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2003-04

भाकृअनुप
ICAR

PROJECT DIRECTORATE OF BIOLOGICAL CONTROL
BANGALORE

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Bangalore 560 024

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PREFACE

The Project Directorate of Biological Control, since its inception in 1993, has made rapid strides in basic research on different aspects of biological control forming the base for technologies in Biointensive Integrated Pest Management. It has a network of 16 crop-oriented field centres in different state agricultural universities and ICAR Institutes. The achievements made in this specialised field include introduction of potential natural enemies for managing exotic pests, development and standardisation of improved breeding and mass production techniques and low temperature storage technology for natural enemies, understanding the tritrophic relationship between host plants, pest insects and natural enemies, development of superior strains of natural enemies for different crop ecosystems and pesticide tolerance and development of biocontrol-based technologies for pest management in crops like sugarcane, cotton, maize, tobacco, vegetables, fruits, etc. Several of these technologies have been transferred to private enterprises for commercial exploitation.

The eleventh annual report of the Project Directorate embodies the endeavours of my scientist colleagues for the period from April 2003 to March 2004. I am sure that the findings presented will be of use to scientists, research workers, administrators, policy makers, farmers and others who are involved or interested in biological control of crop pests and weeds. Suggestions for improvement, collaboration, future research needs and priorities from peer groups have been given due consideration for implementation.

I am extremely grateful to **Dr. Mangala Rai**, Secretary, DARE & Director General, ICAR, New Delhi, for his encouragement and valuable guidance. The support extended by **Dr. G.Kalloo**, Deputy Director General (Crop Sciences & Horticulture), ICAR, New Delhi, is gratefully acknowledged. **Dr. O.P.Dubey**, Assistant Director General (Plant Protection), ICAR, New Delhi, has always encouraged and inspired us to perform better. Sincere thanks are due to all project workers at Project Directorate of Biological Control and different co-ordinating centres of AICRP for completing the allotted research programmes. Thanks are also due to the Vice-chancellors and Directors of Research of SAU-based centres and Directors of ICAR Institute-based centres for providing the facilities.

R. J. Rabindra

कार्यकारी सारांश

परियोजना निदेशक का प्रतिवेदन

जैव नियंत्रण के अखिल भारतीय समन्वित अनुसंधान कार्यक्रम के अंतर्गत गुजरात कृषि विश्वविद्यालय में 3-5 जुलाई, 2003 के दौरान आयोजित 12वीं कार्य समूह बैठक के दौरान नाशीजीव, रोग तथा खरपतवारों के लिए पर्यावरण हितैषी जैव नियंत्रण प्रौद्योगिकी को विकसित करने हेतु दो वर्ष (2003-04 तथा 2004-05) की विस्तृत तकनीकी कार्यक्रम तैयार किया गया, जिसमें मूल तथा प्रायोगिक दोनों प्रकार के अनुसंधान का ध्यान रखा गया। गन्ने की वूली एफिड जैसी उभरती समस्याएं, बी.टी. कपास को चूसने वाले पीडक का पर्यावरण हितैषी तरीके से प्रबंध, जैविक खेती में जैव नियंत्रण को सम्मिलित करना, आदि को कार्यक्रम में शामिल किया गया। इस अनुसंधान कार्य को दस राज्य कृषि विश्वविद्यालयों, जैव नियंत्रण के अखिल भारतीय समन्वित अनुसंधान कार्यक्रम (ए.आई.सी.आर.पी.) के अंतर्गत भा. कृ. अनु. प. के छ: केन्द्रों और कुछ स्वेच्छिक संगठनों को सौंपा गया। अखिल भारतीय समन्वित अनुसंधान कार्यक्रम के अंतर्गत की गई मौलिक तथा प्रायोगिक अनुसंधान की प्रमुख उपलब्धियाँ नीचे सारगर्भित है।

मौलिक अनुसंधान

जैविक नियंत्रण परियोजना निदेशालय

जीववर्गीकरण अध्ययन

कोक्सिनेलिड की तीन नई प्रजातियों को पहचाना गया। भारतीय टेकिनिडे की जांचसूची तैयार की जा रही है। जैव कारक के कीट परिवारों की अन्योन्यक्रिया की पहचान कुंजी तैयार की गई है।

प्राकृतिक शत्रु कीटों का प्रतिपादन

सेसिडोकेरस कोनेक्सा, जिसे *क्रोमोलेना ओडोरेटा* के परीक्षण के लिए लाया गया है, ने परपोषी विशिष्टा के दौरान 78 पौधों में से किसी भी पौधे को ग्रसित नहीं किया। दलहन में *हेलिकोवर्पा आर्मिजेरा* का मूल्यांकन करने के लिए केनिया से *ट्राइकोग्रामा मवनजाई* को प्रतिपादित किया गया है।

पक्सिनिया स्पोगाज़िनि, जो *मिकेनिया मिक्रान्था* का रोगजनक जैव कारक है, को राष्ट्रीय पादप आनुवांशिक संसाधन ब्यूरो (एन बी पी जी आर) नई दिल्ली, के पादप संरक्षण प्रयोगशाला में स्थापित किया गया।

परभक्षी तथा परजीवी कीटों का बहोत्पादन और स्थूल

कार्डियास्टेथस एक्सीगुअस, *ब्लापोटोस्तेथस पेलेसेनस*, *ओरियस टेन्टिलस* और *ओरियस मेक्सिडेन्टस* जैसे एन्थोकोरिड्स को सफलतापूर्वक प्रयोगशाला में बडे पैमाने पर उत्पादित किया जा सका। *कार्डियास्टेथस* और *ब्लापोस्टेथस* भंडार पीडक के लिए प्रभावकारी रहे। *सी. एक्सीगुअस* को 50 परभक्षी के दर से छोडने पर *ओपीसिना अरेनोसेला* के नियंत्रण के लिए प्रभावकारी पाया गया। *ई. अर्गेन्टियोपीलोसस* को बडे पिंज़डे में और अधिक आर्द्रता में रखने पर उनकी पुनरूत्पादन क्षमता बढी।

बी.टी. कपास का परजीवी कीटों पर प्रभाव

बी.टी. तथा बी.टी. रहित कपास की कृषिजोपजाति (कल्टीवार) परजीवीकरण पर *टेलेनोमस* प्रजाति तथा *एरिबोरस अर्जेन्टोपिलोसिस* के द्वारा *स्पोडोप्टरा* पर कोई अन्तर नही पाया गया। *सी. कारनिया* का बी.टी. तथा बी.टी. रहित कपास पर एकसमान प्रभाव था।

सीमियो रसायन द्वारा प्राकृतिक शत्रुओं की क्षमता बढाना

क्राइसोपर्ला कारनिया की एलेक्ट्रो-एन्टेनोग्राम (ई.ए.जी.) अध्ययन से स्पष्ट हुआ कि लीनालूल के प्रति अच्छा प्रभाव देता है। हेक्सेन तथा ट्राकोसेन पर आधारित केरोमोन घोल से *टी. किलोनिस* पर अधिक प्रभाव प्रेरित किया जा सका। पेट्रोलियम ईथर में *एस. लितूरा* को धोने से *कोम्पोलेटिस क्लोराइड़े* की क्रियाशीलता अच्छी रही।

कीट रोगजनक

हेलूला अनडेलिस, *पेरिस ब्रासिके*, *एच. आर्मिजेरा* और *स्पोडोप्टरा एक्सीगूआ* से कीट विषणुओं को अलग किया गया। टमाटर की तीन किस्मों - अर्का आलोक, अर्का मेघाली और अर्का विकास पर एच ए एन पी वी और एस एल एन पी वी की दक्षता पर कोई फर्क नही आया।

जनन्द्रव्य संग्रहण में कीटरोगजनक कवकों की और तेरह नई आइसोलेट को सम्मिलित किया गया। कवकीय आइसोलेट, जो

कि *पी. ज़ाइलोस्टेला*, एफिड के तीन स्पीसीज़ और गन्ने के वूली एफिड के प्रति रोगजनक हैं, को पहचाना गया।

कीटरोगाण्विक सूत्रकृमि (ई.पी.एन) के स्थानीय आइसोलेट के बहोत्पादन के लिए अंत:पात्र तरीका विकसित किया गया। *एस. कार्पोकासे* का स्पांज की तरह का घोल परिवहन के समय स्थिर पाया गया। रेनिफोर्म तथा मूलग्रान्थि सूत्रकृमि के प्रति *अर्थोबोर्टिस ओलिगोस्पोरा* प्रभावकारी पाया गया। *वर्टीसिलियम क्लामाइडोस्पोरियम* के प्रति *अर्थोबोर्टिस ओलिगोस्पोरा* प्रभावकारी पाया गया। *वर्टीसिलियम क्लामाइडोस्पोरियम* के बीटा - तूबिलिन (1-233 बेस) का सीक्वेन्स किया गया और उसे एन.सी.बी.आई., मेरीलैंड, संयुक्त राष्ट्र अमरिका के जीनबैंक में पंजीकृत भी किया गया।

प्राकृतिक शत्रु कीटों के विभेदों का विकास

टी. किलोनिस (अधिक तापमान सहिष्णु और अधिक होस्ट ढूंढने की क्षमति) और *ट्राइकोग्रामाटोइडे बेक्ट्रे* (अधिक होस्ट ढूंढने की क्षमता और *पी. ज़ाइलोस्टेला* के विरुद्ध उपयोग) की सुधरी विभेदों का विकास किया गया।

परभक्षी कीटों के लिए कृत्रिम आहार का विकास

कोक्सिनेलिड, क्राइसोपिड्स और एन्थोकोरिड्स के लिए कृत्रिम आहार विकसित किया गया है। कृत्रिम आहार पर पले होस्ट कीट उतने ही प्रभावी थे जितने की प्राकृतिक आहार से पले कीट। *सी. कारनिया* के कृत्रिम आहार को रेफ्रिजिरेटर में 570 दिनों तक रखा जा सकता है।

पादप रोगों का जैव नियंत्रण

गोबर खाद को *ट्राइकोडर्मा हार्ज़ियानम* के साथ सडाने से टमाटर और भिंडी (जी बी पं यू ऐ सं एवं टी) के अंकुरण तथा विकास में वृद्धि आई। *टी. हार्ज़ियानम* से गोबर खाद में घुलनशील पदार्थ और कई सूक्ष्म पोषण तत्वों की मात्रा में बढोत्तरी हुई।

टी. हार्ज़ियानम और *स्यूडोमोनास फ्लूरोसेन्स* के पर्णिल छिडकाव से काला नमक सुगन्धवाले चावल में ब्राउन स्पाट की संख्या कम हुई और पैदावार अधिक हुई (जी बी पं यू ऐ सं एवं टी)। *टी. हार्ज़ियानम* के पर्णिल छिडकाव से बासमति चावल में ब्लास्ट का प्रभावकारी नियंत्रण हुआ (पी.ऐ.यू.)।

टी. हार्ज़ियानम के टाल्क मिश्रण को कमरे के तापमान में 15% नमी पर 180 दिनों तक रखा जा सकता है। सोरघम में आटे के माध्यम वाला मिश्रण, सी.एफ.यू. को समय के साथ बढाकर 150 दिन तक रखा जा सका (पी डी बी सी)।

फसल पीडकों का जैविक नियंत्रण

गन्ना

क) वूली एफिड का सर्वेक्षण

वूली पफिड का प्रकोप महाराष्ट्र (अत्यधिक), आंध्रप्रदेश (मध्यम), हरियाणा और उत्तर प्रदेश (कम) में देखा गया। *डाइफा एफिडीवोरा* परभक्षी कीट मुख्यत: प्रायद्वीपीय क्षेत्र में अधिक पाया गया। *डी. एफिडीवोरा* के कोकून और लार्वा को प्रवरानगर के आसपास के क्षेत्र में 1285 किसानों के खेतों में छोडा गया। एफिड तथा *डी. एफिडीवोरा* की जनसंख्या सारणी का अध्ययन किया गया।

ख) गन्ना बेधक के लिए *ट्राइकोग्रामा किलोनिस*

टी. किलोनिस के विमोचन से गन्ने की फसल में *सी. ट्रमिडीकोस्टालिस* से हानि कम हुई और उपज भी बढी। पंजाब के मेहली गांव में तना बेधक के प्रभावी नियंत्रण के लिए *टी. किलोनिस* का किसान के खेतों पर प्रदर्शन किया गया। जलन्धर जिले में शीर्ष बेधक के रोकथाम के लिए *टी. जपोनिका* से प्रभावकारी प्रबंध हो सका।

कपास

क) बी.टी. कपास पर जैविक नियंत्रण

बहुस्थानीय परिक्षण में, बी आई पी एम पैकेज, जिसमें *टी. हार्ज़ियानम* से उपचारित बीज, *सी. कारनिया* का विमोचन और पक्षीधाम के स्थापन, शामिल होता है, उतनी ही प्रभावकारी पाई गई जितनी बी.टी. कपास के लिए सिफारिश की गई पैकेज आफ प्रेक्टिस थी। बी.टी. कपास में सूंडियों की संख्या में कमी आई, प्राकृतिक शत्रुओं का संरक्षण हुआ और उपज भी बढी। कृषि विश्वविद्यालय, धारवाड में बी.टी. कपास में सूंडियों का 12-14% आपतन देखा गया जो बी.टी. रहित कपास से थोडा कम था (17-19%)।

ख) *ट्राइकोग्रामा* विभेदों का मूल्यांकन

पंजाब में क्षेत्र परीक्षण में देखा गया कि सूंडियों के प्रति पीडक सहिष्णु *ट्राइकोग्रामा* और स्थानीय विभेद दोनों ही प्रभावी थे। तमिलनाडू कृषि विश्वविद्यालय में पीडक सहिष्णु *ट्राइकोग्रामा* नियंत्रण तरीके से ज्यादा प्रभावी पाया गया। आनंद में पीडक सहिष्णु तथा स्थानीय विभेद दोनों में कोई विशेष अन्तर नही पाया गया।

गुजरात कृषि विश्वविद्यालय, आनंद तथा पंजाब कृषि विश्वविद्यालय में सूंडियों के लिए 100 तथा 150 स्ट्रिप के स्थान पर 200 स्ट्रिप *ट्राइकोग्रामा* का विमोचन अधिक प्रभावकारी रहा।

तम्बाकू

सी.टी.आर.आई., राजमुण्डरी में बी.टी तथा *नोमेरूए रेलेई* दोनों ही *हेलिकोवर्पा आर्मिज़ेरा* के नियंत्रण के लिए प्रभावी पाए गए। एच ए एन पी वी की अपेक्षा बी.टी. अच्छा पाया गया। लंका तम्बाकू में *स्पोडोप्टरा एक्सीगूआ* से हानि अधिक हुई।

दलहनी फसलें

क) अरहर

बहुस्थानीय परीक्षण में समन्वित पीडक प्रबंध पैकेज (आई.पी.एम) जिसमें *ट्राइकोडर्मा* से उपचारित बीज, नीम की खली अर्क 5%, बी. टी./एच ए एन पी वी छिडकाव और बीच-बीच में मक्का लगाने की क्रिया होती है, से फली बेधक का नियंत्रण हुआ और उपज भी बढी (तमिलनाडू कृषि विश्वविद्यालय और गुजरात कृषि विश्वविद्यालय)। तमिलनाडू कृषि विशवविद्यालय तथा गुजरात कृषि विश्वविद्यालय में ई.पी.एन. *हेटरोहॅब्डिटिस* से *एच. आर्मिजेरा* की संख्या कम हुई, फली पर हानि भी कम हुई और उपज बढी।

ख) सोयाबीन और लेबलेब

सोयाबीन पर बी आई पी एम जिसमें *ट्राइकोडर्मा* और *ब्यूवेरिया बेसियाना* घोल का उपयोग होता है, से रोग तथा पीडक से हानि कम हुई और उपज में वृद्धि हुई। (सोयाबीन पर राष्ट्रीय केन्द्र तथा सी.टी.आर.आई.)

एच ए एन पी वी का 1.5×10^{12}/ हे. उपचार से *एच. आर्मिजेरा* द्वारा बीजों पर होने वाली हानि कम हुई और लेबलेब के बीज उत्पादन में वृद्धि हुई। (टी.एन.ऐ.यू)

चावल

आई.पी.एम. जिसमें *ट्राइकोडर्मा, ट्राइकोग्रामा* और *स्यूडोमोनास फ्लूरोसेन्स* और पक्षीधाम का उपयोग होता है, तना बेधक, पत्ती मोडक सूंडियों के नियंत्रण के लिए प्रभावी रहा तथा पैदावार भी अधिक हुई (ऐ.ऐ.यू)। असम कृषि विश्वविद्यालय, केरल कृषि विश्वविद्यालय, पंजाब कृषि विश्वविद्यालय तथा महात्मा फूले कृषि विद्यापीठ मे किए गए बहुस्थानिय परिक्षणों से ज्ञात हुआ कि *ट्राइकोडर्मा जेपोनिका* से तना बेधक तथा पत्ती मोडक सूंडियों का नियंत्रण हुआ और पैदावार अधिक हुआ। पंजाब कृषि विश्वविद्यालय में *टी. किलोनिस तथा टी. जेपोनिका* के सम्मिश्रण से अच्छा नियंत्रण मिला।

जैव नियंत्रण कारक के उपयोग से तैयार किया गया जैविक खेती पैकेज पीडकों के नियंत्रण तथा उपज बढाने के लिए पारम्परिक तरीको की खेती की तुलना में काफ़ी प्रभावकारी पाया गया। पूसा बासमति चावल (पी.ऐ.यू) तथा ज्योति चावल (के.ऐ.यू) में प्राकृतिक शत्रुओं के संरक्षण में बहुत मदद मिली।

तिलहनी फसलें

मूंगफली तथा सरसों

मूंगफली में पत्ती मोडक सूंडियों तथा *एस. लितूरा* के लिए रसायनिक तरीकों की अपेक्षा जैवनियंत्रण आधारित आई.पी.एम. अधिक प्रभावी रहा और उपज भी अधिक हुई। (टी.एन.ऐ.यू)

वर्टीसिलियम लिकानी के छिडकाव से सरसों के एफिड का नियंत्रण किया जा सका। *इश्चियोडोन सूटेलारिस* का विमोचन प्रभावकारी नही था (पी.ऐ.यू.)।

नारियल

टी. एम्ब्रायफेगम के 4000 / पेड की दर से विमोचित करने से *ओपीसिना अरेनोसेला* का अच्छा नियंत्रण हुआ (पी.डी.बी.सी.)। तने पर *गोनियोजस नेफान्टिडिस* छोडना उतना ही प्रभावी था जितना *ओ. अरेनोसेला* के नियंत्रण के लिए शीर्ष पर छोडने से होता है (पी.डी.बी.सी. और के.ऐ.यू.)।

उष्णकटिबंधीय तथा शीतोष्ण फल

अनार के फल बेधक *ड्यूडोरिक्स* पर बी. टी. प्रभावकारी

रहा (आई आई एच आर, एम पी के वि, वाई एस पी यू एच एवं फो)। बेर में बी.टी. तथा *टी. किलोनिस* के विमोचन से *मेरीडार्चेस साइरोडस* (आई आई एच आर) का एक समान नियंत्रण हुआ। बहुस्थानीय अध्ययन से ज्ञात हुआ कि *एनकार्सिया गोडेलोपे* को पपीता, अमरूद और अन्य फसलों के स्पाइरल सफेद मक्खी पर स्थापित किया गया (आई आई एच आर)। केरला में मिर्च पर *ई. गोडेलोपे* की परपोषिता 52-56% रही।

