ANNUAL REPORT
2010-2011

National Bureau of Agriculturally Important Insects

(Indian Council of Agricultural Research)
Bangalore - 560 024

भाकृअनुप
ICAR

NBAII

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Front cover
The Papaya mealybug, *Paracoccus marginatus* and its parasitoid, *Acerophagus papayae*

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Note
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1. PREFACE

Insect fauna with the biggest diversity among the life forms impact agricultural production in a significant way. India being one of the mega biodiversity countries has experienced both the harmful as well as the beneficial impact. While several insect and related arthropod pests like phytophagous mites have caused serious yield losses to agricultural, horticultural and plantation crops, the rich biodiversity pool has opened up immense opportunity of exploiting the parasitoids, predators and beneficial microbes in the ecofriendly pest management. The National Bureau of Agriculturally Important Insects has marched ahead during the year 2010-11 with a clear vision of harnessing the immense potential in biocontrol organisms and other useful insects like the pollinators.

Looking back, the NBAII is proud of its achievements during the year 2010-11. The menace of the papaya mealybug, *Paracoccus marginatus* which ravaged papaya and several other crops was successfully controlled by the distribution and conservation of the exotic parasitoid *Acerophagous papayae* within an unbelievably short time of six months in the state of Tamil Nadu, Kerala, Karnataka and Maharashtra. The parasitoids has also established in the states of Assam and Tripura. I wish to compliment and congratulate all the partners and stake holders involved in this massive programme.

In the preface of the annual report of 2009-10, I promised that the NBAII would forge partnerships and collaborations with all stake holders, both national and international, for the benefit of the farming community. I am happy to say that we have respected this commitment and in one of the biggest national exercises, the NBAII brokered the partnership of about 125 KVKs, 9 Agricultural Universities, Plant Protection Wing of the State Department of Agriculture/ Horticulture in 7 States, the central IPM centres, private industry, Sigo serve, Tamil Nadu, IFGTB, Coimbatore, KFRI, Peechi, Kerala and Rubber Research Institute, Kottayam. I thank all these partners for their responsible involvement and I am happy to let them share the credit of partnering in this monumental effort of classical biological control of the papaya mealybug.

Dr. S. Ayyappan, Secretary, Department of Agricultural Research and Education and Director General, ICAR was a source of great inspiration for which all the members of the family of NBAII and the AICRP on Biological Control of Crop Pests and Weeds are grateful.

Dr. Swapan Kumar Dutta, Deputy Director General (Crop Sciences), ICAR continued to challenge and encourage us for achieving scientific excellence for which we are thankful. He extended his strong hand of support whenever needed which played a key role in the successful implementation of our research programmes.

Dr. T. P. Rajendran, Asst. Director General (PP), ICAR was a tower of support for the NBAII and was always ready to help us in times of need. We enjoyed his association and, his words of encouragement boosted our morale.

I cannot forget the support extended to the NBAII by **Shri Rajiv Mehrishi**, Additional Secretary, DARE and Secretary, ICAR, **Shri Chaman Kumar**, Additional Secretary, DARE and Financial

Advisor, ICAR, **Shri Ravindra Pattar**, Director (Finance), ICAR, **Shri J. Ravi,** Director (Personnel) and **Shri Sanjay Gupta**, Director (Admn.), ICAR

I am grateful to **Dr.B. S. Bhumannavar**, Principal Scientist for his able support in the preparation of this report.

This annual report also will provide information on our achievements in various other areas of research and development. I hope you will find the reading exciting and stimulating. The credit for the outcome of research goes to my colleagues at the NBAII as well as in the different centres of the AICRP on Biological Control of Crop Pests and Weeds.

We look forward to very exciting and adventurous partnerships of tackling the agricultural pests and diseases in sustainable manner and provide relief to the beleaguered farmers of India in the coming years.

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

निष्पादित सारांश

राष्ट्रीय कृषि उपयोगी कीट ब्यूरो, के अधिदेश के अनुसार वृहद अनुसंधान कार्यक्रमों को किया गया। पादप रोगाणुओं के जैविक नियंत्रण संबंधित सभी अनुसंधान कार्यक्रमों को रा.कृ.उ.की.ब्यू. में चल रही परियोजना समन्वयक इकाई के अंतर्गत जारी रखा गया। वर्ष 2010-11 के दौरान रा.कृ.उ.की.ब्यू. के साथ-साथ जैविक नियंत्रण पर अ.भा.स.अनु.परि. के अन्तर्गत 14 राज्य कृषि विश्वविद्यालयों और भारतीय कृषि अनुसंधान परिषद (भा.कृ.अनु.प.) आधारित छः केन्द्रों के अलावा कई स्वैच्छिक केन्द्रों की मुख्य उपलब्धियों को नीचे प्रस्तुत किया गया है। इन सभी ने विभिन्न फसल परिस्थितियों में पीड़कों के प्रति हमारी जंग में प्रभावी जैव नियंत्रण नितियों के अनुसंधान कार्य में महत्वपूर्ण आयाम प्रदान किया।

मौलिक अनुसंधान

राष्ट्रीय कृषि उपयोगी कीट ब्यूरो

जैव वर्गीकरण, जैव विविधता और जैव सुरक्षा विभाग

जैव वर्गीकरण

अ.भा.स.अनु.परि. के अनेक केन्द्रों, राज्य कृषि विश्वविद्यालयों, अन्य विश्वविद्यालयों, कीट जैव वर्गीकरण के अन्तर्गत नेटवर्क परियोजना और विद्यार्थियों सहित 35 संस्थानों के लिए कोक्सीनेलिड, परजीवी कीट हायमेनोप्टेरा और अन्य कीटों को मिलाकर 120 प्रजातियों की पहचान की गई। पहचान कराने के लिए फोटों के साथ अनेक ई-मेल प्रश्न आए थे, उनके उत्तर दिए गए।

प्रोटयुरा, फेमेरोप्टरा, ओडोनेटा, मेन्टोडिया, न्यूरोप्टेरा, एनोप्लूरा और ट्राईकोप्टेरा सहित कीटों के सात गणों वाले भारतीय जन्तुओं की एक सूची को रा.कृ.उ.की.ब्यू. की वेबसाईट पर रखा गया।

रहाइन्कोर्टेलिआ क्रॉच (कोक्सीनेलिडे) की ग्यारह नई प्रजातियों और एन्थोकोरिडे (*एन्थोकोरिस मुरलीधरणी* यामदा) की एक नई प्रजाति को दक्षिण भारत से वर्णित किया गया। *लियोफ्लोईओथ्रिप्स* (थाईसेनोप्टेरा) की भारतीय प्रजाति को पुनः वर्णित किया गया। *लियोफ्लोईओथ्रिप्स* और *माइक्रोटेरिस* (एन्सिर्टिडिए), प्रत्येक की एक नई प्रजाति को कर्नाटक राज्य से वर्णित किया गया। भारत वर्ष में पपीते के मीलीबग कीट पर क्राइसोपिड् के गण, *एपोक्राईसा* को पहली बार अभिलेखित किया गया।

सामान्य परजीवी कीटों, परभक्षी कीटों, खरपतवार नाशी कीटों और विदेशी जैव कारकों की एक सौ पचास फेक्ट शीटों को रा.कृ.उ.की.ब्यू. की वेबसाईट पर उपलब्ध कराया गया। इन कीटों के बारे में कीटों सहित मौलिक निर्धारण और जैविक नियंत्रण संबंधित महत्वपूर्ण सूचनाऐं वेबसाईट पर उपलब्ध कराई गई। 185 प्रजातियों का जैव नियंत्रण उपोदधात का संग्रहण विवरण रा.कृ.उ.की.ब्यू. की वेबसाईट पर उपलब्ध कराया गया।

मांहू की छः प्रजातियों *मीलेनेफिस बेम्बुसे* (कुल्लावे), *ब्रेकीसीफोनीएल्ला मोन्टाना* (वेन डेर गूट), *केपिटोफोरस माइटगोनी* ईस्टोप, *सीरटोवेक्थुना पर्गलेन्डूलोसा* बासु, घोष और रायचौधरी तथा *एफिस कुरोसवाई* ताकाहाशी का विकास किया गया और एफिडस वेबसाईट www.aphidweb.com पर उपलब्ध कराया गया।

सेन्टिनेल कार्डो के साथ क्षेत्रीय अध्ययन से ज्ञात हुआ कि *ट्राइकोग्रामा किलोनिस, ट्रा. एकीये, ट्रा. पिएरीडिस, ट्रा. डेनाऊसीकिडा* और *ट्रा. डेनाईडिफागा* प्रायः पाई गई और बैंगलोर के आसपास पैतृक प्रजाति के रूप फैल गयी। *ट्राइकोग्रामा डेनाईडिफागा* एक नई प्रजाति है जिसको हिमालय की पहाडियों से एकत्र किया गया और *केलोट्रोपिस जिगोन्टिआ* पर *डेनाऊस क्राईसीपस* के अण्डों पर वर्णित किया गया। *ट्रा. डेनाईडिफागा* और *ट्रा. डेनाऊसीकिडा* के आण्विक विश्लेषण में पाया गया कि दोनों भिन्न-भिन्न प्रजातियों से संबंध रखती हैं। *ट्रा. एग्रीए* को अरण्डी के कीट *एरीएडने मेरीओने* के अण्डों से एकत्र किया गया जो कि इस प्रजाति के लिए एक नए पोषक कीट के रूप में अभिलेखित किया गया।

स्किलीओनिडस के लिए विभिन्न पारिस्थितिकियों में जम्मू और कश्मीर (नुबरा वेली, लेह, श्रीनगर), महाराष्ट्र (पुणे, ओरंगाबाद), नई दिल्ली, उत्तर प्रदेश (लखनऊ), तमिलनाडू (कोटागिरी, कोयम्बटूर) और कर्नाटक (ग्यारह जिले) कुल छः राज्यों में सर्वेक्षण किया गया। भविष्य में अध्ययन करने के लिए कुल 3,230 परजीवी कीटों का एकत्रण, संग्रहालयण और सुरक्षित रूप से प्रयोगशाला में धरोहर के रूप में रखा गया। विभिन्न गणों के कीटों जैसे हेटेरोप्टेरा (57), लेपिडोप्टेरा (58), अरक्निडा (15),

होमोप्टेरा (3), न्यूरोप्टेरा (क्राईसोपिडे) (9), डाईक्टिओप्टेरा (10), डिप्टेरा (1), कोलियोप्टेरा (1) और आर्थोप्टेरा (2) के 156 अण्ड समूहों से अण्ड परजीवी कीटों को एकत्र किया गया।

प्लेटीगेस्ट्राईडे के 15 वंश जो कि सीलिओनिने, टेलीनोमिने और टेलीएसीने नामक तीन उपकुलों से संबंध रखती हैं, आभिलेखित की गई। ये 15 वंश निम्नलिखित हैं - *एकेन्थोलेपिथा, केलीसिलिओ, केलोटेलीआ, साइफेकोलस, ड्यूटा, डाईस्क्रीटोबीअस, एनिसरटोसेलिओ, पेल्पोटेलिआ, स्पेरेसिअन, गायोनोयडस, ओडोन्टोसीलिओ, जेनोमीरस, पेरेटेलिनोमस, साईक्स* और *ट्राईसोल्कस* । *ग्रायोनोयडस* और *ओडोन्टोसीलिओ* वंश को, भारत वर्ष से पहली बार अभिलेखित किया गया।

लद्दाख की नुबरा वेली से गुलाब की झाडियों के ऊपर से क्राईसोपिडे के 54 अण्डे एकत्र किए गए और 74.1 प्रतिशत अंडे *टेलिनोमस* स्पे. द्वारा परजीवित पाए गए, जिनमें से 22.22 प्रतिशत लारवे बाहर निकल पाए। धतुरा के पौधे से *अचेरोनिटा स्टिकस* के 48 अंडे एकत्र किए गए जो कि *टेलीनोमस* स्पे. द्वारा परिजीवित थे। *सीलिओसेरडो* (टिडडे की एक फोरेटिक प्रजाति) को घास के टिड्डे *निओर्थेक्रिस एक्यूटिसेप्स* (पायरगोमोर्फिडेः आर्थोप्टेरा) को एकत्र किया गया। यह प्रजाति अभी तक केवल मांडया (कर्नाटक) से ही एकत्र की जाती थी, किन्तु अब कोयम्बटूर (तमिलनाडू) से भी एकत्र की गई।

पपीते के मीलीबग कीट का क्लासिकल जैविक नियंत्रण

एसीरोफेगस पपाये, स्यूडलेप्टोमेस्टिक्स मेक्सिकाना और *एनगाईरस लोएकी* नामक तीन परजीवी कीटों की पाँच खेपें पुएर्टो रिको से आयात की गई, संगरोधित की गई और क्षेत्र में पपीते के मीलीबग कीट, *पेराकोकस मार्जिनेटस* का जैविक नियंत्रण करने के लिए खेत में छोडे गए । ये परजीवी कीट *पे. मार्जिनेटस* के विशेषतः परजीवी कीट हैं और भारत वर्ष में प्रायः पाए जाने वाले *मेकोनेलिकोकस हिर्सुटस, फीनोकोकस सोलीनोप्सिस, फेरीसिआ विरगेटा, प्लेनोकोकस सीट्राई, प्ले. लिलेसीनस, स्यूडोकोकस लोन्जिस्पाईनस* और *लेन्काकोकस ओर्नेटस* नामक अन्य सात मीलबग प्रजातियों को परजीवित नहीं करता है। यह परजीवी कीट अलक्षित लाभदायक जीवों जैसे *माइक्रोमस इगोरोटस, क्राइसोपर्ला जास्ट्रोवी सीलेमी, ब्रूमॉयडस* स्पे., *क्रिप्टोलीमस मोन्ट्रयूजिएरी, गोनिओजस निफेन्टिडिस, ट्राईकोग्रामा किलोनिस, ट्रा. जेपोनिकम, बोम्बीक्स मोरी, एफिस सीरेना इन्डिका, स्किमनस क्रेक्सीवोरा* और *स्पेल्जिस एपिअस* पर आक्रमण नहीं करता है। इन सभी तीनों प्रजातियों के परजीवी कीटों को आलू के अंकुरित नवोदभिदों पर *पे. मार्जिनेटस* के ऊपर गुणित किए जा सकते हैं।

भा.कृ.अनु.प., रा.कृ.वि., कृ.वि.के., एन.जी.ओ. और सी.एस.आर.टी.आई., मैसूर के 250 से अधिक वैज्ञानिकों, विषय विशेषज्ञों, विस्तार अधिकारियों को पपीते के मीलीबग कीट का बहोत्पादन और उन पर परजीवी कीटों का उदभवन के रूप में सितम्बर-दिसम्बर, 2010 के बीच में विभिन्न समूहों में बैच बनाकर प्रशिक्षण प्रदान किया गया। 30 अक्टूबर, 2010 को "पपीते के मीलीबग का प्रबंधन और परजीवी कीटों उदभवन प्रयोग" नामक एक कार्यशाला आयोजित की गई, जिसमें भा.कृ.अनु.प., रा.कृ.वि., कृ.वि.के., के.एफ.आर. आई., आई.एफ.जी.टि.बि., सी.एस.आर.टि.आई. और एन.जी.ओ. के 200 से अधिक वैज्ञानिकों तथा कुछ किसानों ने कार्यशाला में भाग लिया।

पपीते के मीलीबग के परजीवी कीट *एसीरोफेगस पपाये* को तमिलनाडू, कर्नाटक, महाराष्ट्र और आन्ध्र प्रदेश राज्यों में छोडा गया था, वहाँ पर यह परजीवी कीट क्षेत्र में स्थापित हो गया है और पपीते के मीलीबग की सँख्या का सफलतापूर्वक नियंत्रण कर रहा है ।

जैव - स्रोत संरक्षण और उपयोग विभाग

परभक्षी कीट एन्थोकोरिड्स पर अध्ययन

पच्चीस सर्वेक्षणों में *ओरियस* स्पे., *कार्डियास्टेथस एक्जिगुअस, ब्लाप्टोस्टेथस पेलेसेन्स, एन्थोकोरिस मुरलीधरनी, केराईनोकोरिस इन्डिकस* और एन्थोकोरिड्स की पाँच अनजान प्रजातियाँ एकत्र की गई। अध्ययन में पाया गया कि *का. एक्जिगुअस* के जीवन और पुनः उत्पादन के लिए 25 और 30° से.ग्रे. तापक्रम अत्यधिक अनुकूल है। *का. एक्जिगुअस* के अण्डों को 10° से.ग्रे. तापक्रम पर (64% अण्डे सेने योग्य और अण्डों से 64% प्रौढ़ निकलने के साथ) और 15 से.ग्रे. तापक्रम पर 10 दिनों (68% अण्डे सेने योग्य और 68% प्रौढ़ निकलने के साथ) तक संग्रहित किया जा सकता है।

एन्थोकोरिड परभक्षी कीटों का मूल्यांकन

ब्ला. पेलेसेन्स के दो दिन आयू वाले निम्फ 1.5 रेंगने वाले (क्रॉलर्स) का भक्षण प्रतिदिन जबकि सात दिन आयू वाले निम्फ 2.2 क्रॉलर्स प्रतिदिन भक्षण करते हैं। 2 दिन आयू और 7 दिन आयू वाले निम्फ क्रमशः कुल 18 और 29 क्रॉलर्स का भक्षण करते हैं यद्यपि, निम्फों का जीवन काल बहुत कम पाया गया। प्रौढ़ कीट की दशा में 2.6 क्रॉलर्स प्रतिदिन भक्षण करते हैं तथा कुल 31 क्रॉलर्स का भक्षण कर सकते हैं, यद्यपि जब पपीते के मीलीबग का भक्षण करते हैं तो प्रौढ़ जीवन काल 30 दिनों से घटकर 13 दिन रह गया।

एक नए एन्थोकोरिड परभक्षी कीट, *एन्थोकोरिस मुरलीधरनी* यामदा स्पे. नोव. वास्तव में *फेरीसिआ विरगेटा* ग्रस्त *बऊहिनीआ परपुरिआ* वृक्षों से एकत्र किया गया और कपास मीलीबग पर पाले गए। *ए. मुरलीधरणी* के निम्फ दशा वाले कीट प्रतिदिन 4.3 क्रॉलर्स (विस्तार 2 से 10) के भक्षण के साथ कुल 65.3 क्रॉलर्स का भक्षण कर पाए। प्रौढ़ कीट द्वारा कपास के मीलीबग का प्रतिदिन 6.1 (विस्तार 2 से 14) के भक्षण के साथ कुल 124.3 क्रॉलर्स का भक्षण कर पाए। यद्यपि यह एन्थोकोरिड पपीते के मीलीबग का भक्षण नहीं कर पाया।

नामधारी के स्वामित्व वाले पोलीहाऊस में मिर्च फ्रेशनो मिर्च-किस्म-सुप्रीम) में 10 *ब्ला. पेलेसेन्स* प्रति पौधे की दर से 8 बार छोड़ने पर थ्रिप्स से मिर्च की क्षति को महत्वपूर्ण रूप से कम किया जा सका। जैव नियंत्रण वाले प्लॉट से प्राप्त उपज और उसकी गुणवत्ता उतनी ही अच्छी पाई गई जितनी कि रासायनिक नियंत्रण प्लॉट में पाई गई।

नेट हाऊस में मिर्च कि फसल में 10 *ब्ला. पेलेसेन्स* को प्रति पौधे की दर से दस बार छोड़ने पर माइट से मिर्च की क्षति को महत्वपूर्ण रूप से कम किया जा सका। पत्ती मुड़ाव प्रतिशत में 35% (छोड़ने से पहले) से 13.25% (छोड़ने के बाद) तक कमी पाई गई। अनोपचारित पौधों में सिकुड़न, मुड़ाव और शीर्ष भागों में सूखने तथा कली या फूलों को अधखिले जो कि पूर्णतः खिलने में असमर्थ जैसे विशेष प्रकार के लक्षण पाए गए। उपचारित पौधों की ऊँचाई 22.3 जबकि अनोपचारित पौधों की ऊँचाई केवल 8.26% बढ़ी पाई गई।

सिटोट्रोगा सीरीएलेल्ला और *हिप्पोडेमिआ वेरीगेटा* पर अध्ययन

सिटोट्रोगा सीरीएलेल्ला को बिना पेरे हुए गेंहू पर बहुगुणित किया गया। प्रतिदिन 1.33 सी. सी. और महीने का औसतन उत्पादन 36.7 सी. सी. पाया गया। प्रतिवेदन काल के दौरान अण्डों का कुल उत्पादन 403.5 सी. सी. हुआ। श्रीनगर से, *हिप्पोडेमिआ वेरीगेटा* की जैविकी एकत्र करने के बाद उनका परपोषी कीट के रूप में *एफिस क्रेक्सीवोरा* पर अध्ययन किया गया। इस कीट का अण्डा, लारवा और प्यूपा काल क्रमशः 3.4, 7.8 और 4.6 दिनों का पाया गया। लारवे की भक्षण संभाव्यता 32.3 माहू प्रतिदिन पाई गई। इस कीट का लारवा अपने लारवा काल में 226.3 से 258.6 माहू का भक्षण करता है। इस कीट का पूर्व अण्ड-निक्षेपण काल 9-11 दिनों और मादा जनन क्षमता 0.00 से 306.8 अण्डे पाई गई। प्रौढ़ जीवन क्षमता में नर 52.8 और मादा 61.11 दिनों तक जीवित रहती है।

मीलीबग और स्यूडोकोकिड्स का अध्ययन

फीनेकोकीनी जाति से संबंध रखने वाली मीलीबग की निम्नलिखित प्रजातियाँ *फिनेकोकस मेडीरेन्सिस, फीनेकोकस डाइवेरीकेट्स, फीनेकोकस सोलेनाई, रेस्ट्रोकोकस मेंगीफेरे* और *पेराकोकस मार्जिनेटस* को केवल आलू के अंकुरित कन्दों पर आसानी से बहुगुणित किया जा सकता है और कद्दू पर गुणन नहीं किया जा सकता है। स्यूडोकोकस की 42 प्रजातियों को एकत्र किया, सुरक्षित रखा गया और उनकी पहचान की गई। सात प्रजातियों में से *फिनोकोकस* कोकेरेल वंश को अत्याधिक प्रमुख पाया गया, इसके बाद *डाइस्मिकोकस* फेरिस और *स्यूडोकोकस* वेस्टवुड वंश की प्रत्येक की चार प्रजातियों के साथ प्रमुख पाया गया। माहू और कोक्सिडेस की 31 विभिन्न प्रजातियों से प्राकृतिक शत्रु कीटों की कुल 69 प्रजातियाँ एकत्र की गई।

विभिन्न फसल पारिस्थितिकियों में परागणकर्ता कीट

परागणकर्ता कीटों के एकत्रण के लिए कर्नाटक, तमिलनाडू, आन्ध्र प्रदेश और महाराष्ट्र राज्यों में अरहर पारिस्थितिक तन्त्र में सर्वेक्षण किए गए। अरहर की फसल से *जाइलोकोपा* की तीन प्रजातियों *[जा. एस्टुअन्स, जा. लेटीपेस* और *जाइलोकोपा* स्पे., पाँच *मेगाकीले (मे.*

लेन्टाना, मे. वाईकालर, मे. एन्थ्रेसीना, मे. कार्बोनेरिआ, मे. हीरा और *मेगाकीले* स्पे.), *लेसीओग्लोसम* स्पे., *सीरेटीना (पाईथीटिस) बीन्थमी, एपिस फ्लोरिआ, ए. डोर्सेटा* और *ट्राईगेना* स्पे. तथा बिना पहचान वाले हेलीक्टिड एकत्र किए गए। तिल की फसल पर तमिलनाडू में *एपिस डोर्सेटा* और *ए. सीरेना इन्डिका* परागणकर्ता कीटों को अधिकांशतः पाया गया। सूर्यमुखी की फसल में *एपिस डोर्सेटा, ए. सीरेना इन्डिका, एपिस फ्लोरिआ* और *ट्राईगोना इरिडिपेनिस* परागणकर्ता कीटों को बहुलता में पाया गया। कर्नाटक राज्य के गुलबर्गा, बीदर और रायचूर क्षेत्रों के खेतों में रासायनिक कीटनाशकों के लगातार छिड़काव की तुलना में प्राकृतिक रूप से (कीटनाशक रहित) अरहर पारिस्थितिक तन्त्र में बहुतायत रूप में प्राकृतिक शत्रु कीट जैसे-हायमेनोप्टेरन परजीवी कीट (ब्रेकोनिडे, इक्नियुमोनिडे, वेस्पिडे, स्कोलिडे, आदि) और परभक्षी कीट [कोक्सीनेलीडे, मेन्टिडे, क्राईसोपिडे, गोमफिडे-ड्रेगनफलाई, क्लुबिओनिडे (सेक-मकडियाँ) और अरेइनीडे] बहुलता में पाए गए।

कर्नाटक में अरहर की अरूढिगत ढंग से की गई खेती, सिंगापुर चेरी, *मुन्टिन्गिआ केलाबुरा* (कुलः टीलीएसीए), *स्पर्मेकोसी हिस्पिडा* (रूबीएसीए) और *युफोर्बिआ हेटेरोफिल्ला* (युफोर्बिसीए) ये सभी मधुमक्खी की सभी प्रजातियों की महायता करती हैं जबकि *सेन्ट्रोसीमा प्युबीसेन्स* (कुलः फेबेसी) केवल बढ़ई मक्खी की सहायता करती है। क्षेत्रीय परीक्षण में अरहर (किस्म-टी टी बी-7) की 10 लाईनों के बाद 2 लाईन गेंदा (स्थानीय किस्म) और सूर्यमुखी (किस्म KBSH-53) की 2 लाईनें एकान्तर रूप से लगाने पर पाया गया कि अकेले अरहर की फसल लगाने की अपेक्षा अन्तः फसल के साथ अरहर में अधिक संख्या में परागण कर्ता कीट और प्रकृतिक शत्रु कीट आकर्षित होते हैं। अकेले अरहर की फसल उगाने पर *हेलीकोवर्पा*, फली मक्खी और फली बगों के द्वारा क्षति अधिक जबकि अन्तः फसल के साथ अरहर में यह क्षति अपेक्षाकृत कम पाई गई ।

हेलीकोवर्पा आर्मिजेरा में फेरोमोन का पोलीमोर्फिज्म

हे. आर्मिजेरा की विभिन्न भौगोलिक सँख्याओं को नागपुर, बेंगलोर, गुलबर्गा और रायचूर (कर्नाटक) तथा कोयम्बटूर (तमिलनाडू) से एकत्र किया गया।

फेरोमोन अवयव जेड-11-हेक्साडेसीनल और जेड-9-हेक्साडेसीनल के विभिन्न ब्लेन्डस जैसे कि 97:3 (व्यवसायिक ट्रेप बनाने के लिए प्रयोग होने वाला ब्लेन्ड); 91:9 और 85:15 तैयार किए गए और सिलिकल टयूबों में भरकर बाजू के समान ट्रेप में वृक्ष की ऊँचाई पर रखे गए। रायचूर में क्षेत्रीय परीक्षण में 97:3 और 91:9 दोनों ही ब्लेन्डस में महत्वपूर्ण रूप से अधिक सँख्या में नर कीट पकडे गए। प्रयोगशाला में जी सी ई ए डी अध्ययन में, रायचूर से एकत्र किए गए *हे. आर्मिजेरा* के नर कीटों ने 97:3 ब्लेन्ड के प्रति अनुकूल प्रतिक्रिया प्रदर्शित की। पटना में क्षेत्रीय परीक्षण के दौरान 85:15 ब्लेन्ड के अनुपात के प्रयोग करने पर अधिक सँख्या में कीट पकड़ने के परिणाम प्राप्त हुए। रायचूर से एकत्र कीटों की सँख्याओं की अपेक्षा कोयंबटूर प्रयोगशाला वाली मादा कीटों में ई ए जी प्रतिक्रिया अधिक पाई गई।

जीनोमिक्स और बायोइन्फोर्मेटिक्स इकाई

अन्तः सहजीवियों की जैव रासायनिक पहचान और आण्विक चरित्रण

ट्राइकोग्रामेटिड्स

खेतों से एकत्र तितली कुल के कीटों के अण्डों से निकले *ट्राइकोग्रामा एम्ब्रियोफेगम* और *ट्रा. डेनाऊडीफेगा* परजीवी कीटों से यीस्ट और जीवाणुवीय अन्तः सहजीवियों को पृथक किया गया, जिनकी पहचान *पिसीआ एनोमोला, पि. गुईल्लेर्मोन्डाई, केन्डिडा एपिकोला, के. पिमेन्सिस, मेटस्कनीकोविया रीयुकोफाई, हेन्सेनिएस्पोरा युवेरम, विकेरहेमोमायसस एनोमालस, जाइगोसेकरोमायसस रोक्साई, बेसीलस सबटीलिस* और *बे. सीरेअस* के रूप में हुई।

2 *केन्डिडा* प्रजातियों और 10 *पिसीआ* प्रजातियों सहित कुल 20 विभेदों की प्रजाति स्तर को आई टी एस सीक्वेन्स विश्लेषण द्वारा पहचान की गई। एक ब्लास्ट खोज में पाया गया कि यीस्ट विभेद टी सी वाई - 1, टी सी वाई - 2 और टी सी वाई - 3 की सीक्वेन्स *पिसीआ एनोमोला* विभेद के पृथक पी-13 (जीन बैंक एसेशन सँ. ए वाई 349442) के समान पाई गई। *ट्राइकोग्रामा* के साथ यीस्ट और जीवाणु के सभी अन्तः सहजीवियों को विभिन्न स्थानों से एकत्र कर उनका आई टी एस सीक्वेसिंग विश्लेषण *पि. एनोमाला, केन्डिडा* सीएफ *एपिकोला, विकरहेमोमायसस एनोमालस, मेटस्कनीकोविया रीयुकोफाई, हेन्सेनिएस्पोरा युवेरम, केन्डिडा पिमोन्सिस, पि. गुईल्लेर्मोन्डाई, जाइगोसेकरोमायसस*

रोक्साई और जीवाणु जैसे *बेसीलस सीरेअस* और *बेसिलस सबटीलिस* के रूप में पहचान हुई। न्यूक्लिटॉयडे सीक्वेन्सों का निर्धारण किया गया और *पिसीआ एनोमोला* का एक समूह, *केन्डिडा* अन्य दूसरा समूह तथा अन्य संबंधित वाले एक दूसरे से जुड़ाव के परिणाम स्वरूप परिणामों को एक आयाम प्राप्त हुआ।

क्राइसोपरला जास्ट्रोवी सीलेमाई

वाई आई टी एस-पी सी आर के प्रयोग द्वारा यीस्ट इन्टरनल ट्रान्सक्राईब्ड स्पेसर जीन को एम्पलीफाई करने के बाद यीस्ट संवर्धनों का चरित्रण किया गया, जबकि जीवाणु संबर्धनों का चरित्रण 16 एस आर डी एन ए-पी सी आर में केवल जीवाणु के लिए, 16 एस आर डी एन ए रीजन विशेष एम्पलिफाईज के प्रयोग से किया गया।

क्रा.जा. सीलेमाई, परभक्षी कीट के कीटनाशक सहनशील विभेद (पी टी एस 8) से अन्तः सहजीवी पृथक किया और आई टी एस रीजन एम्पलीफाई (798 बी पी रीजन) किया गया। ब्लास्ट खोज में अन्तः सहजीवी *क्लेबसीएल्ला* स्पे. पाया गया। जीन बैंक डाटा बेस में, तापक्रम सहनशील विभेद से प्राप्त अन्तः सहजीवी में 98% *जाइगोसेकरोमायसस* स्पे. के साथ होमोलोजी पाई गई और अन्य यीस्ट संवर्धन में 98% *पिसीआ एनोमाला* के साथ होमालोजी पाई गई। जीन बैंक डाटा बेस में अन्य जीवाणुवीय अन्तः सहजीवी में 97% *स्टेनोट्रोफोमोनाज माल्टोफिलीआ* विभेद के साथ होमोलोजी पाई गई।

कोटेशिआ फ्लूटेल्ले और *ट्राइकोग्रामा ब्रेसीके*

कार्बोहाइड्रेट फर्मेन्टेशन परीक्षण के आधार पर *कोटेशिआ फ्लूटेल्ले* से यीस्ट पृथककृत में माल्टोज, सूक्रोज, गेलेक्टोज, सेलोबीयोज, जाईलोज और रेफीनोज की उपयोगिता दर्शाई और *पिसीआ गुईलेरमोन्डाई* के बहुत नजदीक पाई गई।

ब्लास्ट खोज में पता चला की तिरूपति वाली कीट सँख्या से पृथक किए गए यीस्ट विभेद सी पी वाई 1 की आई टी एस 1-5.8 एस-आई टी एस-2 की सीक्वेन्स *पिसीआ एनोमाला* पृथककरण पी-1 के समान 99% तक पाई गई। होसकोटे वाले कीट में 16 एस आर डी एन ए सीक्वेन्स के ब्लास्ट खोज में विभेद सी पी बी-1 पृथककरण में *बेसीलस सबटीलिस* के समान 100% सीक्वेन्स पाई गई। इसी प्रकार *ट्राइकोग्रामा ब्रेसीके* के सहयोगी के रूप में 16 एस आर डी एन ए सीक्वेन्सिंग विश्लेषण में जीवाणु सहयोगी के रूप में *बेसीलस सीरेअस* विभेद टी बी । में *बेसीलस सीरेअस* के समान 99% पाया गया।

डब्लयू एस जी प्राईमर्स के प्रयोग द्वारा *को.प्लूटेल्ले* की दोनों कीट सँख्याओं से लिंग नियंत्रित करने वाली जीवाणुवीय अन्तः सहजीवी वोल्बेशिआ की खोज की गई। वोल्बेशिआ सरफेश प्रोटीन (डब्लयू एस पी) आधारित पि सी आर विधि से *वोल्बेशिआ* की उपस्थिति सुनिश्चित की गई। एन सी बी आई की ब्लास्ट खोज में *वोल्बेशिआ* सरफेश प्रोटीन की सीक्वेन्सिंग में पता चला कि *वोल्बेशिआ* का ग्रसन 99% की आधिकतम समानता के साथ *ट्राइकोग्रामा डाईरीड* में *वोल्बेशिआ* से संबधित था।

भारतीय कोक्सीनेलिड्स

कोकिसनेलिड की 13 प्रजातियों जैसे - *ब्रुमॉयडस सुचुरेलिस, काईलोकोरस निग्रीटा, काईलोमीनस सेक्समेकुलेटा, कोक्सीनेल्ला सेप्टमपंकटेटा, कोक्सीनेल्ला ट्रान्सवर्सेलिस, क्रिप्टोलीमस मोन्ट्रयूजिएरी, क्यूरीनस कोएरूलीयस, हार्मोनिआ एक्जिरिडिस, हीनोसेपिलेक्ना विजिन्टिआक्टोपंकटेटा, हायपरएस्पिस मेनड्रोनी, इलीइज सीन्कटा, रोडोलिआ एमाबिलिस* और *स्किमनस (पुलुस) लेटीमेकुलेटस* को आई बोल (बोल्ड 2.5) सिस्टम के साथ सभी संबंधित सूचनाऐं जमाकर डी एन ए बार कोड तैयार किया गया। बायोइन्फोर्मेटिक टूल्स के प्रयोग के द्वारा आण्विक चरित्रण के आधार पर कीक्सीनेलिडों की तेरह प्रजातियों की फाइलोजेनी की उत्पत्ति की गई।

फसल पीडकों और खरपतवारों पर अखिल भारतीय समन्वयन अनुसंधान परियोजना

समन्वयक इकाई : रा.कृ.उ.की.ब्यू.

कीट कवकीय रोगाणु

लोबिया में, *वर्टिसिलियम लेकेनाई* (वी एल - 8 पृथककरण) के प्रयोग करने के परिणाम स्वरूप माहू, *एफिस क्रेक्सीवोरा* की सँख्या कम (32.3/पौधा) तथा उपज अत्यधिक (911 कि.ग्रा./हे.) प्राप्त हुई जो कि मोनोक्रोटोफास (0.007%) के समान पाई गई । इन कीट कवकीय रोगाणुओं को *कीलोमीनस सेक्समेकुलेटा* के लिए सुरक्षित पाया गया क्योंकि इनमें माइकोसिस अभिलेखित नहीं पाया गया, यद्यपि

माइक्रोमस टिमिड्स के लारवों में माइकोसिस अभिलेखित किया गया।

एक्रीमोनियम स्पे. और *लीसेनीसिलियम सेलीओटे* का *टेट्रानिकस उर्टिके* के प्रति जैव दक्षता का मूल्यांकन करने के लिए जैव नियंत्रण अनुसंधान फार्म, अट्टूर बेंगलोर में सन 2010-11 के दौरान ग्रीन हाऊस में पेठा, करेला, लौकी, खीरा और तोरई नामक पाँच कुकुरबिटों पर तीन बार परीक्षण किए गए। कवकीय उपचारों में से *एक्रीमोनियम* स्पे. के साथ-साथ कमजोर करने वाले कारक (पी डब्लयू ए -1ए) के उपचार के परिणाम स्वरूप माइट की सघनता में कमी (74.7 से 82.8%) पाई गई।

संतरा और मोसम्बी में *फाईलोकोप्टरूटा ओलेईवोरा* के प्रति *हिर्सुटेल्ला थोम्पसोनाई* के पृथककरणों के परपोषी तथा अपरपोषी दोनों ही रूप में क्षेत्रीय दक्षता की जाँच की गई। मौसम्बी में *हि. थोम्पसोनाई* के दोनों पृथककरणों द्वारा नींबू वर्ग की रस्ट माइट सँख्या को महत्वपूर्ण रूप से कम करते पाया गया, माइट की सँख्या में कमी करने के लिए पोषक-ग्रसन पृथककरण थोडा सा श्रेष्ठ पाया गया।

पादपरोगाणुओं के कवकीय प्रतिरोधियों का बहोत्पादन

रागी के बीजों को अधोस्तर के रूप में, *ट्रा. हरजिएनम* (टी एच 10) के जीवाक्षम प्रोपेग्यूल्स उत्पादन के लिए निवेशन को 28° से.ग्रे. तापक्रम पर रखना उचित पाया गया। जब अधोस्तरों को अत्याधिक तापक्रमों (30° से.ग्रे. या इससे भी अधिक तापक्रम) पर निवेशित किया जाता है तब यह नमी और जल क्रिया में कमी के सहसम्बन्ध को दर्शाता है।

कीटकवकीय रोगाणुओं की दशा में, जाँचे गए अन्य तापक्रमों की तुलना में चावल एक अधोस्तर के रूप में किए परीक्षण में पाया गया कि *मे. एनाईसोप्लिए* और *ब्यू. बेसीआना* की सी.एफ.यू. सँख्या 32° से.ग्रे. पर अत्यधिक (निवेशन के 15 दिनों के बाद क्रमशः 17.4 और $27.0x10^8$/ग्राम) पाई गई।

ज्वार को अधोस्तर के रूप में प्रयोग करने पर निवेशन के 15 दिनों के बाद *ब्यू. बेसीआना* की सी एफ यू सँख्या $26.4x10^8$/ग्राम जबकि रागी में यह $8.4x10^8$/ग्राम पाई गई। *मे. एनाईसोप्लिए* की दशा में, ज्वार अधोस्तर के रूप में आधिकतम सी.एफ.यू. संख्या $29.4x10^8$/ग्राम, जबकि चावल के दानों वाले अधोस्तर में सी एफ यू सँख्या $26.2x10^8$/ग्राम पाई गई।

रेल्सटोनिआ सोलेनेसीरम द्वारा बैंगन की जीवाणुवीय मुरझान का *बेसीलस* स्पे. द्वारा प्रबंधन

बी. मेगाटेरम एन बी ए आई आई 63 (10^8 सी एफ यू/मिली) के टाल्क नियमन से बीज उपचार (4 ग्रा./कि. ग्रा. बीज), मृदा उपचार (5 ग्रा./कि. ग्रा. मृदा), नवोदभिदों की जड़ें डुबोना (10 ग्रा./ली. पानी) और पर्ण छिड़काव (10 ग्राम/ली. पानी) के परिणाम स्वरूप बैंगन में जीवाणुवीय मुरझान को 51 प्रतिशत कम किया गया। *बे. मेगाटेरम* का प्रयोग करने के कारण बैंगन के पौधों की जड़ और तना वृद्धि बहुत अच्छी पाई गई।

मिलॉयडोगाईने के जीवाणुवीय प्रतिरोधक

बैंगन और टमाटर को फसलों के जड़ ग्रन्थि सूत्रकृमि *मिलॉयडोगाईने* स्पे. से ग्रसित अण्ड समूहों से *स्यूडोमोनाज* स्पे. के कुल 15 पृथककरणों को पृथक किया गया। *इन विट्रो* दशा में, जड़ ग्रन्थि के सूत्रकृमि के दूसरी अवस्था के ज्यूवेनिल्स के लिए सात पृथककरणों को प्रतिरोधक के रूप में पाया गया और एन बी ए आई आई - 2 और एन बी ए आई आई - 5 को *मिलॉयडोगाईने* स्पे. के ज्यूवेनिल्स के प्रति 83.33% तक घातक पाया गया।

देशी *बेसीलस थ्यूरिनजिएन्सिस*

ट्रिप्सिन डायजेशन द्वारा विषाक्त को सक्रिय करने की विधि का प्रयोग करके पी डी बी सी-बी टी1, पी डी बी सी-बीटी 2, एन बी ए आई आई बी-टी ए एस, एन बी ए आई आई बी-टी जी 4, एन बी ए आई आई - बी टी 3 और एन बी ए आई आई - बीटी 4, नामक इन छः देशी बी टी का *हे. आर्मिजेरा* के प्रति जाँच परीक्षण किया गया। पी डी बी सी - बी टी 1 निम्ततम एल सी$_{50}$ के साथ अत्यधिक विषैला पाया गया। यद्यपि एन बी ए आई आई - बी टी जी 4 उपचारित पौधों में अरहर की फसल की फलियाँ न्यूनतम क्षतिग्रस्त पाई गई।

पी डी बी सी - बी टी 1, पी डी बी सी - बी टी 2, एन बी ए आई आई - बी टी 3, एन बी ए आई आई - बी टी 4, एन बी ए आई आई - बी टी 5 और एन बी ए आई आई बी-टी जी 4 में क्राई 1 और क्राई 2 जीन्स उपस्थित थे। जिन पृथककरणों में दोहरी विपाक्तता (लेपिडोपटेरा और कोलियोप्टेरा) पाई जाती है उन सभी में क्राई 11 उपस्थित पाया गया।

एस डी एस पेज के द्वारा पैतृक पृथककरण और उदधृत विभेदों के बीजाणु क्रिस्टल मिश्रण का विश्लेषण किया गया। क्राई 1 और क्राई 2 जीनों के साथ बी टी 1, बी टी 2, बी टी 3, बी टी 5, बी टी - एच डी 1, बी टी असम बी टी जी 4 पृथककरण 130 और 60 के डी ए प्रमुख प्रोटीन उत्पादित करते हैं।

अवायुवीय तनाव सहनशील स्यूडोमोनाइस

स्यूडोमोनाज पुटिडा (3 विभेद), *स्यू. प्लेकोग्लोसीकिडा* (2 विभेद), *स्यू. फ्लूओरेसेन्स* (2 विभेद) *एल्केलिजेन्स* स्पे. और *स्यूडोमोनाज* स्पे. में से *स्यू. पुटिडा* (आर पी एफ -9) द्वारा उपचारित पौधों में अत्यधिक 4600 विगर इन्डेक्स पाई गई।

ई पी एन का *'इन विवो'* बहोत्पादन

गेलेरिआ की वृद्धि, जीवन चक्र काल, लारवों का भार और जनन क्षमता के लिए 28 और 30° से.ग्रे. के साथ आपेक्षिक आर्द्रता 50-80% सर्वोत्तम पायी गयी। जनन क्षमता, जीवन चक्र काल और लारवों के भार पर कोई बुरा प्रभाव न पड़ते हुए *गेलेरिआ मीलोनेल्ला* लारवों के उत्पादन के लिए उनके आहार और माध्यम का पुनः विनिर्माण किया गया तथा सुधार किए गए तीन आहारों को निर्मित किया गया और ये मानक आहार से 38-56% तक सस्ते पाए गए।

ई पी एन का *'इन विट्रो'* बहोत्पादन

स्टे. कार्पोकेप्से, स्टे. अब्बासी और *हे. इन्डिका* की गुणन दर और उपज बढाने के लिए वाउटस मीडियम में पहले से ही सहजीवी जीवाणु निवेशन करना, सोया आटा + कुत्ते को खिलाने वाले बिस्किट का मीडियम और कुत्ते को खिलाने वाले बिस्किट के मीडियम को उपज बढ़ाने या अधिक मात्रा में कीट प्राप्त करने के लिए श्रेष्ठ पाया गया।

ई पी एन नियमनों का संग्रहण

हेटेरोरहाब्डिटिस इन्डिका और *हे. बेक्टेरिओफोरा* के भिगोने लायक पाउडर के नियमनों को 8-10 माह तक सुरक्षित रूप से संग्रहित रखने के लिए विधि विकसित की गई।

स्टेईनर्नेमा कार्पोकेप्से, स्टे. अब्बासी, हे. बेक्टेरिओफोरा, हे. इन्डिका और *फोटोरहाब्डस ल्यूमिनेसेन्स* की आण्विक पहचान के लिए आई टी एस और सी ओ आई जीन्स विश्लेषण की विधि का प्रयोग किया गया।

सफेद लट के प्रति ई पी एन का मूल्यांकन

एनोमाला बेंगालेन्सिस ग्रब के दूसरे और तीसरे निरूपीय लारवों के प्रति महाराष्ट्र के *हेटरोरहाब्डिटिस* के दो पृथककरणों और श्रीनगर से *हेटरोरहाब्डिटिस* तथा *स्टेईनर्नेमा* के एक - एक पृथककरण के *इन विट्रो* जाँच परीक्षण में पाया गया कि ये चारों पृथककरण ग्रब के प्रति अत्यन्त प्रभावी पाये गए जिनके कारण 100% घातकता पायी गयी।

गे. मीलोनेल्ला, को. सीफेलोनिका और सफेदलट से प्राप्त *हेटरोरहाब्डिटिस इन्डिका* और *स्टे. कार्पोकेप्से* ने *हे. आर्मिजेरा, स्पो. लिट्यूरा* और *प्लू. जाइलोस्टेल्ला* से प्राप्त पीढ़ी की अपेक्षा *गे. मीलोनेल्ला* और सफेद लट के प्रति अल्पकाल में अति उत्तम परिणाम दर्शाये।

सुपारी की फसल में सफेद लट (*ल्यूकोफोलिस लेपिडिफोरा, एनोमाला बेंगालेन्सिस* और *ल्यू. बुर्मेस्ट्राई*) के प्रति *हेटरोरहाब्डिटिस इन्डिका* और *स्टे. अब्बासी* के भिगोने लायक पाउडर आधारित नियमनों को प्रभावी पाया गया।

पादप परजीवी सूत्रकृमियों का जैविक नियंत्रण

गॉल और जड़ ग्रन्थि सूत्रकृमियों से ग्रसित जड़ों से *आर्थ्रोबोट्रायस कोनोयडस* और *आ. ओलीगोस्पोरा* के एक पृथककरण को नीलमंगला में एक व्यवसायिक पोलीहाऊस की मृदा में मिलाया गया, जिसके परिणाम स्वरूप *मीलॉयडोगाइनि ईन्कोग्निटा* और *रोटीलेन्कुलस रेनिफोर्मिस* में 90-98% तक घातकता आभिलेखित की गई।

पी सी आर विश्लेषक और बीटा - टयूब्यूलिन जीन की सिग्मेन्टस का एम्पलिफिकेशन उपयोग करके *आर्थ्रोबोट्रायस ओलीगोस्पोरा, आ. कोनोयडस* और *डेक्टाईलेल्ला ओविपेरासीटिका* के पृथककरणों का डी एन ए जीनोमिक किया गया।

इन विट्रो में, *पेसीलोमायसस लिलेसीनस* और *पोकोनिआ क्लेमॉयडोस्पोरिआ* के पृथककरणों से जड़ ग्रन्थि सूत्रकृमि के अण्डों और अण्ड समूहों के प्रति विषाक्त पैदा करने वाले सीराईन प्रोटीएज, कोलेजीनेज और काईटिनेज एन्जाईमों का अन्वेषण किया गया।

कवकीय प्रतिरोधकों के सहिष्णु का अवायुवीय तनाव (गो ब पं कृ वि एवं प्रौ)

ट्राइकोडर्मा के एक सौ पृथककरणों को टी-1 से टी-57 और टी एच 51-93 तक, पहाडियों (उत्तराखंड) और उत्तरी भारत के मैदानी भागों से एकत्र किए गए विभिन्न कृषीय दशाओं के अनुसार कोड तैयार किया गया और उनके अवायुवीय तनाव सहिष्णुता (जैसे कि ठंड, सूखा, लवणीयता) का *इन विट्रो* परीक्षण किया गया । सभी पृथककरणों ने विभिन्न प्रकार के पी एच पर सहिष्णुता प्रदर्शित किया, जबकि टी-13, टी-14, टी-50 और टी एच - 68 तापक्रम सहिष्णु पाए गए, टी-1, टी-4, टी-5, टी-9, टी-12, टी-13, टी-14, टी-19, टी-33, टी-39, टी-50, टी-55, टी-57, टी एच-56, टी एच-60, टी एच-61, टी एच-69, टी एच-70 और टी एच 82 पृथककरण लवणीयता के सहिष्णु पाए गए; टी-1, टी-5, टी-9, टी-11, टी-13, टी-14, टी-19, टी-33, टी-36, टी-39, टी-50, टी-56 और टी-57 पृथककरण नमी के सहिष्णु पाए गए तथा टी-14, टी-56 और टी-57 पृथककरणों को पी जी पी सक्रियता (धान) में सर्वोत्तम पाया गया ।

लवणीय दशाओं में, गेंहू की फसल में टी एच-14 को अंकुरण प्रतिशत सुधारने (अनोपचारित की अपेक्षा 33% बढाने के लिए) प्रभावी पाया गया, इसके बाद टी एच - 19 और टी एच - 13 प्रभावी पाए गए । टी एच-14 द्वारा बीज उपचारित फसल में अधिक कोंपले निकलना, जडों की लम्बाई बढना, पौधे में क्लोरोफिल की मात्रा अधिक बढना, झिल्ली सुदृढता ईन्डेक्स बढ़ना, एम डी ए (मेलान डी एल्डिहाईड) के एकत्रण की न्यूनता और प्रोलाईन तथा फिनोलिक्स को बढा ने में उपयोगी पाया गया । धान और गेंहू के पौधों में टी एच-56 और 75 ने जल तनाव के संबंध में अत्यधिक सहिष्णुता दिखाई ।

कवकीय प्रतिरोधकों द्वारा पादप रोगों को जैविक नियंत्रण (गो ब पं कृ वि एवं प्रौ.)

शीथ ब्लाईट की दशा में, पृथककरण 14, 56, 68 और 69 के प्रयोग करने के परिणामस्वरूप रोग ग्रसन नहीं पाया गया, इस प्रकार ये पृथककरण सर्वोत्तम पाए गए। अन्य पृथककरणों और अनोपचारित की अपेक्षा, सभी पृथककरणों में से टी - 75, टी-82 और टी-89 को धान की किस्म कालानमक -3119 की उपज और अन्य सभी वृद्धि मापकों के लिए अति उत्तम पाया गया ।

जैव नियंत्रण प्रौद्योगिकियों (गोबर की खाद में *ट्राइकोडर्मा हरजिएनम* + *स्यूडोमोनाज फ्लूओरेसेन्स* के नियमन 5 से 10 टन / हे. की दर से) या वर्मिकम्पोस्ट में *स्यूडोमोनाज फ्लूओरेसेन्स* (5 से 10 कु./हे. की दर से) का प्रयोग, बीज उपचार / टी एच + पी स्यू फ्लू (10 ग्रा. / कि.ग्रा. बीज की दर से) के मिश्रित नियमन का बायोप्राईमिंग करना तथा जैविक खेती वाले धान की शीथ ब्लाईट प्रभावित फसल में टी एच + पी स्यू फ्लू का 10 ग्रा. / ली. की दर से आवश्यकता के अनुसार छिड़काव के परिणाम स्वरूप देखा गया कि किसान द्वारा अपनाई जाने वाली प्रक्रिया की अपेक्षा जैव नियंत्रण अपनाए गए प्लाट में उपज थोडी कम मिलती है, किन्तु जैविक खेती से उत्पादित धान का मूल्य बाजार में अपेक्षाकृत अधिक मिलता है ।

ट्रा. हरजिएनम पी बी ए टी - 43 और *स्यू. फ्लूओरेसेन्स* पी बी ए पी - 28 के प्रयोग का बडे पैमाने पर क्षेत्रीय प्रदर्शन किया गया जिसमें टमाटर (38.5%), शिमला मिर्च (38.5%), पात गोभी (35.2%), मिर्च (33%), मटर (34.5%), फ्रेन्च बीन (26.7%) और प्याज (16.5%) की उपज किसानों द्वारा अपनाई गई प्रक्रिया की अपेक्षा अधिक बढी पाई गई ।

अनार में पादप परजीवी सूत्रकृमियों का जैविक नियंत्रण (म फु कृ वि)

अनार के चार साल पुराने खेत में, *स्यू. फ्लूओरेसेन्स* का 20 ग्रा./मी.^{2} की दर से मृदा उपचार करने के परिणाम स्वरूप जड़ ग्रन्थि सूत्रकृमि की सँख्या और जड गाँठें / 5 ग्राम जड़, में कमी करने और अनोपचारित की अपेक्षा 1 : 21.8 आई सी बी आर अनुपात के साथ अनार के फलों की उपज 18.2% बढी पाई गई ।

मृदा प्रतिदर्शों से बी टी विभेदों का पृथककरण और चरित्रण (भा.कृ. अनु. सं.)

