (3.4), *S. litura* (2.4) and highest grain yield (2367 kg/ha) was recorded in *H. indica* aqueous formulation @2 b IJs/ha and it was better than spinosad application (Table 36).

5.2.11. Biological suppression of coconut pests

CPCRI

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

An outbreak of *O. arenosella* noticed in Vechoor (Kottayam district, Kerala) with leaf damage to the tune of 61.4% and larval population of 304/ 100 leaflets was brought under control by releases of parasitoids (*Goniozus nephantidis* and *Bracon brevicornis* @10 parasitoids/ palm) at monthly intervals with active participation of farmers and officials of Dept. of Agriculture, Kerala. Population

Table 36. Efficacy of EPN against soybean defoliators

Treatments	Post-treatment larval population/meter row		Per cent tunnelling by stem fly (%)	Grain yield (Kg/ha)
	C. acuta	*S. litura*		
H. indica @ 2b Ijs/ha (talc-based)	4.0[b]	3.1[b]	63.3	2182[b]
S. carpocapsae @ 2b Ijs/ha (talc-based)	4.6[abc]	3.9[bc]	73.3	2024[c]
H. indica @ 2b Ijs/ha (aqueous)	3.4[a]	2.4[a]	70.0	2367[a]
S. carpocapsae @ 2b Ijs/ha (aqueous)	5.1[c]	3.9[bc]	56.7	1999[c]
SlNPV @ 1.5 x 1012 POB/ha	6.1[d]	4.9[c]	56.7	1856[d]
Spinosad 45% SC @ 73 g a.i./ha	4.3a	3.5b	60.0	2180b
Control	9.0e	9.1d	53.3	1480e
			NS	

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

of the pest showed a sharp decline (91 % reduction) after release of parasitoids over a period of 8 months. The pest incidence also showed reduction of leaf damage from 61.4% to 39.4% during this period.

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

Field demonstration trial in 10 ha area undertaken at Alappuzha district, Kerala for management of *O. rhinoceros* by integrating biocontrol agents, *viz*., *O. rhinoceros* virus, *M. anisopliae* and pheromone trap revealed a reduction of 53.6 and 74% in leaf and fresh spindle damage, respectively over the pre treatment period.

(c) Studies on natural enemies of red palm weevil

Field collection of red palm weevil life stages did not reveal any natural infection by pathogens. Among the entomopathogenic nematodes tested, the local isolate of *Heterorhabditis indicus* was found to be more virulent inducing 92.5% mortality of red palm weevil grubs in filter paper bioassay @ 1500 IJ/grub while *H. bacteriophora* caused only 65% mortality. At the same concentration *Steinernema carpocapsae* and *S. abbasi* caused mortality only to the tune of 20% and 15%, respectively. Talc-based EPN formulation of *H. indicus* elicited higher mortality (70%) than water suspension-based formulation (<10%) on coconut petiole based bioassay.

5.2.12. 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 hopper *Idioscopus nitidulus*. The treatments included: *M. anisopliae* @1x10^9 spores/ml with sunflower oil + Triton-x @0.01%; *M. anisopliae* @1x10^9 spores/ml with sunflower oil + Triton-x @0.01% + UV protectant (Multiplex Biocontrol Ltd.) @ 0.01% and control. One spray was given on the inflorescence during the season. It was found that *M. anisopliae* @ 1x10 ^{9} spores/ml with oil and sticker caused a mean of 51 % mortality. Addition of UV protectant increased the mortality to 64.61%. Both the treatments however were at par to each other and significantly better than control.

TNAU

A field experiment was conducted in farmers' field at Unjavelampatti on ten year old Neelam mango. The treatments included T1- application of *Metarhizium anisopliae* @ 1 x 10^9 spores/ml on tree trunk during off season + two sprays during season at weekly interval; T2- application of *M anisopliae* @ 1 x 10^9 spores/ml twice at weekly interval during season alone; T-3 two sprays of imidacloprid 0.3 ml/lit one during off season+ one spray during season at flowering; T-4 one spray of imidacloprid 0.3 ml/lit during season and T-5 control.

The results revealed that application of *M. anisopliae* @ 1 x 10^9 spores/ml on tree trunk during off season + two sprays during the season at weekly interval was effective in reducing the leaf hopper population in the inflorescence (Fig. 36).

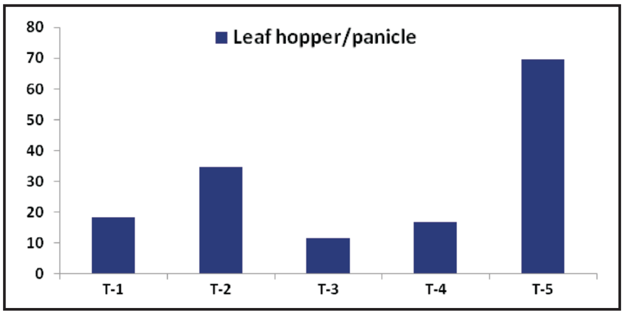


Fig. 36. Evaluation of *M. anisopliae* against mango hoppers at TNAU

MPKV

A field trial was conducted on the research farm of Regional Fruit Research Station, Ganeshkhind, Pune on Keshar mango. The treatments included: T1- Application of *M. anisopliae* @ 1 x 10^7 conidia/lit on tree trunk during off season + at flowering; T2- Application of *M. anisopliae* @ 1 x 10^7 conidia/lit on tree trunk during off season; T3- Application of *V. lecanii* @ 1 x 10^9 conidia/lit on tree trunk during off season + at flowering; T4- Application of *V. lecanii* @ 1 x 10^9 conidia/lit on tree trunk during off season; T5- One spray of imidacloprid 0.3 ml/lit during off season; T6- One spray of imidacloprid 0.3 ml/lit during off season + 1 spray at flowering period and T7- Untreated control.

The results revealed that three sprays of *M. anisopliae* @ $1x10^7$ conidia/lit on tree trunk during off season and similar sprays during flowering was effective in the bio-suppression of hoppers during flowering stage of mango (Table 37).

Table 37. Efficacy of entomofungal pathogens against the mango leaf hopper

Treatments	Mango hopper/ inflorescence	
	Pre-treatment	Post-treatment
M. anisopliae @ $1x10^7$ on tree trunk during off season + at flowering	36.5^a	13.8^b
M. anisopliae @ $1x10^7$ on tree trunk during off season	38.4^a	18.3^c
V. lecanii @ $1x10^9$ on tree trunk during off season + at flowering	33.3^a	19.8^d
V. lecanii @ $1x10^9$ on tree trunk during off season	33.6^a	22.9^e
One spray of imidacloprid @ 0.3 ml/lit during off season	29.7^a	16.2^c
One spray of imidacloprid @ 0.3 ml/lit during off season + 1 Spray at flowering period	28.2^a	8.5^a
Control	32.4^a	48.5^f

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

Evaluation of biological control agents against mango nut weevil

TNAU

Two field experiments were carried out at Paiyur and Uchavelampatti on Neelam variety. The treatments tested were: soil application of *B. bassiana* @ 300 g ($1x10^8$ CFU/g) after raking the soil followed + 5 Kg. FYM; swabbing tree trunk and foliar application of *B. bassiana* $1x10^8$ CFU/ml (T-1); soil application of *P. fluorescens* @ 300 g after raking the soil + 5 kg FYM; swabbing tree trunk and foliar application of *P. fluorescens* (T-2), tying of red ant colony @ 5/tree (T-3) , insecticidal check (T-4) and untreated check (T-5).

The results showed that raking the soil followed by soil application of *B. bassiana* @ 300 g ($1x10^8$ CFU/g) + 5 Kg FYM followed by swabbing tree trunk and foliar application of *B. bassiana* $1x10^8$ CFU/ml recorded lower nut weevil damage in both the locations. However insecticidal check is the most effective treatment in reducing the nut weevil damage (Table 38).

Table 38. Efficacy of entomopathogens against the mango nut weevil

Treatments	Per cent nut weevil infestation (%)	
	Paiyur	Unchavelampatti
T-1	18.2^b	17.23^b
T-2	22.7^c	22.1^c
T-3	25.4^c	24.2^c
T-4	10.3^a	10.9^a
T-5	57.9^d	56.9^d

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

Demonstration of biological suppression of pink mealy bug, *Maconellicoccus hirsutus* on custard apple

MPKV

A field demonstration on effectiveness of *Cryptolaemus montrouzieri* against mealy bugs on five years old custard apple (cv. Balanagar) was conducted in a farmer's field at village Sindavane (Tal. Haweli, Dist. Pune).

Inoculative release of *C. montrouzieri* @ 2,500 beetles/ha in June, 2009 was found to be effective in suppressing mealy bug population to the extent of 78.6 % with 40.2% increase in yield of marketable custard apples.

5.2.13. Biological suppression of pests of temperate fruits

Field evaluation of *Trichogramma embryophagum* against codling moth

SKUAST-Srinagar

A field trial was conducted during May to August, 2009 in four apple orchards located at Mangmore, Hardass (Gonguk), Hardass (Gond) and Shanigund at Kargil. *Trichogramma embryophagum* was released twice @ 4000 adults/tree. Post- release observations revealed that there was a significant reduction in fruit damage in treated plot at Shanigund and highest yield of fruits at Mangmore compared to control plot (Table 39).

Table 39. Impact of *T. embryophagum* on apple fruit damage

Location	Fruit damage (%)	Fruit yield per tree (Kg)
T. embryophagum (Mangmore)	55.8[b]	975
T. embryophagum (Shanigund)	43.3[a]	337
T. embryophagum Hardass (Gonguk)	54.9[b]	855
Untreated control (Hardass-Gond)	79.4[c]	375

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

Laboratory evaluation of entomopathogens against root borer, *Dorysthenes hugelii*

YSPUH & F

A laboratory experiment was conducted to evaluate the effect of *B. brongniartii* and *M. anisopliae* against grubs of apple root borer, *D. hugelii*. The entomofungal pathogens were applied at 10^5 conidia/cm^2, 10^6 conidia/cm^2 and 10^7 conidia/cm^2 and compared with chlorpyriphos (0.06%) and untreated control. Among the entomopathogens, the highest grub mortality was recorded in *M. anisopliae* @ 10^7 conidia/cm^2 followed by *B. brongniartii* @10^7 conidia/cm^2 (Table 40).

Table 40. Efficacy of entomopathogens against apple root borer, *Dorysthenes hugelii*

Treatment	Per cent mortality of root borer (%) (20 DAT)
B. brongniartii @10^5 conidia/cm^2	40.[0bc]
B. brongniartii @10^6 conidia/cm^2	46.7[bc]
B. brongniartii @10^7 conidia/cm^2	53.3[b]
M. anisopliae @10^5 conidia/cm^2	43.3[bc]
M. anisopliae @10^6 conidia/cm^2	36.7[c]
M. anisopliae @10^7 conidia/cm^2	63.3[b]
Chlorpyriphos (0.06%)	93.3[a]
Control	6.7[d]

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

5.2.14. Biological suppression of pests of vegetables

Field evaluation of thelytokous *Trichogramma pretiosum* against *Helicoverpa armigera* on tomato

Multilocation field trials were conducted to evaluate the arrhenotokous and thelytokous *T. pretiosum* against *H. armigera* on tomato. The treatments included six releases of *T. pretiosum* @ 1,00,000/ha/release from flower initiation stage at weekly interval and compared with untreated control.

MPKV

The trial was conducted on research farm at college of agriculture, Pune on tomato (var. Phule Raja). The results revealed that six releases of *T. pretiosum* thelytokous form recorded lowest number of larvae per ten plants, lowest fruit damage and highest marketable fruit yield (Table 41).

OUAT

The results revealed that thelytokous form of *T. pretiosum* was found superior in recording significantly less larvae per ten plants, reducing fruit damage and also recording significantly highest marketable fruit yield (Table 42).

Table 41. Efficacy of thelytokous *T. pretiosum* against *H. armigera* on tomato

Treatments	No. of larvae / 10 plants (post-treatment)	Fruit damage (%)	Per cent parasitisation	Yield of marketable fruits (Kg/ha)
T. pretiosum arrhenotokous	3.1[b]	16.2[b]	43.7	1,98,100[b]
T. pretiosum thelytokous	2.3[a]	12.9[a]	56.7	2,28,100[a]
Control	17.9[c]	32.2[c]		1,43,600[c]

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

Table 42. Efficacy of thelytokous *T. pretiosum* against *H. armigera* on tomato

Treatments	No. of larvae / 10 plants (post-treatment)	Fruit damage (%)	Yield of marketable fruits (Kg/ha)
T. pretiosum arrhenotokous	2.8[b]	8.8[b]	1,48,600[b]
T. pretiosum thelytokous	1.7[a]	5.3[a]	1,72,300[a]
Control	4.2[c]	17.2[c]	1,15,900[c]

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

CAU

The field experiment was conducted during rabi 2009-10 on tomato (var. Pusa Ruby) at three locations. Six releases of thelytokous form of *T. pretiosum* was found to be significantly superior in recording less fruit damage (4.61%) and marketable fruit yield (16,010 kg/ha) compared to arrhenotokous form which recorded 5.35 % fruit damage and 15,850 kg fruits per ha. In the control plot the fruit damage was 11.2% and fruit yield was 13,310 kg/ha.

MPUAT

A field experiment was conducted on tomato (var. Namdhari -UTSAV). Six releases of thelytokous form of *T. pretiosum* recorded lowest fruit damage and highest marketable fruit yield but was on par with arrhenotokous form of *T. pretiosum*. Both the treatments were superior to control (Fig. 37).

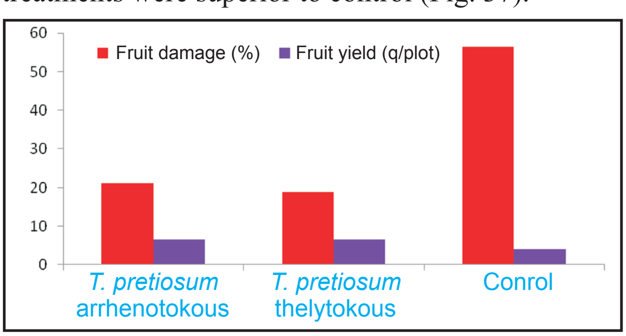


Fig. 37. Efficacy of *T. pretiosum* thelytokous form against *H. armigera* on tomato

IIHR

The field experiment was conted at reserch farm at Hessarghatta. It was observed that thelytokous population is capable of exerting better control over arrhenotokous population. Field parasitism gradually increased to a maximum of 55% from 13%. When first harvest was made, 38% thelytokous parasitoid was recovered from the field as against 27% arrhenotokous population. Data further confirmed that release of thelytokous population reduced the borer damage better compared to arrhenotokous.

TNAU

A field experiment was conducted to evaluate the efficacy of arrhenotokous and thelytokous forms of *T. pretiosum* against *H. armigera* on tomato (var. PKM1). Six releases of thelytokous form of *T. pretiosum* recorded significantly less fruit damage and highest marketable fruit yield (Table 43). Field parasitisation of *H. armigera* eggs was highest (15.5%) in plots where the thelytokous forms were released.

Table 43. Efficacy of thelytokous *T. pretiosum* against *H. armigera* on tomato

Treatments	Fruit damage (%)	Parasitisa-tion (%)	Yield of marketable fruit (Kg/ha)
T. pretiosum arrhenotokous	18.6[b]	8.0	27,600[b]
T. pretiosum thelytokous	12.6[a]	15.0	30,325[a]
Control	28.8[c]		24,675[c]

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

Biological control of cowpea aphid

KAU

A field experiment were conducted to evaluate the efficacy of *Cheilomenes sexmaculata* and *Micromus timidus* against cowpea aphid, *Aphis craccivora* on variety Anaswara. The results revealed that the aphid incidence was significantly low in *C. sexmaculata* released plots. The yield was also higher in *C. sexmaculata* released plots which was on par with chemical application (Table 44). It was concluded that *C. sexmaculata* is more efficient than *M. timidus*.