सेब की फसल में पादपभक्षी माइट के प्राकृतिक शत्रुओं के सर्वेक्षण से परभक्षी माइट, थ्रिप्स एन्थोकोरिड्स और क्राइसोपिड्स की मौजूदगी का पता लगा (वाई एस पी यू एच एवं फो)।

सब्जियों के पीडक

वाम का उपयोग, पौध के जडों का *ट्राइकोडर्मा* में डूबोना, *टी. प्रेटियोसम* का विमोचन (50,000/ हे.) तथा एच ऐ एन पी वी का 1.5×10^{12}/ हे. के आई.पी.एम. पैकेज से टमाटर के *एच. आर्मिजेरा* का नियंत्रण हुआ और उपज बढी (एम पी के वि एवं टी एन ऐ यू)। *ट्राइकोडर्मा, टी. किलोनिस* और ई. पी. एन के उपचार से बैंगन के फलों तथा तने पर हानि कम हुआ और उपज में बढोत्तरी हुई (टी एन ऐ यू)। गांठगोभी में *बी. बासियाना* से *पेरिस ब्रासिके* की मृत्यु संख्या 71% तक रही। तथापि *डाइक्लोर्वोस* अधिक प्रभावकारी रहा (एस के यू ऐ एस एवं टी)। *अपान्टेलेस स्टेनेटोनी*, गर्किन की सूंडी *डाइफानिया इंडिका* के नियंत्रण के लिए प्रभावकारी पाया गया। *ओरियस मैक्सीडेन्टेक्स* को मिर्च के थ्रिप्स का अच्छा परभक्षी पाया गया।

आलू

ट्राइकोडर्मा, वी. लेकानी तथा *कोपीडोसोमा कोहलेरी* के स.पी.प्र. (समन्वित पीडक प्रबंध - आई पी एम) से आलू के कन्द मोथ का नियंत्रण हुआ और उपज में भी बढोत्तरी हुई (एम पी के वि)।

खरपतवार

नियोकेटिना आइकोर्निये तथा *एन. ब्रूकी* को असम, आंध्र प्रदेश, गुजरात, केरल, महाराष्ट्र, तमिलनाडू और पंजाब में सफलतापूर्वक स्थापित किया गया। बहुस्थानीय अध्ययन से ज्ञात हुआ कि पार्थेनियम बीटल *ज़ाइगोग्रामा बाइकोलरेटा* पत्तियां खाकर पौधे के वनस्पति तथा ऊँचाई को घटाता है।

2. EXECUTIVE SUMMARY

In order to develop biocontrol technologies for the eco-friendly management of key pests, diseases and weeds, an extensive technical programme covering both basic and applied research was drawn for two years (2003-04 and 2004-05) in the 12th Work Group Meeting of the AICRP on Biological Control at Gujarat Agricultural University, Anand, during 3-5, July 2003. Emerging problems like the sugarcane woolly aphid, eco-friendly management of sucking pests on *Bt* cotton, and integration of biological control in organic farming, were included in the programme. The research programme was assigned to scientists of the Project Directorate of Biological Control (PDBC) and ten SAU and six ICAR-based centers of the AICRP on biological control and a few voluntary centers. The salient findings of basic and applied research conducted are briefly summarized here.

Basic research

Project Directorate of Biological Control

Biosystematics

Three new species of coccinellids were described. A checklist of Tachinidae of the Indian region is under preparation. An interactive identification key to the families of insect bioagents has been prepared.

Introduction of Natural Enemies

Cecidochares connexa, introduced against *Chromolaena odorata*, did not attack 78 species of plants in host-specificity tests. *Trichogramma mwanzai* has been introduced from Kenya for evaluation against *Helicoverpa armigera* in pulse ecosystem.

Puccinia spegazzinii, the rust pathogen of *Mikania micrantha*, has been established in the containment-cum-quarantine facility (CQF) at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi.

Mass production and evaluation of predators and parasitoids

Anthocorids *Cardiastethus exiguus*, *Blaptostethus pallescens*, *Orius tantillus* and *Orius maxidentex* were successfully mass produced in the laboratory. *Cardiastethus* and *Blaptostethus* were effective against certain storage pests. *C. exiguus* was effective @ 50 per palm against *Opisina arenosella*. Larger cage size and higher humidity enhanced the reproductive performance of *Eriborus argenteopilosus*.

Influence of *Bt* cotton on entomophagous insects

Parasitization rates of *Telenomus* sp. and *E. argenteopilosus* against *Spodoptera litura* did not vary between Bt- and non-Bt cotton cultivars. Response of *Chrysoperla carnea* to *Bt* and non-*Bt* cotton did not vary.

Enhancement of efficiency of natural enemies through semiochemicals

Electro-antennogram (EAG) studies with *C. carnea* revealed a high response to linalool. Kairomone formulations based on hexane and tricosane, and nonacosane evoked a high response in *Trichogramma chilonis*. Larval wash of *S. litura* in petroleum ether increased the performance of *Campoletis chlorideae*.

Insect pathogens

Insect viruses from *Hellula undalis*, *Pieris brassicae*, *H. armigera* and *Spodoptera exigua* have been isolated. The efficacy of *Ha*NPV and *Sl*NPV did not vary in 3 varieties of tomato, *viz.*, Arka Alok, Arka Meghali and Arka Vikas.

Thirteen new isolates of entomopathogenic fungi were added to the germplasm collection. Fungal isolates pathogenic to *Plutella xylostella*, three species of aphids and sugarcane woolly aphid have been identified.

An *in vitro* mass production system for native isolates of EPN has been developed. A sponge formulation of *Steinernema carpocapsae* was found to be stable in transport conditions. *Arthrobotrys oligospora* was effective against reniform and root-knot nematodes. β-tubulin gene (1 to 233 bases) from *Verticillium chlamydosporium* has been sequenced and registered in Genbank, NCBI, Maryland, USA.

Development of improved strains of entomophages

Improved strains of *T. chilonis* (with high temperature tolerance and high host-searching ability) and *Trichogrammatoidea bactrae* (with high host-searching ability for use against *P. xylostella*) have been developed.

Development of artificial diet for predators

Artificial diets have been developed for coccinellids, chrysopids, and anthocorids. Artificial diet-reared predators and host insects were as effective as natural host-reared ones. The artificial diet for *C. carnea* had a shelf-life of up to 570 days under refrigeration.

Biocontrol of plant diseases

Farm yard manure (FYM) composted with *Trichoderma harzianum* enhanced the germination and growth of tomato and okra (GPBUAS & T). *T. harzianum* also increased the water-soluble humic content and several macro and micronutrients in FYM.

Foliar application of *T. harzianum+Pseudomonas fluorescens* significantly reduced the brown spot incidence in Kalanamak scented rice and increased the yield (GPBUAS & T). Foliar sprays of *T. harzianum* effectively controlled blast in Basmati rice (PAU).

The talc formulation of *T. harzianum* had a high shelf-life (180 days) at room temperature at 15% moisture level. In sorghum grain flour-based formulation, CFU increased with time for up to 150 days (PDBC).

BIOLOGICAL SUPPRESSION OF CROP PESTS

Sugarcane

Surveys for woolly aphid

Woolly aphid incidence was noticed in Maharashtra (severe), Andhra (moderate), Haryana and Uttar Pradesh (minor). The predator *Dipha aphidivora* was widely prevalent in the peninsular region. Cocoons and larvae of *D. aphidivora* were released in 1285 farmers' fields around Pravaranagar area. Population dynamics of the aphid and *D. aphidivora* have been studied.

Trichogramma chilonis against sugarcane borers

Releases of *T. chilonis* effectively reduced the damage by *Chilo tumidicostalis* and increased the cane yield. The effectiveness of *T. chilonis* against early shoot borer was demonstrated in the farmers' field in Mehli village in Punjab. In field trials, *T. japonicum* was effective in the management of top borer in Jalandhar district.

Cotton

Biological control in *Bt* cotton

In multi-location trials, a BIPM package consisting of seed treatment with *T. harzianum*, release of *C. carnea* and erection of bird perches was as effective as the recommended package of practices for Bt cotton. *Bt* cotton effectively reduced the incidence of bollworm, conserved natural enemies, and increased the yield. In UAS, Dharwad, 12-14% incidence of bollworm was noticed on Bt cotton, which, however, was slightly lower than that on non-Bt cotton (17-19%).

Evaluation of *Trichogramma* strains

In field trials in Punjab, the pesticide-tolerant *Trichogramma* and local strain were equally effective against bollworms. At TNAU, the pesticide-tolerant *Trichogramma* was more effective than control. In Anand, there were no significant differences between pesticide-tolerant and local strains.

At GAU, Anand, and PAU, release of *Trichogramma* at the rate of 200 strips was significantly more effective than 150 and 100 strips per ha against bollworms.

Tobacco

At CTRI, Rajahmundry, Bt and *Nomuraea rileyi* were equally effective in controlling *Helicoverpa armigera*. Bt was found to be better than *Ha*NPV. Parasitism by *Telenomus remus* and damage by *Spodoptera exigua* were higher on Lanka type tobacco.

Pulses

Pigeonpea

In multi-location demonstrations, the IPM package consisting of *Trichoderma* seed treatment, NSKE 5%

spray, Bt/*Ha*NPV spray and random planting of maize was effective in controlling pod borers and increasing the yield (TNAU, GAU). At TNAU and GAU, the EPN *Heterorhabditis* effectively reduced *H. armigera* population and pod damage and increased the yield.

Soyabean and lablab

On soyabean, BIPM comprising of *Trichoderma* and *Beauveria bassiana* formulations helped in minimizing the damage by pests and diseases and increased the yield (NRC Soyabean and CTRI).

Application of *Ha*NPV at the rate of $1.5x10^{12}$/ha reduced the damage to seeds by *H. armigera* and increased the seed yield in lablab (TNAU).

Rice

IPM involving the use of *Trichoderma*, *Trichogramma* and *Pseudomonas fluorescens* and bird perches effectively controlled stem borer and leaf folder and enhanced the yield (AAU). In multi-location trials at AAU, KAU, PAU and MPKV, *T. japonicum* controlled both stem borer and leaf folder and increased the grain yield. At PAU, however, combination of *T. chilonis* + *T. japonicum* gave better control.

Organic farming package involving use of biocontrol agents was as effective as the conventional package of practices in controlling the pests and increasing the yield in Pusa Basmati Rice (PAU) and Jyothi rice (KAU) and also helped conserve natural enemies.

Oilseeds

In groundnut, biocontrol-based IPM was better than chemical control in controlling leaf folder and *S. litura* larvae and increased the yield (TNAU).

Spraying of *Verticillium lecanii* controlled aphids on mustard. Release of *Ischiodon scutellaris* was, however, not effective (PAU).

Coconut

Release of *T. embryophagum* at the rate of 4000 per palm significantly brought down the population of *Opisina arenosella* (PDBC). Release of *Goniozus nephantidis* on the trunks was as effective as crown release in controlling *O. arenosella* (PDBC, KAU).

Tropical and temperate fruits

Bt was effective against pomegranate fruit borer *Deudorix* spp. (IIHR, MPKV, YSPUH&F). In ber, both Bt and release of *T. chilonis* were very effective against *Meridarches scyrodes* (IIHR). Multilocation studies revealed that *Encarsia guadeloupae* was established on spiralling whitefly on papaya, guava and several other hosts (IIHR). In Kerala, parasitism by *E. guadeloupae* was as high as 52-56% on chillies (KAU).

Survey for the natural enemies of phytophagous mites of apple revealed the occurrence of predatory mites, thrips, anthocorids and chrysopids (YSPUH&F).

Vegetables

IPM package involving the use of VAM, *Trichoderma* seedling root dip, releases of *T. pretiosum* @50,000 per ha and spraying HaNPV at $1.5x10^{12}$ POB/ha controlled *H. armigera* on tomato and increased the yield (MPKV and TNAU). Application of *Trichoderma*, *T. chilonis* and EPN reduced the damage to fruits and shoots and enhanced the yield in brinjal (TNAU). On knol-khol, *B. bassiana* caused 71% mortality of *Pieris brassicae*. Dichlorvos was, however, more effective (SKUAS&T). *Dolichogenidea stantoni* was found promising against gherkin caterpillar *Diaphania indica*. *Orius maxidentex* was found to be an efficient predator of thrips on chillies (IIHR).

Potato

IPM package involving use of *Trichoderma*, *V. lecanii* and *Copidosoma koehleri* gave effective control of the potato tuber moth and increased the yield (MPKV).

Weeds

Neochetina eichhorniae and *N. bruchi* were established successfully in Assam, Andhra Pradesh, Gujarat, Kerala, Maharashtra, Tamil Nadu and Punjab. Multilocation studies revealed that the parthenium beetle, *Zygogramma bicolorata*, reduced the biomass and plant height through defoliation.

3. INTRODUCTION

Brief History

The All India Co-ordinated Research Project on Biological Control of Crop Pests and Weeds was initiated in 1977 under the aegis of the Indian Council of Agricultural Research (ICAR), New Delhi, with funds from the Department of Science and Technology, Government of India. Within two years (1979), ICAR included the project under its research activities with full financial support. When the Commonwealth Institute of Biological Control, Indian Station, Bangalore, was closed in 1988, the Project Co-ordinator's cell was merged with that unit and taken over by the ICAR. The new headquarters called Biological Control Centre (under the administrative control of National Centre for Integrated Pest Management, Faridabad) was shifted to the premises of the erstwhile CIBC, Indian Station. Recognition of the importance of biological control came during the VIII plan with the upgradation of the centre to Project Directorate of Biological Control with headquarters at Bangalore. The Project Directorate started functioning on 19th October 1993. The AICRP started with 13 centres initially and has now increased to 16 centres, all functioning under the Project Directorate.

The Project Directorate is located on the Bangalore-Hyderabad National Highway (NH 3), about 8 km from the Bangalore City Railway Station and 17 km from the Bangalore Airport.

Past achievements

Basic Research

- Eighty-two exotic natural enemies (NEs) have been studied for utilization against alien pests, out of which 56 could be successfully multiplied in the laboratory, 50 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 the same way as indigenous natural enemies.
- The encyrtid parasitoid *Leptomastix dactylopii*, introduced from West Indies in 1983, has successfully established on mealybugs infesting citrus and many other crops in South India.
- Two aphelinid parasitoids of South American origin fortuitously introduced against *Aleurodicus dispersus*; *Encarsia guadeloupae*, colonized in peninsular India from Lakshadweep, has established, displacing the earlier introduced *E.* sp. nr. *meritoria*.
- *Curinus coeruleus* (origin: South America), the coccinellid predator introduced from Thailand in 1988, colonized on subabul psyllid.
- *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 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.
- Biosystematic studies carried out on 200 predatory coccinellids; *Serangium serratum*, *Microserangium brunneonigrum* and *Pseudaspidimerus infuscatus* described as new species from south India. An annotated checklist of the fauna of the Indian subcontinent (excluding Epilachninae) prepared, comprising 418 species under 78 genera and 21 tribes under five subfamilies.
- A sort of classical biological control has been achieved within the country by the redistribution of *Epiricania melanoleuca*, a parasite of *Pyrilla perpusilla*.
- Breeding techniques for 46 host insects standardized including rearing on semi-synthetic diet and cost of production has been worked out.
- Improved laboratory techniques developed for the multiplication of 26 egg parasitoids, six egg-larval

parasitoids, 39 larval/nymphal parasitoids, 25 predators and seven species of weed insects

- A beef liver-based semi-synthetic diet evolved for *Chrysoperla carnea* to facilitate its large-scale production and use.
- Coccinellid predators *Cryptolaemus montrouzieri*, *Cheilomenes sexmaculata* and *Chilocorus nigrita* successfully mass-produced on semi-synthetic diet.
- A new multi-cellular acrylic larval rearing unit devised for efficient and economic mass production of *Helicoverpa armigera* and *Spodoptera litura* for commercial production of host-specific parasitoids and NPV. Several units supplied to Government, ICAR institutes and private entrepreneurs.
- Tritrophic relationships between natural enemies, their hosts and host plants have been determined. *Hyposoter didymator* & *Telenomus remus* preferred to parasitise *Spodoptera litura* larvae and eggs, respectively, on castor and beet root. *Cotesia kazak* preferred tomato, cotton and okra, while *C. marginiventris* preferred knol-khol, castor and cowpea and *Eucelatoria bryani* preferred cotton. Tritrophic interaction studies between the egg parasitoid, *Trichogramma chilonis*, bollworm *H. armigera* and cotton, chickpea, pigeonpea, sunflower and tomato genotypes have helped in identifying biocontrol-friendly genotypes.
- Suitable low temperatures for short-term storage of trichogrammatids, *Sticholotis madagassa*, *E. bryani*, *Carcelia illota*, *Allorhogas pyralophagus*, *Copidosoma koehleri*, *H. didymator*, *C. marginiventris*, *L. dactylopii*, *Sturmiopsis inferens*, and *Pareuchaetes pseudoinsulata* have been determined.
- Superior strains of *T. chilonis* have been identified for cotton, sugarcane and tomato crops.
- An endosulfan-tolerant strain of *T. chilonis* (Endogram) was developed for the first time in the world and the technology transferred to private sector for large-scale production. Presently, 24000 ha of cotton and vegetables have been protected by this technology in 6 states. Endogram has been further modified for tolerance to monocrotophos and fenvalerate.
- A strain of *T. chilonis* strain tolerant to high temperatures (up to 36°C) has been developed for use in areas with high temperature.
- Different pesticides have been screened against 37 natural enemies for identifying the relatively safer ones to be used in a biological control-based integrated approach.
- Kairomones from scale extracts of *Helicoverpa armigera* and *Corcyra cephalonica* increased the predatory potential of chrysopids.
- Acid-hydrolyzed L-tryptophan increased oviposition by *C. carnea* on cotton.
- Primary cell culture from the embryos of *Spodoptera litura* has been established to facilitate the multiplication of obligate microorganisms.
- Two fungal (*Trichoderma harzianum* (PDBCTH 10) and *T. viride* (PDBCTH 23)), and two bacterial antagonists (*Pseudomonas fluorescens* (PDBCTH 23) and *P. putida* (PDBCAB 19)) of many plant pathogens released for commercial production after intensive studies.
- Bacterial antagonists, particularly *Pseudomonas cepacia* (starin N 24), successfully suppressed *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*, recorded.
- Suitable media for mass multiplication of EPN identified. *S. carpocapsae* @ 1.25-5 billion/ha proved effective against brinjal borer, *Leucinodes orbonalis*. Talc-based and alginate-capsule formulations of *S. carpocapsae* and *H. indica* were effective against *S. litura* in tobacco.

- 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 *Verticillium chlamydosporium* was effective in sandy loam soil.
- *Cryptosporiopsis* sp. and *Fusarium pallidoroseum* were successfully evaluated as mycoherbicides for parthenium.
- '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, developed and supplied to end users.