उत्तर भारत के अनेक स्थानों से मृदा प्रतिदर्श एकत्र लिए गए और 10 बी टी विभेदों (सी टी जी - 1 से सी टी जी - 10) को पृथक किया गया। इन बी टी विभेदों का *काईलो पारटीलस* के प्रति प्रयोगशाला में मूल्यांकन करने पर ज्ञात

हुआ कि उपचार के सात दिनों के बाद लारवों में केवल 8.9 से 31.0 प्रतिशत तक घातकता विस्तार पाया गया ।

कीटरोगाण्विक कवक (ई पी एफ) का कवकीय प्रतिरोधकों और सूत्रकृमिभक्षी कवक (कॉलोनी में वृद्धि) के साथ अन्तः क्रिया (ग प्र सं)

कीटरोगाण्विक कवक (ई पी एफ) की सभी प्रजातियों का *ब्यू. बेसीआना* की वृद्धि के रूप में विभिन्न प्रकार का नकारात्मक प्रभाव दिखाई पड़ा, जिसमें से *ब्यू. ब्रोन्गोनीआर्टी* को सबसे अधिक सहिष्णु पाया गया । *ब्यू. ब्रोन्गनीआर्टी* को प्रारम्भ में सहयोगी कवकों के साथ लाभदायक पाया गया, किन्तु 12 वें दिन के बाद कवकों की सभी प्रजातियों के साथ प्रतिस्पर्द्धा के कारण वृद्धि कम दिखाई पड़ी, इन सभी में से *ब्यू. बेसीआना* को सर्वोत्तम पाया गया । *मे. एनाईसोप्लिए* के लिए *व. क्लेमॉयडोस्पोरियम* को वृद्धि सर्वोत्तम सहयोगी के रूप मे पाया गया ।

पूर्णतः वृद्धिकाल में, *ट्राइकोडर्मा* की दोनों प्रजातियों की उपस्थिति में तीनों ई पी एफ की वृद्धि में पूर्णतः प्रतिरोधकता दर्शायी। *ट्राइकोडर्मा* स्पे. की तरह कीटरोगाण्विक कवक के लिए सूत्रकृमिभक्षी कवक कम प्रतिस्पर्धा वाले पाए गए । कवकीय प्रजातियों के परीक्षणों में से *ट्रा. विरिडे* को *व. क्लेमॉयडोस्पोरियम* के लिए बहुत हानिकारक पाया गया । पूरे निरीक्षण काल के दौरान *ट्राईकोडर्मा* स्पे. के अलावा किसी भी कवक प्रजाति को *पे. लिलेसिनस* की वृद्धि के लिए प्रतिरोधक नहीं पाया गया ।

कवकीय प्रतिरोधकों और सूत्रकृमिभक्षी कवक (बीजाणुकरण) के साथ ई पी एफ की अन्तः क्रिया (ग प्र सं)

ब्यू. बेसीआना को *मे. एनाईसोप्लिए* और *व. क्लेमॉयडोस्पोरियम* के सहयोगी के अनुरूप पाया गया । सूत्रकृमिभक्षी कवक के अलावा अधिकतर प्रजातियों के साथ *ब्यू. ब्रोन्गनीआर्टी* को सहिष्णु पाया गया। जब *मे. एनाईसोप्लिए* और *ब्यू. बेसीआना* के बीजाणुओं को आपस में मिलाया गया तब दोनों पर ही आपस में कोई परस्पर प्रभाव प्रदर्शित नहीं किया, जोकि उनके सहयोगी होने का सूचक है । सूत्रकृमिभक्षी कवक और *ट्राइकोडर्मा* स्पे. दोनों ही *मे. एनाईसोप्लिए* के प्रतिरोधी पाए गए । दूसरी तरफ, बीजाणुकरण के दौरान सभी ई पी एफ *पे. लिलेसीनस* के अलावा *व. क्लेमॉयडोस्पोरियम* के अत्यन्त प्रतिरोधी पाए गए । कवकों की सभी प्रजातियों के परीक्षणों मे से *ट्राइकोडर्मा* की दोनों प्रजातियों को *पे. लिलेसीनस* के बीजाणुकरण के लिए अत्यधिक प्रतिरोधकता प्रदर्शित करता है ।

व. क्लेमॉयडोस्पोरियम के बीजाणुकरण पर *मे. एनाईसोप्लिए* और *पे. लिलेसीनस* को अत्यधिक प्रतिकूल पाया गया जबकि *ट्राइकोडर्मा* स्पे. के साथ अच्छा सहयोगी पाया गया । इसके विपरित एक जाँच परिक्षण में *पे. लिलेसीनस* का ई पी एफ द्वारा कोई प्रभाव नहीं दिखाई पड़ा जबकि *ट्राइकोडर्मा* स्पे. द्वारा प्रतिरोधकता अधिक प्रदर्शित की गई । बहुत कम सहयोगी होने के कारण *मे. एनाईसोप्लिए* के साथ *ट्रा. विरिडे* मिलाने पर सभी प्रजातियाँ प्रभावित हुई । यद्यपि, *ट्रा. विरिडे* के अलावा सभी, प्रजातियों से *ट्रा. हरजिएनम* अप्रभावित पाया इसके बाद *पे. लिलेसिनस* द्वारा पाया गया ।

ई पी एफ और कृषीयरसायनों में अन्तः क्रिया (ग प्र सं.)

यद्यपि *ब्यू. बेसीआना* की वृद्धि के साथ रसायनों के रासायनिक स्तर सहयोगी असर में बहुत अंतर था तब भी अनुवीक्षण के अन्तिम दिन (12 वें दिन) विकिरणीय वृद्धि के माध्यम से मेट्रीब्यूजीन, कार्बेन्डेजिम और क्लोरपायरीफोस के विषैले प्रभाव को प्रदर्शित किया । इमिडेक्लोप्रिड और एसीफेट द्वारा, सभी तीनों ई पी एफ की माईसीलियम की वृद्धि को बढाता है, जो कि प्रजातियों की प्रतिस्पर्द्धा के समय भी बढावा देती है । एट्राजीन रसायन की सभी तीनों कवकों के लिए सुरक्षित पाया गया । कवकों की कालोनी वृद्धि के दौरान सभी तीनों कवकों के लिए कार्बेन्डेजिम को अत्यन्त विषैला पाया गया । कार्बेन्डेजिम के समान मेट्रीब्यूजीन को *ब्यू. बेसीआना* और *ब्यू. ब्रोन्गनीआर्टी* के लिए हानिकारक प्रभाव डालता है जबकि *मे. एनाईसोप्लिए* कार्बेन्डेजिम और पेराक्वेट दोनों के प्रति बुरी प्रतिक्रिया दर्शाता है ।

फसल पीड़कों का जैविक नियंत्रण

गन्ना

गोला घाट जिले के बुरागाँव गाँव में स्थित किसानो के खेत (200 हे.) में *ट्राइकोग्रामा किलोनिस* को 50,000/ छोडना की दर से ग्यारह बार छोडने के परिणाम स्वरूप प्लासी बेधक के ग्रसन को 29.5 से 13.6% तक महत्वपूर्ण रूप

से कम किया गया। परजीवी कीट छोडे गए प्लाट से गन्ने की अधिकतम उपज (73,320 कि.ग्रा./हे.) जबकि, किसान द्वारा अपनाई गई कृषिगत प्रक्रिया से कम उपज (71,430 कि.ग्रा./हे.) प्राप्त हुई। सबसे अधिक लाभ *ट्राइकोग्रामा* छोडे गए प्लाट से प्राप्त हुआ (अ कृ वि - जो)।

ट्रा. किलोनिस की तापक्रम सहिष्णु विभेद के एक लाख कीट / हे. की दर से छः बारी में छोड़ने पर तना बेधक कीटो के ग्रसन को 75.8 प्रतिशत तक कम किया तथा उपज 89.9 किग्रा. गन्ने / 50 गन्ने अभिलेखित की गई (म फु कृ वि)।

अप्रैल से जून माह में एक बडे स्तर पर किए गए प्रदर्शन में *ट्रा. किलोनिस* को 50,000 / हे. की दर से 10 दिनों के अन्तराल पर 8 बारी में छोड़ने के परिणाम स्वरूप कोंपल बेधकों के ग्रसन में 56.4 प्रतिशत कमी देखी गई। रासायनिक नियंत्रण (1:7.5) की अपेक्षा परजीवी कीट छोडे गए खेत में लागत-लाभ अनुपात अधिकतम (1:19.2) पाया गया (पं कृ वि)।

पंजाब में, एक बडे स्तर पर किए गए प्रदर्शन में *ट्रा. जेपोनिकम* को अप्रैल से जून माह के दौरान 50,000 / हे. की दर से 10 दिनों के अन्तराल पर 8 बारी में छोड़ने के परिणाम स्वरूप अगोला बेधकों के ग्रसन में 54.7 प्रतिशत कमी देखी गई। रासायनिक नियंत्रण (1:6.5) की अपेक्षा परजीवी कीट छोडे गए खेत में लागत-लाभ अनुपात अधिकतम (1:20.6) पाया गया (पं कृ वि)।

महाराष्ट्र राज्य के पुणे, सांगली, कोल्हापुर, अहमदनगर, नासिक, जलगाँव, जालना और सतारा जिलों में गन्ने के वूली मांहू को देखा गया, किन्तु परभक्षी कीटों *डाइफा एफिडिवोरा* (0.8-2.1 लारवे / पत्ती), *माइक्रोमस इगोरोटस* (1.8-5.6 ग्रब / पत्ती) और सिरफिड (1-2 लारवे / पत्ती) की उपस्थिति तथा *एनकार्सिया फ्लेवोस्कूटेलम* द्वारा परजीवीकरण के कारण पीडको की सघनता न्यूनतम पाई गई (म फु कृ वि)।

जुलाई से अक्टूबर माह के दौरान एक क्षेत्रीय प्रदर्शन में *ट्रा. किलोनिस* को 50,000 प्रति हे. की दर से 10 दिनों के अन्तराल पर बारह बारी में छोडने के परिणाम स्वरूप गन्ने के तना बेधकों के ग्रसन में 58.7 प्रतिशत कमी देखी गई (पं कृ वि)।

प्रयोगशाला में बढ़ते तापक्रम के अन्तर्गत तापक्रम सहिष्णु विभेद के *ट्रा. किलोनिस* द्वारा परजीवीकरण और प्रौढ़ निकलने का सामान्य विभेद के संदर्भ में कोई विशेष अन्तर नहीं पाया गया जबकि 40° से. ग्रे. उच्च तापक्रम विभेदों ने *कोरसेरा सीफेलोनिका, काईलो इन्फसकेटेलस* और *काईलो सेकरीफेगस इन्ड्यूकस* के अण्डों का अधिकतम परजीवीकरण और प्रौढ़ निकलने की दर महत्वपूर्ण रूप से अधिक पाई गई (ग प्र सं)।

कोयम्बटूर और करनाल के *काईलो इन्फसकेटेलस* के जी वी वाले पृथककरण के अर्द्धशोधित घोल की जीवक्षमता अधिक, जिसके कारण डेड हर्ट न्यूनतम (60%) पायी गयी जबकि असम के पृथककरण में न्यूनतम डेड हर्ट 100% पाई गई। एक पखवाडे के अन्तराल पर कोंपल बेधक लारवे अनोपचारित खेत से एकत्र किए गए अप्रैल माह में जी वी की पुनः प्राप्ति न्यूनतम (14.3%) और अक्टूबर माह में अधिकतम (33.2%) हुई (ग प्र सं)।

गमले में किए गए परीक्षण से ज्ञात हुआ कि *ब्यू. बेसीआना* और *मे. एनाईसोप्लिए* का अकेले - अकेले या मिलाकर प्रयोग करने के परिणाम स्वरूप कोंपल बेधकों द्वारा होने वाले डेड हर्ट को कम किया जा सकता है (ग प्र सं)।

कपास

एनेसीअस बेम्बेवेली द्वारा परजीवीकरण दर 15.66 से 21.5% तक भिन्न - भिन्न पाई गई, औसतन 17.63% पाई गई। फसल वृद्धि के शुरूआत में न्यूनतम (16.84%) परजीवीकरण पाया गया जो कि धीरे-धीरे बढ़ता गया और अक्टूबर, 2010 के पहले सप्ताह तक बहुत अधिक (26.72%) पहुँच गया। खान्धा में अक्टूबर, 2010 में परजीवीकरण अधिकतम (21.15%) अभिलेखित किया गया (आ कृ वि - आनन्द)।

कपास में अक्टूबर, 2010 में *फी. सोलीनोप्सिस* देखा गया और पुनः जनवरी फरवरी, 2011 में देखा गया, मार्च, 2011 में अधिक सघनता (9.5 मीलीबग / 5 से. मी. शाखा) देखी गई। पीड़क कीट पर *एनेसीअस बेम्बेवेली* के साथ - साथ कोक्सीनेलीड और क्राइसोपिडों ने आक्रमण किया। पुणे क्षेत्र (इन्दापुर, बारामती क्षेत्र में फरवरी - मार्च, 2011 के दौरान मीलीबग, *सेकारीकोकस सेकारी* बहुत अधिक सँख्या में ग्रसन किया। वनस्पति विज्ञान के साथ - साथ कीट विज्ञान विभाग, कृषि कॉलेज, पुणे के अनुसंधान प्रक्षेत्र पर बहुवर्षीय अरहर फसल में मीलीबग *केक्सीडोहायस्ट्रिक्स इन्सोलिटा*

ग्रीन प्रजातियों को देखा गया । उद्यान फसलों जैसे - अंगूर, अमरूद, शरीफा, चीकू, पपीता और अनार पर *मेकोनेलीकोकस हिर्सुटस, फेरीसिआ विरगेटा, प्लेनोकोकस* स्पे. और *पेराकोकस मार्जिनेटस* से ग्रसित पाया गया । पपीते का मीलीबग एक बडी समस्या के रूप में पश्चिमी महाराष्ट्र के 6 जिलों में फैल गया । परजीवी कीट की देशी, प्रजाति वाले *एसीरोफेगस पपाये* द्वारा मीलीबग राज्य में परजीवित पाए गए । इसके अतिरिक्त *सुबाबुल* के पेड़ मीलीबग की एक अनजानी प्रजाति से ग्रसित पाए गए (म फु कृ वि) ।

तम्बाकू

नर्सरी में *बेसीलस थ्यूरीनजिएन्सिस* वेरा. *कुर्सटेकी* का ई सी 2.0 डी एस एम द्रवीय घोल का प्रयोग करने के परिणाम स्वरूप उपचार के 7 दिनों के बाद *स्पोडोप्टेरा लिट्यूरा* के लिए 24.8% घातक पाया गया। छिड़काव के सात दिनों के बाद *स्पो. लिट्यूरा* द्वारा नवोदभिदों की क्षति न्यूनतम (12.64%) और *स्पो. लिट्यूरा* के लारवों के लिए अत्यधिक (29.97%) घातकता पाई गई जब बी टी का पी एच 7 द्रवीय घोल का छिड़काव नर्सरी में किया गया (के त अनु सं)।

तम्बाकू की नर्सरी में *ब्यू. बेसीआना* का ई सी 1.0 डी एस एम के साथ 10^8 बीजाणु/मिली. की दर से पानी में मिलाकर प्रयोग करने के परिणाम स्वरूप उपचार के 7 दिनों के बाद *स्पो. लिट्यूरा* में 24.5% घातकता देखी गई। पी एच 7 पर *ब्यू. बेसीआना* का छिड़काव करने के सात दिनों के बाद *स्पो. लिट्यूरा* के कारण होने वाली नवोदभिदों की क्षति (15.31%) न्यूनतम और *स्पो. लिट्यूरा* के लारवों के लिए अधिकतम (18.71%) घातक पाया गया (के त अनु सं)।

छः विभेदों की जाँच की गई उनमें से, *हे.* एन पी वी के एन बी ए आई आई विभेद की 1.5 X 10^{12} पी आई बी / हे. की दर से प्रयोग करने के परिणाम स्वरूप *हे. आर्मिजेरा* के लारवों में अधिकतम घातकता (69.18%) और पत्ती की क्षति-न्यूनतम (6.30%) पायी गयी (के त अनु सं) ।

धान

आनन्द में एक क्षेत्रीय सर्वेक्षण में, धान के खेतों में तीन परभक्षी मकडियाँ *नीओस्कोना थीसाई, आर्जिओपी* स्पे. और *फोलकस* स्पे. प्रमुखता से पायी गयी।

गंधी बग के अण्डों को *ऊईनसिर्टेस* स्पे. (एनसिर्टिडे : हायमेनोप्टेरा) और *ग्रायोन* स्पे. (सीलीओनिडे : हायमेनोप्टेरा) द्वारा परजिवित पाए गए और *कोनोसीफेलस लोन्गिपेनिस* (एक्रीडीडे : आर्थोप्टेरा) तथा *माइक्रेस्पिस डिस्कोलर* (कोक्सीनेलिडे : कोलियोप्टेरा) द्वारा भक्षण करते पाए गए (त कृ वि)।

धान की किस्म गुर्जारी पर आई पी एम मोड़्यूल आयोजित करने के लिए क्षेत्रीय प्रदर्शन किया गया । अनोपचरित और किसान द्वारा अपनाई गई प्रक्रियाओं की अपेक्षा आई पी एम मोड़्यूल अपनाने के परिणाम स्वरूप पत्ती मोडक, स्किपर और पादप फुदकों के ग्रसन में महत्वपूर्ण रूप से कमी और दानों की उपज (4,200 कि.ग्रा./हे.) साथ ही साथ चारे की उपज (5,960 कि.ग्रा./हे.) भी अधिक अभिलेखित की गई । अन्य दोनों मोड़्यूलों की तुलना में आई पी एम मोडयूल में परभक्षी मकडियों की सँख्या महत्वपूर्ण रूप से अधिकतम (1.1 मकडियाँ / हिल) अभिलेखित की गई (आ कृ वि - आ) ।

अनोपचारित प्लाट की अपेक्षा सभी जैव-कीटनाशकों (*बेसीलस थ्यूरिनजिएन्सिस, ब्यूवेरिआ बेसीआना, वर्टिसीलियम लेकेनाई* और *नोम्यूरीआ रीलेई*) के उपचार के 10 दिनों के बाद परिणामों ने दर्शाया कि धान की पत्ती मोडक कीट और सफेद पीठ वाले फुदकों की सँख्या का ग्रसन महत्वपूर्ण रूप से कम अभिलेखित हुआ। जैव-कीट नाशकों के छिड़काव से मकडियों की सँख्या भी कम पाई गई । सभी उपचारित प्लॉट में दानों की उपज महत्वपूर्ण रूप से अधिक (3,100 से 3,600 कि.ग्रा./हे.) जबकि अनोपचारित प्लॉट में दानों की उपज कम (केवल 2,000 कि.ग्रा./हे.) आभिलेखित की गई (आ कृ वि-आ)।

बी आई पी एम प्रक्रियाओं श्रेष्ठता सिद्ध करने के लिए दो गाँवों में 200 हेक्टेयर क्षेत्रफल पर उपयोग किया गया। परिणामों से ज्ञात हुआ कि किसानों द्वारा अपनाई गई प्रक्रिया की तुलना में बी आई पी एम पैकेज अपनाने पर ग्रीन लीफ हापर्स की संख्याओं के साथ-साथ तना बेधक और पत्ती मोडक कीट द्वारा क्षाति बहुत कम पाई गई। किसानों द्वारा अपनाई गई प्रक्रिया में केवल 2,935 कि.ग्रा./हे., जबकि बी आई पी एम पैकेज अपनाने पर दानों की उपज अत्यधिक कुल 3,280 कि.ग्रा./हे. पायी गयी। किसान द्वारा अपनाई गई प्रक्रिया की अपेक्षा आई पी एम अपनाए प्लॉट में डेड हर्ट,

श्वेत बालियाँ और पत्ती मोड़क कीट का ग्रसन न्यूनतम (<5%) पाया गया (अ कृ वि - जोरहाट)।

सन् 2010 के दौरान धान (किस्म-ललाट) की फसल पर बी आई पी एम पैकेज की श्रेष्ठता सिद्ध करने के लिए पाँच गाँवों (बेराबोई, मेन्धसाला, भींगरापुर, बेन्टापुर और डयूलाकुर) में बडे स्तर पर आयोजित किया गया। किसानों द्वारा अपनाई गई प्रक्रिया की तुलना में आई पी एम पेकेज अपनाने के परिणाम स्वरूप डेड हर्ट, श्वेत बालियाँ, केस वॉर्म, स्किपर और ग्रीन लीफ हापर्स की सँख्या में महत्वपूर्ण रूप से कमी पाई गइ। आई पी एम पैकेज अपनाने पर लाभदायक जीवों जैसे मकडियों और लेडी बर्ड बीटलों की महत्वपूर्ण रूप से अधिकतम सँख्या पायी गयी। किसानों द्वारा अपनाई गई प्राक्रिया की तुलना में आई पी एम पैकेज अपनाने के परिणाम स्वरूप दानों की उपज अधिकतम (4,251 कि.ग्रा./हे.) और कुल लाभ भी 16,140 रूपये अधिक पाया गया (ओ कृ वि एवं प्रौ)।

थ्रिसुर जिले की विभिन्न पंचायतों के 700 हेक्टेयर क्षेत्रफल पर धान (किस्म-ज्योति और उमा) की फसल पर बी आई पी एम प्रौद्योगिकियों को बडे स्तर पर अपनाया गया। पत्ती मोडक कीट और डेड हर्ट ग्रसन की दृष्टि से बी आई पी एम और किसान की प्रक्रिया के बीच कोई महत्वपूर्ण अन्तर दिखाई नही पडा। यद्यपि, किसान द्वारा अपनाई गई प्रक्रिया की तुलना में बी आई पी एम अपनाये गये प्लॉटों में प्राकृतिक शत्रु कीट जैसे - मकडियों और कोक्सीनेलिडों की सँख्या महत्वपूर्ण रूप से अधिकतम पायी गयी। बी आई पी एम प्लॉट से दानों की उपज 7,595 कि.ग्रा./हे. और किसानों की प्रक्रिया अपनाए गए प्लॉट से 7,430 कि.ग्रा./हे. प्राप्त हुई जो इस बात का सूचक है कि इन दोनों प्रक्रियाओं में कोई विशेष महत्वपूर्ण अन्तर नहीं है (के कृ वि)।

जालन्धर जिले के भोगपुर ब्लॉक स्थित चाहरके गाँव में बासमती धान की किस्म *बासमती*-1121 पर दो स्थानों में 20 हेक्टेयर क्षेत्रफल पर प्रत्येक का जैव-नियंत्रण का बडे स्तर पर प्रदर्शन किया गया। इसका परिणाम यह निकला कि आई पी एम (*ट्रा. किलोनिस* और *ट्रा. जेपोनिकम* प्रत्येक को 1,00,000/हे. की दर से 6 बारी में छोड़ना) द्वारा पत्ती मोडक और तना बेधक कीटों का प्रबंधन *बासमती* धान में बडे स्तर पर रासायनिक नियंत्रण के समान प्रभावी रूप से होना सिद्ध होता है (पं कृ वि)।

धान के पीले तना बेधक और पत्ती मोडक कीट के प्रति ई पी एन का द्रवीय और भिगोने लायक पाउडर नियमनों के मूल्यांकन में ज्ञात हुआ कि जब *एस. फेल्टिए* को द्रवीय अवस्था में प्रयोग किया गया तब पीले तना बेधक के प्रति 50.2 प्रतिशत घातक पाया गया और पत्ती मोडक के प्रति 42.9 प्रतिशत घातक पाया गया किन्तु यह रासायनिक उपचार की तुलना में निम्न स्तर का पाया गया (अ कृ वि - जोरहट)

भुवनेश्वर में, इसी प्रकार के अध्ययनों में पाया गया कि *एस. रिओब्रेव* की द्रवीय अवस्था में जब प्रयोग किया गया, तब डेड हर्ट (8.8%) और पत्ती मोडक (4.5%) द्वारा क्षति महत्वपूर्ण रूप से कम पाई गई और यह अनोपचारित से उत्कृष्ट किन्तु रासायनिक उपचार के समान पाई गई (ओ कृ वि एवं प्रौ)।

केरल में, पी डी बी सी -ई पी एन - 4 के स्पाँज नियमन को धान तना बेधक और पत्ती मोडक कीट के प्रति अत्यधिक घातक पाया गया, किन्तु यह रासायनिक नियन्त्रण से निम्न कोटि का पाया गया (के कृ वि)।

गमले में किए गए परीक्षण में ई पी एन (*स्टेईनर्नेमा* स्पे. (स्ने) को 8 लाख/गमला की दर से) का प्रयोग करने के परिणाम स्वरूप *काईलो सुपरसेलिस* के लारवों के प्रति 55.8% और *नेफेलोक्रोसिस मेडीनेलिस* में 60.0% घातक पाया गया (के कृ वि-इम्फाल)।

दलहनी फसलें

अरहर की फसल में सूर्यमुखी को अन्तः फसल और मक्का को मेडों पर उगाने की तुलना में, अरहर की फसल में सूर्यमुखी को अन्तः फसल और ज्वार को मेडों पर उगाने के परिणाम स्वरूप *हे. आर्मिजेरा* लारवों की सँख्या कम (क्रमशः 6.4/10 पौधे और 3.6/10 पौधे) पाई गई। अरहर के साथ सूर्यमुखी को अन्तः फसल और मक्का को मेडों पर उगाने पर पर्ण फुदकों और मांहू की सँख्या कम और परभक्षी कीटों/स्टिन्क बग और कोक्सीनेलिडों की सँख्या अत्यधिक प्राप्त हुई। अन्य दोनों मोड्यूलों की तुलना में अरहर के साथ सूर्यमुखी अन्तः फसल के रूप में और मेडों पर ज्वार उगाने के परिणाम स्वरूप उपज (1247 कि.ग्रा./हे.) भी अत्यधिक प्राप्त होती है (आ एन जी रंगा कृ वि)।

अकेले अरहर की फसल उगाने की तुलना में जब अरहर के साथ अन्तः फसल के साथ सूर्यमुखी (9:1) और मेडों पर मक्का उगाने पर कटाई के समय *हे. आर्मिजेरा* द्वारा फली कम क्षतिग्रस्त अभिलेखित की गई। अकेले अरहर की फसल उगाने के उपचार की तुलना में सूर्यमुखी को अन्तः फसल और मक्का को मेडों पर उगाकर अरहर की फसल के प्लॉटों में कोक्सीनेलिड की सँख्या और दानों की उपज अत्यधिक अभिलेखित की गई (आ कृ वि - आ)।

अरहर में, अनोपचारित प्लॉट (1.9) की तुलना में *हे.* एन पी वी का $1.5x10^{12}$ पी ओ बी/हे.+0.5% कच्ची चीनी+0.1% टिपाल और द्वितीय निरूप के लारवों को हाथ से पकडने पर *हे. आर्मिजेरा* की सँख्या महत्वपूर्ण रूप से कम अभिलेखित की गई। यद्यपि, *जी. अर्टिका* और *मेरूका टेस्टयूलेटिस* के द्वारा होने वाली क्षति को इस उपचार से नियंत्रित करने में असफल साबित हुआ। अनोपचारित फसल से उपज कम (630 कि.ग्रा./हे.) जबकि *हे.* एन पी वी छिड़काव + *हे. आर्मिजेरा* के लारवों को हाथ से पकडने के उपचार से उपज महत्वपूर्ण रूप से अत्यधिक (1,140 कि.ग्रा./हे.) प्राप्त हुई (आ कृ वि - आनन्द)।

किसानों द्वारा अपनाई जाने वाली प्रक्रियाओं के प्रति चने (किस्म- जी जी-2) में पीड़कों के प्रति बी आई पी एम की उत्कृष्टता साबित करने की प्रक्रिया की गई। किसानों द्वारा अपनाई जाने वाली प्रक्रिया और अनोपचारित प्लॉट की अपेक्षा बी आई पी एम पैकेज वाले प्लॉट में *हे. आर्मिजेरा* की सँख्या महत्वपूर्ण रूप से न्यूनतम (0.1/पौधा), फली क्षति कम (1.9%) और मुरझान रोग का ग्रसन कम (5.4%) तथा दानों की उपज अत्यधिक (836 कि.ग्रा./हे.) अभिलेखित की गई (आ कृ वि-आनंद)

सोयाबीन में पत्ती भक्षक कीटों के प्रति ई पी एन के मूल्यांकन में ज्ञात हुआ कि *हे. इन्डिका* के द्रवीय नियमन के प्रयोग करने पर *स्पो. लिट्यूरा* की सँख्या न्यूनतम (3.17) जबकि *स्टे. कार्पोकेप्से* के टाल्क आधारित नियमन का प्रयोग करने पर सेमीलूपर की सँख्या न्यूनतम (2.5) पाई गई। यद्यपि, रासायनिक नियंत्रण की तुलना में ई पी एन के सभी नियमनों को निम्न कोटि का पाया गया (डी एस आर - इन्दौर)।

क्षेत्रीय परीक्षण में, *ब्यू. बेसीआना* के भिगोने लायक पाउडर का 1.5 कि.ग्रा./हे. की दर से प्रयोग करने के परिणाम स्वरूप *हे. आर्मिजेरा* और *एक्सिलेस्टिस एटमोसा* द्वारा दानों की क्षति महत्वपूर्ण रूप से न्यूनतम और अरहर के दानों की उपज अत्यधिक प्राप्त हुई जो कि *ब्यू. बेसीआना* के एस सी नियमन या बी टी से आधिक पाई गई किन्तु स्पिनोसेड के प्रयोग की तुलना में निम्न स्तर की पायी गयी (ज ने कृ वि वि)।

सोयाबीन (किस्म जे एस - 335) के पीड़कों के प्रति ई पी एन की उत्कृष्टता सिद्ध करने के लिए किए गए परीक्षण में ज्ञात हुआ कि *हे. इन्डिका* का 100 मिली./मी.^{2} की दर से द्रवीय नियमन प्रयोग करने के परिणाम स्वरूप *सी. एक्यूटा* (1.5), *स्पो. लिट्यूरा* (4.7) के लारवों की सँख्या न्यूनतम और दानों की उपज अत्यधिक (980.9 कि.ग्रा./हे.) प्राप्त हुई और इसको स्पिनोसेड के प्रयोग से उत्कृष्ट पाया गया (ज ने कृ वि वि)।

सोयाबीन के पत्ती भक्षक कीटों के प्रति कीटरोगाण्विकों के मूल्यांकन में पाया गया कि बी टी के छिड़काव किए गए प्लॉटों में *सी. एक्यूटा* (2.3) *स्पो. लिट्यूरा* (4.0) के लारवों की सँख्या न्यूनतम और दानों की उपज अत्यधिक (1,181 कि.ग्रा./हे.) आभिलेखित की गई। इसके बाद *ब्यू. बेसीआना* के छिड़काव को अच्छा उपचार पाया गया (ज ने कृ वि वि)।

तिलहनी फसलें

अरण्डी के केप्सूल बेधकों के अण्डों को *ट्राइकोग्रामा किलोनिस* (22.9%), *ट्रा. जेपोनिकम* (13.1%), *ट्राइकोग्रामेटॉयडिआ बेक्टेर* (17.3%) और *ट्रा. एकीय* (12.6%) द्वारा परजीवित पाया गया (आ एन जी रंगा कृ वि)।

कोयम्बटूर में, मूँगफली के सुरंगी कीट को बी टी की 1 कि.ग्रा./हे. की दर से या एन एस के ई 5% के छिड़काव व *ट्रा. किलोनिस* को चार बार छोडने के द्वारा प्रभावपूर्ण ढंग से प्रबंधन किया जा सकता है। बी टी छिडकाव के द्वारा अधिकतम उपज (1,496 कि.ग्रा./हे.), इसके बाद एन एस के ई 5% छिड़काव से प्राप्त हुई (त कृ वि)।

नारियल

केरल राज्य के आलापुझा जिले के देवीकुलान्गरा पंचायत में 100 हे. क्षेत्रफल पर *ओरीक्टस रहाईनोसेरोस* के प्रबंधन के लिए समेकित जैवनियंत्रण कारकों जैस *ओरिक्टस रहाईनोसेरोस* विषाणु, *मेटारहाईजियम एनाईसोप्लिए* और फेरोमोन प्रपंच के प्रयोग का क्षेत्रीय जाँच प्रदर्शन किया गया।

प्रजनन वाली जगहों पर प्रयोग करने के लिए किसानों को *मे. एनाईसोप्लिए* पैकेट (चावल मीडिया में 100 सँख्याओं में बीजाणुवित कवकों की 100 ग्राम मात्रा) दिए गए। पी सी आई फेरोफोन वाले फेरोमोन प्रपंचों (पी वी सी प्रपंच) को लगाने से औसतन 5.8 बीटल/प्रपंच/माह के हिसाब से एकत्र की गई (के फ रो अनु सं)।

मृदा कॉलम जैवविश्लेषण में ई पी एन की चार प्रजातियों के मूल्यांकन में नारियल की सफेद लट *(ल्यूकोफोलिस कोनिओफोरा)* के प्रति *हेटेरोरहाब्डिटिस* स्पे. की अपेक्षा *स्टे. कार्पोकेप्से* और *स्टे. अब्बासी* को 5000 आई जे/ग्रब की दर से उपयोग करना अत्यन्त प्रभावी पाया गया। मृदा कॉलम जैव विश्लेषण में नारियल की सफेद लट के प्रति *स्टे. कार्पोकेप्से* के साथ -साथ *स्टे. अब्बासी* का 5,000 आई जे का ईमिडेक्लोप्रिड (0.002%) के साथ सिनर्जिस्टिक अन्तः क्रिया के प्रदर्शन में केवल 48 घंटों में घातकता (85%) देखी गई (के फ रो अनु सं)।

रेड पाम विविल की ग्रब के प्रति ई पी एन के जाँच परीक्षण में पाया गया कि रेड पाम विविल की ग्रब के प्रति *हे. बेक्टेरिओफोरा* (613.5 आई जे) की अपेक्षा *हे. इन्डिका* (355.5 आई जे) को 96 घंटो के समान समय के प्रयोग करने पर *हे. इन्डिका* की अधिकतम एल सी$_{50}$ को अत्यधिक विषैला पाया गया (के फ रो अनु सं)।

कोट्टायाम जिले के वेचूर में किए गए प्रदर्शन में, परजीवी कीटों (*गोनिओजस निफेन्टिडिस* और *ब्रेकोन ब्रेविकोर्निस* को 10 परजीवी कीट/ताड वृक्ष की दर से) को छोड़ने के परिणाम स्वरूप कीट नियंत्रण और परजीवी कीट छोडे गए क्षेत्रों में *ओ. एरेनोसेल्ला* से पूर्णतः मुक्त ताड़ वृक्ष पाए गए (के फ रो अनु सं)।

सन् 2010 के दौरान मुथालामाडा (पालकाड-जिला) में *कार्डियाएस्टेथस एक्जिगुअस* को 50 निम्फ/ताड की दर से 5 दिनों के अन्तराल पर तीन बार छोड़ना और *गोनिओजस निफेन्टिडिस* को 10 प्रौढ़/वृक्ष की दर से एक पखवाडे के अन्तराल पर चार बार छोड़ने पर *ओपिसीना एरेनोसेल्ला* के लारवों की सँख्या को 5.7 से 0.7 प्रति पत्ती तक महत्वपूर्ण रूप से कम कर देता है (के कृ वि)।

उष्ण कटिबंधीय फलवृक्ष

अमरूद में, चाय वाली मच्छर बग, *हेलोपेल्टिस एन्टोनाई* के प्रबंधन के लिए *ब्यू. बेसीआना* का छिड़काव प्रभावी पाया गया, जिसमें फलों की क्षति न्यूनतम (5.0%) अभिलेखित की गई जबकि अनोपचारित दशा में फलों की क्षति अधिक (39.6%) पाई गई (भा बा अनु सं)।

मे. एनाईसोप्लिए और रासायनिक दोनों के प्रयोग करने पर आम के पुष्पक्रम पर आम के फूदकों की सँख्या महत्वपूर्ण रूप से कम (क्रमशः 21 और 3) जबकि अनोपचारित दशा में फूदकों की सँख्या अधिक (110) अभिलेखित की गई। फूदके पुष्पक्रम को अत्यधिक क्षति पहुँचाकर उसी उद्यान के बिना फूलों वाले वृक्षों पर एकत्र हो जाते हैं (भा बा अनु सं)।

बेमौसम के दौरान वृक्ष की शाखाओं + मौसम के दौरान साप्ताहिक अन्तराल पर *मे. एनाईसोप्लिए* का $1x10^9$ बीजाणु / मिली. की दर से छिड़काव करने पर पुष्पक्रम में आम के फूदकों के प्रति प्रभावी पाया गया (त कृ वि)।

केरल में पपीते के मीलीबग पर प्राकृतिक शत्रु कीट जैसे *स्किमनस* स्पे. और *स्पेल्जिस एपिअस* अभिलेखित किए गए (के कृ वि)।

तमिलनाडु में, पपीते के मीलीबग के प्राकृतिक शत्रु कीट जैसे *स्पेल्जिस एपिअस, क्रिप्टोलीमस मोन्ट्रोयूजिएरी, स्किमनस कोक्सीवोरा, ब्रूमॉयडस सुचूरेलिस, कीलोमीनस सेक्समेकुलेटस, कोक्सीनेल्ला ट्रान्सवर्सेलिस, क्लेडीस्कोडस सेकेराई* और *इश्चिओडोन स्कूटेलेरिस* अभिलेखित किए गए (त कृ वि)।

महाराष्ट्र में पपीते (किस्म-ताईवान 786) पर प्राकृतिक शत्रु कीट जैसे *स्पेल्जिस एपिअस, कोक्सीनेल्ला सेप्टमपंकटेटा, स्किमनस* स्पे., एन्थोकोरिड्स, *मालडा* स्पे., *ब्रूमॉयडस* स्पे., सिरफिड, मकडियाँ और एनसिर्टिड परजीवी कीट, *एसीरोफेगस पपाये* एकत्र किए गए (म फु कृ वि)।

तमिलनाडु में, 6 महीनों में 3,00,000 परजीवी कीटों का बहुगुणन किया गया और तमिलनाडु के सभी 32 जिलों में पपीते के मीलीबग के प्रबंधन के लिए किसानों के खेत में 100 परजीवी कीट/गाँव की दर से छोड़े गए। परजीवी कीट छोड़े गए पाँच स्थानों पर अध्ययन में 90 दिनों के अन्दर मीलीबग की सँख्या बहुत अधिक मात्रा (84 से 99 प्रतिशत) कम कर दिया (त कृ वि)।

चित्तूर जिले के पपीते (किस्म ताईवान, रेड लेडी) के बाग में *ए. पपाये* के कुल 300 परजीवी कीटों को 50 प्रौढ़

प्रति पखवाडा के अन्तराल पर और *ए. लोकेई* और *पी. मेक्सीकाना* के 100 प्रौढ़ छोड़े गए। लगभग तीन महीनों में, *ए. पपाये* परजीवी कीट पपीते के मीलीबग पर फैल गए उन्हें पूरी तरह परजीवित करते हुए उनके ऊपर स्थापित हो गए और मीलीबग की सँख्या को नगण्य स्तर तक पँहुचा दिया। बेंगलोर के पास सोलादेवनहल्ली और बागलूर में भी पपीते के मीलीबग पर *ए. पपाये,* परजीवी कीटों को छोड़ा गया (भा बा अनु सं)।

अक्टूबर, 2010 में पुणे में अप्लावित रूप से परजीवी कीट को 1,500 प्रौढ़ प्रति एकड़ की दर से मीलीबग से ग्रसित (95%) पपीते के बाग में छोडे गए और जनवरी, 2011 में इन परजीवी कीटों ने मीलीबग की सँख्या को 85 - 92% तक कम कर दिया। इसी प्रकार जलगाँव, धुले और थाने जिलों में मीलीबग से ग्रसित बागों में अप्लावित रूप से 1000 परजीवी कीट प्रति एकड की दर से अक्टूबर, 2010 में छोडे गये और जनवरी 2011 तक मीलीबग की सँख्या को प्रभावी ढंग से बहुत कम (65 से 85%) कर दिया (म फु कृ वि)।

सभी छः कीटनाशकों (एसीफेट 0.75 ग्रा./ली., इमिडोक्लोप्रिड 0.3 मिली./ली.; एसीटोमीप्रिड 0.2 ग्रा./ली., बूप्रोफेजीन 1.25 मिली./ली., डाईमेथोएट 1.5 मिली./ली. और क्लोरवोस 1 मिली./ली. की दर से) पपीते के मीलीबग परजीवी कीट *ए. पपाये* के लिए अत्यधिक विषैले पाए गए, इनके परिणाम स्वरूप परजीवी कीटों में 100% घातकता पाई गई (भा. बा. अनु. सं.)।

शरीफे में जून, 2010 में *कि. मोन्ट्रोयूजिएरी* को अप्लावित रूप से 2500 बीटल/हे. की दर से छोड़ने पर मीलीबग की सँख्या को 80.9% तक कम करने के लिए प्रभावी और शरीफे की बाजार योग्य उपज को 49.8% बढाने के लिए प्रभावी पाया गया (म फु कृ वि)।

शीतोष्ण फल वृक्ष

बाग - ए - खोमीनी उद्यान में *ट्राइकोग्रामा एम्ब्रियोफेगम* को दो बार क्रमबद्ध रूप से छोडने पर फलक्षति 31.4% तक कम पायी गयी जबकि अनोपचारित क्षेत्र में फलक्षति 77.3% पायी गयी (शे क कृ वि वि एवं प्रौ)

प्रयोगशाला में किए गए ई पी एन मूल्यांकन में, ई पी एन II (40 आई जे/सेमी^{2}) को सेब जड बेधक के प्रति अत्यधिक घातक (83.3%) पाया गया और इसके बाद ई पी एन I (40 आई जे/सेमी^{2}) को घातक (80.0%) पाया गया। *ब्यूवेरीआ ब्रोन्गनीआर्टी* और *मे. एनाईसोप्लिए* को जड़ बेधक *डोरीस्थेनेस हयूजेलि* के लिए क्रमशः 66.7 से 66.0 प्रतिशत घातक पाया गया (य सि प बा एवं वा वि)।

सब्जियों वाली फसलें

बी टी (वायोलेप) (1.0 कि.ग्रा./हे. $5x10^7$ बीजाणु/मि.ग्रा. की दर से) या *हे* एन पी वी ($1.5x10^{12}$ पी ओ बी/हे की दर से) या *ब्यू. बेसीआना* (1.0 कि.ग्रा./हे. $2x10^8$ सी एफ यू/ग्रा.) या *मे. एनाईसोप्लिए* (1.0 कि.ग्रा./हे. 10^8 सी एफ यू/ग्रा. की दर से) या *न्यू. रिलेई* पी डी बी सी विभेद (10^{12} बीजाणु/हे. की दर से) के प्रयोग करने के परिणाम स्वरूप *हे. आर्मिजेरा* के लारवों की सँख्या कम करने और टमाटर की फल उपज बढाने के लिए अत्यन्त महत्वपूर्ण तथा आपस में सभी एक समान पाए गए। यद्यपि एन पी वी उपचारित प्लॉटों से अधिकतम उपज (16160 कि.ग्रा./हे.) अभिलेखित की गई (आ कृ वि - आनंद)।

अनोपचारित और किसानो द्वारा अपनाई गई प्रक्रिया की तुलना में बी आई पी एम पैकेज अपनाने के परिणाम स्वरूप माहू (0.8), पर्ण फुदके (0.3) और श्वेत मक्खी (0.3) की सँख्यायें प्रति पत्ती महत्वपूर्ण रूप से कम पाई गई, फल कम क्षतिग्रस्त पाए गए और फल की उपज महत्वपूर्ण रूप से बढ़ी पाई गई (आ कृ वि - आनंद)।

भिंडी की फसल में *क्ला. पेलेसेन्स* के 10 या 20 निम्फ / पौधे की दर से 10 दिनों के अन्तराल पर चार बारी छोडने के परिणाम स्वरूप माइट की सँख्या को महत्वपूर्ण रूप से कम (96.6%) किया और यह रासायनिक छिड़काव के समान (97.6%) पाया गया। यद्यपि, अनोपचारित क्षेत्र में माइट की सँख्या 19.1 से 32.7 प्रति पौधा बढ़ी पाई गई (के कृ वि)।

एन बी ए आई आई - बी टी विभेदों की उत्कृष्टता सिद्ध करने के परीक्षण में ज्ञात हुआ कि पी डी बी सी-बी टी-2 (48.9%) की तुलना में पी डी बी सी - बी टी - 1(57.6%) द्वारा *प्लूटेल्ला जाईलोस्टेल्ला* के लारवों में अत्यधिक प्रतिशत घातकता सबित हुई (अ कृ वि-जोरहाट)। यद्यापि पं कृ वि में पी डी बी सी - बी टी -1(55.5%) की तुलना में पी डी बी सी-बी टी-2 (66.0%) द्वारा *हे. आर्मिजेरा* के लारवों में घातकता अत्यधिक प्रतिशत साबित हुई (पं कृ वि)।

सेम के माइट ग्रसित पौधे पर एक बारी में 20 परभक्षी माइट/पौधे की दर से छोडने के परिणाम स्वरूप माइट छोड़ने

के 20 दिनों के बाद माइट की सँख्या पूर्णतः समाप्त हो गई और परभक्षी माइट छोड़ने के 10 और 20 दिनों के बाद परभक्षी माइटों की सँख्या प्रति पौधा क्रमशः 367±8.6 तथा 779±8.4 बढ़ी पाई गई (य सि प बा एवं वा वि)।

ट्राइकोग्रामा प्रेटीओजम थेलीटोकोअस विभेद को 1 लाख/ हे. की दर से साप्ताहिक अन्तराल पर पौध रोपण के 45 दिनों के बाद से छः बारी छोडने पर *हे. आर्मिजेरा* के ग्रसन को कम करने और टमाटर के फलों की बाजार योग्य उपज को बढ़ाने के लिए प्रभावी पाया गया (म फु कृ वि, म प्र कृ वि एवं प्रौ, त कृ वि, के कृ वि और ओ कृ वि एवं प्रौ)।

बैंगन के कोंपल बेधक और फल बेधक के प्रति आई पी एम पैकेज की उत्कृष्टता सिद्ध करने के लिए पाँच गाँवों में परीक्षण किए गए जिसमें ज्ञात हुआ कि किसान प्रक्रिया से आई पी एम पैकेज उत्कृष्ट है जिसके परिणामतः मुरझान (3.2%), कोंपल बेधक (8.9%) और फल बेधक द्वारा क्षति (13.7%) महत्वपूर्ण रूप से कम पाई गई और बाजार योग्य उपज महत्वपूर्ण रूप से बढ़ी, परिणाम स्वरूप किसान प्रक्रिया द्वारा खेती की अपेक्षा 69,737 रूपयों का अत्यधिक लाभ प्राप्त हुआ (ओ कृ वि एवं प्रौ)।

पासीघाट में किए गए अध्ययनों से पता चलता है कि बैंगन में जैव नियंत्रण आधारित आई पी एम प्लॉट और किसान प्रक्रिया अपनाने से नर्सरी में पौधे मुरझान प्रतिशत, फल क्षति प्रतिशतता और बैंगन की बाजार योग्य उपज के बीच कोई विशेष महत्वपूर्ण अन्तर नहीं है। यद्यपि इन दोनों उपचारों को, अनोपचार से उत्कृष्ट पाया गया।

कीलोमीनस सेक्समेकुलेटा के 1500 बीटल/हे. की दर से प्रौढ़ों को एक बारी में छोड़ने पर लोबिया के माहू को नियंत्रित करने के लिए रासायनिक प्रयोग के समान अच्छा पाया गया। परभक्षी कीट छोडे गए प्लॉट (1.5/पौधा) और रासायनिक प्रयोग किए गए प्लॉट (1.7/ पौधा) में माहू की सँख्याओं में कोई विशेष अन्तर नहीं पाया गया। इसी प्रकार परभक्षी कीट छोडे गए प्लॉट (10,340 कि.ग्रा./हे.) और रासायनिक प्रयोग किए गए प्लॉट (10,530 कि.ग्रा./हे.) में लोबिया की उपज में कोई विशेष अन्तर नहीं पाया गया (के कृ वि)।

फूलगोभी में *प्लू. जाईलोस्टेल्ला* और *स्पो. लिट्यूरा* के प्रति आई पी एम मोडयूल की उत्कृष्टता जाँच परीक्षण में ज्ञात हुअ कि उपचार के बाद *प्लू. जाईलोस्टेल्ला* और *स्पो. लिट्यूरा* का जैव नियंत्रण आधारित आई पी एम प्लॉट (0.69/पत्ती और 0.25/पत्ती) में और किसान द्वारा अपनाई गई प्रक्रिया वाले प्लॉट (0.40/ पत्ती और 0.21/पत्ती) में कोई विशेष अन्तर नहीं पाया गया किन्तु इन दोनों उपचारों को अनोपचार से उत्कृष्ट पाया गया (के कृ वि - इम्फाल)।

टमाटर में आई पी एम की उत्कृष्टता सिद्ध करने के लिए परीक्षण से पता चला कि नर्सरी में पौधा घातकता प्रतिशत, फल क्षति प्रतिशत और टमाटर की बाजार योग्य उपज की दृष्टि में जैव नियंत्रण आधारित आई पी एम और किसान प्रक्रियाओं में कोई विशेष अन्तर नहीं हैं। यद्यपि इन दोनों उपचारों को अनोपचार से उत्कृष्ट पाया गया (के कृ वि- पासीघाट)।

जीरा

जीरा में, मुरझान रोग के प्रति प्रतिरोधी जैव रासायनिकों के साथ उत्कृष्टता सिद्ध करने के लिए *ट्रा. हरजिएनम* (पी डी बी सी) द्वारा बीज उपचार करने के परिणाम स्वरूप रोग ग्रसन न्यूनतम (2%) और जीरे के दानों की उपज अत्याधिक (1,141 कि.ग्रा./हे.) प्राप्त हुई (म प्र कृ वि एवं प्रौ)।

अन्‍ जैव नियंत्रण कारकों की तुलना में *व. लेकेनाई* के प्रयोग करने पर जीरे के माहू में अत्यधिक घातकता (84.7%) अभिलेखित की गई किन्तु यह ईमिडेक्लोप्रिड से निम्न स्तर की पाई गई। अजाडीरेक्टिन प्रयोग किए गए प्लॉट से दानों की उपज अधिकतम (995 कि.ग्रा./हे.) पाई गई जो कि ईमिडेक्लोप्रिड के समान ही पाई गई (म प्र कृ वि एवं प्रौ)।

सफेद लट का जैविक नियंत्रण

मृदा में *ब्यू. बेसीआना, मे. एनाईसोप्लिए, हे. इन्डिका* और *स्टेईनर्नेमा कार्पोकेप्से* के प्रयोग करने पर सफेद लट की ग्रब द्वारा आलू कन्द कम (31.4 - 38.0%) क्षतिग्रस्त पाए गए जबकि अनोपचारित दशा में अधिक (59.2%) क्षतिग्रस्त पाए गए (य सि प बा एवं वा वि)।

मूँगफली में, सफेद लट के प्रति कीटरोगण्विक कवक की उत्कृष्टता परीक्षण के परिणामों से पता चला की *मे. एनाईसोप्लिए* को $1x10^{13}$ कोनिडिआ/हे. की दर से प्रयोग करने पर पादप घातकता (4.6%) न्यूनतम और दानों की

उपज (1,524 कि.ग्रा./हे.) प्राप्त हुई। यह उपचार क्लोरपायरीफॉस के समान उपज बढाने वाला पाया गया (म प्र कृ वि एवं प्रौ)।

गेंहू में दीमक का जैविक नियंत्रण

अन्य ई पी एन की तुलना में *मे. एनाईसोप्लिए* का $1x10^{13}$ कीनिडिआ/हे. और *स्टे. कार्पोकेप्से* ई एन-11 का 5 बी आई जे/हे. की दर से प्रयोग करने पर दीमक क्षति नियंत्रित और गेंहू के पौधे की घातकता न्यूनतम (5.12 और 4.72%) पाई तथा उपज अधिकतम (4,020 और 3,960 कि. ग्रा./हे.) पाई गई किन्तु यह क्लोरपायरीफॉस की तुलना में निम्न स्तर की पाई गई (म प्र कृ वि एवं प्रौ)।

पोली हाऊस फसल के पीडकों का प्रबंधन

शिमला मिर्च में *स्किर्टोथ्रिप्स डोर्सेलिस* के प्रति विभिन्न जैव-नियंत्रण कारकों की दक्षता सिद्ध करने वाले परीक्षण में पाया गया कि *क्ला. पेलेसेन्स* छोड़े गए प्लॉट में अनोपचारित की अपेक्षा थ्रिप्स की अत्यधिक प्रतिशत कमी पाई गई। कीटरोगण्विक नियमनों को रासायनिक प्रयोग के समान ही प्रभावी पाया गया (भा बा अनु सं)।

शिमला मिर्च में, *स्किर्टोथ्रिप्स डोर्सेलिस* के प्रति *क्ला. पेलेसेन्स* के मूल्यांकन में पाया कि *क्ला. पेलेसेन्स* को 10/पौधा की दर से एक बार छोड़ने के परिणाम स्वरूप कीट का प्रभावी ढंग से नियंत्रण हुआ और उपज बढ़ी (भा बा अनु सं)।

एक परीक्षण में, फ्रेन्च बीन की फसल में *ट्राईएल्यूरोडस वेपोरेरीओरम* के प्रति *व. लेकेनाई* का शुद्ध संवर्धन के साथ-साथ नियमन और *पे. फ्यूमोसोरोसीअस* के शुद्ध संवर्धन के प्रयोग करने पर पाया गया कि *व. लेकेनाई* का 10^{9} बीजाणु/मिली. सान्द्रता वाला नियमन श्वेत मक्खी के प्रति अत्यधिक घातक साबित हुआ (य सि प बा एवं वा वि)।

गुलाब के पौधों पर जब 20 एन्थोकोरिडस छोडते हैं तब मकडी माइटों की सँख्या 21.1 से 6.4 तक कम हो जाती है। अनोपचारित प्लॉट में माइट की संख्या 16.2 से 25.1 प्रति पौधा बढ़ी पाई गई (शे क कृ वि वि एवं प्रौ)।

पुणे में, *क्ला. पेलेसेन्स* को 20 निम्फ/पौधा की दर से चार बारी में छोडने पर गुलाब में माइट की सँख्या को 63.1 से 26.8 प्रति 5 पत्तियों तक कम कर देता है और अनोपचारित से श्रेष्ठ किन्तु एबेमेक्टिन (15.4 माइट/5 पत्तियाँ) से निम्न स्तर का पाया गया (म फु कृ वि)।

कोयम्बटूर में, *क्ला. पेलेसेन्स* की 20 निम्फ प्रति पौधा की दर से चार बार छोडने के परिणाम स्वरूप स्पाईडर माइट की सँख्या 232 से 41 प्रति 5 पत्तियाँ तक कम पाई गई और 21.3% पत्ती क्षतिग्रस्त पाई गई, यह उपचार, अनोपचार से श्रेष्ठ तथा एबेमेक्टिन 0.3 मि.ली./ली. की दर से छिड़काव के समान पाया गया (त कृ वि)।

गुलाब में, स्पाईडर माइट के प्रति कीटकवकीय रोगाणुओं की उत्कृष्टता सिद्ध करने वाले परीक्षण में पाया कि *हि. थोम्पसोनाई* का 10^{8} सी एफ यू/मि.ली. की दर से प्रयोग करने पर माइट की सँख्या को महत्वपूर्ण रूप से कम (36.1 माईट/5 पत्तियाँ/गुलाब पौधा) पाया गया इसके बाद *व. लेकेनाई* (44.1 माईट/5 पत्तियाँ/गुलाब पौधा) पाया गया। यद्यपि, एबेमेक्टिन को 0.3 मि.ली./ली. की दर से प्रयोग करना माईट (*टेट्रानिकस उर्टिके* कोच) की सँख्या नियंत्रित करने के लिए अत्यधिक प्रभावी पाया गया (म फु कृ वि)।

कार्नेशन में, *व. लेकेनाई* को 10^{8} सी एफ यू/मि.ली. की दर से प्रयोग करने पर मांहू का ग्रसन महत्वपूर्ण रूप से कम और डंठलें/प्लॉट अधिक सँख्या में पायी गयी इसके बाद *ब्यू. बेसीआना* और *मे. एनाईसोप्लिए* प्रभावी पाए गए (त कृ वि)।

पोलीहाऊस में माईट के प्रति जैविक नियंत्रण कारकों के मूल्यांकन में कार्नेशन पर *स्टेथोरस पाओपरकुलस* को छोड़ने के परिणाम स्वरूप दो धब्बे वाली माईट को कम करने के लिए अत्यन्त प्रभावी पाया गया, इसके बाद *हि. थोम्पसोनाई, एम्बलिसीअस* स्पे. और *ब्यू. बेसीआना* प्रभावी पाए गए। यद्यपि, एबेमेक्टिन 0.3 मिली./ली. का छिड़काव सर्वोत्तम पाया गया (त कृ वि)।

भण्डारण कीटों का जैविक नियंत्रण

धान भण्डार में, *को. सीफेलोनिका* के प्रति एन्थोकोरिड्स के मूल्यांकन में म फु कृ वि, त कृ वि और पं कृ वि में पाया गया कि *क्ला. पेलेसेन्स* और *जा. फ्लेविपस* को 10, 20 और 30 निम्फ/10 कि ग्रा. धान की दर से छाडने पर *को. सीफेलोनिका* की सँख्या को महत्वपूर्ण रूप से कम किया

गया। म फ़ कृ वि में यद्यपि, एक माह के बाद एन्थोकोरिड का न तो निम्फ और न ही प्रौढ़ डिब्बे में दिखाई दिया जबकि त कृ वि, पं कृ वि और आ एन जी रंगा कृ वि में छोड़ने के एक महीने के बाद *जा. फ्लेविपस* के प्रौढ़ अत्यधिक सँख्या में अभिलेखित किए गए।

खरपतवार नियंत्रण

त्रिचुर में बिना गाँठ वाले पौधों की तुलना में, तना गाँठ मक्खी, *सेसीडोकेरस कोनेक्सा* को छोड़ने के परिणाम स्वरूप गाँठ वाले पौधों में पौधे की ऊँचाई और शाखाओं की सँख्या में महत्वपूर्ण रूप से कमी पाई गई (के कृ वि)।

3. EXECUTIVE SUMMARY

A comprehensive research programme was undertaken to address the mandate of the National Bureau of Agriculturally Important Insects. 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 2010-11 are presented below They testify to the headway 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

One hundred and twenty species of insects including coccinellids, parasitic Hymenoptera, and other insects were identified for 35 institutions including various AICRP centres, state agricultural universities, other universities, partners under the Network Project on Insect Biosystematics and students. Several e-mail queries with photo attachments for identification were answered.