Table 44. Efficacy of predators against cowpea aphid

Treatments	Aphids/plant (post release)	Per cent plants infested	Grain yield (kg/ha)
C. sexmaculata	1.2[a]	5.0[a]	4,743[a]
M. timidus	7.1[b]	9.1[ab]	4,427[b]
Malathion 0.1%	4.7[b]	5.6[a]	4,761[a]
Control	15.4[c]	16.6[b]	4,205[b]

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

Demonstration of biocontrol-based IPM module against the pests of cauliflower

CAU

The experiment was conducted during rabi, 2009-10 in the farmers' field. The IPM module included planting of mustard as trap crop to collect and destroy *P. xylostella*; mechanical collection and destruction of egg masses and first instar larvae of *S. litura*; release of *T. brassicae* @ 1,00,000/ha against *P. xylostella*; need based application of SlNPV and application of NSKE 5%. The farmers practice included application of profenphos @ 0.05% at 30,45 and 60 DAT.

The results revealed that the population reduction of *P. xylostella* in biocontrol-based IPM plot was superior to control and inferior to farmers practice. But there was no significant difference in the population of *S. litura* larvae in biocontrol-based IPM plots and farmers practice plots (Table 45).

Table 45. Efficacy of biocontrol-based IPM on pests of cauliflower

Treatments	*P. xylostella* larvae/leaf (post treatment)	*S. litura* larvae/plant (post treatment)
Biocontrol-based IPM	0.35[b]	0.11[a]
Farmers practice	0.10[a]	0.15a
Control	0.61[c]	0.23[b]

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

Validation of biocontrol-based IPM for important pests of tomato

CAU

The experiment was conducted during rabi 2009-10 on tomato (var.Pusa Ruby) at three locations. In the IPM module, the nursery bed was treated with *T. viride* @ 50gm/sq.m tomato crop was intercropped with marigold (10:1 ratio), six releases of *T. chilonis* @ 50,000/ha were made at weekly interval, one round of *Ha*NPV was applied just after the first harvest @250LE/ha and one round of *Sl* NPV @250LE/ha was applied 40 days after transplanting, and pheromone traps of *Spodoptera litura* were installed @ 15 traps /ha. In the farmers practice blitox 50 WP was applied @ 0.25 per cent as soil drenching at 15 DAS and profenophos @ 0.05% was sprayed at 60, 75, and 90 DAT.

The results indicated that there was no significant difference in per cent plant mortality in the nursery, per cent fruit damage and marketable yield of tomato between biocontrol-based IPM plot and farmers practice (Table 46). However, both the treatments were superior to control.

Table 46. Evaluation of biocontol-based IPM against *H. armigera* on tomato

Treatments	Per cent plant mortality in nursery	Per cent fruits damaged	Yield of marketable fruits (kg/ha)
Biocontrol-based IPM	4.0[a]	4.4[a]	15,650[a]
Farmers practice	3.6[a]	4.0[a]	15,760[a]
Control	9.3[b]	10.7[b]	13,560[b]

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

GBPUAT

During Kharif 2009, field demonstrations were conducted in more than 20 farmers fields on IPM package on different vegetables crops in district Chamoli of Uttarakhand. IPM packages resulted in 32.79% increase in tomato yield, 21.46% increase in chilli yield and 13.97% increase in capsicum yield. There was 4.7% increase in yield of cabbage due to IPM package.

Farmer participatory demonstration of biocontrol-based IPM for important pests of brinjal

OUAT

Field trial was conducted at Bhubaneswar to evaluated biocontrol-based IPM against import pests of brinjal. The IPM based treatments included preparation of raised nursery bed, soil solarisation of nursery beds for 2-3 weeks, seed treatment with *T. viride* @ 4g/ka + soil application of *P. lilacinus* @ 12 kg WP along with FYM, yellow sticky trap, soil application of NSKE, pheromone traps @ 12/ha, spraying of NSKE @ 5% at weekly interval, releases of *T. chilonis* @ 50,000/ha, collection and destruction of damaged shoots and fruits, use of bacterial wilt resistant variety and spot application of insecticides for sucking pests.

The results indicated that the IPM package was far superior to the farmers practice resulting in significantly less wilt, shoot borer and fruit borer damage and significant increase in marketable yield resulting in highest net returns of Rs. 63,036 over the farmers' practice (Table 47).

Table 47. Evalution of biocontrol-based IPM against brinjal pests

	Biocontrol-based IPM	Farmers' practice
Per cent wilted plants in nursery	2.8	9.7
Per cent shoot borer incidence	8.3	18.7
Per cent fruits bored	12.9	29.5
Yield (kg/ha)	18,362	10,483
C:B ratio	1:4.5	1:1.5
Net returns over farmers' practice (in Rs.)	63,036	

IIHR

A field trial was conducted to evaluate IPM, BIPM-I, BIPM-II, insecticide against brinjal pests. The treatment consisted of IPM (Neem cake @ 250 kg/ha three times, spraying of neem soap @4% + endosulfan 2 ml/l or cypermetirin 0.3 ml/l at 15 days interval), BIPM-I (erection of pheromone trap @12/ha, release of *T. chilonis* @50,000/ha + two sprays of Bt @ 1ml/l), BIPM – II (erection of pheromone trap @12/ha, release of *T. chilonis* @50,000/ha + two sprays of Bt @ 1ml/l + maize as border crop), Insecticidal check (Coragen @ 0.3 ml/l once in 10 days) and untreated control.

The results indicated that the BIPM-II module recorded lowest fruit damage of 17.2% which was on par with insecticide (17.3) and far superior control. However, BIPM-I module recorded highest marketable fruit yield of 42,100 kg/ha which was superior even to the insecticide spray (Fig. 38).

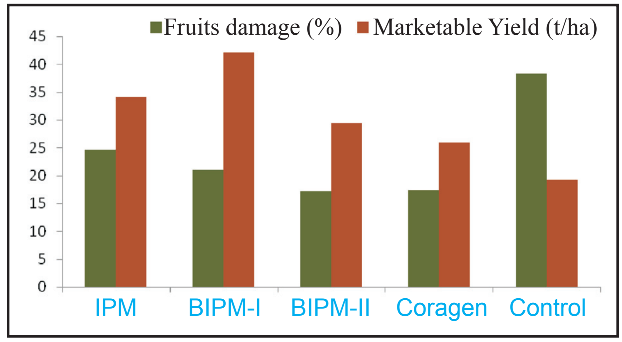


Fig. 38. Evaluation of IPM and BIPM modules against brinjal pests

Evalution of NBAII Bt strains against *Plutella xylostella*

Multilocation trials were conducted to evaluate some Bt isolates of NBAII, PDBC-BT1, PDBC-BT2 against *P. xylostella* on cabbage. These isolates were compared with HD1 standard strain along with control.

PAU

The results revealed that highest mortality of 86.2% was recorded in Bt isolate PDBC-BT1 followed by PDBC-BT2 (82.1%). The mortality recorded by the isolate PDBC-BT2 was on par with the standard check HD1 (78.6%).

AAU

The results of bioassays indicated that the Bt isolate PDBC-BT1 gave a mortality of 78.3, 68.3, 63.3% of *P. xylostella* at dilutions of 10^{-1}, 10^{-2} and 10^{-3} and these figures were 76.6, 65.2 and 61.8% in case of PDBC-BT2 at the same dilutions. However at dilutions of 10^{-6} the isolate PDBC-BT2 recorded 32.5% mortality whereas in PDBC-BT1 it was 25.4%, respectively.

5.2.15. Biological suppression of pests of cumin

MPUAT

(i) Evaluation of biocontrol agents against the cumin aphid

A field experiment was conducted to evaluate effectiveness of biocontrol agents against cumin aphid. The treatments included (a) three times release of *Chysoperla* sp. @ 50,000/ha, (b) spray of *B. bassiana* @ 1 x 10^7 spores/ha, (c) spray of *M. anisopliae* @ 1 x 10^7 spores/ha, (d) spray of *V. lecanii* @ 1 x 10^7 spores/ha, (e) spray of Azadiractin 0.03% @ 3 ml/l (f) spray of imidacloprid @ 30 g a.i./ha and control.

The results indicated that among the biocontrol agents, *V. lecanii* recorded higher aphid mortality (86.7%) which was superior to other biocontrol agents but inferior to imidacloprid. Highest grain yield was recorded in azadiractin plots (1004 kg/ha) which was significantly inferior to imidacloprid (Table 48).

Table 48. Efficacy of biocontrol agents against cumin aphid

Treatment	Per cent aphid mortality (14 DAT)	Grain yield (kg/ha)
Chrysoperla sp.50,000/ha	39.0[e]	756[f]
B. bassiana @ 1 x 10^7 spores/ha	56.4[d]	939[d]
M. anisopliae @ 1 x 10^7 spores/ha	61.2[c]	930[e]
V. lecanii @ 1 x 10^7 spores/ha	86.7[b]	951[c]
Azadiractin 0.03% @ 3 ml/l	80.3[b]	1004[b]
imidacloprid @ 30 g a.i./ha	92.4[a]	1046[a]
control	-	612[g]

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

Table 49. Effect of antagonists on the wilt of cumin

Treatments	Disease incidence (%)	Grain Yield (kg/ha)
T. harzianum (PDBC) @ 10g/kg seed & soil treatment @ 2.5 kg/ha	2.0	1135[a]
T. harzianum (RCA) @ 10g/kg seed & soil treatment @ 2.5 kg/ha	2.0	1103[a]
P. flulorescens (NCIPM) @ 10g/kg seed & soil treatment @ 2.5 kg/ha	3.0	1015[a]
T. viride (PDBC) @ 10g/kg seed & soil treatment @ 2.5 kg/ha	2.0	1071[a]
Carbendazium @ 10g/kg seed & soil treatment 2.5 kg/ha	8.0	1149[a]
Control	54.0	873[b]

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

(ii) Evalution of biocontrol agents against cumin wilt

A field experiment was conducted to evalute the effect of seed treatment by different antagonistic biopesticides on cumin wilt. The treatments included seed treatment with (a) *T. harzianum* (PDBC) (b) *T. harzianum* (RCA, Udaipur), (c) *P. fluorescens* (NCIPM), (d) *T. viride* (PDBC), (e) carbendazium and (f) control. The antagonists were also applied to soil @ 2.5 kg/ha.

The results revealed that seed treatment with *T. harzianum* (PDBC) recorded lowest disease incidence (2%) and highest grain yield of cumin (1135 kg/ha) (Table 49).

5.2.16. Biological suppression of papaya mealybugs

TNAU

A field experiment was conducted to evaluate the efficacy of *Scymnus coccivora* for the suppression of papaya mealybug, *Paracoccus marginatus*. *Scymnus coccivora* grubs were released three times @ 20/infested plant at 15 days interval. This was compared with farmers' practice of spray if imidacloprid 0.5 ml/l followed by azadiractin 1% at ml/l at 15 days interval.

The results indicated that the mealybug population was 26.7 per 25cm^2 leaf area on *S. coccivora* release plot which was significantly inferior to imidacloprid spray (21.0) and superior to control 99.7). However, the natural predators such as *Spalgis epius* and *S. coccivora* were abundant on control as well predator release plots and absent in chemical treated plot.

5.2.17. Biological suppression of white grubs

Potato

YSPUHF

A field experiment was laid out at the Agriculture Department Potato Farm, Shilaru in collaboration with HPKV, Palampur to evaluate three entomopathogenic fungi along with two species of EPN against white grubs affecting potato. The

Table 50. Efficacy of entomopathogens against potato whitegrubs

Treatments	Whitegrubs/m row (90DAP)	Mycosis (%)	Tuber damage (%)	Marketable tuber yield (kg/ha)
M. anisopliae	0.9[a]	52.6	5.6[a]	25,800[a]
B. bassiana	1.6[b]	37.2	9.4[b]	22,900[a]
M. anisopliae + *B. bassiana*	1.8[b]	39.8	8.7[a]	24,500[a]
Chlorpyriphos	1.7[b]	-	14.9[c]	23,400[a]
Control	4.2[c]	-	20.6[d]	18,700[b]

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

treatments were *B. brongniartii*, *B. bassiana* and *M. anisopliae* each @ 10^{14} conidia/ha, EPN *H. indica* and *S. carpocapsae* each @ 4 b IJs/ha along with control.

The results revealed that the whitegrub mortality was highest in *B. bassiana* (37.4%) treatment followed by *B. brongniartii* (34.3%), *S. carpocapsae* (32.4%) and *H. indica* (32.3%).

MPKV

An experiment was conducted on farmers' field at village Kolharwadi on potato (var. Kufri Jyoti) to evaluate the entomopathogenic fungi against the whitegrubs. The treatments were *M. anisopliae* enriched FYM (@2 x 10^{10} conidia/ka) @ 20 kg/plot (T-1), *B. bassiana* enriched FYM (2 x 10^{10} conidia/kg) @ 20 kg/plot (T02), *M. anisopliae* + *B. bassiana* enriched FYM @ 20 kg/plot (T03), application of chlorpyriphos 0.1% (T04) and control (T-5).

The results revealed that *M. anisopliae* enriched farm yard manure was the most effective against the whitegrubs with highest mycosis (52.6%), least tuber damage and highest marketable yield. All the fungal treatments were on a par in increasing the yield (Table 50).

Groundnut: MPUAT

A field experiment was conducted to evaluate the entomopathogenic fungi and EPN against whitegrubs attacking groundnut (var. TAG-24).

The results revealed that significantly lowest plant mortality (4.8%) and highest grain yield (1512 kg/ha) were recorded in *M. anisopliae* @ 1 x 10^{13} conidia/ha (Table 51). This tretament was however, not as good as chlorpyriphos in ehancing the yield.

Table 51. Efficacy of entomopathogens and EPN against whitegrubs in groundnut

Treatments	Plant mortality (%)	Grain yield (kg/ha)
M. anisopliae @ 1 x 10^{13} conidia/ha	4.8[a]	1512[b]
H. indica (PDBC) 13.31 @ 5 b IJs/ha	8.2[c]	1315[c]
S. carpocapsae (PDBC) EN11 @ 5 b Ijs/ha	7.4[b]	1365[bc]
B. brongniartii @ 1 x 10^{13} conidia/ha	10.7[e]	1225[cd]
B. bassiana 1 x 10^{13} conidia/ha	10.5[d]	1265[c]
B. bassiana granular formulation @ 1 x 10^{13} conidia/ha	11.2[f]	1172[d]
chlorpyriphos 20EC @ 20 ml/kg	-	1620[a]
Control	28.3[g]	860[e]

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

5.2.18. Biological suppression of termites

MPUAT

An experiment was conducted to evaluate fungal entomopathogens and EPN against termites in wheat (var. Raj-3077).

Application of *M. anisopliae* @ 1 x 10^{13} conidia/ha effectively suppressed termite damage and recorded signifcantly less plant mortality of wheat (4.6%) and higher yield (4230 kg/ha) compared to EPN but was inferior to chlorpyriphos (Table 52).

Table 52. Efficacy of entomopathogens & EPN against whitegrubs in groundnut

Treatments	Plant mortality (%)	Grain yield (kg/ha)
M. anisopliae @ 1 x 10^{13} conidia/ha	4.6^{b}	4230^{ab}
H. indica (PDBC) 13.31 @ 2.5 b IJs/ha	15.2^{e}	3845^{bc}
H. indica (PDBC) 13.31 @ 5 b IJs/ha	6.8^{cd}	4022^{b}
S. carpocapsae (PDBC) EN11 @ 2.5 b Ijs/ha	16.2^{f}	3772^{c}
S. carpocapsae (PDBC) EN11 @ 5 b Ijs/ha	4.7^{bc}	3920^{bc}
NSKE 100 kg/ha	8.2^{d}	3810^{c}
Seed treatment with chlorpyriphos 20 EC @ 5 ml/kg	3.1a	4460^{a}
Control	35.1^{g}	2660^{d}

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

5.2.19. Biological suppression of polyhouse crop pests

(i) Biological suppression of root-knot nematodes on carnation

MPKV

An experiment was laid out in Hi-Tech floriculture project, college of agriculture, Pune on carnation (var. Gaudina) to evaluate biocontrol agents against root-knot nematode. The treatments included soil application of *P. lilacinus* and *Arthrobotrys oligospora* each @ 20 kg formulated dust/ha, carbofuran @ 2 kg a.i./ha with untreated control.

Among the fungal pathogens, soil aopplication of *P. lilacinus* was found to be better with 41.1% decline in root-knot nematode population and 2.2 root knot index/plant than *A. oligospora.* However, carbofuran was significantly superior to these fungal pathogens (Table 53).