Applied Research

- Inundative releases of *Trichogramma chilonis* and *T. japonicum* have proved effective in suppressing sugarcane tissue borers.
- *Beauveria bassiana, B. brongniarti* and *Metarhizium anisopliae* were mass cultured and utilized effectively against sugarcane white grubs.
- *Trichogramma chilonis* has proved effective against maize stem borer, *Chilo partellus.*
- Biocontrol-based IPM modules involving trichogrammatid releases were found better than insecticides for the control of stem borer and leaf folder of rice.
- IPM modules for cotton crop have been formulated, comprising the use of oxydemeton methyl (0.03%), releases of *C. carnea, T. chilonis* and spray of *Ha*NPV. The module gave higher yields and conserved natural enemies better than insecticidal sprays alone.
- *Bt* and *Ha*NPV were important components of BIPM of pod borer complex in pigeon pea and pod borer of chickpea.
- Integration of *Telenomus remus, C. carnea,* insect pathogens and NSKE was successful in the management of *S. litura* on tobacco. The cost-benefit ratio for BIPM was better (1:2.74) than that for chemical control (1:1.52).
- Inundative releases of parasitoids *Apanteles taragamae, Bracon hebetor, Goniozus nephantidis* and *Brachymeria nosatoi* against *Opisina arenosella* on coconut, coinciding the first release with the appearance of the pest, have proved effective.
- *Oryctes* baculovirus has been highly successful in reducing *Oryctes rhinoceros* populations in Kerala, Lakshadweep and Andaman Islands.
- *Cryptolaemus montrouzieri* has effectively suppressed *Planococcus citri* on citrus and grapes, *Pulvinaria psidii, Ferrisia virgata, Maconellicoccus hirsutus* and *Rastrococcus iceryoides* on guava, grapes and mango, respectively.
- Impact of *Trichogramma, Cryptolaemus, C. carnea, Ha*NPV and *Sl*NPV has been successfully demonstrated in Punjab, Andhra Pradesh, Karnataka, Maharashtra, Gujarat and Tamil Nadu.
- *Aphelinus mali* and several coccinellid predators were found effective against apple woolly aphid.
- San Jose scale parasitoids, *Encarsia perniciosi* and *Aphytis* sp., were well established in Jammu & Kashmir and Himachal Pradesh.
- *Trichogrammatoidea bactrae* and *Bt* were found effective against *Plutella xylostella.*
- Tomato fruit borer, *H. armigera,* was effectively controlled by releases of *T. pretiosum* and *Ha*NPV.
- *Copidosoma koehleri* and *Bt* were found effective against potato tuber moth in country stores.

Mandate

Project Directorate of Biological Control, Bangalore

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

AICRP on biological control of crop pests and weeds

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

Organisational set-up

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

Financial statement (2003-04)

Project Directorate of Biological Control, Bangalore

Head	Plan	Non-plan	Total
Pay & allowances	00.00	109.12	109.12
TA	03.00	02.20	05.20
Other charges including equipment	21.80	25.00	46.80
Works/petty works	01.00	01.00	02.00
Total	25.80	137.32	163.12

AICRP Centres (ICAR share only)

Name of the centre	Amount sanctioned and expenditure (Rs.)
CPCRI, Kayangulam	*
CTRI, Rajahmundry	*
IARI, New Delhi	*
IIHR, Bangalore	*
IISR, Lucknow	*
SBI, Coimbatore	*
AAU, Jorhat	10,39,839
ANGRAU, Hyderabad	13,10,333
GAU, Anand	31,92,293
KAU, Thrissur	08,53,000
MPKV, Pune	14,28,754
PAU, Ludhiana	21,55,372
SKUAS&T, Srinagar	21,19,231
TNAU, Coimbatore	13,16,441
YSPUH&F, Nauni, Solan	09,72,504
GBPUA&T, Pantnagar	02,92,000
Total	1,46,79,767

* Since the Project has been merged with Non-Plan, ICAR Institute-based centres did not maintain separate budget account

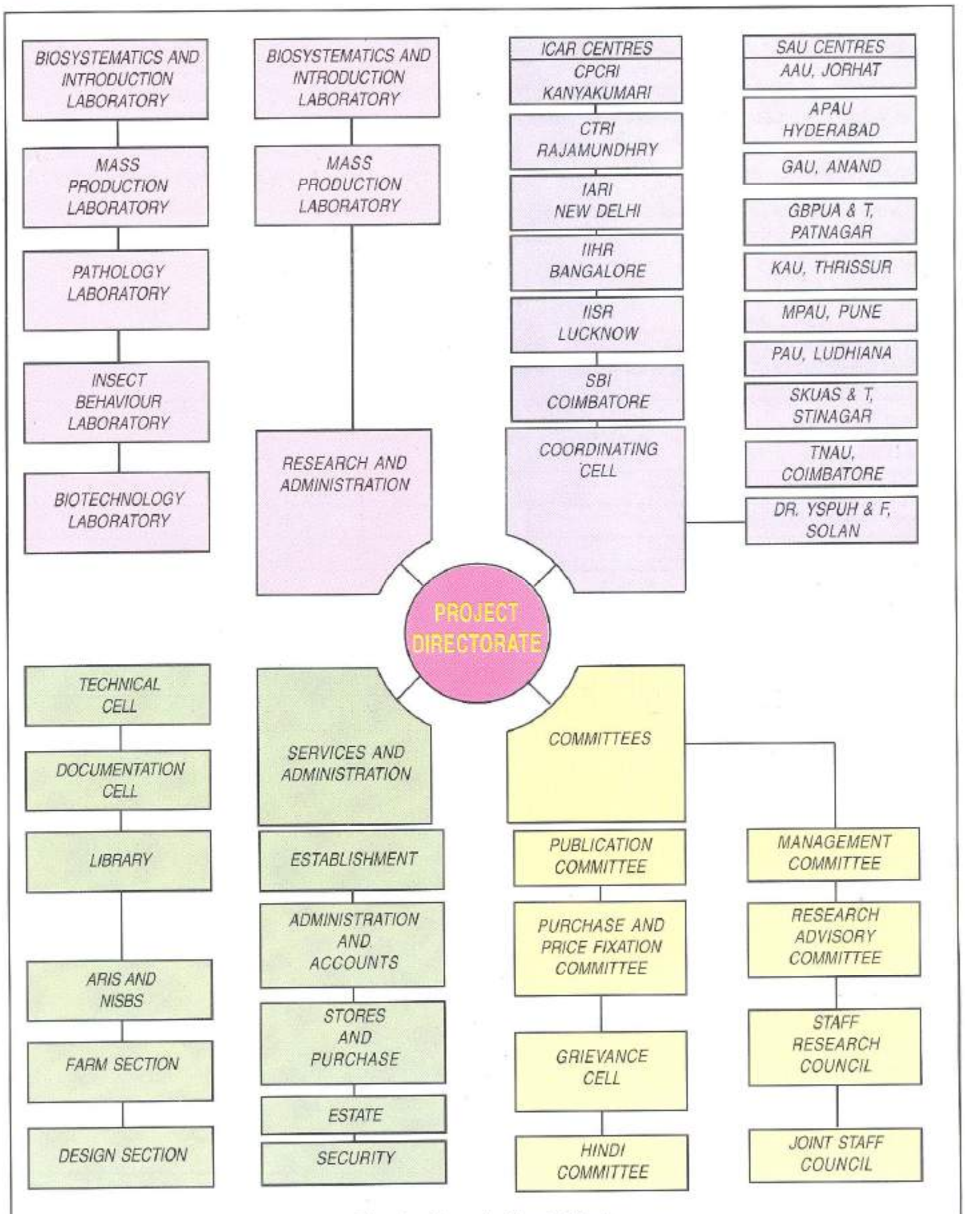

Fig. 1. Organizational Chart

Staff position

Category	Posts sanctioned up to 31-03-2004 *	Posts filled up to 31-03-2004	Vacant positions
PDBC, Bangalore			
Research Management	01	01	-
Scientific	25	22	3
Technical	18	18	-
Administrative	07	06	1
Supporting	06	6	-
Sub-total (a)	57	53	4
SAU-based Centres			
Scientific	21	21	-
Technical	31	31	-
Administrative	1	1	-
Sub-total (b)	53	53	-
ICAR Institute-based Centres			
Scientific	-	-	-
Technical	-	-	-
Sub-total (c)	-	-	-
Grand total (a+b+c)	110	106	4

4. RESEARCH ACHIEVEMENTS

Importation of natural enemies

Pure culture of stem gall fly, *Cecidochares connexa* was raised on potted *Chromolaena odorata* plants and behavioural studies were made in detail. Adult flies lived for 7-12 days. Stem swelling was first visible 15 days after oviposition, and the gall generally developed at a node and occasionally at internode with a single pair of leaves. The life cycle from egg to adult took 59.5-71.1 days, averaging 65.3 days.

Seventy-five host plants were tested for host specificity and the results indicated that the gallfly laid eggs and completed development only on *C. odorata*. A survey was conducted in Kodagu, Hassan and Shimoga districts of Karnataka to identify suitable locations for field release and collection of baseline data.

Trichogramma mwanzai, the egg parasitoid introduced from Kenya for the biological control of *Helicoverpa armigera* and other lepidopteran tissue borers, was quarantined successfully and a pure culture was raised using *Corcyra cephalonica* eggs.

Puccinia spegazzinii, the rust fungus specific to *Mikania micrantha*, imported from CABI, UK, was successfully established on *Mikania* plants at the quarantine laboratory at NBPGR, New Delhi, and was tested against 10 plant species for host-specificity.

Taxonomic studies

Tachinidae of the Indian subcontinent

A checklist to 220 species under 33 genera, 20 tribes and four subfamilies has been prepared.

Coccinellidae of the Indian subcontinent

Five more species were added to the illustrated guide to common coccinellids of the Indian Subcontinent. Three new species were described and two nomenclatural changes effected. An annotated checklist of the Epilachninae of the Indian subcontinent was completed based on the latest World catalogue of Epilachninae.

Development of an interactive identification key to important families of insect parasitoids and predators

An interactive identification key to 41 important families of insect parasitoids belonging to four orders and 25 major families of insect predators belonging to 11 orders was constructed on LucID platform. The key provides notes on diagnosis, economic importance, and illustrations and/or photographs of habitus and diagnostic characters. A pictorial guide to these families in a non-interactive format on CD is under compilation for the benefit of students and economic entomologists.

Evaluation of natural enemies

Host plant influence on parasitization by *Telenomus* sp.

Telenomus sp. parasitized 93.92% *Spodoptera litura* eggs on rose, 61.17% on *Bt* cotton and 15.51% on MCU-7 cotton when the parasitoid: host ratio was 1:2 compared to 94.73, 62.25 and 22.85%, respectively, when the ratio was 1:1. It was observed that *S. litura* preferred to lay eggs on all three varieties of tobacco tested - BanketA1 (32.1%), K326 (26.9%) and Gold Streak (41.0%). Parasitism by *T. remus* was maximum on Gold Streak (74.7%), followed by BanketA1 (12.9%) and K326 (5.5%) (Fig.2). This experiment indicated that *Telenomus* sp. could be further tested in small plot trials on Gold Streak.

Performance of *Eriborus argenteopilosus* on *Bt* and non-*Bt* cotton

In a no-choice test, parasitism was 20-28% on MCU-10 and 43.30% on Bt cotton. Comparatively lower parasitism was obtained in multiple-choice test. Irrespective of the variety, mean per cent parasitism was higher in no-choice test (31.79%) than in multiple-choice test (17.17%), with no significant difference between the two. Similarly, irrespective of the method of testing, a mean parasitism of 18.68% was recorded on MCU-10 and 30.28% on Bt cotton. The values were, however, not significantly different (Table 1), showing that Bt cotton was not deleterious to the parasitoid.

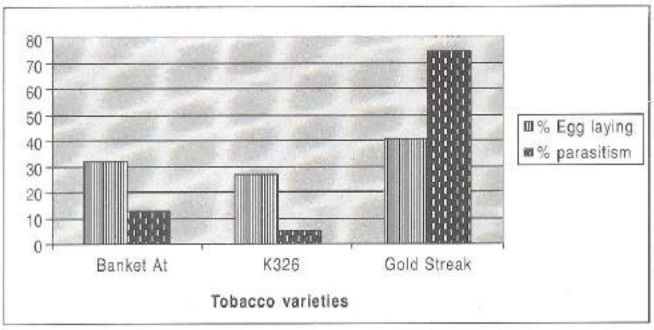

Fig 2. Egg laying by *S. litura* and parasitism by *Telenomus* sp. on three tobacco varieties

Table 1. Comparative parasitism by *Eriborus argenteopilosus* on *Helicoverpa armigera*

Cotton variety	Per cent parasitism		Mean
	No-choice test	Multiple-choice test	
MCU-10	20.28	17.08	18.68
Bt cotton	43.30	17.25	30.28
Mean	31.79	17.17	

Evaluation of anthocorid predators on bruchid pests

The anthocorids, *Cardiastethus exiguus* and *Blaptostethus pallescens*, were evaluated against *Callosobruchus* spp. on kabuli chenna and green gram. Seventy per cent bruchid emergence was observed in control, while release of *C. exiguus* nymphs and adults resulted in 50 and 63.3% bruchid emergence. When *B. pallescens* nymphs and adults were released, 60 and 50% bruchid emergence, respectively, was recorded. In green gram, the release of *C. exiguus* and *B. pallescens* adults resulted in reduced adult emergence (50 and 55%, respectively) compared to control (63%). The results need to be confirmed.

Blaptostethus pallescens on *Sitotroga cerealella* eggs infesting rice

Emergence of *S. cerealella* adults was 58% in control, whereas in the treatment with *B. pallescens* adults, it was only 29.4%. Minimum emergence (12.6%) was recorded when *B. pallescens* nymphs were released, which indicated that release of *B. pallescens* in the nymphal stage could be more effective against *S. cerealella*.

Field evaluation of *Cardiastethus exiguus* on *Opisina arenosella*

At Allalsandra, Bangalore, a field trial was conducted to evaluate the performance of *C. exiguus* on *O. arenosella* infesting coconut. The larval population per leaflet was 0.81 in the pre-treatment and 0.01 in the post-treatment. The per cent infested leaves was 73.45 in the pre-treatment observation and in the last observation, it had reduced to 34.6%. The count of *C. exiguus*/leaflet was very low during all the observations, probably because the pest load was also low.

Mass culture of natural enemies

Improvement in the multiplication of the ichneumonid parasitoid, *Eriborus argenteopilosus*

Large cages measuring 42.5 x 42.5 x 62.5cm were effective for multiplying *E. argenteopilosus*. High parasitism (70 to 81.25%) was obtained in some exposures with high female progeny (60%). The parasitoid was continuously reared for 8 generations. From December last week, there was a drastic reduction in humidity to about 40±5%. Higher humidity (60-70%) was necessary for sustenance of the parasitoid. The humidity in the laboratory was increased to 60±5% and the humidity within the cages was also increased using wet sponges. Use of large cages at 60-70% RH can improve the performance of *E. argenteopilosus* with respect to mating, parasitism, adult emergence and sex ratio.

Continuous laboratory rearing of *Orius tantillus* on UV-irradiated *Sitotroga cerealella* eggs

When *Orius tantillus* was reared on *C. cephalonica* eggs, maximum adults were obtained in the 1st (70 nos.) and 2nd (82 nos.) generations. After the 2nd generation, there was a drastic reduction in adult emergence. When reared on *S. cerealella* eggs, from the 15 field-collected females, more than 100 adults were obtained in each generation. From the 6th to 11th generations, 250 to 450 adults could be obtained per generation (Fig. 3). There was a significant reduction in progeny production from 12th generation, which indicated that there is a need to rejuvenate the laboratory culture with wild culture at the end of 11 generations in the laboratory. This experiment indicated that UV-irradiated *S. cerealella* eggs could be utilized effectively for the multiplication of *O. tantillus*.

Development of mass production technique for mite predators

Stethorus pauperculus (Coleoptera: Coccinellidae) and *Oligota* sp. (Coleoptera: Staphylinidae), took 14.4 and 11.0 days to complete their life cycles on *Tetranychus neocaledonicus*. In the laboratory, maximum mortality was seen during the pupal period. Moist sand was the only substrate on which they pupated.

Development of mass production technique for natural enemies of sugarcane woolly aphid

Dipha aphidivora (Lepidoptera: Pyralidae), *Micromus igorotus*, and *Micromus* sp. (Neuroptera: Hemerobiidae) (Plate 1A & B), predators of the sugarcane woolly aphid, were collected from Arabhavi, Belgaum, Bailhongal, Dharwar, Gokak and Pune. They occurred at varying densities in the localities surveyed. These

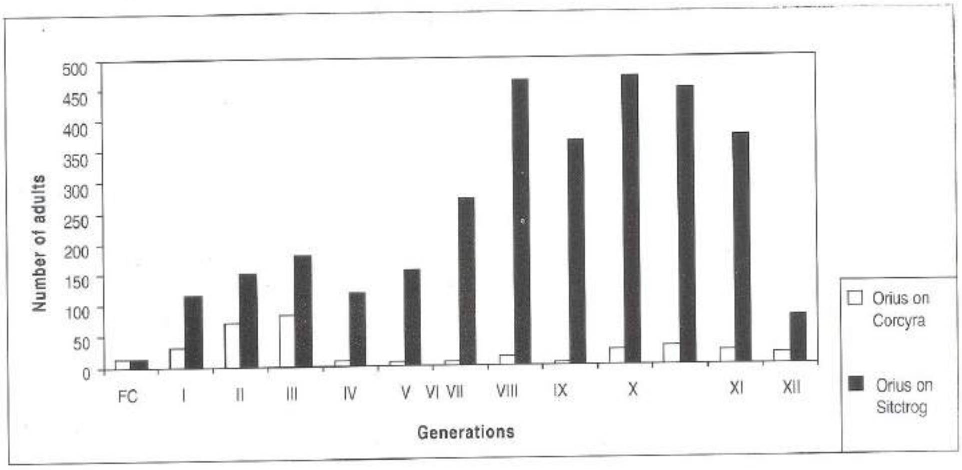

Fig. 3. ***Orius tantillus*** **reared for generations on UV-irradiated eggs of** ***Corcyra cephalonica*** **and** ***Sitotroga cerealella*** **(FC – Field collected; 1 – 12 – Lab-reared generations)**

Plate 1. A) *Micromus* sp. (Neuroptera: Hemerobiidae) and B) *Dipha aphidivora* (Lepidoptera: Pyralidae) : Potential predators of the sugarcane woolly aphid (*Ceratovacuna lanigera*)

predators and the ladybirds, *Synonycha grandis* and *Anisolemnia dilatata*, were reared successfully on alternative aphid prey. Among various substrates, paper and plastic surfaces were preferred for egg laying by *D. aphidivora*.

Studies on behavioural response of natural enemies and tritrophic interaction

Herbivore-induced plant synomones and their utilization in enhancement of the efficiency of natural enemies

Thirty-six plant volatile compounds consisting of alkenes, monoterpenes and sesquiterpenes from leaves and flowers of 19 varieties/hybrids of maize were identified using GC-MS system. Dodecane was the most prevalent compound. Flowers released significantly more number of compounds in comparison to leaves. In some varieties, specific compounds like hexadecanoic acid; 9, octadecanoic acid and (Z)-octadecanoic acid were detected which exhibited synomonal activity.