Checklists of the Indian fauna of seven orders of insects, including Protura, Ephemeroptera, Odonata, Mantodea, Neuroptera, Anoplura, and Trichoptera, were hosted in the website of NBAII.

Eleven new species of *Rhynchortalia* Crotch (Coccinellidae) and one new species of Anthocoridae (*Anthocoris muraleedharani* Yamada) were described from southern India. Indian species of *Liophloeothrips* (Thysanoptera) were revised. One new species each of *Liophloeothrips* and *Microterys* (Encyrtidae) were described from Karnataka. The chrysopid genus *Apochrysa* was recorded for the first time from India on papaya mealybug.

One hundred and fifty-five factsheets on common parasitoids, predators, weed killers and invasives have been hosted on the website of NBAII. The sites provide basic diagnostic and biological information on these insects with photographs and other illustrations. A compilation of biocontrol introductions in India with details on 185 species was made available from the NBAII's website.

Fact sheets for six 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 was developed and updated for the website on aphids www.aphidweb.com.

Field studies with sentinel cards indicated that *Trichogramma chilonis, T. achaeae, T. pieridis, T. danausicida* and *T. danaidiphaga* are common and widespread native species around Bangalore. *Trichogramma danaidiphaga*, a new species was collected from the Himalayas and described from the eggs of *Danaus chrysippus* on *Calotropis gigantea*. Molecular analyses revealed that *T. danausicida* and *T. danaidiphaga* are two distinct species. *T. agriae* were collected from the eggs of *Ariadne merione* on castor, which is a new host record for this species.

Surveys were conducted in different ecosystems for scelionids in six states, *viz*., Jammu and Kashmir (Nubra Valley, Leh; Srinagar), Maharastra (Pune, Aurangabad), New Delhi, Uttar Pradesh (Lucknow), Tamil Nadu (Kotagiri, Coimbatore) and Karnataka (eleven districts). A total of 3230 parasitoids were collected, curated and preserved for future studies. Egg parasitoids were collected from 156 egg masses of different orders of insects such as Heteroptera (57), Lepidoptera (58), Arachnida (15) Homoptera (3), Neuroptera (Chrysopidae) (9), Dictyoptera (10), Diptera (1), Coleoptera (1) and Orthoptera (2).

Fifteen genera of Platygastridae belonging to three subfamilies - Scelioninae, Telenominae and Teleasinae were recorded. The fifteen genera are *Acantholapitha, Calliscelio, Calotelea, Cyphacolus, Duta, Dyscritobaeus, Encyrtoscelio, Palpoteleia, Sparasion, Gryonoides, Odontoscelio, Xenomerus, Paratelenomus, Psix* and *Trissolcus*. The genera *Gryonoides* and *Odonotscelio* are reported for the first time from India.

Fiftyfour eggs of Chrysopidae were collected on rose bushes in the Nubra Valley in Ladakh and 74.1 per cent of the eggs were parasitized by *Telenomus* sp. while per cent larval emergence was 22.22. Forty-eight eggs of *Acherontia styx* collected on *Datura* were parasitized by *Telenomus* sp. *Sceliocerdo* (a phoretic species on grasshopper) was collected on the grasshopper *Neorthacris acuticeps* (Pyrgomorphidae: Orthoptera). This species had so far been collected only from Mandy (Karnataka), but has now been collected from Coimbatore (Tamil Nadu) also.

Classical Biological Control of papaya mealybug

The three parasitoid species, viz., *Acerophagus papayae, Pseudleptomastix mexicana* and *Anagyrus loecki* were imported in five consignments from Puerto Rico, quarantined and field released for the biological suppression of papaya mealybug, *Paracoccus marginatus*. The parasitoids were specific to *P. marginatus* and did not parasitise seven other species of mealybugs common in India, i.e. *Maconellicoccus hirsutus, Phenococcus solenopsis, Ferrisia virgata, Planococcus citri, P. lilacinus, Pseudococcus longispinus* and *Lankacoccus ornatus*. The parasitoids did not attack the following non target beneficial organisms, i.e. *Micromus igorotus, Chrysoperla zastrowi sillemi, Brumoides* sp., *Cryptolaemus montrouzieri, Goniozus nephantidis, Trichogramma chilonis, T. japanicum, Bombyx mori, Apis cerana indica, Scymnus coccivora*, and *Spalgis epius*. All the three species of parasitoids could be multiplied on *P. marginatus* grown on potato sprouts.

Training on the mass production of papaya mealybug and its introduced parasitoids was conducted for over 250 scientists, subject matter specialists, extension officers of ICAR, SAUs, KVKs, NGOs and CSRTI, Mysore in different batches between September-November, 2010. One workshop on "Management of papaya mealybug and deployment of introduced parasitoids" was conducted on 30th October, 2010 and over 200 scientists from ICAR, SAUs, KVKs, KFRI, IFGTB, CSRTI and NGOs and a few farmers attended the workshop.

The papaya mealy bug parasitoid *Acerophagus papayae* has established at all release spots in Tamilnadu, Karnataka, Maharashtra and Andhra Pradesh and suppressing the population of papaya mealybug successfully.

Division of bio-resource conservation and utilization

Studies on predatory anthocorids

Twenty five surveys were made and *Orius* spp., *Cardiastethus exiguus, Blaptostethus pallescens, Anthocoris muraleedharani, Carayanocoris indicus* and five unidentified species of anthocorids were collected. It was found that rearing the *C. exiguus* at 25 and 30°C was most suitable for survival and reproduction. The eggs of *C. exiguus* can be stored for 5 days at 10°C (with 64% hatching and 64% adult emergence) and 10 days at 15°C (with 68% hatching and 68% adult emergence).

Evaluation of anthocorid predators

The 2 day old nymph of *B. pallescens* could feed 1.5 crawlers per day whereas 7 days old nymph could feed 2.2 crawlers per day. A total of 18 and 29 crawlers were fed by 2 days and 7 days old nymphs, respectively, however the survival of the nymphs was very poor. In case of adults, 2.6 crawlers were fed per day and the adult could feed on 31 crawlers, however the adult longevity was reduced from 30 to 13 days when fed on papaya mealybug.

The new anthocorid predator *Anthocoris muraleedharani* Yamada sp. nov. originally collected from *Bauhinia prpurea* trees infested by *Ferrisia virgata* could be reared on cotton mealybug. During the nymphal stage, *A. muraleedharani* could feed on a total of 65.3 crawlers of cotton mealybug (CMB), with a feeding of 4.3 (range: 2 to 10) crawlers per day. The adult could feed on a total of 124.3 crawlers with a per day feeding of 6.1 (range: 2 to 14) CMB crawlers. However, this anthocorid could not feed on papaya mealybug.

Eight releases of *B. pallescens* @ 10 per plant reduced the thrips damage on chlli significantly (Freshno chilli-var. Supreme) at a polyhouse belonging to Namdhari. The yield and the quality of the produce from the biocontrol plot were as good as those of the chemical control plot.

Ten releases of *B. pallescens* @ 10 per plant reduced the mite damage on chilli significantly at a net house. The per cent leaf curling was reduced from 35 % (pre-release) to 13.25% (post release). The control plants showed the typical symptoms of shriveling and curling and drying of terminal portions and flowers or buds which failed to open. The per cent increase in height of the treated plants was 22.3, while in the control, it was only 8.26%.

Studies on *Sitotroga cerealella* and *Hippodemia variegata*

Sitotroga cerealella was mass produced on unhusked wheat. Per day production was 1.33cc and average production per month was 36.7cc. The total production of egg was 403.5 cc during the period under report. Biology of *Hippodemia varigata* collected from Srinagar was studied by providing *Aphis craccivora* as host. The egg, larval and pupal period lasted for 3.4, 7.8 and 4.6 days respectively. The larval feeding potential was 32.3 aphids per day. The total larval feeding potential varied from 226.3 to 258.6 aphids. The pre-oviposition period varied from 9-11 days and the female fecundity varied from 0.00 to 306.8 eggs. The adult longevity was 52.8 days in male and 61.11 days in female.

Studies on mealybugs and pseudococcids

The mealybug species, *Phenacoccus madeirensis*, *Phenacoccus divaricatus*, *Phenacoccus solani*, *Rastrococcus mangiferae*, and *Paracoccus marginatus* belonging to the tribe Phenacoccini could be successfully mass multiplied only on sprouted potato and not on pumpkin. A total of 42 species of pseudococcids were collected, preserved and identified. The genus *Phenococcus* Cockerell was the most predominant with seven species under it followed by genera *Dysmicoccus* Ferris and *Pseudococcus* Westwood with four species in each. A total of 69 species of natural enemies were collected on 31 different species of aphids and coccids.

Pollinators in different crop ecosystems

Surveys were undertaken in pigeonpea ecosystem at Karnataka, Tamilnadu, Andhra Pradesh and Maharashtra for the collection of pollinators. Three species of *Xylocopa* (*X. aestuans*, *X. latipes* and *Xylocopa* sp.), five of *Megachile* (*M. lanata*, *M. bicolor*, *M. anthracina*, *M. carbonaria*, *M. hera* and *Megachile* sp.), *Lasioglossum* sp., *Ceratina (Pithitis) binghami*, *Apis florea*, *A. dorsata and Trigona* sp. and an unidentified Halictid were collected from pigeonpea. On gingelly crop *Apis dorsata* and *A. cerana indica* were the most common pollinators in Tamilnadu. On sunflower *Apis dorsata*, *Apis cerana indica*, *Apis florea* and *Trigona iridipennis* were found to be dominant pollinators. Naturally maintained (pesticide-free) pigeonpea ecosystem supported a wide variety of natural enemies like hymenopteran parasitoids (Braconidae, Ichneumonidae, Vespidae, Scoliidae etc.) and predators (Coccinellidae, Mantidae, Chrysopidae, Gomphidae- dragonflies, Clubionidae (sac spiders) and Araenidae) when compared to continuously sprayed fields of Gulbarga, Bidar and Raichur areas of Karnataka.

In the nontraditional pigeonpea area of Karnataka, Singapore cherry, *Muntingia calabura* (Fam: Tiliaceae), *Spermacoce hispida* (Rubiaceae) and *Euphorbia heterophylla* (Euphorbiaceae) supported all species of honey bees, whereas *Centrosema pubescens* (Fam: Fabaceae) supported only carpenter bees. Intercropping pigeonpea (cv. TTB-7) 10 rows with marigold (cv. Local) 2 rows and sunflower (cv.KBSH-53) 2 rows alternatively attracted more number of pollinators and natural enemies when compared with the sole pigeonpea crop. The pod damage by *Helicoverpa*, pod flies and pod bugs were relatively less in intercropped pigeonpea compared to sole crop.

Polymorphism in pheromone reception in *Helicoverpa armigera*.

Different geographic populations of *H. armigera* were collected from Nagpur, Bangalore, Gulbarga and Raichur (Karnataka) and Coimbatore (Tamil Nadu).

Different blends of pheromone components Z-11-hexadecenal and Z-9-hexadecenal like 97:3 (blend used commercially for the traps); 91:9 and 85:15 were prepared and loaded into the silicone tubes and kept in the sleeve traps at the canopy height. In the field trial at Raichur, there was significant number of males caught in both the blends 97:3 and 91:9. The males of *H. armigera* collected from Raichur, showed response to the blend of 97:3 in GCEAD studies in the laboratory. In the field trial at Patna, the blend ratio 85:15 gave better. The Coimbatore females elicited more EAG response than that of Raichur population.

Division of Genomics and Bioinformatics

Biochemical identification and molecular characterization of endosymbionts

Trichogrammatids

The yeast and bacterial endosymbionts isolated from *Trichogramma embryophagum* and *T. danaudiphaga* parasitoids emerged from field-collected lepidopteran eggs were identified as *Pichia anomola*, *P. guillermondii*, *Candida apicola*, *C. pimensis*, *Metschnikowia reukaufii*, *Hanseniaspora uvarum*, *Wickerhamomyces anomalus*, *Zygosaccharomyces rouxii*, *Bacillus subtilis* and *B. cereus*.

A total of 20 strains, including 2 *Candida* species and 10 *Pichia* species were identified to species level by ITS sequence analysis. A BLAST search revealed that yeast strains Tcy1, Tcy2 and Tcy3 had sequence similarities to their corresponding type strain *Pichia anomala* isolate P13 (GenBank Accession No. AY349442). All the endosymbiotic yeasts and bacteria associated with *Trichogramma* obtained from different locations were identified by ITS sequencing analysis as *P. anomala*, *Candida* cf. *apicola*, *Wickerhamomyces anomalus*, *Metschnikowia reukaufii*, *Hanseniaspora uvarum*, *Candida pimensis*, *P. guillermondii*, *Zygosaccharomyces rouxii*, and bacteria as *Bacillus cereus* and *Bacillus subtilis*. Nucleotide sequences were aligned and the results confirmed by clustering that *Pichia anomola* as one group, *Candida* as another and other related ones joining with each other.

Chrysoperla zastrowi sillemi

The yeast cultures were characterized using the YITS-PCR that amplifies the yeast Internal Transcribed Spacer gene, whereas the bacterial cultures were characterized using the 16S rDNA-PCR that amplifies the 16S rDNA region specific only to bacteria.

The endosymbiont from pesticide-tolerant strain (PTS 8) of the *C. z. sillemi* predator was isolated and the ITS region was amplified (798bp region). The BLAST search found the endosymbiont to be *Klebsiella* sp. The endosymbiont from temperature-tolerant strain showed 98% homology with *Zygosaccharomyces* sp. and another yeast culture showed 98% homology with *Pichia anomala* in the GenBank database. Another bacterial endosymbiont showed 97% homology with *Stenotrophomonas maltophilia* strain in the Genbank database.

Cotesia plutellae and *Trichogramma brassicae*

Based on carbohydrate fermentation test, yeast isolated from *Cotesia plutellae* showed utilization of maltose, sucrose, galactose, cellobiose, xylose and raffinose and was found to be very close to *Pichia guillermondii*.

A BLAST search revealed that yeast strain Cpy1 isolated from Tirupati population had an ITS1-5.8S-ITS-2 sequence similarity of 99% with their corresponding type strain *Pichia anomala* isolate P1. The output of the BLAST search of 16s rDNA sequence of strain Cpb1 isolated from Hoskote population showed 100% sequence identity with *Bacillus subtilis*. Likewise, bacteria associated with *Trichogramma brassicae* was identified by 16s rDNA sequencing analysis as *Bacillus cereus* strain Tb1 and was 99% similar to *Bacillus cereus*.

The sex regulating bacterial endosymbiont *wolbachia* was detected in both the populations of *C. plutellae* using wsp primers. The presence of *wolbachia* was verified by a PCR method based on the *wolbachia* surface protein (wsp). Sequencing of the *wolbachia* surface protein, wsp, revealed *wolbachia* infection was related to *wolbachia* in *Trichogramma dyrtid* with maximum similarity of 99% with BLAST test search of NCBI.

Indian coccinellids

DNA Barcodes for the 13 species of coccinellids, viz., *Brumoides suturalis, Chilocorus nigrita, Cheilomenes sexmaculata, Coccinella septempunctata, Coccinella transversalis, Cryptolaemus montrouzieri, Curinus coeruleus, Harmonia axyridis, Henosepilachna vigintioctopunctata, Hyperaspis maindroni, Illeis cincta, Rodolia amabilis* and *Scymnus (Pullus) latemaculatus* were generated by submitting the all relevant information with the iBOL(BOLD2.5) system. The phylogeny of thirteen species of coccinellids was generated based on molecular character by bioinformatics tool.

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

Co-ordinating Cell: NBAII

Entomofungal pathogens

Application of *Verticillium lecanii* (VI-8 isolate) recorded lowest population of *Aphis craccivora* (32.3/plant) and highest yield (911kg/ha) and was on par with monocrotophos (0.007%). The fungal pathogen was found safe to *Cheilomenes sexmaculata* as no mycosis was recorded, however 1.7 - 3.1% mycosis was recorded on the larvae of *Micromus timidus*.

The bioefficacy *Acremonium* sp. and *Lecanicillium psalliotae*, was evaluated against *Tetranychus urticae* on five cucurbits, viz. ash gourd, bitter gourd, bottle gourd, cucumber and ridge gourd, in three rounds of experiments set up in the greenhouse at the Biocontrol Research Farm, Attur, Bangalore, during 2010-11. Among the fungal treatments, *Acremonium* sp. applied subsequent to the treatment with a weakening agent (PWA-1A) was the best in terms of reduction (74.7 to 82.8%) of the mite density.

Field bioefficacy of both host- and non-host derived *Hirsutella thompsonii* isolates against *Phyllocoptruta oleivora* on orange and sweet orange was done. On sweet orange both *H. thompsonii* isolates were able to significantly reduce the population of the citrus rust mite, the host-derived isolate being slightly better in terms of reduction in mite population.

Mass production of fungal antagonists of plant pathogens

Incubation at 28°C was the most optimum temperature for the production of viable propagules of *Trichoderma harzianum* (TH10) on ragi as substrate. This was correlating to the declining moisture content and water activity when substrates were incubated at elevated temperatures (30°C or above).

In case of entomofungal pathogens, the highest cfu counts of *M. anisopliae* and *B. bassiana* were recorded at 32°C (17.4 and 27.0 x 10^8/g respectively after 15 days of incubation) on rice as substrate compared to other temperatures tested.

The cfu of *B. bassiana* on sorghum, 15 days after inoculation was 26.4 x 10^8/g whereas on ragi it was 8.4 x 10^8/g. In case of *M. anisopliae*, on sorghum substrate, the maximum cfu count was 29.4 x 10^8/g, whereas on rice grain substrate it was 26.2 x 10^8/g.

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

A combined application of the talc-based formulation of *B. megaterium* NBAII 63 (10^8 cfu/ml) as seed treatment (4g /kg of seed), soil application (5g /kg of soil), seedling root dip (10g /L of water) and foliar spray (10g /L of water) resulted in 51 per cent reduction of bacterial wilt in brinjal. Good root and shoot growth of the brinjal plants were recorded due to application *B. megaterium*.

Bacterial antagonists of *Meloidogyne*

A total 15 isolates of *Pseudomonas* spp. were isolated from infected egg masses of root-knot nematode, *Meloidogyne* spp. in brinjal and tomato crops. Seven isolates were found inhibitory to second stage juveniles of root-knot nematode under *in-vitro* condition and isolates NBAII-2 and NBAII-5 resulted up to 83.33% mortality of juveniles of *Meloidogyne* spp.

Indigenous *Bacillus thuringiensis*

Six indigenous Bt namely PDBC-BT1, PDBC-BT2, NBAIIB-TAS, NBAIIB-TG4, NBAII-BT3 and NBAII-BT4 were screened against *H. armigera* using toxins activated by trypsin digestion. PDBC-BT1 was the most toxic with the lower LC_{50}. NBAII-BTG4-treated plants however recorded the lowest pod damage in pigeonpea.

Cry1 and *Cry2* Genes were present in PDBC-BT1, PDBC-BT2 NBAII-BT3, NBAII-BT4, NBAII-BT5, and NBAIIB-TG4. Cry11 was present in all the isolates which is supposed to have dual toxicity (Lepidoptera and Coleoptera).

The spore-crystal mixture of the native isolates and the reference strains were analyzed by SDS-PAGE. BT1, BT2, BT3, BT5, BT-HD 1,BT ASSAM BT G4 isolates produced major proteins of 130and 60kDa consistent with the *cry1 and cry2*genes.

Abiotic stress tolerant Pseudomonads

Among *Pseudomonas putida* (3 strains), *P. plecoglossicida (2 strains), P. fluorescens (2 strains), Alcaligenes.* sp. and *Pseudomonas* sp. the highest vigour index of 4600 was observed in the plants treated with *P. putida* (RPF-9).

'In vivo' mass production of EPN

The optimal temperature for growth, duration of life cycle, larval biomass and fecundity of *Galleria* ranged between 28 and 30°C at a relative humidity of 50-80%. The diets and the media were redesigned and three modified diets have supported the *Galleria mellonella* larval production without any adverse effects on fecundity, duration of life-cycle and larval biomass and cheaper by 38-56% less than the standard diet.

'In vitro' production of EPN

Prior inoculation of symbiotic bacteria into Wout's medium, soy flour + dog biscuit medium and dog biscuit medium was found to enhance the yield and rate of multiplication of *S. carpocapsae*, *S. abbasi* and *H. indica*.

Shelf life of EPN formulations

Wettable powder formulations of *Heterorhabditis indica* and *H. bacteriophora* were developed with a shelf-life of 8-10 months.

Molecular identification using ITS and COI genes analysis approach has been devised for *Steinernema carpocapsae*, *Steinernema abbasi*, *Heterorhabditis bacteriophora*, *Heterorhabditis indica* and *Photorhabdus luminescens*.

Evaluation of EPN against whitegrubs

'In vitro' screening of two isolates of *Heterorhabditis* from Maharastra and one of *Heterorhabditis* and *Steinernema* from Srinagar against second and third instar grubs of *Anomala bengalensis* revealed that all the four isolates were effective causing 100% mortality to grubs.

Heterorhabditis indica and *S. carpocapsae* obtained from *G. mellonella*, *C. cephalonica* and root grub exhibited better infectivity in shorter duration against *G. mellonella* and root grub compared to the progeny obtained from *H. armigera*, *S. litura* and *P. xylostella*.

Wettable powder formulations of EPN *Heterorhabditis indica* and *S. abbasi* were effective against the root grubs (*Leucopholis lepidophora*, *Anomala bengalensis* and *L. burmestrii*) in arecanut.

Biological control of plant parasitic nematodes

An isolate of *Arthrobotrys conoides* and *A. oligospora* collected from the galled and root-knot nematode-infected roots and soil mix of commercial polyhouse in Nelamangala recorded 90-98% mortality of *Meloidogyne incognita* and *Rotylenchulus reniformis*.

Genomic DNA from isolates of *Arthrobotrys oligospora*, *A. conoides* and *Dactylella oviparasitica* were used for PCR analysis and amplification of segments of beta-tubulin gene. Based on the molecular size of the respective amplicons, the fungal identity was confirmed.

Serine protease, collagenase and chitinase enzymes responsible for virulence against root-knot nematode eggs and egg masses, were detected in the isolates of *Paecilomyces lilacinus* and *Pochonia chlamydosporia* under *in vitro*.

Fungal antagonists tolerant to abiotic stress (GBPUAT)

One hundred isolates of *Trichoderma* coded as T-1 to T-57 and Th 51 -93 from different farming situations in the hills (Uttarakhand) and plains of North India were collected and screened *in vitro* for their tolerance to abiotic stresses (i.e. cold, drought, salinity). All isolates showed tolerance to varying degree of pH, whereas isolates T-13, T-14 , T-50 and Th-68 were tolerant to temperature, 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-57, Th-56, Th-60, Th-61, Th-69, Th-70 &Th-82 were tolerant to salinity, 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 tolerant to moisture and isolates T-14, Th-56 and T-57 for PGP activity (rice) were found best.

In wheat, Th-14 was effective in improving germination percentage (33 % increase over control) followed by Th-19 and Th-13 under saline conditions. The Isolate Th-14 also enhanced higher shoot, root lengths, total chlorophyll content, increased membrane stability index, lower accumulation of MDA content and increased proline and phenolics in treated seedlings. Th 56 and 75 induced maximum tolerance to water stress of rice and wheat plants.

Biological suppression of plant diseases with fungal antagonists (GBPUAT)

In case of sheath blight, isolates 14, 56, 68 and 69 were found best with no disease incidence. Among all isolates only T-75, T-82 and T- 89 performed best in terms of all the growth parameters and yield of rice cv Kalanamak-3119 in comparison to other isolates and check.

In large scale demonstration of biocontrol technologies (FYM colonized with mixed formulation of *Trichoderma harzianum* + *Pseudomonas fluorescens* (@ 5 to 10 tons/ha) or use of vermicompost colonized with *Pseudomonas fluorescens* (@ 5 to 10 q/ha), seed treatment/ biopriming with mixed formulation of TH + PsF (@ 10g/kg seed) and need-based spray of TH+PsF (@ 10 g/l) in fields affected with sheath blight) in organic rice it was seen that though yields were slightly lower in biocontrol plots as compared to farmers' practice, the organic rice fetched higher price.

In large scale field demonstrations application of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28 increased the yields of tomato (38.5%), capsicum (38.5%), cabbage (35.2%), chilli (33%), pea (34.5%), French bean (26.7%) and onion (16.5%) over the farmers practice.

Biological control of plant parasitic nematodes in Pomegranate (MPKV)

On four year old pomegranate, soil application of *P. fluorescens* @ 20 g/m^2 was most effective in reducing the root knot nematode population and number of root galls/5 g roots and increased 18.2% fruit yield of pomegranate over control with 1: 21.8 ICBR.

Isolation and characterization of Bt strains from the soil samples (IARI)

Soil samples were collected from several places in northern India and ten Bt strains (GTG-1 to GTG-10) were isolated. Laboratory evaluation of these Bt strains against *Chilo partellus* revealed that seven days after the treatment the mortality of the larvae ranged from 8.9 to 31.0 per cent only.

Interaction of Entomopathogenic fungi (EPF) with fungal antagonists and nematophagous fungi (Colony growth) (SBI)

All the species of entomopathogenic fungi (EPF) had negative impact on the growth of *B. bassiana* in varying degrees of which *B. brongniartii* was the most tolerable. *B. brongniartii* initially benefitted by companion fungi but by day 12, showed slower growth due to competition from all species of which *B. bassiana* was the most compatible. For *M. anisopliae*, *V. chlamydosporium* was most companionable to grow with.

There was complete inhibition of growth of the three EPF in the presence of both of *Trichoderma* species throughout the growth period. Unlike *Trichoderma* spp., nematophagous fungi were less competitive to entomopathogenic fungi. Among the target fungal species tested, *T. viride* was most harmful to *V. chlamydosporium*. Except *Trichoderma* spp., other fungi species were not interfering with the growth of *P. lilacinus* during the entire period of observation.

Interaction of EPF with fungal antagonists and nematophagous fungi (Sporulation)(SBI)

Beauveria bassiana was compatible with *M. anisopliae* and *V. chlamydosporium*. *B. brongniartii* was tolerant of most species except the nematophagous fungi. When inoculated together, sporulation of *M. anisopliae* and *B. bassiana* was mutually unaffected indicating their compatibility. Both the nematophagous fungi and *Trichoderma* spp. were inhibitive to *M. anisopliae*. On the other hand, all the EPF were highly inhibitive to *V. chlamydosporium* but not to *P. lilacinus* during sporulation. Among all species of fungi tested both species of *Trichoderma* were highly inhibitive to sporulation of *P. lilacinus*.

M. anisopliae and *P. lilacinus* were highly adverse to the sporulation of *V. chlamydosporium* while the *Trichoderma* spp. are compatible with it. On the contrary *P. lilacinus* was unaffected by EPF while it was inhibited by *Trichoderma* spp. the most. All species affected *T. viride* with *M. anisopliae* being the least competitive. However, *T. harzianum* was unaffected by most species except *T. viride* followed by *P. lilacinus*.

Interaction among EPF and agrochemicals (SBI)

The final day (12^{th} day) observations on the radial growth showed the toxic effect of metribuzin, carbendazim and chlorpyriphos though there was distinct influence of combination of species *B. bassiana* was grown with, on the levels of its vulnerability to the chemicals. Growth of mycelium in all three EPF was enhanced by imidacloprid and acephate which compensated even for the species competition. Atrazine was the chemical which was next safest for all three fungi. Carbendazim was most toxic to all three fungi during colony growth. Metribuzin was on par with carbendazim in its harmful effect to *B. bassiana* and *B. brongniatii* while *M. anisopliae* reacted worse to both carbendazim and paraquat.

Biological suppression crop pests

Sugarcane

Eleven releases of *Trichogramma chilonis* @50,000/release in a farmer's field (200ha) located at Buragaon village in Golaghat district significantly reduced the incidence of Plassey borer from 29.5 to 13. 6%. Maximum sugarcane yield was recorded in the parasitoid-released plot (73,320 kg/ha) as against farmers practice (71,430 kg/ha). The highest net return was obtained in the *Trichogramma*-released plot (AAU-J).

Six releases of a temperature-tolerant strain of *T. chilonis* @ 1 lakh/ha resulted in the reduction of internode borer incidence by 75.8 per cent and recorded 89.9 kg cane yield/50 canes (MPKV).

In a large-scale demonstration, eight releases of *T. chilonis* at 10 days interval during April to June @50,000/ha resulted in reduction of early shoot borer incidence by 56.4 per cent. The cost benefit ratio in release field (1:19.2) was higher than chemical control (1:7.5) (PAU).

In a large-scale demonstration in Punjab, eight releases of *T. japonicum* at 10 days interval during April to June @ 50,000/ha resulted in reduction of top borer incidence by 54.7 per cent. The cost benefit ratio in release field (1:20.6) was higher than chemical control (1:6.5) (PAU).

Sugarcane woolly aphids were noticed in Pune, Sangli, Kolhapur, Ahmednagar, Nashik, Jalgaon, Jalna and Satara districts of Maharashtra, but the pest intensity was low owing to occurrence of predators *Dipha aphidivora* (0.8–2.1 larvae/leaf), *Micromus igorotus* (1.8-5.6 grubs/leaf) and syrphids (1-2 larvae/leaf) and parasitism by *Encarsia flavoscutellum* (MPKV).

In a field demonstration, twelve releases of *T. chilonis* at 10 days interval during July to October @50,000 per ha resulted in reduction of sugarcane stalk borer incidence by 58.7 percent (PAU).

Under ambient temperature in the laboratory the parasitism and adult emergence of the *T. chilonis* HT strain and normal strain were not significantly different while at 40°c HT strain had significantly higher parasitism and adult emergence rates on eggs of *Corcyra cephalonica*, *Chilo infuscatellus* and *Chilo sacchariphagus indicus* (SBI).

The persistence of semi purified suspension of Coimbatore and Karnal isolate of the GV of *Chilo infuscutellus* was the highest recording lowest dead hearts (60%) while that of Assam isolate was the lowest recording 100% dead hearts. Fortnightly collection of shoot borer larvae from the control plot revealed the lowest recovery of GV in April (14.3 %) and the highest in October, 2010 (33.2%) (SBI).

Results of a pot culture experiment revealed that application of *B. bassiana* and *M. anisopliae* singly or in combination was able to reduce dead hearts caused by shoot borer significantly (SBI).

Cotton

The parasitism rate of *Aenasius bambawalei* varied from 15.66 to 21.15 % with an average of 17.63%. Minimum (16.84%) parasitism was found during early phase of crop growth which increased in subsequent weeks and reached a peak (26.72 %)) during the first week of October 2010. Maximum parasitism (21.15 %) was recorded at Khandha during October 2010 (AAU-Anand).

In cotton, *P. solenopsis* was noticed in October, 2010 and again appeared in January-February, 2011 with high intensity (9.5 mealy bugs/5 cm shoot) in March, 2011. The pest was attacked by *Aenaesius bambawalei* as well as coccinellids and chrysopids. The mealybug *Saccharicoccus sacchari* was very serious during February-March, 2011 in Pune (Indapur, Baramati areas) region. The mealybug species, *Ceccidohystrix insolita* Green was observed on perennial cultivar of pigeon pea maintained at research farm of Botany as well as Entomology Division, College of Agriculture, Pune. In orchard crops, grape, guava, custard apple, sapota, papaya and pomegranate were attacked by *Maconellicoccus hirsutus*, *Ferrisia virgata*, *Planococcus* sp. and *Paracoccus marginatus*. The papaya mealybug (PMB) was very serious and distributed in 6 districts of western Maharashtra. It was found to be parasitisized by indigenous species of parasitoid, *Acerophagus papayae* in the state. Besides, *Subabul* was found attacked by unidentified species of mealybug (MPKV).

Tobacco

Application of *Bacillus thuringiensis* var. *kurstaki* in aqueous solutions with EC 2.0 dSm, resulted in 24.8% mortality of *Spodoptera litura*, 7 days after the treatment in the nursery. Seven days after spraying, there was significantly lowest seedling damage (12.64%) caused by *S. litura* and highest larval mortality of *S. litura* (29.97%) when Bt in aqueous solution with pH 7 was sprayed (CTRI).

Application of *Beauveria bassiana*@ 10^8 spores/ml in water with EC 1.0 dSm, resulted in 24.5% mortality of *S. litura*, 7 days after the treatment in the tobacco nursery. Seven days after spraying *B. bassiana*, there was significantly lowest seedling damage (15.31%) caused by *S. litura* and highest larval mortality of *S. litura* (18.71%) at pH 7 (CTRI).

Among the six strains tested, the NBAII strain of Ha NPV at a concentration of @ 1.5 $\times 10^{12}$ PIB/h and resulted in highest larval mortality (69.18%) of *H. armigera* and lowest leaf damage (6.30 %) (CTRI).

Rice

In a field survey at Anand, three predatory spiders *Neoscona theisi*, *Argiope* sp. and *Pholcus* sp. were found be dominant in rice fields (AAU-A).

The eggs of gundhi bug were parasitized by *Ooencyrtus* sp. (Encyrtidae: Hymenoptera) and *Gryon* sp. (Scelionidae: Hymenoptera) and predated by *Conocephalus longipennis* (Acrididae: Orthoptera) and *Micraspis discolor* (Coccinellidae: Coleoptera) (TNAU).

Field demonstration of IPM module was conducted on rice variety Gurjari. The results indicated that IPM module registered significantly less incidence of leaf folder, skipper and plant hopper and higher grain (4200 kg/ha) as well as fodder (5960 kg/ha) yields were recorded from the IPM block over Farmers' practice and untreated control over the control. Significantly higher (1.1 spiders /hill) population of predatory spider was recorded in IPM module in comparison to rest of the two other modules evaluated. (AAU-A).

The results revealed that significantly lower incidence of rice leaf folder and white-backed plant hopper population was recorded 10 days after the spray in all the bio-pesticide (*Bacillus thuringiensis, Beauveria bassiana, Verticillium lecanii* and *Nomurea rileyi*) treated plots compared to the control. The bio-pesticide spray also reduced the population of spiders. All the treated plots recorded significantly higher grain (3,100 to 3,600 kg/ha) yield over untreated check (2,000 kg/ha) (AAU-A).

Validation of BIPM practice carried out in an area of 200ha in two villages. The results revealed that 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 (3,280 kg/ha) than the farmers practice (2,935 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-Jorhat).

Large scale validation of BIPM package was conducted at five villages (Beraboi, Mendhasala, Bhingarapur, Bentapur and Deulakur) on rice (var. Lalat) during 2010. 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. The beneficial fauna like spiders and lady bird beetles were significantly higher in IPM package. The IPM package recorded significantly higher grain yield (4,251 kg/h) and the net returns over farmers practice was ₹16,140 (OUAT).

The large scale adoption of BIPM technologies was carried out on rice (var. Jyothi and Uma) in an area of 700 hectares in different panchayats in Thrissur district. 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 7,595 kg/ha in BIPM plot and 7,430 kg/ha in farmers practice plot indicating that there is no significant difference between them (KAU).

Large scale demonstration of biocontrol was conducted in Basmati rice at two locations in village Chaharke of Bhoghpur block in district Jalandhar on variety *Basmati* – 1121 over an area of 20 ha each. It can be concluded that IPM (6 releases of *T. chilonis* and *T. japonicum* each @ 1, 00,000/ha) proved as effective as chemical control on large scale for the management of leaf folder and stem borer of *Basmati* rice. (PAU).

Evaluation of aqueous and wp formulations of EPN against rice yellow stem borer and leaf folder revealed that *S. feltiae* when applied in aqueous form recorded 50.2 per cent mortality of yellow stem borer and 42.9 per cent mortality of leaf folder but was found inferior to chemical treatment (AAU-Jorhat).

Similar studies at Bhubaneswar revealed that *S. riobrave* when applied in aqueous form recorded significantly less dead hearts (8.8%) and leaf folder damage (4.5%) and was superior to control but on par with chemical treatment (OUAT).

In Kerala, a sponge formulation of PDBC-EPN-4 recorded higher mortality of rice stem borer and leaf folder, but was inferior to chemical control (KAU).

In a pot culture experiment, application of EPN (*Steinernema* sp. (Runne) @ 8 lakh/pot resulted in the mortality of 55.8% in larvae of *Chilo suppressalis* and 60.0% in *Cnaphalocrocis medinalis* (CAU-Imphal).

Pulses

Pigeonpea intercropped with sunflower and border crop of sorghum recorded the least population of *H. armigera* larvae (3.6/10 plants) compared to pigeonpea intercropped with sunflower and border crop of maize (6.4/10 plants). The population of leaf hoppers and aphids was lower and population of predatory stink bug and coccinellids was higher in pigeonpea intercropped with sunflower with border crop of maize. Yield was also higher in the pigeonpea intercropped with sunflower with border crop of sorghum (1247 kg/h) than the other two modules (ANGRAU).

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 Coccinellid and grain yield was recorded on pigeonpea plots intercropped with sunflower and border crop of maize over the treatment of pigeonpea grown as sole crop (AAU-A).

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 lower population (0.4) of *H. armigera* in pigeonpea compared to control plot (1.9). However, this treatment failed to suppress the damage due to *G. ertica* and *Maruca testulatis*. Significantly higher (1,140 kg/h) grain yield was recorded in the treatment of HaNPV spray + hand picking of *H. armigera* larvae over untreated check (630 kg/h) (AAU-Anand).

Validation of BIPM practices against pests of chickpea (var. GG-2) was done against farmers' practice. The results revealed that the BIPM package recorded significantly lower population of *H. armigera* (0.1/plant), low pod damage (1.9%), and incidence of wilt disease (5.4%) and higher grain yield (836 kg/ha) as compared to farmers practice and control (AAU-Anand).

Evaluation of EPN against soybean defoliators revealed that lowest larval population of *S. litura* (3.17) was recorded in *H. indica* aqueous formulation whereas lowest semilooper (2.5) was recorded in *S. carpocapsae* talc-based formulation. However all EPN formulations were inferior to chemical control (DSR-Indore).

In a field trial, application of *B. bassiana* WP @ 1.5 kg/ha recorded significantly lesser grain damage by *H. armigera* and *Exelastis atmosa* and also recorded higher grain yield of pigeonpea compared to *B. bassiana* SC formulation or Bt but was inferior to Spinosad (JNKVV).

Validation of EPN against pests of soybean (var. JS-335) revealed lowest larval population of *C. acuta* (1.5), *S. litura* (4.7) and highest grain yield (980.9 kg/ha) in *H. indica* aqueous formulation @ 100ml/m^2 and it was better than spinosad application (JNKVV).

Evaluation of entomopathogens against soybean defoliators revealed that *B.t.k.* sprayed plots recorded lowest larval number of *C. acuta* (2.3), *S. litura* (4.0) and highest grain yield (1,181 kg/ha). Sprays of *B. bassiana* was the next best treatment (JNKVV).

Oilseeds

Eggs of castor capsule borer were parasitized by *Trichogramma chilonis* (22.9%), *T. japonicum* (13.1%), *Trichogrammatoidea bactrae* (17.3%) and *T. achaeae* (12.6%)(ANGRAU).

Groundnut leaf miner could be effectively managed by spraying of Bt @ 1 kg/ha or NSKE 5% followed by four releases of *T. chilonis* in Coimbatore. Highest yield was obtained in Bt spray (1,496 kg/ha) followed by NSKE 5% spray (TNAU).

Coconut

Field demonstration trial in 100 ha area undertaken at Devikulangara Panchayat, Alappuzha district, Kerala for management of *Oryctes rhinoceros* by integrating biocontrol agents, *viz.*, *Oryctes rhinoceros* virus, *Metarhizium anisopliae* and pheromone trap. *M. anisopliae* packets (100 numbers containing 100 g of sporulated fungus in rice media) were supplied to famers for applying in breeding sites. Pheromone traps (PVC traps) set up with PCI pheromone lure recorded an average collection of 5.8 beetle/trap/month (CPCRI).

Among the four species of EPN evaluated against coconut white grub (*Leucopholis coneophora), S. carpocapsae* and *S. abbasi* @5000 IJ/grub was found to be more effective than *Heterorhabditis* spp. in soil column bioassay. Synergistic interaction of *S. carpocapsae* as well as *S. abbasi* @ 5000 IJ with imidachlorprid (0.002%) against coconut white grub was observed accelerating the kill (85%) within a period of 48 h in soil column bioassay (CPCRI).

Laboratory screening of EPN against red palm weevil indicated a higher LC_{50} of *H. bacteriophora* (613.5 IJ) than *H. indica* (355.5 IJ) for the same exposure time of 96 h indicating higher toxicity of *H. indica* against grubs of red palm weevil (CPCRI).

Releases of parasitoids (*Goniozus nephantidis* and *Bracon brevicornis* @10 parasitoids/ palm) in the demonstration plot at Vechoor, Kottayam Dist., brought the pest under control and there was complete recovery of palms from *O. arenosella* incidence in parasitoid-released areas (CPCRI).

Three releases of *Cardiastethus exiguus* @ 50 nymphs/palm at 5 days interval and four releases of

Goniozus nephantidis @10 adults/palm at fortnightly interval, significantly reduced *Opisina arenosella* larvae from 5.7 to 0.7 per leaflet in Muthalamada (Palakkad district) during 2010 (KAU).

Tropical fruits

The tea mosquito bug, *Helopeltis antonii* on guava could be effectively managed by spraying *Beauveria bassiana* which recorded lowest per cent fruit damage (5.0%) compared to control (39.6%) (IIHR).

Significantly lowest mango hopper population was recorded per inflorescence in both *M. anisopliae* (21) and chemical (3) treatments as compared to control (110). The hoppers after causing severe damage to inflorescence have moved away and aggregated on unflowered trees situated in the same orchard (IIHR).

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 mango leaf hopper population in the inflorescence (TNAU).

The natural enemies like *Spalgis epius* and *Scymnus* sp. were recorded on papaya mealybug in Kerala (KAU).

The natural enemies recorded on papaya mealybug in Tamilnadu include *Spalgis epius, Cryptolaemus montrouzieri, Scymnus coccivora, Brumoides suturalis, Cheilomenus sexmaculatus, Coccinella transversalis, Cladiscodes sacchari,* and *Ischiodon scutellaris* (TNAU).

The natural enemies collected on papaya (var. Taiwan 786) in Maharashtra included *Spalgius epius, Coccinella septempunctata, Scymnus* sp., Anthocorids, *Mallada* sp., *Brumoides* sp., Syrphids, Spiders and the Encyrtid parasitoid, *Acerophagus papayae* (MPKV).

In Tamilnadu 3,00,000 parasitoids were mass multiplied in six months and released in farmers field @ 100 parasitoids/village in all the 32 districts of Tamil Nadu for the management of papaya mealybug. There was a remarkable reduction (84 to 99 per cent) in mealybug population 90 days after release from five locations studied (TNAU).

A total of 300 parasitoids of *A. papayae* @ 50 adults at fortnight interval and 100 adults of *A. loecki* and *P. maxicana* were released in a papaya (var. Taiwan Var. Red Lady) orchard at Chitoor. In about three months time, *A. papayae* established and arrested the spread of papaya mealybug and brought down the mealybug population to negligible level. The parasitoid *A. papayae* has also been released at Soladevanahalli and Baglur near Bangalore on papaya mealybug (IIHR).

Inoculative release of the parasitoid, *A. papayae* @ 1,500 adults per acre during October, 2010 in mealybug infested papaya orchards (95% incidence) at Pune reduced the mealybug population by 85-92% by January, 2011. Similarly inoculative releases of 1000 parasitoids per acre during October, 2010 at Jalgaon, Dhule and Thane districts (65 to 85% mealybug incidence) brought down the mealybug population effectively by January, 2011 (MPKV).

All the six insecticides (Acephate @0.75g/L, Imidacloprid @ 0.3ml/L, Acetomiprid @ 0.2g/L, Buprofezin @ 1.25ml/L, Dimethoate @ 1.5ml/L and Dichlorvos @ 1ml/L) were found extremely toxic to the exotic papaya mealybug parasitoid, *A. papayae* resulting in 100% mortality (IIHR).

Inoculative release of *C. montrouzieri* @ 2,500 beetles/ha in June, 2010 was found effective in suppressing the mealy bug population to the extent of 80.9% with 49.8% increase in the yield of marketable custard apples (MPKV).

Temperate fruits

At Bagh-e-Khomini orchard two sequential releases of *Trichogramma embryophagum*, reduced the fruit damage to 31.4% as compared to 77.3% in control (SKAUS&T).

In a laboratory evaluation, the *H. Indica* (40IJ/cm^2) recorded highest mortality (83.3%) of apple root borer and this was followed by *S. carpocapsae* (40IJ/cm^2) (80.0%). *Beauveria brongniartii* and *M. anisopliae* were ineffective to the root borer *Dorysthenes hugelii* recording mortality of 66.7 to 66.0 per cent, respectively (YSPUHF).

Vegetable crops

Application of *Bt* (Biolep) (@ 1.0 kg/ha 5 X 10^7 spores/mg) or HaNPV (@ 1.5 X 10^{12} POB/ha) or *B. bassiana* (@ 1.0 kg/ha 2 X 10^8 cfu/g) or *M. anisopliae* (@ 1.0 kg/ha 10^8 cfu/g) or *N. rileyi* PDBC strain (@ 10^{12} spores/ha) significantly reduced the population of *H. armigera* larvae and increased the fruit yield of tomato and were on par with each other. However highest fruit yield was recorded in NPV-treated plots (16160 kg/ha) (AAU-Anand).

The BIPM package recorded significantly less number of aphids (0.8), leaf hoppers (0.3) and whiteflies (0.3) per leaf, reduced fruit damage and increased fruit yield (2346 kg/ha) compared to the farmers' practice and control (AAU-Anand).

Four releases of *B. pallescens* either at 10 or 20 nymphs/plant at 10 days interval, significantly reduced the mite population (96.6%) on okra and was on par with the chemical spray (97.6%). However in the control the mite numbers increased from 19.1 to 32.7 per plant (KAU).

Validation of NBAII Bt strains revealed that higher per cent mortality of *Plutella xylostella* larvae was recorded in Bt strain PDBC-BT-1 (57.6%) compared to PDBC-BT-2 (48.9%) (AAU-Jorhat). At PAU however, higher per cent cumulative mortality of *H. armigera* larvae was recorded in Bt strain PDBC-BT-2 (60.0%) compared to PDBC-BT-1 (55.5%) (PAU).

Single release 20 predatory mites per mite-infested bean plant wiped out the population of pest mite 20 days after the release and the predatory mite population increased to 367±8.6 and 779±8.4 mites per plant after 10 and 20 days of release respectively (YSPUH & F).

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

Validation of IPM packages against brinjal shoot and fruit borer in five villages revealed that the IPM package was far superior to the farmers practice resulting in significantly less wilt (3.2%), shoot borer (8.9%) and fruit borer damage (13.7%) and significant increase in marketable yield resulting in highest net returns of ₹ 69,737 over the farmers' practice (OUAT).

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

Single release of *Cheilomenes sexmaculata* adults @ 1500 beetles/ha was as good as chemical application for the control of cowpea aphid. There was no significant difference in the population of aphids in the release plot (1.5 per plant) and chemical application plot (1.7/plant). Similarly there was no significant difference in the yield of cowpea in the released plot (10,340 kg/ha) and chemical application plot (10,530 kg/ha) (KAU).

Validation trial of IPM module against *P. xylostella* and *S. litura* in cauliflower revealed that there was no significant difference in the the population of *P. xylostella* and *S. litura* in biocontrol-based IPM plot (0.69/leaf and 0.25/leaf) and farmers practice plot (0.40/leaf and 0.21/leaf) but both were superior to control (CAU-Imphal).

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

Cumin

Validation trials with antagonistic biopesticides against cumin wilt revealed that seed treatment with *T. harzianum* (PDBC) recorded lowest disease incidence (2%) and highest grain yield of cumin (1,141 kg/ha) (MPUAT).

Application of *V. lecanii* recorded higher cumin aphid mortality (84.7%) than other biocontrol agents but inferior to imidacloprid. Highest grain yield was recorded in azadiractin plots (995 kg/ha) which was on par with imidacloprid (MPUAT).

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 (31.4-38.0%) as compared to control (59.2%) (YSPUHF).

Results of validation trial on entomopathogenic fungi against whitegrubs attacking groundnut revealed that significantly lowest plant mortality (4.6%) and highest grain yield (1,524 kg/ha) were recorded in *M. anisopliae* @ 1 x 10^{13} conidia/ha. This tretament was on par with chlorpyriphos in ehancing the yield (MPUAT).

Biological control of termites in wheat

Application of *M. anisopliae* @ 1 x 10^{13} conidia/ha and *S. carpocapsae* EN-11 @ 5blj/ha effectively suppressed termite damage and recorded signifcantly less plant mortality of wheat (5.12 and 4.72%) and higher yield (4,020 and 3,960 kg/ha) compared to other EPN but was inferior to chlorpyriphos (MPUAT).

Polyhouse crop pests

Validation of efficacy of different biocontrol agents against *Scirtothrips dorsalis* on capsicum revealed that highest per cent reduction of thrips over control was in *B. pallescens*-released plot. Application of entomopathogenic formulations was as effective as chemical application (IIHR).

Evaluation of *B. pallescens* against *Scirtothrips dorsalis* on capsicum indicated that single release of *B. pallescens* @ 10/plant resulted in effective control of the pest and increased yield (IIHR).

In an experiment with *V. lecanii* pure culture as well as formulation, and *P. fumosoroseus* pure culture against *Trialeurodes vaporariorum* on French beans, highest mortality of the whitefly was recorded in *V. lecanii* formulation @ 10^{9} spore/ ml concentration (YSPUH & F).

On rose plants, the population of spider mites declined from 21.1 to 6.4 when 20 anthocorids were released. In the control plot, the mite population increased from 16.2 to 25.1 per plant (SKUAS & T).

At Pune, four releases of *B. pallescens* @ 20 nymphs/plant significantly reduced the mite population from 63.1 to 26.8 per 5 leaves on rose and found superior to control but inferior to abemectin (15.4 mites/5 leaves) (MPKV).

At Coimbatore, four releases of *B. pallescens* @ 20 nymphs per plant significantly reduced the population of spider mite from 232 to 41 per 5 leaves and recorded 21.3% leaf damage was superior to control and on par with Abamectin 0.3 ml / 1 spray (TNAU).

Validation of entomofungal pathogens against spider mites on rose indicated that three sprays of *H. thompsonii* @ 10^{8} CFU/ml found significantly superior in recording 36.1 mites/5 leaves/rose plant, followed by *V. lecanii* (44.1 mites/5 leaves/ plant). However, abamectin @ 0.3 ml/lit was the most effective in suppressing mite (*Tetranychus urticae* Koch.) population (MPKV).

On carnation, *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* (TNAU).

In a polyhouse evaluation of biological control agents against mites on carnation release of *Stethorus pauperculus* was the most effective in reducing two spotted spider mite followed by *H. thompsonii, Amblyseius* sp. and *B. bassiana*. However, spraying Abamectin 0.3 ml /l was the most effective (TNAU).

Biological suppression of storage pests

Evaluation of anthocorids against *C. cephalonica* in stored rice 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, TNAU and PAU. However, neither live nymphs nor adults of the anthocorids were observed after a month in the containers at MPKV whereas at TNAU, PAU and ANGRAU higher number of adults of *X. flavipes* were recorded one month after the release.

Weed control

Releases of the stem gall fly, *Cecidochares connexa* resulted in significant reduction in plant height and number of branches on galled plants compared to non-galled plants at Trichur (KAU).

Revenue generation

A revenue of Rs. 29,91,478 was generated during the year 2010-11, which includes sale of biocontrol agents, consultation fee, sale of technology, training fee, sample testing fee, project work for PG students, sale of publications, guest house license fee and sale of farm produce.

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 centres based in 14 agricultural universities and 6 ICAR institutes.

Notable achievements in the past

Basic Research

- Ninety-four exotic natural enemies (NEs) have been studied for utilization against alien pests, out of which 62 could be successfully multiplied in the laboratory, 52 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, *Acerophagus papayae*, introduced from Peurto Rico in 2010, has successfully controlled the papaya mealybug, *Paracoccus marginatus* infesting papaya, tapioca, mulberry sunflower, cotton and several crops plants in south India.
- *Trichogramma brassicae*, an egg parasitoid, introduced from Canada was successfully quarantined and found suitable for biological control of *Plutella xylostella* on cole crops recording more than 90% parasitization.
- The sugarcane woolly aphid, *Ceratovacuna lanigera* has been successfully managed by the deployment of two predators, *Dipha aphidivora* and *Micromus igorotus* and one parasitoid, *Encarsia flavoscutellum*.
- Two eulophid parasitoids, *Quadrastichus mendeli* and *Selitrichodes kryceri* introduced from Israel in 2009 have successfully established and suppressing the population of ecalyptus gall wasp, *Leptocybe invasa*.
- Earlier reported predator, *Chrysoperla carnea* now has been identified as *Chrysoperla zastrowi sillemi* through acoustic analysis of mating calls.
- DNA barcode for the invasive pest, coconut leaf beetle *Brontispa longissima* was generated for the first time in the world and will be useful for the rapid identification of the pest in the event of invasion into our country.
- *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 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*.
- URL: http://www.nbaii.res.in/Featured%20insects/featured-insects.html - Factsheets on agriculturally important insects. (for 155 species of common bioagents, invasives, and pests)

- URL: http://www.nbaii.res.in/Introductions/Insects/index.htm - Biocontrol introductions. (for ~185 species of introduced bioagents in India)
- 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 aphids of Karnataka was hosted- URL: aphids www.aphidweb.com.
- Improved laboratory techniques were developed for the multiplication of 27 egg parasitoids, seven egg-larval parasitoids, 42 larval/nymphal parasitoids, 25 predators and seven species of weed insects.
- *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 zastrowi sillemi* to facilitate its large-scale production and use.
- Toddy palm leaf powder-based artificial diet was developed for rearing *Opisina arenosella*
- 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.
- Talc-based formulation of *Bacillus megaterium* has been developed for the management of bacterial wilts of tomato and brinjal caused by *Ralstonia solanacearum*.
- Isolates of *Trichoderma harzianum* tolerant to carbendazim and salinity with good biocontrol potential against four important plant pathogens have been identified.
- Two fungal (*Trichoderma harzianum*-PDBC-TH 10 and *T. viride*-PDBC-TH 23), and two bacterial antagonists (*Pseudomonas fluorescens*-PDBC-AB 2, 29 & 30 and *Pseudomonas putida*-PDBC-AB 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* 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 effective 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.
- 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 SlNPV @ 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 sillemi* and *Nomuraea rileyi* (@ 10^{13} spores/ha) for the management of *Helicoverpa armigera* on tobacco were effective.
- *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 sillemi, 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 (2010-11) (Rs.in lakhs)

National Bureau of Agriculturally Important Insects, Bangalore

Head	Plan	Non-plan	Total
Pay & allowances	00.00	381.23	381.23
TA	07.00	04.00	11.00
Other charges including equipment-Lib.	245.60	56.95	302.55
Information Technology	01.00	-	1.00
Works/petty works	49.77	0.00	49.77
HRD	02.63	-	02.63
Pension	0.00	17.30	17.30
Loan	0.00	0.24	0.24
Total	**306.00**	**459.72**	**765.72**

AICRP Centres (ICAR share only) expenditure

Name of the centre	Expenditure (Rs. in lakhs)
AAU, Anand	13.93
AAU, Jorhat	17.50
ANGRAU, Hyderabad	17.43
Dr.YSPUH&F, Nauni, Solan	10.00
GBPUA&T, Pantnagar	14.38
KAU, Thrissur	21.00
MPKV, Pune	17.94
PAU, Ludhiana	21.89
SKUAS&T, Srinagar	16.75
TNAU, Coimbatore	20.67
PC Cell, Bangalore	54.89
MPUAT, Udaipur	01.56
JNKVV, Jabalpur	01.86
OUAT, Bhubaneshwar	01.86
CAU, Manipur	03.34
Total	**235.00**

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).