Table 53. Effect of fungal pathogens against root-knot nematodes on carnation

Treatments	Per cent decline in nematode population (post-treatment)	Root-knot index	Per cent reduction in gall index
P. lilacinus	41.1^{b}	2.2	25.5^{a}
A.oligospora	29.4^{c}	2.2	24.6^{a}
Carbofuran	83.1^{a}	2.1	28.7^{a}
Control	0.0^{d}	2.9	0.0

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

(ii) Biological suppression of root-knot nematode on tomato

MPKV

An experiment was laid out in Hi-Tech floriculture project, college of agriculture, Pune on tomato (var. Phyle Raja) to evaluate biocontrol agents against the root-knot nematode. The treatments included soil application of *P. lilacinus* and *Arthrobotrys oligospora* each @ 20 kg dust formulation/ha, carbofuran @ 2 kg a.i./ha and untreated control.

Soil aopplication of *P. lilacinus* showed 48.6% decline in root-knot nematode population and 2.3 root-knot index/plant with higher yield, followed by *A. oligospora.* However, carbofuran was significantly superior to these fungal pathogens (Table 54).

Table 54. Effect of fungal pathogens against root-knot nematode on tomato

Treatments	Per cent decline in nematode population	Per cent reduction in gall index	Fruit yield (kg/ha)
P. lilacinus	48.6^{b}	28.2	41,700^{a}
A.oligospora	37.2^{c}	23.8	40,500^{a}
Carbofuran	73.9^{a}	30.2	42,700^{a}
Control	0.0^{d}		31,700^{b}

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

(iii) Evaluation of anthocorid predator, *B. pallescens* against spider mite

A:Chillies: AAU-A

An experiment was laid out in polyhouse to evaluate *B. pallescens* against spider mite on chilly (var. Ujuala). The treatments included (a) Four releases of *B. pallescens* were done @ 10/ plant and (b) four releases of *B. pallescens* @ 20/plant at 15 days interval, (c) spraying of dimethoate @ 0.1% and (d) control.

The results indicated that four releases of *B. pallescens* resulted in post release count of 0.9 mites per plant when 10 anthocorids were released per plant, 1.4 mites per plant when 20 anthocorids were released per plant. This was inferior to chemical control and superior to control.

B:Rose

(a) MPKV

An experiment was laid out in polyhouse to evaluate *B. pallescens* against spider mites on rose (var. Passion). The treatments included (a) Four releases of *B. pallescens* @ 10/plant and (b) four releases of *B. pallescens* @ 20/plant at 15 days interval, (c) spraying of abamectin @ 0.5 m/l and (d) control.

The results indicated that four release of *B. pallescens* @ 20/plant resulted in lesser number of mites (29.2) per plant which was superior to control (91.5 mites/plant) and inferior to abamectin (17.4 mites/plant).

(b) SKUAS & T

An experiment was laid out in polyhouse to evaluate *B. pallescens* against spider mites on rose. The treatments included (a) Four releases of *B. pallescens* @ 10/ plant and (b) four releases of *B. pallescens* @ 20/plant at 15 days interval, (c) spraying of dichlorvos @ 0.5% and (d) control.

The population of spider mite declined from 43.9 to 10.7 on anthocorid released plants. A single application of dichlorvos @ 0.05% however reduced the population of spidermites to an average of 6.2/10 plants.

(iv) Biological suppression of sucking pests on carnation

TNAU

An experiment was laid out to evaluate the efficacy of bicontrol agents against aphids and thrips attacking carnation in polyhouse. The treatments included (a) spraying *B. bassiana* @ 10^8 CFU/ml (b) spraying *M. anisopliae* @ 10^8 CFU/ml (c) spraying *Hirsutella thompsonii* @ 10^8 CFU/ml (d) spraying *V. lecanii* @ 10^8 CFU/ml (e) release of *Stethorus pauperculus* (f) release of *B. pallescens* @ 10/plant (g) spraying insecticide (h) control.

Among the biocontrol agents, *V. lecanii* @ 10^8 CFU/ml recorded significantly less aphid incidence and higher number of stalks/plot which was followed by *B. bassiana* and *M. anisopliae* (Table 55). However the insecticide-treated plot was significantly superior to other treatments.

Table 55. Evaluation of biocontrol agents against aphids and thrips on carnation

Treatments	Aphids/ 10 plants	Per cent leaf damage by thrips (post treatment)	Healthy flower stalks/ plot
B. bassiana @ 10^8 CFU/ml	72^b	18.3^c	$2,780^b$
M. anisopliae @ 10^8 CFU/ml	162^c	20.8^c	$2,734^b$
Hirsutella thompsonii @ 10^8 CFU/ml	274^d	25.4^d	$2,711^b$
V. lecanii @ 10^8 CFU/ml	56^b	14.9^b	$2,800^b$
Release of *Stethorus pauperculus*	204^c	12.2^b	$2,740^b$
Release of *B. pallescens* @ 10/plant	253^d	22.4^c	$2,808^b$
spraying insecticide	63^a	6.2^a	$2,080^a$
Control	412^e	30.8^e	$2,570^c$

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

(v) Biological suppression of mites on carnation

TNAU

An experiment was laid out in polyhouse to evaluate biological control agents against mites on carnation. The tretments included (a) release of predatory mite *Amblyseius* sp. @ 10/plant (b) spraying of *B. bassiana* 10^8 CFU/ml (c) spraying of *H. thompsonii* @ 10^8 CFU/ml (d) release of *Stethorus pauperculus* (e) spraying of dicofol 18.5 EC @ 2 ml/l (f) control.

Release of *S. pauperculus* and *Amblyseius* sp. was effective in reducing two spotted spider mite followed by *H. thompsonii* and *B. bassiana*. However, spraying dicofol reduced the mite populatin significantly over all other treatments (Table 56).

Table 56. Evaluation of biocontrol agents against spider mites on carnation

Treatments	Spider mites/10 plants (post treatment)	Healthy flower stalks/plot
Amblyseius sp. @ 10/plant	17.7[b]	2775[b]
B. bassiana @ 10^8 CFU/ml	47.7[b]	2,770[b]
Hirsutella thompsonii @ 10^8 CFU/ml	36.8[d]	2,815[b]
Release of *Stethorus pauperculus*	15.8[c]	2,820[b]
spriying insecticide	3.9[a]	3,150[a]
Control	82.4[e]	1,915[c]

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

MPKV

Results of an experiment conducted in polyhouse at Hi-Tech Floriculture project at Pune on carnation (Var. Tempo) indicated that *H. thompsonii* significantly reduced the population of mites (5.0) followed by *V. lecanii* (5.6). However, abamectin was the most effective of all the treatments (Table 57).

Table 57. Evaluation of biocontrol agents against spider mites on carnation

Treatments	Mite population/flower (post treatment)
B. bassiana @ 10^8 CFU/ml	9.0[d]
M. anisopliae @ 10^8 CFU/ml	9.2[d]
Hirsutella thompsonii @ 10^8 CFU/ml	5.0[b]
V. lecanii @ 10^8 CFU/ml	5.6[c]
Release of *B. pallescens*	15.7[d]
Abamectin 1.0 EC	3.5[a]
Control	35.8[e]

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

(vi) Biological suppression of spider mites on capsicum

YSPUH & F

An experiment was laid out in polyhouse for the suppression of spider mites on capsicum. The treaments included (a) sequential application of econeem-econeem-release of *Neoseiulus longispinosus* (T-1) (b) sequential application of Melia extract-econeem-release of *N. longispinosus* (T-2) (c) three releases of *N. longispinosus* (T-3) (d) sequential application of melia extract- Melia extract- release of *N. longispinosus* (T-4) (e) three times application of profenphos (T-5) and (f) three times application of water (control) (T-6).

The results indicated that three releases of *N. longispinosus* resulted significantly less spider mites 0.8 per leaf compared to other treatments, however application of profenphos three times recorded the lowest mite population post treatment (0.2) (Table 58).

Table 58. Effect of combinations of biopesticides on spider mite on capsicum

Treatments	Mite population/leaf (post treatment)
T-1	3.5[b]
T-2	5.9[c]
T-3	0.8[a]
T-4	4.5[b]
T-5	0.2[a]
T-6	29.3[d]

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

5.2.20. Biological suppression of storage pests.

Evaluation of anthocorid predators against storage pests in rice.

An experiment was conducted to evaluate the efficiency of *B. pallescens* in suppressing *C. cephalonica* in stored rice. The results revealed that release of *B. pallescens* and *X. flavipes* @ 10,20 and 30 nymphs/10 kg rice significantly suppressed the population of *C. cephalonica* at MPKV and PAU (Table 59).

5.2.21. Biological suppression of weeds

Biological suppression of *Chromolaena odorata*

KAU

Cecidochares connexa was released in areas near Vellanikkara for the control of *Chromolaena odorata*.

Table 59. Efficacy of *B. pallescens* and *X. flavipes* against *C. cephalonica* in stored rice

Treatments	No. of corcyra moths emerged (MPKV)	Number of corcyra larvae (PAU)
B. pallescens @ 10 nymphs/10 kg	50.0[e]	26.5[a]
B. pallescens @ 20 nymphs/10 kg	28.0[c]	15.3[a]
B. pallescens @ 30 nymphs/10 kg	11.0[a]	12.3[a]
X. flavipes @ 10 nymphs/10 kg	32.0[d]	24.8[a]
X. flavipes @ 20 nymphs/10 kg	20.0[b]	17.3[a]
X. flavipes @ 30 nymphs/10 kg	9.0[a]	15.0[a]
Untreated control	79.0[f]	65.3[b]

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

Post release observations showed the presence of galls indicating that the gallfly was establishing and spreading in Kerala.

5.2.22. Large scale demonstration of proven biocontrol technologies

Rice

KAU

Large scale adoption of BIPM package of rice was demonstrated in 295 ha area covering seven villages (Ayyanthole, Avinissery, Cherpu, Ollur, Vallachira, Paralam and Koorkkenchery). The BIPM package included (a) seed treatment with *P. fluorescens* @8 g/kg, (b) five release of *T. japonicum* @ 1 lakh/ha/ release from 20 DAT at 10 days interval, (c) spraying of *P. fluorescens* @2%, (d) application of neem oil 0.5%. This was compared to farmers' practice of spraying triazophos @ 625 ml/ha and methyl parathion @ 0.05%.

The results indicated non significant difference between these two packages, however the population of natural enemies was high in BIPM package than farmers practice (Table 60).

Table 60. Effect of BIPM package on pests of rice

Parameters	BIPM package	Farmers practice
Per cent dead heart (%)	0.8	0.6
Leaf folder incidence (%)	1.0	0.6
Coccinellid/hill	0.5	0.07
Spiders/hill	1.2	0.2
White earheads (%)	0.5	1.9
Rice bug incidence (%)	0.5	1.2
Grain weight kg/ha	7,925	7,757

AAU-J

The large scale demonstration was conducted in thee villages (Majkuri Gaon teok, Hahsora chetia goan, and Pirakota) in 400 ha rice crop. The results revealed that the population of GLH/hill, per cent dead hearts and leaf folder damage was least in BIPM package compared to farmers'practice. The BIPM package recorded higher yield and higher net returns over farmers' practice (Table 61).

Table 61. Effect of BIPM package on pests of rice

Parameters	BIPM package	Farmers practice
GLH/hill (post treatment)	3.6	6.9
Dead heart (%)	4.6	7.9
Leaf folder damage (%)	3.5	6.6
Grain yield (kg/ha)	3,165	2,864
Net return over farmers practice (Rupees)	8732	-

PAU

Large scale demonstration of biocontrol was conducted in Basmati rice at Chimwali and Veeranwali khurd covering 4 ha. In biocontrol plots, seven releases of *T. chilonis* and *T. japonicum* were made each @ 1 lakh/ha at weekly interval from 30 DAT. In farmers practice two application of cartap hydrochloride (padan 4G) were given @ 25 kg/ha at 40 and 60 DAT.

There is no significant difference between biocontrol and farmers practice in basmati rice (Table 62).

Table 62. Effect of IPM package on pests of basmati rice

Parameters	Biocontrol	Farmers practice
Dead hearts (%)	0.6	0.4
Leaf folder (%)	0.7	0.3
White ears (%)	2.7	1.7
Grain yield (kg/ha)	4650	4710

Sugarcane

AAU-J

A large scale demonstration of biocontrol technology was conducted against plassy borer in the farmers field at village Dergoan in an area of 100 ha sugarcane (var. Dhansiri). The biocontrol technology included eleven releases of *T. chilonis* @ 50,000/ha at 10 days interval from second week of July.

The results indicated that the egg parasitism and per cent healthy cane was higher in biocontrol plots compared to farmers practice. The biocontrol plots recorded higher cane yield and net returns (Table 63).

Table 63. Effect of IPM package on plassy borer of sugarcane

Parameters	Biocontrol	Farmers practice
Post treatment egg parasitism (%)	34.0	14.2
Per cent healthy cane (%)	84.1	75.7
Yield (kg/ha)	78,400	65,900
Net return over farmers practice (Rs)	25,000	

Another demonstration of IPM technology was conducted against plassy borer in the farmers field at village Halowa goan in an area of 1ha sugarcane (var. Dhansiri). The IPM technology included four releases of *C. flavipes* @ 500/ha at 10 days interval from second week of July (Table 64).

Table 64. Effect of IPM package on plassy borer of sugarcane

Parameters	IPM	Farmers practice
Larval parasitism (%)	8.4	13.2
Per cent healthy cane (%)	77.5	75.0
Yield (kg/ha)	69,340	63,440

5.2.22. Biological suppression of stalk borer, *Chilo auricilius*

PAU

The efficacy of *T. chilonis* was demonstrated over an area of 40 ha at village Chachrari (Distt. Kapurthala) for the management of stalk borer, *C. auricilius*. The parasitoids were released 12 times at 10 days interval during July to October @ 50,000 ha^{-1}. The control plot was 0.4 ha. The incidence of stalk borer and per cent parasitism were recorded from both the plots.

The incidence of stalk borer in control was 10.8 per cent as compared to 4.8 per cent in release field, which resulted in 55.4 per cent reduction in damage. The parasitisation in release fields was high (54.8%) as compared to control (4.6 %). It can be concluded that 12 releases of *T. chilonis* at 50,000 ha^{-1} at 10 days interval proved effective and reduced the incidence of stalk borer by 55.4 per cent.

In another large scale demonstration conducted along with sugarmills in an area of 4500 ha, it was found that 12 releases of *T. chilonis* @ 50,000 ha^{-1} at 10 days internal during July to October reduced the incidence of stalk borer by 61.45 per cent.

Cotton

Large scale demonstration of BIPM module in Bt cotton was conducted in farmers fields. The BIPM package included (a) seed treatment with *Trichoderma* @ 8g/kg, (b) border row of maize crop around cotton, (c) bird perches @ 10/ha, (d) two to three releases of *Chrysoperla* sp. against sucking pests @ 14,000/ha, (e) spraying SlNPV @ 1 x 10^{10} POB/ha, (f) spraying NSKE @ 5%, (g) release of *Trichogrammatoidea bactrae* @ 1.5 lahh/ha/ week against pink boll worm. The farmers' practice included spray of monocrotophos and endosulfan.

AAU-Anand

The Large scale demonstration was conducted at farmers' field at Shardapur village in 1 ha area of Bt cotton (Bikaneri Narmada).

The results revealed that the population of whitefly, aphid and leaf hopper, green boll damage and locule damage were significantly less in BIPM module compared to farmers practice. The seed cotton yield was also significantly higher in BIPM package. The population of natural enemies was also higher in BIPM package compared to farmers practice (Table 65).

Table 65. Efficacy of BIPM module in suppression pests of Bt cotton (AAU-Anand)

Treatments	Sucking pests/ 3 leaves			Green boll damage (%)	Locule damage (%)	Seed cotton yield (kg/ha)
	whitefly	aphid	Leaf hopper			
BIPM module	0.9[a]	3.1a	1.5[a]	2.8[a]	3.5[a]	2,416[a]
Farmers practice	2.6[b]	5.1[b]	3.2[b]	7.3[b]	5.8[b]	1,320[b]

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

Table 66. Efficacy of BIPM package in suppression pests of Bt cotton (TNAU)

Treatments	Sucking pests/ 3 leaves			Green boll damage (%)	Locule damage (%)	Seed cotton yield (kg/ha)
	whitefly	aphid	Leaf hopper			
BIPM module	2.2[a]	2.4[a]	15.6[a]	1.5[a]	1.6[a]	2,485[a]
Farmers practice	3.5[b]	9.5[b]	17.2[b]	3.5[b]	3.6[b]	2,140[b]

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

TNAU

Large scale demonstration of BIPM package in Bt cotton was conducted in eleven farmers fields in 25ha area. The results revealed that the population of sucking pests, green boll damage and locule damage were significantly lower in BIPM plots with higher seed cotton yield (Table 66).