Electrophysiological response of *C. carnea* to nine fractions of cotton volatiles revealed that 6-day-old female responds highest to L-linalool (-1.977), followed by tetradecane (-1.183), myrcene (-1.098) and dodecane (-1.07). No significant difference was observed in EAG responses of *C. carnea* to Bt - and non-Bt cotton. However, *H. armigera* showed significantly higher response to volatiles from non-Bt cotton than to those from Bt-cotton.

Marigold flower aqueous extract elicited higher response in *T. chilonis* and resulted in significantly higher parasitization of *H. armigera* eggs (75.8%). Similarly, *C. carnea* females showed significantly greater response to marigold extract. Chickpea leaf surface glandular trichomes and their sticky exudates played a negative role in parasitization of *H. armigera* eggs by *T. chilonis*.

Field efficacy of kairomones as reinforcing agents for trichogrammatids on cotton

A field trial was conducted using kairomones of *Corcyra* as reinforcing agents for *T. chilonis*. The pre-treatment parasitization was very low in all the treatments Highest per cent parasitization was observed in the kairomone-treated plots. In both treated and untreated control plots, there was a slight increase in parasitization and both were on par (Table 2).

Selection of solvents for kairomonal formulations to increase the efficiency of trichogrammatids

In order to identify a suitable solvent for preparing kairomone formulations for trichogrammatids, several organic solvents were used in the preparation of

Table 2. Effect of kairomone treatment on parasitization by *Trichogramma chilonis* on *H. armigera* under field conditions

Treatment	Per cent parasitization in		
	Pre-treatment	Post-treatment-1	Post-treatment-2
Treated	8.0	14.0	33.0
Treated control	2.0	10.0	18.0
Untreated control	2.0	5.0	20.0

kairomones and bioassays were done in wind tunnel olfactometer and in multiple-choice tests at room conditions. Kairomone extracts of *Corcyra* scales (1%) fortified with tricosane or pentacosane or nonacosane (0.1 %) using hexane, petroleum ether and dichloromethane were tested in wind tunnel method. Among the solvents, hexane trapped larger number of adults (3.8), while tricosane recorded higher number of eggs trapped. Parasitization of *T. chilonis* also was higher with the same combinations (9.20%).

Development of kairomonal formulations to increase the efficiency of trichogrammatids

Kairomonal formulations of *Corcyra* scales at a constant concentration (1%) and varying concentrations of kairomone compounds at 0.1%, 0.2% and 0.3% were assayed in wind tunnel and multiple-choice tests under room conditions. Nonacosane (0.3%) recorded highest parasitization (16.8%), followed by 0.3% tricosane (16.0%). At 0.2%, the compounds did not elicit significant behavioral response. In the multiple-choice tests, the kairomonal formulations were sprayed on *Corcyra* egg strips and exposed to adult trichogrammatids. Nonacosane (0.1%) recorded highest parasitization (30.24%), followed by pentacosane 0.2% and 0.1% (29.80 and 28.82% parasitization, respectively).

Kairomones to improve the performance of *Campoletis chlorideae*

Parasitization of *S. litura* on castor leaves treated with kairomonal extracts (from *S. litura*) by *Campoletis chorideae* was significantly higher (15.98%) than that in untreated control (1.33%).

Influence of diet on the behavioral response of *Campoletis chlorideae*

Larval wash of *S. litura* extracted from four-day-old larvae reared on natural diet (castor leaves) attracted more number of adults of *C. chlorideae* (3.75) than that from larvae reared on artificial diet (1.25) in Y-tube olfactometer studies.

Influence of host age on the behavioral responses of *Eriborus argenteopilosus*

Kairomonal extracts from 4-day-old larvae of *S. litura* attracted larger number of *E. argenteopilosus* adults than those from 1-,6- and 9-day-old larvae in Y-tube olfactometer.

Kairomones to increase the efficiency of *T. chilonis* on cotton cultivars

Effect of kairomones on parasitization rate of *Helicoverpa armigera* eggs by *T. chilonis* on cotton varieties MCU-5, MCU-9 and Abathita was studied. The highest increase in parasitization was noticed in tricosane-treated MCU-9, followed by tricosane-treated MCU-5. In the other treatments, there was no significant difference (Table 3).

Evaluation of improved strains of natural enemies

Field evaluation of high temperature tolerant strain (HTTS) of *T. chilonis* against sugarcane borers

Table 3. Parasitization of *H. armigera* by *T. chilonis* on kairomone-treated cotton cultivars

Variety	Kairomone	Per cent increase in parasitization
MCU-5	Tricosane	40.0
	Pentacosane	21.5
MCU-9	Tricosane	43.0
	Pentacosane	4.1*
Abadhita	Tricosane	1.9*
	Pentacosane	22.4

* Increase over control not significant

Trichogramma chilonis

Field trials were carried out in collaboration with KCP Sugar Mills Ltd., Vayyuru (Andhra Pradesh); Vasantdada Sugar Institute, Pune (Maharashtra); CCSHAU, Karnal (Haryana); IARI, New Delhi at Sonipat; Mwana through IARI, New Delhi and PAU, Ludhiana to evaluate the high temperature-tolerant strain (HTTS) having high host searching ability. The parasitoids were released 6 – 10 times @ 100,000 / ha at fortnightly interval.

At Pune, mean incidence of shoot borer was significantly lower in HTTS plots (3.2%) compared to untreated control (6.1%), but on par with local strain. The infestation index of internode borer was less in HTTS and local strain released plots in comparison to control. At harvest, average number of millable canes in 10 m rows in HTTS, local strain and control released plots were 61.9, 60.0 and 46.4 and yield was 58.2, 54.6 and 41.4 t / ha, respectively. The release of HTTS increased the cane yield by 3.6 t / ha over local strain and 16.8 t / ha over control.

At Karnal, the incidence of shoot borer in general was low in the experimental as well as control plots. The pre-treatment incidence of this borer ranged from 3.9 to 4.7 per cent. The field receiving PDBC strain recorded 8.2 per cent *C. infuscatellus* incidence 10 days after the last release (end June) as against 8.9 per cent in plots receiving local strain and 10.9 in check plot. The incidence and intensity of stalk borer in the field receiving the PDBC strain were 34.7 and 6.7 per cent, respectively, while with the local strain it was 38.5 and 5.8 per cent. In the check plot, 37.2 per cent higher incidence and 41.5 per cent higher intensity of *C. auricilius* was recorded.

At Ludhiana, the egg mass parasitism was 29.5, 28.0, 7.7 and 8.5 per cent and borer incidence was 6.9, 8.0, 6.3 and 13.4 per cent in HTTS, local strain, insecticide (Padan)-treated and untreated plots. The yield recorded was 586, 578, 583 and 519 q / ha, respectively.

Trichogramma japonicum

A field trial was carried out in collaboration with IISR, Lucknow, against sugarcane top borer by releasing *T. japonicum* twice against each brood followed by one release of *Tetrastichus howardi*. The incidence recorded was 15.3, 15.0 and 17.6 per cent in HTTS, insecticide (Furadan) and untreated plots, respectively. However, yield was on par in HTTS and insecticide treatments. The maximum and minimum temperatures were 29.0 – 43.2 and 17.7 – 28.6°C, respectively, during the trial period.

Field evaluation of multiple insecticide-tolerant strain (MITS) of *T. chilonis* against cotton bollworms

Field trials were carried out in collaboration with PAU, Ludhiana; GAU, Gujarat; UAS, Raichur, and TNAU, Coimbatore, to evaluate the efficacy of multiple insecticide-tolerant strain of *T. chilonis* against cotton bollworms. The results indicated that the MITS performed better than other treatments in all locations in terms of high egg parasitism and less damage to fruiting bodies. The yield recorded was highest in MITS plots in all locations and it was significantly higher than local strain

(LS), insecticide check plot (ICP) and untreated control (UC) (Table 4). The results indicated the usefulness of MITS in combination with insecticides in enhancing the yield and its superiority to insecticidal control of bollworms.

Field evaluation of high host searching strain of *T. chilonis* and *Trichogrammatoidea bactrae* against *Pectinophora gossypiella* in Karnataka

Field trials were carried out in collaboration with UAS, Raichur, to evaluate *T. chilonis* and *T. bactrae* against pink bollworm (PBW) on cotton.

At Raichur, green boll damage due to PBW was 16.6, 35.2 and 67.3%, open locule damage 31.3, 47.5 and 65.3% and number of larvae / boll 0.14, 0.53 and 0.86 in *T. bactrae*, *T. chilonis* and untreated control plots, respectively. Releases of HHSS of *T. bactrae* reduced the green boll damage by 52.9 and 75.3%, locule damage by 34.1 and 52.1% and number of larvae / boll by 73.6 and 83.7% compared to releases of *T. chilonis* and untreated control, respectively.

Evaluation of trichogrammatids against *Plutella xylostella* in the laboratory on cabbage

The experiments were carried out in the laboratory on potted plants during winter 2003 and summer 2004 using cabbage var. Shristi. The HHSS of *Trichogrammatoidea bactrae* parasitised 64.9% eggs, significantly more than any other species / strain. In general HHSS gave higher parasitism compared to laboratory strains. The effective dosage obtained was 100: 5 (host eggs: parasitoids). The larval population of DBM was lowest (4.89 larvae / plant) in the treatment with two releases of *T. bactrae*, followed by its combination with dichlorvos (6.91) and untreated control (46.53). The yield data indicated that synchronization of *T. bactrae* releases with egg laying and early protection resulted in higher mean weight of heads in (550 g/head) compared to 396 g in combination, 340 g in insecticide treatment and 126 g in untreated control. The results indicate that *T. bactrae* could be used against DBM as a component in BIPM system.

Evaluation of trichogrammatids against *Earias vittella* in the laboratory

Of the different species of *Trichogramma* evaluated against *Earias vittella*, in terms of parasitism and adult emergence, *T. achaeae*, *T. chilonis*, *T. embryophagum* and *T. brasiliense* were the most suitable. At different dosages, parasitism by *T. brasiliense* was significantly higher (40.4%) than other species tested (9.4 to 30.8%). Among various species, per cent parasitism on potted plants was significantly higher by *T. chilonis* (81.0%) compared to 4.0, 7.0 and 14.0%, respectively, by

Table 4. Efficacy of multiple insecticide-tolerant strain of *T. chilonis* against bollworms of cotton in different locations

Place	Egg parasitism (%)				Fruiting bodies damage (%)				Yield of seed cotton (kg / ha)			
	MITS	LS	IC	UC	MITS	LS	IC	UC	MITS	LS	IC	UC
Ludhiana	11.1	10.9	0.0	1.2	7.9	8.9	10.4	50.9	1612	1580	1510	248
Anand	33.0	29.3	9.2	15.5	11.2	11.5	14.3	26.2	1978	1892	1817	1330
Raichur	11.3	3.4	0.0	2.8	32.6	37.3	38.7	62.3	860	691	780	175
Coimbatore	22.1	19.1	1.8	5.4	14.4	16.4	15.3	25.7	2007	1956	1930	1367

MITS = multiple insecticide-tolerant strain, LS = local strain, IC = insecticide control practice, UC = untreated control

T. embryophagum, *T. brasiliense* and *T. achaeae*. In the presence of the host plant, *T. chilonis* exhibited greater host recognition than other species and could be utilized for field evaluation against *E. vittella*.

Field evaluation of *T. embryophagum* and *T. chilonis* against *Opisina arenosella* on coconut

Release of *T. embryophagum* and *T. chilonis* @ 1000/ palm significantly reduced the larval population of *O. arenosella*. The larval population per 20 leaflets was 1 – 4 in *T. chilonis* released palms, compared to 0 – 2 in *T. embryophagum* released palms and these were significantly lower compared to control (17 larvae/20 leaflets). Thus in *Trichogramma* released plots 76.4 to 100.0% reduction of *O. arenosella* population was recorded during the first generation.

Storage of 'Tricho' cards in refrigerator for field release

Results of storage studies indicated that 7-day-old parasitized cards can be stored in a refrigerator for 6 days and emergence will be completed within 8 hours of its removal from refrigerator. The adult emergence declined sharply after 6 days of storage. Similarly, 8-day-old parasitized cards can be kept for 9 days before making field release. This will enable all the parasitoids to emerge from cards in the field within 28 h and 73.7% emergence was recorded. Storage beyond 9 days resulted in drastic decrease in emergence.

Selection for low-temperature and pesticide-tolerance in *Chrysoperla carnea*

A strain of *C. carnea* adapted to low temperatures has been selected by acclimatizing the predator to low temperature (18°C). The strain tolerant to low temperature was developed after rearing for 9 generations at low temperatures. This strain can be used during winter months against aphids and other pests. *C. carnea* was exposed to monocrotophos (0.0025%) and Confidor (0.0005%) for two generations to develop an insecticide-tolerant strain. The mortality after two generations of exposure revealed increasing tendency for adaptation to insecticides. The experiment will continue till tolerance to field recommended dosages is achieved.

Studies on artificial diets for host insects

Opisina arenosella

The modified artificial diet comprising of toddy palm leaf powder with defatted soya and kabuligram had a larval survival of 86.6 per cent and pupation of 78.2 per cent. Its shelf life was 20-22 days. The cost of rearing a pupa on the artificial diet worked out to Rs 0.87 based on per cent pupation (78.2), as compared to Rs. 0.71 (92.0% pupation) on natural diet. Higher fecundity (122.8) and larval survival (91.9) were obtained when infested gallery with frass was utilized as a substratum for oviposition.

Artificial diet-reared host sustained the development of the late-larval parasitoid, *Goniozus nephantidis* and pupal parasitoids, *Brachymeria nephantidis* and *B. nosatoi*. The biological attributes were comparable with that of the host reared on natural diet, but the per centage parasitization was lower.

Plutella xylostella

The soya-based diet with cabbage leaf powder developed for rearing *P. xylostella* was further refined. The diet recorded a larval survival of 61.6 per cent and fecundity of 70.2 compared to those reared on mustard seedlings (96.0 and 89.6, respectively). The cost of rearing a pupa on the artificial diet worked out to Rs. 0.28 based on the per cent pupation of 66.2. The shelf life of the diet at room temperature (25-27°C) was 18 days. The diet composition by Texas (A&M) provided very low larval survival (20.2%). Aluminium foil dipped in cabbage and cauliflower leaf extract when used as a substrate for oviposition provided a fecundity of 74.6 and 50.4, respectively, while the per centage egg hatch (82.2) and larval survival (86.6) were higher on cabbage leaf extract.

The percentage parasitization and adult longevity of the larval parasitoid, *Cotesia plutellae*, on artificial diet reared host was 77.2% and 8.12 days, respectively, while on the natural diet-reared host, they were 90.6% and 13.5 days, respectively.

Studies on artificial diets (AD) for natural enemies

Cryptolaemus montrouzieri

An artificial diet was evaluated for rearing *C. montrouzieri*. Per cent pupation and adult emergence of *C. montrouzieri* on artificial diet were 67.7% and 63.1%, respectively. On mealy bugs, the corresponding values were 85% and 83%, respectively.

An attempt was also made to rear the larvae of *C. montrouzieri* in groups (10 and 20) on the artificial diet (AD). Mean developmental time ranged from 20 to 31 days. Larval duration was extended irrespective of the group size. The adult emergence was poor and ranged from 9 to 27%. Highest survival was recorded in 10/group (18-27 %), which was less compared to the larvae reared individually (63.1 %). Final instar larvae were found to be highly cannibalistic on other instar larvae.

Cheilomenes sexmaculata

The mean pupation and adult emergence of two - to three-day-old larvae reared on AD were 65% and 62.4%, respectively. The corresponding values on natural diet (aphids) were 70% and 69%, respectively.

Chilocorus nigrita

The pupation and adult emergence of two to three-day-old larvae of *C. nigrita* reared on artificial diet were 62 and 57%, respectively, and on natural diet the corresponding values were 81.0% and 75%.

Orius tantillus

Two-three-day old nymphs of *O. tantillus* were reared on artificial diet and insect prey in different combinations. Highest survival was recorded on *Sitotroga* eggs (76%), followed by *Corcyra* eggs (75%), AD (I) (69 %) and AD (II) (57.8%) (diet used for *C. carnea* rearing). Nymphal period ranged from 10.6 (AD-I + beans) to 15.3 days (beans alone). Longevity of adults varied from 4.3 (on beans) to 30.0 days (on *Corcyra* eggs), respectively.

Chrysoperla carnea

Chrysoperla carnea larvae (one-day-old) were reared continuously using artificial diet from F_{22} to F_{31} generations. Pupation and adult emergence varied from 86% to 90% (Mean=88%) and 83.0 to 90.0% (Mean=86%), respectively, in different generations. When newly hatched larvae were reared on AD, pupation and adult emergence were 87.9% and 85.4%, respectively. Mean pupation and adult emergence of *C. carnea* were 88.9% and 86.1%, respectively, on *Corcyra* eggs.

The artificial diet for *C. carnea* could be stored for up to 560-570 days in a refrigerator at 5°C. The pupation and adult emergence were 72.5% and 62.0%, respectively. The survival started decreasing after this period.

Studies on insect pathogens

Insect viruses

A nucleopolyhedrovirus from *Hellula undalis*, granuloviruses from *Pieris brassicae* and *Helicoverpa armigera* and an ascovirus (suspected) from *Spodoptera exigua*, have been isolated and reported for the first time.

The NPV of *Crocidolomia binotalis* when tested against second instar larvae @ $1x10^5$ OBs/ml through leaf surface contamination technique, resulted in cent per cent mortality within 6-7 days after inoculation. Pathogenicity of the granulovirus from *P. brassicae* was confirmed against second instar larvae, causing 100% mortality, when administered through leaf surface contamination technique, without showing any skin breaking. The incubation period ranged 6-10 days.

For the suspected ascovirus of *S. exigua*, inoculation by parental means was found highly infective when compared to injection method.

A preliminary study was done on the efficacy of *Plutella xylostella* GV (*PxGV*) in the green house and the initial population of 20 was reduced to 1.3 per plant in virus treated plants when compared to 20 larvae per plant in untreated control. Number of leaf holes with feeding marks was found to be 86% in *PxGV* treated in potted plants, when compared to 94% in untreated control. The yield was higher in *PxGV*-treated (236 g) plants than in untreated control (170 g).

The Gv of *S. litura* caused 100% mortality of first instar larvae through diet surface contamination technique at five concentrations from $1x10^{12}$ to $1x10^8$

OB/ml. In 3rd instar larvae, reduction in larval weight and leaf area consumed was observed at $1x10^{12}$ OB/ml. However they were not statistically significant.

The NPV of *C. binotalis* was non-cross-infective to other pests of cruciferous crops such as *P. xylostella, H. undalis, Trichoplusia ni, S. litura* and *H. armigera*. *S. litura* GV was not cross-infective to *Galleria mellonella, H. armigera, C. cephalonica, E. vittella, P. xylostella* and *Bombyx mori*. *S. exigua* was found to be susceptible.

Bioassays were conducted to study the influence of three varieties of tomato (Arka Alok, Arka Meghali and Arka Vikas) on the susceptibility of *S. litura* to *Sl*NPV. The LC_{50} values for *S. litura* on these varieties were not found to differ significantly. The highest mortality ranged from 93 to 97 per cent at a dosage of 5×10^4 POBs/ml.