ORGANISATIONAL CHART

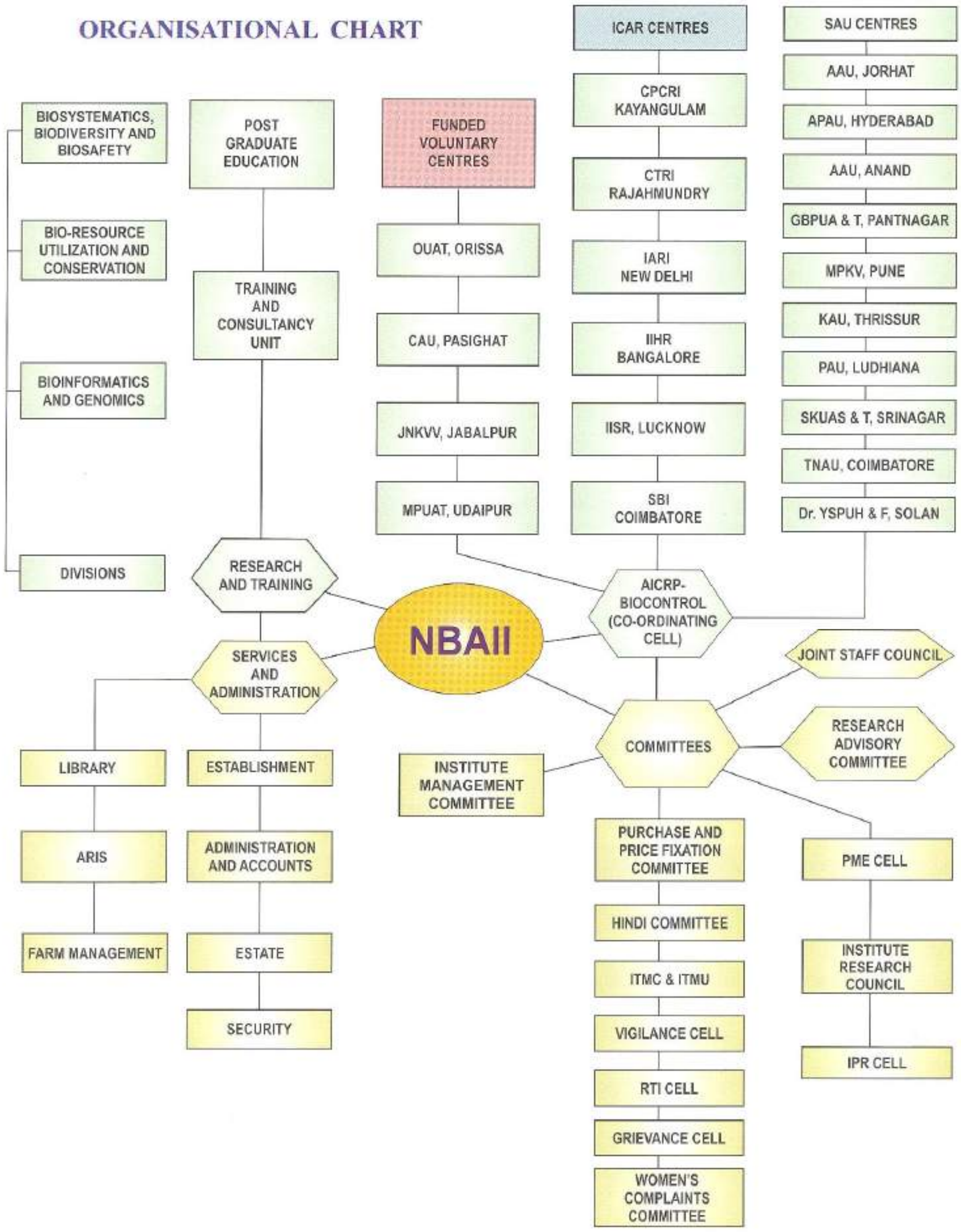


Fig. 1 : The Organisation Chart of NBAII

5. RESEARCH ACHIEVEMENTS

5.1. National Bureau of Agriculturally Important Insects

5.1.1. Division of biosystematics, biodiversity and biosafety

Identification services

One hundred and twenty species of insects including coccinellids, parasitic Hymenoptera, and other insects were identified for 35 institutions including various AICRP centres, state agricultural universities, other universities, partners under the Network Project on Insect Biosystematics and students. Several e-mail queries with photo attachments for identification were answered.

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

Checklists of the Indian fauna of insects belonging to Protura, Ephemeroptera, Odonata, Mantodea, Neuroptera, Anoplura, and Trichoptera, were hosted in the website of NBAII.

Biosystematic studies on agriculturally important insects

Eleven new species of *Rhynchortalia* Crotch (Coccinellidae) and one new species of Anthocoridae (*Anthocoris muraleedharani* Yamada) were described from southern India. Indian species of *Liophloeothrips* (Thysanoptera) were revised. One new species each of *Liophloeothrips* and *Microterys* (Encyrtidae) were described from Karnataka. The chrysopid genus *Apochrysa* was recorded for the first time from India on papaya mealybug.

Web content on agriculturally important insects

One hundred and fiftyfive factsheets on common parasitoids, predators, weed killers and invasives have been hosted on the website of NBAII. The sites provide basic diagnostic and biological information on these insects with photographs and other illustrations. A compilation of biocontrol introductions in India with details on 185 species was made available from the NBAII's website.

Computer-aided keys / web content / websites maintained

URL: **http://www.nbaii.res.in/Featured%20insects/featured-insects.html** - Factsheets on agriculturally important insects. (for 155 species of common bioagents, invasives, and pests)

URL: - Biocontrol introductions. (for ~185 species of introduced bioagents in India)

Updation of www.aphidweb.com

Fact sheets for six species of aphids, viz., *Melanaphis bambusae* (Fullaway), *Brachysiphoniella montana* (van der Goot), *Capitophorus mitegoni* Eastop, *Ceratovacuna perglandulosa* Basu, Ghosh and Raychaudhuri, *Ceratovacuna perglandulosa* Basu, Ghosh and Raychaudhuri and *Aphis kurosawai* Takahashi was developed and updated for the website on aphids www.aphidweb.com.

Biosystematic studies on *Trichogramma*

Different species of Trichogramma were collected from Jammu and Kashmir, New Delhi, Maharashtra, Tamil Nadu and Karnataka. Field studies with sentinel cards indicated that *T. chilonis, T. achaeae, T. pieridis, T. danausicida* and *T. danaidiphaga* are common and widespread native species around Bangalore.

Trichogramma danaidiphaga, a new species was collected from the Himalayas in Leh, Jammu and Kashmir at an altitude of 10,000 feet (highest for a native *Trichogrmma* species so far collected) and described from the eggs of *Danaus chrysippus* on *Calotropis gigantea*. Molecular analyses revealed that *T. danausicida* and *T. danaidiphaga* are two distinct species. These species were also found to differ in their abilities to parasitize *Corcyra cephalonica* – while *T. danausicida* parasitized the eggs of *C. cephalonica, T. danaidiphaga* failed to do so. A new species of *Trichogrammatoidea* has been collected from Karnataka which is being described.

Trichogramma agriae were collected from the eggs of *Ariadne merione* on castor, which is a new host record for this species. *Trichogramma achaeae* was collected for the first time from the eggs of *Anomis* sp. on bhendi (*Abelmoschus esculentus*). The live cultures of 15 species of *Trichogrammatoidea*/ *Trichogramma* and two species of *Uscana* are maintained.

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

Surveys were conducted in different ecosystems for scelionids in six states, *viz*., Jammu and Kashmir (Nubra Valley, Leh; Srinagar), Maharashtra (Pune, Aurangabad), New Delhi, Uttar Pradesh (Lucknow), Tamil Nadu (Kotagiri, Coimbatore) and Karnataka (eleven districts). Different agroecosystems such as rice, sugarcane, oats, wheat, maize, pulses, vegetables and fruits in addition to forests and uncultivated fields were surveyed for insect eggs.

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, Eulophidae, Encyrtidae and Eupelmidae. A total of 3230 parasitoids were collected, curated and preserved for future studies. Egg parasitoids were collected from 156 egg masses of different orders of insects such as Heteroptera (57), Lepidoptera (58), Arachnida (15) Homoptera (3), Neuroptera (Chrysopidae) (9), Dictyoptera (10), Diptera (1), Coleoptera (1) and Orthoptera (2).

Fifteen genera of Platygastridae belonging to three subfamilies - Scelioninae, Telenominae and Teleasinae were recorded. The fifteen genera are *Acantholapitha, Calliscelio, Calotelea, Cyphacolus, Duta, Dyscritobaeus, Encyrtoscelio* (Fig. 2), *Palpoteleia, Sparasion* (Fig. 3), *Gryonoides, Odontoscelio, Xenomerus, Paratelenomus, Psix and Trissolcus*. The genera *Gryonoides* and *Odonotscelio* are reported for the first time from India. The genera *Dyscritobaeus* and *Palpoteleia* (Fig. 4) which were hitherto recorded only from Uttarakhand are reported for the first time from South India. The genus *Encyrtoscelio* which was earlier recorded from New Delhi is reported for the first time from South India. Three genera, *viz*., *Acantholapitha, Calotelea* and *Sparasion* are reported for the first time from Karnataka.

Eggs of *Netria* sp. (Notodontidae), a pest on sapota were parasitized by Encyrtidae. An average of seven parastioids emerged per egg. Fiftyfour eggs of Chrysopidae were collected on rose bushes in the Nubra Valley in Ladakh and 74.1 per cent of the eggs were parasitized by *Telenomus* sp. while per cent larval emergence was 22.2. Forty-eight eggs of *Acherontia styx* collected on *Datura* were parasitized by *Telenomus* sp. The per cent parasitisation was 58.0. Two cultures of *Telenomus* spp. are maintained in the laboratory on eggs of *Spodptera litura*.

Telenomus spp. that emerged from eggs of different lepidopterans *viz. Hasora, Jamides celeno, Acherontia styx, Lampides boeticus* and some unidentified lepidotperans failed to parasitise eggs of *Spodopera litura* and *Samia cynthia* in the laboratory.

Sceliocerdo (Fig. 5) (a phoretic species on grasshopper) was collected on the grasshopper *Neorthacris acuticeps* (Pyrgomorphidae: Orthoptera). This species had so far been collected only from Mandy (Karnataka), but has now been collected from Coimbatore (Tamil Nadu) also.

Fig. 2. *Encyrtoscelio* sp.

Fig. 3. *Sparasion* sp.

Fig. 4. *Palpoteleia* sp.

Fig. 5. Phoretic adults of *Sceliocerdo* on grasshopper's abdomen

Classical Biological Control of papaya mealybug, *Paracoccus marginatus*

Papaya mealybug, *Paracoccus marginatus*

The papaya mealybug, *Paracoccus marginatus* reported for the first time in July 2008 on papaya from Coimbatore (Tamilnadu) spread to several states in south India through the movement of infested fruits. The mealybug is very destructive, killing the young plants and rendering the infested fruits unfit for human consumption and unmarketable (Fig. 6). The mealybug is polyphagous attacking several agricultural and horticultural crops like tapioca, pigeonpea, cotton, okra, tomato, brinjal, teak, silk cotton, mulberry, *Jatropha, Plumeria* and numerous weeds including *Parthenium hysterophorus, Sida acuta, Acalypha indica, Eupatorium adenophorum* and *Cassia sericea*.

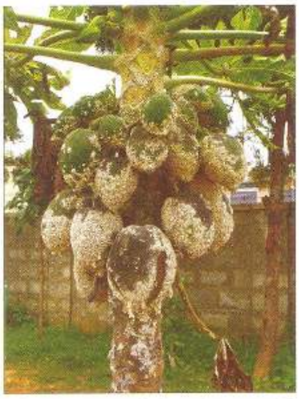


Fig. 6. Mealybug-infested papaya fruit

Importation of exotic parasitoids

The three parasitoid species, viz., *Acerophagus papayae* (fig. 7), *Pseudleptomastix mexicana* and *Anagyrus loecki* were imported in five consignments from Puerto Rico and the first consignment was received on the 15[th] of July 2010 based on the import permits issued by the Plant Protection Advisor Govt. of India.

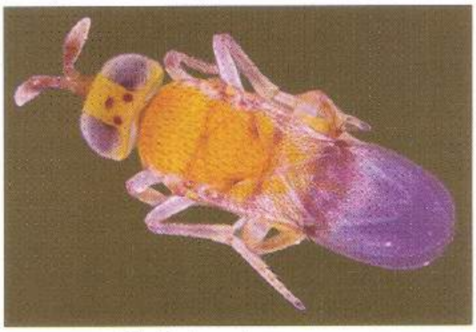


Fig. 7. *Acerophagus papayae*

Quarantining of exotic parasitoids

The cultures of the three parasitoids were maintained on papaya mealybugs reared on potato sprouts. Second generation pure cultures of the parasitoids were used for screening. The parasitoids were specific to *P. marginatus* and did not parasitise seven species of mealybugs common in India, i.e. *Maconellicoccus hirsutus, Phenococcus solenopsis, Ferrisia virgata, Planococcus citri, P. lilacinus, Pseudococcus longispinus* and *Lankacoccus ornatus*.

The parasitoids did not attack the following non target beneficial organisms: *Micromus igorotus, Chrysoperla zastrowi sillemi, Brumoides* sp., *Cryptolaemus montrouzieri, Goniozus nephantidis, Trichogramma chilonis, T. japanicum, Bombyx mori, Apis cerana indica, Scymnus coccivora,* and *Spalgis epius*.

Mass production of exotic parasitoids

All the three species of parasitoids could be multiplied on *P. marginatus* grown on potato sprouts (Fig. 8).

Fig. 8. Sprouted potato with mealybug nymphs

Training on mass production of exotic parasitoids

Training on the mass production of papaya mealybug and its introduced parasitoids was conducted for over 250 scientists, subject matter specialists, extension officers of ICAR, SAUs, KVKs, NGOs and CSRTI, Mysore in different batches between September-November, 2010. One workshop on "Management of papaya mealybug and deployment of introduced parasitoids" was conducted on 30th October, 2010 and 225 scientists from ICAR, SAUs, KVKs, KFRI, IFGTB, CSRTI and NGOs and a few farmers attended the workshop.

Field release and establishment

TNAU, Coimbatore

The papaya mealy bug parasitoid *Acerophagus papayae* obtained from NBAII was mass multiplied in seven college campuses and 14 KVKs and about 45,000 parasitoids were released throughout Tamil Nadu for management of the pest on papaya, cassava, mulberry and teak. Feedback from the leading papaya growers has revealed that the pest has been suppressed by the parasitoids effectively in the districts of Coimbatore, Erode, Tiruppur, Madurai and Dindigal districts. The farmers are extremely happy that they are now able to manage the pest without a single spray of chemical pesticide.

MPKV, Pune

Very good control of the papaya mealy bug has been achieved by the release of the parasitoid, *A. papayae* in the orchard of Regional Fruit Research Station, GaneshKhind and those of the papaya growers of Shri Shamrao BabuRao of Uruli Kanchan Village and Shri Dattatraya Haribhau Kand of Lonikand village. Use of chemical pesticides has been totally dispensed with.

5.1.2. Division of bio-resource conservation and utilization

Studies on predatory anthocorids

Surveys

During the year 2010-11, 25 surveys were made and *Orius* spp., *Cardiastethus exiguus*, *Blaptostethus pallescens*, *Anthocoris muraleedharani*, *Carayanocoris indicus* and five unidentified species of anthocorids were collected.

Mass production and storage of *Cardiastethus exiguus*

The anthocorid was reared at 20, 25 and 30°C, and 35±5% RH. It was found that for rearing of *C. exiguus*, 25 and 30°C was most suitable for survival and reproduction. The developmental period was significantly prolonged and the progeny production and survival was affected at 20°C.

The eggs of *C. exiguus* can be stored for 5 days at 10°C (with 64% hatching and 64% adult emergence) and 10 days at 15°C (with 68% hatching and 68% adult emergence). The incubation period could be staggered to 10 days by storing at 10°C or 15°C for 5 days, whereas the incubation period could be staggered to 13 days by storing at 15°C for 10 days.

Cardiastethus exiguus adults could be stored at 10°C for up to 5 days and at 15°C for up to 15 days. However, when stored for 10 days at 10°C, there was a significant reduction in survival and progeny production.

Feeding potential of *Blaptostethus pallescens* on Papaya mealy bug

The progeny of *B. pallescens* collected from mealybug infested papaya trees from Pune were used to find out the feeding potential. The 2 day old nymph could feed on 1.5 crawlers per day whereas 7 days old nymph could feed 2.2 crawlers per day. A total of 18 and 29 crawlers were fed by 2 days and 7 days old nymphs, respectively, however the survival of the nymphs was very poor. In case of adults, 2.6 crawlers were fed per day and the adult could feed on 31 crawlers, however the adult longevity was reduced from 30 to 13 days when fed on papaya mealybug.

Feeding potential of *Anthocoris muraleedharanii* on cotton mealybug

The anthocorid predator *Anthocoris muraleedharani* Yamada sp. nov. (Fig. 9) originally collected from *Bauhinia prpurea* trees infested by *Ferrisia virgata* could be reared on cotton mealybug. During the nymphal stage, *A. muraleedharani* could feed on a total of 65.3 crawlers of cotton mealybug (CMB), with a feeding of 4.3 (range: 2 to 10) crawlers per day. The adult could feed on a total of 124.3 crawlers with a per day feeding of 6.1 (range: 2 to 14) CMB crawlers. The day-wise feeding potential of *A. muraleedharani* is depicted in Fig 10. However, this anthocorid could not feed on papaya mealybug.

Fig. 9. *Anthocoris muraleedharani* feeding on cotton mealybug

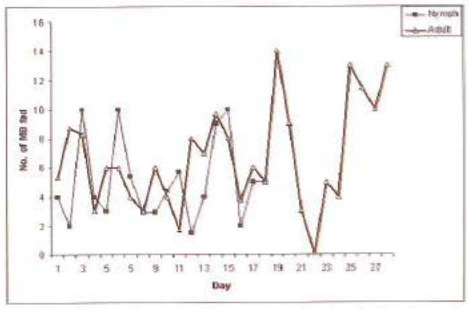


Fig.10. Day-wise feeding potential of *Anthocoris muraleedharani* on cotton mealy bug

Evaluation of *Blaptostethus pallescens* against *Frankliniella schultzei* infesting chilli in polyhouse

Eight releases of *B. pallescens* @ 10 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 4.7, whereas in the chemical control (with fifteen chemical applications) it was 7.8, indicating a significant reduction of thrips population in the bio-control plot. The yield and the quality of the produce from the biocontrol plot (48.4 kg/100 plants) were as good as those from the chemical control plot.

Evaluation of *Blaptostethus pallescens* against chilli mite in nethouse

Ten releases of *B. pallescens* @ 10 per plant reduced the mite damage on chilli significantly at a net house. The per cent leaf curling was reduced from 35.0 % (pre-release) to 13.3% (post release). The control plants showed the typical symptoms of shriveling and curling and drying of terminal portions and flowers or buds which failed to open. The per cent increase in height of the treated plants was 22.3, while in the control, it was only 8.3%.

Biology of *Hippodemia varigata*

Biology of *Hippodemia varigata* collected from Srinagar was studied by providing *Aphis craccivora* as host. The egg, larval and pupal period lasted for 3.4, 7.8 and 4.6 days respectively. The larval feeding potential was 32.3 aphids per day. The total larval feeding potential varied from 226.3 to 258.6 aphids. The pre-oviposition period varied from 9-11 days and the highest fecundity recorded was 306.8 eggs. The adult longevity was 52.8 days in male and 61.1 days in female.

Mass multiplication of different species of mealybugs

The mealybug species, *Phenacoccus madeirensis*, *Phenacoccus divaricatus*, *Phenacoccus solani*, *Rastrococcus mangiferae*, and *Paracoccus marginatus* belonging to the tribe Phenacoccini could be successfully mass multiplied only on sprouted potato and not on pumpkin.

Collection, preservation and identification of pseudococcids

The following 42 species of pseudococcids were collected, preserved and identified (Table 1). The genus *Phenococcus* Cockerell was the most predominant with seven species under it followed by genera *Dysmicoccus* Ferris and *Pseudococcus* Westwood with four species in each.

Table 1. List of identified mealybug species

Name of genera	Species
Antonina Signoret	*A. graminis* (Maskell)
	A. maritima Ayyar
Brevenia Groux	*B. rehi* (Lindinger)
Chaetococcus Maskell	*C. bambusae* (Maskell)
Coccidohystrix Lindinger	*C. eleusines* Williams
	C. insolita (Green)
Dysmicoccus Ferris	*D. brevipes* (Cockerell)
	D. finitimus Williams
	D. neobrevipes Beardsley
	D. subterreus Williams
Ferrisia Fullaway	*F. malvastra* Mc Daniel
	F. virgata (Cockerell)
Formicoccus Takahashi	*F. robustus* (Ezzat and McConnell)
Geococcus Green	*G. citrinus* Kuwana
	G. coffeae Green
Heliococcus Šulc	*H. buteae* Williams
Lankacoccus Williams	*L. ornatus* (Green)
Maconellicoccus Ezzat	*M. hirsutus* (Green)
	M. multipori (Takahashi)
Nipaecoccus Šulc	*N. viridis* (Newstead)
Palmicultor Williams	*P. palmarum* (Ehrhorn)
Paracoccus Ezzat and McConnell	*P. marginatus* Williams and Granara de Willink (Fig. 11)
Phenacoccus Cockerell	*P. divaricatus* Williams (Fig. 12)
	P. indicus (Avashi and Shafee)
	P. madeirensis Green (Fig. 13)
	P. parvus Morrison (Fig. 14)
	P. saccharifolli (Green)
	P. solani Ferris (Fig. 15)
	P. solenopsis Tinsley
Planococcus Ferris	*P. citri* (Risso)
	P. lilacinus (Cockerell)
Pseudococcus Westwood	*P. baliteus* Lit
	P. cryptus Hempel
	P. jackbeardsleyi Gimpel and Miller
	P. longispinus (Targioni Tazzetti)
Rastrococcus Ferris	*R. iceryoides* (Green)
	R. mangiferae (Green)
Rhizoecus Künckel d' Herculais	*R. amorphophalli* Betrem *Rhizoecus* sp.
Saccharicoccus Ferris	*S. sacchari* (Cockerell)
Trionymus Berg	*T. bambusae* (Green)
Vryburgia De Lotto	*V. bova* Williams


Fig. 11. *Paracoccus marginatus*


Fig. 12. *Phenacoccus divaricatus*


Fig. 13. *Phenacoccus madeirensis*

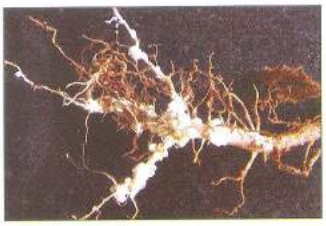


Fig. 14. *Phenacoccus parvus*


Fig. 15. *Phenacoccus solani*

Natural enemies collected from different species of aphids and coccids

The following 69 species of natural enemies were collected on 31 different species of aphids and coccids (Table 2).

Table 2. List of aphids, coccids and their natural enemies collected

Host	Parasitoid
Planococcus sp.	*Homalotylus indicus* (Agarwal)
	Promuscidea unfasciativentris Girault
	Leptomastix sp.
Phenacoccus madeirensis	*Allotropa* sp.
Ferrisia virgata	*Aenasius advena* Compere
	Homalotylus sp.
	Blepyrus insularis (Cameron)
Rastrococcus iceryoides	*Promuscidea unfasciativentris* Girault
	Anagyrus sp.
	Leucopis sp.
	Praleurocerus viridis
Antonina sp.	*Anagyrus* sp.
Diaspis echinocacti	*Tetrastichus* sp.
	Cybocephalus sp.
	Aphytis sp.
Indet. scale	*Coccophagus* sp.
Indet. scale	*Prochiloneurus aegyptiacus* (Mercet)
Phenacoccus sp.	*Allotropa japonica* Ashmead
Marsipococcus sp.	*Cheiloneurus* sp.
Cerococcus sp.	*Allotropa* sp.
	Leptomastix sp.
Formicoccus robustus	*Prochiloneurus javanicus*
Indet Coccid on Neem	*Microterys* sp.
Asterolecanium sp.	*Marietta leopardina* Motschulsky
Megapulvinaria maxima	*Metaphycus* sp.
	Scymnus coccivora
Drepanococcus sp.	*Anicetus* sp.
	Metaphycus sp.
Saissetia nigra	*Coccophagus* sp.
	Scutellista sp.
	Coccophagus cowperi Gir.
Coccidohystrix insolita	*Promuscidea unfasciativentris* Girault

	Prochiloneurus pulchellus Silvestri
Saissetia coffeae	*Scutellista* sp.
	Coccophagus sp.
Coccus spp.	*Tetrastichus* sp.
	Scutellista sp.
	Cephaleta brunniventris Motschulsky
	Metaphycus sp.
	Coccophagus ceroplastae (Howard)
	Coccophagus bixittatus Compere
	Aprostocetus sp.
	Scutellista caeralea
Coccus viridis	*Coccophagus* sp.
	Promusciea sp.
	Encyrtus ouriantic
Nipaecoccus viridis	*Anagyrus* sp.
	Coccophagus sp.
	Leucopis sp.
	Cocoxenus perspicax
	Anagyrus sp.
	Chartocerus sp.
	Scymnus coccivora
	Aprostoceus purpureus
Ingisia sp.	*Marietta leopardina* Motschulsky
	Tetrastichus sp.
Chionaspis sp.	*Cephalata aubtraliensis*
	Leptomastix sp.
Chaetococcus sp.	*Microterys* sp.
	Metaphycus sp.
	Marietta leopardina Motschulsky
Lac insect	*Tachardiphagus* sp.
	Coccophagus sp.
	Aprostocetus purpureus
Aphis nerii	*Aphelinus* sp.
Eriosoma lanigerum	*Aphelinus mali*
Phenacoccus parvus	*Cheiloneurus* sp.
Pulvinaria psidi	*Coccophagus* sp.
Maconellicoccus hirsutus	*Leucopis* sp.

Pollinators in different crop ecosystem

A survey was conducted on pigeonpea ecosystem in Karnataka, Tamilnadu, Andhra Pradesh and Maharashtra for the collection of pollinators. Three species of *Xylocopa* (*X. aestuans*, *X. latipes* and *Xylocopa* sp.), five species of *Megachile* (*M. lanata*, *M. bicolor*, *M. anthracina*, *M. carbonaria*, *M. hera* and *Megachile* sp.), *Lasioglossum* sp., *Ceratina (Pithitis) binghami*, *Apis florea*, *A. dorsata* and *Trigona* sp. and unidentified Halictid were collected from pigeonpea. On gingelly crop *Apis dorsata* and *A. cerana indica* were the common pollinators in Tamilnadu. On sunflower *Apis dorsata*, *Apis cerana indica*, *Apis florea* and *Trigona iridipennis* were found to be dominant pollinators.

Naturally maintained (pesticide free) pigeonpea ecosystem supported a wide variety of natural enemies like hymenopteran parasitoids (Braconidae, Ichneumonidae, Vespidae, Scoliidae etc.) and predators (Coccinellidae, Mantidae, Chrysopidae, Gomphidae- dragonflies, Clubionidae (sac spiders) and Araenidae) when compared to sprayed fields of Gulbarga, Bidar and Raichur areas of Karnataka.

Flora which supports and conserves different pollinators

In the nontraditional pigeonpea area of Karnataka, Singapore cherry, *Muntingia calabura* (Fam: Tiliaceae), *Spermacoce hispida* (Rubiaceae) (Fig. 16) and *Euphorbia heterophylla* (Euphorbiaceae) supported all species of honey bees, whereas *Centrosema pubescens* (Fam: Fabaceae) supported only carpenter bees.

A replicated field trial of intercropping pigeon pea (cv. TTB-7) 10 rows with marigold (cv. Local) 2 rows and sunflower (cv.KBSH-53) 2 rows alternatively indicated that both marigold and sunflower served as attractant crops for both the pollinators and natural enemies when compared with the sole pigeon pea crop. The pod damage by *Helicoverpa*, pod flies and pod bugs was relatively less (47.5%) in intercropped pigeon pea (Fig. 17) compared to sole crop (55.3%).

Fig. 16. ***Apis dorsata*** **visiting** ***Spermacoce hispida***

Fig. 17. Intercropped pigeonpea

Polymorphism in pheromone reception in *Helicoverpa armigera*

Different geographical populations of *H. armigera* were collected from Nagpur, Bangalore, Gulbarga and Raichur (Karnataka) and Coimbatore (Tamil Nadu).

The pheromone glands of virgin females were dissected out by pressing the last abdominal tip gently and were averted out (Fig. 18). However there was no variation in the morphology of the pheromone glands of laboratory, and Coimbatore populations..

Fig. 18. The pheromone gland of *H. armigera*

Three field trials were conducted, one each at NBAII Research Farm, Attur, University of Agricultural Sciences, Raichur and ICAR complex for Eastern Region, Patna to find out the polymorphism in the respective field populations of *H. armigera*. A large plot of around 2000 Sqm was used for the experiment with the cotton as the crop. Pheromone components Z-11-hexadecenal and Z-9-hexadecenal were obtained in pure form from commercial firm and different blends like 97:3 (blend used commercially for the traps); 91:9 and 85:15 were prepared and loaded into the silicone tubes and kept in the sleeve traps at the canopy height. The number of males caught were counted and recorded at weekly intervals.

In field trial at NBAII Research Farm, Attur, the number of males caught was very low, probably because of the non-crop vegetation in the surrounding areas. Males were caught both in 97:3 and 85:15 ratio. However since the number of males caught were in low numbers no conclusion could be made. In the field trial at Raichur, there was significant number of males caught in both the blends 97:3 and 91:9. The males of *H. armigera* collected from Raichur, showed response to the blend of 97:3 in GCEAD studies in the laboratory. In the field trial at Patna, the blend ratio 85:15 gave better capture and incidence of the pest was more in the flowering stage than other stages.

Electroantennogram studies on *H. armigera*

Generally the pheromone analogues elicited more response than the gland extracts. In case of laboratory population cross response was observed with the Raichur population eliciting better response than the laboratory population. However in Coimbatore population laboratory females elicited more response than Raichur populations while in Nagpur population Raichur population elicited better response.

Rice plant volatiles enhance parasitism

Highest percentage parasitization by *Trichogramma chilonis* was recorded in the methanol extract of rice variety KADAMBA. Highest percentage parasitization by *Trichogramma japonicum* was recorded in methanol extract of rice variety CTH-1 (48.52%).

Standardization of growth conditions in solid state fermentation for mass production of *Trichoderma harzianum*, *Metarrhizium anisopliae* and *Beauveria bassiana*

Incubation temperature

Effect of incubation temperature on the production of viable propagules of *T. harzianum* (TH10) was studied under solid state fermentation with ragi as substrate. Incubation at 28°C was the most optimum for the production of viable propagules (Fig. 19) of *T. harzianum*. This was correlating to the declining moisture content and water activity when substrates were incubated at elevated temperatures

(30°C or above). Similar results were obtained with sugarcane bagasse as inert support. However sponge as a inert support was not found suitable since it did not favour retention of water activity which is crucial for the fungal growth and development.

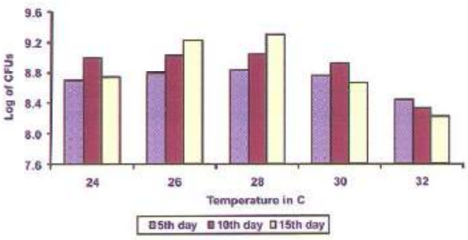


Fig. 19. Effect of incubation temperature on biomass production of *T. harzianum* in SSF with ragi as solid substrate.

In case of *M. anisopliae* and *B. bassiana* highest cfu counts were recorded at 32°C (17.4 and 27.0 x 10^8/g respectively after 15 days of incubation) on rice as substrate compared to other temperatures tested. In case of sugarcane bagasse, cfu counts of *B. bassiana* at temperatures of 28 and 30°C were 4.3 and 3.8 x 10^8/g respectively which were much lower than rice substrate.

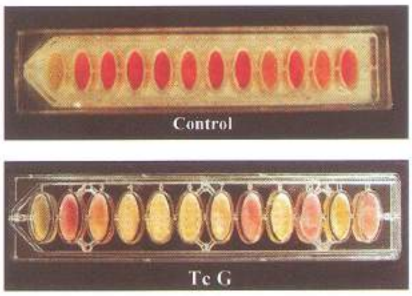
Effect of incubation moisture content

In case of *B. bassiana*, on sorghum (8 h soaking), the cfu count 15 days after inoculation was 26.4 x 10^8/g whereas on ragi (12 h soaking), the cfu was only 8.4 x 10^8/g. In case of *M. anisopliae*, on sorghum substrate (10 h soaking), the cfu count 15 days after inoculation was 29.4 x 10^8/g, whereas on rice grain substrate (2 hrs 15 min soaking), the cfu count was only 26.2 x 10^8/g.

5.1.3. Division of Genomics and Bioinformatics

Biochemical identification of endosymbionts

The yeast and bacterial endosymbionts isolated from *Trichogramma embryophagum* and *T. danaudiphaga* parasitoids emerged from field collected lepidopteran eggs were identified as *Pichia anomola*, *P. guillermondii*, *Candida apicola*, *C. pimensis*, *Metschnikowia reukaufii*, *Hanseniaspora uvarum*, *Wickerhamomyces anomalus*, *Zygosaccharomyces rouxii*, *Bacillus subtilis* and *B. cereus*. Identification of *Candida* species based on biochemical methods was done using HiCandida Identification Kit (Himedia Laboratories). Based on carbohydrade fermentation test, yeast isolated from Gurdaspur was found utilizing sugars, *viz*., maltose, sucrose, galactose, cellobiose, xylose and raffinose and was found to be very close to *Candida lypolitica* and yeasts isolated from Srinagar showed utilizing sugars, *viz*., maltose, sucrose, galactose, xylose and raffinose and was found to be very close *Candida guillermondii* (Fig. 20).



Candida lypolitica

Candida guillermondii

Fig. 20. Biochemical identification of yeast endosymbionts of *Trichogramma chilonis*

DNA sequencing and identification of symbionts

Twenty strains, including 2 of *Candida* species and 10 of *Pichia* species were identified to species level by ITS sequence analysis. A BLAST search revealed that yeast strains Tcy1, Tcy2 and Tcy3 had sequence similarities to their corresponding type strain *Pichia anomala* isolate P13 (GenBank Accession No. AY349442). All the endosymbiotic yeasts and bacteria associated with *Trichogramma* obtained from different locations were identified by ITS sequencing analysis as *P. anomala*, *Candida* cf. *apicola*, *Wickerhamomyces anomalus*, *Metschnikowia reukaufii*, *Hanseniaspora uvarum*, *Candida pimensis*, *P. guillermondii*, *Zygosaccharomyces rouxii*, and bacteria as *Bacillus cereus* and *Bacillus subtilis* (Fig. 21 & 22).

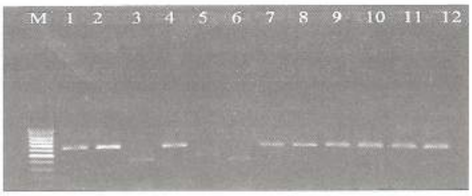


Fig. 21. PCR amplification of ITS region of different yeast species and strains isolated from *Trichogramma* species (Lane M: 100bp ladder, Lane 1: *Pichia anomala* Tcy2, Lane 2: *P. anomala* Tcy5, Lane 3: *P. guillermondii*, Lane 4: *Wickerhamomyces anomalus*, Lane 5: *Candida apicola* Tcy3, Lane 6: *Candida pimensis*, Lane 7: *P. anomala* Tcy 6, Lane 8: *Zygosacharomyces rouxii*, Lane 9: *P. anomala* Tcy4, Lane 10: *Metschnikowia reukaufii*, Lane 11: *P. anomala* Tcy7, Lane 12: *P. anomala* Tcy1)

Fig. 22. PCR amplification of bacterial endosymbionts isolated from *Trichogramma* species (Lane M: 100 bp ladder, Lane 1: *Bacillus subtilis* from *T. embryophagum*, Lane 2: *Bacillus cereus* from *T. simblidis*)

Phylogenetic analysis of endosymbionts cultured from different populations of *Trichogramma*

Nucleotide sequences were aligned and the results confirmed by clustering *Pichia anomola* as one group, *Candida* as another and other related ones joining with each other.

Molecular characterization of endosymbionts cultured from different populations of *Chrysoperla zastrowi sillemi*

The yeast cultures from *C. z. sillemi* were characterized using the YITS-PCR that amplifies the yeast Internal Transcribed Spacer gene, whereas the bacterial cultures were characterized using the 16S rDNA-PCR that amplifies the 16S rDNA region specific only to bacteria (fig. 23, 24 & 25).

The endosymbiont from pesticide-tolerant strain (PTS 8) of the *C. z. sillemi* predator was isolated and the ITS region was amplified (798bp region). The

Fig 23. Gel image of DNA of endosymbionts isolated from different populations of *Chrysoperla zastrowi sillemi*.

Fig 24. Gel image of YITS region amplified at base pairs ranging from 300- 700 bp

Fig 25. Gel image of 16S rDNA region amplified at 1000bp

BLAST search found the endosymbiont to be *Klebsiella* sp. The temperature tolerant strain was subjected to 34°C, wherein two yeasts and one bacterial endosymbionts were isolated from the adults. The amplified PCR products were subjected to sequencing and one particular yeast culture resulted in a 782bp sequence that on blast in NCBI, showed 98% homology with *Zygosaccharomyces* sp. in the GenBank database and another yeast culture obtained was PCR amplified for its ITS-2 region (602bp) and showed 98% homology with *Pichia anomala* in the GenBank database. The bacterial endosymbiont amplified (500bp) and sequenced showed 97% homology with *Stenotrophomonas maltophilia* strain in the Genbank database.

Molecular characterization of endosymbionts cultured from different populations of *Cotesia plutellae* and *Trichogramma brassicae*

Identification of *Candida* species based on biochemical methods was done using HiCandida Identification Kit (Himedia Laboratories). Based on carbohydrate fermentation test, yeast isolated from *Cotesia plutellae* showed utilization of maltose, sucrose, galactose, cellobiose, xylose and raffinose and was found to be very close to *Pichia guillermondii* (Fig. 26).

Fig. 26. Biochemical identification of yeast endosymbiont of *Cotesia plutellae*

DNA sequencing and identification of endosymbionts

A BLAST search revealed that yeast strain Cpy1 isolated from Tirupati population had an ITS1-5.8S-ITS-2 sequence similarity of 99% with their corresponding type strain *Pichia anomala* isolate P13 (GenBank Accession No. AY349442). The output of the BLAST search of 16s rDNA sequence of strain Cpb1 isolated from Hoskote population showed 100% sequence identity with bacteria sequence in GenBank, *Bacillus subtilis*.

Likewise, bacteria associated with *Trichogramma brassicae* was identified by 16s rDNA sequencing analysis as *Bacillus cereus* strain Tb1 and was 99% similar to the bacterial sequence in GenBank, *Bacillus cereus*.

Detection of Wolbachia in *Cotesia plutellae*

The sex regulating bacterial endosymbiont wolbachia was detected in both the populations of *C. plutellae* using wsp primers. The assay was based on PCR-mediated amplification of and sequence determination of 16S rRNA gene. The presence of *wolbachia* was verified by a PCR method based on the wolbachia surface protein (wsp). Sequencing of the *Wolbachia* surface protein, wsp, revealed *Wolbachia* infection was related to *wolbachia* in *Trichogramma dyriid* with maximum similarity of 99% with BLAST test search of NCBI.

Molecular characterization of Indian coccinellids

Thirteen species of coccinellids were collected from Bangalore, Pune and Srinagar and DNA of *Coccinella septempunctata, Harmonia octomaculata, H. axyridis, Henosepilachna vigintioctopunctata, Hippodamia variegata and Propylea* sp. was extracted by using modified Lysis method protocol (Dr. Douglas Lab, Cornell University). Chelax method was employed to extract DNA from the small sized coccinellids, *viz., Scymnus (Neopullus) hoffmanni, Scymnus (Scymnus) nubilus* and *Jauravia sp.*

Cytochrome oxidase-I gene (COI) amplification

PCR reaction was performed using Biorad icycler (fig. 27). The following primer pair was used to standardize the PCR protocol for COI gene amplification, forward primer: 5 -GGTCAACAAATCATAAAGATATTGG-3 and reverse primer: 5 -TAAACTTCAGGGTGACCAAAAAATCA-3 . PCR products were electrophoresed on 1.5% agarose gel (ACROS) and visualized by ethidium bromide staining.

Fig. 27. PCR product of COI gene (550bp to 700bp) for five species of *coccinellids Coccinella septempunctata, Harmonia octomaculata, H. axyridis, Henosepilachna vigintioctopunctata, S. latemaculates, Rodalia amabilis, Brumoides suturalis* and *Propylea* sp.

Gene Sequencing and DNA barcode generation

DNA Barcodes for the 13 species of coccinellids, viz., *Brumoides suturalis, Chilocorus nigrita, Cheilomenes sexmaculata, Coccinella septempunctata, Coccinella transversalis,* *Cryptolaemus montrouzieri*, *Curinus coeruleus*, *Harmonia axyridis*, *Henosepilachna vigintioctopunctata*, *Hyperaspis maindroni*, *Illeis cincta*, *Rodolia amabilis* and *Scymnus (Pullus) latemaculatus* were generated by submitting all relevant information to the iBOL(BOLD2.5) system.

Confirmations of these 13 species were done by using the bioinformatics tools *viz*., MegaBLAST with the already available data from online public domain, for the first time submitting species *viz., Brumoides suturalis* the confirmation has been done with the nearest genus group. The e-value, penalty score and the maximum query coverage have been taken as the important measures to confirm the identity of that particular species.

Annotation of gene was done using ORF finder. The coding CDs span were predicted by ExPasy and were looked for start codon and stop codon and for the frames were the coding region were present. Based on the BlastX result, the actual frame where the coding region was present has been considered. Using Bioinformatics tools the sequences were translated to protein coding sequences and the GenBank submission was made by New BANKIT.

Phylogeny of Important Coccinellids

The phylogeny of thirteen species of coccinellids was generated based on molecular character by bioinformatics tool. Mitochondrial gene of Cytochrome c-Oxidase-5 gene has been taken as marker gene to generate the phylogeny tree (fig. 28). The sequences were aligned by means of bioinformatics tool ClustalW 1.8, and the consensus was generated. Based on the guide tree developed from the ClustalW analysis the phylogenetic tree was constructed based on Neighbor Joining method using MEGA software. The bootstrap value and maximum parsimony were taken as important parameters to construct the tree.

The phylogenetic tree shows that, two clades *viz., Rodalia amabilis* and all other coccinellids in one clade, but further they are sub divided into different clades. Among the coccinellids belong to the second clade, *Henosepilachna vigintioctopunctata* has separate branch from the rest of the coccinellids. In this phylogenetic tree, *Brumoides suturalis* and *Harmonia axyridis* are having very close relationship to each other by showing the bootstrap support as 100 and they might be the newly formed group since they are found in the top of the topology.

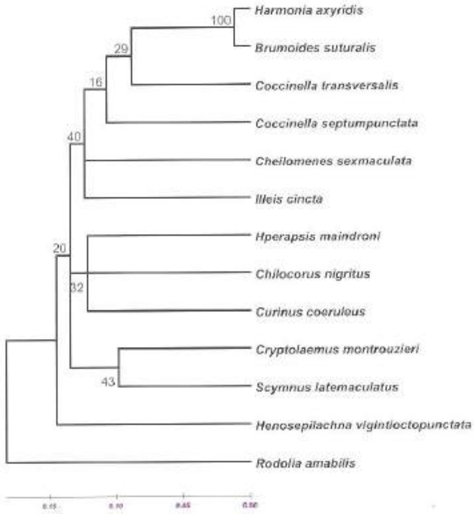


Fig. 28. Phylogeny of Important Coccinellids

Molecular identification of promising *Bacillus* spp. effective against *Ralstonia solanacearum*

Bacterial DNA of six promising *Bacillus* spp. were isolated using the HiPurA genomic DNA isolation kit from HiMedia (Mumbai). These six isolates of *Bacillus* were identified through 16s rDNA analysis (Table 3). Amplification of 16S rRNA gene

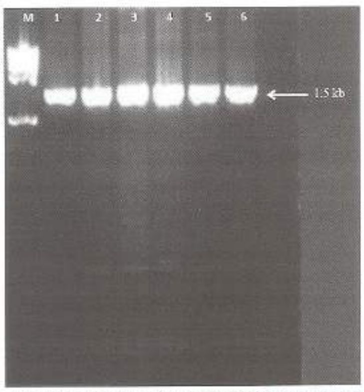


Fig. 29. Agarose gel showing 16S rRNA amplification of 1.5kb M-1 kb DNA ladder; lane 1-NBAII 63; lane 2- NBAII 7; lane 3- NBAII 25; lane 4- NBAII 71; lane 5- NBAII 33; lane 6- NBAII 65

was performed from the genomic DNA of bacteria. Purified PCR products were sequenced by Chromous Biotech (Bangalore) using16S sequencing primer. Similarity search of the 16S rRNA sequences was done using the BLAST function of NCBI Genbank. The 16S rRNA sequences were aligned with other *Bacillus* sp.16S rRNA sequences obtained from Genbank using Clustalx software. Amplification of 16S rRNA gene was performed from the genomic DNA of six bacteria. PCR products were visualized in agarose gels showing the amplification of 16S rRNA gene with 1.5 kb (Fig.29).

Table 3. Identified *Bacillus* isolates and their accession numbers

Bacillus isolates	Identified species	Accession Number
NBAII-33	*Bacillus cereus*	HQ162491
NBAII-63	*Bacillus megaterium*	HQ162492
NBAII-25	*Bacillus subtilis*	HQ162493
NBAII-7	*Bacillus cereus*	HQ162494
NBAII-71	*Bacillus cereus*	HQ162495
NBAII-65	*Bacillus megaterium*	HQ162496

Molecular characterization of indigenous Bt strains

PCR studies showed that *Cry1* and *Cry2* Genes were present in PDBC-BT1, PDBC-BT2 NBAII-BT3, NBAII-BT4, NBAII-BT5, and NBAIIB-TG4 (Table 4 and Fig. 30 & 31). Specific Cry primers showed that *Cry1*Aa was not detected in NBAII-BT4 and NBAII-BTAS. *Cry1*Ab and *Cry1*Ac were present

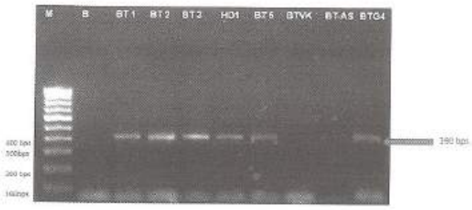


Fig. 30. PCR analysis using *Cry1*Aa Specific Primer

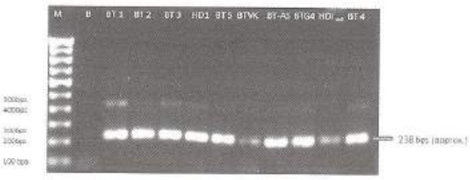


Fig. 31. PCR analysis using Cry 1Ac Specific Primer

Table 4. Cry genes detected in indigenous *Bacillus thuringiensis* isolates

Cry genes analyzed by PCR	Indigenous Bt isolates						
	PDBC -BT1	PDBC-BT2	NBAII -BT3	NBAII -BT4	NBAII -BT5	NBAII -BTG4	NBAII -BTAS
Cry1	✓	✓	✓	x	✓	✓	✓
Cry2	✓	✓	✓	✓	✓	✓	x
Cry1Aa	✓	✓	✓	x	✓	✓	x
Cry1Ab	✓	✓	✓	✓	✓	✓	✓
Cry1Ac	✓	✓	✓	✓	✓	✓	✓
Cry1C	x	x	x	✓	x	x	x
Cry1D	x	x	x	✓	x	x	x
Cry1E	✓	✓	✓	x	✓	x	✓
Cry1F	x	x	x	x	x	x	x
Cry1G	✓	x	x	✓	✓	x	✓
Cry1H	x	x	x	x	x	x	x
Cry1I	✓	✓	✓	✓	✓	✓	✓
Cry19	x	x	x	x	x	x	x

in all isolates. Cry1C and Cry1D were detected only in NBAII-BT-4. Cry1E was not present in NBAII-BT-4 and NBAII-BTG4. Cry1F and Cry19 were not detected in any of the isolates. Cry1I was present in all the isolates which is supposed to have dual toxicity (Lepidoptera and Coleoptera).

The spore-crystal mixture of the native isolates and the reference strains were analyzed by SDS-PAGE. BT1, BT2, BT3, BT5, BT-HD 1,BT ASSAM BT G4 isolates produced major proteins of 130 and 60kDa consistent with the *cry1 and cry2* genes.

The sequence analysis of the *Cry1*Aa gene PCR product of the indigenous *B. thuringiensis* isolate PDBC-BT1 showed that it had 97% match with the *B. thuringiensis* strain BLB1 (GenBank Acc. GU322940). The *Cry1*Aa gene sequence of PDBC-BT2 had 99% similarity the BLB1 strain. The *Cry*1Ac sequence of NBAII-BT3 had only 68% match with the *B. thuringiensis* strain S3299-1 (Acc. GU446674.1) which could imply that it could harbour a novel *Cry1*Ac gene. The *Cry1*Aa gene of NBAII-BT5 had 94% matching with the BLB1 strain. The *Cry1*Aa gene of NBAII-BT-G4 had 99% with BLB1 but the complete sequence had 100% similarity with *B. thuringiensis* strain Br64 *Cry1*Ea9 implying that the strain is different from others.

GenBank submissions of partial sequence of Cry1 gene of Bt

Partial sequence (completely aligned) of cry1Ab gene of the indigenous *Bacillus thuringiensis* isolates PDBC-BT1 (Acc. No. JF501454), PDBC-BT2 (JF501455), NBAII-BT5 (JF501456) and NBAII-BTAS (JF501457) submitted and accession numbers assigned. The protein sequence obtained by blast(n) was also submitted.

Molecular identification and cataloguing of EPN

Molecular identification using (multi-loci) ITS and COI gene analysis approach has been devised for *Steinernema carpocapsae* strain NBAII-SC11, *Steinernema abbasi* isolate NBAII-SA1, *Heterorhabditis bacteriophora* isolate NBAII-Hbb4, *Heterorhabditis indica* isolate NBAII-Hi1 and *Photorhabdus luminescens* isolate HiP5.0.

Nematode-derived fungi and bacteria for exploitation in agriculture

One new isolate of *Arthrobotrys conoides* (fig. 32) was collected from the galled and root-knot nematode -nfected roots and soil mix of commercial polyhouse in Nelamangala. Under *in vitro* conditions, *A. conoides* and *A. oligospora* have shown 90-98% mortality of *Meloidogyne incognita* and *Rotylenchulus reniformis*. These isolates exhibited high per cent infection of egg masses and eggs under *in vitro* and *in vivo* against root-knot and reniform nematodes.

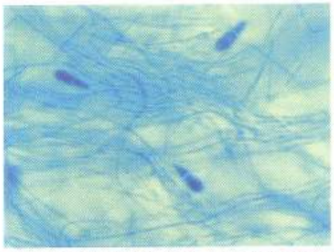


Fig. 32. Cercospores (40x) of *A. conoides* isolated from nematode egg masses

Molecular identification of nematode-derived antagonistic fungi

Genomic DNA from isolates of *Arthrobotrys oligospora*, *A. conoides* and *Dactylella oviparasitica* were used for PCR analysis and amplification of segments of beta-tubulin gene (Fig. 33). Based on the

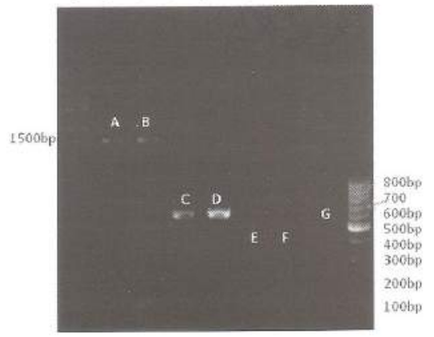


Fig. 33. Amplified products of virulence gene coding for serine protease in isolates of *P. chlamydosporia* and identification gene beta tubulin in isolates of *A. oligospora*, *A. conoides* and *Dactylella oviparasitica*. Lane 1, DNA Marker(); Lane 2, Alkaline protease gene from *P. chlamydosporia* NBAII PC/AP1 (1549bp); Lane 3, Alkaline serine protease gene from *P. chlamydosporia* NBAII PC/VC1 (1549bp); Lane 4, Beta tubulin gene from *A. oligospora* NBAII AO1 (567); Lane 5, Beta tubulin gene from *A. conoides* NBAII AC1 (567bp); Lane 6, Beta tubulin gene of *P. chlamydosporia* NBAII PC/AP1 (App. 270);Lane 7, Beta tubulin gene of *P. chlamydosporia* NBAII PC/VC1 (App. 270); Lane 8, ITS region of *D. oviparasitica* (475 bases); Lane 9, 100bp marker.

molecular size of the respective amplicons, the fungal identity was confirmed.

Molecular identification of root-knot nematodes

PCR amplification of conserved ITS regions of DNA samples extracted from the root-knot nematodes collected from Mandya and Bangalore were sequenced and submitted to NCBI gene bank and were used for the identification of root-knot nematodes (Fig. 34).

Fig. 34. Amplified products of 28S r RNA - ITS region of *Meloidogyne* species. (Lane 1 - 1Kb Marker; Lane 2 - *Meloidogyne* (Attur tomato); Lane 3 - *Meloidogyne* (Attur brinjal); Lane 4- *Meloidogyne* (Maddur paddy); Lane 5 - *Meloidogyne* (Maddur Okra).

Mode of action and virulence factors of the isolates of *P. lilacinus* and *Pochonia chlamydosporia* against root-knot nematodes

Gene coding for serine protease, responsible for virulence against root-knot nematode eggs and egg masses, was amplified from the isolates of *P. chlamydosporia* (Fig. 35).

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. 36). Enzymes and their activities were detected through zones of clearance in the media inoculated with specific fungal discs. The activities were variable with different fungal cultures indicating the differences in their contents and subsequent differences in bioactivity.

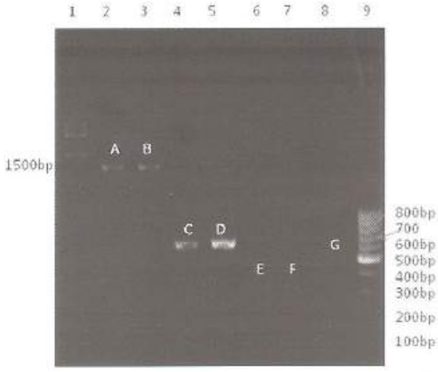


Fig. 35 : Amplified products of virulence gene coding for serine protease in isolates of *P. chlamydosporia* and identification gene beta tubulin in isolates of *A. oligospora*, *A. conoides* and *Dactylella oviparasitica*.
Lane 1, DNA Marker(); Lane 2, Alkaline protease gene from *P. chlamydosporia* NBAII PC/AP1 (1549bp); Lane 3, Alkaline serine protease gene from *P. chlamydosporia* NBAII PC/VC1 (1549bp); Lane 4, Beta tubulin gene from *A. oligospora* NBAII AO1 (567); Lane 5, Beta tubulin gene from *A. conoides* NBAII AC1 (567bp); Lane 6, Beta tubulin gene of *P. chlamydosporia* NBAII PC/AP1 (App. 270);Lane 7, Beta tubulin gene of *P. chlamydosporia* NBAII PC/VC1 (App. 270); Lane 8, ITS region of *D. oviparasitica* (475bp); Lane 9, 100bp marker.