MPKV

The large scale demonstration on BIPM for Bt cotton was conducted on farmers' fields at village Morane over 59 ha on variety Rashi-2.

The results indicated that the populations of aphids, leaf hoppers, thrips and mealybugs were lower in BIPM package compared to farmers practice. The BIPM also recorded less locule damage and boll damage and higher seed cotton yield (Table 67).

Table 67. Effect of BIPM package on pests of Bt cotton

Parameters	BIPM	Farmers practice
Aphids/3 leaves	4.5	7.9
Leaf hoppers/3 leaves	2.5	3.0
Thrips/3 leaves	3.9	5.4
White flies/3 leaves	3.1	3.7
Mealy bugs/3 leaves	3.5	5.9
Locule damage (%)	2.3	3.3
Boll damage (%)	1.1	3.2
Seed cotton yield (kg/ha)	2,110	1,690
ICBR	1:1.96	1:0.87

PAU

The large scale demonstration of BIPM of Bt cotton was conducted at in farmers' fields at villages Khuban and Karni Khera over an area of 36 ha.

The results indicated that there was no difference between BIPM and farmers practice in reducing the populations of aphids, whiteflies and leaf hoppers, but more number of predators were recorded in BIPM plots. The farmers practice recorded slightly higher seed cotton yield than BIPM plot (Table 68).

Table 68. Effect of BIPM package on pests of Bt cotton

Parameters	BIPM	Farmers practice
Aphids/3 leaves	1.6	1.5
whiteflies/3 leaves	12.1	10.0
Leaf hoppers/3 leaves	1.7	1.6
Predators/plant	0.4	0.2
Seed cotton yield (kg/ha)	2,500	2,550

6. TECHNOLOGY ASSESSED, TRANSFERRED AND MATERIALS DEVELOPED

6.1 Technology assessed

Sugarcane

AAU-Jorhat

Large scale demonstration of effectiveness of *Trichogramma chilonis* against the plassy borer *Chilo tumidicostalis* in sugar cane was carried out in a farmer's field on Dhansiri variety at Dergaon area in Golaghat district covering an area of near about 100ha. Eleven releases of *T. chilonis* were made @ 50,000/ha/release at 10 days interval from July second week to October first week, 2009. The release of *T. chilonis* resulted in significantly reduced infested cane and higher cane yield (78,400 kg/ha) than in farmers' practice.

PAU

A large scale field demonstration on efficacy of *T. chilonis* for the management of stalk borer *Chilo auricilius* on sugarcane was conducted over an area of 4500 acres was carried out in collaboration with three sugar mills of the state i.e. Doaba Co-operative Sugar Mills Ltd. Nawanshahar, Morinda Co- operative Sugar Mills Ltd. Morinda and Nahar Sugar Mills Amloh. The egg parasitoid, *T. chilonis* was released from July to October in all the three mill areas at 10 days interval @ 50,000/ha. The incidence of *C. auricilius* in IPM fields ranged from 0.7 to 9.3 per cent whereas in control it ranged from 1.7 to 27.5%. The reduction in cane damage over control in these three mills ranged from 54.4 to 66.2 percent.

MPKV

Field demonstration of temperature-tolerant strain of *T. chilonis* and against internode borer on sugarcane revealed that six releases @ 1 lakh/ha/release found effective in reducing the pest incidence and increased the cane yield.

Plant parasitic nematodes

MPKV Rahuri

The antagonistic fungi *T. harzianum* @ 5 kg/ha and *P. chlamydosporia* @ 20 kg/ were evaluated against the reniform nematode *Rotylenchulus reniformis* in redgram (var. Vipula) in Kharif 2009 at Rahuri. Combined application of ha was the most effective in reducing the reniform nematode population (number of females) and increased the yield of pigeonpea.

Biological control of nematodes on pomegranate var. (Mrudula) in farmers orchard with soil application of *P. fluorescens* @ 20 g/m2 was most effective in reducing the root knot nematode population (34.5%) and number of root galls /5 g roots (26.7%) and increased 19.4% yield of pomegranate with 1: 11.8 ICBR

AAU, Anand

The biological control of plant parasitic cyst nematodes at farmers' field at Jambusar (Dist-Bhuruch) on pigeonpea variety BDN2 during Kharif 2009, indicated that 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.

T. harzianum + *P. chlamydosporia* @ 5.0 kg/ha talc formulation (108 spores/g) and 20kg/ha talc formulation (108 spores/g) than other treatments viz., Carbofuran @ 2.0 kg a.i./ha (100 g/m2), Vermicompost (VC) @ 1 t/ha (50 g/m2) , Neem cake (NC) @ ½ t/ha, VC+ Carbosulfan seed treatment @ 3% (W/W), NC+ Carbosulfan seed treatment @ 3% (W/W) and Carbosulfan seed treatment @ 3% (W/W.

A field experiment was conducted in pomegranate (var. Sinduri) orchard in farmers field to evaluate the biocontrol agents against cyst nematode. Significantly higher reduction of Root Knot Index (RKI) was recorded in *P. lilacinus* + mustard cake followed by *P. chlamydosporia* along with mustard cake. Significantly highest (2966 kg/ ha) yield was harvested from the plants treated with P. *chlamydosporia* + mustard cake and *P. lilacinus* + mustard cake over rest of the treatments.

IPM of rice pests

GBPUA&T, Pantnagar

In a large scale demonstration covering an area of 1000ha of Taraori basmati rice, application of mixed formulation of *T. harzianum* and *P. fluorescens* through FYM, seed treatment and foliar spray effectively suppressed both bacterial late blight and stem borers in organically cultivated rice (Pusa-1121, Taraori basmati and Pusa-1). The average yield of organically cultivated Pusa-1121 was 3,250 kg/ha and Taraori basmati was 2,000 kg/ha and Pusa-1 was 4,000 kg/ha fetching a price of Rs. 2,300 and Rs. 3,500 and Rs. 2,200 per quintal respectively which on an average is Rs.400.0 higher than conventionally grown crop.

OUAT, Bhubaneshwar

Large scale field demonstration was conducted on rice variety Lalat in five locations viz., RRTTS, Bhubaneswar, Uradah – I, Uradah - II , Narua and Adaspur. The IPM package included (a) seedling root dip in 2% P. fluorescens (b)two sprays of *B. Bassiana* at 21 and 35 DAT (c) Bird perches @10/ ha (d)six release of *T. japonicum* @ 1,00,000/ha at 10 days interval from 15 DAT (e) spraying of Bt @ 2 kg/ha, two times (f) spraying of *P. fluorescens* @ 2 kg/ha (g) spraying of nimazol @ 2.5 lit/ha and (h) auto confusion pheromone placement. The farmers' practice included 5 times spray of monocrotophos or triazophos or bufrofezin or spinosad or chloropyriphos or chloropyriphos+ and also fungicide sprays. IPM package was more effective in managing the insect pests of rice in comparison to the farmers' practice of only chemical pesticide application.

The incidence of YSB, GLH and other foliar pests were significantly less in IPM package with significant increase in yield over the farmers practice.

Large scale adoption of proven biocontrol technologies for coconut pests

CPCRI, Kayangulam

An outbreak of *Opisina arenosella* was noticed in Vechoor (Kottayam district, Kerala) infesting about 5000 coconut palms with leaf damage to the tune of 61.4% and pest population of 304/100 leaflets. The area was selected for demonstrating biocontrol technology with active participation of Officials of Dept.of Agriculture, Kerala and farmers of the area. Pre release pest incidence and count of pest stages were recorded during June 2009. Releases of larval parasitoids (*Goniozus nephantidis* and *Bracon brevicornis*@10parasitoids/palm) at monthly intervals were undertaken. The pest incidence and population showed a sharp decline after release of parasitoids.

To increase awareness and adoption of biocontrol technology for management of *Orcytes rhinoceros* using the green muscardine fungus (GMF) *Metarhizium anisopliae,* transfer of technology programmes such as on and off campus training programmes, seminars and method demonstrations were undertaken. The programme was implemented in 10 Wards of Thekkekkara panchayat of Alappuzha Dist. (covering 1000 ha.) under a DBT funded scheme. Knowledge and skill upgradation on the use of GMF for biocontrol of rhinoceros beetle to 286 participant farmers including rural women was done through off campus training programes and facilitated treatment of 264 breeding sites with *M. anisopliae* under the farmer participatory programme.

6.2 Technology developed

NBAII, Bangalore

Invert-emulsion formulation of Trichoderma (for the biological control of plant diseases, suitable as seed treatment, soil application and foliar spray)

It is a water-in-oil type (invert emulsion) formulation of *Trichoderma harzianum.* It has no components that cause phytotoxicity i.e. its component are not derived from mineral oils or any sources that cause phytotoxic effect. It has good biocontrol potential that has been verified by pot and field experiments with groundnut diseases. It has been tested as seed treatment, soil application and foliar application. It has provided good control of root rot of groundnut caused by *Macrophomina phaseolina* and *Sclerotium rolfsii.* It has a good shelf life of 8 months which is much longer compared to the 4-6 months of shelf life commercial formulations that are based on liquid fermentation.

Kairomone attractants for trichogrammatids/ Chrysopids (attractant is used for reinforcing the trichogrammatids or chrysopids populations in the field).

The kairomone attractant is based on tricosane, a compound present in the scales of lepidopteran moths along with the stabilizers and presented in the form of rubber septa. In field experiments conducted on cotton and rice, the use of these kairomone septa increased the abundance of the *Trichogramma chilonis* and *T. japonicum* respectively. Dosage is around 50 septa per ha for cotton crops and 150 septa per ha for rice crops, preferably along with the eggs of *Corcyra cephalonica* presented as bits. The advantage of using the attractant is that the repeated inundative releases of Trichogrammatids will be reduced with ultimate reduction in cost of natural enemies. And also the released and field adapted Trichogrammatids show higher searching efficiency than adults released inundatively. This will also be effective for chrysopids when used in conjunction with the tryptophan attractant.

6.3 Materials developed

DNA sequences generated and deposited

GenBank accession number GU975841 was obtained for ITS sequences of *Trichogramma achaeae*

GenBank accession number HM446251was obtained for ITS sequences of *Brontispa longissima*

GenBank accession number FJ154102 was obtained for ITS sequences of *Cheilomenes sexmaculata*

GenBank accession numbers were obtained for ITS sequences of 43 *Trichoderma* isolates

GenBank accession numbers were obtained for *tef1* sequences of 41 *Trichoderma* isolates

GenBank accession number were obtained for ITS sequences of 7 non-pathogenic isolates of *Fusarium* spp.

DNA bar codes

EPN

COI gene amplification and sequencing has been done for 12 EPN isolates to generate data for DNA bar coding to catalogue the EPN diversity and check the label claims in EPN formulations

Coconut leaf beetle *Brontispa longissima*

(Barcode Id: BRLON001-10, GenBank Accession No: HM446251 , COI -5P -670bp)

DNA barcode for the invasive pest, coconut leaf beetle *Brontispa longissima* was generated for the first time in the world. The pest is already present in Myanmar and Maldives and there is a grave threat of this pest invading India. DNA barcode will be useful for the early detection of the pest in the event of invasion to our country.

7. EDUCATION AND TRAINING

Name	Training programme	Duration	Place
B.S.Bhumannavar	Vigilance Officer training programme	25.05.2009 to 27.05.2009	NIANP, Bangalore
B. Amarnath	Handling of CAT cases & court cases	26.08.2009 to 29.08.2009	ISTM, New Delhi
K. Veenakumari	Taxanomy of Scelionidae	21.09.2009 to 30.09.2009	ZSI, Calicut
B. Amarnath	Administrative Vigilance-I	05.10.2009 to 09.10.2009	ISTM, New Delhi
M. Nagesh R. Thippeswamy	Recent advance in EST analysis & their annotation	20.10.2009 to 23.10.2009	IISR, Calicut
B. Amarnath	Administrative vigilance - II	09.11.2009 to 20.11.2009	ISTM, New Delhi
D. Sundararaju	Management of stress related disorders	5.11.2009 to 6.11.2009	NAARM, Hyderabad
G. Sivakumar	Short course on cropping system models	12.12.2009 to 16.12.2009	ICRISAT, Hyderabad
T. Venkatesan M. Nagesh	DNA bar coding of fish and marine life	3.12.2009 to 12.12.2009	NBFGR, Lucknow
S.K.Jalali B. Ramanujam P. Sreerama Kumar R. Rangeswaran	Bioinformatics applications in crop science	21.12.2009 to 23.12.2009	IARI, Pusa, New Delhi
Y. Lalitha	Technical and administrative support for consortia based research in agriculture	22.02.2010 to 27.02.2010	NAARM, Hyderabad
P.K.Sonkusare	Networking and web hosting	02.02.2010 to 03.02.2010	NAARM, Hyderabad
K. Veenakumari	Training workshop on wildlife conservation- Issues and challenges	08.03.2010 to 12.03.2010	Wildlife Institute of India, Dehra Dun
S.K.Jalali	National workshop for the sensitization of the ARIS Incharge about the uniformity guidelines for websites	19.03.2010	NBPGR, New Delhi
Satendra Kumar	Second National residential functional workshop on official languages	02.02.2010 to 03.02.2010	Hotel Sandesh The Prince, Mysore

8. AWARDS AND RECOGNITIONS

Dr. R. J. Rabindra

- Renominated "Member of Board of Management" (ICAR representative) of the University of Agricultural Sciences, Bangalore for a period of three years (2009-2012).

Dr. Chandish, R. Ballal

- Received DST Travel Grant for the trip to attend The IOBC meeting on protected cultivation at the Mediterranean Agronomic Institute at Chania, Isle of Crete, Greece and presented a research paper; 6th to 11th September, 2009. Received additional grant from IOBC towards subsistence at Chania, Greece.
- Invited as member of Board of Adjucators to evaluate a Ph D thesis on "Identification of coconut pest management practices among farmers of Kerala and validation of few farmer-friendly green strategies against selected pest insects."

Dr. Shylesha, A.N.

- Joint recipient of "International IPM Recognition Award" for Sustainable Adoption of Eggplant IPM in South Asia by the Jury of 6th International IPM Symposium held at Oregon, USA (March 24, 2009).

Dr. Venkatesan, T.

- Recognized as PG Guide by the University of Mysore in the field of Entomology for M.Sc students.

Dr. Sriram, S.

- Recognized as Chairman of the Advisory Committee for Mr. Suresh Patil, M.SC. student of Plant Pathology Department, UAS, Bangalore. The student submitted the thesis in August 2009.
- Acted as member of advisory committee of three M.Sc. (Agri) students
- Evaluated two M.Sc. thesis submitted to TNAU in the discipline of Plant Pathology
- As a Resource person to set question papers for the course 'Advances in plant virology' for the Ph.D. programme in TNAU, Coimbatore

9. LINKAGES AND COLLABORATION IN INDIA AND ABROAD INCLUDING EXTERNAL PROJECTS

Research Projects funded by lateral sources operating at National Bureau of Agriculturally Important Insects, 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 genetically improved strain of egg parasitoid *Trichogramma chilonis* with combined tolerance to insecticides and high temperature for the biological control of lepidopterous pests

DNA based early detection of post-harvest diseases in mango, banana and management using consortia of bioagents.

Development of fungal bionematicides: Scale up, post-harvest processing, storage stability, toxicology and field evaluation.

Genetic and functional analysis of novel genes from *Photorhabdus luminescens* and *Xenorhabdus nematophilus,* symtiotic bacteria associated with entomopathogenic nematodes for insect pest management.

ICAR Cess-Fund

Network Project on Biosystematics.

TMC MM1 3.3 "Development, validation, utilization and/or commercialization of bio-pesticides and bio-inoculants"

ICAR Network project: Outreach programme on Diagnosis and management of leaf spot diseases of field and horticultural crops, Title of the sub-Project: 'Biological Control of *Colletotrichum* Diseases of Chillies' (ORP on leaf spot diseases).