Pot culture experiments were conducted to find out the effect of these tomato varieties on the persistence of *Ha*NPV. Highest mortality of 78-85 per cent was recorded with samples collected immediately after spraying (zero day), which decreased to 29.8-33.53 per cent with samples collected four days after spraying. The original activity remaining (OAR) after four days ranged from 30.30 to 39.44 per cent. But there was no significant difference in the OAR per centage for *Ha*NPV between the varieties. Similar pot experiments were also conducted to study the persistence of *Sl*NPV. The highest mortality was 90-91 per cent on zero day after spraying which reduced to 39 to 41 per cent four days after spraying. The OAR was highest after day one (82-91%), but on day four it ranged 39-45 per cent. The *Sl*NPV persisted 1.3 times longer than *Ha*NPV on these varieties.

Entomofungal pathogens

Collection

Thirteen new isolates of entomopathogenic fungi belonging to *Beauveria bassiana* (Bb-9, Bb-10 and Bb-11), *Metarhizium anisopliae* (Ma-5, Ma-6 and Ma-7), *Verticillium lecanii* (Vl-5, Vl-6 and Vl-7), *Beauveria brongniartii* (Bbr-1), *Nomuraea rileyi* (Nr-38), *Paecilomyces fumosoroseus* (Pfm-1) and *Fusarium pallidoroseum* (Fp1) were collected from various hosts/ cropping systems in different locations.

Development of oil-based formulations of *Nomuraea rileyi*

Different vegetable and mineral oils were tested for their effect on conidial germination of *N. rileyi*. Maximum germination of conidia was observed in sunflower oil (79.8%), followed by gingelly oil (75.3%). The germination of conidia in diesel and kerosene were 71.5% and 68.3%, respectively. Maximum conidial germination (82.3%) was observed in the combination of diesel + sunflower oil (7:3 ratio).

Bioassay of oil-based formulations of *N. rileyi* against *S. litura*

Conidial suspension in diesel + sunflower oil (7:3 ratio) and aqueous suspension @ $1X10^8$ spores/ml were tested against *S. litura* on castor leaves. The mortality of *S. litura* (74-79%) did not vary significantly between the two formulations.

Bioassay of fungal pathogens on *P. xylostella*

Bioassays were conducted on *P. xylostella* with *B. bassiana* (11 isolates), *M. anisopliae* (7 isolates), *V. lecanii* (7 isolates) and *P. fumosoroseus* (1 isolate) using detached cabbage leaf technique at 10^7 spores/ml concentration. Observations on mortality were recorded on 10th day after treatment. Maximum mortality of *P. xylostella* was observed with *B. bassiana* isolates, Bb-6 (88.62%), Bb-1 (85.42%) and Bb-11 (84.47%). Among the *M. anisopliae* isolates, Ma-5 and Ma-1 caused 78.44 and 76.23% mortality, respectively. *P. fumosoroseus* (53.78%) and *V. lecanii* (20.4 to 38.8%) were less effective.

Compatibility of fungicides and insecticides with *N. rileyi*

Ten commonly used fungicides, *viz.*, carbendazim (Bavistin 0.1%), mancozeb (DithaneM-45 0.3%), captan (0.2%), hexaconazole (Contaf, 0.05%), triadimefon (Bayleton 0.1%), thiophanate methyl (Themifit 0.1%), chlorothalonil (Kavach 0.1%), copper oxychloride (Blitox

0.3%), wettable sulphur (Sulpheux 0.3%) and Bordaeux mixture (1%) and ten insecticides, *viz.*, endosulfan (Thiodan 0.07%), monocrotophos (Nuvacron 0.05%), quinalphos (Ekalux 0.05%), chlorpyriphos (Hexaban 0.2%), dichlorvos (0.1%), profenphos, methyl parathion (Metacid 0.15%), cypermethrin (Cymbush 0.015%), trichlorfan and fenvalerate (0.05%) were tested at recommended concentrations for their inhibitory effect on five promising isolates of *N. rileyi* (Nr-3, Nr-7, Nr-12, Nr-17, Nr-26). Carbendazim, mancozeb, captan, propiconazole, thiaphanate methyl, hexaconazole, chlorothalonil and tridemefon were highly inhibitory causing 100% inhibition of growth and conidial germination in all the isolates. Wettable sulphur, copper oxychloride and Bordaeux mixture were less toxic (54.15, 28.03 and 30.42% inhibition of growth, respectively) and did not inhibit conidial germination. Among the insecticides, except fenvalerate, others had a highly inhibitory effect on all five isolates

Evaluation of *B. bassiana, M. anisopliae* and *V. lecanii* against aphid species

Biomass and spore production of different isolates of *B. bassiana, M. anisopliae* and *V. lecanii* were estimated in stationary and shake cultures of potato dextrose broth (PDB) medium after 10 days. *B. bassiana* isolate, Bb-5a showed maximum sporulation in stationary (62.5 spores) and shake cultures (362.0). *M. anisopliae* isolate, Ma-4 showed maximum sporulation in stationary culture (28.0), while Ma-2 showed peak production in shake culture (0.80). Vl-2 in stationary culture (7.28) and Vl-5 in shake culture (2.30) showed maximum sporulation.

Spore production of different isolates on rice

Four isolates each of *B. bassiana, M. anisopliae,* and *V. lecanii* were cultured following the two-stage system of mass production (Diphasic fermentation system) for the collection of debris-free spore dust. Initially, the broth culture inoculum of respective isolates were grown in liquid medium (PDB) for three days in shake cultures and further continued on solid media (rice media) for growth and sporulation. Spore production, spore dust recovery and the spore count in the spore dust on rice media were estimated after 10 days (Table 5). Bb-5a, Ma-4 and Vl-5 were the best isolates of the respective groups in terms of these parameters.

Pathogenicity of *B. bassiana, M. anisopliae* and *V. lecanii* isolates to three aphid species

Bioassays with different isolates of *B. bassiana, M. anisopliae* and *V. lecanii* were conducted on three aphid species, *viz., Aphis craccivora, A. gossypii* and *Rhopalosiphum maidis* by detached leaf bioassay technique, using the leaves of their respective host plants, *viz.* cowpea, cotton and maize. Observations on mortality of aphids were recorded on 10^{th} day after treatment. Maximum mortality of all three aphids was observed with Bb-5a isolate. Bb-5a, Ma-4 and Vl-1 caused 60.5, 60.0 and 74.0% mortality of *A. craccivora* and 8.8, 38.0 and 68.0% mortality of *A. gossypii*, respectively. In case of *R. maidis*, only Bb-5a caused 50% mortality.

Field testing of fungal pathogens against sugarcane woolly aphid

Metarhizium anisopliae (Ma-4) and *B. bassiana* (Bb-5a) were tested against sugarcane woolly aphid at a spore concentration 10^8 spores/ml in infested sugarcane fields (mylar cage study) at Arabhavi in Belgaum district in Karnataka. Spray of pure aqueous spore suspension of *M. anisopliae* (Ma-4) caused maximum mortality (71.33%) with 31.68% mycosis of the aphid (Fig.4).

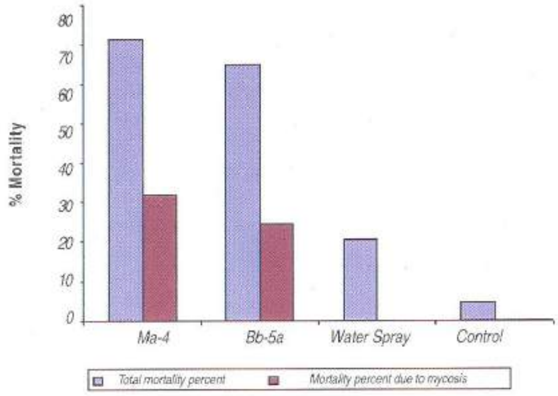

Fig.4. Per cent mortality and mycosis of sugarcane woolly aphids due to *B. bassiana* and *M. anisopliae*

Table 5. Mass Production of different isolates of *B. bassiana*, *M. anisopliae* and *V. lecanii* on rice medium

Pathogen	Isolate	Spore count in sporulated rice x 10^8 spores/g	Quantity of spore dust collected from rice media (mg/g)	Viable spore count on spore dust CFUx 10^8/g
B. bassiana	Bb3	22.25	22.40	15.00
	Bb4	36.80	6.00	162.50
	Bb5a	**96.00**	**28.00**	**470.00**
	Bb6	21.20	10.70	62.00
Mean		44.06	16.78	177.38
M. anisopliae	Ma2	24.80	45.50	130.00
	Ma3	29.80	9.20	121.00
	Ma4	**49.80**	**13.60**	**250.00**
	Ma5	12.40	5.80	17.00
Mean		29.20	18.53	129.50
V. lecanii	Vl1	1.55	9.10	0.10
	Vl2a	1.68	**15.60**	1.85
	Vl3a	0.23	5.00	0.15
	Vl5	**17.50**	9.20	**17.00**
Mean		5.24	9.73	4.77
CD (P=0.05)		6.40	-	22.26

Susceptibility of predator of sugarcane woolly aphid, *Dipha aphidivora,* to fungal pathogens

Laboratory bioassay studies with *M. anisopliae* (Ma-4) and *B. bassiana* (Bb-5a) were conducted to study their infectivity to the predator, *Dipha aphidivora*, at 1X10^{8} spores/ml. *M. anisopliae* (Ma-4) caused 46.34% mortality with 41.54% mycosis and *B. bassiana*, 31.25% mortality with 29.54% mycosis (Fig 5). All the stages of the predator were susceptible.

Pathogens of phytophagous mites

Periodic surveys for fungal pathogens of phytophagous mites were carried out. The fungal species that were frequently found associated with *Tetranychus* spp. were *Neozygites floridana, Fusarium* spp., *Penicillium* spp., *Aspergillus* spp., *Verticillium* spp., and *Acremonium* spp. The broad mite, *Polyphagotarsonemus latus*, also yielded similar kind of Hyphomycetes. For the first time, *Aceria litchii* was found infected with putative *H. thompsonii*. Occurrence of *N. floridana* in association with *Tetranychus urticae* and *Tetranychus neocaledonicus* was also studied. Pathogenicity was proved wherever needed.

During 2003-04, unusually large numbers of black cadavers of spider mites infected by *N. floridana* on the foliage of tomato, brinjal, cowpea, rose, french bean and *Mikania micrantha* were observed. Microscopic examination revealed that mite bodies were crowded with dark brown resting spores of *N. floridana*. *In T. urticae*, the frequency of occurrence was 22.0% and the maximum incidence was 42.0%. For *T. neocaledonicus*, they were 14.0% and 34.7%, respectively.

Screening of entomofungal pathogens against phytophagous mites in the laboratory

Experiments were done to study the infectivity of fungal pathogens, namely, *Hirsutella thompsonii* [isolate MF(Ag)5], *H. thompsonii* var. *synnematosa* [isolate MF(Ag)27], *Sporothrix fungorum* [isolate MF(Ag)15], *Verticillium psalliotae* [isolate MF(Ag)22], *and Acremonium* sp. [isolate MF(Ag)24] to phytophagous mites. *B. bassiana, M. anisopliae, N. rileyi* and *V. lecanii* isolates from various insect hosts were screened against phytophagous mites, *T. urticae*, *Tetranychus neocaledonicus, Polyphagotarsonemus latus* and *Aceria litchii*. Through the preliminary investigations, cross infectivity of different pathogens to the four mite species was proved. Both *H. thompsonii* and *H. thompsonii* var. *synnematosa* were not retrieved from dead *P. latus*, although there was mortality of the host. Similarly, *M. anisopliae*, *B. bassiana*, *Acremonium* sp. and *S. fungorum* were not recovered from dead *Tetranychus* spp.

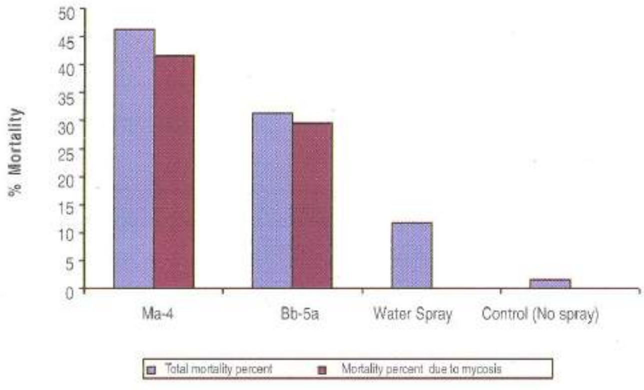

Fig. 5. Susceptibility of *Dipha aphidivora* to *M. anisopliae* and *B. bassiana*

Effect of *H. thompsonii* on *Tetranychus* spp.

Experiments were done to study the infectivity of the coconut mite-derived *H. thompsonii* to *T. urticae* and *T. neocaledonicus* in closed Petri dish moist chambers, open petri dish moist chambers and on cowpea plants in the shade and under sunlight. Both nymphs and adults of the mite species were studied for their susceptibility to *H. thompsonii*.

The fungus was able to kill the two *Tetranychus* spp. in closed as well as open moist chambers. The maximum mortality (100%) of both species was obtained in closed petri dishes at 5 DAT. Mortality started at 2 DAT itself. In general, the infection was more in adults than in nymphs. In the shade, *T. urticae* and *T. neocaledonicus* caused up to 70% motality. However, under sunlight in open conditions, only around 60 % mortality was noticed.

Scanning electron microscopy confirmed the pathogenicity of the fungus to the mite species (Plates 2 & 3).

Effect of *H. thompsonii* on *T. neocaledonicus*

These experiments were done on intact plants of cowpea, brinjal and bhendi in open sunlight. On cowpea, brinjal and bhendi, more than 70% mortality of both nymphs and adults was obtained. Adults showed higher mortality rates at 5 DAT on cowpea (79.8%), brinjal (73.8%) and bhendi (76.8%). The incidence of infection was 50-60% in all the cases and steadily increased till the end of observations.

Plate 2. *T. urticae* infected with *H. thompsonii*

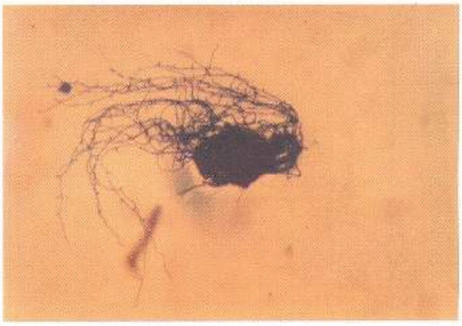

Plate 3. *T. urticae* infected with *H. thompsonii*

Effect of *H. thompsonii* and *V. lecanii* against *T. neocaledonicus* on brinjal

These experiments were done on intact plants of brinjal in the greenhouse (> 35 ºC at daytime). Four concentrations (1 x 10^5, 10^6, 10^7 and 10^8 conidia/ mL) of *H. thompsonii* and *V. lecanii* were tested against *T. neocaledonicus*.

In the case of *H. thompsonii*, maximum mortality (37.75%) of the mite was obtained 10 days after treatment at the highest concentration (1x10^8 conidia/ml). The fungus was recovered from dead mites on the fungus-treated plants and not on the control plants. In the case of *V. lecanii*, the maximum mortality (26.05%) was obtained 10 days after treatment at the highest concentration used.

Effect of *H. thompsonii* var. *synnematosa* on *T. urticae*

A concentration of 1 x 10^8 conidia/ml of *H. thompsonii* var. *synnematosa* produced 98.9% mortality of *T. urticae*. When the mites were allowed to crawl for five minutes on a mat of *H. thompsonii* var. *synnematosa* culture on PDA at 28 ± 2 ºC (day temperature), 96.7% mortality was observed.

Faster mass production technology for *H. thompsonii*

A simple magnetic stirrer technique for faster mass production of *H. thompsonii* var. *synnematosa* has been developed and is in the process of applying for a patent.

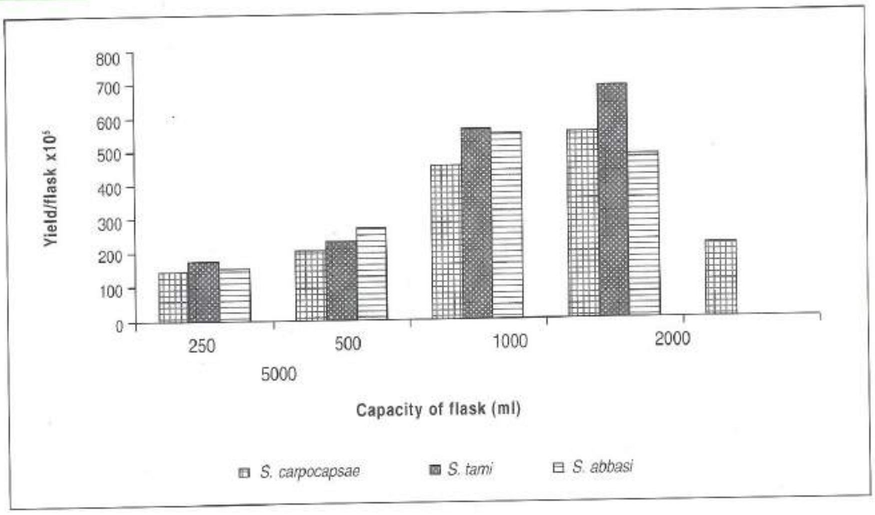

Fig. 6: Yield of *S. carpocapsae, S. tami* and *S. abbasi* in scale-up on artificial media

Entomopathogenic nematodes against important lepidopteran pests

Mass production of *Steinernema carpocapsae, S. tami* and *S. abbasi* was tried on modified egg yolk media. *S. tami* yielded a maximum of $173x10^5$ljs/250 ml aliquot cultures. Increasing the culture volume did not result in a concomitant increase in the productivity of ljs. The productivity *S. abbasi* and *S. carpocapsae* was lower. Positive correlation was observed between yield of ljs and flask volume up to 1000 ml (Fig. 6).

Mass production of *Heterorhabditis* sp. on suitable media

Since *in vitro* mass production of *Heterorhabditis* was found difficult and inconsistent on standard media, alternate media based on animal sources, beef kidney, liver, meat and chicken liver were tested for *H. indica* (PDBC EN 6.71) and *H. bacteriophora. H. bacteriophora* yield was higher in all the media tested compared to *H. indica*(PDBC EN 6.71). Media with beef kidney and liver were found more suitable for both *Heterorhabditis* spp. as higher yields were obtained..

Bioefficacy of EPN isolates against/cardamom root grub, *Basilepta fulvicorne*

Steinernema carpocapsae 11, *S. bicornutum, S. feltiae, S. abbasi, H. indica* isolates PDBCEN 13.3 & PDBCEN 14.2 and *H. bacteriophora* were found promising against *B. fulvicorne* causing 100% mortality at 48 h exposure, followed by *S. carpocapsae* PDBCEN 6.11 and *S. riobrave* and *H. indica* PDBCEN 6.71

The yield of nematodes in *B. fulvicorne* averaged between 44,800 and 1,04,000 ljs/grub with *H. indica* PDBCEN 13.3 recording the highest, followed by *H. bacteriophora*. Among *Steinernema* spp., *S. carpocapsae* 11 yielded the highest, followed by *S. abbasi.*

Bioefficacy of *S. carpocapsae* and *S. abbasi* against DBM larvae, *P. xylostella*

Bioefficiency of *S. abbasi* and *S. carpocapsae* against *P. xylostella* larvae was compared using dose-response assay. Mortality of DBM larvae increased as nematode dosage was increased. Total mortality (100%) was observed at 72 h at all dosages (Fig. 7).