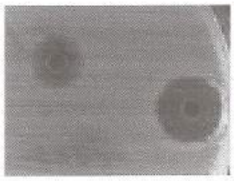


Fig. 36. Clearance zone in casein-rich medium by the *A. oligospora* and *P. chlamydosporia*

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

5.2.1. Studies on plant disease and nematode management

NBAII

Promising *Pseudomonas* isolates against *Meloidogyne* spp.

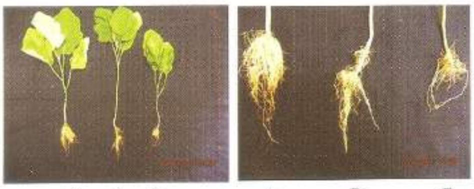
Fifteen isolates of *Pseudomonas* spp. were obtained from infected egg masses of root-knot nematode, *Meloidogyne* spp. collected from brinjal and tomato plants. Seven isolates were found inhibitory to second stage juveniles of root-knot nematode under *in-vitro* condition and isolates NBAII-2 and NBAII-5 resulted up to 83.3% mortality of juveniles of *Meloidogyne* spp.

Management of soil-borne diseases in rain-fed pulses and oilseed through saline-tolerant antagonistic bacteria

Saline-tolerant antagonistic bacteria were selected from the culture collections of NBAII (under NAIP project) for *in vitro* and field testing in groundnut, chickpea and pigeonpea. The organisms selected for testing in rain fed crops were *Pseudomonas putida* (3 strains), *P. plecoglossicida* (2 strains), *P. fluorescens* (2 strains), *Alcaligenes.* sp. and *Pseudomonas* sp. Highest vigour index of 4600 was observed in the plants treated with *P. putida* (RPF-9). Under saline amended conditions highest vigour index of 4020 was observed again with plants raised from seed treated with *P. putida* (RPF-9). The lowest (569) was in control.

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

A combined application of the talc based formulation of *B. megaterium* NBAII 63 (10^8 cfu/ml) as seed treatment (4g /kg of seed), soil application (5g /kg of soil), seedling root dip (10g /L of water) and foliar spray (10g /L of water) in combination resulted in 51 percent reduction of bacterial wilt in brinjal. Good root and shoot growth of the brinjal plants were recorded due to application *B. megaterium* (Fig 37).



A B C A B C

Fig. 37. Effect of *B. megaterium* on root and shoot growth of brinjal plants; A and B-Plants treated with *B. megaterium*; C-Control (pathogen inoculated)

GBPUAT

In vitro screening of antagonists for tolerance to abiotic stresses (i.e. cold, drought, salinity) and their performance under rain-fed conditions.

One hundred isolates of *Trichoderma* coded as T-1 to T-57 and Th 51-93 from different farming situations in the hills (Uttarakhand) and plains of North India were collected and screened *in vitro* for their tolerance to cold, drought and salinity. All isolates showed tolerance to varying degree of pH, whereas isolates T-13, T-14 , T-50 and Th-68 were tolerant to temperature, 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-57, Th-56, Th-60, Th-61, Th-69, Th-70 &Th-82 were tolerant to salinity, 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 tolerant to moisture and isolates T-14, Th-56 and T-57 for PGP activity (rice) were found best.

Trichoderma resistant to salinity

In wheat, Th-14 was the most effective in improving germination percentage (33 % increase over control) followed by Th-19 and Th-13 under saline conditions. Seedlings raised from seeds bioprimed with Th-14 followed by Th-19 had significantly higher shoot (25% and 21% increase over control, respectively) and root lengths (31% and 28% increase over control, respectively) compared to other treatments under both normal and saline conditions. Total cholorophyll content and membrane stability index were reduced in untreated plants in comparison to treated plants at all stress levels. The highest chlorophyll content (2.41 mg/g fr.wt.) and membrane stability index (63.34) was recorded in Th-14 treatment followed by Th-19 (2.27 mg/g fr.wt. chlorophyll content and 63.27% MSI) under salt stress. The treatments Th-14, Th-19 and Th-13 showed lower accumulation of MDA content whereas proline content and phenolics were higher in treated plants under both non-saline and saline conditions. Highest MDA content was observed in untreated plants at all stress levels from 0 dSm-1(1.93µmol/g fr.wt.) to 6 dSm-1(7.80µmol/g fr.wt.), indicating maximum damage due to oxidative stress. In rice, untreated plants were more sensitive to salt stress. Lengths and fresh weights of shoot and root, number of leaves, photosynthetic rate, chlorophyll fluorescence, total chlorophyll content, SPAD value, and MSI were reduced in control plants in comparison to selected *Trichoderma*-treated plants. The MSI decreased as salt stress level increased .The MSI was reduced to more than 50% under 240mM NaCl (38.04%) from 0 mM NaCl (84.74%), considering the mean MSI of all treatments. MSI was significantly higher in Th-14 (63.34%) treated rice plants considering mean at salt stress. *Trichoderma* treated plants had relatively higher levels of phenolics while lower accumulation of MDA content. Data of yield attributing characters like number of tillers, number of panicles, panicle length and 1000 grain weight, etc. revealed that *Trichoderma*-treated plants performed significantly better than untreated plants under both normal and saline soils. *Trichoderma* treated seedlings showed significantly higher expression pattern for the genes as compared to untreated plants with increase in salt concentration.

Trichoderma resistant to drought

All selected isolates enhanced the water stress tolerance of rice and wheat plants. In rice, Th 56 and 75 induced maximum tolerance to water stress. Treatment of rice with Th 56 showed no sign of wilting even at 5 DDS as against complete wilting of untreated rice plants. In wheat, plants treated with Th 56 showed no sign of wilting even at 7 DDS. Drought induced physiological and biochemical changes in chlorophyll content, SPAD value, photosynthetic rate, stomatal conductance, membrane stability index, proline content, MDA content and total phenolics were delayed by drought tolerant *Trichoderma harzianum* strains. Total chlorophyll content and relative greenness (SPAD value) were significantly decreased under drought stress from 3 to 9d in rice and 4 to 13d in wheat. Minimum reduction in chlorophyll content and SPAD value was reported in Th 56 and Th 75 at 9 DDS in rice and Th 82 and Th 56 at 13 DDS in wheat. Limiting watering from 1 to 9 DDS in rice and 4 to 13 DDS in wheat caused a severe loss in membrane stability in untreated plants, approximately 51 per cent and 53.6 per cent loss was found in untreated rice and wheat plants, respectively. However, significantly less fluctuation in MSI value was observed in *Trichoderma* treated plants. Minimum per cent loss in MSI value was recorded by Th 56 in both rice and wheat. Photosynthetic rate and stomatal conductance were significantly reduced under drought stress in both treated and untreated plants. However, treatment with *Trichoderma* isolates suppressed the reduction in photosynthetic rate and stomatal conductance as compared to control in both rice and wheat. Chlorophyll fluorescence (Fv/Fm) was severely affected under drought conditions in untreated plants. Treated plants showed comparatively less changes in Fv/Fm ratio under limited watering conditions as compared to untreated control. Minimum reduction in chlorophyll fluorescence was observed for Th 56 in both rice and wheat plants. Stress related compounds such as proline, MDA, and hydrogen peroxide content increased under drought stress in both treated and untreated plants however, the increase was non-significant in treated wheat and rice plants. Minimum per cent increase over unstressed plants in proline, MDA, and hydrogen peroxide content was recorded in Th 56. A significantly higher level of phenolics content was found in rice plants treated with drought tolerant *Trichoderma* strains as the conditions of drought increased in comparison to untreated rice plants. Expression profiling of some key genes potentially involved under stress condition was found directly correlated with biochemical and physiological parameters studied in plants treated with T-56. Only expression pattern of LOX was unaffected by treatments.

Evaluation of *Trichoderma* in rice (Kalanamak-3119 and Kalanamak- 3131) under rain fed conditions

Results of a field experiment 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 during Kharif 2010 showed that isolates 14, 56, 68 and 69 were found best which showed no disease incidence of sheath blight. No *Trichoderma* isolates was effective against the stem borer, grass hopper and leaf folder. Among all isolates only T-75, T-82 and T-89 performed best in terms of all the growth parameters and yield of rice cv Kalanamak-3119.

Large scale field demonstrations of biocontrol of plant diseases management

Rice

Large scale demonstration of biocontrol technologies was conducted on organically cultivated rice cultivars Taraori Basmati and Pusa -1460. The biocontrol treatments included FYM colonized with mixed formulation of *Trichoderma harzianum* + *Pseudomonas fluorescens* (@ 5 to 10 tons/ha) or use of vermicompost colonized with *Pseudomonas fluorescens* (@ 5 to 10 q/ha), seed treatment/ biopriming with mixed formulation of TH + PsF (@ 10g/kg seed) 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

Table 5. Large scale demonstration of biocontrol agents on organically cultivated rice

Rice	Yield (kg/ha)	Value (₹/kg)	Value of yield (₹/ha)
Organic Taraori Basmati	2,500	26.00	65,000
Organic Pusa-1460	3,500	21.00	73,500
Farmers practice Taraori basmati	3,000	20.00	60,000
Farmers practice (Pusa-1460)	4,000	16.00	64,000

farmers' practice, the organic fetched higher price (Table 5).

Several Organic Farmers Associations are following biocontrol technologies in rice for the past eight years over an area of 500 ha for the management of rice diseases.

Vegetables

Large scale field demonstrations on biocontrol technologies under low input system in Uttarkhand hills in two districts, namely Pithoragarh and Chamoli was conducted. The BIPM package included: a) solarization of nursery soil; b) seed treatment with mixed formulation of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28 @ 10g/kg seed; c) Seedling dip in mixed formulation of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28 @ 10g/l; d) use of vermicompost colonized with *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28; e) 2-3 sprays of mixed formulation of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-28 @ 10g/l; 1-2 sprays of soluneem which was compared with farmers' practice.

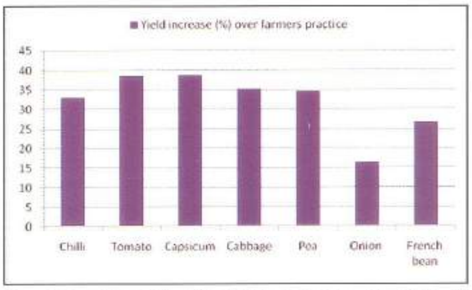


Fig. 38. Impact of BIPM package on yield of vegetables in Uttarakhand hills

Average values of pooled results demonstrate that in all the vegetables the biocontrol technologies were found to increase the yields as compared to farmers practice. The pooled results indicate that in tomato up to 38.5% yield was observed as compared to farmer's practice (Fig. 38). In capsicum also the increase in yield was as high as 38.5%. In chilli up to 33% increase in yield was observed as compared to the farmer's practice. Cabbage and pea also showed the same trend with increase in yield ranging from 9.3-35.2 % and 10.0 - 34.5 respectively in different farmer's fields.

MPKV

Biological control of plant parasitic nematodes in Pomegrante

A field experiment was conducted on four year old pomegranate (var. Bhagwa) orchard in farmers' field at village New Nirpur, (Dist. Nashik) to evaluate the biocontrol agents against the root knot nematode. The bioagents, *Pseudomonas fluorescens* @ 20 g/m^2 (10^8 spores/g), *Trichoderma viride* @ 20 g/m^2

Table 6. Effect of Biocontrol agents on root knot nematode population and yield in pomegranate

Treatment	Nematode population/ 200 cm^3 soil	No. of root galls/ 5 g roots	Yield (kg/ha)	ICBR
P. fluorescens @ 20g/m^2	310.0^a	14.0^a	19,500^a	1 : 21.8
T. viride @ 20g/m^2	335.0^a	18.2^b	19,200^a	1 : 19.9
Cartap hydrochloride 4G @ 0.3 g a.i./m^2	345.0^a	18.5^b	18,800^a	-
Carbofuran 3G @ 0.3 g ai./m^2	320.0^a	14.7^a	19,100^a	1 : 12.9
Control	720.0^b	32.7^c	16.500^b	

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

(10^8 spores/g), chemical pesticides cartap hydrochloride 4G @ 0.3 g a.i./m^2, carbofuran 3G @ 0.3 g a.i./m^2 were applied in soil along with FYM at *Bahar* (blossom) treatment.

The results revealed that all the treatments were effective in reducing the root knot nematode population in soil as well as in roots and increased the fruit yield. Soil application of *P. fluorescens* @ 20 g/m^2 was most effective in reducing the root knot nematode population and root galls and increasing the fruit yield of pomegranate over control with 1: 21.8 ICBR. It was, followed by carbofuran 3G @ 0.3 g ai./m^2 and *T. viride* @ 20 g/m^2 (Table 6).

5.2.2. Studies on insect pathogens

NBAII

Entomofungal pathogens against *Aphis craccivora on cowpea*

In a field trial at NBAII research farm, Attur, entomofungal pathogens were evaluated against *Aphis craccivora* on cowpea. Among the four entomofungal pathogens evaluated, application of *V. lecanii* (Vl-8 isolate) recorded the lowest aphid population (32.3/plant) and highest yield (911kg/ha) and was on par with monocrotophos (0.007%) (Table 7).

These entomofungal pathogens were found safe against *Cheilomenes sexmaculata* as no mycosis was recorded, however 1.7 - 3.1% mycosis was recorded on the larvae of *Micromus timidus*.

Table. 7. Efficacy of entomofungal pathogens against *Aphis craccivora* on cowpea

Treatment	No. of aphids/ plant	Yield of cowpea (kg/ha)
Beauveria bassiana (Bb-5a)	41.2^{ab}	811^{bc}
Metarhizium anisopliae (Ma-4)	47.8^{ab}	822^{bc}
Verticillium lecanii (Vl-8)	32.3^{a}	911^{a}
Paecilomyces fumosoroseus (Pfu-1)	78.9^{c}	677^{bc}
Monocrotophos (0.007%)	28.9^{a}	1011^{a}
Control	116.4^{d}	577^{cd}

Enhancing the efficacy of fungi against *Tetranychus urticae* on five cucurbits

The bioefficacy of two pathogenic fungi, viz. *Acremonium* sp. and *Lecanicillium psalliotae*, was evaluated against *Tetranychus urticae* on five cucurbits, viz. ash gourd, bitter gourd, bottle gourd, cucumber and ridge gourd, in three rounds of experiments set up in the greenhouse at the Biocontrol Research Farm, Attur, Bangalore, during 2010-11.

Data on the post treatment mite population revealed that *Acremonium* sp. was more effective than *L. psalliotae* and that prior application of a weakening agent enhanced the efficacy of both the fungal pathogens.

Bioefficacy of host- and non-host-derived *Hirsutella thompsonii* isolates against *Phyllocoptruta oleivora* on two citrus species

Field bioefficacy of both host- and non-host derived *Hirsutella thompsonii* F.E. Fisher isolates against *P. oleivora* was studied on orange and sweet orange. Both *H. thompsonii* isolates were equally effective in reducing the population of the citrus rust mite on orange to an extent of about 82.0 per cent in orange and 88.4 per cent in sweet orange.

Activated *Bt* toxin assay against *Helicoverpa armigera*

Six indigenous Bt namely PDBC-BT1, PDBC-BT2, NBAIIB-TAS, NBAIIB-TG4, NBAII-BT3 and NBAII-BT4 were screened against *H. armigera* using toxins activated by trypsin digestion. At 96h PDBC-BT1 was the most toxic recording an LC_{50} value of 0.8 µg/ml.

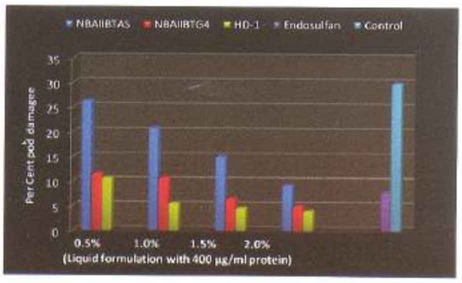


Fig. 39. Effect of liquid Bt spray on pigeon pea pod damage

Field evaluation of an indigenous Bt against pigeonpea pod borer, *Helicoverpa armigera*

In a field trial on pigeonpea, application of 2.0 per cent liquid formulation of NBAII-BTG4 was the most effective in reducing the pod damage and better than endosulfan (Fig. 39).

'In vitro' screening of EPN

'In vitro' screening of two isolates of *Heterorhabditis* from Maharastra and one isolate of *Heterorhabditis* and *Steinernema* from Srinagar against second and third instar grubs of *Anomala bengalensis* revealed that all the four isolates caused 100% mortality of grubs in 60-72 hrs up to a depth of 15 cm.

'In vivo' mass production of EPN

The optimal temperature for growth, duration of life cycle, larval biomass and fecundity of *Galleria* ranged between 28 and 30°C at a relative humidity of 50-80%. The diets and the media were redesigned and three modified diets supported the *Galleria mellonella* larval production without any adverse effects on fecundity, duration of life-cycle and larval biomass and was cheaper than the standard diet by 38-56%.

For mass production of *S. carpocapsae* the optimum initial inoculum was 109 IJs in *Corcyra cephalonica* and 56 IJs in *G. mellonella* and for *S. feltiae* it was 100 IJs for *C. cephalonica* and 32 IJs for *G. mellonella*. *Heterorhabditis bacteriophora* numbers increased as inoculum level increased in *C. cephalonica* whereas 36 IJ was optimum in *G. mellonella*. Overall, production levels of the EPN were higher in *G. mellonella* compared to *C. cephalonica*.

'In vitro' production of EPN

Prior inoculation of symbiotic bacteria into Wout's medium, soy flour + dog biscuit medium or dog biscuit medium was found to enhance the yield and rate of multiplication of *S. carpocapsae*, *S. abbasi* and *H. indica*.

Performance of NBAII isolates of EPN

'In vitro' studies were carried out with wettable powder formulations of *H. indica* against 20 late instar larvae of *G. mellonella*, *C. cephalonica*, *Helicoverpa armigera*, *Spodoptera litura* and *Plutella xylostella* in Petri plates. The median lethal concentration (LC_{50}) of wettable powder formulation of *H. indica* at 52h post-inoculation was 32 IJs (Y=-6.12 + 4.18 X), 47 IJs (Y= -1.4 + 0.87 X), 112 IJs (Y=-3.74 +1.87 X) and 158 IJs/larva (Y= -6.81 + 3.14 X) for final instar larvae of *G. mellonella*, *P. xylostella*, *S. litura* and *H. armigera*, respectively. A positive correlation was observation between the dosage of wettable powder of *H. indica* and mortality of *G. mellonella* and a negative correlation between the dosage and the time of mortality. The optimum dosage levels differed among different host insects.

Heterorhabditis indica and *S. carpocapsae* obtained from *G. mellonella*, *C. cephalonica* and root grub exhibited better infectivity in shorter duration against *G. mellonella* and root grub compared to the progeny obtained from *H. armigera*, *S. litura* and *P. xylostella*.

Shelf life of EPN formulations

Wettable powder formulations of *Heterorhabditis indica* and *H. bacteriophora* with a shelf-life of 8-10 months were developed (Fig. 40) and applied for IP protection through patent application (Patent application No. 3094/CHE/2010). Shelf-life of the WP formulations of both the nematode species was consistent with more than 90% viability at 8-10 months which reduced to 88% at 10-12 months.

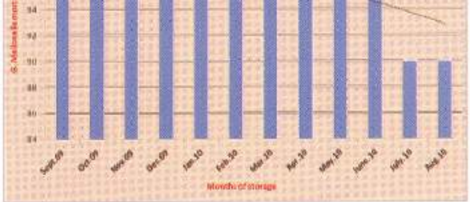


Fig. 40. Shelf-life of *H. indica* wettable formulation in terms of bioefficacy against *G. mellonella*

Field evaluation of EPN against root grubs of arecanut

Field evaluation of wettable powder and aqueous formulations of *H. indica* and *S. abbasi* against root grubs, *Leucopholis lepidophora*, *Anomala bengalensis* and *L. burmestrii* in arecanut field at

Sulya and Banakal was carried out. *Heterorhabditis indica* and *S. abbasi* recorded root grub mortality in 6 and 8 days, respectively. The EPN established well in treated fields and recovered in large number from treated soils up to 12 months and effectively controlled the root grubs apart from promoting fresh roots and foliage with recovery of treated plants (Fig. 41).

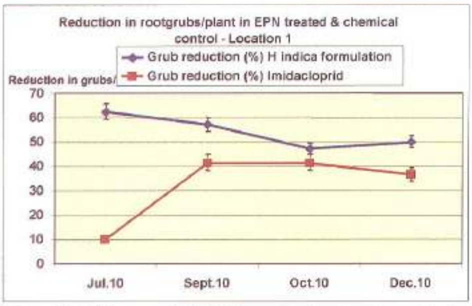


Fig. 41. Efficacy of EPN in reducing root grubs in arecanut field at Sulya.

In a second field trial, seven EPN isolates, *H. indica* isolate NBAII-Hi01, *H. indica* isolate NBAII-Hi03, *H. indica* isolate NBAII-Hi05, *H. bacteriophora* isolate NBAII-Hbb01, *S. carpocapsae*, *S. feltiae* and *S. abbasi* gave consistent reduction (40-46% over control) of grub populations.

In a third field trial, application of wettable powder formulations of EPN between last week of June and 1st week of July (immediately after pre-monsoon shower) in arecanut fields of Karavali and Malnad, Karnataka established EPN in advance and recorded higher grub mortality (grub size <1.5 cm)

IARI

Isolation and characterization of Bt strains from the soil samples

Soil samples were collected from several places in northern India and ten Bt strains (GTG-1 to GTG-10) were isolated. Laboratory evaluation of these Bt strains against *Chilo partellus* revealed that seven days after the treatment, the mortality of the larvae ranged from 8.9 to 31.0.

SBI

Interaction of Entomopathogenic fungi (EPF) with fungal antagonists and nematophagous fungi (Colony growth)

The colony growth of *B. bassiana*, *B. brongniartii* and *M. anisopliae*, *Verticillium chlamydosporium*, *Paecilomyces lilacinus*, *Trichoderma viride*, *T. harzianum* in the presence of each other in 28 combinations was studied. All the species had negative impact on the growth of *B. bassiana* in varying degrees of which *B. brongniartii* was the most tolerable. *B. brongniartii* initially benefitted by companion fungi but by day 12, showed slower growth due to competition from all species of which *B. bassiana* was the most compatible. For *M. anisopliae*, *V. chlamydosporium* was most companionable to grow with.

There was complete inhibition of growth of the three EPF in the presence of both of *Trichoderma* species throughout the growth period. Unlike *Trichoderma* spp., nematophagous fungi were less inhibitive to entomopathogenic fungi. *T. viride* was most harmful to *V. chlamydosporium*. Except *Trichoderma* spp., other fungi species were not interfering with the growth of *P. lilacinus* during the entire period of observation. The effects of competition were less severe when the colony plugs of target fungi were inoculated farther away from each other on dual culture plates.

Interaction of EPF with fungal antagonists and nematophagous fungi (Sporulation)

The three EPF, two fungal antagonists and two nematophagous fungi were tested for their ability to sporulate in the presence of each other by inoculating them together in potato dextrose medium which was compared with their ability to sporulate when inoculated individually.

B. bassiana was compatible with *M. anisopliae* and *V. chlamydosporium*. *Beaveria brongniartii* was the most tolerant of the species tested except the nematophagous fungi. When inoculated together, sporulation of *M. anisopliae* and *B. bassiana* was mutually unaffected indicating their compatibility. Both the nematophagous fungi and *Trichoderma* spp. were inhibitive to *M. anisopliae*. In general, the EPF were more compatible with each other than with the fungal antagonists and nematophagous fungi during fungal growth and sporulation. On the other hand, all the EPF were highly inhibitive to *V. chlamydosporium* but not to *P. lilacinus* during sporulation. Among all species of fungi tested, both species of *Trichoderma* were highly inhibitive to sporulation of *P. lilacinus*.

Metarhizium anisopliae and P. lilacinus were highly adverse to the sporulation of *V. chlamydosporium* while the *Trichoderma* spp. were compatible. On the contrary *P. lilacinus* was unaffected by EPF while it was inhibited by *Trichoderma* spp. the most. All species affected *T. viride* with *M. anisopliae* being the least competitive. However, *T. harzianum* was unaffected by most species except *T. viride* followed by *P. lilacinus*.

Colony growth in the presence of agrochemicals

Observations on the radial growth of the EPF showed toxic effect of metribuzin, carbendazim and chlorpyriphos though there was distinct influence of combination of species *B. bassiana* was grown with, on the levels of its vulnerability to the chemicals. Growth of mycelium in all three EPF was enhanced by imidacloprid and acephate which compensated even for the species competition.

Sporulation in the presence of agrochemicals

In terms of sporulation, *B. bassiana* was the most tolerant to the agrochemicals tested followed by *M. anisopliae*. Among the agrochemicals tested, Pendimethalin and Carbebdazim were completely inhibitive to all the three EPF. Further, *B. brongniartii* was hyper sensitive with zero sporulation when exposed to chlorpyriphos and acephate. Chemicals safe to *B. bassiana* were malathion and imidacloprid. The atrazine and insecticide acephate were moderately safe to *B. bassiana*.

Beauveria brongniartii was sensitive to all chemicals barring Malathion (2.08 x 10^9/100ml). Imidacloprid and atrazine were moderately safe. Atrazine was the safest and also stimulatory to the sporulation of *M. anisopliae*.

5.2.3. Biological suppression of sugarcane pests

Demonstration of efficacy of *Trichogramma chilonis* and *Cotesia flavipes* against the plassy borer, *Chilo tumidicostalis* -AAU-J

Large scale demonstration of effectiveness of *T. chilonis* against the plassy borer was carried out in a farmers' field on Dhansiri variety at Buragaon village in Golaghat district covering an area of 200 ha. In farmer's practice, endosulfan 35 EC @ 3ml/lit was applied four times during June to September. Eleven releases of *T. chilonis* @ 50,000/ha/release at 10 days interval from June to November 2010 reduced the damage on the cane, however it was on par with the farmers' practice (Fig. 42).

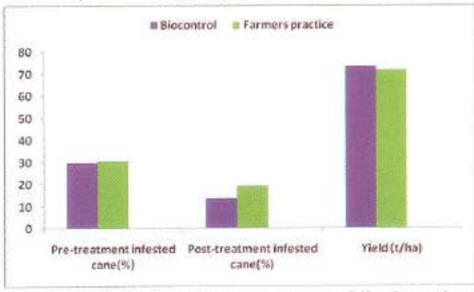


Fig. 42. Evaluation of *Trichogramma chilonis* against plassy borer

In another demonstration, four releases of *C. flavipes* @ 500/ha from June to September at monthly interval on one hectare sugarcane (var. Dhansiri) at village Khonikar gaon (Golaghat district) reduced the plassy borer damage from 29.45 to 24.15 with cane yield of 63.8 t/ha, whereas the farmers' practice reduced the cane damage from 25.41 to 15.74 with the cane yield of 70.4 t/ha.

Evaluation of temperture-tolerant *Trichogramma chilonis* against the sugarcane internode borer (INB)-MPKV

An experiment was conducted to evaluate *T. chilonis* temperature-tolerant (TTS) and (SAS strains) against the internode borer on sugarcane (var. Co 671). The results revealed that six releases of *T. chilonis* (TTS strain) @ 1 lakh/ha/release was more effective in reducing the pest incidence and increasing the cane yield than *T. chilonis* (SAS) strain (Table 8).

Table 8. 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	4.0[a]	6.9[a]	89.9[a]
T. chilonis SAS @ 1 lakh/ha	3.9[a]	14.1[b]	84.6[a]
Untreated control	4.1[a]	28.6[c]	76.4[b]

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

Pooled analysis of three years data revealed that six releases of TTS of T. chilonis @ 1 lakh adults/ha was significantly superior to SAS strain of the parasitoid recording 7.3% incidence of INB in sugarcane and 85.9 kg yield per 50 canes (Table 9).

Table 9. Efficacy of *Trichogramma chilonis* against INB on sugarcane (Pooled data from 2008-09, 2009-10 and 2010-11)

Treatment	INB Incidence		Yield (kg/50 canes)
	Pre-release	Post-release	
T. chilonis TTS @ 1 lakh/ha	3.6[a]	7.3[a]	85.9[a]
T. chilonis SAS @ 1 lakh/ha	3.9[a]	13.2[b]	79.9[a]
Untreated control	4.0[a]	26.5[c]	74.0[b]

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

Survey and assessment of impact of natural enemies on incidence of sugarcane woolly aphid (SWA)- MPKV

The incidence of SWA and its natural enemies were recorded in Pune, Satara, Sangli, Kolhapur, Ahmednagar, Nashik, Dhule, Jalgaon, Aurangabad and Jalna districts of Maharashtra. The sugarcane fields were surveyed during July to October, 2010. The pest incidence was observed in August-September in Kasarsai, Pawananagar, Daund, Kalamb, Indapur areas in Pune district, Krishna riverside fields in Limb, Kidgaon, Udtare, Bhuinj, Vadagaon Haveli, Koparde, Padegaon areas of Satara district and fields at Panchaganga riverside in Kolhapur, but at low intensity. It was followed by the occurrence of predators like *Dipha aphidivora* (0.8-2.1 larvae/leaf), *Micromus igorotus* (1.8-5.6 grubs/leaf) and syrphid, *Eupodes confrator* (1-2 larvae/leaf) in September-October, 2010. The parasitoid, *Encarsia flavoscutellum* was observed at Paedgaon, Dist. Satara. Thus, it is clear that the natural enemies of SWA have established well in western Maharashtra suppressing the pest incidence below EIL.

Demonstration on the efficacy of temperature-tolerant strain (TTS) of *T. chilonis* 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 village Haripur and Mohalon (Distt. Jalandhar) 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 reduced by *T. chilonis* release and it was on par with chemical treatment (Table 10). The mean per cent reduction of shoot borer incidence over control was 56.4%. There was no significant difference in cane yield in the parasitoid-released and chemical control plot, however the cost-benefit ratio was higher in parasitoid released plot (1:19.2).

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 (3.1%) in the release field in comparison to control (7.5%). The per cent parasitisation was significantly higher in release fields (57.2%) as compared to control (3.6 %).

Table 10. Demonstration of *T. chilonis* (temperature-tolerant strain) against *C. infuscatellus*

Treatments	Incidence of *C. infuscatellus* (%)	Per cent reduction over control	Yield (kg/ha)	Cost:Benefit ratio
T. chilonis (TTS)	6.8[a]	56.4	71,700[a]	1:19.2
Padan @25kg/ha	6.5[a]	58.3	72,600[a]	1:7.5
Control	15.6[b]	-	65,300[b]	

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

Table 11. Demonstration of *T. japonicum* (temperature-tolerant strain) against *S. excerptalis*

Treatments	Incidence of *S. excerptalis* (%)	Parasitism (%)	Yield (kg/ha)	Cost:Benefit ratio
T. japonicum (temperature tolerant strain) 50,000/ha	6.7[a]	34.3[a]	72,420[a]	1:20.6
Chemical control (Thimet 10G @ 30 kg/ha)	6.3[a]	2.7[b]	73,170[a]	1:6.5
Control	14.8[b]	3.1[b]	65,540[b]	

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

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 0.67 to 7.5 per cent whereas in control it ranged from 1.43 to 23.5%. The reduction in cane damage over control in these three mills ranged from 46.3 to 68.1 per cent.

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, *Scirpophaga excerptalis* was carried out at Gohawar and Paddi Khalsa (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. *T. japonicum* reduced the incidence of top borer and enhanced the cane yield, however it was on par with chemical control. The per cent parasitism in the released plot was 34.3% with a higher cost:benefit ratio of 1:20.6 (Table 11).

Large scale demonstration of effectiveness of *T. japonicum* against top borer, *Scirpophaga excerptalis* over an area of 1000 acres was carried out in collaboration with two sugar mills of the state i.e. Doaba Co- operative Sugar Mills Ltd. Nawanshahar and Morinda Co- operative Sugar Mills Ltd. Morinda. The egg parasitoid, *T. japonicum* was released from mid - April to end – June, at 10 days interval @ 50,000 per ha. The incidence of *Scirpophaga excerptalis* at Nawanshahar and Morinda in release fields was 1.6 and 0.6 per cent respectively. The reduction in damage by top borer over control in these two mills was 54.2 per cent.

Evaluation of heat tolerant strain of *T. chilonis*: SBI

The parasitization efficacy and per cent adult emergence of heat tolerant strain (HT) of *T. chilonis* were assessed in the laboratory and pot culture against the factitious host *Corcyra cephalonica* and native host sugarcane shoot borer (SB), *Chilo infuscatellus* and sugarcane internode borer (INB), *Chilo sacchariphagus indicus*. When tested under ambient temperature in the laboratory the parasitism and adult emergence of the HT strain and normal strain were not significantly different while at 40°c HT strain had significantly higher parasitism and adult emergence rates on all hosts tested (Fig 43). Similarly in pot

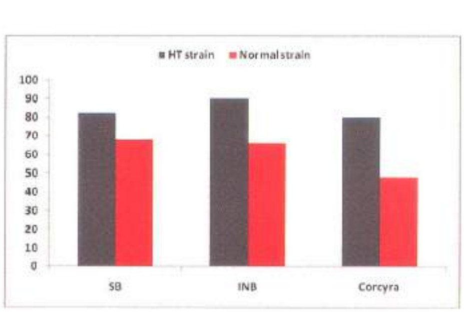


Fig. 43. Efficacy of heat-tolerant strain of *T. chilonis* against sugarcane borers at 40°C

culture, the host searching efficiency of the HT strain was proven through higher parasitism on the trap cards on 60 day old sugarcane plants.

Efficacy of the GV isolates of *Chilo infuscutellus* in pot culture: SBI

The semi purified virus was sprayed on 30 days old sugarcane plants. The first instar larvae of shoot borer were released on virus-sprayed plants and were exposed to sunlight for 7 days. The persistence of semi purified suspension of Coimbatore and Karnal isolate of the GV was the highest while that of Assam isolate was the lowest (fig. 44).

Fortnightly collection of shoot borer larvae from the control plot revealed the lowest recovery of GV in April (14.3 %) and the highest in October, 2010 (33.2%).

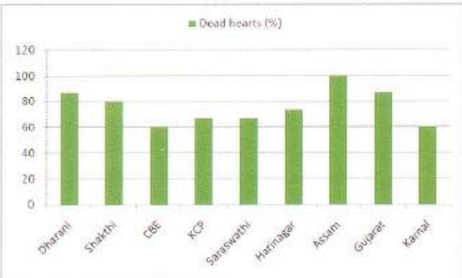


Fig. 44. Efficacy of different GV isolates against sugarcane shoot borer

Mass production of GV of sugarcane shoot borer: SBI

Of the all instars tested to improve virus harvest while being reared on diet, late third instar with lower inoculums or fourth instar with higher inoculums produced good results with and high per cent of virosed larvae (> 85 %). Hence, it is absolutely necessary to rear the shoot borer larvae in two steps i.e., the larvae are to be reared up to III[rd]/IV[th] instar in a set of diet and after inoculation with virus can be transferred to another set of diet for further rearing. The standardization of mass rearing of shoot borer for virus production resulted in a recovery of 37.5% of IV instar larvae in group rearing while single vial rearing of larvae resulted in a recovery of 75-80% in different batches.

Efficacy of the combined application of EPF against shoot borer: SBI

Mortality of III[rd] instar shoot borer larvae was the lowest with *B. bassiana* application followed by *B. brongniartii* and the highest when it preceded the application of either *B. brongniartii* or *M. anisopliae* at 24 hr intervals. Except the combination wherein *B. bassiana* followed the application of *B. brongniartii*, all other combinations tested gave equal or better larval mortality rates. However severe competition was observed in sporulation. Whenever *B. bassiana* was applied with *M. anisopliae* either before or after the latter, sporulation was the most affected. Regardless of sequence of application, *B. brongniartii* also affected the sporulation of *B. bassiana* but to a lesser degree.

The combination of *B. brongniartii* with *B. bassiana* preceding the former' application resulted in maximum larval mortality rates. However, when the *B. bassiana* application followed *B. brongniartii*, the larval mortality was reduced but still better than *B. brongniartii* used alone. All combinations of fungi with *B. brongniartii* regardless of sequence improved the mortality rates than the individual fungus. However, spore harvest per larva was highest only when *B. brongniartii* was used alone. There was no sporulation of *B. brongniartii* when used with *M. anisopliae* either before or after. The virulence of *M. anisopliae* was neither reduced not improved by either the presence of another fungus or its sequence of application. The mortality rates of shoot borer larvae were statistically similar. Similarly, the spore harvest per larva was also not affected seriously by the other fungi except in the combination of *M. anisopliae* application preceded by *B. bassiana* application.

In a pot culture experiment, the results revealed that application of *B. bassiana* and *M. anisopliae* singly or in combination were able to reduce dead hearts significantly.

Efficacy of combined application of EPF with granulosis virus against shoot borer: SBI

In the laboratory and in pot culture experiments were laid out for assessment of efficacy of combined application of the three EPF and granulosis virus against third instar of shoot borer. The virus predominated over the EPF irrespective of the species of EPF involved or the sequence of application. No cadaver was covered with fungus mycelium or spores. The same set of experiments was laid on pot culture to assess the "dead hearts" in various treatments. In all combination treatments there were significant reduction of dead hearts compared to treatments with single agent. Similarly the sequence of application did not an impact on the efficacy.

5.2.4. Biological suppression of cotton pests

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

AAU-Anand

Surveys in cotton fields revealed that the parasitism on cotton mealybug by *Aenasius bambawalei* ranged from 15.66 to 21.15 % with an average of 17.63 %. Initially 16.8 % parasitism was found during the crop season which increased in subsequent weeks and attained a maximum of 26.7 % during the first week of October 2010. The highest parasitism by *A. bambawalei* was recorded at Khandha (21.2 %) and the lowest at Bhilapur (15.7%). *Aenasius bambawalei*, a promising parasitoid of the cotton mealybug was mass multiplied successfully on *Phenococcus solenopsis* raised on sprouted potatoes.

Monitoring the biodiversity and outbreaks of invasive mealy bugs and their natural enemies on field / horticultural / medicinal and aromatic crops

MPKV

Cotton (early and late sown), sugarcane, pigeon pea, soybean, sunflower, ornamentals- rose, marigold, hibiscus, hollyhock, acalifa, aboli, different weeds including parthenium were found to be attacked with mealybug species viz., *Phenacoccus solenopsis, Saccharicoccus sacchari, Planococcus* sp. and *Paracoccus marginatus*. In cotton, *P. solenopsis* was noticed in October, 2010 and again appeared in January-February, 2011 with high intensity (9.5 mealy bugs/5 cm shoot) in March, 2011. It was also observed on parthenium in these periods. The pest was invaded by the parasitization of *Aenaesius bambawalei* as well as coccinellids, chrysopids and brumoids. The mealybug *Saccharicoccus sacchari* was very serious during February-March, 2011 in Pune (Indapur, Baramati areas) region. *Ceccidohystrix insolita* Green was observed on perennial cultivar of pigeonpea maintained at research farm of Botany as well as Entomology Division, College of Agriculture, Pune. Grape vine, guava, custard apple, sapota, papaya and pomegranate were attacked by *Maconellicoccus hirsutus, Ferrisia virgata, Planococcus* sp. and *Paracoccus marginatus*. The papaya mealybug (PMB) was very serious and distributed in 6 districts of western Maharashtra. It was found to be parasitisized by indigenous species of parasitoid, *Acerophagus papayae* in the state. Besides, *Subabul* was found attacked by unidentified species of mealybug.

5.2.5. Biological suppression of tobacco pests: CTRI

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 of different EC and 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 (32.13%). Highest larval mortality of *S. litura* was recorded when *B.t.k.* was applied in suspension at EC 2.0 dSm (24.8%) (Table 12).

Table 12. Effect of water EC on the efficacy of *B. thuringensis* on *Spodoptera litura* larvae

EC	Seedlings damage (7 DAT) (%)	Larval mortality (%)
E.C. 0.5 dSm	16.72[a]	21.36[a]
E.C. 1.0 dSm	15.17[a]	20.75[a]
E.C. 2.0 dSm	14.89[a]	24.80[a]
E.C. 4.0 dSm	16.01[a]	24.53[a]
E.C. 6.0 dSm	16.26[a]	22.97[a]
DW	17.07[a]	20.50[a]
Control	32.13[b]	8.55[b]

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

Seven days after spraying, there was significantly lowest seedling damage (12.64%) caused by *S. litura* and highest larval mortality of *S. litura* (29.97%) at pH 7. However control recorded the highest seedling damage (27.01%) and lowest larval mortality (13.44%) (Table 13).

Table 13. Effect of water pH on the efficacy of *B. thuringensis* on *Spodoptera litura* larvae

pH	Seedlings damage (7 DAT) (%)	Larval mortality (%)
pH 5	17.43[c]	19.52[bc]
pH 6	15.42[b]	25.04[d]
pH 7	12.64[a]	29.97[de]
pH 8	15.65[b]	26.78[de]
pH 9	18.71[bc]	16.34[b]
Distilled Water	13.12[ab]	27.68[de]
Control	27.01[d]	13.44[a]

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

Studies n the influence of water quality on the efficacy of *Beauveria bassiana* against *Spodoptera litura*

Beauveria bassiana@ 10^8 spores/ml was applied to tobacco nursery with water with different EC and pH. Seven days after spraying, there was significantly lowest seedling damage (18.37%) caused by *S. litura* at EC 0.05 dSm and highest larval mortality of *S. litura* (24.53%) at EC 1.0 dSm. However control recorded the highest seedling damage (34.42%), whereas lowest larval mortality was recorded at EC 6.0 dSm (7.14%) (Table 14).

Table 14. Effect of water EC on the efficacy of *B. bassiana* on *Spodoptera litura* larvae

EC	Seedling damage (7 DAT) (%)	Larval mortality (%)
E.C. 0.5 dSm	18.37[a]	22.20[d]
E.C. 1.0 dSm	21.93[ab]	24.53[d]
E.C. 2.0 dSm	22.99[b]	18.07[c]
E.C. 4.0 dSm	24.80[bc]	10.85[ab]
E.C. 6.0 dSm	27.92[c]	7.14[a]
DW	18.37[a]	23.79[d]
Control	34.42[d]	11.66[b]

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

Seven days after spraying *B. bassiana*, there was significantly lowest seedling damage (15.31%) caused by *S. litura* and highest larval mortality of *S. litura* (18.71%) at pH 7. However control recorded the highest seedling damage (33.97%) and lowest larval mortality (7.33%) (Table 15).

Table 15. Effect of water pH on the efficacy of *B. bassiana* on *Spodoptera litura* larvae

pH	Seedlings damage (7 DAT) (%)	Larval mortality (%)
pH 5	22.43[c]	13.15[bc]
pH 6	18.17[ab]	16.57[cd]
pH 7	15.31[a]	18.71[d]
pH 8	18.88[b]	15.65[cd]
pH 9	25.07[c]	9.54[ab]
Distilled Water	16.72[ab]	19.24[d]
Control (No spray)	33.97[d]	7.33[a]

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

Field evaluation of different isolates of HaNPV against *Helicoverpa armigera*

The HaNPV isolates obtained from AAU (Anand), NBAII (Bangalore), PCI (Bangalore), CTRI (Rajahmundry) and Jeelugumilli were evaluated @ 1.5 x10^{12} PIB/h. Five second instar larvae of *H. armigera* were released on the sprayed leaf terminals of five tagged tobacco plants and observations were recorded seven days after treatment with different isolates.

The results revealed that NBAII isolate of HaNPV caused significantly highest larval mortality (69.18%) and lowest leaf damage (6.30 %) as compared to other isolates (Table 16).

Table 16. Comparative efficacy of HaNPV isolates against *Helicoverpa armigera* on tobacco

HaNPV isolates	Larval mortality (7 DAT) (%)	Leaf damage (7 DAT) (%)
Jeelugumilli	38.25^{b}	11.49^{b}
PCI (Bangalore),	54.93^{cd}	8.16^{a}
AAU (Anand)	44.08^{bc}	11.59^{b}
NBAII (Bangalore)	69.18^{e}	6.30^{a}
CTRI (Rajahmundry)	57.80^{de}	6.09^{a}
Control	11.21^{a}	21.89^{c}

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

5.2.6. Biological suppression of rice pests

AAU-Anand

In a field survey at Anand, three predatory spiders *Neoscona theisi*, *Argiope sp.* and *Pholcus* sp. were found be dominant in rice fields.

Survey for the identification of potential natural enemies of the gundhi bug of rice

TNAU

The eggs of gundhi bug were parasitized by *Ooencyrtus* sp. (Encyrtidae: Hymenoptera) and *Gryon* sp. (Scelionidae: Hymenoptera) and predated by *Conocephalus longipennis* (Acrididae: Orthoptera) and *Micraspis discolor* (Coccinellidae: Coleoptera).

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

AAU-Jorhat

Large scale validation of BIPM package was carried out on rice (var. Ranjit) in an area of 200 ha in two villages (Pirakota and Hahsora). The IPM package included (a) seedling root dip in 2% *P. fluorescens* (b) two sprays of *B. Bassiana* @ 10^{13}spore/ha 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) need based application of botanicals (Pestoneem@ 3 ml/lit) against sucking pests (f) spraying of *P. fluorescens* @ 2 kg/ha and (g) auto confusion pheromone placement. The farmers' practice included 5 time spray of monocrotophos or triazophos or bufrofezin or spinosad or chloropyriphos or chloropyriphos+ and also fungicide sprays.

The results revealed that 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 (3,280 kg/ha) than the farmers practice (2,935 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 17).

Table 17. Demonstration of IPM in farmers' rice fields in Assam

Parameters	IPM package	Farmers' practice
GLH /hill	3.1	7.3
Dead heart @60 DAT (%)	4.1	8.2
White ear @60 DAT (%)	4.4	8.5
Leaf folder damage (%)	3.8	7.9
Grain yield (kg/ha)	3,280	2,935
Net returns over farmers practice (₹/ha)	1,754	

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

OUAT

Large scale validation of BIPM package was conducted at five villages (Beraboi, Mendhasala, Bhingarapur, Bentapur and Deulakur) on rice (var. Lalat) during 2010. 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. 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. The beneficial fauna like spiders and lady bird beetles were significantly higher in IPM package. The IPM package recorded significantly higher grain yield (4,251 kg/h) and the net returns over farmers practice was ₹ 16,140 (Fig. 45 & Table 18).

Fig. 45. The IPM rice plot (OUAT, Orissa)

Table 18. Demonstration of IPM in farmers' rice fields (OUAT, Orissa)

Parameters	IPM package	Farmers' practice
GLH /hill	3.9	10.9
Dead heart (%)	5.1	11.1
White ear (%)	7.2	15.9
Leaf folder damage (%)	5.4	9.8
Caseworm incidence (%)	2.5	3.8
Skipper incidence (%)	2.9	6.3
Spider /hill	4.7	1.6
Lady bird beetle /hill	2.2	0.9
Grain yield (kg/ha)	4,251	3,201
Net returns over farmers practice (₹/ha)	16,140	

KAU

The large scale adoption of BIPM technologies was carried out on rice (var. Jyothi and Uma) in an area of 700 hectares in different panchayats in Thrissur district. 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 7,595 kg/ha in BIPM plot and 7,430 kg/ha in farmers practice plot indicating that there is no significant difference between them (Fig. 46).

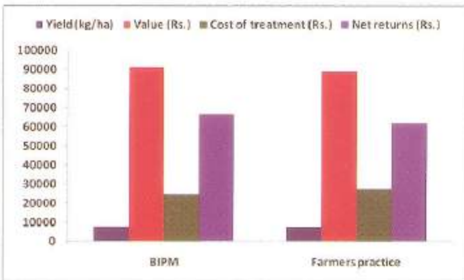


Fig. 46. Impact of IPM on rice pests and diseases (Kerala)

PAU

Large scale demonstration of biocontrol was conducted in Basmati rice at two locations in village Chaharke of Bhoghpur block in district Jalandhar on variety *Basmati* – 1121 over an area of 20 ha each. In biocontrol plots, six 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.

Table 19. Effect of IPM package on pests of basmati rice

Parameters	2010-11 data		2009-10 and 2010-11 (Pooled)	
	IPM package	Farmers practice	IPM package	Farmers practice
Dead hearts (%)	1.9	1.2	1.3	0.8
Leaf folder (%)	4.1	2.2	2.4	1.3
White ears (%)	4.9	2.9	3.8	4.6
Grain yield (kg/ha)	4,150	4,320	4,400	4,510
Value of yield/ha (₹)	83,000	86,400	88,000	90,200
Net return (₹/ha)	70,135	71,255	75,135	75,055

Ther IPM package was as effective as the farmers practice in basmati rice. It can be concluded that IPM (6 releases of *T. chilonis* and *T. japonicum* each @ 1,00,000/ha) proved as effective as chemical control for the management of leaf folder and stem borer of *Basmati* rice (Table 19).

AAU-Anand

Field demonstration was conducted on rice variety Gurjari. The IPM package included (a) Use of resistant cultivar of paddy (Gurjari), (b) Transplanting of paddy seedlings during first fortnight of July; (c) Installation of pheromone traps for yellow stem borer @ 40 traps /ha for mass trapping the male moths; (d) Installation of bird perches @ 50/ha; (e) Collection and destruction of egg masses of stem borer; (f) Release of *Trichogramma* wasps @ 1.0 lakh/ ha/ week starting at appearance of egg mass; (g) Application of neem-based granular insecticide (Vakil 5 G) two times (30 and 45 DAT); and (h) Need base-application of NSKE @ 5 % or any commercial Azadirachtin-based formulation @ 0.0005%. The farmers' practice included spraying of monocrotophos and endosulfan. The control included variety-GR-11.

The results indicated that IPM module and farmer's practices registered significantly less incidence of leaf folder, skipper and plant hopper over the control. Significantly higher (1.1 spiders /hill) population of predatory spider was recorded in IPM module in comparison to rest of the two other modules evaluated. Higher grain (4200 kg/ha) as well as fodder (5960 kg/ha) yields were recorded from the IPM block over Farmers' practice and untreated control (Table 20).

Table 20. Demonstration of IPM in rice field (AAU, Anand)

Parameters	IPM	Farmer's practices	Control
Leaf folder damage (%)	0.5^{a}	1.9^{b}	8.9^{c}
Paddy skipper damage (%)	0.03^{a}	0.04^{a}	0.08^{b}
Plant hoppers / hill	0.6^{a}	0.9^{a}	1.9^{b}
Spiders / hill	1.1^{a}	0.8^{b}	0.7^{c}
Grain yield (kg / ha)	$4,200^{a}$	$3,456^{b}$	$2,835^{c}$
Fodder yield (kg/ha)	$5,960^{a}$	$4,575^{b}$	$4,272^{b}$

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

Evaluation of microbial bio-pesticides against rice leaf folder and WBPH: AAU-Anand

Bacillus thuringiensis, *Beauveria bassiana*, *Verticillium lecanii* and *Nomurea rileyi* were evaluated against rice leaf folder and white backed plant hopper (WBPH) along with cartap hydrochloride as check in rice variety GR-11. The results revealed that significantly lower incidence of rice leaf folder and white-backed plant hopper population was recorded 10 days after the spray in all the bio-pesticide-reated plots compared to the control (Table 21). The bio-pesticide spray also reduced the population of spiders. All the treated plots recorded significantly higher grain yield (3,100 to 3,600 kg/ha) over untreated check (2,000 kg/ha).

Table 21. Efficacy of microbial insecticides against rice leaf folder and white backed plant hopper

Treatments	Leaf folder damage @10 DAS (%)	WBPH number/ hill @10 DAS	Spider number/ hill @10 DAS	Grain yield (kg/h)
B. thuringiensis (5 X 10^{7} spores/mg) @ 1.0 kg/ha	1.0^{b}	0.4^{d}	0.9^{c}	$3,400^{a}$
B. bassiana (2 X 10^{8} cfu/gm) @ 1.0 kg/ha	0.7^{b}	0.4^{bc}	0.9^{c}	$3,100^{a}$
V. lecanii (2 X 10^{8} cfu/gm) @ 1.0 kg/ha	1.0^{b}	0.5^{cd}	0.9^{c}	$3,500^{a}$
N. rileyi (2 X 10^{8} cfu/gm) @ 1.0 kg/ha	0.9^{b}	0.4^{bc}	1.0^{b}	$3,500^{a}$
Cartap hydrochloride @ 0.05 %	0.7^{b}	0.5^{b}	1.0^{b}	$3,800^{a}$
Untreated control (Check)	5.0^{a}	1.4^{a}	1.9^{a}	$2,000^{b}$

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

Evaluation of EPN against rice pests in net house

AAU-Jorhat

A pot culture experiment was conducted on rice (var. Ranjit) in the green house at Department of Entomology, AAU, Jorhat to evaluate the bio-efficacy of EPN against yellow stem borer, *Scircophaga incertulus* and rice leaf folder, *Cnaphalocrosis medinalis*. The treatments were *Steinernema riobrave*, aqueous (250 ml/pot) and wettble powder (100 g/pot) formulation, *Steinernema feltiae*, aqueous and wettable powder formulation and Chloropyriphos 20 EC@ 2 ml/l.

The results revealed that *S. feltiae* when applied in aqueous form recorded 50.2 per cent mortality of yellow stem borer and 42.9 per cent mortality of leaf folder but was inferior to chemical treatment (Table 22).

Table 22. Efficacy of EPN against yellow stem borer and leaf folder on rice

Treatments	Per cent mortality (10 DAT)	
	Yellow stem borer	Leaf folder
S. riobrave (AF)	46.43[c]	34.40[cd]
S. feltiae (AF)	50.20[b]	42.98[b]
S. riobrave (WP)	31.56[e]	31.92[d]
S. feltiae (WP)	36.48[d]	37.42[c]
Chloropyriphos 20 EC	90.00[a]	65.46[a]

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

OUAT

A pot culture experiment was conducted on rice to evaluate the bio-efficacy of EPN against yellow stem borer, *Scircophaga incertulus* and rice leaf folder, *Cnaphalocrosis medinalis*. The treatments were *Steinernema riobrave*, aqueous and wettble powder formulation, *Steinernema feltiae*, aqueous formulations, *S. feltiae*, wettable powder formulation and Chloropyriphos 20 EC @ 2 ml/l. All the EPN formulations were applied @ 8 lakh IJ/pot.

The results revealed that *S. riobrave* when applied in aqueous form recorded significantly less dead hearts (8.8%) and leaf folder damage (4.5%) and was superior to control and on par with chemical treatment (Table 23).

Table 23. Efficacy of EPN against yellow stem borer and leaf folder on rice.

Treatments (EPN @ 8 lakh IJ/pot)	Dead hearts(%)	Leaf folder damage (%)
S. riobrave (AF)	8.8[a]	4.5[a]
S. feltiae (AF)	11.7[ab]	5.9[b]
S. riobrave (WP)	14.1[b]	8.9[bc]
S. feltiae (WP)	17.3[c]	9.9[bc]
Carbofuran granule @ 33kg/ha	7.5[a]	4.5[a]
Control	17.8[d]	16.3[d]

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

PAU

A net house experiment was conducted to evaluate the efficacy of sponge formulation of *Steinernema abbasi*, *Heterorhabditis indica* against the stem borer and leaf folder of rice (var. Pusa Basmati 1121) and compared with chlorpyriphos 20 EC (@ 10 ml/l) and control. The results indicated that the sponge formulation of *H. indica* recorded higher mortality of stem borer and leaf folder, but was inferior to chemical control (Table 24).

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

Treatments	% Mortality	
	stem borer	leaf folder
Steinernema abbasi	35.1[c]	26.9[c]
Heterorhabditis indica	39.5[b]	34.8[b]
Chlorpyriphos 20 EC	100.0[a]	100.0[a]
Control	0.0[c]	0.0[d]

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

KAU

A pot experiment was conducted on rice to evaluate efficacy of three species of EPN against yellow stem borer and leaf folder. The results revealed that EPN failed to reduce either the incidence of yellow stem borer or leaf folder and was on par with control whereas the chemical treatment could significantly reduce the dame by yellow stem borer and leaf folder at Thrissur.