PhytoFuRa – An outreach programme of IISR on*Phytophthora, Fusarium* and *Ralstonia* Diseases of Horticultural and Agricultural Crops.

AMAAS (ICAR)

Microbial control of insect pests – II.

IPR

Intellectual Property Management and Transfer/ Commercialization of Agricultural Technology Scheme (up scaling of existing component i.e. Intellectual Property Right (IPR) under ICAR Head quarter scheme on management on information services).

10. AICRP / COORDINATION UNIT / NATIONAL CENTRES

With a view to fulfill the mandate of the AICRP on Biological Control effectively and efficiently, the NBAII is functioning with the following ICAR Institute-based and State Agricultural University-based centres.

Headquarters

National Bureau of Agriculturally Important Insects, Bangalore	Basic research

ICAR Institute-based centers

1.	Central Tobacco Research Institute, Rajahmundry	Tobacco, soybean
2.	CPCRI Regional Centre, Kayangulam	Coconut
3.	Indian Agricultural Research Institute, New Delhi	Basic research
4.	Indian Institute of Horticultural Research, Bangalore	Fruits and vegetables
5.	Indian Institute of Sugarcane Research, Lucknow	Sugarcane
6.	Sugarcane Breeding Institute, Coimbatore	Sugarcane

State Agricultural University-based centres

1.	Acharya N.G. Ranga Agricultural University, Hyderabad	Sugarcane, cotton and vegetables
2.	Anand Agricultural University, Anand	Cotton, pulses, oilseeds, vegetables and weeds
3.	Assam Agricultural University, Jorhat	Sugarcane, pulses, rice and weeds
4.	Dr. Y. S. Parmar University of Horticulture and Forestry, Solan	Fruits, vegetables and weeds
5.	Govind Ballabh Pant University of Agriculture and Technology, Pantnagar	Plant disease antagonists
6.	Kerala Agricultural University, Thrissur	Rice, coconut, weeds, fruits and coconut
7.	Mahatma Phule Krishi Vidyapeeth, Pune	Sugarcane, cotton, soybean and guava

8.	Punjab Agricultural University, Ludhiana	Sugarcane, cotton, oilseeds, tomato, rice and weeds
9.	Sher-e-Kashmir University of Agricultural Sciences & Technology, Srinagar	Temperate fruits and vegetables
10.	Tamil Nadu Agricultural University, Coimbatore	Sugarcane, cotton, pulses and tomato

Voluntary centres (partially funded)

1.	Jawaharlal Nehru Krishi Viswavidyalaya, Krishi Nagar, Adhartal, Jabalpur-482 004.	Pulses
2.	Maharana Pratap University of Agriculture & Technology, Udaipur-313 001.	Vegetables, white grubs and termite
3.	Orissa University of Agriculture & Technoogy Siripur, Bhubaneswar, Khurda-751 003.	Rice, Vegetables
4.	Central Agricultural University, College of Horticulture & Forestry, Pasighat-791 102.	Rice, Vegetables

Voluntary centres

1.	Chaudhary Charan Singh Haryana Agricultural University, Hisar	Sugarcane
2.	College of Agriculture, Kolhapur	White grubs, Weeds
3.	Mahatma Phule University of Agriculture and Technology	Vegetables
4.	National Research Centre for Soybean, Indore	Soybean
5.	National Research Centre for weed Science, Jabalpur	Weeds
6.	Navasari Agricultural University	Sugarcane, Coconut
7.	S.D. Agricultural University	Vegetables
8.	University of Agricultural Sciences, Bangalore	Cotton, pigeonpea
9.	University of Agricultural Sciences, Dharwad	Cotton, chickpea
10.	Vasantdada Sugar Institute, Pune	Sugarcane

11. LIST OF PUBLICATIONS

Research papers published in referreed scientific journals

NBAII, Bangalore

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MPKV, Pune

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PAU, Ludhiana

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12. LIST OF APPROVED ONGOING PROJECTS/ EXPERIMENTS

I. BASIC RESEARCH

National Bureau of Agriculturally Important Insects

1. Cataloguing of insect fauna of India, with emphasis on minor orders
2. Biosystematics of *Trichogramma* and *Trichogrammatoidea*
3. Introduction and studies on natural enemies of some new exotic insect pests and weeds
4. Biodiversity of oophagous parasitoids with special reference to Scelionidae (Hymenoptera)
5. Development of production protocols and evaluation of anthocorid predators
6. Biodiversity of aphids, coccids and their natural enemies
7. Polymorphism in pheromone reception in *Helicoverpa armigera*
8. Influence of elevated levels of carbon di oxide on the tritrophic interactions in some crops
9. Formulations of pheromones of important borer and other crop pests and kairomones for natural enemies using nanotechnology
10. Attractants for natural enemies of rice pests for use in the conservation of natural enemies
11. Studies on bee pollinators in crop-ecosystems with special reference to pulses and oilseed crops
12. Biological and molecular characterization of inter and intra specific variation in trichogrammatids
13. Selection of superior strain of *Chrysoperla carnea* and *Cryptolaemus montrouzieri* from different agro-ecosystems and their molecular characterization
14. Selection of superior strains of certain parasitoids and their characterization
15. Molecular characterization of Indian coccinellids
16. Phytophagous mites as a source of microbes for harnessing in pest management
17. Standardization of solid state fermentation conditions and development of prototypes with semi-automation for the mass production of *Trichoderma* spp.
18. Management of bacterial wilts of tomato land brinjal caused by *Ralstonia solanacearum* through *Bacillus* spp.
19. Biological control of *Alternaria* leaf blight of tomato
20. Isolation, characterization and toxicity of indigenous *Bacillus thuringiensis* strains against lepidopterous pests
21. Isolation and characterization of plant growth promoting endophytic bacteria and development of improved formulations
22. Mass production and exploitation of entomopathogenic nematodes against white grubs from diverse habitats
23. Nematode-derived fungi and bacteria for exploitation in agriculture
24. Data base on entomopathogenic nematodes

AICRP on Biological Control

I. Biodiversity of biocontrol agents from various agro-ecological zones

Trichogramma – All centres

Chrysoperla – All centres

Goniozus and Braconid species (KAU, ANGRAU, CPCRI, TNAU, OUAT, AAU-J)

Cryptolaemous (except SKUAS & T) – All centres

Spiders – All centres

Insect-derived EPNs – All centres

Soil samples for isolation of antagonistic organisms – All centres

Anthocorids – All centres

Bio-diversity of insect pests and their natural enemies in horticultural ecosystems (YSPUH & F)

II. BIOLOGICAL SUPPRESSION OF PESTS AND DISEASES IN FIELD

Plant diseases and nematodes

1. *In vitro* screening of available isolates of antagonists for their tolerance to abiotic stresses (i.e. cold, drought, salinity) and their performance under rain-fed conditions of hills and plains (normal soils) (GBPUAT)
2. Field evaluation of promising strains under rain-fed conditions (GBPUA&T)
3. Field validation of biocontrol technologies (GBPUA&T)
4. Introduction of new antagonists in a consortium formulation of biocontrol and biofertilizer agents (GBPUA&T)
5. Impact assessment of biocontrol technologies transferred to the farmers of Uttarakhand through AICRP on Biological control (GBPUA&T)
6. Biological control of plant diseases and nematodes using antagonists (Collaboration with AICRP on plant parasitic nematodes, MPKV, Rahuri)
7. Biological control of post-harvest fruit rot in Mango land papaya using yeasts (GBPUA & T, AAU-A, PAU)

III. BIOLOGICAL SUPPRESSION OF SUGARCANE PESTS

1. Demonstration on the use of *T. chilonis* (temperature tolerant strain) against early shoot borer (PAU, CCSHAU)
2. To study the influence of plant structural complexity on the behavior of *T. chilonis* (SBI)
3. To standardize group rearing of the host for mass production of GV of *C. infuscatellus* (SBI)
4. To collect GV isolates from different factory zones and assess the virulence of GV isolates on *Chilo infuscatellus* (SBI)
5. Evaluation of *Metarhizium anisopliae* against termites (IISR)
6. Termite control with Entomopathogenic Nematodes (IISR, PAU, NBAII)

IV. BIOLOGICAL SUPPRESSION OF COTTON PESTS

1. Monitoring the biodiversity and outbreaks of invasive mealybugs and their natural enemies on horticultural/ field/ medicinal land aromatic crops (MPKV, TNAU, AAU-A, ANGRAU, PAU)
2. Evaluation of coccinellid predators against cotton mealybug (AAU-A, ANGRAU, MPKV, PAU, TNAU)

V. BIOLOGICAL SUPPRESSION OF TOBACCO PESTS

1. Effect of water quality on the performance of *B.t.K* and entomopathogenic fungi, *viz. Nomuraea rileyi* and *Beauveria bassiana* against *S. litura* / *H. armigera* in tobacoo (CTRI)
2. Comparative study on performance of different isolates of *H. armigera* NPV from coastal A. P.

3. Studies on the performance of *B. bassiana* and *Pseudomonas fluorescens* as endophytic microbes in suppression of tobacco stem borer *Scrobipalpa heliopa* (CTRI)

4. Development of software and field manuals for identification and utilization of bioagents for alternative cropping systems to tobacco (CTRI)

VI. BIOLOGICAL SUPPRESSION OF RICE PESTS

1. Preliminary evaluation/ screening of EPN against YSB, striped borer and leaf folder in rice (KAU, GBPUAT, AAU-J, PAU, CAU, OUAT)

2. Survey for the identification of potential natural enemies of the gundhi bug, *Leptocorisa* sp. (KAU, AAU-J, PAU, CAU, NAU, TNAU)

3. Studies on Granulosis virus of rice leaf folder, *Cnaphalocrocis medinalis* (KAU)

4. Evaluation of different microbial formulations for the management of rice panicle mite, *Stenotarsonemus spinkii* (ANGRAU, NAU)

5. Large-scale demonstration of IPM for rice pests and diseases in the farmer's field (OUAT)

6. Efficacy of pheromone mediated auto-confusion technology against rice yellow stem borer, *Scirpophaga incertulas*

VII. BIOLOGICAL SUPPRESSION OF PESTS OF MAIZE

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

VIII. BIOLOGICAL SUPPRESSION OF PULSE CROP PESTS

1. Influence of crop habitat diversity on biodiversity of pests of pigeonpea and their natural enemies (TNAU, ANGRAU, AAU-A & JNKVV)

2. Impact of bio-suppression of *H. armigera* on the incidence of other lepidopteran pod borer species of pigeonpea (AAU-A, JNKVV)

3. Microbial control of *H. armigera* and *Adisura atkinsoni* on *Dolichos lablab* (ANGRAU)

4. Fixing economic threshold level for NPV application for the control of *Helicoverpa armigera* on chickpea (PAU)

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 *Spodoptera litura* and *Uroleucon carthami* in non spiny safflower varieties (ANGRAU)

4. Biological control of groundnut leaf miner (TNAU)

5. Evaluation of entomophagous pathogens against pests defoliators infesting soybean (JNKVV)

6. Preliminary screening of EPN against *Spodoptera litura* in soybean (JNKVV, NRC soybean)

IX. BIOLOGICAL SUPPRESSION OF COCONUT

1. Large area demonstration of integrated biocontrol technology against *Oryctes rhinoceros* (CPCRI)

2. Studies on natural enemies of red palm weevil (CPCRI)

X. BIOLOGICAL SUPPRESSION OF PESTS IN TROPICAL FRUITS

1. Large scale field evaluation of *Metarhizium anisopliae* against mango hoppers (TNAU)

2. Evaluation of biological control agents against mango nut weevil (TNAU)

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. Studies on the predators of phytophagous mites on apple and beans (YSPUH&F)

4. Laboratory evaluation of some bioagents against the root borer *Dorysthenes hugelii* as pest of apple (YSPUH&F)

5. Biological control of phytophagous mites on apple/ beans/ rose (YSPUH&F)

XII. BIOLOGICAL SUPPRESSION OF PESTS OF VEGETABLE CROPS

1. Preliminary field evaluation of thelytokous *Trichogramma pretiosum* against *Helicoverpa armigera* of tomato (YSPUH & F, MPKV, PAU, OUAT, CAU, MPUAT, IIHR, TNAU)

2. Demonstration of biological control of DBM and other lepidopteran pests on cabbage (IIHR, PAU)

3. Survey for parasitoids of *Liriomyza trifolii*, the serpentine leaf miner of tomato (YSPUH & F)

4. Developing biointensive package for the pests of cole crops (YSPUH & F)

5. Biological control of cowpea aphid (KAU)

6. Demonstration of biocontrol based IPM module against pests of cauliflower (CAU)

7. Validation of bio-control based IPM for important pests of tomato (CAU)

8. Farmer participatory demonstration of bio-control based IPM for important pests of brinjal (CAU, OUAT, IIHR)

9. Biological control of cabbage aphids (*Brevicoryne brassicae*) (SKUAST-S)

10. Evaluation of PDBC Bt strains (PDBCBT1 and PDBCBT2) against *Plutella xylostella* and *Helicoverpa armigera* (TNAU, PAU, AAU-A)

XIII. BIOLOGICAL SUPPRESSION OF PESTS OF SEED SPICES

1. Evaluation of different bioagents against cumin aphid (MPUAT, NRC Seed spices, NBAII, CAZRI, Jodhpur)

2. Evaluation of biocontrol agents against cumin wilt (MPUAT*)

XIV. BIOLOGICAL CONTROL OF TEA MOSQUITO BUG

1. Survey for the natural enemies of tea mosquito bug Guava (IIHR, TNAU), Cashew (TNAU), Tea (KAU)

XV. BIOLOGICAL CONTROL OF MEALYBUGS

1. Monitoring biodiversity and out breaks for invasive mealybugs on horticultural crops (IIHR)

2. Biological control of cotton mealybug (*Phenacoccus solenapsis*) (ANGRAU, TNAU, AAU-A, MPKV, PAU)

3. Biological control of papaya mealybug, *Paracoccus marginatus* (TNAU, IIHR)

4. Standardization of mass production technique for papaya mealybug parasitoid *Cladiscodes sacchari* (TNAU)

5. Evaluation of ciccinellid predators against papaya mealybug (TNAU)

6. Evaluation of some biocontrol agents for the control of brinjal mealybug, *Coccidohystrix insolitus* (OUAT)

XVI. BIOLOGICAL SUPPRESSION OF WHITE GRUBS

1. Biological control of scarabaeids (*Brahmina cariacea*) in potato (YSPUH & F in collaboration with HPKV, Palampur)

2. Biological suppression of scarabaeids infesting groundnut (MPUAT)

XVII. BIOLOGICAL CONTROL OF TERMITES

1. Augmentation of microbes for biological suppression of termite in wheat (MPUAT, RAU, Bikaner, RARS, Durgapur, Station trial to be conducted and to be included in AICRP white grubs)

XVIII. BIOLOGICAL SUPPRESSION OF PESTS IN POLYHOUSES

1. Biological management of root-knot nematodes infesting tomato and carnation in polyhouses (KAU, MPKV, YSPUH & F, GBPUAT, AAU-A, ANGRAU, TNAU, SKUAS & T) (In linkage with AICRP-Nematodes)
2. Evaluation of anthocorid predator, *Blaptostethus pallescens* against spider mites in polyhouses (All centres with polyhouses) (New & ongoing KAU, MPKV) + All centres of AINP- Acarology except KAU and USPUH & F)
3. Evaluation of biological control agents against sap sucking pests of ornamentals under polyhouse conditions (all centres with polyhouses)
4. Evaluation of biological control agents against mites in carnation under polyhouse conditions (TNAU) with AINP (Acarology)
5. Biocontrol of greenhouse whiteflies (GHWF) on beans/ cucumber/ rose under polyhouse conditions (YSPUH & F)

XIX. BIOLOGICAL SUPPRESSION OF STORAGE PESTS

1. Evaluation of anthocorid predators against storage pests in rice (TNAU, MPKV, ANGRAU, PAU)

XX. BIOLOGICAL SUPPRESSION OF WEEDS

1. Biocontrol of *Chromolaena odorata* utilizing *Cecidochares connexa* by inoculative release (KAU, AAU-J)

XXI. ENABLING LARGE SCALE ADOPTION OF PROVEN BIOCONTROL TECHNOLOGIES

1. **Rice** (AAU-J, KAU, PAU, NCIPM)
2. **Brinjal** (IIHR)
3. **Sugarcane**
   - i Demonstration of biocontrol for the suppression of Plassey borer, *Chilo tumidicostalis* using *Trichogramma chilonis* and *Cotesia flavipes* (AAU-J)
   - ii Use of *Trichogramma chilonis* temperature-tolerant strain (TTS) against early shoot borer, *Chilo infuscatellus* (PAU)
   - iii Use of *Trichogramma chilonis* for the suppression of the stalk borer *Chilo auricilius* (PAU)
   - iv Use of *Trichogramma japonicum* for the suppression of top borer (*Scirpophaga excerptalis*) of sugarcane
4. **Bt Cotton** (ANGRAU, AAU-A, PAU, MPKV, TNAU, UAS, Raichur)
5. **Coconut**
   - i Surveillance and need-based control of coconut lef caterpillar, *Opisina arenosella* in Kerala, Tamilnadu and Andhra Pradesh (CPCRI, KAU, TNAU, ANGRAU)
   - *ii* *Oryctes rhinoceros* management using *Metarrhizium aniosopliae* var. *major* and *baculovirus* in Andhra Pradesh (ANGRAU)

13. CONSULTANCY, PATENTS AND COMMERCIALISATION OF TECHNOLOGY

NBAII

- Quality testing of 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*, and other microbial biocontrol agents 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

XIIIth Research Advisory Committee Meeting held from 26-27 June, 2009

The thirteenth Research Advisory Committee Meeting was held in the conference hall of National Bureau of Agriculturally Important Insects, Bangalore from 26-27 June 2009 under the chairmanship of **Dr. A. N. Mukhopadhyay** . The other members who attended the meeting were Dr. T. P. Rajendran, ADG (PP); Dr. B. S. Parmar; Dr. C. Manoharachary; Dr. D. J. Patel; Dr. C. A. Viraktamath and Dr. R. J. Rabindra.