The LC_{50} values for both species reduced with increase in exposure time. *S.carpocapsae* was found more effective than *S. abbasi* against DBM larvae (Table 6).

Positive correlation was observed between per cent mortality and time of exposure. LT_{50} values for concentrations of 20,40 & 60 Ijs/larva were found to be 31,25 & 23 h. and 34, 30 & 25 h. for *S.carpocapsae* and *S. abbasi*, respectively.

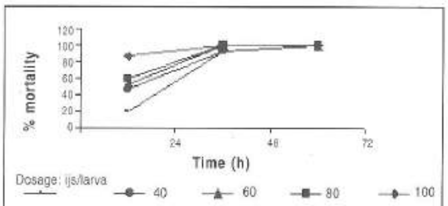

Fig. 7: Effect of dose of *S. carpocapsae* on *P. xylostella* mortality

Shelf-life of talc-based formulations of different isolates of EPN

Viability of Ijs of *S. abbasi*, *S. bicornutum*, *S. carpocapsae* and *H. indica* in talc-based formulation stored for 10 months was checked in terms of pathogenicity against final instar larvae of *G. mellonella*. Absolute mortality was observed at 48h post exposure due to *S. abbasi* and *H. indica* 13.3 whereas *S. carpocapsae* 11 and *S. bicornutum* caused absolute mortality at 72h. The results indicate that Ijs of all the nematodes were viable and infective in talc-based formulation for a period of 10 months.

Storage and bulk transport

Polyether polyurethane foam (sponge) was found ideal for bulk storage and transport of nematodes. Utilizing this method, *S. carpocapsae* was stored and transported to Delhi, Kanpur and Srinagar. Ninety-eight per cent survival was observed after a 7-day period of shipment.

Antagonistic agents against plant parasitic nematodes

Substrate media modifications

Different solid substrates, *viz.*, bran, broken grain, oil cakes, standard mycological media, etc., were evaluated for spore production of *A. oligospora* (PDBC AO1). The production cycle and yield per cycle on broken barley followed by broken corn were found to be the best (Fig. 8a, b).

Table 6: LC_{50} and LC_{90} values calculated from dosage-response assays conducted with *S. carpocapsae* PDBC EN 6.11 and *S. abbasi* PDBC EN 3.1 in lab

Nematode isolate	Incubation period (h)	LC_{50} Number of nematodes / larva	Min-max Number of nematodes / larva	LC_{90} Number of nematodes / larva
S. carpocapsae (PDBC EN 6.11)	24	48	32-67	173
	48	5	-	19
S. abbasi (PDBC EN 3.1)	24	61	42-103	263
	48	11	0.2-20	36

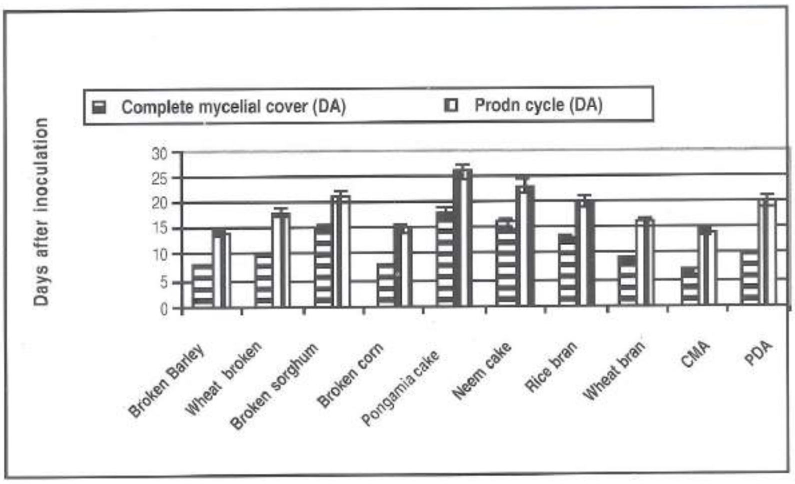

Fig. 8a. Influence of solid substrates on chlamydospore production of *Arthrobotrys oligospora* (PDBC AO1)

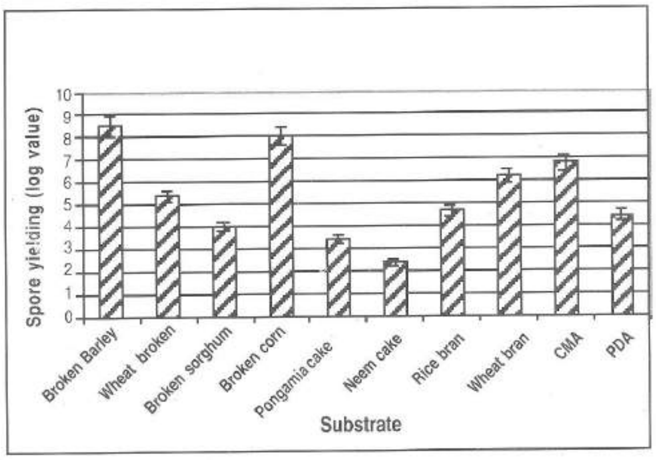

Fig. 8b. Influence of solid substrates on spore yield/g (log value), pH and temperature optima of *A. oligospora* (PDBC AO1)

Bioefficacy of *Arthrobotrys oligospora* (PDBC AO1) against root-knot and reniform nematode juveniles

On tomato *Arthrobotrys oligospora* (PDBC AO1) caused significant reduction in number of root-knot and reniform nematodes infecting the roots, root-knot index and production of females, while the per cent healthy root increased significantly.

Molecular identification of antagonistic fungi (*Pochonia chlamydosporia*)

The genomic DNA of native isolates of *P. chlamydosporia* were subjected to PCR with specific β-tubulin gene primers (forward and reverse) (Plate 4), 270-kbp amplicon partially sequenced and deposited in NCBI Genbank (accession numbers PDBC VC - AY 593965; PDBC VC56-AY 603497 and PDBC VC57-AY 642328).

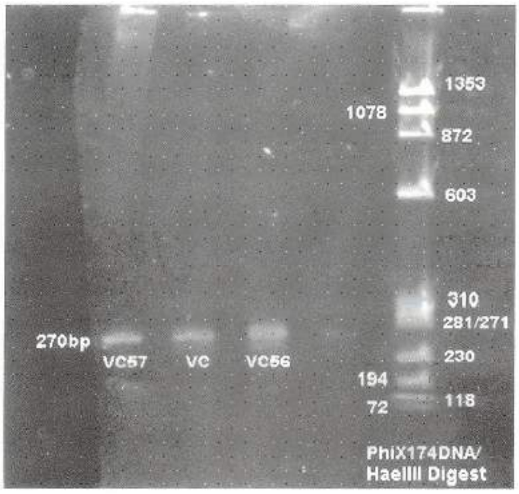

Plate 4. PCR amplicons of *P. chlamydosporia* PDBC isolates with β-tubulin gene primers

Behavior of antagonistic fungi and influence of biotic and abiotic factors on the fungi - Suitability of soil types for *Paecilomyces lilacinus* and *Pochonia chlamydosporia*

Red laterite, alluvial, loamy and mountain soils were suitable for effective parasitization of egg masses of root-knot and reniform nematodes by the fungi and multiplication of their propagules. The efficacy of these fungi was reduced in black cotton soil.

Efficacy of talc formulation of *P. lilacinus* against *Meloidogyne incognita* on gherkins

Use of talc formulation (20 kg/ha) of *P. lilacinus* as pre-plant treatment against root-knot nematode in gherkin (Cv. Calipso) resulted in significant reduction in root-knot index and number of egg masses/g root (Table 7). Application of *P. lilacinus* (10 kg/ha) + nematicide, however, resulted in lowest root-gall index and highest yield of fruits.

Table 7. Effect of *P. lilacinus* against root-knot nematodes on gherkin

Treatment	Plant mortality after germination	Root-gall index(0-5 scale)	Yield of fruits/plant (kg)	NMR * (Pi/Pf)	Per cent healthy roots
P. lilacinus	3.2	2.4	0.98	1.92	42
Nematicide	44.4	3.0	0.67	2.11	34
P. lilacinus + nematicide (at ½ dose each)	36.8	1.2	1.22	1.24	69
Control	1.8	4.2	0.52	4.30	18
CD (P=0.05)	3.12	1.12	0.28	0.11	6.54

* NMR= Nematode multiplication rate

Table 8. Efficacy of talc formulation of *P. lilacinus* against root-knot nematodes in okra

Treatment	Plant			Root-knot nematode	
	RKI * (0-5 scale)	Healthy root (%)	Healthy plants (%)	Egg mass parasitized (%)	Increase/ Reductionin nematode populations (%)
PL in talc	2.8	31	48	56	(-) 24
Nematicide	2.2	56	58	4	(-) 22
PL + Nematicide	1.2	69	77	53	(-) 48
Untreated check	4.1	19	35	3	(+) 94
CD (P=0.05)	0.26	7.44	9.11	10.33	11.14

* RKI : Root-knot Index

Field evaluation of talc formulation of *P. lilacinus* against root-knot nematode on okra

Micro-plot experiments carried out in root-knot nematode infested farmer's field to evaluate the performance of the talc formulation of *P. lilacinus* against root-knot nematode in okra at 20 kg showed significant reduction in root-knot index and nematode populations (Table 8).

Compatibility of *Trichoderma* sp. and *P. lilacinus* with fungicides

Copper oxychloride (1000, 2000, 3000 ppm), metalaxyl (50,100, 200 ppm), mancozeb (2000 ppm) and potassium phosphonate (2000 ppm) in PDA were compatible with native isolate of *Trichoderma* sp. in terms of mycelial growth. In case of *P. lilacinus*, potassium phosphonate was more compatible than other fungicides.

Management of *Phytophthora*-nematode disease complex in black pepper in the green house

Black pepper cuttings treated with a combination of antagonistic organisms and fungicide, *viz.*, *Trichoderma* sp. + *P. lilacinus* and metalaxyl, mancozeb or potassium phosphonate and grown in *Phytophthora*-root-knot nematode sick-soil remained healthy and produced new buds and young leaves (Table 9).

Table 9. Integrated management of *Phytophthora* foot rot-nematode complex in black pepper cuttings

Treatments	Per cent establishment of black pepper cuttings (10 Days)	Per cent sprouting of established cuttings (15 days)	Per cent mortality (10 days)	Root galling of tomato* (0-5 scale)
Trichoderma sp. + *P. lilacinus* (4g each/pot)	80	60	30	1.5
Mancozeb (100ppm)	60	60	20	1.5
Akomin (2000ppm)	60	60	30	1.8
Trichoderma sp. + *P. lilacinus* (4 g each/pot) + Mancozeb (100ppm)	80	80	20	1.0
Trichoderma sp. + *P. lilacinus* (4 g each/pot) + akomin (2000 ppm)	80	70	30	1.5
Trichoderma sp. + *P. lilacinus* (4g each/pot) + neem cake	80	60	30	1.0
Trichoderma sp. + *P. lilacinus* (4g each/pot) + Mancozeb (100ppm)+ neem cake (20g/pot)	100	100	0	-
Trichoderma sp. + *P. lilacinus* (4g each/pot) + akomin (2000ppm) + neem cake (20g/pot)	90	90	10	-
Healthy	100	100	0	-
M. incognita + *Phytophthora*	40	30	80	2.5

Cultures of host insects/ parasitoids/ predators/ nematodes/ antagonists/ pathogens

Host cultures

Cultures of *Corcyra cephalonica, Chilo partellus, Phthorimaea operculella, Plutella xylostella, Helicoverpa armigera, Spodoptera litura, S. exigua,, Aphis craccivora, Ferrisia virgata, Planococcus citri, Hemiberlesia lataniae, Tetranychus neocaledonicus, Opisina arenosella, Galleria mellonella, Trichoplusia ni* and *Crocidolomia binotalis*, are being maintained on natural food or artificial diet.

Parasitoids

Campoletis chlorideae, Eriborus argenteopilosus, Telenomus sp., *Encarsia guadeloupae, Cotesia flavipes, Cotesia plutellae, Goniozus nephantidis, Brachymeria nephantidis, B. nosatoi*, and *Coccidoxenoides peregrinus* and eleven species of *Trichogramma* and eleven of its strains are being maintained.

Predators

Cheilomenes sexmaculata, Coccinella septempunctata, Ischiodon scutellaris, Cryptolaemus montrouzieri, Scymnus coccivora, Pharoscymnus horni, Chilocorus nigrita, Chrysoperla carnea, Mallada boninensis, M. astur, Apertochrysa sp., *Cardiastethus exiguus, Orius tantillus, Blaptostethus pallescens, Brumoides suturalis, Paragus serratus* and *Curinus coeruleus* are being maintained.

Insect pathogens

Nuclear polyhedrosis viruses of *H. armigera* and *S. litura* and granulosis virus of *P. xylostella* are being maintained on their host insects. A culture of *Nomuraea rileyi*, a fungal pathogen, is maintained.

Antagonistic fungi maintained (with number of isolates in parentheses) are *Trichoderma harzianum* (20), *T. viride* (32), *T. hamatum* (1), *T. virens* (12), *T. koningi* (1), *T. pseudokoningi* (1), *T. piluliferum* (1), *T. longibrachiatum* (1), *T. polysporum* (1), and *Chaetomium globosum* (1).

Bacterial antagonists (number of isolates in parentheses) maintained are fluorescent pseudomonads (96), *Pseudomonas fluorescens* (24), *Pseudomonas* spp. (4), *Alcaligenes odorans* (1), *Bacillus subtilis* (4), *Bacillus thuringiensis* (6) and endophytic bacteria (35).

Entomopathogenic nematodes maintained are *Steinernema glaseri* (1 strain), *S. carpocapsae* (2 strains), *S. bicornutum* (1 strain) and *Heterorhabditis indica* (1 strain).

The nematophagous fungi/bacteria maintained are *Arthobotrys oligospora, Fusarium oxysporum* (4 isolates), *F. sporotrichoides, Paecilomyces lilacinus* (5 isolates), *Phoma glomerata, Trichoderma harzianum* (7), *T. viride, Verticillium chlamydosporium, Pasteuria penetrans* (5 isolates) and *Pseudomonas flourescens* (3 isolates).

An isolate of parthenium leaf spot disease WF (Ph) 30 of *Fusarium pallidoroseum* (Cooke) Sac. (=*F. semitectum* Auct.) is maintained.

Shipments

Four hundred and ten shipments (comprising of 85 host insect cultures, 51 predatory cultures, 130 parasitoid cultures, 82 insect pathogens, 45 antagonists, 2 EPNs and 15 weed insects) were sent to different research organizations as nucleus cultures or as finished products. Two multi-cellular trays for rearing *Helicoverpa armigera* were also supplied.

Software development

Expert system 'BIORICE' was developed for bio-control of rice pests. The software can work as an expert, in the absence of a scientist. Based on the pictures of the pest or symptoms, the pest can be identified and bio-control measures are suggested for the pest. Information about the morphology, geographic distribution, natural enemy complex, host range, IPM and scope for further research are included in the software. A picture gallery is provided for the natural enemies.

National Information system on Biological Suppression of crop pests

To improve the information system 'PDBC-INFOBASE', hundreds of pictures were collected and included in the software.

Knowledge Base System of *H. armigera* and its natural enemies

"Helico-info", a CD, has been developed to help scientists, researchers, extension workers, NGOs and farmers to get information about *H. armigera* and its natural enemies for successful biocontrol. The CD gives details about the taxonomy, bionomics, distribution, biocontrol and natural enemies of the pest. The species of *Helicoverpa/Heliothis* and population dynamics of *H. armigera* in relation to abiotic factors are also added. Video clips on the biology of *H. armigera* have been included.

Decision support system for identification of potential natural enemies and pesticides safer to natural enemies

A software "Safer pesticides in biocontrol" has been developed in Visual Basic 6.0, which gives information about pests on different crops, natural enemies and pesticides that are safer to these natural enemies. This would help the users to select insecticides safer to natural enemies.

Biological suppression of sugarcane pests

Survey and surveillance of woolly aphid and its natural enemies

IISR

Severe infestation was noticed in *adsali* crop (var. Co8014, Co86032, Co8011) in Pune, Satara and Sangli districts of Maharashtra. Two predators - *Dipha aphidivora* (Pyralidae) and *Micromus* sp. (Hemerobiidae)-were widely prevalent. Releases of *D. aphidivora* and *Micromus* sp. were made in different villages of Pravaranagar area, which subsequently got established.

MPKV

Dipha aphidivora, *Micromus* spp. and a syrphid were observed on the woolly aphids. The aphid incidence was recorded in January, 2003 and persisted up to middle of April 2003 with a peak (44.22 to 48.8 aphids/ 2.5 cm^2/ leaf) during 4^{th} and 5^{th} met. weeks, i.e., in the second fortnight of January. The pest incidence was not observed at temperatures beyond 39° C. Peak activity (50.3 to 53.2 aphids/ 2.5 cm^2/ leaf) was observed in July-August and declined after September, 2003. *D. aphidivora* was noticed in 26^{th} Met. week (last week of June, 2003) and its activity peaked from middle of August till the end of September (4.0 to 8.0 larvae/leaf). Aphid population was negatively and significantly correlated with maximum temperature ($r = -0.4774$), and significantly and positively correlated with relative humidity (evening) ($r = 0.34906$). The populations of woolly aphid and *D. aphidivora* were positively correlated. The larvae of *D. aphidivora* were parasitized by *Apanteles* spp. (4%) in January 2004.

AAU

At the Sugarcane Research Station, Buralikson, the aphid appeared from July till the month of February 2004. *D. aphidovora* appeared in July 2003 and its activity was host density-dependent. An unidentified coccinellid predator was also observed in September-October. Maximum and minimum temperature, and total rainfall were positively correlated with the pest population.

CCSHAU

In Haryana, minor incidence of the aphid was noticed in a village in Yamunanagar district in 2002-03. All quarantine measures were adopted including burning of cane residues *in situ* in infected fields, which resulted in a completely pest-free crop. In western Uttar Pradesh, the infestation varied from light to severe in Gangeshwar sugar factory zone, Deoband and Triveni Sugar factory zone, Khatouli. The predators included syrphids, ladybirds, and *Chrysoperla carnea*.

ANGRAU

Aphid incidence was noticed in Medak and Nizamabad districts of Telangana region, West Godavari, East Godavari, Krishna, Visakhapatnam, Vizianagaram and Srikakulam districts in coastal Andhra region and Chittoor in Rayalaseema region in fresh and ratoon crops. Crop at drooping stage was found to be more susceptible. Syrphids, chrysopids, coccinellids, and *D. aphidivora* were also recorded.

Maintenance and supply of *Epiricania melanoleuca* for use against *Pyrilla perpusilla*

PAU

The cocoons of *E. melanoleuca* were collected in large numbers from Nawanshahar mill area and redistributed over 4 ha at Karni Khera village (Distt. Ferozepur), where it was absent @ 4000/ha. The pest was brought under control within a month.

CCSHAU

Epiricania melanoleuca and the egg parasitoid, *Ooencyrtus papilionis* were mass-produced and supplied to the farmers of Haryana state for redistribution in 3789 and 5325 acres of *Pyrilla*-infested sugarcane fields.