CAU, Imphal

A pot culture experiment was conducted on rice in Pasighat to evaluate the bio-efficacy of local strains EPN against stripe borer, *Chilo suppressalis* and rice leaf folder, *Cnaphalocrosis medinalis*. The treatments were *Steinernema* sp. (Runne), *Steinernema* sp. (Sille), *Steinernema* sp. (2-1), *Steinernema* sp . (2-4) and *Steinernema* sp. (4-2) (all applied @ 8 lakh/pot) and profenophos @0.05%. The results revealed that *Steinernema* sp. (Runne) recorded significantly highest mortality of *C. suppressalis* and *C. medinalis* compared to other EPN, however chemical application was superior to all EPN (Table 25).

Table. 25. Efficacy of EPN against stripe borer and leaf folder on rice.

Treatments	% Mortality	
	C. suppressalis	*C. medinalis*
Steinernema sp. (Runne)	55.8^b	60.0^b
Steinernema sp. (Sille)	45.0^c	56.0^b
Steinernema sp. (2-1)	43.1^c	54.0^b
Steinernema sp. (2-4)	41.4^c	44.0^b
Steinernema sp. (4-2)	41.3^c	42.0^c
Profenophos 0.05%	73.9^a	88.0a

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

5.2.7. Biological suppression of pulse crop pests

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

The influence of crop habitat diversity on 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 (Fig. 47).

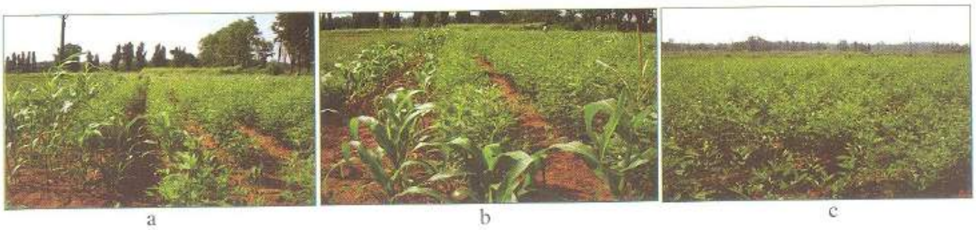
ANGRAU

Pigeonpea intercropped with sunflower and border crop of sorghum recorded the least population of *H. armigera* larvae (3.6/10 plants) compared to pigeonpea intercropped with sunflower and border crop of maize (6.4/10 plants). The population of leaf hoppers and aphids was lower and population of predatory stink bug and coccinellids was higher in pigeonpea intercropped with sunflower with border crop of maize. Yield was also higher in the pigeonpea intercropped with sunflower with border crop of sorghum (1247 kg/h) than the other two modules (Table 26).

Table 26. Effect of crop habitat diversity on pests of pigeonpea

Parameters	P+S+So	P+S+M	P
H. armigera Larvae/10 plants	3.6^a	6.4^a	20.1^b
Leaf hoppers/10 plants	42.3	42.9	58.9
Aphids/10 plants	168.1	106.4	297.8
Predatory stink bugs/10 plants	61.5	72.5	68.2
Predatory coccinellids/10 plants	24.8	27.7	22.2
Spiders/10 plants	9.9^a	3.7^b	4.8^b
Pigeonpea Yield (kg/h)	1247^a	1157^a	667^b
Sunflower yield (kg/h)	775	975	
Sorghum yield (kg/h)	2175	-	-
Maize yield (kg/ha)	-	6325	-

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



a b c

Fig. 47. Pigeonpea intercropped with sunflower with sorghum (a) maize (b) as border crop and sole crop of pigeonpea (c)

AAU-Anand

Pigeonpea intercropped with sunflower (9:1) and border crop of maize recorded reduced pod damage by *H. armigera* at harvest compared to sole crop. Significantly higher number of Coccinellid and grain yield was recorded on pigeonpea plots intercropped with sunflower and border crop of maize over the treatment of pigeonpea grown as sole crop (Table 27).

Table 27. Influence of crop habitat diversity on incidence of *H. armigera* and natural enemies on pigeonpea at Anand

Parameters	P+S+M	P+S+So	P
H. armigera larvae / 5 twigs	0.9^{c}	1.0^{b}	1.3^{a}
Pod damage (%)	6.4^{b}	7.5^{b}	12.9^{a}
Chrysoperla /plant	0.3^{a}	0.3^{a}	0.3^{a}
Coccinellids/plant	0.7^{b}	0.5^{a}	0.4^{a}
Grain Yield (kg/ha)	1204^{a}	1123^{ab}	1012^{b}

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

Evauation of HaNPV against *Helicoverpa armigera* on pigeonpea: AAU-Anand

An experiment was conducted to evaluate the impact of bio-suppression of *H. armigera* on the incidence of *Grapholitica.ertica* and *Maruca testulatis* on pigeonpea. 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 lower population (0.4) of *H. armigera* in pigeonpea compared to control plot (1.9). However, this treatment failed to suppress the damage due to *G. ertica* and *M. testulatis*. Significantly higher (1,140 kg/h) grain yield was recorded in the treatment of HaNPV spray + hand picking of *H. armigera* larvae over untreated check (630 kg/h) (Table 28).

Table 28. Impact of HaNPV on pod borer complex of pigeonpea in Anand

Observations	NPV	Endosulfan (350 g a.i./ha)	Control
H. armigera larvae/ 5 plants	0.4^{a}	0.3^{a}	1.9^{b}
G. ertica larvae/5 plants	0.9^{b}	0.8^{a}	1.9^{b}
M. testulatis larvae/ 5 plants	1.1^{bc}	0.8^{a}	1.6^{c}
Pod damage by the borer complex (%)	11.4^{a}	10.9^{a}	16.3^{b}
Grain yield (kg/ha)	$1,140^{a}$	$1,330^{a}$	630^{b}

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

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, DOR Bt @ 1.5 kg/ha and 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 29).

Table 29. Impact of entomopathogens on the pod borer complex of pigeonpea

Treatments	Grain damage (%) due to		Grain yield (kg/ha)
	H. armigera	*E. atomosa*	
B. bassiana DOR SC @250 mg/l	6.5[d]	1.9[c]	943.5[d]
B. bassiana DOR SC @ 300 mg/l	4.1[c]	1.6[c]	1,117.4[c]
B. bassiana WP@1 kg/ha	2.9[b]	1.3[bc]	1,516.9[b]
B. bassiana WP @ 1.5 kg/ha	2.6[b]	0.8[b]	1,436.6[b]
Bt @ 1.5 kg/ha	3.6[c]	1.3[bc]	1,177.9[c]
Spinosad 45% SC W/W 73 g a.i./ha	0.0[a]	0.0[a]	2,731.7[a]
Control	7.6[e]	3.2[d]	743.3[d]

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

Field demonstration of BIPM practices against pests of chickpea : AAU-Anand

A field demonstration was conducted to evaluate the BIPM practices against the farmers' practice against pests of chickpea (var. GG-2). The BIPM package consisted of (a) Seed treatment with *Trichoderma viride* @ 8 g /kg seed at the time of sowing against wilt disease, (b) Use of FYM @ 10 ton/ha enriched with *T. viride* for wilt disease, (c) Installation of pheromone traps @ 40 traps/ha at 15 days after sowing for trapping *H. armigera* moths, (d) Alternate spraying of HaNPV @ 250 LE /ha and Neem Seed Kernel Extract (NSKE) @ 5 % or neem-based commercial insecticide (30 ml/10 lit. water) during vegetative stage, at flowering stage and at pod formation stage for the suppression of *H. armigera*. The farmers' practice included spraying of endosulfan 35 EC (0.07 %) or chlorpyriphos 20 EC (0.04 %) or quinalphos 25 EC (0.05 %) or methyl parathion 2% or fenvalerate 0.4 % dust (20-25 kg/ha along with control.

The results revealed that the BIPM package recorded significantly lower population of *H. armigera*, pod damage, low incidence of wilt disease and higher grain yield as compared to farmers practice and control (Table 30).

Table 30. Impact of BIPM module against *H. armigera* and wilt disease in Chickpea

Treatments	Larva / plant	Pod damage (%)	Wilt (%)	Grain yield (kg/ha)
BIPM	0.1[c]	1.9[c]	5.4[c]	836[a]
Chemical	0.2[b]	2.6[b]	6.9[b]	762[b]
Control	0.5[a]	5.4[a]	12.0[a]	562[c]

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

Evaluation of EPN against defoliators of soybean

DSR, Indore

A field experiment was conducted to evaluate the efficacy of EPN in the control of soybean defoliators (*S. litura* and semiloopers, *Chrysodeixis acuta* and *Diachrysia orichalcea)* during Kharif 2010-11 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, Bt (DiPel 8 L) 1.0 l/ha, Quinalphos 25 EC 1.5 l/ha and control.

The results revealed that lowest larval population of *S. litura* (3.17) was recorded in *H. indica* aqueous formulation whereas lowest semilooper (2.5) was recorded in *S. carpocapsae* talc-based formulation. However all EPN formulations were inferior to chemical control (Table 31). As the soybean crop in this region suffered from disease complex due to continuous cloudy weather, the yield levels were too low, and the treatment effect on yield could not be established.

Table 31. Efficacy of EPN against soybean defoliators

Treatments	Larvae/meter row (10 DAT)	
	S. litura	Semilooper
H. indica @ 2b Ijs/ha (talc-based)	3.6^{cd}	2.6^{ab}
S. carpocapsae @ *2b* Ijs/ha (talc-based)	3.5^{bcd}	2.5^{ab}
H. indica @ 2b Ijs/ha (aqueous)	3.8^{cd}	2.7^{ab}
S. carpocapsae @ *2b* Ijs/ha (aqueous)	3.2^{bc}	2.8^{b}
Bt (DiPel 8 L) 1.0 l/ha	2.8^{b}	2.4^{ab}
Quinalphos 25 EC 1.5 l/ha	1.8^{a}	1.9^{a}
Control	8.6^{e}	10.8^{c}

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

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 @ 100g or ml/m^2, SINPV @ 1.5 x 10^{12} POB/ha, Spinosad 45%SC and control.

The results revealed that lowest larval population of *C. acuta* (1.5), *S. litura* (4.7) and highest grain yield (980.9 kg/ha) was recorded in *H. indica* aqueous formulation @ 100ml/m^2 and it was better than spinosad application (Table 32).

Evaluation of entomopathogens against soybean defoliators: JNKVV

A field experiment was carried out in Kharif 2010-11 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* (2.3), *S. litura* (4.0) and highest grain yield (1,181 kg/ha). Sprays of *B. bassiana* was the next best treatment (Table 33).

Table 32. 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 @ 100g/m^2 (talc-based)	1.8^{b}	5.3^{ab}	43.3	923.8^{b}
S. carpocapsae @ 100g/m^2 (talc-based)	2.0^{b}	5.8^{bc}	42.3	783.3^{c}
H. indica @ 100ml/m^2 (aqueous)	1.5^{a}	4.7^{a}	43.0	980.9^{a}
S. carpocapsae @ 100ml/m^2 (aqueous)	2.9^{d}	6.4^{cd}	40.0	709.5^{c}
SINPV @ 1.5 x 10^{12} POB/ha	2.8^{d}	6.5^{de}	39.7	728.6^{cd}
Spinosad 45% SC @ 73 g a.i./ha	2.3^{bc}	6.1^{cd}	42.3	772.6^{bcd}
Control	4.1^{e}	7.4^{e}	45.0	654.8^{d}

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

Table 33. 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	2.7^{b}	4.4^{a}	40.3	956.4^{b}
M. anisopliae @ 10^{13} spores/ha	3.0^{b}	5.1^{b}	44.3	911.2^{c}
V. lecanii @ 10^{13} spores/ha	3.2^{bc}	5.7^{b}	43.0	746.9^{b}
B.t.k. @ 10^{13} spores/ha	2.3^{a}	4.0^{a}	43.0	1181.9^{c}
Dipel	3.2^{bc}	5.7^{b}	45.0	761.9^{b}
Spinosad 45% SC @ 73 g a.i./ha	3.3^{bc}	5.8^{b}	44.0	756.2^{b}
Control	4.6^{c}	6.7^{c}	44.7	679.8^{a}

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

5.2.8. Biological suppression of oilseed crop pests

Laboratory evaluation of trichogramma against castor capsule borer: ANGRAU

Eggs of castor capsule borer were parasitized by *Trichogramma chilonis* (22.9%), *T. japonicum* (13.1%), *Trichogrammatoidea bactrae* (17.3%) and *T. achaeae* (12.6%).

Biological control of groundnut leaf miner: TNAU

A field trial was conducted in farmers' field at Aliyarnagar on variety TMV 7. The treatments included four release of *T. chilonis* @ 1,00,000/ha at 10 days interval, Bt @ 1 kg/ha at 60 and 75 DAS, NSKE 5 % at 60 and 75 DAS, a chemical check (Endosulfan 250 g a.i./ha at 60 and 75 DAS) and an untreated control.

The results showed that among biocontrol agents, *Bt* @ 1 kg/ha was the most effective followed by two sprays of NSKE 5% spray and four releases of *Trichogramma chilonis* @ 100,000/ha at 10 days interval were effective against the groundnut leaf miner *Aproaerema modicella* by reducing the larval population and per cent damage. However, endosulfan was significantly superior to *T. chilonis* and NSKE 5% treated plots (fig. 48).

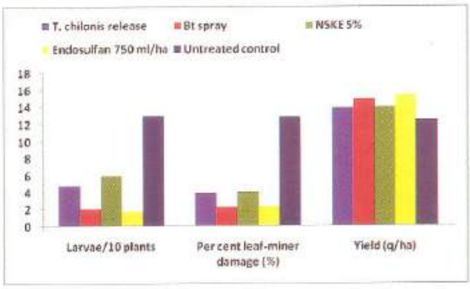


Fig. 48 : Efficacy of *T. chilonis*, Bt and NSKE against groundnut leaf-miner.

5.2.9. Biological suppression of coconut pests

Large area demonstration of integrated biocontrol technology against *Oryctes rhinoceros*: CPCRI

Farmer-participatory large scale field validation for management of *O. rhinoceros* by integrating biocontrol agents (*Metarhizium anisopliae* and *Oryctes rhinoceros* virus) and pheromone trapping was initiated in two wards of Devikulangara Panchayat, Alappuzha District comprising an approximate area of 100 ha. Pre treatment incidence of rhinoceros beetle was 81% with 14% palms showing spindle damage. Average leaf damage was 21.7%. *M. anisopliae* packets (100 numbers containing 100 g of sporulated fungus in rice media) were supplied to farmers for applying in breeding sites. Pheromone traps (PVC traps) set up with PCI pheromone lure recorded an average collection of 5.8 beetle /trap/month.

Laboratory screening of EPN against red palm weevil grub and other white grubs: CPCRI

Four species of entomopathogenic nematodes (EPN) *viz*., *Steinernema abbasi*, *S. carpocapsae*, *Heterorhabditis bacteriophora* and *H. indica* were evaluated against red palm weevil grub in soil column bioassay. The results indicated the LC_{50} of *H. bacteriophora* was found to be higher (613.5 IJ) than that of *H. indica* (355.5 IJ) for the same exposure time of 96 h indicating higher toxicity of *H. indica* against grubs of red palm weevil. The data on LC_{90} also evinced a similar effect with at least 3 fold increases in *H. bacteriophora* concentration required for attaining 90% kill of test insect. Talc-based *H. indica* formulation (10^{6} IJ) fortified with chitosan 0.25% was field evaluated against red palm weevil infested palm.

Among the four species of EPN evaluated against coconut white grub (*Leucopholis coneophora*), *S. carpocapsae* and *S. abbasi* @5000 IJ/grub were found to be more effective than *Heterorhabditis* spp. in soil column bioassay. Synergistic interaction of *S. carpocapsae* as well as *S. abbasi* @ 5000 IJ with imidacloprid (0.002%) against coconut white grub was observed accelerating the kill (85%) within a period of 48 h in soil column bioassay.

Surveillance and need based control of coconut leaf eating caterpillar, *Opisina arenosella* in Kerala

Endemic areas of coconut black headed caterpillar (*Opisina arenosella*) in Kerala were surveyed during the year to locate pest incidence. Low to medium level of pest incidence was noticed in Trivandrum and Muthalamada (Palakkad). Other endemic areas in Alappuzha, Kollam and Ernakulam Dist. were free of pest incidence. In the demonstration plot at Vechoor, Kottayam Dist., there was complete recovery of palms from *O. arenosella* incidence in parasitoid-released areas.

Survey conducted in Trivandum District recorded medium to mild infestation of palms with *O. arenosella* in newer areas with pest incidence in 30-40% leaves and population of 450/100 leaflets. Mild to medium level of pest infestation (30-35% leaves infested, with a pest population of 188/100 leaflet) in approx. 100 ha was reported from Muthalamada Krishi bhavan area of Palakkad Dist. during January 2011.

Evaluation of natural enemies against *Opisina arenosella*: KAU

Three releases of *Cardiastethus exiguus* @ 50 nymphs/palm at 5 days interval and four releases of *Goniozus nephantidis* @10 adults/palm at fortnightly interval, significantly reduced *Opisina arenosella* larvae from 5.7 to 0.7 per leaflet in Muthalamada (Palakkad district) during 2010.

5.2.10. Biological suppression of tropical fruit pests

Field evaluation of *B. bassiana* against *Helopeltis antonii* on guava: IIHR

A field experiment was conducted to test the efficacy of *B. bassiana*, mycojaal (commercial formulation of *B. bassiana*), Lamba-cyhalothrin 0.5ml/L, acetamiprid 0.2g/L, Pongamia soap 10g/L and IIHR botanical @10ml/L. against *H. antonii* on guava (var. Allahabad Safed). The treatments were applied three times at 15 days interval at onset of fruit setting stage.

The results revealed that significantly lowest per cent fruit damage (5.02%) was recorded in IIHR isolate *Beauveria bassiana* as compared to 39.58 % in untreated check. The other treatments such as

Table. 34. Effect of *Beauveria bassiana* on *Helopeltis antonii* on guava

Treatment	Fruit damage (%)	
	Pre-treatment	30 DAT
Cyhalothrin 0.5ml/l	18.4	1.9[a]
Acetamiprid 0.2g/l	16.7	1.7[a]
Pongamia soap 10g/l	20.2	15.4[c]
Beauveria bassiana (PCI)	19.7	18.2[c]
Botanical (IIHR)	18.3	16.3[c]
Beauveria bassiana (IIHR)	18.2	5.0[b]
Control	20.3	39.9[d]

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

Pongamia soap, IIHR botanical and commercial formulation of *B. bassiana* recorded 16.3 to 18.18% fruit damage (Table 34). Lamda – cyhalothrin and acetamiprid recorded the lowest fruit damage of 1.91 and 1.67 % respectively.

Evaluation of biocontrol agents against mango hoppers

IIHR

Field evaluation of *M. anisopliae* was carried out against mango hoppers, *Idioscopus* spp. A mixture of two species of hoppers was recorded with *Idioscopus nitidulus* (80%) and *I. nagpurieneneis* (20%). Weekly sprays of *M. anisopliae* @1×10^9 spores/ml with sunflower oil + Triton-x @0.01% were initiated when 4-5 hoppers per inflorescence were seen and compared with single spray of imidachloprid @ 0.3ml/L at pre-flowering stage along with control (no spray).

The results revealed that significantly lowest hopper population was recorded per inflorescence in both *M. anisopliae* (21) and chemical (3) treatments as compared to control (110). The hoppers after causing severe damage to inflorescence have moved away and aggregated on unflowered trees situated in the same orchard.

TNAU

A field experiment was conducted in farmers' field at Unjavelampatti on twelve year old Neelam mango. The treatments included T1- application of *Metarhizium anisopliae* @ 1×10^9 spores/ml (IIHR strain) on tree trunk during off season + two sprays during season at weekly interval; T2- application of *M anisopliae* @ 1×10^9 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* @ 1×10^9 spores/ml on tree trunk during off season + two sprays during the season at weekly interval (T1) was effective in reducing the leaf hopper population in the inflorescence (Fig. 49). However imidacloprid (T3) was the most effective.

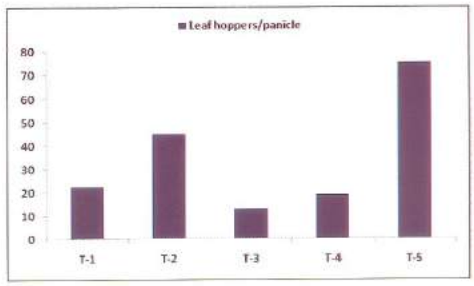


Fig. 49. Evaluation of *M. anisopliae* against mango hoppers at TNAU

Survey for the papaya mealybug and its natural enemies

KAU

Several field surveys were conducted at Ollukkara, Vellanikkara, Madakkathara, Cheroor and Nattika for the collection of natural enemies on papaya mealybug. The natural enemies like *Spalgis epius* and *Scymnus* sp. were recorded on papaya mealybug in Kerala.

TNAU

In Tamilnadu, the papaya mealybug was recorded on *Nerium oleander, Jatropha curcas, Achyranthes aspera, Chromolaena odorata, Codiaeum variegatum, Hibisicus rosa-sinensis, Emblica officinalis, Phyllanthus emblica, Parthenium hysterophorus, Croton bonplandianus, Malvastrum coromandelianum, Solanum trilobatum, Allamanda cathartica, Azadirachta indica, Gossypium herbaceum , Bombax ceiba, Cajanus cajan, Acalypha indica, Psidium guajava, Coccinia indica, Coleus aromaticus, Ipomoea batatas, Abutilon indicum, Leucaena leucocephala, Bauhinia* sp., *Annona squamosa, Durio zibethinus, Chloris barbata, Sedum* sp., *Euphorbia hirta, Mukia scabrella, Plumeria alba, Heliotropium indicum, Morus alba, Ipomea quamoclit, Anacardium occidentale, Coffea arabica, Lagasca mollis, Tecoma stans, Ocimum sanctum, Tridax procumbens, Vernonia cinerea, Malpighia punicifolia, Abelmoschus esculentus, Acalypha hispida, Pothus aureus.*

In the mulberry ecosystem, the papaya mealybug was recorded on *Abutilon indicum, Acalypha indica, Allmania nodifora, Amaranthus viridis, Cardiospernum halicacabum, Cassia nigiriam, Chloris inflate, Cleome gynandra, Cleome viscose and Parthenium hysterophorus.*

The natural enemies recorded on papaya mealybug in Tamilnadu include *Spalgis epius, Cryptolaemus montrouzieri, Scymnus coccivora, Brumoides suturalis, Cheilomenus sexmaculatus, Coccinella transversalis,* and *Ischiodon scutellaris.*

MPKV

In Maharashtra, the papaya mealybug was recorded on Parthenium, Neem, Guava, teak, mulberry, *Manilkara hexandra, Plumeria alba, Amaranthus* spp., *Hibiscus rosa-sinensis,* weeds such as *Coperonia palustris, Sonchus oleraceous, Euphorbia heterophylla, Commelina benghalensis, Amaranthus dubius, Acalypha indica* and *Trianthema portulacastrum,*

The natural enemies collected on papaya (var. Taiwan 786) included *Spalgius epius, Coccinella septempunctata, Scymnus* sp., Anthocorids, *Mallada* sp., *Brumoides* sp., Syrphids, Spiders, Encyrtid parasitoid, *Acerophagus papayae.*

ANGRAU

In Andhra Pradesh, the papaya mealybug was recorded on papaya, custard apple, cotton, tapioca, bhendi, redgram, brinjal, marigold, *Parthenium* spp., *Acalypha indica* etc in Chittor and Kadapa districts.

Mass production of papaya mealybug parasitoids

TNAU

In Coimbatore, TNAU obtained the nucleus culture of the parasitoids from NBAII. Training on mass multiplication of mealybug parasitoids were immediately given to plant protection scientists of TNAU from seven colleges, 36 research stations and 14 Krishi Vigyan Kendras within a fortnight so as to take up mass production throughout Tamil Nadu on a war footing.

Within a period of five months, 3,00,000 parasitoids mass multiplied by TNAU were released in farmers field @ 100 parasitoids/village in all the 32 districts of Tamil Nadu in the presence of District Collectors and officials of line Departments. The pest is successfully controlled.

Field evaluation of encyrtid parasitoid, *Acerophagus papayae* against papaya mealybug

IIHR

Anagyrus loecki, Acerophagous papayae and *Pseudleptomastix mexicana* were received from NBAII, Bangalore for mass multiplication and subsequent field releases. A total of 300 parasitoids of *A. papayae* @ 50 adults at fortnight interval and 100 adults of *A. loecki and P. maxicana* were released in a papaya (var. Taiwan var. Red Lady) orchard at Chitoor. In about three months time, *A. papayae* established and arrested the spread of papaya mealybug and brought down the mealybug population to negligible level. The parasitoid *A. papayae* also got established in another papaya (var. Arka Prabhath) orchard and brought down the mealybug population to low level in four months time. The parasitoid *A. papayae* has also been released in several papaya (Red Lady) orchards at Soladevanahalli and Baglur near Bangalore.

MPKV

Surveys were conducted in eleven papaya growing districts of Maharashtra for the collection of natural enemies on papaya mealybug, *P. marginatus.* The incidence of papaya mealybug was highest (95%) in different orchards in September, 2010 which came down to 7.5% due to the activity of natural enemies by the end of December, 2010.

Inoculative release of the parasitoid, *A. papayae* @ 1,500 adults per acre during October, 2010 in mealybug infested papaya orchards (95% incidence) at Pune reduced the mealybug population by 85-92% by January, 2011. Similarly inoculative releases of 1000 parasitoids per acre during October, 2010 at Jalgaon, Dhule and Thane districts (65 to 85% mealybug incidence) brought down the mealybug population dramatically by January, 2011.

TNAU

Field experiments were conducted at five locations in Erode and Coimbatore districts of Tamil Nadu at farmers field during October 2010 to February 2011. One hundred adults of *A. papayae* were released in each orchard.

The results revealed that in the released plots the mealybug population was significantly reduced from 66.8 to 7.52 /25 cm^2, 90 days after the release, whereas the mealybug population increased from 64.8 to 141.2/25 cm^2 in the un-released plot. There was a remarkable reduction (84 to 99 per cent) in mealybug population 90 days after release from five locations studied.

Toxicity of insecticides to *Acerophagus papayae*: IIHR

In a laboratory, it was found that all the six insecticides (Acephate @0.75g/L, Imidacloprid @ 0.3ml/L, Acetomiprid @ 0.2g/L, Buprofezin @ 1.25ml/L, Dimethoate @ 1.5ml/L and Dichlorvos @ 1ml/L) were extremely toxic to the exotic papaya mealybug parasitoid, *A. papayae* resulting in 100% mortality.

Demonstration of biological suppression of pink mealy bug, *M. hirsutus* on custard apple: MPKV

Field demonstration on effectiveness of Australian lady bird beetle, *Cryptolaemus montrouzieri* against mealybug on four year old custard apple was conducted in three farmers' orchards at village Sakurde (Pune Dist.).

Inoculative release of *C. montrouzieri* @ 2,500 beetles/ha in June, 2010 was found to be effective in suppressing the mealy bug population to the extent of 80.9% with 49.8% increase in the yield of marketable custard apples.

5.2.11. Biological suppression of pests of temperate fruits

Field evaluation of *Trichogramma embryophagum* against codling moth: SKUAST-Srinagar

A field trial was conducted during 2010 in five apple orchards located at Mangmore, Shanigund, Hardass (Gonguk), Bagh-e-khomini and Kharrol at Kargil. *Trichogramma embryophagum* was released twice @ 4000 adults/tree in all the orchards except Kharrol. At Kharrol, in addition to two sequential releases of *T. cacoeciae*, pheromone traps (cod lure) were used twice @ 4 traps/ orchard. Post- release observations revealed that there was a significant reduction in fruit damage in treated plot at Mangmore and highest yield of fruits at Bagh-e-Khomini compared to control plot (Table 35).

Table 35. Impact of *T. embryophagum* and *T. cacoeciae* on fruit damage in apple by codling moth at Kargil, during 2010

Locations	Fruit damage (%)	Fruit yield per tree (Kg)
Mangmore	51.2[bc]	111.0[d]
Shanigund	44.1[b]	41.2[b]
Hardas (Gongkuk)	48.6[bc]	54.7[b]
Bagh-e- Khomini	31.4[a]	138.7[e]
Kharrol	40.4[b]	58.7[c]
Untreated Control Hardas (Gond)	77.3[d]	19.5[a]

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

Laboratory evaluation of entomopathogens and EPN against root borer, *Dorysthenes hugelii*: YSPUH & F

A laboratory experiment was conducted to evaluate the efficacy of *B. brongniartii*, *B. bassiana*, *M. anisopliae*, *Steirenema carpocapsae* and *Heterorhabditis indica* against grubs of apple root borer, *D. hugelii*. The entomofungal pathogens were applied at 10^5 / cm^2 and 10^6 conidia/cm^2. The EPN *S. carpocapsae* and *H. indica* were applied at 10, 20 & 40 IJ/cm^2 and compared with chlorpyriphos (0.06%) and untreated control. Among the entomopathogens, the highest grub mortality was recorded in *B. brongniatrii* @ 10^6 conidia/cm^2. Among the EPN, the highest mortality was recorded in *H. indica* (@ 40 IJ/cm^2) (Table 36).

Table 36. Efficacy of entomopathogens and EPN against apple root borer, *Dorysthenes hugelii*

Treatments	Per cent mortality of root borer (%) (14 DAT)
S. carpocapsae (10 IJ/cm^2)	66.7^{def}
S. carpocapsae (20 IJ/cm^2)	76.7^{bcd}
S. carpocapsae (40 IJ/cm^2)	80.0^{bc}
H. indica (10 IJ/cm^2)	70.0^{de}
H. indica (20 IJ/cm^2)	76.7^{bcd}
H. indica (40 IJ/cm^2)	83.3^{b}
B. brogniatrii (10^5 conidia/cm^2)	63.3^{efg}
B. brogniatrii (10^6 conidia/cm^2)	66.7^{de}
Metarhizium anisopliae (10^5 conidia/cm^2)	50.0^{g}
Metarhizium anisopliae (10^6 conidia/cm^2)	60.0^{efg}
Beauveria bassiana (10^5 conidia/cm^2)	53.3^{fg}
Beauveria bassiana (10^6 conidia/cm^2)	60.0^{efg}
Chlorpyriphos (0.06%)	96.7^{a}
Control	10.0^{h}

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

5.2.12. Biological suppression of pests of vegetable crops

Evaluation of microbial insecticide formulations against the fruit borer of tomato

AAU-Anand

A field trial was laid out to evaluate the efficacy of microbial insecticides against *Helicoverpa armigera* on tomato (var. GT-2). The treatments included *Bt* (Biolep) @ 1.0 kg/ha (5 X 10^7 spores/mg), HaNPV @ 1.5 X 10^{12} POB/ha, *B. bassiana* @ 1.0 kg/ha (2 X 10^8 cfu/g), *M. anisopliae* @ 1.0 kg/ha (10^8 cfu/g), *N. rileyi* PDBC strain @ 10^{12} spores/ha, Endosulfan 0.07 % (farmers' practice), Spinosad 48 SC 0.024 % (5ml / 10 litre), Cartap hydrochloride 50% SP 0.05 % and Control (No spray).

The results revealed that all the treatments significantly reduced the population of *H. armigera*, reduced the fruit damage and increased the fruit yield compared to the control, however the highest fruit yield was recorded in NPV which was on par with chemical insecticides treated plots (Table 37).

Validation and demonstration of BIPM in kharif okra: AAU-Anand

In a field trial, BIPM package was evaluated against farmers' practice for the control of pests of okra (var. GO-2). The BIPM included (a) Seed treatment with thiamethoxam 70WS @ 2.8 g/kg seed (b) Soil application of bionematicide, *Paecilomyces lilacinus* @ 25 kg/ha, (c) Timely sowing of the crop, (d) Installation of pheromone traps @ 40 /ha for mass trapping of moths each of *Earias* spp. and *H.*

Table 37. Efficacy of microbial insecticides against *H. armigera* on tomato

Treatments	*H. armigera* larvae / plant		Fruit damage(%)		Fruit yield (Kg/ha)
	Beforespray	7DAT	Beforespray	7DAT	
Bt (Biolep) @ 1.0 kg / ha	1.0^{a}	0.9^{b}	3.8^{a}	3.2^{b}	14704^{bcd}
NPV @ 1.5 x 10^{12} POB /ha	0.9^{a}	0.9^{b}	3.7^{a}	2.9^{b}	16160^{abc}
B. bassiana @ 1.0 kg / ha	1.0^{a}	0.9^{b}	4.0^{a}	3.3^{b}	14280^{bcd}
M. anisopliae @ 1.0 kg / ha	1.1^{a}	0.7^{c}	4.1^{a}	3.7^{b}	13818^{cde}
N. rileyi @ 10^{12} spores / ha	1.0^{a}	0.9^{b}	4.2^{a}	3.5^{b}	12619^{de}
Endosulfan 0.07 %	1.0^{a}	0.4^{d}	4.3^{a}	2.0^{b}	17531^{ab}
Spinosad 0.024 %	0.8^{a}	0.4^{d}	3.5^{a}	1.5^{b}	18118^{a}
Cartap hydrochloride 0.05 %	0.9^{a}	0.6^{c}	3.8^{a}	2.6^{b}	16509^{abc}
Control (no spray)	0.8^{a}	1.6^{a}	4.0^{a}	6.3^{a}	11006^{e}

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

Table 38. Effect of BIPM package against insect pests of okra

Treatments	Sucking pests / leaf			Fruit damage (%)	Fruit Yield (kg/ha)
	Aphid	Leaf hopper	Whitefly		
BIPM	0.8[c]	0.3[c]	0.3[c]	4.9[b]	2346[a]
Farmer's practices	1.4[b]	0.8[b]	0.8[b]	8.9[b]	2161[a]
Untreated check	2.1[a]	1.0[a]	1.1[a]	15.4[a]	1216[b]

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

armigera, (e) Regular clipping the infested shoots due to spotted bollworm and (f) Need-based alternate spray application of NSKE (5%), *Bt* (1.5 kg/ha) and *Beauveria bassiana* ($2x10^8$ cfu/g) @ 30 g/10 lit. water. The farmers' practice was need based synthetic insecticidal/miticidal spray (i.e. Endosulfan, quinalphos, Fenazaquin, DDVP etc.) along with untreated control.

The BIPM package recorded significantly less number of aphids, leaf hoppers and whiteflies, reduced fruit damage and increased fruit yield compared to the farmers' practice and control (Table 38).

Biological suppression of spider mites on okra: KAU

An experiment was conducted to evaluate the efficacy of *Blaptostethus pallescens* against spider mites, *Tetranychus urticae* on okra. The anthocorid, *B. pallescens* was released four times @ 10 nymphs/plant and 20 nymphs/plant and compared with spray of abamectin 1.9 EC @ 0.3 ml/ l.

The result showed that four releases of *B. pallescens* either at 10 or 20 nymphs/plant at 10 days interval, significantly reduced the mite population (96.6%) and was on par with the chemical spray (97.6%). However in the control the mite numbers increased from 19.1 to 32.7 per plant.

Laboratory evaluation of NBAII Bt strains against *Plutella xylostella*: AAU-Jorhat

An experiment was laid out to evaluate two NBAII-Bt strains (PDBC-BT-1 and PDBC BT-2) against *P. xylostella*. The Bt formulation was serial diluted from 10^{-1} to 10^{-6} and evaluated against third instar larvae of *P. xylostella*.

The results revealed that higher per cent mortality of *P. xylostella* larvae was recorded in Bt strain PDBC-BT-1 compared to PDBC-BT-2 (Table 39).

Table 39. Efficacy of NBAII Bt strains against *P. xylostella*

Bt Concentration	Per cent mortality (%) (72 HAT)		
	PDBC BT-1	PDBC BT-2	Control
10^{-1}	78.7[a]	63.8[a]	20.5
10^{-2}	67.5[b]	61.8[a]	17.9
10^{-3}	60.1[bc]	52.3[bc]	21.5
10^{-4}	55.4[cd]	47.9[c]	27.9
10^{-5}	47.9[d]	42.1[d]	20.5
10^{-6}	36.2[e]	25.6[e]	22.5
Mean	57.6	48.9	21.8

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

Laboratory evaluation of NBAII Bt strains against *Helicoverpa armigera*: PAU

An experiment was laid out to evaluate two NBAII Bt strains (PDBC BT-1 and PDBC BT-2) against *H. armigera*. The Bt formulation was serial diluted from 10^{-1} to 10^{-6} and Tween 80 @ 0.01% was added to it for uniform spreading and evaluated against second instar larvae of *H. armigera*. The results revealed that higher per cent cumulative mortality of *H. armigera* larvae was recorded in Bt strain PDBC BT-2 compared to PDBC BT-1 (Table 40).

Table 40. Efficacy of NBAII Bt strains against *H. armigera*

Bt Concentration	Per cent cumulative mortality (%) (10DAT)			
	PDBC BT-1	PDBC BT-2	HD1	Control
10^{-1}	100.0^{a}	100.0^{a}	100.0^{a}	12.5e
10^{-2}	100.0^{a}	85.0^{b}	100.0^{a}	12.5e
10^{-3}	100.0^{a}	85.0^{b}	100.0^{a}	12.5e
10^{-4}	90.0^{a}	80.0^{bc}	92.5^{a}	12.5e
10^{-5}	70.0^{c}	65.0^{c}	75.0^{c}	12.5e
10^{-6}	55.5^{d}	60.0^{cd}	57.5^{d}	12.5e

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

Biological control of bean mite: YSPUH & F

Single release 20 predatory mites per mite infested bean plants wiped out the population of pest mite 20 days after the release and the predatory mite population increased to 367±8.6 and 779±8.4 mites per plant after 10 and 20 days of release respectively.

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

YSPUH & F

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.

OUAT

The results revealed that thelytokous form of *T. pretiosum* was superior in recording significantly less number of larvae per ten plants, reducing fruit damage and also recording significantly highest marketable fruit yield (Tables 41 and 42).

Table 41. Efficacy of thelytokous *T. pretiosum* against *H. armigera* on tomato (trial 1)

Treatments	No. of larvae / 10 plants (post-treatment)	Fruit damage (%)	Yield of marketable fruits (Kg/ha)
T. pretiosum arrhenotokous	2.2^{b}	9.1^{b}	$1,68,100^{b}$
T. pretiosum thelytokous	1.3^{a}	6.9^{a}	$1,95,400^{a}$
Control	4.7^{c}	14.2^{c}	$1,10,200^{c}$

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 (trial 2)

Treatments	No. of larvae / 10 plants (post-treatment)	Fruit damage (%)	Yield of marketable fruits (Kg/ha)
T. pretiosum arrhenotokous	3.9^{b}	12.4^{b}	$1,53,800^{b}$
T. pretiosum thelytokous	1.8^{a}	6.1^{a}	$1,91,100^{a}$
Control	4.8^{c}	19.7^{c}	$1,28,800^{c}$

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

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.50).

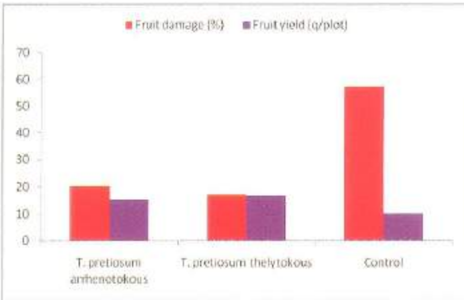


Fig. 50. Efficacy of *T. pretiosum* thelytokous form against *H. armigera* on tomato

TNAU

A field experiment was conducted to evaluate the efficacy of thelytokous and arrhenotokous forms of *T. pretiosum* against *H. armigera* on tomato (var. PKM1). Six releases of thelytokous form of *T. pretiosum* @ 1 lakh/ha recorded significantly less fruit damage and higher marketable fruit yield (Table 43). Field parasitisation of *H. armigera* eggs was higher (23%) in plots where the thelytokous forms were released.

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

Treatments	Fruit damage	Parasitisation (%)	Yield of marketable fruit (kg/ha)
T. pretiosum arrhenotokous	13.4[b]	12	30,625[b]
T. pretiosum thelytokous	10.0[a]	23	35,750[a]
Control	21.5[c]		28,125[c]

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

MPKV

A field experiment was conducted on research farm at college of agriculture, Pune on tomato (var. Vaibhav) to evaluate the efficacy of thelytokous *T. pretiosum* against *H. armigera* on tomato. Six releases of thelytokous strain of *T. pretiosum* @ 1 lakh/h at weekly interval significantly reduced the larval population of *H. armigera*, reduced the fruit damage and recorded highest fruit yield (Table 44).

Table 44. 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	5.2[b]	20.1[a]	1,89,400[b]
T. pretiosum thelytokous	2.6[a]	16.4[a]	2,18,200[a]
Control	19.3[c]	40.8[b]	1,34,600[c]

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

CAU, Pasighat

The field experiment was conducted during rabi 2010-11 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 (5.98%) and marketable fruit yield (15,830 kg/ha) compared to arrhenotokous form which recorded 7.58 % fruit damage and 15,270 kg fruits per ha. In the control plot the fruit damage was 10.9% and fruit yield was 14,380 kg/ha.

Farmer-participatory demonstration of biocontrol-based IPM against shoot and fruit borer of brinjal

OUAT

Field trial was conducted at five villages (Kakharubasta, Kulei, Bangursingh, Saradhapur, Hatakaranda) at Bhubaneswar to evaluated biocontrol-based IPM against import pests of brinjal (Fig. 51). 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

Fig.51. Biocontrol-based IPM plot at farmers field

damage and significant increase in marketable yield resulting in highest net returns of 69,737 over the farmers' practice (Table 45).

Table 45. Evalution of biocontrol-based IPM against brinjal pests

Parameters	Biocontrol-based IPM	Farmers' practice
wilted plants in nursery (%)	3.2	9.1
Shoot damage (%)	8.9	22.0
Fruit damage (%)	13.7	29.5
Fruit yield (kg/ha)	19,383	11,193
C:B ratio	1:4.9	1:1.8
Net returns over farmer's practice (in ₹s)	69,737	

CAU

The demonstration was conducted during rabi, 2010-11 on the biocontrol-based IPM package against pests of brinjal (var. Hybrid 41) in three farmers fields. Biocontrol-based IPM included: Treatment of seeds with *T. viride* @ 4g/ kg of seed, eight releases of *Trichogramma chilonis* @ 50,000/ha at weekly interval starting from 45DAT, installation of pheromone traps of *L. orbonalis* @ 12 traps /ha. and spraying of neem oil @ 4ml/lit at weekly interval from 80 DAT. The farmers' practice included application of carbofuran @ 1 kg a.i./ha before sowing, soil drenching with blitox 50 WP @ 0.25 per cent and spraying of Profenophos @ 0.05% at 45, 60 , 75 and 90 DAT and compared with control (untreated check).

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

Biological control of cowpea aphid: KAU

A field experiment were conducted to evaluate the efficacy of *Cheilomenes sexmaculata* against cowpea aphid, *Aphis craccivora* on variety Anaswara of cowpea. *Cheilomenes sexmaculata* adults were released @ 1500 beetles/ha. 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 47). It was concluded that release of *C. sexmaculata* is as good as chemical application for the control of cowpea aphid.

Table 47. Efficacy of predators against cowpea aphid.

Treatments	Aphids/ plant (post release)	Per cent plants infested	Cowpea yield (kg/ha)
C. sexmaculata	1.5[a]	6.9[a]	10,340[a]
Malathion 0.1%	1.7[a]	5.8[a]	10,530[a]
Control	8.0[b]	26.1[b]	7,580[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 (Fig. 52). 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*; six

Table 46. Evaluation of biocontol-based IPM against brinjal shoot and fruit borer

Parameters	Biocontrol-based IPM	Farmers' practice	Control
Per cent wilted plants in the nursery	4.4[a]	4.0[a]	10.7[b]
Per cent shoot borer incidence			
Per cent fruits bored	5.3[a]	5.4[a]	9.0[b]
Marketable fruit yield (kg/h)	23.5[a]	24.0[a]	22.2[b]

Means followed by a common letter in a row are not significantly different by DMRT (P=0.05) release of *T. brassicae* @ 1,00,000/ha @ weekly interval from 30 to 60 DAT 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 *P. xylostella* and *S. litura* larvae in biocontrol-based IPM plots and farmers practice plots (Table 48).

Table 48. 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	0.7[a]	0.3[a]
Farmers practice	0.4[a]	0.2[a]
Control	1.0[b]	0.4[b]

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

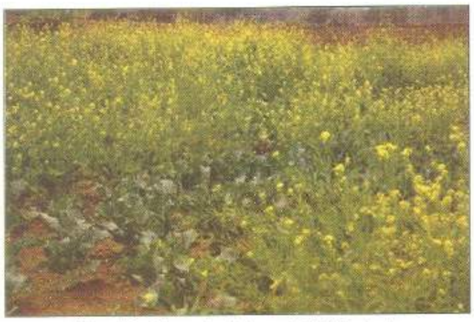


Fig. 52. Bicontrol-based IPM plot on cauliflower at Imphal

Validation of biocontrol-based IPM for important pests of tomato: CAU

The experiment was conducted during rabi 2010-11 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 49). However, both the treatments were superior to control.)

Table 49. Evaluation of biocontol-based IPM against *H. armigera* on tomato

Treatments	Per cent plant mortality	Per cent fruits damaged	Yield of marketable fruits (kg/ha)
Biocontrol-based IPM	5.4[a]	4.4[a]	16,150[a]
Farmers practice	4.6[a]	3.8[a]	16,050[a]
Control	11.2[b]	10.4[b]	14,220[b]

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

5.2.13. Biological suppression of pests of cumin: MPUAT

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 (var. RZ-19) 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 (1,141 kg/ha) (Table 50).

Table 50. 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	11.4^{a}
T. harzianum (RCA) @ 10g/kg seed & soil treatment @ 2.5 kg/ha	2.0	11.2^{a}
P. flulorescens (NCIPM) @ 10g/kg seed & soil treatment @ 2.5 kg/ha	3.0	10.5^{ab}
T. viride (PDBC) @ 10g/kg seed & soil treatment @ 2.5 kg/ha	2.0	11.3^{a}
Carbendazium @ 10g/kg seed & soil treatment 2.5 kg/ha	8.0	11.6^{a}
Control	54.0	7.9^{ab}

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

Evaluation of biocontrol agents against the cumin aphid

A field experiment was conducted to evaluate effectiveness of biocontrol agents against aphids on cumin (var. RZ-2009) The treatments included (a) three times release of *Chysoperla* sp. @ 50,000/ha, (b) spray of *B. bassiana* @ 1 x 10^7 spores/ml, (c) spray of *M. anisopliae* @ 1 x 10^7 spores/ml, (d) spray of *V. lecanii* @ 1 x 10^7 spores/ml, (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 (84.74%) which was superior to other biocontrol agents but inferior to imidacloprid. Highest grain yield was recorded in azadiractin plots (995 kg/ha) which was on par with imidacloprid (Table 51).

Table 51. 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^{a}	732^{a}
B. bassiana @ 1 x 10^7 spores/ml	58.4^{b}	920^{a}
M. anisopliae @ 1 x 10^7 spores/ml	62.2^{b}	940^{a}
V. lecanii @ 1 x 10^7 spores/ml	84.7^{c}	952^{a}
Azadiractin 0.03% @ 3 ml/l	85.3^{c}	995^{a}
imidacloprid @ 30 g a.i./ha	92.1^{d}	1041^{a}
control	-	604^{b}

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

5.2.14. Biological suppression of white grubs

Potato: YSPUH & F

A field lexperiment was laid out to evaluate three entomopathogenic fungi and two species of EPN against white grubs affecting potato. The treatments were *B. brongniartii*, *B. bassiana* and *M. anisopliae* each @ 10^{14} conidia/ha, EPN *H. indica* and *S. carpocapsae* each @ 4 b IJ/ha along with control.

The results revealed that the whitegrub infestation was lowest in *B. bassiana* (31.4%) treatment followed by *M. anisopliae* (32.7%), *S. carpocapsae* (34.9%), *B. brongiartii* (37.3%) and *H. indica* (38.0%) as against 59.2 % in control.

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 (4.64%) and highest grain yield (1,524 kg/ha) were recorded in *M. anisopliae* @ 1 x 10^{13} conidia/ha (Table 52). This tretament was on par with chlorpyriphos in ehancing the yield.

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

Treatments	Plant mortality (%)	Grain yield (kg/ha)
M. anisopliae @ 1 x 10^{13} conidia/ha	4.6^{a}	$1{,}524^{a}$
H. indica (PDBC) 13.31 @ 5 b IJs/ha	7.6^{b}	$1{,}360^{b}$
S. carpocapsae (PDBC) EN11 @ 5 b Ijs/ha	8.3^{b}	$1{,}370^{b}$
B. brongniartii @ 1 x 10^{13} conidia/ha	11.3^{c}	$1{,}280^{b}$
B. bassiana 1 x 10^{13} conidia/ha	11.5^{c}	$1{,}250^{bc}$
B. bassiana granular formulation @ 1 x 10^{13} conidia/ha	10.1^{c}	$1{,}160^{c}$
chlorpyriphos 20EC @ 20 ml/kg	0.0	$1{,}640^{a}$
Control	29.3^{d}	920^{d}

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

5.2.15. Biological suppression of termites: MPUAT

A field 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 and *S. carpocapsae* EN-11 @ 5bIj/ha effectively suppressed termite damage and recorded signifcantly less plant mortality of wheat (5.12 and 4.72%) and higher yield (4,020 and 3,960 kg/ha) compared to other EPN but was inferior to chlorpyriphos (Table 53).

5.2.16. Biological suppression of polyhouse crop pests

Bio- intensive management of *Scirtothrips dorsalis* on capsicum in polyhouse: IIHR

An experiment was laid out in a polyhouse to evaluate entomopathogens, *M. anisopliae, B. bassiana, V. lecanii* (all applied @1x10^{9} spores/ml + adjuvants), release of *B. pallescens* (@2 nymphs/plant), spraying neem soap10%, spraying spinosad 0.3ml/L and spraying acephate @0.7g/l. Pinching of the terminal shoots at weekly intervals with flowering was carried out 4 times to sustain the crop for a longer period. Highest per cent reduction of thrips over control was recorded in *B. pallescens* release plot. Application of entomopathogenic formulations was as effective as chemical application.

Evaluation of anthocorid predator, *B. pallescens* against thrips on capsicum: IIHR

An experiment was laid out in polyhouse to evaluate *B. pallescens* against *Scirtothrips dorsalis* on capsicum. The treatment included single release of *B. pallescens* @ 2,5 and 10 per plant.

The results indicated that a single release of *B. pallescens* @ 10/plant resulted in post release count of 0.6 to 1.7 thrips with 25.6 kg fruit yield. The population of thrips on control plants ranged from 0.8 to 15.2 per plant with 1.94 kg fruit yield.

Table 53. Efficacy of entomopathogens and EPN against whitegrubs in groundnut

Treatments	Plant mortality (%)	Grain yield (kg/ha)
M. anisopliae @ 1 x 10^{13} conidia/ha	5.1^{ab}	$4{,}020^{ab}$
H. indica (PDBC) 13.31 @ 2.5 b IJs/ha	14.2^{c}	$3{,}863^{b}$
H. indica (PDBC) 13.31 @ 5 b IJs/ha	6.3^{b}	$4{,}123^{ab}$
S. carpocapsae (PDBC) EN11 @ 2.5 b Ijs/ha	14.6^{c}	$3{,}780^{b}$
S. carpocapsae (PDBC) EN11 @ 5 b Ijs/ha	4.7^{ab}	$3{,}960^{ab}$
NSKE 100 kg/ha	7.3^{b}	$3{,}810^{b}$
Seed treatment with chlorpyriphos 20 EC @ 5 ml/kg	3.2^{a}	$4{,}326^{a}$
Control	31.1^{d}	$2{,}765^{c}$

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

Biological suppression of white fly on French beans: YSPUH & F

An experiment was laid out in polyhouse on French beans against whitefly *Trialeurodes vaporariorum*. The treatments included application of *V. lecanii* formulation, *V. lecanii* pure culture and *P. fumosoroseus* pure culture at different concentration ranging from 10^6 to 10^{10} spore per ml containing 0.02 per cent Tween-80. The results revealed that highest mortality of the whitefly was recorded in *V. lecanii* formulation @ 10^9 spore/ ml concentration (Table 54).

Table 54. Evaluation of *V. lecanii* and *P. fumosoroseus* against *T. vaporariorum*

Treatment Concentration (spore/ml)	Mean per cent mortality (15 DAT)		
	V. lecanii formulation	*V. lecanii* pure culture	*P. fumosoroseus* pure culture
10^{10}	-	30.9^a	-
10^9	33.4^a	28.1^a	15.00^a
10^8	32.5^a	27.1^{ab}	8.13^b
10^7	19.7^b	23.1^{ab}	6.56^b
10^6	12.8^c	21.25^b	3.13^c
Control	2.8^d	5.00^c	1.26^d

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

Evaluation of anthocorid predator, *B. pallescens* against spider mites

Rose

SKUAS & T

An experiment was laid out in polyhouse to evaluate *B. pallescens* against spider mites on rose. The treatments included (a) Three releases of *B. pallescens* @ 10/ plant (@10 days interval), (b) Three releases of *B. pallescens* @ 20/plant (@ 10 days interval) and (c) three times spraying of abamectin @ 0.3 ml/ l and (d) control.

The population of spider mites declined from 19.7 to 10.4 when 10 anthocorids were released per plant and from 21.1 to 6.4 when 20 anthocorids were released. However, three times application of abamectin @ 0.3 ml/l, reduced spider mite population from 20.0 to 4.9 per plant. In the control plot, the mite population increased from 16.2 to 25.1 per plant.

MPKV

A trial was laid out in polyhouse to evaluate *B. pallescens* against spider mites n rose (var. Skyline). The treatments consisted of four releases of release of anthocorids @ 10 and 20 nymphs/ plant, spraying of chemical insecticide abamectin 1.9 EC @ 0.3 ml/lit and untreated control.

The results revealed that four releases of *B. pallescens* @ 20 nymphs/plant significantly reduced the mite population from 63.1 to 26.8 per 5 leaves and found superior to control but inferior to abemectin (15.4 mites/5 leaves).

TNAU

The experiment was laid out in the polyhouse to evaluate *B. pallescens* against spider mites on rose. The treatments included four releases of *B. pallescens* @ 10, 20/plant at 15 days interval and spraying Abamectin 0.3 ml / l along with control.

The results revealed that four releases of *B. pallescens* @ 20 nymphs per plant significantly reduced the population of spider mite from 232 to 41 per 5 leaves and recorded 21.3% leaf damage and was on par with Abamectin 0.3 ml / l spray (Table 55).

Table. 55. Efficacy of *B. pallescens* against spider mites on rose

Treatments	No. of mites/ 5 leaf		Leaf damage (%)
	Pre-treatment	Post-treatment	
B. pallescens @ 10 nymphs/ plant	226^a	112^b	38.7^c
B. pallescens @ 20 nymphs/ plant	232^a	41^a	21.3^b
Abamectin 0.3 ml/l	241^a	13^a	4.3^a
Untreated control	240^a	368^c	67.7^d

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

Biological suppression of sucking pests (spider mite) on rose: MPKV

An experiment was laid out to evaluate the efficacy of bicontrol agents against spider mite, *Tetranychus urticae* attacking rose (var. Skyline) 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) five release of *B. pallescens* @ 10/plant (g) spraying insecticide abamectin 1.9 EC @ 0.3 ml/lit (h) control.

The results indicated that three sprays of *H. thompsonii* @ 10^8 CFU/ml was significantly superior in recording 36.1 mites/5 leaves/plant, followed by *V. lecanii* (44.1 mites/5 leaves/ plant). However, abamectin @ 0.3 ml/lit was the most effective in suppressing mite (*Tetranychus urticae Koch.*) population (Table 56).