Dr. R. J. Rabindra, Director welcomed the Chairman and the Members of the RAC and briefed them about the activities of the newly formed Bureau and detailed how the existing research projects were re-oriented to the mandate of NBAII. He stressed the need for harnessing the natural enemies and to give biocontrol inputs in the farmers' field for sustainable agriculture. He summarized the salient achievements of research work done during 2008-09.

Dr. A. N. Mukhopadhyay, the Chairman of the RAC in his opening remarks 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 developing and promoting sustainable Bio-Intensive Pest Management (BIPM) methods and conservation and utilization of other beneficials like the pollinators and other insects was crucial to increasing the food production.

The RAC reviewed the action taken report on various recommendations made during the previous RAC held on 18th August, 2008. Then the scientists made a detailed presentation on the progress of work under the individual institute projects during the year 2008-09.

In view of the elevation of the PDBC to the National Bureau of Agriculturally Important Insects, the RAC had detailed discussion on the road map for the research activities of the bureau.

The following recommendations emerged out of detailed discussions on the projects:

New areas of research for the newly created NBAII

1. Inventory of alien pests-tracking of invasives and anticipatory and strategic research-develop linkages for CBC
2. Strengthening of biosystematics of insect pests and mites as well as beneficial with application of molecular tools including DNA bar-coding
3. Research on intra species diversity of pests, natural enemies and beneficials.
4. Pollinator diversity, floral biology and conservation.
5. Detritivore diversity.
6. Establishing national and international linkages for development of data bases for insect bio-resources.
7. Genetic enhancement of beneficial insects for enhancing their usefulness in agriculture.
8. Research on identification of useful genes to be taken up on long term basis
9. Exploitation of insect-derived beneficial microbes in pest management.

General Recommendations

1. Since the PDBC has been up-graded to NBAII, one or two more entomologists can be added to the RAC.
2. A functional linkage should be established with the proposed new National Institute of Biotic stress management.
3. The success story of biological control of the sugarcane woolly aphid may be highlighted appropriately including one high level press conference.
4. Scientists involved in formulation of microbials may be sent for training at Agriculture Chemical Division IARI/Institute of Pesticide Formulation Technology.
5. The data- base on biocontrol agents may be uploaded on the web site.
6. Information on identification service to be included in the report in future.
7. Colour compendium of selected natural enemies with identification guide may be published.

Scientific points

1. Facilities may be developed for further research in recording insect songs which might help in insect identification. Better equipment may be procured for the song analysis.
2. In addition to morphological characters, molecular identification also should be supplemented in the taxonomy of Trichogrammatids.
3. The intra-species diversity in *Trichogramma achaea* needs to be studied.
4. The proposal for the introduction of strains of *Anagyrus kamali* should be re-examined for full justification. Attempts may be made to colonize *Cecidochares connexa* on *Chromolaena* in humid areas.
5. A careful study may be made to identify mirids predating on *Phenococcus solenopsis*.
6. *Helicoverpa armigera* from different agroclimatic zones maintained at CICR, may be utilized for studies on polymorphism/tritrophic interaction. The impact of elevated levels of Co2 on the tritrophic interaction may be studied on a) *Helicoverpa armigera* on tomato and b) *Plutella xylostella* on cabbage.
7. The field efficacy of *Micromus timidus* against *Aphis craccivora* may be assessed through the AICRP on Biological Control. The scientist can supply the nucleus culture of *M. timidus* along with a protocol for mass rearing the same so that the AICRP scientists mass produce and conduct the field trials.
8. Identify nano-particles suitable and safe in agriculture system as dispensers of insect pheromones. A continuous search for data on safety of nano particles should be made. The mechanism of slow release of nano formulations should be clearly understood.
9. NBAII can develop linkage with AICRP on Honey Bees and pollinators for studies on role of non-Apis pollinators in agriculture.
10. WHO protocol should be followed while formulating WP formulations of EPN and also the existing WP formulations of all bio-pesticides should be tested for suspensibility and wettability, wet sieving, acidity/alkalinity and pH and other standard parameters
11. Standard protocol may be followed for column assay on scarabaeidae with EPN. Bio efficacy studies maybe conducted in bigger cement pots. The expertise available at AICRP on white grub unit, UAS, GKVK may be consulted.
12. The rust of *Mikania* (*Puccinia spegazinii*) has not established in the field under Indian conditions and hence the institute project on *Mikania* may be kept in abeyance. Similarly the control of parthenium with the rust fungus *Puccinia partheniicola* may not work under field conditions. In the project on mite-derived fungi, only pathogenic forms should be focused. A new project on microbial interaction in different soil types with reference to biocontrol agents should be initiated.
13. Details of prevailing/ambient temperature should be given when information on shelf life of microbial formulations are presented.

14. NBAII isolates of *Bacillus* should also be tested against *Ralstonia solanacearum*

15. Duration of seedling dip with antagonistic organisms may be restricted to two minutes instead of 30 minutes. In view of launching of the PhytoFuRa project, the programme needs to be re-oriented.

16. Bio-efficacy of antagonistic formulations should include percentage germination of seeds in addition to seedling mortality. The formulations of promising isolates of antagonists should be tested initially in small field plots at NBAII.

17. Scientists working on microbial formulations should test the shelf life under a pressure of 25 g/cm^2.

18. The nomenclature of the invert emulsion may be clearly defined. Seed dressing formulation of antagonists also needs to be developed.

Institute Research Council Meeting held on 25th June, 2009

The Institute Research Council Meeting of the NBAII, Bangalore was held on 25th June, 2009 under the Chairmanship of **Dr. R. J. Rabindra**, Director, NBAII. The following scientists presented the report on the targets achieved for the period 01-04-2008 to 31-03-2009 and also technical programme for 2000-10.

Dr. R. J. Rabindra, Director and Chairman of the IRC welcomed all the scientists. **Dr. B. S. Bhumannavar**, Member Secretary presented the action taken report followed by the remarks by the Director, the Chairman of the IRC. The chairman pointed out that monitoring of the research projects by respective laboratory chiefs is crucial to carrying out the envisaged research programme successfully. It was decided that the lab chief will hold monthly meetings with the scientists to discuss the progress of research problems encountered, follow up action on IRC and RAC recommendations etc.

A need was felt to clearly justify the role of Co-PI as identified in RPF-I with the actual execution of the research project. The PIs are also advised to hold frequent interaction with the Co-PI to ensure that there is a meaningful participation by the whole team. It was agreed that the Director will take up the quarterly reviews of new projects to ensure that the scientists are facilitated to take up various research activities without major problems. Following this brief interaction the scientists presented their research work.

After detailed discussions on the presentations on the achievements as per the targets given in their respective projects following points emerged out as recommendation for the on-going projects.

- Cataloguing of insects under some important minor orders was presented in RPF-I. However it was suggested that Dr. Poorani should give a brief proposal for cataloguing one of the major orders of the agriculturally important insects. The scientist should submit a proposal for sending the dead specimens for identification in order to get the permission of the Plant Protection Adviser.
- The scientist working on Trichogramma taxonomy should indicate the live cultures of species that are maintained for further utilisation.
- The scientist working on oophagous parasitoids was advised to concentrate on the oophagous parasitoids of agricultural pests.
- In the Introduction of exotic natural enemies project efforts should be made to introduce new biocontrol agents for *Mimosa diplotricha* and re-introduction of eucalyptus gall wasp parasitoids.
- Anthocorids have been found to be efficient predators of coconut black headed caterpillar and mites. It was suggested that for commercialization a business development plan for anthacorid production should be prepared.
- *Micromus timidus* has been identified as an efficient predator of *Aphis craccivora*. It was suggested that *A. craccivora* may be incorporated in the AICRP trials as one of the biocontrol components.
- In biodiversity of aphids, coccids and their natural enemies project, surveys may be conducted in mega biodiversity hot spots

- Based on the information collected on the diversity of pollinators, a hypothetical model for conservation strategy for selected ecosystems should be developed.
- In the project on the influence of elevated levels of carbon di-oxide, as suggested in the RAC, held on 26-27th June, 2009, the studies may be focused on a) *Helicoverpa armigera* on tomato and b) *Plutella xylostella* on cabbage/cauliflower.
- In the proposed study on variations in pheromones due to polymorphic forms of *H. armigera,* the target crop was identified as tomato. *H. armigera* populations from diverse geographical locations (locations should be defined) should be studied for variations in the pheromone interaction. As suggested in the RAC, different populations available at CICR, Nagpur may be obtained for the study.
- Studies on nano formulations should be restricted only to pheromones of *H. armigera* and brinjal shoot and fruit borer. The methodology should be defined. As suggested in the RAC, information should be updated on the safety of nano-formulations.
- In the project on biological and molecular characterization of inter and intra specific variation in trichogrammatids, the work may be intensified including more populations collected through the AICRP.
- The research work on *Cotesia flavipes* should focus on enhancing the biological attributes particularly longevity to enable commercial scale mass production. The improved strain of *Goniozus* identified in the project may be given to AICRP centre for evaluation.
- In addition to the populations of chrysopids available at the bureau, the scientist should also study the different populations of chrysopids supplied by AICRP centres.
- The work needs to be intensified in nematode-derived fungi and bacteria for exploitation in agriculture
- Mass production of EPN has been attempted on different host insects and data on the yield of EPN and different lepidopteran species were presented. It was suggested that the bioassay should be conducted to study the effect of host insects on the virulence of the EPN. In all studies involving white grub species identity should be established.
- The work on mite-derived fungal pathogens needs intensification with special attention to pathogenic forms.
- The project on the biocontrol of *Mikenia* may be kept in abeyance since none of the rust isolates has established so far in Assam and Kerala. A new project on interaction of soil microbes with biocontrol agents like *Trichoderma* spp, *Pseudomonas flulorescens* and other antagonistic organisms like *Paecilomyces*, *Metarhizium*, *Beauveria* etc may be proposed.
- In the project on biological control of Alternaria leaf blight of tomato, the scientist expressed problems encountered in the farmers fields, it was advised that the trial may be conducted at IIHR. It was decided that 19 isolates of *Verticillum lecanii* should be sent to TNAU for evaluation against the papaya melaybug *Paracoccus morginatus*.
- A new project on semi automation of solid state prototype to be developed should facilitate temperature control as well as sterilization process.
- A technology of solid state fermentation of Bt needs to be developed. The scientist should now come out with a standard formulation (mixtures, spores and crystals) for testing the same in this current season through the AICRP on Biological Control. Work should also be initiated on the solid state fermentation technology for mass production of Bt.
- The work needs to be intensified on isolation and characterization of plant growth promoting endophytic bacteria and development of improved formulations

- The scientist was advised to gear up the research activities in the project on Management of bacterial wilts of tomato and brinjal caused by *Ralstonia solanacearum* through *Bacillus* spp.

Institute Management Committee Meetings

XVI IMC Meeting

The XVI IMC meeting was held on 21st March, 2009, at NBAII under the chairmanship of Dr. R. J. Rabindra, Director. The other members who attended the meeting were Dr. S. Prabhukumar, Dr. K. Prabhudas, Dr. M. Edward Raja, Dr. K. P. Jayanth, Mr. S. Bilgrami and Mr. B. Amarnath.

The committee recommended the following:

Construction of Repository building at Hebbal campus of NBAII at 72.28 lakhs and Insectory building at Attur campus at NBAII at 74.31 lakhs. Purchase of Microscope (Rs. 15.0 lakhs), Arthropod collection equipment kit (Rs. 10.0 lakh) instead of Dehumidifier (rs. 5.0 lakhs), Arthropod collection equipment kit (Rs. 20.0 lakhs).

XVII IMC Meeting

The XVII meeting was held on 6th October, 2009. A presentation was made in the IMC held on 6.10.09 on the major thrust areas of research of NBAII, for which tie ups/linkages with other national and international institutions are required so that NBAII's mandate can be fulfilled. These include characterization and documentation of insect biodiversity, monitoring for invasives/exotic pests, exploratory surveys for biocontrol agents including exchanges, utilization of beneficial insects, and documentation on pest management systems and databases.

The IMC recommended the proposal of replacement of HPLC with gradient pump, detectors with software, (which is obsolete and the suppliers (Spinco Biotech Pvt. Ltd, Bangalore) is not be able to provide service support for this system) on buy-back with limited tender. The following equipments were recommended under equipment costing less than 5.0 lakhs category under XI plan funds.

Equipment	Qty	Approx. Cost (Rs. in lakh)	Indentor
Digital water bath	1	1.00	Dr. G. Sivakumar
Incubation chamber	1	4.50	Dr. K. S. Murthy
Microwave oven	04	0.90	Dr. G. Sivakumar, Dr. T. Venkatesan, Dr. B. Ramanujam, Dr. R. Rangeshwaran
Electronic balance	1	2.00	Dr. K. S. Murthy
Liquid Nitrogen Container	2	1.50	Dr. K. S. Murthy
Hot Air Oven	5	3.20	Mr. C. B. Dasan, DR. C. R. Ballal, Dr. T. Venkatesan, Dr. B. Ramanujam, Dr. G. Sivakumar
Gel Doc System	1	4.00	Dr. K. S. Murthy
Data Acquisition	1	4.50	Dr. N.Bakthavatsalam
2D Gel System	1	3.00	Dr. R. Rangeshwaran
Pre Freezer	1	3.00	Dr. R. Rangeshwaran
Vortex Shaker	1	1.90	Dr. T. Venkatesan
Bench Top Ph. Meter	1	0.25	Dr. G. Sivakumar
Refrigerated Incubator Shaker	1	4.80	Dr. G. Sivakumar
Orbital Low Speed Shaker	1	1.00	Dr. G. Sivakumar
BOD Incubator	3	2.80	Dr. K. S. Murthy, Mr. C. B. Dasan, Dr. S. Sriram
Total		38.35	

The Committee the proposal for purchase of Generator of 100 KV for the quarantine laboratory in place of one lift which is approved in the EFC.

The Committee approves the proposal of consultancy charges amounting to Rs.1,00,000/- in terms of Johl's committee's recommendation from the following DOW Agro Sciences Consultancy projects. .

Bioefficacy studies of Cotton and Maize Tissues : Rs.50,000/-

Baseline susceptible studies of pests of cotton and maize against *Bt.* Proteins : Rs.50,000/-

The committee emphasized the need to meet the target of atleast 80% expenditure before December 2009.