Evaluation of EPN and *Beauveria brongniartii* against white grubs

CCSHAU

The EPN *Heterorhabditis indica* (0.5, 1.0 and 1.5 and 2.0 billion IJs per hectare) and *B. brongniartii* $1x10^{10}$, $1x10^{11}$ and $1x10^{12}$ spores/ha were applied along the furrows coinciding with first instar stage of the grub. Phorate @ 2.0 kg a.i./ha was used for comparison. The pre-treatment mean population of grubs per meter row length ranged from 3.1 to 5.5. At 30 days after application, the EPN treated plots contained a mean of 2.6 to 4.7 grubs/meter row length, being minimum in the plot receiving the highest number of infective juveniles. With *B. brongniartii* treatments, the reduction in grub population varied from 11.8 to 23.6 per cent, the maximum being at $2x10^8$ spores/ha. Insecticide treatment caused a population reduction of 58.3 per cent.

Field evaluation of *Trichogramma chilonis* against *Chilo tumidicostalis* and *Chilo infuscatellus*

AAU

At the Sugarcane Research Station, Buralikson, *T. chilonis* releases @ 50,000 / ha at 10 days interval (9 releases in all) on variety Dhansiri (Co BLN 9605) reduced the damage due to *Chilo tumidicostalis* by 63.64% over control (farmers' practice) and gave higher yield (78t / ha).

PAU

The efficacy of *T. chilonis* – Ludhiana strain (eight releases @50,000/ha at 10 days interval, during mid-April to June 2003) against early shoot borer, *Chilo infuscatellus*, was studied in field trials on variety CoJ 83 at Mehli village (Nawanshahr dist.) and compared with chemical control (Padan 4G @ 25.0kg/ha) and untreated control. The incidence of early shoot borer in parasitoid-released field (9.80%) and chemical control (9.40%) was on par and significantly less than that in control (21.40%). The reduction in damage was 54.2 over chemical control and 56.1 per cent over untreated control. The egg parasitization (37.4%) and yield (578.4 q/ha) were higher in parasitoid-released fields than in chemical control and untreated control.

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

IISR

Temperature-tolerant strain of *T. japonicum* @ 1,00,000/ha at weekly interval (at start of egg laying in each brood, i.e., 2 releases in each brood) and pupal parasitoid, *Tetrastichus howardi* (5,000/ha once at pupal stage in each brood), were evaluated at IISR farm (var. CoLk 8102) along with application of carbofuran (1 kg a.i./ha against III brood of top borer only in synchronization with pest activity during the last week of June). Top borer incidence (II brood) ranged 1.95-3.15 in released fields and was on par with control (Table 10). Incidence of III brood was 16.53-19.24% with release of bioagents as against furadan application (13.88%) and control (26.14%). The suppressive role of bioagents was significant in III brood of top borer, but not in IV and V brood possibly due to heavy rainfall around the time of their release.

Table 10. Field evaluation of temperature tolerant strain of *Trichogramma japonicum* and *Tetrastichus howardi* against sugarcane top borer, *Scirpophaga excerptalis*

Treatment	Incidence of top borer (%)*				Yield (t/ha)
	II brood	III brood	IV brood	V brood	
Trichogramma japonicum	1.95	18.02[a]	29.49	11.68	90.88
T.j + Tetrastichus howardi	2.68	19.24[a]	30.35	12.79	85.10
T. howardi	2.21	16.55[a]	28.23	8.23	87.33
Furadan 3 G	3.10	13.88[a]	28.85	14.05	103.11
Control	3.15	26.03[b]	28.86	12.32	91.77

* Means followed by the same letter are not statistically significant (P=0.05) by DMRT

PAU

Release of *T. japonicum* (6 times at 10 days interval from May to June @50,000 per ha) was compared with chemical control and untreated control at Mansurpur and Haripur (Distt. Jalandhar). At both locations, the incidence of top borer was significantly higher in control (mean=22.60%) than in parasitoid released (10.80%) and chemical control (9.74%) plots. Egg parasitization of *S. excerptalis* in released plots was much higher (mean=19.59 %) compared to chemical control (2.42 %) and untreated control (2.50 %). The yield in the parasitoid-released field (566.0q/ha) and chemical control (571.4q/ha) was on par and significantly higher than control (475.0q/ha) at both locations.

Biological suppression of cotton pests

BIPM for Bt cotton

ANGRAU

BIPM practices were evaluated on Bt and non-Bt cotton at Agricultural Research Station, Warangal, during kharif 2003-04. Damage due to *H. armigera* was higher on non-Bt cotton than on Bt cotton. At 45 DAS, population of sucking pests was higher with farmers' practice than with BIPM, both on Bt and non-Bt cotton. Aphid population was lower on non-Bt cotton with BIPM than on Bt cotton with farmers' practices (Table 11). In general, sucking pests were more when farmers' practices were followed. Seed treatment with Gaucho was effective in checking sucking pests only in the early stages of the crop. At 60 DAS, sucking pests, especially aphids and whiteflies, started flaring up, but their overall incidence was lower on non-Bt cotton.

Bt cotton recorded considerably less square and boll damage in both BIPM and farmers' practice modules. Non-Bt cotton with farmers' practices recorded highest square and boll damage. Bollworm damage was slightly higher on Bt cotton with farmers' practice than with BIPM. Egg parasitism was higher in Bt cotton + BIPM than in non-Bt cotton + BIPM, but negligible on both under farmers' practice. Bt cotton under BIPM supported the highest coccinellid population than non-Bt cotton under BIPM (Table 12). Spider population was higher with BIPM on both Bt cotton and non-Bt cotton. Bt cotton gave higher yields both with BIPM and farmers' practice.

GAU

The bud, boll, and locule damage was significantly lower on Bt cotton with BIPM package than on non-Bt cotton with BIPM and farmers' practice. The damage to the locules due to *E. vittella* was also significantly lower in Bt cotton+BIPM. The population of sucking pests was significantly lower on Bt cotton with BIPM than on non-Bt cotton with farmers' practices. The yield of Bt cotton with

Table 11. Biointesive Pest Management (BIPM) for Bt-cotton

Treatment	Sucking pests / 15 leaves			% Damage by boll worms				Yield (kg/ha)
	Aphid	Jassid	Whitefly	Bud	Boll	Locules		
						Ev	*Pg*	
Bt cotton+ BIPM	2.97[a]	1.65[a]	1.61[a]	3.61[a]	3.84[a]	5.26[a]	5.55[a]	2611[a]
Non-Bt cotton+ BIPM	7.53[c]	2.12[c]	2.10[c]	14.58[c]	21.02[b]	21.62[c]	29.79[c]	1825[b]
Bt cotton+farmers' practices	3.36[b]	1.81[b]	1.77[b]	4.13[b]	4.52[a]	6.11[b]	6.64[b]	2514[a]
Non-Bt cotton + farmers' practices	8.17[d]	2.31[d]	2.35[d]	15.47[d]	23.04[c]	22.22[c]	31.05[d]	1708[b]

* Means followed by the same letter are not significant statistically (P=0.05) by DMRT
Ev - Earias vittella; Pg - Pectinophora gossypiella

BIPM was significantly higher than that of non-Bt cotton with farmers' practices.

MPKV

The damage caused by *Earias* spp. (squares and bolls) was statistically lower on *Bt* cotton both with BIPM and existing package of practices than on non-Bt cotton. *Bt* cotton with BIPM package gave maximum kapas yield (1815 kg/ha), but was on par with *Bt* cotton with existing package (1650 kg/ha). Sucking pest population (aphids, jassids, thrips and whiteflies) was lower on *Bt* cotton with existing package of practices (25.36, 6.12, 43.24 and 2.02, respectively). Mite population was least on *Bt* cotton with BIPM package (1.88/three leaves). Population of natural enemies (coccinellids and chrysopids) was maximum on *Bt* cotton with BIPM package (11.20 and 14.90/five plants, respectively).

UAS, Dharwad

In general, the growth of Bt cotton was better than non-Bt cotton crop despite the deficit rainfall received in 2003. The incidence of sucking pests and bollworms was less due to moisture stress. Hence, the yield levels were less during the current season. The mean aphid population per leaf showed significant difference in BIPM compared to RPP packages. But no significant difference was observed between Bt and non-Bt cotton under BIPM. A higher mean thrips population was recorded on Bt and non-Bt cotton with BIPM package than with RPP (Table 13).

The natural enemies, particularly syrphids, were significantly more in BIPM treatment than in RPP on both Bt and non-Bt cotton. The population of coccinellids was more on Bt cotton with BIPM than in RPP package. The

Table 12. Natural enemies in different treatments of Bt cotton at ANGRAU, Hyderabad

Treatment	Mean population of natural enemies per 25 plants					Per cent *T. chilonis*
	Cc	*Cs*	G	S	*R*	
Bt cotton + BIPM	71	52	19.17	6.83	1. 83	13.75
Non-Bt cotton + BIPM	65. 50	47. 83	18.0	6.50	1. 67	27.33
Bt cotton+ farmers' practices	48. 30	40. 50	11.67	4.67	4. 33	14.33
Non-Bt cotton + farmers' practices	33. 50	31.67	7.0	2. 83	3. 5	8.17

Cc: *C. carnea* (E+L+A); Cs: *C. sexmaculata* (E+L+P+A); G: *Geocoris* (N+A); E= Eggs; L=Larva; P=Pupa; A=Adults
S: Staphylinids (adults) and R: *Rogas* (cocoons)

Table 13. Incidence of sucking pests on Bt and non-Bt cotton at UAS, Dharwad

Treatment	Sucking pest population/leaf (mean of 3 observations)		
	Aphids	Thrips	Leafhoppers
Bt cotton+BIPM	6.25	44.08	3.23
Non-Bt cotton+BIPM	6.33	44.00	2.41
Bt cotton+RPP	4.66	31.75	3.41
Non-Bt cotton+RPP	4.35	32.60	2.55
CD (P=0.05)	1.22	1.26	1.04

Table 14. Evaluation of pesticide tolerant strain of *T. chilonis* on cotton at village Khuban (Distt. Ferozepur), Punjab, during 2003

Parameters	Releases of *T. chilonis*		PAU spray Schedule	Control
	PT strain	PAU strain		
Incidence among fruiting bodies (%)				
SBW	0.96[b]	0.48[a]	0.90[b]	5.99[c]
Ha	7.02[a]	8.40[ab]	9.50[b]	44.87[c]
Total	7.98[a]	8.88[ab]	10.40[b]	50.87[c]
Incidence among green bolls (%)				
SBW	0.97[a]	1.20[a]	1.94[b]	5.21[c]
Ha	8.96[a]	9.94[ab]	13.18[b]	38.00[c]
Total	9.93[a]	11.14[a]	15.12[b]	43.20[c]
Parasitization of *H. armigera* eggs	10.93[a]	9.14[b]	0.00[d]	1.20[c]
Yield (q/ha)	16.12[a]	15.80[ab]	15.10[b]	2.48[c]

Variety: Ankur 651; * Means followed by the same letter in a horizontal column are not significant statistically (P=0.05) by DMRT; SBW= Spotted bollworm, Ha= *Helicoverpa armigera*, PT= Pesticide tolerant strain

chrysopid population was higher in BIPM plots (8.56 / plant) than in RPP plots (4.75 per plant). The mean per cent bollworm damage was the least on Bt cotton with BIPM (12.16)/RPP (14.58). The highest mean boll damage was recorded on non-Bt cotton under RPP (18.50).

The yield of seed cotton was significantly higher in Bt cotton + RPP (13.0 q/ha) than in Bt cotton + BIPM (11.0 q/ha). Non-Bt cotton + RPP (12.25 q/ha) yielded on par with these. The lowest yield was recorded in non-Bt + BIPM (8.50 q/ha). Thus, Bt cotton under RPP or BIPM performed better in terms of reduced pest load and higher seed cotton yield. The per cent egg parasitization of bollworms by *T. chilonis* was significantly higher in BIPM (12.75 %) and the least (5.25%) on non-Bt cotton with RPP.

Evaluation of pesticide-tolerant strain of *Trichogramma chilonis* on cotton

PAU

In a field trial at Khuban village (Distt. Ferozepur), the individual and cumulative incidence of spotted bollworm and *H. armigera* among the intact fruiting bodies was significantly lower with releases of pesticide-tolerant and local strains of *T. chilonis* and PAU spray schedule. The incidence of bollworms among intact fruiting bodies and green bolls was significantly lower with pesticide-tolerant strain of *T. chilonis* than PAU spray schedule, but on par with PAU strain of *T. chilonis*. The parasitisation of *H. armigera* eggs was higher when pesticide-tolerant strain was released and was significantly better than that with PAU strain. The highest yield was obtained with releases of pesticide-tolerant strain, on par with PAU strain, which in turn was on par with PAU spray schedule (Table 14).

TNAU

In field trials with LRA 5166 cotton, marginal but significant control of *H. armigera* larval populations was obtained in plots receiving pesticide-tolerant *Trichogramma* and insecticide application compared to insecticides alone and susceptible *Trichogramma* release + sequential insecticide application (endosulfan

1 and 4, phosalone 2, quinalphos 3 and 5, chlorpyriphos 6, monocrotophos 7 and 8[th] spray). These treatments and insecticide check were significantly superior to control in reducing the larval population (Table 15). Highest level of parasitism (31.6%) was recorded after the fifth release of pesticide-tolerant strain, which was significantly better than releases of conventional strain (26.4%). Least activity of the parasitoid was noticed in plots receiving insecticides alone (1.2%) and control (4.4%) after the fifth release of the parasitoid.

Damage to fruiting parts was significantly reduced in treatments with pesticide-tolerant and pesticide-susceptible *T. chilonis* + sequential insecticide application. Higher seed cotton yield was obtained in plots receiving *Trichogramma* treatment and insecticide application (2006.5 and 1956.3 kg/ha), than insecticide application (1929.0 kg/ha) and control (1366.5 kg/ha).

GAU

The insecticide-tolerant strain and local strain were equally effective in reducing bud, boll, and locule damage due to bollworms. The per cent parasitism obtained was slightly higher with the tolerant strain than in other treatments. Lowest parasitism was recorded with farmers' practices (Table 16).

Standardization of release points for *Trichogramma* sp. (to be released @ 1,50,000 / ha/ week)

GAU

Trichogramma chilonis releases at 200 points were significantly more effective than those at 150 points and 100 points. The bud and boll damage and locule damage

Table 15. Field evaluation of multiple pesticide-tolerant *Trichogramma chilonis* against *H. armigera* on cotton (var. LRA 5166)

Treatments	Insecticide application days after sowing (DAS)								
	Pre-treatment	Spray 1 (68)	Spray 2 (77)	Spray 3 (85)	Spray 4 (94)	Spray 5 (109)	Spray 6 (120)	Spray 7 (137)	Spray 8 (145)
		Trichogramma releases after insecticide application (DAS)							
		Release 1 (70)	Release 2 (80)	Release 3 (88)	Release 4 (98)	Release 5 (112)	Release 6 (125)	Release 7 (140)	Release 8 (147)
		Population of *H. armigera*/10 plants after spray application and *Trichogramma release***							
		9 DAT	8 DAT	9 DAT	9 DAT	10 DAT	7 DAT	8 DAT	9 DAT
Trichogramma chilonis (pesticide tolerant strain) + sequentialinsecticide application *	4.2	4.6^{a}	5.6^{c}	6.4^{a}	3.6^{a}	4.4^{a}	2.8^{a}	1.6^{b}	0.8^{a}
Trichogramma chilonis (pesticide susceptible strain) + sequentialinsecticide application *	4.6	4.8^{a}	5.8^{a}	7.2^{b}	3.8^{a}	5.2^{a}	3.4^{b}	1.2^{b}	0.4^{a}
Insecticide alone	4.2	3.6^{a}	7.2^{a}	6.0^{a}	3.8^{a}	5.6^{a}	1.6^{a}	0.2^{a}	0.2^{a}
Control	4.8	5.2^{a}	10.8^{b}	9.8^{b}	10.2^{b}	14.8^{b}	8.8^{c}	6.2^{c}	6.4^{b}

- Endosulfan spray 1 and 4; Phosalone spray 2; Quinalphos spray 3 and 5; chlorpyriphos spray 6; monocrotophos spray 7 and 8; Observations recorded days after each spray application; In vertical columns, means followed by similar letters are not different statistically (P=0.05) by DMRT

Table 16. Efficacy of pesticide-tolerant strain of *Trichogramma chilonis* against cotton bollworms at GAU

Treatment	% damage by boll worms				per cent *T.chilonis*	Yield (kg./ ha.)
	Bud	Boll	Locules			
			E. v.	*P. g.*		
Tolerant strain	15.49[a]	19.32[a]	20.96[a]	21.98[a]	33.00	1978[a]
Local strain	15.90[a]	19.47[a]	21.20[a]	22.15[a]	29.33	1892[a]
Farmers' practice	16.19[a]	20.62[a]	22.45[b]	28.11[b]	9.16	1817[a]
Control	23.32[b]	28.52[b]	34.01[c]	36.15[c]	15.50	1330[b]

* Means followed by the same letter are not significant statistically (P=0.05) by DMRT

due to *E.vittella* were also significantly lower in this treatment.

PAU

Releases of adult trichogrammatids were better than use of tricho-cards. The incidence of spotted bollworms, *H. armigera* and total incidence among intact fruiting bodies and green bolls in control were significantly higher than in other treatments. The total bollworm incidence in green bolls was lowest with releases of adults and was on par with releases as parasitized egg cards at 150 and 200 points/ha, but was significantly lower than that at 100 points (Table 17).

The parasitisation of *H. armigera* eggs was highest in adult releases, but on par with releases at 200 points (14.63%), but significantly higher than that at 150 and 100 points. The seed cotton yield in *T. chilonis* released-plots was significantly higher than that in control. Adult releases resulted in higher yield than tricho-cards.

Influence of cotton cultivars / hybrids on the parasitization efficiency of *Trichogramma chilonis* (GAU)

Among five cultivars tested, desi hybrids G.Cot.16 and G.Cot.10 recorded lower bud (12.94 and 13.39, respectively) and boll damage (17.71 and 18.41, respectively), but also gave lower yields (1100 and 1030 kg/ha, respectively). The other hybrids - G.Cot.Hy.6, 8 and 10 - did not differ much with respect to bud and boll damage. Parasitism levels of *T. chilonis* were lower in desi hybrids in general (16.67-18.83%) and did not differ much between cultivars.

Evaluation of *Nomuraea rileyi* against *H. armigera* on cotton (TNAU)

In field trials, *N. rileyi* formulations (aqueous and oil-in-water emulsion) were as effective as endosulfan 0.07% after second spray in reducing the larval incidence. Damage to fruiting parts was significantly higher in *N. rileyi*-treated plots than in insecticidal control. Correspondingly, higher boll retention was noticed in endosulfan-treated plots compared to fungal treatments. Yield was significantly higher in insecticide-treated plot than in *N. rileyi* treated plots (Table 18).

Biological suppression of tobacco pests (CTRI)

Biological Control of *Helicoverpa armigera* on tobacco

Mean larval population of *H. armigera* per panicle at seven days after treatment was significantly lower in plots treated with *B.t.kurstaki*@1 kg/ha (0.83) than in all other treatments. There was no significant difference between *N. rileyi* @10^{12} conidia /ha (1.77) and *N. rileyi* @10^{13} conidia /ha (1.80), which were on par with NPV @1.5×10^{12} PIB/ha (2.23).