Table 56. Evaluation of biocontrol agents against spider mite on rose

Treatments	Spider mites/5 leaves/ plant	
	Pre-treatment	Post treatment
B. bassiana @ 10^8 CFU/ml	78.9^a	58.2^c
M. anisopliae @ 10^8 CFU/ml	81.3^a	50.4^c
Hirsutella thompsonii @ 10^8 CFU/ml	80.4^a	36.1^b
V. lecanii @ 10^8 CFU/ml	78.7^a	44.1^b
Five release of *B. pallescens* @ 10/plant	78.4^a	62.8^d
spraying insecticide (abamectin 1.9 EC @ 0.3 ml/lit)	80.6^a	20.1^a
Control	79.9^a	100.9^e

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

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 Abamectin 0.3 ml / 1 (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 57). However the insecticide-treated plot was significantly superior to other treatments.

Table 57. 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	51^b	12.8^b	2,170^b
M. anisopliae @ 10^8 CFU/ml	93^c	19.1^c	2,155^b
Hirsutella thompsonii @ 10^8 CFU/ml	178^d	20.0^c	2,200^b
V. lecanii @ 10^8 CFU/ml	42^b	11.9^b	2,275^b
Release of *Stethorus pauperculus*	124^c	10.9^b	2,260^b
Release of *B. pallescens* @ 10/plant	171^d	17.9^c	2,301^b
spraying insecticide	14^a	3.9^a	2,740^a
Control	213^e	25.9^d	1,975^c

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

Biological suppression of mites on carnation: TNAU

An experiment was laid out in polyhouse at Elkhil Farms, Ooty to evaluate biological control agents against mites on carnation (var. Domingo). 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* was effective in reducing two spootted spider mite followed by *H. thompsonii*, *Amblyseius* sp and *B. bassiana*. However, spraying Abamectin 0.3 ml /l reduced the mite populatin significantly over all other treatments (Table 58).

Table 58. Evaluation of biocontrol agents against spider mites on carnation

Treatments	Spider mites/ 10 plants (post treatment)	Healthy flower stalks/ plot
Amblyseius sp. @ 10/plant	20.3^{b}	$2,345^{b}$
B. bassiana @ 10^{8} CFU/ml	43.0^{d}	$2,175^{c}$
Hirsutella thompsonii @ 10^{8} CFU/ml	37.7^{c}	$2,410^{b}$
Release of *Stethorus pauperculus*	17.7^{b}	$2,430^{b}$
Sprying insecticide (Abamectin 0.3 ml / l)	2.7^{a}	$2,640^{a}$
Control	63.3^{e}	$1,875^{d}$

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

5.2.17. Biological suppression of storage pests

MPKV

An experiment was conducted to evaluate the efficacy of *B. pallescens* and *X. flavipes* 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, TNAU and PAU (Table 59). However, neither live nymphs nor adults of the anthocorids were observed after a month in the containers at MPKV whereas at TNAU, PAU and ANGRAU higher number of adults of *X. flavipes* were recorded one month after the release.

5.2.18. Biological suppression of *Chromolaena odorata*

KAU

Releases of stem gall fly, *Cecidochares connexa* resulted in significant reduction in plant height and number of branches on galled plants compared to non-galled plants.

Table 59. Efficacy of anthocorids against rice moth in stored rice

Treatments	No. of *Corcyra* moth emerged			
	MPKV	TNAU	PAU	ANGRAU
B. pallescens @ 10 nymphs / 10 kg rice	57.5^{e}	59.0^{e}	46.5^{de}	88.5^{bc}
B. pallescens @ 20 nymphs / 10 kg rice	35.5^{d}	34.0^{c}	41.0^{de}	84.5^{abc}
B. pallescens @ 30 nymphs/ 10 kg rice	16.0^{a}	12.0^{a}	33.8^{cd}	78.3^{abc}
X. flavipes @ 10 nymphs / 10 kg rice	31.5^{c}	39.0^{d}	21.3^{bc}	79.0^{abc}
X. flavipes @ 20 nymphs / 10 kg rice	19.0^{b}	21.0^{b}	13.8^{ab}	65.0^{ab}
X. flavipes @ 30 nymphs / 10 kg rice	13.0^{a}	7.0^{a}	8.8^{a}	59.3^{a}
Untreated control	80.5^{f}	83.0^{f}	56.3^{e}	95.3^{c}

6. TECHNOLOGY ASSESSED, TRANSFERRED AND MATERIALS DEVELOPED

DNA sequences generated and deposited

FJ599744, 573 bp DNA linear, Jalali, S. K., Venkatesan, T., Sriram, S., Rajeshwari, R. and Mahiba Helen,S. *Pichia anomala* strain Tcy2 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete sequence; and 28S ribosomal RNA gene, partial sequence.

2. FJ224365, 579 bp DNA linear, Jalali, S. K., Venkatesan, T., Sriram, S. and Rajeshwari, R., *Pichia anomala* strain Tcy1 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete sequence; and 28S ribosomal RNA gene, partial sequence.

3. FJ224365, 579 bp DNA linear, Jalali, S. K., Venkatesan, T., Sriram, S. and Rajeshwari, R. *Pichia anomala* strain Tcy1 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete sequence; and 28S ribosomal RNA gene, partial sequence.

4. HQ221884, 389 bp, DNA linear, Rajeshwari, R., Jalali, S. K., Venkatesan, T., Prashanth, M., Khan, A. A. and Sriram, S. *Metschnikowia reukaufii* isolate TCJK1 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete sequence; and 28S ribosomal RNA gene, partial sequence.

5. HM601457, 349 bp DNA linear, Jalali, S. K., Rajeshwari, R., Venkatesan, T., Sriram, S. and Lalitha, Y. *Metschnikowia reukaufii* strain Tcy18 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete sequence; and 26S ribosomal RNA gene, partial sequence.

6. HM601459, 724 bp. DNA linear, Jalali, S. K., Rajeshwari, R., Venkatesan, T., Sriram, S. and Lalitha,Y. *Hanseniaspora uvarum* strain Tcy19 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete sequence; and 26S ribosomal RNA gene, partial sequence.

7. GU391355, 1452 bp DNA linear, Jalali, S. K., Rajeshwari, R., Sriram, S., Venkatesan, T., Lalitha, Y. and Mahiba Helen, S. *Bacillus subtilis* strain Tc1 16S ribosomal RNA gene, partial sequence.

8. HQ696994, 541 bp DNA linear, Rajeshwari, R., Jalali, S. K., Venkatesan, T. and Sriram, S. *Wickerhamomyces* sp. Tcy10 internal transcribed spacer 1, partial sequence; 5.8S ribosomal RNA gene, complete sequence; and internal transcribed spacer 2, partial sequence.

9. Rangeshwaran, R. Karmakar, P., Ashwitha, K. and Sivakumar, G. 2011. Partial sequence (completely aligned) of cry1Ab gene of the indigenous *Bacillus thuringiensis* isolate (PDBCBT1) submitted to Genbank (Bankit No. 1437744 GenBank Acc. No. JF501454).

10. Rangeshwaran, R. Karmakar, P., Ashwitha, K. and Sivakumar, G. 2011. Partial sequence of cry1Ab gene of the indigenous *Bacillus thuringiensis* isolate (PDBCBT2) submitted to Genbank (Bankit No. 1437744, GenBank Acc. No. JF501455).

11. Rangeshwaran, R., Karmakar, P., Ashwitha, K. and Sivakumar, G.2011. Partial sequence of cry1Ab gene of the indigenous *Bacillus thuringiensis* isolate (NBAIIBT5) submitted to Genbank (Bankit No. 1437744, GenBank Acc. No. JF501456).

12. Rangeshwaran, R., Karmakar, P., Ashwitha, K. and Sivakumar, G. 2011. Partial sequence of cry1Ab gene of the indigenous *Bacillus thuringiensis* isolate (NBAIIBTAS) submitted to Genbank (Bankit No. 1437744, GenBank Acc. No. JF501457).

13. Sivakumar GenBank submissions

Partial sequence Bacillus megaterium	(NBAII 63) submitted Acc. No HQ162492
Partial sequence Bacillus subtilis	(NBAII 25) submitted Acc. NO HQ162493
Partial sequence Bacillus cereus	(NBAII 7) submitted Acc. NO HQ162494
Partial sequence B. cereus	(NBAII 71) submitted Acc. NO HQ162495
Partial sequence B. cereus	(NBAII 33) submitted Acc. NO HQ162491
Partial sequence B. megaterium	(NBAII 65) submitted Acc. NO HQ162496

7. EDUCATION AND TRAINING

Name	Training programme	Duration	Place
International			
Dr. Deepa Bhagat	Training on "Crop diseases and pest ecological control for developing countries"	24.5.2010 to 4.7.2010	South China Agricultural University, China
Dr. (Mrs.) Y. Lalitha	12th Workshop of the Arthropod Mass rearing and quality control working group of the IOBC	19.10.2010 to 22.10.2010	International Atomic Energy Agency at Vienna, Austria.
Dr. (Mrs.) Ankita Gupta	Training on "Basics of taxonomy: Describing, illustrating and writing biodiversity"	8.11.2010 to 19.11.2010	Sven loven Centre for Marine Sciences, Kristineberg, Sweden.
Ms. R. Gandhi Gracy	Training on "Application of bioinformatics in entomological research"	5.9.2010 to 5.12.2010	Cornell University, Ithaca, New York, USA
National			
Ms. R. Gandhi Gracy	Summer internship at the Bioinformatics Centre	1..7.2010 to 16.7.2010	I.I.Sc. Bangalore
Dr. R. Rangeshwaran	Microbial identification and gene mining: A bioinformatic approach"	1.9.2010 to10.9.2010	NBAIM, Mau, U.P. 275101.
Dr. G. Sivakumar Mr. P. Raveendran	Training on "Research Station management"	11.10.2010 to 16.10.2010	ICRISAT, Patancheru, Hyderabad
Dr. B. Ramanujam Dr. S. K. Jalali	Training on "MDP on Managing Quality in Agricultural Research System"	25.10.2010 to 29.10.2010	IIM, Lucknow.
Dr. Rajkumar	Sensitization training work shop on bioinformatic and its various applications	8.11.2010 to 12.11.2010	NBAII, Bangalore
Dr. D. Sundararaju Mr. P. K. Sankusare	Training on "Strengthening Statistical Computing for NARS"	8-11.2010 to 13.11.2010	USA, Bangalore
Dr. G. Sivakumar	Training on "Metagenomics: Methods and Applications in Microbiology"	11.1.2011 to 20.1.2011	NBAIM, Mau Nath Bhanjan, U.P.
Dr. T. Venkatesan	Training on "Bioinformatics Resources and Tools for Agricultural Research"	24.1.2011 to 29.1.2011	IASRI, New Delhi
Dr. Ankita Gupta	Training on Insect Bioinformatics	7.2.2011 to 17.2.2011	NBAII, Bangalore
Dr. Ankita Gupta	21 days Advanced Training Course on "Biorational Insect Pest management"	17.2.2011 to 9.3.2011	Dept. of Agril. Ento., CAFT, TNAU, Coimbatore
Dr. Rajkumar	Statistical modeling in Agriculture	15.02.2011 to 07.03.2011	IASRI, Delhi
Dr. M. Nagesh	Data Mining and computational methods in bioinformatics for microbial research	4.3.2011 to 15.3.2011	NBAIM, Mau, UP

8. AWARDS AND RECOGNITIONS

NBAII

- University of Mysore has recognized National Bureau of Agriculturally Important Insects as its affiliate Institute for conducting research leading to Ph. D. degree in the field of Zoology, Biotechnology and Microbiology subjects.

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. B. S. Bhumannavar

- Vice-President, Society for Biocontrol Advancement, Bangalore.
- Nodal officer for Project Information and management system of ICAR (PIMS-ICAR)
- Nodal officer for Results Framework Document (RFD) of NBAII
- Vigilance Officer, NBAII
- Chairman, PME Cell, NBAII
- Chairman, ITMU, NBAII for the year 2010-11
- Member-Secretary, ITMC, NBAII for the year 2010-11

Dr. Veenakumari & Dr. Prashanth Mohanraj

- The book entitled "Andaman Nicobar Dweep Samooh Ke Titliyaan" authored by Dr. Veenakumari K., Prashanth Mohanraj, Srivastava, R. C. and Verma, S. K. bagged Dr. Rajendra Prasad Puruskar, an ICAR award under technical Books in Hindi in Agricultural and Allied Sciences for the years 2007-08.

Ms. L. Lakshmi

- Won first prize in Javelin throw and third prize in shotput during ICAR Zonal Sports Meet at Bangalore during 2010-11.

Dr. Deepa Bhagat

- Selected for Training on "Crop diseases and pest ecological control for developing countries" from 24.5.2010 to 4.7.2010 at South China Agricultural University, China.

Ms. R. Gandhi Gracy

- Selected for Training on "Application of bioinformatics in entomological research" from 5.9.2010 to 5.12.2010 at Cornell University, Ithaca, New York, USA.

Dr. (Mrs.) Ankita Gupta

- Selected for Training on "Basics of taxonomy: Describing, illustrating and writing biodiversity" from 8.11.2010 to 19.11.2010 at Sven loven Centre for Marine Sciences, Kristineberg, Sweden.

Dr. (Mrs.) Y. Lalitha

- Received DST Travel Grant for the trip to attend the 12th Workshop of the Arthropod Mass rearing and quality control working group of the IOBC from 19.10.2010 to 22.10.2010 at International Atomic Energy Agency at Vienna, Austria.

YSPUH & F

Dr Usha Chauhan

- Received Netherland fellowship programme for attending ICRA 2010 short course on "Multi-stakeholder processes for knowledge based rural innovation" from 24 January, 2010 to 30 April, 2010 at Wageningen, The Netherlands.

- Received TWAS fellowship (from Academy of Sciences for the Developing World) for attending XIII. International Congress of Acarology at Recife-PE, Brazil from 23-27, August, 2010.

IIHR

Dr. A. Krishnamoorthy

- Chief Editor, Journal of Horticultural Sciences, Society for Promotion of Horticulture, Bangalore
- President, Association for Advancement of Pest Management in Horticultural ecosystems, Bangalore.
- Vice-President, Society for Biocontrol Advancement, Bangalore.
- Appointed as Nodal officer to conduct ICAR UG and PG exams during 17 and 18 April 2010.
- Appointed as Nodal officer to conduct ARS /NET exams by ASRB in 2010.

CPCRI

Dr. Chandrika Mohan

- Oral presentation entitled "Natural enemy complex associated with coconut eriophyid mite, *Aceria guerreronis* Keifer" by Chandrika Mohan, Rajan, P. and Nair, C. P. R. was adjudged as the Best Oral Presentation in the *International Conference on Coconut Biodiversity for Prosperity*.
- Poster presentation entitled "Emerging pests of coconut in India" by Rajan, P., Josephrajkumar, A., Chandrika Mohan and Subaharan, K. was adjudged as the Best Poster in the *International Conference on Coconut Biodiversity for Prosperity*.

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

DNA based early detection of post-harvest diseases in mango, banana and management using consortia of bioagents (NBAII work-Isolation of pathogens and microflora from fruit surfaces of mango for post hasrvest management in collaboration with Dept. of Plant Pathology, TNAU, Coimbatore)

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.

Nanoparticles for enhancing shelf life/storage and field application of semiochemicals.

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).

ICAR-National Fund for Basic, Strategic and Frontier application Research in Agriculture-Funded

Identification of nucleopolyhedrovirus (NPV) encoded proteins and small RNAs and the feasibility of their expression in plant to control Helicoverpa" (NBAII is Co-operating centre and ICGEB, New Delhi is the lead centre)

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	
Central Tobacco Research Institute, Rajahmundry	Tobacco, soybean
CPCRI Regional Centre, Kayangulam	Coconut
Indian Agricultural Research Institute, New Delhi	Basic research
Indian Institute of Horticultural Research, Bangalore	Fruits and vegetables
Indian Institute of Sugarcane Research, Lucknow	Sugarcane
Sugarcane Breeding Institute, Coimbatore	Sugarcane
State Agricultural University-based centres	
Acharya N.G. Ranga Agricultural University, Hyderabad	Sugarcane, cotton and vegetables
Anand Agricultural University, Anand	Cotton, pulses, oilseeds, vegetables and weeds
Assam Agricultural University, Jorhat	Sugarcane, pulses, rice and weeds
Dr. Y. S. Parmar University of Horticulture and Forestry, Solan	Fruits, vegetables and weeds
Govind Ballabh Pant University of Agriculture and Technology, Pantnagar	Plant disease antagonists
Kerala Agricultural University, Thrissur	Rice, coconut, weeds, fruits and coconut
Mahatma Phule Krishi Vidyapeeth, Pune	Sugarcane, cotton, soybean and guava
Punjab Agricultural University, Ludhiana	Sugarcane, cotton, oilseeds, tomato, rice and weeds
Sher-e-Kashmir University of Agricultural Sciences & Technology, Srinagar	Temperate fruits and vegetables
Tamil Nadu Agricultural University, Coimbatore	Sugarcane, cotton, pulses and tomato
Voluntary centres (partiallyfunded)	
Jawaharlal Nehru Krishi Viswavidyalaya, Krishi Nagar, Adhartal, Jabalpur-482 004.	Pulses
Maharana Pratap University of Agriculture & Technology, Udaipur-313 001.	Vegetables, white grubs and termite
Orissa University of Agriculture & Technoogy, Siripur, Bhubaneswar, Khurda-751 003.	Rice, Vegetables
Central Agricultural University, College of Horticulture & Forestry, Pasighat-791 102.	Rice, Vegetables

Voluntary centres

Chaudhary Charan Singh Haryana Agricultural University, Hisar	Sugarcane
College of Agriculture, Kolhapur	White grubs, Weeds
Mahatma Phule University of Agriculture and Technology	Vegetables
National Research Centre for Soybean, Indore	Soybean
National Research Centre for weed Science, Jabalpur	Weeds
Navasari Agricultural University	Sugarcane, Coconut
S.D. Agricultural University	Vegetables
University of Agricultural Sciences, Bangalore	Cotton, pigeonpea
University of Agricultural Sciences, Dharwad	Cotton, chickpea
Vasantdada Sugar Institute, Pune	Sugarcane

11. LIST OF PUBLICATIONS

Research papers published in refereed scientific journals

NBAII

Ankita Gupta, 2010. First record of *Brachymeria jambolana* Gahan (Hymenoptera: Chalcididae) as a pupal parasitoid of *Graphium doson* (C. & R. Felder) (Lepidoptera: Papilionidae). *Journal of Biological control*.**24** (4): 363–365.

Henry, C. S., Brooks, S. J., Johnson, J. B., Venkatesan, T. and Peter, D. 2010. The most important lacewing species in Indian agricultural crops, *Chrysoperla sillemi* (Esben-Petersen), is a subspecies of *Chrysoperla zastrowi* (Esben-Petersen) (Neuroptera: Chrysopidae). *Journal of Natural History*, **44**: 2543-2555.

Joshi, S., Rabindra, R. J. and Rajendran, T. P. 2010. Biological control of aphids. *Journal of Biological Control*, **24** (3): 185-202.

Mohanraj, P, Ali, T. M. and **Veenakumari, K.** 2010. Formicidae of the Andaman and Nicobar Islands (Indian Ocean: Bay of Bengal). *Journal of Insect Science* **10**:172 available online: insectscience.org/10.172

Nagaraja, H. and Prashanth Mohanraj, 2010. A new species of *Trichogramma* (Hymenoptera : Trichogrammatidae) from South India. *Journal of Biological Control*, **24**(4): 297 – 299.

Patil, S., Sriram, S., Naik, M. K. 2010. Plant pathogenic viruses and their use in nanotechnology. *Agrobios Newsletter*, **8**(10): 15-16

Poorani, J. and Slipinski, A. 2010. A review of *Rhynchortalia* Crotch (Coleoptera: Coccinellidae: Ortaliinae). Zootaxa, **2423**: 25-43.

Rangeshwaran, R. Vajid, N. V., Ramanujam, B., Sriram, S., Bhaskaran, T. V., Satendar Kumar, 2010. Additives in powder based formulation for enhanced shelf life of *Pseudomonas fluorescens* and *Bacillus* sp. Journal of Biological Control. **24**: 158-163.

Satpathy S., Shivalingaswamy, T. M., Kumar, A., Rai, A. B. and Rai, M. 2010. Potentiality of Chinese cabbage (*Brassica rapa* subsp. *pekinensis*) as trap crop for diamondback moth, (*Plutella xylostella* L.) management in cabbage. *Indian Journal of agricultural Science*. **80**(3): 238-241

Sriram, S. and Savitha, M. J. 2011. Enumeration of colony forming units of *Trichoderma* in formulations – precautions to be taken to avoid errors during serial dilution. *Journal of Biological Control*. **25**(1): 64-67.

Sriram, S., Palanna, K. B. and Ramanujam, B. 2010. Effect of chitin on the shelf life of *Trichoderma harzianum* in talc formualtion. *Indian Journal of Agricultural Sciences*. **80**(10): 930-932.

Sriram, S., Savitha, M. J. and Ramanujam, B. 2010. *Trichoderma*-enriched coco-peat for the management of *Phytophthora* and *Fusarium* diseases of chilli and tomato in nurseries. *Journal of Biological Control*. **24**(4): 311-316.

Tyagi, K. and Vikaskumar, 2011. The Indian species of Liophloeothrips Priesner (Thysanoptera) Phlaeothriplidae), with one new species. *Zootaxa*, **2803**: 21-31.

Venkatesan, T. Nesil, L.B., Jalali, S. K., shylesha, A. N. and Rabindra, R. J. 2011. Characterization and identification of *Acerophagus papayae* Noyes and Schauff (Hymenoptera: Encyrtidae), an introduced parasitoid of papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink through DNA barcode. *Journal of Biological Control*. **25**(1): 11-13

Yamada, K., Ballal, C. R., Gupta, T. and Poorani, J. 2010. Description of a new species of *Anthocoris* (Hemiptera: Heteroptera: Anthocoridae) from southern India, associated with striped mealybug on purple orchid tree. *Acta Entomologica Musei Nationalis Pragae.* **50**(2): 415-424.

AAU-A

Chakraborty, D. and Korat, D. M. 2010. Biology of green lacewing, *Chrysoperla carnea* (Stephens) in middle Gujarat conditions. *Karnataka Journal of Agricultural Science,* **23**(3) : 500-502.

Chakraborty, D. and Korat, D. M. 2010. Feeding efficiency of green lace wing, *Chrysoperla carnea* (Stephens) on different species of aphids. *Karnataka Journal of Agricultural Science,* **23**(5): 793-794

Dabhi, M. R. and Korat, D. M. 2010. Host preference and site of oviposition by females of *Bracon hebator* Say. *Insect Environment*, **16**(2): 55-57.

Dabhi, M. R. and Korat, D. M. 2010. Copulation and paralyzing behaviour of *Bracon hebator* Say. *Insect Environment*, **16**(2): 59.

Dabhi, M. R., Korat, D. M. and Borad, P. K. 2010. Influence of colour on the oviposition behaviour of *Bracon hebator* Say. *Insect Environment*, **16**(2): 53-54.

Dabhi, M. R., Korat, D. M. and Borad, P. K. 2010. Influence of light sources in attracting adults of *Bracon hebetor* Say. *Insect Environment*, **16**(2): 57-58.

Dike, S. S., Patel, V. J., Korat, D. M. and Mehta, A. M. 2010. Preliminary field evaluation of insecticides against yellow stem borer, *Scirpophagus incertulus* (Walker) infesting rice. *Insect Environment*, **16**(1): 3-5.

Godhani, P. H., Jani, J. J., Patel, R. M. and Yadav, D. N. 2010. Impact of intercropping on natural enemies of insect-pests in cotton. *Research on Crops* **11(2)**: 511-515.

Godhani, P. H., Patel, R. M., Bhaskar H., Jani, J. J., Yadav, D. N., Korat, D. M. and Patel. B. H. 2010. Evaluation of bio-intensive pest management (BIPM) module in cotton. *GAU Research Journal*, **35**(1): 35-39.

Korat, D. M., Chakraborty, D. and Dabhi, M. R. 2010. Bio-Intensive approaches in suppression of *Helicoverpa armigera* (Hubner) in Gujarat. *Green Farming*, **1** (1): 102-105.

Patel, B. H., Godhani, P. H. and Korat, D. M. 2010. Efficacy of Biosoft *Beauveria bassiana* (Bals.) Vuill against diamond back moth, *Plutella xylostella* (L) on cabbage. *Indian Journal of Applied Entomology*, **24**(1): 36-39.

Patel, B. H., Koshiya D. J., Korat D. M. and Vaishnav, P. R. 2010. Significance of irrigation intervals and nitrogen levels in management of chilli thrips, *Scirtothrips dorsalis* Hood. *Indian J. Appl. Entomol.*, **24** (1): 93-95.

Patel, C. S., Jani, J. J., Parekh, V. B., Darji, V. B. and Vaishnav, P. R. 2010. Geographic variations and their impact on bioefficacy amongst *Helicoverpa armigera* Nuclear Polyhedrosis Virus isolates from India. *World Journal of Microbiol Biotechnology*, **26**:783–794.

Patel, S. K., Patel, B. H. and Korat, D. M. 2010. Effect of organic manures and its combination with inorganic fertilizers on insect pests infesting cowpea. *Indian Journal of Applied Entomology*, **24**(1): 27-31.

Patel, S. K., Patel, B. H., Korat, D. M. and Dabhi, M. R. 2010. Seasonal incidence of major insect pests of cowpea, *Vigna unguiculata* (Linn.) Walpers in relation to weather parameters. *Karnataka Journal of Agricultural Science*, 23(3): 497-499.

CPCRI

Chandrika Mohan, Radhakrishnan Nair, C.P., Kesavan Nampoothiri, C. and Rajan, P. 2010. Leaf-eating caterpillar (*Opisina arenosella*)-induced yield loss in coconut palm. *International Journal of Tropical Insect Science*, **30**:132-137.

Chandrika Mohan and Rajan, P. 2010. Biology of *Campsomeriella collaris* Fab., a natural enemy of coconut white grub, *Leucopholis coneophora* Burm. *Insect Environment*, **15**(4): 167-168.

Chandrika Mohan, Rajan, P., Nair, C. P. R., Sunny Thomas and Anithkumari, P. 2010. Farmer friendly production technology of the green muscardine fungus for the management of rhinoceros beetle. *Indian Coconut Journal*, **53**(7): 27-30.

Josephrajkumar, A., Rajan, P., Chandrika Mohan and Thomas, R. J. 2011. First record of Asian grey weevil (*Myllocerus undatus*) on coconut from Kerala, India. *Phytoparasitica,* **39**(1): 63-65.

Josephrajkumar, A., Rajan, P., Chandrika Mohan and Jacob, P. M. 2010. Re-invasion and bio-suppression of spiralling whitefly, *Aleurodicus dispersus* Russell on coconut in Minicoy Island. *Indian Coconut Journal,* **53**(2): 20-23.

Josephrajkumar, A., Rajan, P., Chandrika Mohan and Namboothiri, C. G. N. 2011. Diversity and management of scale insects infesting coconut. *Indian Coconut Journal,* **53**(9): 25-29.

Rajan, P., Chandrika Mohan and Josephrajkumar, A. 2010. Have coconuts without pest infection. *Indian Horticulture,* **55**(5): 33-37.

IIHR

Ganga Visalakshy, P.N., Mani, M., Krishnamoorthy, A. and Pillai, K. G. 2010. Epizootics of *Entomophthora* sp. on mango inflorescence hopper, *Idioscopus nitidulus* (Walker). *Journal of Biological Control,* **24**(3): 274–275.

Sharma, D., Krishnamoorthy P. N. and Krishnamoorthy, A. 2009. Comparative study of pesticide residue pattern in vegetables grown using IPM and non-IPM practices, *Journal of Horticultural Science, 4(2): 191-194.*

KAU

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

Lyla, K. R. and Philip, B.M. 2010. Incidence of papaya mealy bug *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae) in Kerala. *Insect Environment,* **15**(4): 156.

Lyla, K. R., Philip, B. M. and Sinish, M. S. 2011. Field release and establishment of *Cecidochares connexa* (Macquart) (Diptera: Tephritidae) on *Chromolaena odorata* (L.) King and Robinson in Kerala. *Journal of Biological Control,* **25**(1): 58-59.

MPKV

Pokharkar, D. S., Nakat, R. V., Tamboli, N. D., Dhane, A. S., Jadhav, S. S., Chandele, A. G. and Rabindra, R. J. 2010. Occurrence of *Acerophagus papayae* Noyes and Schauff (Hymenoptera: Encyrtidae) on papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink, in Pune region of Maharashtra state. *Journal of Biological Control,* **24** (3): 291.

Pokharkar, D. S., Kale, I. K. and Pawar, D. B. 2011. Management of onion thrips (*Thrips tabaci* L.) through varietal screening and newer insecticides. *Journal of Agricultural Research and Technology,* **36**(2): 237-240.

PAU

Aggarwal, N. and Dhawan, A. K. 2010. Impact of insecticide resistance management on pest complex in cotton and monitoring studies in *Helicoverpa armigera* (Hubner). *Indian Journal of Ecology,* **36**(2): 170-73.

Aggarwal, N. Jindal, V. and Vikram, S. 2010. Comparative efficacy of insecticides against sucking pests' complex in transgenic cotton. *Pestology,* **34**(8): 46-49.

Joshi, N., Virk, J. S. and Brar, K. S. 2010. Efficacy of a *Bacillus thuringiensis* var. *kurstaki* Berliner formulation against shoot and fruit borer, *Leucinodes orbonalis* Guenee on Brinjal. *Journal of Insect Science,* **23**(2):121-124.

Kaur, H., Virk, J. S. and Kaur, R. 2010. Biology of Australian ladybird beetle *Cryptolaemus montrouzieri* Mulstan on mealybug *Phenacoccus solenopsis* Tinsley. *Journal of Biological Control,* **24**(2): 155-57.

Sharma, S., Virk, J. S, Kaur, R., Aggarwal, N. and Mahal, M. S. 2010. Monitoring Studies on natural parasitization of Cotton Mealy Bug *Phenacoccus solenopsis* Tinsley by parasitoid, *Aenasius bambawalei* Hayat in Punjab. *Indian Journal of Ecology,* **37**(2): 226-228.

Virk, J. S. and Sarao, P. S. 2010. Comparative bioefficacy of insecticides against brown plant hopper, *Nilaparvata lugens* (Stal.) on paddy. *Indian Journal of Plant Protection,* **38**(1): 101-103.

TNAU

Durairaj, C., Karthikeyan, G., Ganapathy, N. and Karuppuchamy, P.2010. Predisposition effect of *Liriomyza trifolii* damage to Alternaria leaf spot disease in tomato. *Karnataka Journal of Agricultural Science,* **23**(1): 161-162.

Ganapathy, N., Durairaj, C. and Karuppuchamy, P. 2010. Bio-ecology and management of serpentine leaf miner, *Liriomyza trifolii* (Burgess) in cowpea. *Karnataka Journal of Agricultural Science,* **23**(1): 159-160.

Mahalkshmi, V., Kalyanasundaram, M., Karuppuchamy, P. and Kannan, M. 2010. Bioecology and Management of Cotton mealy bug. *Entomon,* **35**(2):11-17.

Suresh, S., Jothimani, R, Sivasubramanian, P., Karuppuchamy, P., Samiappan, R. and Jonathan, E. I. 2010. Invasive mealybugs of Tamil Nadu and their management. *Karnataka Journal of Agricultural Science,* **23**(1): 6-9.

SKUAS & T

Ahmad, M. J. 2009. A new species of *Brachymeria* Westwood (Hymenoptera: Chalcididae) on rice skipper, *Parnara guttata* (Lepidoptera : Hesperiidae) from South Kashmir. *Journal of the Bombay Natural History Society,* **106**(2): 198-200.

Ahmad, M. J. and Singhara, G. S. 2010. Yield loss assessment of rice cultivars by granivorous birds at pre harvest. *Annals of Plant Protection Sciences,* **18**(2): 521-522.

Ahmad, M. J., Yaqoob, M. and Sajad, M. 2010. Seasonal abundance of leaf miner *Chromatomyia horticola* (Goureau) (Diptera: Agromyzidae) on brown sarson, *Brassica campestris,* and role of its *Diglyphus* parasitoids (Hymenoptera: Eulophidae) in Kashmir valley. *Journal of Biological Control,* **24**(4): 300-304.

YSPUH & F

Ajay Sharma, Usha Chauhan, Gupta, P. R. 2010. Bioefficacy of some biopesticides and its effects on various biological parameters of two spotted spider mite *Tetranychus urticae* Koch (Acari: Tetranychdiae) on sweet pepper, *Capsicum annum. Journal of Entomological Research,* 34(3): 195-202.

Papers presented in symposia/ seminar/ workshops

International

IIHR

Ganga Visalashy, P. N. and Krishnamoorthy, A. 2010. Comparative field efficacy of various entomopathogenic fungi against *Thrips tabaci*: Prospects for Organic Production of Onion in India. 28th International Horticultural Congress, Lisbon-Portugal, 22-27 August 2010.

Ganga Visalakshy, P. N. 2010. Status of Biological control of *Parthenium hysterophorus* by *Zygogramma bicolorata* in India.1st IOBC International Workshop on Biological Control and Management of *Parthenium hysterophorus Nairboi, Kenya, 1-5.10.2010, Kenya.*

YSPUH & F

Usha Chauhan, Gupta, P. R. and Sharma, A. 2010. Management of two spotted spider mite, *Tetranychus urticae* Koch on Carnation with the help of biopesticides and predator *Neoseiulus longispinosus* Evans (Acari: Phytoseiidae). Paper presented in XIII International Congress of Acarology at Recife-PE, Brazil, August, 23-27, 2010.

Usha Chauhan. 2010. Predators of the plant feeding mite, *Tetranychus cinnabarinus* Boisdual in Solan, Himachal Pradesh, India. Audio-Video presented in XIII International Congress of Acarology at Recife-PE, Brazil, August, 23-27, 2010.

Usha Chauhan. 2010. Mass rearing of *Neoseiulus longispinosus* (Evans) (Acari:Phytoseiidae) under field and laboratory conditions in Himachal Pradesh in India. Paper presented at AMRQC 12th Workshop at Vienna International Centre, Vienna, Austria from 19-22 October 2010.

National

NBII

Ankita Gupta, Ballal, C. R. and Rabindra, R. J. 2010. Role of women in biodiversity in different agroecosystems. *In*: National Seminar on Gender and biodiversity organized by DRWA & UNDP, National Biodiversity Authority, Chennai, Bhubaneshwar 28th -29th , Dec, 2010. pp. 12-14.

Ballal, C. R. and Bakthavatsalam, N. 2010. Physical and chemical attributes of host plants in tri-trophic interactions. During 34th Annual Conference of the Ethological Society of India and National Conference – Colloquium on Ethology from organism down to Ethobiomolecule (ECEODE 2010) 16 - 18

December, 2010, p-10-11, Abstract Book, 65pp.

Gupta, T. and Ballal, C. R. 2011. Field evaluation of an anthocorid predator *Blaptostethus pallescens* Poppius against *Thrips tabaci* Lindeman on onion. In *National Symposium on Alliums: Current Scenario and Emerging Trends,* 12 to 14th March, 2011, Organised by Indian Society of Alliums, Directorate of Onion and Garlic Research, Pune, p. 233.

Sriram, S. and R. Rajeshwari, R . 2010. Bio-control potential of selected chitinase producing isolates of *Trichoderma virens*. Accepted for Poster presentation at *"Molecular Approaches for Management of Fungal Diseases of Crop Plants"* held during 27-30 December, 2010.

Sriram, S., Savitha, M. J and Sharma, Y. 2010. Oligonucleotide-barcode based identification of native *Trichoderma* isolates antagonistic to cumin wilt pathogen *Fusarium oxysporum* f. sp. *Cuminis*. Accepted for Poster presentation at *"Molecular Approaches for Management of Fungal Diseases of Crop Plants"* held during 27-30 December, 2010.

Ramanujam, B., Bhasha, H., Vinaya, H., Rangeshwaran, R and Sriram, S. 2010. Mass production and formulation of promising yeast antagonists of chilli anthracnose pathogen, *Colletotrichum capsici*. Oral Presentation made at *"Molecular Approaches for Management of Fungal Diseases of Crop Plants"* held during 27-30 December, 2010.

Ramanujam, B., Vinaya, H., Bhasha, H., Rangeshwaran. R. and Sriram, S. 2010. Screening of bacterial and yeast isolates against chilli anthracnose pathogen, *Colletotrichum capsici* by fruit bioassay. Poster presentation at *"Molecular Approaches for Management of Fungal Diseases of Crop Plants"* held during 27-30 December, 2010.

Ramanujam, B., Srinivasa, N., S. Sriram, S and Rangeshwaran, R. 2010. Evaluation of fungal and bacterial antagonists against *Alternaria* blight of tomato. Poster presentation at *"Molecular Approaches for Management of Fungal Diseases of Crop Plants"* held during 27-30 December, 2010.

Yamada, K., Bindu, K., Nasreem, A., Nasser, M., Ballal, C. R. And Poorani, J. 2010. The flower bugs found in agro-ecosystems of Southern India (Heteroptera Anthocoridae). Presented at the Fourth Quinquennial Meeting of the International Heteropterists Society, July 12-12, 2010 in Tianjin, China.

AAU-A

Jani, J. J., Patel, A. D., Patel, B. A. and Korat, D. M. 2010. "Evaluation of biocontrol agents, organic amendments and chemicals against *Hetrodera cajani* infecting pigeonpea" Paper presented at session 4 on Disease Management of 32nd Annual Conference 7 Symposium on *Innovations in Plant Pathology research & Human resource Development* organized by Junagadh Agricultural University, Junagadh & Indian Society of Mycology & Plant Pathology on November 24026, 2010.

Jani, J. J. 2011. Intimidation level of resistance against genetically modified insect resistant cotton: Indian perspective. Lead paper presented at National seminar on *"Pest Management through Transgenesis in Agroecosystem"* organized by Dept. of Entomology, MPUAT, Udaipur during February 25-26, 2011.

Parvez Noushad and J. J. Jani. 2011. Success avenue of modern trends of crop production in India: Nine years of *Bt* cotton. paper presented at National seminar on *"Pest Management through Transgenesis in Agroecosystem"* organized by Dept. of Entomology, MPUAT, Udaipur during February 25-26, 2011.

Patel Ankit and Jani. J. J. 2011. Present Indian regulatory system and approaches for netically modified crops. Paper presented at National seminar on *"Pest Management through Transgenesis in Agroecosystem"* organized by Dept. of Entomology, MPUAT, Udaipur during February 25-26, 2011.

Patel, B, H., Nikam, N. D. and Korat D. M. 2010. Biology of cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera:Pseudococcidae) in laboratory. A paper presented in 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.

Patel, B, H., Patel, H. M., Patel, B. K. and Korat D. M.2010. Seasonal abundance and extent of parasitism due to *Aenasius bambawalei* Haya on cotton mealy bug in middle Gujarat. A paper presented in *National Confernce on paradigm shift in cotton research and cultivation* organized at Surat by NAU, Navsari during 19 to 21, October 2010.

Patel, B. H., Patel, H. M., Solanki, R. F. and Korat, D. M. 2011. "Impact of cropping patterns on some predatory fauna of insect pests infesting *Bt* cotton". paper presented at National seminar on *"Pest Management through Transgenesis in Agroecosystem"* organized by Dept. of Entomology, MPUAT, Udaipur during February 25-26, 2011.

Patel, C. S., Jani, J. J. and Parekh, V. B. 2011. Diversity of the 25K FP gene amongst four wild type Indian geographic isolates of *Helicoverpa armigera* nucleopolyhedrovirus. Paper presented at National seminar on *"Pest Management through Transgenesis in Agroecosystem"* organized by Dept. of Entomology, MPUAT, Udaipur during February 25-26, 2011.

Patel, H. M., Patel, B. H., Solanki R. F. and Korat, D. M. 2011. Demonstration of crop diversity in suppression of insect pests infesting *Bt* cotton. Paper presented at National seminar on *"Pest Management through Transgenesis in Agroecosystem"* organized by Dept. of Entomology, MPUAT, Udaipur during February 25-26, 2011.

Pathak Lenna and Jani. J. J. 2011. Impact of genetically modified crops (GMC) on native soil microorganisms. Paper presented at National seminar on *"Pest Management through Transgenesis in Agroecosystem"* organized by Dept. of Entomology, MPUAT, Udaipur during February 25-26, 2011.

Solanki, R. F., Patel, B. H., Patel H. M. and Korat, D. M. 2011. Extent of parasitism due to *Aenasius bambawalei* Hayat on mealy bug infesting *Bt* cotton. Paper presented at National seminar on *"Pest Management through Transgenesis in Agroecosystem"* organized by Dept. of Entomology, MPUAT, Udaipur during February 25-26, 2011.

CPCRI

Anithakumari, P. And Chandrika Mohan 2010. Biocontrol of rhinoceros beetle in coconut-participatory adaptationof low input multiplication of *Metarhizium anisopliae* fungus and bridging adoption gap. Paper presented in *International Conference on Coconut Biodiversity for prosperity,* CPCRI, Kasaragod 25-28 October 2010. p181-182.

Chandrika Mohan, Josephrajkumar, A. and Rajan, P. 2010. Biological methods of pest management in coconut pp 91-101 In: *International Conference on Coconut Biodiversity for Prosperity* (Eds.) George V. Thomas, D. Balasimha, V. Krishnakumar, A. Jerard and R. Bhat, Central Plantation Crops Research Institute, Kasaragod, 25-28, October, 2010.

Chandrika Mohan, Rajan, P. and Nair, C.P.R. 2010. Natural enemy complex associated with coconut eriophyid mite, *Aceria guerreronis* Keifer. *Oral presentation in International Conference on Coconut Biodiversity for Prosperity*, Central Plantation Crops Research Institute, Kasaragod, 25-28, October, 2010, p 124.

Rajan, P., Josephrajkumar, A., Chandrika Mohan and Subaharan, K. 2010. Emerging pests of coconut in India. *Poster presentation in International Conference on Coconut Biodiversity for Prosperity*, Central Plantation Crops Research Institute, Kasaragod, 25-28, October, 2010, p 134.

Sneha Soman and Chandrika Mohan. 2010. Compatibility of *Metarhizium anisopliae* (Metsch.) Sorokin with some chemical and botanical pesticides used in coconut pest management. *Poster presentation in XIX PLACROSYM,* RRII, Kottayam, December 7-10, 2010, p195-196.

IIHR

Ganga Visalashy, P. N. and Krishnamoorthy, A. 2011. Relative field efficacy of entomopathogens against *Thrips tabaci*. Paper presented in *National Symposium on Alliums emerging trends* held by Society for Alliums at Pune from 12-14 March, 2011.

Krishnamoorthy, A. 2010. Biological Control of whitefly. Paper presented during one day group meeting on Management of whiteflies in agricultural and Horticultural crops. Held at IIHR, Bangalore, 17 May, 2010.

MPKV

Chandele, A. G., Nakat, R. V., Pokharkar, D. S., Tamboli, N. D. and Dhane A. S. 2011. Invasion of papaya mealybug, *Paracoccus marginatus* W & G (Hemiptera: Pseudococcidae) and its natural enemies in Maharashtra. Paper presented in the *'International Conference on Biodiversity and its Conservation'* held at Modern College of Arts, Science and Commerce, Pune on 28-30, January 2011.

Nakat, R. V., Pokharkar, D. S., Dhane, A. S. and Tamboli, N. D. 2010. Biocontrol impact of *Acerophagus papayae* N & S on papaya mealybug, *Paracoccus marginatus* W & G in Pune region of Maharashtra. Paper presented in *'National consultation on strategies for development and conservation of imported parasitoids of papaya mealybug'* held at NBAII, Bangalore on 30th October 2010.

Chandele, A. G., Nakat, R. V., Pokharkar, D. S., Tamboli, N. D. and Dhane, A. S. 2010. Status of papaya mealybug, *Paracoccus marginatus* W & G (Hemiptera: Pseudococcidae) in Maharashtra. Paper presented in *'National consultation on strategies for development and conservation of imported parasitoids of papaya mealybug'* held at NBAII, Bangalore on 30th October 2010.

PAU

Joshi, N, Jana, S. and Virk, J. S. 2010. Effect of *Bacillus thuringiensis* isolates at different concentrations of spore crystal toxin complex on larval mortality of *H. armigera* In National symposium on *"Perspective and Challenges of Integrated Pest Management for Sustainable Agriculture"* held at YSPUH&F, Nauni (Solan) , from November 19-21, 2010. Abstract No 5.40, Page 174.

Joshi, N., Kaur, R. and Virk, J. S. 2010. Efficacy of fungal isolates for management of *Spodoptera litura* (Fabricius). In third Biopesticide Conference held at CCC, HAU Hisar from 20-22, October, 2010. Abstract No PP-21, Page 159-60.

Kaur, R., Joshi, N., Virk, J. S. and Sharma, S. 2010. Evaluation of biocontrol technologies for the management of foliar diseases and fruit borer incidence in tomato. In *National Symposium on Perspectives and Challenges of Integrated Pest Management for Sustainable Agriculture*, November 19-21,2010, Dr Y S Parmar University of Horticulture & Forestry, Nauni, Solan, Himachal Pardesh. Abstract No. 6.19, Page 202.

Kaur, R. and Virk, J. S. 2010. Comparetive field efficacy of Arrhenotokous and Thelytokous populations of *Trichogramma pretiosum* Riley against the tomato fruit borer *Helicoverpa armigera* (Hubner). In *third Biopesticide Conference* held at CCC, HAU Hisar from 20-22, October, 2010. Abstract No PP-3, Page 123-24.

Virk, J. S, Aulakh, C. S., Kaur, R., Joshi, N. and Shama, S. 2010. Evaluation of egg parasitoids *Trichogramma chilonis* Ishii and *T. japonicum* Ashmead for the management of leaf-folder and stem borer on organic and inorganic *basmati* rice. In *National Symposium on Perspectives and Challenges of Integrated Pest Management for Sustainable Agriculture*, November 19-21, 2010, Dr Y S Parmar University of Horticulture & Forestry, Nauni, Solan, Himachal Pardesh. Abstract No. 3.29, Page 96.

Virk, J. S and Dhawan, A. K. 2011.Possible impact of climate changes on arthropod natural enemies- A prediction. In International Conference on *"Preparing Agriculture for Climate Change"* held at Punjab Agricultural University Ludhiana. 6-8 February, 2011, pp. 224-25 (Abst).

Virk, J. S., Joshi, N., Kaur, R., Sharma, S. and Mahal, M. S. 2010. Field demonstration of the effectiveness of *Trichogramma chilonis* Ishii against *Chilo auricilius* Dudgeon in Punjab. In third Biopesticide Conference held at CCC, HAU Hisar from 20-22, October, 2010. Abstract No PP-4, Page 125-26.

Virk, J. S. and Joshi, N. 2011 . Microbes as bio control agents for the management of bee wax moths. In: Experience exchange workshop on *"Prospects and promotion of apiculture for augmenting hive & crop productivity"* held at Punjab Agricultural University Ludhiana. Feb. 23-24, 2011 pp 232-33 (Abst).

Virk , J. S., Kaur, R. and Sharma, S. 2011. Role of parasitoids in the management of bee wax *moth* species. In: Honey Festival-cum-Experience Exchange Wokshop on Prospects and Promotion of Apiculture for Augmenting Hive & Crop Productivity. 22-24 February, 2011, PAU, Ludhiana. Abstract No. 4.9, Page 235-236.

TNAU

Kalyanasundaram, M., Sivakumar, S., Karuppuchamy, P. and Samiyappan, R. 2010. Ecofriendly management of mango nut weevil *Sternochetus mangiferae* (Fabricus) using red ant *Oecophylla smaragdina*. Paper presented in the *National conference on Plant protection in Agriculture through Eco-friendly Techniques and Traditional farming practices*, organized by the Entomological Research Association, Udaipur held between 18 and 20 February 2010.

YSPUH & F

Kumar Ajay, Sharma, P.L. and Gupta, P. R. 2010. Laboratory evaluation of local isolate of *Nomuraea rileyi* (Farlow) Samson against *Spodoptera litura* (Fabricius) (Noctuidae: Lepidoptera). Paper presented at National Symposium on *"Perspectives and Challenges of Integrated Pest Management for Sustainable Agriculture"* organized by Indian Society of Pest Management and Economic Zoology at Dr Y.S. Parmar University of Horticulture and Forestry, Solan, November 19-21, 2010.

Usha Chauhan and Bakshi, A. K. 2010. Natural enemies of the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood) in mid-hill regions of Himachal Pradesh. Paper presented in National Symposium on *"Perspectives and Challenges of Integrated Pest Management for Sustainable Agriculture"* organized by Indian Society of Pest Management and Economiv Zoology at Dr Y.S. Parmar University of Horticulture and Forestry, Solan, November 19-21, 2010.

Book chapter/ Scientific reviews

NBAII

Rai, A.B., Shivalingaswamy, T. M., Satpathy, S., Pandey, K. K. and Rai, M. 2010. *Emerging trends and strategies for the management of pests and diseases in vegetable crops*. IIVR, Varanasi. 216pp.

Shivalingaswamy, T. M., Satpathy, S and Rai, A.B. 2010. Recent Advances in Management of Insect Pests of Vegetables Crops In: *Sustainable crop protection strategies*, (Eds.) H.R. Sardana, O.M. Bambawale and D. Prasad, Vol.2, Daya Publishing House, New Delhi, 819pp

Sreerama Kumar, P. and Leena Singh. 2010. Comprehending the potential of non-host-specific acarophilic fungal species in the control of *Tetranychus urticae*. *In:* Abstract Book, *Thirteenth International Congress of Acarolgy*, August 23-27, 2010, Recife-PE, Brazil, p. 266 (Abstract No. 492).

Sreerama Kumar, P. and Leena Singh. 2010. Microbial natural enemies of mites, pp. 173-181. *Advances in Agricultural Acarology*. Compendium, ICAR-Sponsored Summer School Advances in Agricultural Acarology, 08-28 October 2010 (Eds Srinivasa, N., Mallik, B. and Chinnamade Gowda, C.). All-India Network Project (Agricultural Acarology) & Department of Agricultural Entomology, University of Agricultural Sciences, Bangalore.

Veenakumari, K., Prashanth Mohanraj, Srivastava, R. C.and Verma, S. K. 2009. *"Andaman Nicobar Dweep samooh Ke Titliyaan"*. Central Agricultural Research Institute, Port Blair, Andaman and Nicobar islands, India p. viii+186.

AAU-J

Barkataky, R. N., Basit, A. and Hazarika, L. K. 2010. *Water hyacinth weevil: An appropriate bio-control agent*. Lap Lambert Academic Publisher AG & Co K.G. Germany, 72 pP.

CPCRI

Chandrika Mohan. 2010. Biological control of rhinoceros beetle using *Oryctes rhinoceros* virus. P 100-110. *In: Harnessing the potential of Biopesticides against pests and diseases; its implications in sustainable crop protection*. November 9-29, 2010, TNAU, Coimbatore

Chandrika Mohan, Rajan, P. and Josephrajkumar, A. 2010. Strategies to manage black headed caterpillar infestation in coconut. In: *In a Nutshell: Essays on Coconut* (Ed.) CV Ananda Bose, Coconut Development Board, Kera Bhavan, Kochi 185-190p.

Josephrajkumar, A., Rajan, P. and Chandrika Mohan 2010. Scale insects, mealybugs and whiteflies of coconut palm and their management. In: *In a*

Nutshell: Essays on Coconut (Ed.) C. V. Ananda Bose, Coconut Development Board, Kera Bhavan, Kochi, 199-206 p.

Nair, C. P. R., Rajan, P., Chandrika Mohan and Josephrajkumar, A. 2010. Rhinoceros beetle and Red palm weevil-two major pests of coconut palm in India. In: *In a Nutshell: Essays on Coconut* (Ed.) C.V. Ananda Bose, Coconut Development Board, Kera Bhavan, Kochi pP.178-184.

Rajan, P. Chandrika Mohan and Josephrajkumar, A. 2010. Coconut eriophyid mite, *Aceria guerreronis* Keifer. In: *In a Nutshell: Essays on Coconut* (Ed.) CV Ananda Bose, Coconut Development Board, Kera Bhavan, Kochi, 191-198 p.

TNAU

Jeyarani, S., Karuppuchamy P. and Sathiah, N.2010. Characterization of geographical isolates of *Helicoverpa armigera* Nucleopolyhedrovirus (HaNPV) In *"Non chemical Insect Pest Management"* (Eds: Dr. S. Ignacimuthu and B.V.David) Elite Publishing House Pvt. Ltd, New Delhi. P 116-122.

Kalyanasundaram, M., P.Karuppuchamy, M.Kannan and M.Suganthi. 2010. *Dipha aphidivora* (Meyrick), a potential bioagent for the management of sugarcane woolliy aphid. In *"Non chemical Insect Pest Management"* (Eds: Dr. S. Ignacimuthu and B.V.David) Elite Publishing House Pvt. Ltd, New Delhi. P 164-168.

Popular articles/ Technical/ Extension/ Bulletins/ Reports

NBAII

Shylesha, A. N., Joshi, S., Rabindra, R. J. and Bhumannavar, B.S. 2010. Classical biological control of the papaya mealybug. *Technical Folder*, National Bureau of Agriculturally Important Insects, Bangalore, 4 pp.

Shylesha, A. N., Joshi, S., Rabindra, R. J. and Bhumannavar, B.S. 2010. Classical biological control of the papaya mealybug. *Technical Folder* (In Bengali Language), National Bureau of Agriculturally Important Insects, Bangalore, 4 pp.

AAU-J

Basit, A. 2010. Su-songhoto Padhatire Kit Patanga Nityantran, Dainik Janambhumi 1st July, 2010. (Regional language)

Saikia, D. K. 2010. Sak Pasaleer Kit Patangar Aru Rugar Samanbit Niyantan Bibastha, March, 2010. (Regional language)

Saikia, D. K.and Basit, A. 2011. Jaibik Padhatire Kit Patanga Niyantranor Byabostha. Asomiya Khobor (Regional Language)

KAU

Lyla, K. R. and Manichellappan. 2011. *Mealymoottakkethire mithrakeedangal Kerala Karshakan January 2011*. Published by Farm Information Beureau, Kerala. pp.38-39.

Lyla, K. R. 2011. AICRP on Biological Control of Crop Pests and Weeds, Vellanikkara, Kerala Extension Bulletin.

Lyla, K. R. 2011. Jaiveeka Roga Keeda Niyanthrana upadhikalum upayogikkenda reethikalum (Malayalam)

Lyla, K. R. and Manichellappan. 2011. Papaya mealymoottayude Jaiveekaniyanthranam (Malayalam)

MPKV

Pokharkar, D. S. and Nakat, R. V. 2010. Mass production technique of *Cryptolaemus montrouzieri*, a predator of mealy bug. *Drakshavrutta*, June, 2010, pP. 10-11.

Pokharkar, D. S., Nakat, R. V., Jadhav, S. S., Tamboli, N. D. and Dhane, A. S. 2010. New record of Papaya mealy bug in Pune region in news papers 'Daily SAKAL' and 'AGRO-WON' on 4th August, 2010.

Pokharkar, D. S., Nakat, R. V., Jadhav, S. S., Tamboli, N. D. and Dhane, A. S. 2010. New record of papaya mealybug parasitoid, *Acerophagus papayae* in 'AGRO-WON' on 31st August 2010.

Pokharkar, D. S. and Nakat, R. V. 2010. Management of insect pests in grape orchards using biocontrol agents. *Drakshavrutta, Golden Jubilee seminar-2010 of MRDBS, Pune* held on September 26-27, 2010, pp. 93-97.

Dr. Pokharkar, D. S. 2010. New record of Papaya mealy bug in Pune region in news paper *Indian Express* on 5th September, 2010.

Dr. Pokharkar, D. S. 2010. Management of mealy bugs in grape with natural enemies in *AGRO-OWN* dated, 10th October 2010.

Dr. Pokharkar, D. S. 2010. *Mitra kitakane wachavali papayachi bagh* (The bioagents saved the papaya orchards from the ravages of mealy bugs) published in AGRO-WON dated 14th December 2010.