XVIII IMC Meeting

The XVIII meeting was held on 11th December, 2009. A presentation was made on "Anticipatory and Strategic plans for the Alien invasive pest, the coconut leaf beetle *Brontispa longissima"* by Dr. R. J. Rabindra, Director, NBAII, Bangalore .

IMC recommended for procurement of new computers (with an estimated cost of Rs.18.00 lakh under plan/Non-Plan -34 Computers) under plan replacing the old ones having outdated configuration under buy-back scheme.

The IMC recommended that the two outdated laptop computers can be replaced under Non-plan budget following codal formalities.

The IMC approves the following two civil works

(i) The construction of a gas room at Attur Farm is urgently to be done at an approximate cost of Rs.2.50 lakh under Non-Plan (minor works) to carry out studies on climate change

(ii) Providing cauvery water connection to Guest House/Hostel/Administrative Block/Labs/ Quarantine building from the sump. The estimated cost is Rs.2.50 lakh (Non plan minor works). An amount of Rs.5.00 is provided under minor works of non-plan.

The IMC recommended the proposal for additional bore wells at a cost of 5.3 lakhs. The proposal for the replacement of kitchen cabinets at a cost of 2.7 lakhs is approved subject to availability of funds under fixtures.

The committee recommended the following equipments costing less than 5.0 lakhs to be purchased under the XI Plan EFC funds under that category

Name of the equipment	Value Approx. (Rs.)
Vacuum filter pump (1 No.)	46,575
Refrigerated incubator shaker (1 No)	4,00,000
Refractometer (1 No.)	12,375
Photocopier (1 No.)	2,50,000
Printer/Scanner 8 Nos	1,31,000
Deep Freezer	60,000
Stereozoom Microscope	4,53,077
Spectro photometer	4,50,000
Server for Library	3,00,000
Digital Cameras (8 Nos.)	1,82,800
Video camera (2 No.)	47,000
Computer desktop (5 Nos.)	2,50,000
Autoclave	50,000
Magnetic Stirrer (2 Nos.)	1,50,000
Malaise Trap	30,000
Global position system	1,50,000
Binoculars (5 Nos.)	1,00,000
Server for ARIS	3,90,000
Glow sign board (3 Nos.)	1,28,025

The committee approves the additional allocation of Rs. 4.0 lakhs to meet from the overall savings under the head Plan – Equipment for the import of GC-EAD from M/s. Syntech, Germany EAD and Agilent Technologies, (USA) for the Gas Chromotograph

The IMC recommended for the import of the following equipments subject to the availability of funds under the head Plan- Equipments as approved in the EFC.

Equipment and Quantity	Total value in Rs.	Company name
Autoclave (2 Nos.)	8,46,600	Tomy Digital, Japan
Microscope accessory (Cell-D software)	1,83,105	Olympus, Singapore
Microscope Accessories (Drawing tube, measuring of graticule)	1,77,540	Olympus, Singapore
Microscope Accessory (Camera attachment)	2,30,000	Leica, Germany
Stereo zoom Microscope (1 No.)	15,07,000	Leica, Germany
Research Microscope with image analyzer (1 No.)	4,99,402	Olympus, Singapore
Stereo zoom Microscope (1 No.)	5,33,860	Olympus, Singapore
Gel-Rocker (1 No.)	71,810	Labnet, USA

The IMC recommends the proposal of purchase of one generator of 100 KVA capacity at an approximate cost of Rs.10.00 lakh from out of the savings of Rs.10.05 lakh under the equipment Compactor (Moveable aisle) system for insect collections sanctioned in the XI plan EFC as item No.20 subject to the condition that:

a) The total sanctioned amount for equipment shall not be exceeded

b) All codal formalities for getting the proposal vetted by the CPWD will be followed

15. PARTICIPATION OF SCIENTISTS IN CONFERENCES, MEETINGS, WORKSHOPS, AND SYMPOSIA IN INDIA AND ABROAD

NBAII, Bangalore

Rabindra, R. J.

- On 17th April, 2004 reviewed the progress of work of AICRP Centre at Dr.Y.S.Parmar University of Horticulture and Forestry, Solan.
- Reviewed the progress of work of AICRP centre at Assam Agricultural University, Jorhat on 20th April, 2009.
- Reviewed the progress of work of AICRP on BC centre at CPCRI, Kayangulam on 4th and 5th May, 2009.
- Reviewed the progress of work of AICRP centre at ANGRAU, Hyderabad on 22nd June, 2009 and delivered a lecture in ICAR sponsored summer school in biological control.
- Reviewed the progress of work of AICRP centre at CTRI, Rajamundry on 29.6.09
- Reviewed the progress of work of AICRP centre at OUAT, Bhubaneshwar on 19th August, 2009.
- Reviewed the progress of work of AICRP centre at TNAU Coimbatore and held discussions with Director, CPPS and Vice Chancellor on Rice Biocontrol and papaya mealy bug biocontrol on 1st September, 2009.
- On 8th September, 2009 left for JNKVV, Jabalpur for the review of the progress of work of the AICRP centre.
- Reviewed the progress of work of AICRP centre at KAU, Thrissur on 29th September, 09
- Reviewed the progress of work of AICRP centres at SBI and TNAU, Coimbatore on 30th September, 2009.
- Reviewed the progress of work of AICRP Centre at SKUAS&T, Srinagar on 16th October, 2009.
- Reviewed the progress of work of AICRP at College of Agriculture, Pune on 30.10.09 in the forenoon of 30th October, 2009.
- On 31st October, 2009 forenoon reviewed the progress of work of AICRP centre at ANGRAU, Hyderabad.
- Reviewed the progress of work of AICRP centre at PAU, Ludhiana on 6th November, 2009.
- 9th November, 2009 forenoon reviewed the progress of work of AICRP centre at Maharana Pratap University of Agriculture and Technology, Udaipur.
- Reviewed the progress of work of a new AICRP centre at College of Horticulture and Forestry, Central Agricultural University, Pasighat.
- On 5th January 2010 after noon reviewed the progress of work of AICRP centre at JNKVV, Jabalpur.
- On 25th February, 2010 Reviewed the progress of work of AICRP centre at IISR Lucknow.
- On 19th March, 2010 reviewed the progress of work of AICRP centre at G.B. Pant University of Agricultural Sciences and Technology, Pantnagar.

Poorani, J.

- Attended the Review meeting of the Network Project on Insect Biosystematics held at NBAII, Bangalore, on 12-13 March 2010 and presented the annual report for NBAII centre.
- Attended one CAC meeting and four CIC meetings of the NAIP project, "Effect of abiotic stresses on the natural enemies of crop pests: *Trichogramma, Chrysoperla, Trichoderma,* and *Pseudomonas* and mechanism of tolerance to these stresses" and presented the reports for the assigned research component.
- Attended a one-day National Consultation workshop on "Advancing the Science of Taxonomy in India for Biodiversity Conservation" in Bangalore on February 23, 2010" and helped in drafting the recommendations.

Ballal, C. R.

- The IOBC meeting on protected cultivation at the Mediterranean Agronomic Institute at Chania, Isle of Crete, Greece and presented a research paper; 6th to 11th September, 2009
- Interactive Meeting of NCIPM-PDBC and presented Work done at PDBC under the Cotton Mission Mode Project TMC MM1 3.3 during 2008-09.
- The XVIII Biocontrol Workers Group Meeting at Assam Agricultural University, Jorhat during 29th to 30th May, 2009.
- Symposium on 'Bio-safety and Environmental Impact of Genetically Modified Organisms and Conventional Technologies for Pest Management' during 20-21st November, 2009 organized at ICRISAT – Patancheru, Hyderabad (AP).
- The Xth Annual Discussion Meeting on Molecular strategies in Insect Plant Interactions: Role of Chemical Ecology in Host Specialisation at University of Madras, Chennai on 22nd Nov, 2009.
- The National Conference on Plant Protection in Agriculture through Eco-friendly techniques and traditional farming practices at SKRAU, Durgapura. The conference was organized by the Dept of Entomology, Agriculture Research Station, S K Rajasthan Agricultural University, Durgapura, Jaipur 18-02-2010 to 20-02-2010.
- The Annual Meeting of the Cotton Mission Mode Project TMC MM1 3.3 at CICR Nagpur on the 20th March, 2010.

Veenakumari, K.

- Attended Workshop on AICRP Biocontrol at AAU, Jorhat, Assam from 29-30th May, 2009.
- Attended training for 8 days on the identification of different genera of Scelionidae under Dr. K. Rajmohana, Zoological Survey of India for Western Ghats, Calicut.
- Wildlife Conservation: Issues and Challenges' sponsored by Department of Science and technology in the Wildlife Institute of India, Dehradun from 8-12 March, 2010.

Sivakumar, G.

- The International conference on Plant Pathology held at IARI, New Delhi from 10-13, November, 2009 and presented a paper on Evaluation of soil solarization, fungicides and biocontrol agents for the management of *Phytophthora* infections in black pepper nursery.

Bakthavatsalam, N.

- Xth Discussion meeting on entomology held at Chennai during 22-11--2009.and presented a paper Molecular basis of olfaction in *Drosophila*: A potential tool for semiochemical research by Bakthavatsalam, N , Tuhin Subhra Chakrabarthy, Obaid siddiqi and Rabindra R. J. 2009.
- Annual Work Seminar at NCBS, Bangalore and presented a paper on Agonism and antagonism in olfactory receptors in *Drosophila melanogaster* By Srikanya Kundo, Bakthavatsalam, N., Tuhin Subra Chakraborty, Komban,. S. J. and Obaid Siddiqi. 2009.

- Concept note on *Scope of the use of pheromones and semiochemicals for the management of mealy bugs*. Presented on the Brain storming session on sucking pests conducted at IIHR during 5-6th December 2009.

- Nano technology in Agriculture held at Mubai during 26-27th March 2010, and presented a Concept note on development of nanoformulations of brinjal fruit and shoot borer pheromone.

Rangeshwaran, R.

- First Asian PGPR Congress for Sustainable Agriculture' held at Hyderabad from 21 to 24th June 2009 and presented a paper on 'role of chickpea endophytic bacteria in plant growth promotion and induction of systemic resistance' By Rangeshwaran, R., Ramanujam, B. and Sriram, S. 2009.

- 7th Pacific Rim Conference on the Biotechnology of Bt and its Environmental Impact, held at Delhi from 25th to 28th November, 2009 and presented a paper titled Isolation and characterization of indigenous *Bacillus thuringiensis* for toxicity against *Helicoverpa armigera*' by R. Rangeshwaran, K. Veena Kumari, K. Revathi, G. Sivakumar and N. Vajid. 2009.

- 'Bio-safety and Environmental Impact of Genetically Modified Organisms and Conventional Technologies for Pest Management' at ICRISAT – Patancheru, (AP) from 19-11-09 to 22-11-09 and presented a paper entitled 'Evaluation of environmental safety of microbial pesticides' by R. J. Rabindra, R. Rangeshwaran, S. Sriram and B. Ramanujam. 2009.

Gandhi Gracy

- National Seminar on Speices : Improving productivity and Quality with focus on Himalayan Spices. Held on 22-24 October, 2009 at UAS&T of Jammu, India and presented a paper titled 'Laboratory evaluation of botanicals against chilli mite *Polyphagotarsonemus latus* (Bank)' by Rai, A.B., Gandhi Gracy, R., Satpathy, S., Kodandaram, M. H., Akilesh Kumur and Shivalingaswamy. T. M. 2009.

Sreeramakumar, P.

- Fifth International Conference on Biopesticides: Stakeholders' Perspectives organised by the Society for Promotion and Innovation of Biopesticides (SPIB) in collaboration with The Energy and Resources Institute (TERI), Stein Auditorium, India Habitat Centre Complex, New Delhi, 26-30 April 2009.

- National Consultation on Biological Weed Management held at the Directorate of Weed Science Research, Jabalpur, 17-18 March 2010 and delivered an invited lecture.

Deepa Bhagat

- Nanotechnology in agriculture held at Mumbai during 26th -27th March 2010 and presented a Concept note on Development of nanoformulations of brinjal fruit and shoot borer pheromone in the Brainstorming session.

CPCRI, Kayangulam

Chandrika Mohan

- Attended the "XVIII th Workshop of AICRP on Biological Control of Crop Pests and weeds" held at AAU, Jorhat during 29-30 May, 2009 and presented the work on Biocontrol of coconut pests.

- Participated in the Interaction Meeting of Entomologists of Horticulture Division of ICAR Institutes during 10-11 June 2009 at CISH, Lucknow

- Attended the Workshop cum training programme for technical support group constituted for 'Replanting and rejuvenating coconut seedlings" of CDB on 6/7/09

- Attended Research Advisory Committee meeting of CPCRI during 17-18 December 2009 at CPCRI, Kasaragod

IISR, Lucknow

Arun Baitha

- XVIII Biocontrol Workers Group Meeting on Biological Control of Crop Pests & Weeds at AAU, Jorhat (Assam) on 29-30 th May 2009.
- Group Meeting on Advances in Plant Disease Management at IISR, Lucknow on 12 th March, 2010.

IIHR, Bangalore

Ganga Visalakshy. P.N.

- International conference on Biopestiicdes-Stake Holders Perspectives organized by Society for promotion oand innovation of biopesticides with TERI, held at India Habitat Centre, Delhi from 26- 4-09 to 30-4-09.
- National conference on Biotechnology and Microbiology in Human Welfare –the Indian Scenario at Modi Institute of Technology and Science, Deemed university, Sikar, Rajasthan, from 26-27 September, 2009.
- Interactive meeting on Management of Mealy bugs in Horticultural and Agricultural Crops, held at IIHR on 5th to 6th December, 2009 at IIHR, Bangalore
- Attended the group meeting on Leaf hoppers, Plant hoppers & Psyllds, on 5th to 6th December, 2009 at IIHR, Bangalore.

Krishnamoorthy, A.

- International conference on Biopestiicdes- Stake Holders Perspectives organized by Society for promotion and innovation of biopesticides with TERI,held at India Habitat Cent International conference on Biopesticides- Stake Holders Perspectives held at India habitat centre, Delhi from 26- 4-09 to 30-4-09.
- XVIII Bio-control workers group meeting on biological control of crop pests and weeds at Assam Agri.University, 27.5.09 to 29.5.09.
- Interactive Interaction meeting of Entomologists of ICAR Institutes of Horticulture Division (June, 10-11, 2009) at CISH, Lucknow.
- Meeting on Management of Mealy bugs in Horticultural and Agricultural Crops, held at IIHR on 5th to 6th December,2009, at IIHR, Bangalore.
- Group meeting on Leaf hoppers, Plant hoppers & Psyllds, on 5th to 6th December,2009 at IIHR, Bangalore Annexure -4.
- Meeting on Brain storming session on Okra. Held at IIVR, Varanasi, 3-4, January, 2010.
- National conference on Production of Quality Seeds and Planting material – Health Management in Horticultural Crops, NASC Complex, 11-14 March, 2010 New Delhi.

AAU, Anand

Patel, B.H.

- National Conference on Plant Protection in Agriculture through Eco-friendly Techniques and Traditional Farming Practices organized by Department of Entomology, Agri. Res. Station, Jaipur (Rajasthan) under the aegis of Entomological Research Association, Udaipur on February 18-20, 2010.
- State level seminar on ‘Organic farming for environmental safety and agriculture sustainability’ held at Navsari during 6-7 March, 2010.

Korat, D. M.

- State level seminar on ‘Organic farming for environmental safety and agriculture sustainability’held at Navsari during 6-7 March, 2010.

Jani, J. J.

- National Seminar on “Zoology, life processes & Nanotechnology” held at Goa on 8th -10th February 2010.
- Krushi mela, farmer’s meeting and other special occasions as per the directives received from Directorate of Extension Education, AAU, Anand.

ANGRAU, Hyderabad

Rahman, S .J.

- Summer school on "Role of Biological Control and in IPM vis – a vis Insect Resistance Management" as a Guest Speaker in Summer school on IRM strategies in RARS, Lam, Guntur on 17-11-2009.
- National Symposium on "Climate change, Plant Protection and Food Security" held at Directorate of Research, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal on 17-19 December,2009 and delivered a talk on "Changing role of biological control in IPM under present agricultural scenario".

Dr. YSPUH&F, Solan

Sharma P. L.

- National Symposium on Lifestyle Floriculture: Challenges and Apportunities, organized by Indian Society of Ornamental Horticulture at Dr YS Parmar University of Horticulture and Forestry, Solan w.e.f. March 19-21, 2010 and presented a paper titled Studies on pathgenesis of local isolate of *Nomuraea rileyi* (Farlow) Samson against *Spodoptera litura*(Fabricius) (Noctuidae : Lepidoptera)*"*by Kumar Ajay, Sharma PL and Gupta PR entitled "presented by Sharma PL. Abstract No. 3.42, pp. 71-72.
- XVIII Biocontrol Workers' Group Meeting, held by the Project Directorate of Biological Control, Bangalore on May29-30, 2009 at Assam Agricultural University, Jorhat.
- "Entrepreneurship development programme on microbial pesticides" organized by Zonal Technology Management and Business Planning Development Unit, IARI, New Delhi w.e.f.31-08-09 to 03-09-09.

KAU, Thrissur

Lyla, K. R.

- XVIII Biocontrol workers group meeting held at Assam Agricultural University, Jorhat on 29th and 30th May, 2008.

MPKV, Pune

Pokharkar, D. S.

- Stake holders' meeting with QRT of NCIPM on 04/4/2009 at Sakhar Sankul, Pune and discussed the status of biopesticides production, constraints in their use and availability to users.
- Research Review Committee Meeting in Plant Protection - Agril. Entomology and Nematology held at MPKV, Rahuri on 16th April 2009 and presented the research report of the project.
- XVIII Biocontrol Workers' Group Meeting of AICRP on Biological Control of Crop Pests and Weeds at Assam Agricultural University, Jorhat, presented the research report of the project and finalized the research programme for the year 2009-11.
- One-day seminar on 'Production Technology of Potato' at NRCOG, Rajgurunagar on 11th Sept. 2009 organized by FARMS, Pune and SOURCE foundation, Pune.
- Research Programme Planning Meeting for 2010-11 organized by Head, Department of Entomology, MPKV, Rahuri at Biocontrol Lab. Hall, and presented and discussed the technical programme of AICRP on Biocontrol.
- Research Review Meeting on 26/8/2009 called by the Associate Director of Research, NARP (PZ), Ganeshkhind, Pune-411007 and explained the progress of research trials and activities of the project.
- 63rd Meeting of Board of Studies on September 9-10, 2009 at the Department of Entomology, MPKV, Rahuri and finalized the syllabus of the UG course 'Mass Production of Bioagents and Biopesticides'.
- Research Review Meeting 2009-10 organized by the Director of Research, MPKV, Rahuri in ADR Meeting Hall, NARP, PZ, Ganeshkhind, Pune on 05/02/2010 and presented progress of research work carried out in 2009-2010.

Nakat, R. V.

- Stake holders' meeting with QRT of NCIPM on 04/4/2009 at Sakhar Sankul, Pune and discussed the status of biopesticides production, constraints in their use and availability to users.
- Research Review Committee Meeting in Plant Protection - Agril. Entomology and Nematology held at MPKV, Rahuri on 16th April 2009 and presented the research report of the project.
- XVIII Biocontrol Workers' Group Meeting of AICRP on Biological Control of Crop Pests and Weeds at Assam Agricultural University, Jorhat, presented the research report of the project and finalized the research programme for the year 2009-11.
- One-day seminar on 'Production Technology of Potato' at NRCOG, Rajgurunagar on 11th Sept. 2009 organized by FARMS, Pune and SOURCE foundation, Pune.
- Research Programme Planning Meeting for 2010-11 organized by Head, Department of Entomology, MPKV, Rahuri at Biocontrol Lab. Hall, and presented and discussed the technical programme of AICRP on Biocontrol.

Tamboli, N. D.

- Two days training on Techniques in fermenter technology at MPKV, Rahuri on 30 and 31/12/2009.

PAU, Ludhiana

Naveen Aggarwal

- XVIII All India Biocontrol Workers' Group Meeting of AICRP on Biological Control of Insect Pests and Weeds held at Assam Agricultural University, Jorhat on May 29-30, 2009.
- 9th Agriculture Science Congress on Technological and Institutional Innovations for Enhancing Agriculture Income, June 22-24, 2009, SKAUST, Sri Nagar.
- Research and Extension Specialists Workshop for *Rabi* crops August 18-19, 2009 at PAU, Ludhiana.
- National Symposium on 'Cotton opportunities and Emerging Threats' held at CICR, Nagpur from September 2-4, 2009.
- *Kisan Mela* at PAU, Ludhiana on September 18-19, 2008.
- Research and Extension Specialists Workshop on Vegetable, Fruit and Flower Crops (December 16-17, 2009) at PAU, Ludhiana.
- Group meeting on 'Expression of Interest in Entomology' held on March 2-3, 2010 at PAU, Ludhiana.

Rabinder Kaur

- XVIII All India Biocontrol Workers' Group Meeting of AICRP on Biological Control of Insect Pests and Weeds held at Assam Agricultural University, Jorhat on May 29-30, 2009.
- *Kisan Mela* at PAU, Ludhiana on September 18-19, 2008.
- Research and Extension Specialists Workshop on Vegetable, Fruit and Flower Crops (December 16-17, 2009) at PAU, Ludhiana.
- National Conference on Plant Protection in Agriculture through Eco- Friendly techniques and traditional farming practices held at Agricultural Research Station, Durgapura, Jaipur, February 18-20, 2010.
- Group meeting on 'Expression of Interest in Entomology' held on March 2-3, 2010 at PAU, Ludhiana.

Neelam Joshi

- Research and Extension Specialists Workshop for *Rabi* crops August 18-19, 2009 at PAU, Ludhiana.
- *Kisan Mela* at PAU, Ludhiana on September 18-19, 2008.

- Research and Extension Specialists Workshop on Vegetable, Fruit and Flower Crops (December 16-17, 2009) at PAU, Ludhiana.
- National Conference on Plant Protection in Agriculture through Eco- Friendly techniques and traditional farming practices held at Agricultural Research Station, Durgapura, Jaipur, February 18-20, 2010.
- Group meeting on 'Expression of Interest in Entomology' held on March 2-3, 2010 at PAU, Ludhiana.

Sudhendu Sharma

- Research and Extension Specialists Workshop for *Rabi* crops August 18-19, 2009 at PAU, Ludhiana.
- *Kisan Mela* at PAU, Ludhiana on September 18-19, 2008.
- Research and Extension Specialists Workshop on Vegetable, Fruit and Flower Crops (December 16-17, 2009) at PAU, Ludhiana.
- Group meeting on 'Expression of Interest in Entomology' held on March 2-3, 2010 at PAU, Ludhiana.

SKUAS&T, Srinagar

Sajjad Mohi-ud-din

- XVIII Bio control Workers Group Meeting held in Assam Agricultural University, Jorhat.
- Attended 9th Agricultural Science Congress from 22-24th June' 2009., held in SKUAST-K.
- International Conference on Hangul from 8-10th October' 2009, held in SKUAST-K.21 days' training programme on Recent Advances in Bio intensive Integrated Pest Management, at Chaudhary Charan Singh University of Agriculture, Hissar, Haryana, from 2nd March 2010 to 22nd March' 2010.
- 3 days training programme on "Advanced Technologies for Temperate Rice production", organized by the Division of Agronomy, SKUAST-K, Shalimar from 17- 19th March' 2010.
- 3 days' Training Programme on " Management of Honey bee diseases", organized by the Division of Entomology, SKUAST-K, Shalimar from 29- 31st March' 2010.

TNAU, Coimbatore

Karuppuchamy, P.

- Special meeting on the coconut leaf beetle *Brontispa longissima* on 21.11.2009 at NBAII, Bangalore.

Kalyanasundaram, M.

- Training programme on Multimedia content Development from 2 to 12 th December, 2009 at NAARM, Hyderabad.
- National conference on Plant Protection in Agriculture through ecofriendly techniques and traditional farming practices held at ARS, Jaipur from February 18-20,2010.
- Training programme on General Greenhouse Management from 1-3, March, 2010 at Horticulture Training Centre, Pune.

16. WORKSHOPS, SEMINARS, SUMMER INSTITUTES AND TRAINING

Trainings conducted at NBAII

- Mass production of *Trichogramma* egg parasitoids- 24th and 25th April, 2009 (2 persons).
- Mass production of quality bioagents like egg parasitoids, coccinellid predators, *Chrysoperla carnea*, anthocorids, entomopathogenic fungi, antagonistic fungi (*Trichoderma* spp.), Bt & *Pseudomonas* and entomopathogenic nematodes"- 20th and 25th July, 2009 (5 persons).
- Mass production of chrysopids-14th & 15th September 2009 (1 person).
- Sample preparation and use of GCMS in volatile analysis -6-7th October, 2009 (1 person)
- Sample preparation and use of Electro Antennogram for semiochemical research- 8-9th October, 2009 (1 person).
- Mass production of quality antagonistic fungi, *Trichoderma*, Entomopathogenic fungi, *Metarhizium*, *Beauveria* and *Verticillium*, *Pseudomonas*, Bt and *Paecilomyces*- 26-29th October, 2009 (2 persons).
- "Mass production of endosulfan tolerant trichogramma, anthocorids and *Cryptolaemus montrouzieri*- 18 to 21st January 2010 (3 persons).
- "Mass production of *Ha*NPV, *Sl*NPV, *Trichoderma harzianum*, *Trichoderma viridae*, *Verticillium lecanii*, *Metarhizium anisopliae* and *Nomuraea*" - 1-3 March, 2010 (6 persons).
- "Mass production of *Ha*NPV, *Sl*NPV, *Trichoderma harzianum*, *Trichoderma viridae*, *Verticillium lecanii*, *Metarhizium anisopliae* and *Nomuraea*" - 22-24 March, 1020 (10 persons).

Winter school organized

Organized 21 days winter school entitled "Recent Advances in Biological Control of Plant Diseases" with Dr. S. Sriram as Course Director from 01.12.2009 to 21.12.2009.

17. DISTINGUISHED VISITORS

Dr. Swapan Kumar Dutta, Deputy Director General (Crop Sciences), ICAR visited NBAII research laboratories on 20.9.2010.

Dr. S. P. Singh, Former Project Director (PDBC) visited NBAII on 20.10.2009 and participated in ICAR Foundation day celebrations.

Dr. Kasturi Rangan, Former Chairman, ISRO and Member of Planning Commission visited NBAII on 16th December 2009 along **Shri. L. Rynjah**, Principal Advisor, **Dr. V. V. Sadamate**, Advisor, and **Smt. Vandana Dwivedi**, Jt. Advisor, Planning Commission for an Interface meeting.

18. PERSONNEL

National Bureau of Agriculturally Important Insects, Bangalore

Dr. R. J. Rabindra	Director	Dr. S. K. Jalali	Senior Scientist
Dr. B. S. Bhumannavar	Principal Scientist	Dr. T. Venkatesan	Senior Scientist
Dr. D. Sundararaju	Principal Scientist	Dr. P. Sreerama Kumar	Senior Scientist
Dr. N. Bakthavatsalam	Principal Scientist	Dr. K. Srinivasa Murthy	Senior Scientist
Dr. B. Ramanujam	Principal Scientist	Dr. S. Sriram	Senior Scientist
Dr. Prashanth Mohanraj	Principal Scientist	Dr. Sunil Joshi	Senior Scientist
Dr. (Ms.) Veena Kumari	Principal Scientist	Dr. R. Rangeshwaran	Senior Scientist
Dr. (Ms.) J. Poorani	Principal Scientist	Dr. G. Sivakumar	Senior Scientist
Dr. (Ms.) Chandish R. Ballal	Principal Scientist	Ms. M. Pratheepa	Scientist (SS)
Dr. M. Nagesh	Principal Scientist	Dr. (Ms.) Deepa Bhagat	Scientist (SS)
Dr. A. N. Shylesha	Principal Scientist	Ms. R. Gandhi Gracy	Scientist

Central Tobacco Research Institute, Rajahmundry

Mr. S. Gunneswara Rao	Scientist (SG)

Central Plantation Crops Research Institute, Regional Station, Kayangulam

Dr. (Ms.) Chandrika Mohan	Senior Scientist

Indian Agricultural Research Institute, New Delhi

Dr. G. T. Gujar	Principal Scientist

Indian Institute of Sugarcane Research, Lucknow

Dr. Arun Baitha	Senior Scientist

Indian Institute of Horticultural Research, Bangalore

Dr. M. Mani	Principal Scientist
Dr. A. Krishnamoorthy	Principal Scientist
Dr. (Ms.) P. N. Ganga Visalakshy	Senior Scientist

Sugarcane Breeding Institute, Coimbatore

Dr. N. Geetha	Senior 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. S. J. Rahman	Principal Scientist
Smt. G. Anitha	Scientist

Assam Agricultural University, Jorhat

Dr. A. Basit	Principal Scientist
Dr. D. K. Saikia	Principal Scientist

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

Dr. Usha Chauhan	Senior Entomologist
Dr. P.L. Sharma	Entomologist

Govind Ballabh Pant University of Agricultural Science & Technology, Pantnagar

Dr. (Ms.) Nijam Waris Zaidi	Assistant Professor

Kerala Agricultural University, Thrissur

Dr. Babu M. Philip	Professor
Dr. (Ms.) K. R. Lyla	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
Dr. (Ms.) Rabinder Kaur	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

Jawaharlal Nehru Agricultural University, Jabalpur

Dr. S. B. Das	Seni or Scientist (Entomology)

Maharana Pratap University of Agriculture & Technology, Udaipur

Dr. B. S. Rana	Associate Professor

Central Agricultural University, Pasighat

Dr. K. Mamocha Singh	Associate Professor

Orissa University of Agriculture & Technology, Bhubaneshwar

Dr. B. K. Mishra	Entomologist

19. INFRASTRUCTURE DEVELOPMENT

Equipment

The laboratories were further strengthened with the acquisition of several equipments like image analysis system complete with software, video camera, video playing unit and computer for requisite analysis of data; gas chromatography (GCMS), HPLC, Ultra refrigerated centrifuge; auto Elisa reader; RTPCR; Fomenters'; Electrophoresis and electro focussing unit; Inverted phase contrast microscope with fluorescence; Deep freezer (-85°C); automatic microtome, leaf area analysis system; electro antennogram; insect activity meter; LCD projector; Freezer drier; sun test machine; optima UV visible spectrophotometer, digital bench top incubated/refrigerated shaker, thermo forma upright single door freezer, viscometer, BioCV 16 Lid for Bioassay tray, digital camera attachment, etc.,

Library

The library has a collection of 1,948 books, 1,537 volumes of journals, 61 bulletins and several miscellaneous publications including several reprints on various aspects of biological control. Fourteen foreign and seven Indian journals were subscribed for. CD-ROM - abstracts upgraded up to November 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 NBAII and is available in CD. National Bureau of Agriculturally Important Insects domain name has been registered with ERNET India, New Delhi. NBAII web site had been hoisted with web site address: www.nbaii.res.in. The mail server has been configured in the ARIS Cell and the official E-mail id is: nbaii.icar@gmail.com.

National Insect Reference Collection

The PDBC has 5,550 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 1300 slides has been added. NBAII'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. New generator of 100 KV was installed separately for the newly constructed quarantine laboratory. Pavement of main road access to the NBAII has been completed. The compound was re-constructed with grill and main entrance gate was also erected. A new security room was constructed at the entrance. Neo sign boards of NBAII were fixed over the main building for better visibility. Name boards have been fixed on all the laboratories and buildings.

Farm development

All main roads inside the farm have been metalled and tarred. New gates were erected at the entrance of the farm. The polyhouse and net house were repaired. Pavement of open space in front of the laboratory, poly house and net house was completed.

20. EMPOWERMENT OF WOMEN

During 2009-2010, the participation of women in different training programmes was as follows:

Mass production Trichogramma egg parasitoids (24-25 April, 2009)

Mrs. Daisy Sunil, Unit Manager, L.F. Agri Clinic and Organic Farming Service Centre, Little Flower Nursery, Kalavoor, P.O. , Pin 688 522, Alleppey, Kerala

Mass Production endoslulfan tolerant trichogramma, anthocorids and *Cryptolaemus montrouzieri* (18-21 January, 2010)

Mrs. Hemlata Choudhari, Churamanpur, madhaila, Varanasi (U.P.)