Pokharkar, D. S., Nakat, R. V., Tamboli, N. D. and Dhane, A. S. 2011. Control of mealy bugs in custard apple orchard. *Bhusawanardhan*, 3(10): 29-31.

Nakat, R. V. and Tamboli, N. D. 2011. Lowering of Betelvine. *Bhusawardhan*, **3**(10): 26-28.

Dhane, A. S., Tamboli, N. D. and Nakat, R. V. 2011. Integrated pest management of aphids. *Bhusawanardhan*, **3**(12): 21-25.

Nakat, R. V., Tamboli, N. D. and Dhane, A. S. 2011. Biointensive pest management of mealy bugs. *Bhusawanardhan*, **3**(12): 26-30.

PAU

Aggarwal, N., Jindal, J. and Brar, D. S. 2011. Pest management in spring maize for higher yield. Progressive Farming, **47**(2): 8-10.

Aggarwal, N., Jindal, J. and Brar, S. .P S. 2011. Bahar ruti makki: Vadh jhar lye kire makudian di rokhtham. Changi Kheti **47**(2): 14-16.

Aggarwal, N. and Jindal, J. 2010. Makki de kwality beej utpadan lye paudh surakhia de visesh dhang. Training Manual, Directorate of Extension education. Pp. 18-21.

TNAU

A pamphlet in Tamil on papaya mealy bug management was prepared and distributed to the farmers and extension functionaries.

A brochure Tamil on papaya mealy bug management through parasitoids was prepared and distributed to the farmers and extension functionaries.

CPCRI

Anithakumari, P. and Chandrika Mohan 2010. Green fungus against black beetle. *Kerala Karshakan*, 56 (1): 20-23.

Chandrika Mohan and Anithakumari, P. 2010. Women friendly biocontrol methods for management of rhinoceros beetle - a practical note (Malayalam). Information booklet No 3/10. CPCRI (RS) Kayamkulam.

Chandrika Mohan, Rajan, P. and Anithakumari, P. 2010. Farm level production of green muscardine fungus for the management of rhinoceros beetle. Extension booklet, CPCRI, Regional Station, 8 p.

Chandrika Mohan and Josephrajkumar, A. 2010. *Black headed caterpillar of coconut- Training on technological updates.* 10-12 November, 2010, 29 p.

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. Biodiversity of economically important Indian Microgastrinae (Braconidae) supported by molecular phylogenetic studies
6. Development of production protocols and evaluation of anthocorid predators
7. Biodiversity of aphids, coccids and their natural enemies
8. Polymorphism in pheromone reception in *Helicoverpa armigera*
9. Influence of elevated levels of carbon di oxide on the tritrophic interactions in some crops
10. Semiochemicals for the management of coleopteran pests
11. Formulations of pheromones of important borer and other crop pests and kairomones for natural enemies using nanotechnology
12. Attractants for natural enemies of rice pests for use in the conservation of natural enemies
13. Studies on bee pollinators in crop-ecosystems with special reference to pulses and oilseed crops
14. In situ conservation of natural enemies and pollinators in pigeon pea and sunflower ecosystems
15. Isolation, identification and characterization of endosymbionts of trichogrammatids and their role on the fitness attributes
16. Studies on molecular characterization and identification of endosymbionts of chrysopid predators and their role on the biological attributes
17. Studies on *Trichogramma brassicae* and *Cotesia plutellae* interaction with their host in cabbage ecosystem
18. Molecular characterization of Indian coccinellids
19. Phytophagous mites as a source of microbes for harnessing in pest management
20. Interactions of microbial control agents in diverse soil types
21. Standardization of solid state fermentation conditions and development of prototypes with semi-automation for the mass production of *Trichoderma* spp., *Metarrhizium anisopliae* and *Beauveria bassiana*
22. Management of bacterial wilts of tomato land brinjal caused by *Ralstonia solanacearum* through *Bacillus* spp.
23. Evaluation of fungal pathogens on *Aphis craccivora* in cowpea and *Bemisia tabaci* in tomato and capsicum
24. Isolation, characterization and toxicity of indigenous *Bacillus thuringiensis* strains against lepidopterous pests
25. Bio-intensive management of root-knot nematode and /Fusarium disease complex in tomato and okra using PGPR

26. Mass production and exploitation of entomopathogenic nematodes against white grubs from diverse habitats
27. Nematode-derived fungi and bacteria for exploitation in agriculture
28. 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 – All centres (except SKUAS & T)

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 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)

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 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)

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

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 (AAU-A – tomato; MPKV, Pune- Carnation; NBAII to supply the inputs)
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. 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)

XXII Surveillance and monitoring for the mealybugs (All centres except SKUAST-S, Srinagar)

XXIII Survey for the spread of the pest, base line data on the mealybug and natural enemies, mass production and release of imported parasitoids, establishment, conservation and impact assessment. (TNAU, KAU, ANGRAU, MPKV (Pune), Tripura University, Agartala)

XXIV Biological control of nematodes in pomegranate (MPKV (Pune), AAU (Anand), NBAII to supply the inputs

13. CONSULTANCY, PATENTS AND COMMERCIALISATION OF TECHNOLOGY

NBAII

- Quality testing of several biopesticides
- EAG and GC-MS analysis for samples received from various organizations
- Bioassay of *Bt* proteins against lepidopteran pests
- Mass production and supply of trichogrammatids and coccinellids for biological control of various pests
- Mass production and supply of *Trichoderma*, *Pseudomonas*, etc for management of plant diseases
- Mass production and large scale supply of host insects like *Corcyra cephalonica*, *Spodoptera litura*, *Helicoverpa armigera* for research and commercial units
- Mass production and supply of *Goniozus nephantidis* and *Cardiastethus exiquus* for the biological control of *Opisina arenosella* on coconut

14. MEETINGS HELD AND SIGNIFICANT DECISION MADE

XIVth Research Advisory Committee Meeting held from 18-19 June, 2010

The fourteenth Research Advisory Committee Meeting was held in the conference hall of National Bureau of Agriculturally Important Insects (NBAII), Bangalore from 18-19 June 2010 under the chairmanship of **Dr. A. N. Mukhopadhyay.** The other members who attended the meeting were Dr. D. J. Patel; Dr. C. A. Viraktamath; Dr. C. Manoharachary; Dr. T. P. Rajendran ADG (PP) and Dr. R. J. Rabindra

Dr. R. J. Rabindra, Director, NBAII welcomed the Chairman and the Members of the RAC and briefed them about the activities of the newly formed Bureau and detailed as to how the existing research projects were re-oriented to the mandate of NBAII. He made a brief presentation of salient findings of all the institute projects for the year 2009-2010 and also listed the new projects initiated.

Dr. A. N. Mukhopadhyay, the Chairman of the RAC in his opening remarks indicated that the 21st Century is "The Century for Environment". He emphasized that conservation of bioresources is the order of the day. In this context the role of plant protection scientists is highly important in managing the pests (diseases, nematodes, insects, mites etc.) attacking our crops in a sustainable way through conservation of biocontrol agents, honey bees and pollinators. Increasing food production has certain limitations as the cultivable land is decreasing, so he stressed the need for reducing the food losses in the field and in storage. If the plant protection scientists can reduce by 35-40% food loss we can not only save Rs. 40,000 to 50,000 crore, but also make it available for national consumption. Further he stressed that our agricultural products have to meet the international standards or else our export consignments will be rejected as it happened in the case of tea consignment which was rejected due to high dicofol residues and grapes consignment rejected due to high bavistin residues. He told that we have to focus on a few pests of national importance and come out with suitable sustainable technology to manage them. Simply patenting several technologies has no meaning if these technologies are not commercialized. The scientists should focus on the development of such technologies which can be commercialized.

The RAC took note of the action taken report presented by Dr. B. S. Bhumannavar, Member-Secretary on various recommendations during the thirteenth RAC held on 26-27 June, 2009.

The scientists incharge of the three divisions made detailed presentations on the progress of work during the year 2009-10 under the different projects.

The RAC appreciated the progress made in the different research programmes during the year 2009-10 and noted with high level of satisfaction that the scientists have been facilitated with the state of the art equipment, farm facilities with net house, poly house and field facilities to carryout their research programmes. The bureau has also made a reasonably good attempt to reorient the focus of research as per mandate as reflected by the good progress made in the area of exploiting the biodiversity.

The RAC made the following recommendations:

1. Organizing winter school for 5 consecutive years on biodiversity of insects, mites and related Arthropod genetic resources (IMRA) for capacity building for NARS on biosystematics and biodiversity.
2. Develop a National Exploration Plan for collection of IMRA in specific ecosystems including biodiversity hot spots and a master plan may be prepared for preparation of distribution maps of IMRA genetic resources of economic importance.
3. Development of good museums through the network programs of biosystematics with funding under the XII plan period.

4. To meet the mandated requirements of NBAII, capacity building of suitable scientist may be taken up in a phased manner to initiate taxonomic research work in different insect groups like, Coleoptera, Lepidoptera, Diptera, Hemiptera and Orthoptera in which no taxonomic expertise is available in India. A master plan for the next 10 years in this regard has to be prepared for submission to the council.
5. The NBAII in consultation with NCIPM may draft a note on the current status of manufacturing and marketing processes of microbial biocontrol agents towards fruitful implementation of IPM.
6. Successful technologies developed and evaluated in multi location experiments may be commercialized as per ICAR norms.
7. An interface meeting with seed industry may be organized at the institute to sensitise the industry about scope of seed treatment with antagonists for securing good plant stand in crop production.
8. Biological control in poly house for the sustainable management of pests, diseases and nematodes has to be encouraged through the AICRP net work to facilitate large scale adoption by the growers.

The RAC also made the following observations for the consideration of the scientists of NBAII.

1. The nano-formulation of insect pheromones should be tested in the field for their persistence. The newly developed polymer for impregnation of methyl eugenol can be field-tested for its persistence in comparison with the presently available cardboard impregnation method.
2. *Anagyrus kamali* can be collected from different agro-ecosystems of India and screened for their efficacy for suppressing *Maconellicoccus* mealybug.
3. Biodegradable alternate materials may be identified in the place of sponge as a carrier for mass production of fungal antagonists.
4. *Paecilomyces lilacinus* isolates available at various locations in India can be collected and tested against root-knot nematode to identify a virulent strain which will be tolerant to abiotic stress.
5. The timing of application of EPN formulations for the management of early instars of white grubs of arecanut has to be standardized.
6. Metabolities of *Xenorhabdus* and *Photorhabdus* bacteria as well as those of the EPN should be tried for control of plant parasitic nematodes.
7. Fungal pathogens found to be promising against the sucking pests particularly white flies, may be evaluated in the field/poly house.
8. NBAII has large collections of biocontrol agents representing *Trichoderma*, *Metarhizium*, *Beauveria*, *Paecilomyces*, endophytic bacteria (*Pseudomonas*, *Bacillus*) and few others. It is suggested to take up their strain differentiation, testing their efficacy through proper dosage/ concentration under laboratory conditions, polyhouse and at field site, production of viable and effective inoculums through solid state fermentation, determination of quality, shelf life and performance under different conditions and commercialization.
9. Germplasm conservation, Genebank and DNA barcodes, inventorization and database may be taken up by NBAII.
10. Genomics and nano-technology to be strengthened.

B. General observations:

1. Efforts should be made to bring qualified taxonomists from NARS system into the NBAII fold to enhance the biosystematics and fauna studies.
2. Since NBAII is very young, it is necessary to bring out visibility and this can be done through publications of hand books with good colour photographs in various areas of insect taxonomy, either books or soft copies also to be uploaded in the website.
3. A good document may be brought out on the success stories of the erstwhile PDBC.
4. The national mandate of harnessing the biodiversity of insects, mites and related arthropods resources is enormous and the present strength of scientist, technical, administrative and supporting staff needs consideration for strengthening in a phased manner during the XII plan period.

XV Research Advisory Committee Meeting held on 15.2.2011

The XV meeting of the Research Advisory Committee (RAC) of the National Bureau of Agriculturally Important Insects (NBAII) was held on 15.2.2011 under the chairmanship of Dr. B. Senapathi. The other members who attended the meeting were Dr. T. P. Rajendran, ADG (PP), Dr. B. V. David; Dr. R. K. Jain; Dr. S. K. Gupta; Dr. H. K. Bajaj and Dr. R. J. Rabindra.

Dr. R. J. Rabindra, Director of the NBAII welcomed the chairman and members of the RAC and briefed RAC on the focus of the 15th meeting of the RAC convened with the specific objective of reviewing the achievements made so far during the XI plan and examining the projections for the XII plan.

Dr. T. P. Rajendran, Asst. Director General (Plant Protection), Indian Council of Agricultural Research, emphasized the need for integration of research programmes of the NBAII with the ongoing programme of the ICAR as well as the National Agricultural Research System.

The Chairman in his remarks traced the growth the PDBC into NBAII. While complimenting the scientists of the NBAII for their contributions like the successful biological control for sugarcane woolly aphid and the papaya meaybug as well as commercialization's of formulations of antagonists, the chairman pointed out the strengths and weaknesses as well as the future road map for the bureau in the 12th plan. Emphasis has to be given for holistic management of pest complexes (e.g. pigeonpea pest complex), enhancing biocontrol under climate change, exploiting spider biodiversity, enhancing the efficacy of biocontrol organisms through genetic improvement, understanding the diversity and role of pollinators and soil microbial diversity and performance of biocontrol agents. The necessity to develop linkages with other institutions working on biocontrol agents, honeybees and pollinators, lac insects and other agriculturally important insects and other arthropods in the National Agricultural Research System was emphasized.

Responding to the action taken report, the RAC pointed out the following points:

a) The draft not eon the current status of manufacturing and marketing of microbial biocontrol agents should be expedited.

b) The number of biocontrol agents out of the inset germplasm maintained should be indicated.

c) There should be a clear projection on the functional integration of the insect biosystematic net work project with the NBAII programme.

Then presentations were made theme-wise on the achievements of the XI plan. The salient achievements were presented and then the XII plan projects with expected output and anticipated outcome were presented by the scientists them-wise. These projections were discussed by the members of the RAC and it was suggested to incorporate the following aspects in the XII plan projections.

General Recommendations

1. For strengthening the research programs of the NBAII, the following research areas are needed to be added during XII plan period.
   a) Acarology
   b) Pollination for increased productivity
   c) Soil arthropods for soil health

   Additional man power of scientists, technician and supporting staff along with necessary infrastructure need to be sanctioned during the XII plan period.
2. Strengthening of functional linkages with the national and international institutions
3. Capacity building for scientists of the Bureau in both national and international institutions
4. Establishment of insect museum

Specific Recommendations (in addition to the division-wise projections presented and modified)

1. Division of Biosystematics, Biodiversity and Bio-safety
   a) Identification of biosystematics studies on a few selected families/genera and strengthening of identification services.
   b) Biodiversity of pollinators, their conservation and utilization in protected cultivation of high priced cross pollinated vegetables
2. Division of Bio-research, conservation and utilization

a) Exploration, introduction, and standardization of mass multiplication and release procedure of exotic natural enemies of those pests, diseases and weeds which are not effectively managed by indigenous natural enemies.

b) While collecting the germplasm of insects, related arthropods of agriculturally importance, microbial biocontrol agents including EPN and entomophilic nematodes should be covered.

3. Division of Genomics and Bioinformatics

a) Whole genome sequencing may be done only for *Chrysoperla zastrowi sillemi* and *Plutella*

b) Exploitation of endosymbionts for enhancing fitness attributes and tolerance to pesticide and high temperature in natural enemies

c) Molecular characterization and development of DNA barcode for agriculturally important NES, pests and pollinators.

d) Proteomic analysis in *Apis cerana indica* and thrips vector-virus interaction.

Institute Research Council Meeting held on 11th and 13th August and 22-23 September, 2010

The Institute Research Council Meeting of the NBAII, Bangalore was held on 11 & 13 August, and 22 & 23 September, 2010 under the Chairmanship of **Dr. R. J. Rabindra**, Director, NBAII.

Dr. R. J. Rabindra, Director and Chairman of the IRC welcomed all the scientists and informed that the contents in the annual report for 2009-10 were well appreciated by ADG (PP). Since the planning commission is putting more pressure on the council for more outcome oriented outputs, the scientists should bring visibility in their achievements. In the changed scenario of NBAII, scientist can modify and re-orient their research as per the mandate of the NBAII. It was suggested that before presenting the RPF-I for the new projects, the scientists should present their RPF-I within the division and with the suggested modifications, they can present in the IRC Meeting.

The scientists presented the report on the targets achieved for the period 01-04-2009 to 31-03-2010 and also technical programme for 2010-11. After detailed discussions on the presentations on the achievements as per the targets given in their respective projects following points emerged as recommendations for the on-going projects.

- Good progress has been made in the Cataloguing project
- Progress in the project on biosystematics of *Trichogramma* is satisfactory
- The progress in the project on biodiversity of oophagous parasitoids was as per target. The name of Dr. J. Poorani, Co-PI may be deleted as there is no role in the project
- The progress made in the project for the introduction of papaya mealybug parasitoids is appreciable. Efforts should be made to introduce additional biocontrol agents of parthenium like seed feeding weevil, *Smicronyx lutulentus* and stem borer, *Caramenta*. Efforts could be made to introduce *Heteropsylla spinulosa* for the biological control of *Mimosa diplotricha*. Re-distribution of stem gall fly of *Chromolaena* can be taken up through AICRP centres.
- The project on production protocols and evaluation of anthocorids is extended for two more years for completing the field and laboratory studies by releasing the anthocorids and to quantify bio-diversity. Dr. Prashanth Mohanraj name can be deleted from this project as he has no specific role. An exploratory project on cryopreservation of embryos of insects has to be formulated.
- Good progress has been made in the project on biodiversity of aphids, coccids and their natural enemies.
- No progress has been made in the project on influence of elevated levels of carbon di-oxide. The scientists have to gear up action plan in their work.
- The kairomonal diversity component has to be studied. Role of kairomonal perception in *H. armigera* can also be studied. (midterm correction). Since in the earlier projects no output leading to outcome was seen, special care and action should bestowed for a clear outcome.

- The project on attractants for natural enemies of rice pests is extended for two years till 31.3.2012 to enable the PI to complete the development of attractant chemical formulation which can be used for attracting parasitoids and predators of pests of rice for conservation.
- The traps of IIHR and PCI for fruit fly can be tested for studying the field persistence with nano-fibre formulation.
- Experiments to measure the role of pollinators in enhancing the yield of pulse crops have to be designed.
- The achievements in the project on molecular characterization of inter and intra specific variation in trichogrammatids are very good. *Trichogramma chilonis* produced by a biocontrol laboratory (preferably Mandya lab.) can be studied for the wolbachia transmission. The scientist should submit the RPF- III along a separate page giving the out-put, out-come and the future road map.
- Good progress has been made on molecular characterization of Indian coccinellids
- Validation of mite fungal pathogens against citrus rust mite has to be done.
- The project on *Bacillus thuringiensis* is extended upto 31.11.2010 and the scientist has to complete all the pending items of research and submit the RPF III. A commercializaable virulent isolates of Bt should be the outcome.
- Pot culture studies for survival in soil with improved methodology of surface sterilization of seed, seedling and irrigation water etc to be done. The Devikulam isolate of *Bacillus* sp. can be taken up for formulation aspects along with its species identification.
- Good progress has been made on solid state formulation of Trichoderma spp. Work on semi automation may be hastened.
- Scientists who presented their RPF-I for the new projects should modify the technical programme as per discussion and re-submit the same for approval.

General recommendations

1. The components of the format for generating pass port data on insect germplasm has to be developed (Dr. Prashanth Mohan Raj –Trichogrammatids; Ms. Gandhi Gracy-Coccinellids; Dr. T. Venkatesan-Chrysoperla)
2. The genetic diversity of different populations of *Anagyrus kamali* can be studied against the meallybug, *Maconellicoccus hirsutus* to record relative performance. (Dr. Sunil Joshi)
3. The new revised names of insects should not be printed in the Institutes annual report and other publications till the taxonomic papers involving the new name are published. (TDC).
4. All the scientists were advised to focus their research projects to enable generation of product/ process/ technologies which will be absorbed by stake holders and particularly farmers.
5. An analysis of the outcome of research projects during the past 20 years has to be initiated. (Action: PME Cell).

Institute Management Committee Meetings

The XIX IMC meeting was held on 28th July, 2010 at NBAII under the chairmanship of Dr. R. J. Rabindra, Director. The other members who attended the meeting were Dr. K. Prabhudas, Dr. K. P. Jayanth, Mr. S. Bilgrami and Dr. D. Sundararaju. The presentation on the following topic was made to the IMC members.

"Strategic plans for classical biological control of the papaya mealybug *Paracoccus marginatus*" by Dr. A. N. Shylesha

Abstract: The papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae), is a polyphagus insect and a pest of various tropical fruits, vegetables, and ornamental plants. Its host range includes *Carica papaya* *Citrus* spp. *Persea americana* (avocado), *Solanum melongena* (eggplant), *Hibiscus* spp *Plumeria* spp. *Acalypha* spp and more than 12 weed hosts, *It* was first described by Williams and Granara de Willink (1992) and re described by Miller and Miller (2002). *P. marginatus* was originally reported from the neo tropical regions in Belize, Costa Rica, Guatemala, and Mexico, in the Republic of Palau in 2003 (Muniappan et al. 2006, Walker et al. 2006) and from Hawaii In 2004, on papaya, plumeria, hibiscus, and *Jatropha* spp. L. (Heu et al. 2007). The pest was recorded in India during 2007 from Coimbatore and has spread to most of the southern states.

The papaya mealybug (*Paracoccus marginatus*) is currently causing substantial damage in Tamil Nadu, Karnataka and Kerala and has become established on various fruit and vegetable crops. Mulberry being one of the important hosts, the pest is threatening sericulture industry in India. Papaya mealy bug attacks the foliage and fruits of different crops , causing severe damage to crops, fruits and vegetables. Many of the chemicals tested were found to be ineffective on this pest and were not cost effective. Biological control of *P. marginatus* has been found to be effective in many of the countries like Guam, Palau, Srilanka and Hawai.

Looking into the importance of the pest and effectiveness of biocontrol agents in containing this pest, we have introduced all the three species of the Papaya mealybug parasitoids Viz., *Acerophagus papayae, Anagyrus loecki,* and *Pseudleptomastix mexicana* for the management and are currently being studied in quarantine laboratory at NBAII, Hebbal, Bengaluru.

The IMC recommended the following:

The IMC appreciated the efforts taken by the NBAII to import the parasitoids for the management of the papaya mealybug.

To send a reminder on the completion of quarantine building and get the audit para dropped.

The IMC appreciated the action taken on the commercialization of technologies and to drop this objection.

The IMC suggested that the audit para on encapsulation machine- unfruitful expenditure of Rs. 29.88 lakhs may be pursued with the ICAR.

The IMC ratifies the Composition of committee for assessment of technical staff under Category II and III

The IMC approved the importation of the following equipments under plan funds of less than Rs. 5.00 lakh category:

			No.	Cost Rs. in lakh
1.	Stereozoom microscope	:	2 Nos	Rs.4.90
2.	Image anlyser	:	1 No.	Rs. 3.00
3.	Rotary evaporator	:	1 No.	Rs.3.00

The IMC recommends the substitution of equipment listed at 1) and 2) below with Flash Chromatography with Detector in view of justification furnished by the Institute. Further, there is no additional liability of funds due to substitution of the equipment.

The IMC approved the proposal for purchase of 34 Nos. of desktop computers in lieu of the field data recorder.

The IMC recommended for the purchase of 20 Nos. of file storage cabinets for record room

IMC approved the proposal for the purchase of below items under the category of less than Rs.5.00 lakh approved in the EFC of the XI plan as it is not exceeding the total sanctioned amount in the EFC.

Sl. No.	APPROVED EQUIPMENT		Substitution for item now proposed	Amount in lakh
	EFC equipment	Cost Rs. in lakh		
1.	Chromatography with detector	8.00	Flash chromatography with detector	15.50
2.	GC fraction collector	8.00		

	ITEM	COST Rs. in lakh
1.	Malaise Traps	0.55
2.	Distillation unit	1.50
3.	Refrigerator (6 Nos.)	2.00
4.	Portable Carbondioxide Monitor	0.50
5.	Platform scale	0.075
6.	Balance	0.325
7.	Stereozoom microscope	4.90
8.	AC for aris cell	0.25
9.	Miscellaneous lab fixtures	0.73
10.	Rotor	0.90
11.	Balance weighing	0.35
12.	Powerpack	0.86
13.	Gel Rock	0.19
14.	Electronic pipette	1.00
15.	Multichannel pipette	1.00
16.	Dot blot	0.80
17.	Copier-cum-scanner	0.125
18.	Insect setting box & cabinets	0.90
19.	DSLR Camera (accessory)	1.00
20.	Microwave ovens (4 Nos.)	0.95
21.	UPS 1.5 KVA (23 Nos)	4.99
	TOTAL	**23.895**

The committee recommended for the construction of Repository Lab and Insectaries Lab at Attur Farm and advised to follow the codal formalities.

The IMC approved the proposal of engaging Dr. P. V. Mahalakshmi and Dr. Vishwanath Patil as authorized medical attendants for a further period of one year.

XX IMC Meeting

The XX IMC meeting was held on 6th September, 2010 under the chairmanship of Dr. R. J. Rabindra, Director. The other member sho attended the meeting were Dr. S. Prabhukumar, Dr. K. Prabhudas, Dr. K. P. Jayanth, Dr. Sundararaju.

Update on the quarantine screening for the three imported parasitoids of papaya mealybug *P. marginatus* was presented before the IMC. Seven species of locally available mealybugs were tested for host specificity and all the available natural enemies and productive insects were screened for safety. The results indicated that the parasitoids did not accept them as hosts nor inflicted any parasite related injury to them. The study reports are submitted to PPA for release permit.

The IMC recommended the following:

- The IMC appreciated the dropping of audit para on quarantine lab. by C & AG.
- The IMC suggested that the audit para Encapsulation Machine may be pursued with the ICAR.
- The IMC approved the proposal of purchase of the OTC at a cost of Rs.29.36 lakh.
- The IMC approved for the proposal of conversion of staff rest room to the Reception Room to be constructed in the NBAII campus at Hebbal.

15. PARTICIPATION OF SCIENTISTS IN CONFERENCES, MEETINGS, WORKSHOPS, SYMPOSIA, ETC. IN INDIA AND ABROAD

INTERNATIONAL

NBAII

Dr. N. Bakthavatsalam attended

- International seminar on IPM held at Xaviers College, Palayamkottai during 22-25th February, 2011 and presented a paper on "Semiochemicals for the management of pests, what next?"

Dr. Prashant Mohanraj attended

- International Symposium on IPM' held at Palayamkottai, Tamil Nadu from 23 -25 February, 2011 and presented a paper on Advances in biosystematics of *Trichogramma* and *Trichogrammatoidea* (Hymenoptera: Trichogrammatidae) in India. By Nagaraja, H., Prashanth Mohanraj and Jalali, S. K., 2010.

NATIONAL

NBAII

Dr. N. Bakthavatsalam attended

- National seminar on Invasive Pests with particular reference to *Luprops tristis*, a nuisance pest of Kerala held at Calicut during 17-18th February 2011and presented key note address on "Invasive pests of agricultural importance and their management through classical biological control"

Ms. Gandhi Gracy attended

- National Symposium on "Silver Jubilee of Bioinformatics in India-(DBT BTIsNet)" Pondicherry University, Pondicherry on 2.02.2011.

Dr. J. Poorani attended

- Attended the National Consultation on Agro-biodiversity held at NASC, New Delhi, on May 26-27 2010, acted as rapporteur for two sessions and helped in drafting the recommendations.
- Attended the National Consultation on strategies for deployment and conservation of imported parasitoids of papaya mealy bug on 30th October, 2010 at NBAII, Bangalore.

Dr. K. Srinivas murthy attended

- National Consultation on strategies for deployment and conservation of imported parasitoids of papaya mealy bug on 30th October, 2010 at NBAII, Bangalore.
- Brainstroming Meet on Application of Bio-informatics on Insects and their Resources at NBAII, on 9th August, 2010.
- Meeting on finalising package for Black headed Caterpillar infestation in coconut on 27.1.2011 at Lal Bagh, Bangalore, organised by the Directorate of Horticulture, Bangalore.
- Sensitisation workshop on coconut leaf beetle *Brontispa longissima* on 20th September 2010 at NBAII, Bangalore (Venue: IVRI, Bangalore)
- Consortium Implementation Committee meeting of the NAIP project "Effect of abiotic stresses on the natural enemies of crop pests: *Trichogramma*. *Chrysoperla*, *Trichoderma*, *Pseudomonas* and mechanism of tolerance to these stresses" held on 3rd April, 2010, 30th July, 2010 & 29th January, 2011.

- Thematic Annual Workshop 2011 of the NAIP (Basic & Strategic Research in Frontier Areas of Plant Science (NAIP component- 4), 7-8th March, 2011 at IIHR, Bangalore.

Dr. Rajkumar attended

- National Consultation Meeting on Strategies for Deployment of the Imported Parasitoids of Papaya Mealy bug on 30th October, 2010 at NBAII Bangalore

Dr. Ankita Gupta attended

- National seminar on Gender & Biodiversity organized by DRWA in collaboration with UNDP, National Biodiversity Authority, Chennai, on 28-29th December, 2010 at DRWA, Bhubaneshwar and delivered a lecture on the topic "Role of women in biodiversity in different agro-ecosytems"

Dr. T.M. Shivalingaswamy attended

- Launch workshop of the National Fund for BSFARA sponsored project on "Identification of nucleopolyhedrousvirus (NPV) encoded proteins and small RNAs and feasibility of their expression in plant to control *Helicoverpa armigera*" on 24.3.2011 at ICGEB, New Delhi.

Dr. D. Sundararaju attended

- PLACROSYM XIX at Kottayam from 06-12-2010 to 09-12-10 and made a oral presentation of the paper entitled "Studies on extent of pollination and fruit set in cashew"

Dr. M. Nagesh attended

- 3rd National Conference on Biopesticides Emerging trends 2010 and presented a lead paper entitled "Bacterial toxins and their potential in application in insect pest management" by M. Nagesh, Seema Wahab, Saleem Javeed and Rijo Joseph organized by the Society of Biopesticides Sciences, India and CCSHAU, Hisar, 20-22 November 2010.
- National Agricultural Science Congress, NBFGR, Lucknow and presented a paper on "Enhancing soil antagonistic potential for the control of rootgrubs (Coleoptera: Scarabaeidae) using entomopathogenic nematodes: A field study in arecanut ecosystem.

Dr. G. Sivakumar attended

- Participated in the Group meeting of the AICRP on Biocontrol of crop of crop pests and weeds held at Sher - e - Kashmir university of Agriculture and technology, Shalimar, Srinagar from 28.05.2010 to 29.05.2010.
- Participated in Krishi Mela organized by University of Agricultural Sciences, Bangalore from 11th to 14th November, 2010.
- Attended national symposium held at ICAR research complex, Goa, from 4-5, March, 2011 and presented a paper titled Characterization and screening of *Bacillus* spp against *Ralstonia solanacearum* causing bacterial wilt of brinjal and tomato, by Sivakumar G, Rangeswaran R, Sriram S and Ramanujam B. 2011.

Dr. Sunil Joshi attended

- Participated in Krishi Mela organized by University of Agricultural Sciences, Bangalore from 11th to 14th November, 2010
- Attended meeting on 'National Consultation Meeting on Strategies for Deployment of the Imported Parasitoids of Papaya Mealybug' on 30th October, 2010

Dr. T. Venkatesan attended

- Attended Annual group meet of all India Coordinated Research project on biological control of crop pests and weeds at Sher-e-kashmir University of Agriculture & Technology, Kashmir during 28-29th May, 2010.

Dr. Chandish. R. Ballal attended

- One day consultation Meeting on Organic Farming on 23rd April 2010, at NASC New Delhi.
- National Consultation on strategies for deployment and conservation of imported parasitoids of papaya mealybug held on 30th October, 2010 at IVRI Auditorium, organised by NBAII, Bangalore. Anchored the Programme.
- 34th Annual Conference of the Ethological

Society of India and National Conference – Colloquium on Ethology from organism down to Ethobiomolecule (ECEODE 2010) 16 to 18 December, 2010 at Trivandrum

- National Symposium on "Alliums: Current Scenario and Emerging trends" 12th to 14th March, 2011 organised by Directorate of Onion and Garlic Research, Rajgurunagar, Pune held at Vaikunth Mehta National Institute of Co-operative Management, University Road, Pune.

AAU-A

Dr. D. M. Korat attended

- A seminar on "Protection of plant varieties and farmers' right act and seed industry" organized by National Seed Association of India, New Delhi, Anand Agricultural University, Anand and Gujarat state seeds producers Association, Ahmedabad on 7th April, 2010.
- Joint Agricultural Research Council meeting of State Agricultural University, Gujarat state at Junagadh on 15th April, 2010.
- National seminar on "production technology marketing of acid-lime in India" organized by Acid lime growers Association of India, Pune, Gujarat Bagayat Vikas Parishad, Anand, KVK, Ganpat University Kherva, Mehsana, Dept of Horticulture, Govt. of Gujarat Gandhinagar, National Horticulture Mission, New Delhi and National Horticultural Board, New Delhi during 7 to 9 September, 2010.

Patel, B, H attended

- 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.
- National seminar on Pest Management through Transgenesis in Agroecosystem, organized at MPUAT, Udaipur during February 25-26, 2011.

Dr. Jani, J. J. attended

- National seminar on Pest Management through Transgenesis in Agroecosystem, organized at MPUAT, Udaipur during February 25-26, 2011. He presented a Lead paper entitled, "Intimidation level of resistance against genetically modified insect resistant cotton : Indian perspective" and Chaired one session on transgenics.

AAU-J

Dr. Basit, A. attended

- Awareness campaign cum training on biological control of papaya mealy bug at KVK, Kahikuchi, Guwahati on 24.01.11.
- XVIII Biocontrol workers Group Meeting held at Shere-e-Kashmir University of Agriculture & Technology, Srinagar on 28-29 May, 2010.

Dr. D. K. Saikia attended

- Awareness campaign cum training on biological control of papaya mealy bug at KVK, Kahikuchi, Guwahati on 24.01.11.
- XVIII Biocontrol workers Group Meeting held at Shere-e-Kashmir University of Agriculture & Technology, Srinagar on 28-29 May,

ANGRAU

Dr. Rahman, S. J. attended

- ZREAC meeting of the Southern Telengana Zone held at Zilla Parishad Office, Mahboobnagar Dt. On 25 and 26 August.

Ms. Anitha, G. attended

- ZREAC meeting of the Southern Telengana Zone held at Zilla Parishad Office, Mahboobnagar Dt. On 25 and 26 August.

CPCRI

Dr. Chandrika Mohan attended

- XIX AICRP workshop on Biocontrol of crop pests and weeds at Sher-e-Kashmir University of Agricultural Sciences and Technology – Kashmir, Srinagar during 28-29 May, 2010.

- International Conference on Coconut Biodiversity for Prosperity, CPCRI, Kasaragod during 25-28 October, 2010.

KAU

Dr. Lyla, K. R. attended

- Training programme on mass production of parsitoids of papaya mealy bug organized by NBAII, Bangalore from 28-29, September, 2010.
- XIX Biocontrol workers group meeting held at Sher-e Kashmir University of Agriculture and Technology, Shalimar, Kashmir on 28th and 29th May, 2010.
- National consultation of Strategies of imported parasitoids of papaya mealy bug on 30-10-2010 organized by NBAII, Bangalore.

MPKV

Dr. Pokharkar, D. S. attended

- The Research Review Committee Meeting in Plant Protection - Agril. Entomology and Nematology held at MPKV, Rahuri on 20th April 2010 and presented the research report of the project.
- 65th Board of Studies Meeting in Agril. Entomology and Nematology at the Department of Entomology, MPKV, Rahuri on 27th and 28th July 2010 and discussed Ph. D. synopsis and ORWs of PG students.
- A meeting for finalization of strategies on management of papaya mealybug organized by the Head, Dept. of Entomology, MPKV, Rahuri at the Division of Entomology, College of Agriculture, Pune on 23rd and 24th August, 2010.
- Two days training programme for mass production techniques of *Acerophagus papayae*, a parasitoid of papaya mealybug at NBAII, Bangalore on 6th to 8th September, 2010.
- the Golden Jubilee seminar-2010 on Grapes organized by Maharashtra State Grape Growers Association, Pune on 26th and 27th September, 2010.
- 66th Board of Studies Meeting in Agricultural Entomology including Sericulture, Zoology and Nematology held at Biocontrol lab., Department of Entomology, MPKV, Rahuri on 24th February 2011 and discussed Ph. D. synopsis and ORWs of M. Sc. (Agri.) students.
- The Research Programme Planning Meeting in Agricultural Entomology and Nematology for 2011-12 on 25th February 2011 organized by the Head, Department of Entomology, MPKV, Rahuri at Biocontrol Lab. and presented as well as discussed the technical programme of AICRP on Biocontrol.
- The Sub-Jury for the first ever Mahindra Samridhi India Agriculture Award 2011 on 19th January 2011 and scrutinized 90 applications.

Dr. R.V. Nakat attended

- A Research Review Committee Meeting in Plant Protection - Agricultural Entomology and Nematology held at MPKV, Rahuri on 20th April 2010 and presented the research report of the project.
- Research Release Finding Committee meeting at MPKV, Rahuri on 05/05/2010 and presented the recommendation of cotton.
- XIX Biocontrol Workers Group Meeting on Biological control of crop pests and weeds at Sher-e- Kashmir University of Agricultural Sciences and Technology, Shalimar, Srinagar, Kashmir on 28th and 29th May 2010 and presented the report on Biological suppression of storage pests.
- A meeting for finalization of strategies on management of papaya mealybug organized by the Head, Dept. of Entomology, MPKV, Rahuri at the Division of Entomology, College of Agriculture, Pune on 23rd and 24th August, 2010.
- Two days training programme for mass production techniques of *Acerophagus papayae*, a parasitoid of papaya mealybug at NBAII, Bangalore on 6th to 8th September, 2010.

- National consultation on strategies for development and conservation of imported parasitoids of papaya mealybug' at NBAII, Bangalore held on 30th October, 2010.
- 66th Board of Studies Meeting in Agricultural Entomology including Sericulture, Zoology and Nematology held at Biocontrol lab., Department of Entomology, MPKV, Rahuri on 24th February 2011 and discussed Ph. D. synopsis and ORWs of M. Sc. (Agri.) students.
- the Research Programme Planning Meeting in Agricultural Entomology and Nematology for 2011-12 on 25th February 2011 organized by the Head, Department of Entomology, MPKV, Rahuri at Biocontrol Lab. and presented as well as discussed the technical programme of AICRP on Biocontrol.

PAU

Dr. Neelam Joshi attended

- XIX Annual biocontrol workers group meeting of AICRP on Biological Control of Insect Pests and Weeds held at SKUAST-S at Srinagar, on May 28-29, 2010.
- Research and Extension Specialists Workshop for *Rabi* crops August 19-20, 2010 at PAU, Ludhiana.
- *Kisan Mela* at PAU, Ludhiana on September 14-15, 2010.
- Research and Extension Specialists Workshop on Vegetable, Fruit and Flower Crops (November 2-3,2010) at PAU, Ludhiana.
- National symposium on "Perspective and Challenges of Integrated Pest Management for Sustainable Agriculture" held at YSPUH&F, Nauni (Solan) , from November 19-21, 2010.
- *Kisan Mela* at PAU, Ludhiana on March 17-18, 2011.
- Honey festival cum workshop on prospects and promotions of apiculture for augmenting hive and crop productivity held at PAU, Ludhiana from February 22-24, 2011.
- Research and Extension Specialists Workshop for *Kharif* crops February 14-15, 2011 at PAU, Ludhiana.
- winter school on "Advances in Agricultural Entomology" held in Department of Entomology, Punjab Agricultural University, Ludhiana from 20th December, 2010 to 9th January, 2011.

Dr. Aggarwal, N. attended

- XIX Annual biocontrol workers group meeting of AICRP on Biological Control of Insect Pests and Weeds held at SKUAST-S at Srinagar, on May 28-29, 2010.
- Research and Extension Specialists Workshop for *Rabi* crops August 19-20, 2010 at PAU, Ludhiana.
- *Kisan Mela* at PAU, Ludhiana on September 14-15, 2010.
- Research and Extension Specialists Workshop on Vegetable, Fruit and Flower Crops (November 2-3, 2010) at PAU, Ludhiana.
- Conference on "Biopesticides in Food and Environment Security" held at CCSHAU, Hisar (October 20-22, 2010).
- *Kisan Mela* at PAU, Ludhiana on March 17-18, 2011.
- Honey festival cum workshop on prospects and promotions of apiculture for augmenting hive and crop productivity held at PAU, Ludhiana from February 22-24, 2011.
- Research and Extension Specialists Workshop for *Kharif* crops February 14-15, 2011 at PAU, Ludhiana.
- International Conference on "*Preparing Agriculture for Climate Change*" held at Punjab Agricultural University Ludhiana. Feb. 6-8, 2011.

Dr. Kaur, R. attended

- XIX Annual biocontrol workers group meeting of AICRP on Biological Control of Insect Pests and Weeds held at SKUAST-S at Srinagar, on May 28-29, 2010.
- In libraray orientation programme held on 15th June 2010 at P.A.U. Ludhiana.

- Research and Extension Specialists Workshop for *Rabi* crops August 19-20, 2010 at PAU, Ludhiana.
- *Kisan Mela* at PAU, Ludhiana on September 14-15, 2010.
- Research and Extension Specialists Workshop on Vegetable, Fruit and Flower Crops (November 2-3,2010) at PAU, Ludhiana.
- National symposium on "Perspective and Challenges of Integrated Pest Management for Sustainable Agriculture" held at YSPUH&F, Nauni (Solan), from November 19-21, 2010.
- *Kisan Mela* at PAU, Ludhiana on March 17-18, 2011.
- Honey festival cum workshop on prospects and promotions of apiculture for augmenting hive and crop productivity held at PAU, Ludhiana from February 22-24, 2011.
- Research and Extension Specialists Workshop for *Kharif* crops February 14-15, 2011 at PAU, Ludhiana.
- winter school on "Advances in Agricultural Entomology" held in Department of Entomology, Punjab Agricultural University, Ludhiana from 20th December, 2010 to 9th January, 2011.

Shri. Sharma, S. attended

- XIX Annual biocontrol workers group meeting of AICRP on Biological Control of Insect Pests and Weeds held at SKUAST-S at Srinagar, on May 28-29, 2010.
- Research and Extension Specialists Workshop for *Rabi* crops August 19-20, 2010 at PAU, Ludhiana.
- *Kisan Mela* at PAU, Ludhiana on September 14-15, 2010.
- Research and Extension Specialists Workshop on Vegetable, Fruit and Flower Crops (November 2-3,2010) at PAU, Ludhiana.
- Honey festival cum workshop on prospects and promotions of apiculture for augmenting hive and crop productivity held at PAU, Ludhiana from February 22-24, 2011.
- winter school on "Advances in Agricultural Entomology" held in Department of Entomology, Punjab Agricultural University, Ludhiana from 20th December, 2010 to 9th January, 2011.

TNAU

Dr. Kalyanasunaram, M. attended

- The training on Quality control of biopesticides at NHIM, Hyderabad from 18.4.2011 to 29.4.2011.

YSPUH & F

Dr. Usha Chauhan attended

- XIX Biocontrol Workers' Group Meeting, held by National Bureau of Agriculturally Important Insects, Bangalore on May28-29, 2010 at SKUAT, Srinagar.

Dr. Sharma, P. L. attended

- XIX Biocontrol Workers' Group Meeting, held by National Bureau of Agriculturally Important Insects, Bangalore on May28-29, 2010 at SKUAT, Srinagar.

SKUAS & T

Dr. Jamal Ahmad attended

- XIX Biocontrol workers Group Meeting at SKUAST-K.
- 6th J &K Congress, held in the University of Kashmir, from 2- 4, December, 2010.
- Three day's training Programme on "Management of Honey bee Diseases" from 29- 31st March' 2010, Organized by the Division of Entomology.
- Scientific Advisory Committee (SAC) of KVK, Srinagar, Suhma on 7th December' 2010.
- One day Work shop on Intellectual Property Rights, on 26th February' 2010, organized by the Directorate of Extension Education, SKUAST-K.

16. WORKSHOPS, SEMINARS, SUMMER INSTITUTES, TRAINING ETC.

Group Meeting

- NBAII conducted XIX Biocontrol Workers' Group Meeting from 28-29 May, 2010 at SKUAT, Srinagar.

Trainings conducted by NBAII

- Mass production of *Trichoderma* sp., *Beauveria bassiana*, *Pseudomonas fluorescens*, *Paecilomyces lilacinus* and EPN from 2.8.2010 to 6.8.2010 (2 persons)
- Conducted a training programme for the "Parterns' meet" under the project on Bioinformatics on 9.8.2010 for 40 persosns
- Mass production of pesticide tolerant strain of *Trichogramma chilonis*, baseline toxicity, screening of commonly used insecticides from 25.10.2010 to 30.20. 2010 (1 person)
- Mass production of *Trichoderma viridae, Beauveria bassiana, Metarhizium anisopliae* from 29.11.2010 to 1.12.2010 (1 person)
- Conducted "Sensitization Training programme on bioinformatics from 8-12 November, 2010 (14 persons from ICAR and SAUs)
- Mass production of papaya mealy bug and its introduced parasitoids from 6-29th September, 2010, 28-30th October, 2010, 1-2nd November, 2010 (for 250 scientists, subject matter specialists, extension officers of ICAR, SAUs, KVKs, NGOs and CSRTI, Mysore)
- Management of papaya mealy bug and deployment of introduced parasitoids on 30.10.2010 (for 200 scientists from ICAR, SAUs, KVK, KFRI, CSRTI and NGOs and a few farmers)
- International Training programme on "Biological control of Crop Pests and Weeds" from 24.11.2010 to 7.12.2010 (for Mrs. Yi Hui Wu from Miaoli Taiwan 36441, **R.O. China**, Mr. Mohd. Desa Haji Hassim, from **Malaysia** and Mr. Abdulaziz Ali Darwish , from **Syria**).
- Conducted training on "Subject training on insect bioinformatics" under the bioinformatics project from 7-17 February, 2011 for 15 persons.
- Mass production of *Pseudomonas fluorescens, Beauveria bassiana, Verticillium lecanii* and *Metarhizium anisopliae* from 14.3.2011 to 18.3.2011 (2 persons)

AAU, Anand

- Two days training programme on "Plant protection in horticultural crops' under the auspice of National Horticulture Mission, Govt. of India New Delhi in which 50 orchard owners (progressive farmers) each of Baroda (Dt. 14-15, September, 2010), Anand (Dt.28-29 September, 2010) and Kheda (Dt. 27-28 December, 2010) district of middle Gujarat were participated.
- One day training programme on "Biological control of crop pests" in the month of January-February, 2011 for 40 farmers.

AAU, Johrat

- Six traning programmes on Integrated pest management with special reference to use of bioagent/ biopesticides in vegetables, rice & sugarcane for 274 farmers.

Dr. D.K. Saikia

- Dr. D.K.Saikia conducted an off - campus training on "Production and use of bio pesticides and biocontrol agents" at Sameti, Medziphema, Nagaland on 25-27 November'2010.

CPCRI

- Conducted a special training programme on "Technological Updates of Black headed caterpillar of coconut" at CPCRI, Regional Station, Kayangulam during November 10-12, 2010 for 10 officers from Department of Horticulture, Karnataka (Tumkur) and Department of Agriculture, Kerala (Course Director: Chandrika Mohan).
- Conducted training cum field demonstration on Integrated management of rhinoceros beetle involving the use of pheromone traps, field release of beetles inoculated with *Oryctes rhinoceros* virus, treatment of manure pits with *Metarhizium anisopliae* in Edava panchayat, Trivandrum district on 22-05-2010.

KAU

- One day training programme was carried out to the Scientists of Kerala Agricultural University on mass production and release of the parasitoids of papaya mealy bug on 01/02/2011.
- One day training programme to the Farm officers of different stations of Kerala Agricultural University on mass production and release of the parasitoids of papaya mealy bug on 09/02/2011.
- Five training programmes on on mass production and release of the parasitoids of papaya mealy bug to the farmers at different KVK's.

MPKV

Radio Talks

- Dr. R. V. Nakat delivered radio talk on 'Control of mealybug on crop' on 02/02/2011 and broadcasted on 08/02/2011 on AIR, Pune-centre.
- Shri. A.S. Dhane delivered radio talk on 'Integrated Pest Management of aphids' on 26/02/2011 and broadcasted on 27/02/2011 on AIR, Pune centre.

Television programme

- Dr. D. S. Pokharkar gave TV programme on 'New record of Papaya mealy bug and its parasitoid, *Acerophagus papayae* in Pune region' and broadcasted on Star Mazha TV Channel on 14/09/2010 and 28/09/2010.
- Dr. D.S. Pokharkar gave TV programme on 'Biological control of parthenium weed by *Zygogramma biocolorata*' and broadcasted on Star Mazha TV channel on 01/9/2010 and 27/09/2010.

MPUAT, Udaipur

- Organzed National seminar on "Pest Management through Transgenesis in Agroecosystem" during February 25-26, 2011.

TNAU

- Mass production of papaya mealy bug parasitoids-Field release and evaluation techniques to 75 entomologists from all colleges, Research stations and KVKs from TNAU
- Biological control in fruit crops to 100 farmers of Dharmapuri District
- Biological control in protected cultivation to 30 state dept. officials at Ooty
- Mass production of papaya mealy bug parasitoids-Field release and evaluation techniques to 20 scientists from IFGTB, Coimbatore, 200 farmers functionorganized by KVK, Gandhigram, Dindigul Dt., Senthil papain officials, 80 farmers at Pochampalli, Dharmapuri Dt., All KVK scientists of TNAU.
- Mass production of biocontrol agents- Field release and evaluation techniques to 20 Scientists all over India during CAFT programme
- Biological control of mealybug in guava to 75 farmers at Ayakudi, Dindigul Dt.
- Role of biocontrol in IPM to 80 officials throughout India from Syngenta Agrochemicals.

17. DISTINGUISHED VISITORS

Dr. S. AYYAPPAN, Secretary, DARE and Director General, Indian Council of Agricultural Research, (ICAR), New Delhi inaugurated the Quarantine laboratory on 23th June, 2010.

Dr. Marc Gilkey - USDA, US Embassy, New Delhi who Felicitated the importation of three papaya mealy bug parasitoids from APHIS facility at Peurto Rico visited the quarantine facility at NBAII on 21.9.2010 where the exotic parasitoids were being quarantined.

A Delegation from Royal Government of Bhutan consisting of **Dr. Doe Doe,** Programme Director, National plant Protection Centre, Department of Agriculture, Semtokha, P.O.Box 670, Thimphu, Bhutan; **Dr. Thinlay,** Advisor on Plant Protection, **Dr. Karma Chophyll,** Head, Weeds Science Division, **Dr. Phuntsho Loday,** Entomologist, **Dr. Karma Lhaden,** Entomologist and **Dr. M. B. Rai,** Plant Protection Product Division visited NBAII on 25.1.2011.

18. PERSONNEL

National Bureau of Agriculturally Important Insects, Bangalore

Dr. R. J. Rabindra	**Director**
Dr. B. S. Bhumannavar	Principal Scientist
Dr. D. Sundararaju	Principal Scientist
Dr. N. Bakthavatsalam	Principal Scientist
Dr. B. Ramanujam	Principal Scientist
Dr. Prashanth Mohanraj	Principal Scientist
Dr. (Ms.) Veena Kumari	Principal Scientist
Dr. (Ms.) J. Poorani	Principal Scientist
Dr. (Ms.) Chandish R. Ballal	Principal Scientist
Dr. M. Nagesh	Principal Scientist
Dr. A. N. Shylesha	Principal Scientist
Dr. S. K. Jalali	Principal Scientist
Dr. T. Venkatesan	Senior Scientist
Dr. P. Sreerama Kumar	Senior Scientist
Dr. K. Srinivasa Murthy	Senior Scientist
Dr. S. Sriram	Senior Scientist
Dr. Sunil Joshi	Senior Scientist
Dr. R. Rangeshwaran	Senior Scientist
Dr. G. Sivakumar	Senior Scientist
Ms. M. Pratheepa	Scientist (SS)
Dr. (Ms.) Deepa Bhagat	Scientist (SS)
Ms. R. Gandhi Gracy	Scientist
Dr. Ankita Gupta	Scientist
Dr. Rajkumar	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	Senior 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 AT NBAII

Equipment

The laboratories were further strengthened with the acquisition of several equipments like Vortex shaker, Vacuum filter pump, Orbital low speed shaker, Hot air ovens, refrigerated incubator shaker, digital water bath, incubation chamber, electronic balances, BOD incubators, Liquid nitrogen containers, Pre-freezer, Digital cameras, Photocopier, Printer cum copier cum scanners, magnetic stirrer, Stereozoom microscope with camera, Elisa reader, autoclave, bench top pH meter, fermentor, global position systems, insect storing boxes, UPS with stabilizers, gel rocker. Computer systems numbering 34 have been upgraded with latest operating system in all the laboroties including ARIS Cell.

Library

The library has a collection of 1,983 books, 1,537 volumes of journals, 61 bulletins and several miscellaneous publications including several reprints on various aspects of biological control. Eleven foreign and eight Indian journals were subscribed for. On-line version of the Plant Protection Database updated upto April, 2011.

ARIS Cell

The server has been up-graded along with newly up-graded computers. 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 11,000 authentically identified specimens 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.

Farm development

An automated open top CO_2 chamber with six units with temperature and humidity control to study the elevated levels of CO_2 on the tritrophic interaction bet2ween host plant, host insect and natural enemy has been established. The following civil and other works were taken up in the NBAII research farm, Attur: Chainlink fencing for vegetable block, constructin of toilets for labour, asphalting of major roads, fixing of pavers infront of farm building, fixing of cattle drop at the main entrance and installation of diesel generator set.

20. EMPOWERMENT OF WOMEN

During 2010-2011, the participation of women in different training programmes was as follows:

Mass production of *Trichoderma viridae, Beauveria, Metarhizium* (29.11.2010 to 1.12.2010)

Dr. S. Indira Devi, Scientist, Microbial Resource Division, institute of Bioresource and Sustainable Development, Govt. of India, Takyelpet, Imphal - 795 001.

Biological control of crop pests and weeds (International training programme) (24.11.2010 to 7.12.2010)

Mrs. Yi Hui Wu, Taiwan, Assistant Research Fellow, Miaoli District Agriculture Research & Extension Station, council of Agriculture, Executive Yuan, 42, Min Tsu Road, Dahu, Miaoli Taiwan.

Mass production of *Pseudomonas fluorescens* and *Beauveria bassiana, Verticillium lecanii* and *Metarhizium anisopliae* (14.3.2011 to 18.3.2011)

Ms. Shaikh Kausar Shabnoor and Ms. Kuralkar Sneha Shrikrushna from Ellor Biotech & Agro Services Pvt. Ltd, Udyoga Mitra, Chitegaon, Aurangabad and Mss. Manisha Suvendra Singh from Vasundhara Agro tech Pvt. Ltd., K-36 MIDC, Waluj, Aurangabad.

"Synthesis of Nanomaterials" (6.1.2011 to 6.2.2011)

Ms. Asfiya Unnisa, M.Sc. Biotechnology, Acharya Bangalore B-School, No. 3 Lingadheeranahalli, Off Magadi Road, Bangalore-91.

"Detection of resistant alleles for pesticide tolerance in certain natural enemies using molecular techniques"

Ms. Solanki Eshita,

Hands on training under RAWE programme for 12 weeks for the Final year Agri. Biotech students from Agricultural College, Hassan

Ms. Puspalatha, Ms. Divya, P., Ms. Gayethri, M., Ms. Vinutha, D. N., Ms. Pushpa, B. N., Ms. Varalakashmi, B.C., Ms. Sushma, P.P., Ms. Humara Jabeen, Ms. Kalaivani, M.