Laboratory observation of field population also indicated that the mean per cent larval mortality of *H. armigera* was highest in *B.t.k.* (25%), followed by Ha NPV (20%), and *N. rileyi* @ 10^{12} conidia and 10^{13} conidia (12.5

Table 17. Standardization of release points for *Trichogramma chilonis* at Khuban (Distt. Ferozepur), Punjab, during 2003

Parameters	Releases of *T. chilonis* (Tricho-cards and adults)				
	100 points/ha	150 points/ha	200 points/ha	Adults	Control
Incidence among fruiting bodies (%)					
SBW	3.54^{ab}	2.75^{a}	2.63^{a}	2.04^{a}	5.58^{c}
Ha	26.64^{d}	22.30^{c}	18.85^{b}	15.59^{a}	43.36^{e}
Total	30.18^{c}	25.05^{b}	21.48^{b}	17.63^{a}	48.94^{d}
Incidence among green bolls (%)					
SBW	5.80^{c}	5.23^{ab}	5.00^{ab}	4.30^{a}	7.47^{d}
Ha	25.75^{a}	24.67^{a}	23.30^{a}	22.57^{a}	39.58^{c}
Total	31.55^{b}	29.90^{ab}	28.30^{a}	26.87^{a}	47.05^{c}
Parasitisation of *H. armigera* eggs	10.14^{d}	11.99^{c}	14.63^{b}	17.41^{a}	1.13^{e}
Yield (Q/ha) 6.80^{c}	7.10^{c}	7.62^{b}	8.24^{a}	2.75^{d}	

Variety: Ankur 651, SBW= Spotted bollworm, Ha= *Helicoverpa armigera*

* Means followed by the same letter are not significant statistically (P=0.05) by DMRT

Table 18. Field efficacy of formulations of *Nomuraea rileyi* against *H. armigera* on cotton (Var. LRA 5166)

Treatments	Square damage (%)		Boll damage (%)*	Bolls retained/ 5 plants	Yield (kg/ha)
	Pre-treatment	After treatment*			
N. rileyi aqueous suspension ($5x10^{11}$ spores/ha)	23.29	21.8^{b}	15.4^{b}	103.6^{b}	1886.8^{b}
N. rileyi oil in water emulsion ($5x10^{11}$ spores/ha)	27.84	19.5^{b}	17.2^{b}	104.8^{b}	1890.3^{b}
Endosulfan 35 EC 0.07%	27.16	12.2^{a}	13.2^{a}	117.3^{a}	1968.5^{a}
Control	24.27	39.4^{c}	28.4^{b}	91.2^{c}	1643.5^{c}

In vertical columns, means (of five replications) followed by similar letters are not statistically different (P=0.05) by DMRT.

and 10%, respectively) compared to control plots (5%). Incidence of *Campoletis chlorideae* was not noticed in *N. rileyi* treatments.

Identification and utilization of biocontrol agents for the management of *Spodoptera exigua*

Apanteles sp., *Chelonus formosanus* and *Peribaea orbata* were the principal parasitoids of *S. exigua* in tobacco nursery.

Among four types of tobacco tested in the field, the highest mean per cent parasitization of *S. exigua* by *T. remus* (27.38 %) and *Glyptapanteles africanus* (33.77%) were obtained on Lanka tobacco. Lowest parasitization by both parasitoids occurred on Turkish tobacco (5.65 and 8.58%, respectively).

Biological suppression of pulse crop pests

Pigeonpea

IPM demonstration on pigeonpea

TNAU

The field efficacy of IPM package against major pests on reproductive parts was evaluated at Puthur village. Blister beetle infestation was significantly reduced (from 11.8 to 2.1 beetles / 3 shoots) after application of NSKE 5% coinciding with the peak beetle activity after the first two rounds of spraying. Incidence of *H. armigera* and damage to flowers were significantly reduced in plots treated with *Ha*NPV compared to control. The pod and seed damage was significantly lower in IPM package than control. Seed yield was higher (1246.8 kg/ha) with IPM package than in control (720.2 kg/ha). The net C: B ratio was 1:3.86.

GAU

The IPM package reduced the number of larvae/5 plants (4.0%), pod damage (5.04%) and grain damage (3.26%) and gave higher yield (1376 kg/ha) than farmers' practices (15 numbers, 9.1%, 5.8% and 1063 kg/ha, respectively).

ANGRAU

Larval population of *H. armigera* was less (34.58/10 plants) in IPM block than in farmers' practice (45.08/ 10 plants). Pod fly and pod wasp incidence did not vary much between IPM and farmers' practice. Yield was higher (1726 kg/ha) in IPM than in farmers' practice (1667 kg/ ha).

Evaluation of EPN (*Heterorhabditis indica*) against *Mylabris pustulata* and lepidopteran pod borers

ANGRAU

Application of *H. indica* @ 0.5-2.0 billion/ha effectively controlled larval populations of *H. armigera* three days after application, the least population (9.60) being at the highest dosage (2.0-billions/ha), followed by that (10.80) at 1.0 billion/ha. At 7 days after spray, similar trend was observed (9.00 and 10.80 at 2.0 and 1.0 billion/ha, respectively). The per cent pod damage also was minimum (11.0) at 1.0 and 2.0 billion /ha. Yield was maximum (1522 Kg/ha) when 2.0 billion EPN /ha was applied.

TNAU

In a field trial at Puthur village, reduced larval population of *H. armigera* due to EPN @ 2.0 billion ijs/ha compared to endosulfan application was recorded. Reduced dosage of nematode application resulted in insignificant control.

Blister beetle population during the period of study ranged 3.22 - 4.8 at 10 days after 1st application and 1.02 - 2.0 after 10 days of the third application. The beetle mortality was also insignificant in all the plots (1.8 to 6.6%). Pod damage was significantly lower in endosulfan-treated plots (16.8%), followed by EPN @ 2 billion IJ/ha (21.3%). A reduction in dosage of nematode resulted in increased pod damage on par with control. The grain yield was significantly higher in endosulfan treatment (704.8 kg/ha) than in EPN @ 2 billion IJs/ha (678.5 kg/ha).

GAU

Larval population of *H. armigera* did not vary much between control and EPN treatments. But yield was higher with EPN @1.5 billion / ha (1300 kg/ha) and 1.0 billion / ha (1248 kg / ha) when compared to control (1100 kg/ha).

Soybean

Evaluation of BIPM package on soybean

NRC Soybean, Indore

BIPM package was more effective against soyabean pest complex than farmers' practice. The comparative performance of BIPM and farmers' practice against soyabean pest complex is summarised in Table 19.

MPKV

In a field trial at Pune, BIPM practice including release of *Telenomus remus* for *S. litura* and *T. chilonis*

Table 19.Evaluation of BIPM in Soybean

Incidence of insect pests and yield	BIPM	Farmers' practice	't' value
Blue beetle (*Cneorane* spp.)/mrl*	1.52	2.67	10.97*
Linseed caterpillar (*S. exigua*) – larvae/mrl	0.54	2.28	10.42*
Gram pod borer (*H. armigera*) – larvae/mrl	0.21	0.69	6.34*
Tobacco caterpillar (*S. litura*) – larvae/mrl	0.50	1.71	16.04*
Green semiloopers (*Chrysodeixis acuta*) – larvae/mrl	0.40	1.76	15.94*
Girdle beetle (*Obereopsis brevis*) – plant infestation (%)	0.02	28.57	23.58*
Stem fly (*Melanagromyza sojae*) – stem tunneling (%)	3.20	6.24	6.61*
Mean grain yield (q/ha)	37.36	29.21	7.52*

* meter row length

for *H. armigera* @ 1,00,000 parasitoids/ha and spraying *Sl*NPV (@ 1.5 x 10^{12} POBs/ha) depending on the incidence of the pests significantly reduced the larval population of *S. litura* over farmer's practice. The grain yield was higher with BIPM package than farmers' practice, but the differences were not significant.

CTRI

The BIPM package was on par with chemical control in reducing the mean larval population of *S.litura*. The population of predators was higher in BIPM plots, being responsible for partial control of leaf webber though chemicals were not used. The mean seed yield was higher (874.25 kg/ha) in BIPM than in chemical control (663.25 kg/ha).

Lablab bean

Microbial control of *H. armigera* and *Adisura atkinsoni* on lablab

TNAU

In a field trial, application of *Ha*NPV (0.75 - 1.5 x 10^{12} POB/ha), *B.t.* (1 kg/ha), and *N. rileyi* (1.5 x 10^{13} conidia/ha) were effective in reducing the larval population of *H. armigera* and *A. atkinsoni* on lablab and were on par with insecticidal check, endosulfan (350 g a.i./ha).

Pod damage was maximum during the first round of application and declined subsequently in different treatments except control. The seed damage was significantly lower in NPV applied at higher doses, which was on par with insecticides in general. Maximum seed yield (2258 kg/ha) was obtained in plots receiving NPV at the highest dose, followed by *N. rileyi* (2230 kg / ha), and endosulfan (2160 kg / ha).

Biological suppression of rice pests

Relative abundance of natural enemies of important rice pests

AAU

At Borholla, Allengmore village and AAU, Jorhat, beetles, spiders, dragonflies, damselflies, crickets, and grasshoppers were the dominant predators. Among the spiders, *Lycosa pseudoannulata*, *Argiope catenulata* and *Neoscona* sp. were predominant. *Cardiochiles philippensis*, *Telenomus* sp., *Aulosaphes* sp., *Cotesia flavipes*, and *Trichogramma japonicum* were recorded.

KAU

Thirty-two species of spiders belonging to 8 families and 20 genera were recorded from seven rice fields of Thrissur district. Maximum number of species was recorded from Araneidae (8 species), followed by Tetragnathidae (7) and Salticidae (7). During the rabi season, *T. javana* and *T. mandibulata* were the most abundant, and in kharif, *T. javana* and *T. andamanensis* were dominant. Nine species of spiders were newly recorded during this year. About 53% of the spiders were hunting type while the rest were web builders. Nine species were recorded almost throughout the crop season, viz., *L. pseudoannulata*, *T. javana*, *T. andamanensis*, *T. mandibulata*, *Oxyopes sunandae*, *Orsinome* sp., *Neoscona natica*, *Leucauge* sp. and *Argiope* sp. The major parasitoids of stem borer eggs were *Tetrastichus schoenobii* and *Telenomus* sp. On gall midge, *Platygaster malabaricus*, *P. oryzae* and *P. inderdaadi* were recorded.

MPKV

The yellow stem borer was parasitized by *Trichogramma* spp. (5.75-11.50%), *Telenomus* spp. (3.25-6.75%), *Apanteles* spp. and *Bracon* spp. (7.50-11.00 %). The leaf folder was parasitized by *Trichogramma* spp. (6.50 %), *Bracon* spp. and *Cotesia* spp. (14.25 %).

PAU

At Behram (Distt. Nawanshahar), egg parasitism in *Scirpophaga incertulas* was very high. Six species of egg parasitoids, namely, *Trichogramma* sp. (3.40%), *T. chilonis* (2.27%), *T. japonicum* (17.04%), *Telenomus* sp. (9.09%), *T. dignoides* (47.72%) and an unidentified species were recorded. Two larval parasitoids, *Bracon* sp. (10.63%) and *Cotesia flavipes* (6.38%), on leaf folder, and *Stenobracon nicevillei* (14.28 %) on stem borer, were recorded. Pupal parasitism was 6.25 % by *Tetrastichus* sp. in *S. incertulas* and 9.37 % by *Brachymeria* sp. in *C. medinalis*. Among the spiders, *Tetragnathus javana*, *Araneus inustus*, *Oxyopes javanus* and *T. virescens* were dominant.

Isolation of fungal pathogens from rice ecosystem (PAU)

Four fungal pathogens, namely, *Aspergillus parasiticus*, *A. niger*, *Penicillium* sp., and *Beauveria bassiana*, were isolated from *C. medinalis*.

Development of rearing techniques for key natural enemies of rice hispa (AAU)

Parasitization of rice hispa eggs by *Oligosita* sp. and larvae by *Scutibracon hispae* was observed in August-September. Efforts to multiply these parasitoids on hispa and *Corcyra* eggs / larvae were not successful.

Development of biointensive IPM for rice stem borer (AAU)

In field trials, the BIPM treatments had significantly less dead heart population at 51 days after transplantation than farmers' practice, but chemical control was slightly superior. The population of dead hearts on 57 DAT and white ears was lower in BIPM and chemical control than in farmers' practice. The yield was significantly higher in BIPM module than in chemical control and farmers' practice. The highest C-B ratio was obtained with BIPM (Table 20).

Evaluation of *Trichogramma japonicum* and *T. chilonis* against rice stem borer and leaf folder

AAU

In a field trial at Borholla (Assam) during kharif, 2003, *T. japonicum* and *T. chilonis* @ 1,00,000/ha were released

Table 20. Bio-intensive IPM for rice stem borer

Treatment	Per cent dead hearts at weekly intervals				Per cent white ear heads	Yield (kg/ha)	C:B ratio
	I week	II week	III week	IV week			
IPM module	6.36[a]	4.56[a]	2.71[a]	2.22[a]	2.84[a]	4396.35[b]	1: 2.93
Chemical control	5.71[a]	3.13[a]	2.28[a]	2.56[a]	3.96[a]	3943.46[b]	1: 2.38
Farmers' practice	8.29[b]	9.68[b]	14.94[b]	13.50[b]	9.76[b]	3273.07[c]	1: 2.76

* Means followed by the same letter are not significant statistically (P=0.05) by DMRT

at weekly intervals singly and in combination, coinciding with the first occurrence of stem borer/leaf folder. In the third week after release, the incidence of dead heart was lower in the plot receiving *T. japonicum* (2.9%) than in *T. chilonis* released plot (3.2%) and control (13.2%). The white ear head incidence was also significantly lower with combination of parasitoids (2.7%), followed by *T. japonicum* (3.7%) and *T. chilonis* (4.2%) releases alone. Significantly higher yield was obtained with *T. japonicum* + *T. chilonis* (4344.8 kg/ha) than with *T. japonicum* (4231.6 kg/ha) and *T. chilonis* (3991.4 kg/ha) releases alone.

The leaf folder damaged leaves declined from 2nd week and the reduction was higher when both species were released in combination than in *T. chilonis* releases alone. The incidence of leaf folder-damaged leaves was lower in *T. japonicum* released plot (3.25 %) than in control (6.23 %). The number of leaf folder-damaged leaves in chemical control was on par with biocontrol. At 3 and 4 weeks after release, lower incidence of leaf folder-damaged leaves was obtained with releases of both species (2.45 and 2.12, respectively), which was on par with that in *T. chilonis* releases alone (2.41 and 2.19, respectively) (Table 21).

KAU

Significantly lower leaf folder attack was observed in chemical control on 30 DAT (0.9%) and 37 DAT (1.8%), followed by releases of *T. japonicum* (2.8%). On 45 DAT there was no significant difference in leaf folder incidence between treatments. Post-treatment incidence was significantly lower in chemical control. On 30 and 37 DAT, stem borer incidence was on par in all the treatments. But on 45 DAT, dead heart incidence was significantly lower with releases of both species (2.7%), followed by *T. japonicum* releases (4.7%). When post-treatment dead heart incidence data were pooled and analyzed, all the treatments were on par. Significantly higher incidence of white ear heads was recorded in control (19/m^2). The yield did not differ significantly between treatments (Table 21).

MPKV

The per cent dead hearts (2.3%) and leaf folder damage (3.5%) at 45 days and white ears (2.9%) at 94 days after transplanting were minimum with the releases of *T. japonicum* + *T. chilonis* each @ 1,00,000 parasitoids/ha. Combined releases of both species recorded the highest grain yield (41.6 q/ha) (Table 21).

PAU

The per cent leaf folder damage on variety PR 114 was significantly lower in all treatments (1.7 - 2.0%) than control (5.85%). Combined releases of both parasitoids resulted in significantly lower incidence of leaf folder than other treatments (1.7%). Significantly higher yield was obtained with combination of parasitoids (69.5 q/ha) and chemical control (69.1 q/ha) (Table 21).

Table 21. Effectiveness of *T. japonicum* and *T. chilonis* against paddy leaf folder

Treatment	Damage by leaf folder (%)				Yield (kg/ha)			
	AAU	KAU	MPKV	PAU	AAU	KAU	MPKV	PAU
Releases of *T. chilonis* @1,00,000/ha	2.41^a	4.20^{bc}	4.81^a	8.26^a	39.91^a	31.62^a	41.60^a	57.68^c
Releases of *T. japonicum* @1,00,000/ha	3.26^a	2.78^b	5.77^b	12.63^b	42.32^a	32.88^a	39.00^a	65.60^b
Releases of *T. chilonis* + *T. japonicum* each @1,00,000	2.45^a	5.43^c	3.53^a	7.40^a	43.45^a	32.13^a	38.20^a	69.51^a
Chemical control	3.27^a	1.77^a	4.50^a	8.14^a	41.90^a	32.00^a	36.80^a	69.05^a
Control	6.10^b	4.28^c	13.29^c	13.99^c	34.60^b	29.38	29.40^b	56.38^c

* Means followed by the same letter are not significant statistically (P=0.05) by DMRT

Evaluation of entomofungal pathogens on sucking pests of rice

KAU

During kharif (2003-04), significantly lower number of hoppers was observed in chemical control, than in *M. anisopliae* and *B. bassiana*-treated plots. Maximum hopper population was recorded in control. There was no significant difference in the mean number of hoppers/hill on 20th day after 1st spray and 10th day after 2nd spray. Post-treatment counts of hoppers/hill and rice bugs also did not differ significantly between treatments. On 10th day after 1st spray, hoppers were significantly fewer in *M. anisopliae*-treated plot, followed by *B. bassiana* sprayed plot (Table 22). On 20th day after 1st spray, in all treatments, the populations of hoppers increased and were on par. The II spray was given at this stage.

During rabi (2003-04), on 10th day after second spray, population was significantly lowest in chemical control (1.56), but on par with *B. bassiana*-treated plot (2.40). After third spray, population came to 0.92/hill in *B. bassiana*-treated plot. The same trend was observed in post-treatment counts with lowest count in *B. bassiana* treated plot. There was no significant difference in the count of rice bugs/hill in different treatments. There was no significant difference in the incidence of white ear heads and grain yield in different treatments during both seasons.

TNAU

Beauveria bassiana and *M. anisopliae* were not as effective as insecticides (fenthion @ 500 ml/ha and monocrotophos @1000 ml/ha) against sucking pests (brown plant hopper, green leaf hopper, white backed plant hopper). Green leaf hoppers were the predominant sucking pests during the trial period. The mycosis levels were significantly higher in fungus-treated plots. The highest yield was obtained in *B. bassiana*-treated plots, which was on par with that in insecticide-treated plots (Table 23).

AAU

The infestation of green leaf hopper was observed at the late stage of the crop (Table 24). Immediately after the occurrence of green leaf hopper, sprays of *Beauveria bassiana*, *M. anisopliae* and insecticide (chlorpyriphos 20 EC @ 1 lit/ha) were made. Insecticidal control was superior to entomofungal pathogens in terms of reduction in sucking pest population and increased yields.

Impact of organic farming on conservation and augmentation of natural enemies of rice pests

PAU

In field experiments at Karni Khera (Distt. Ferozepur) on Pusa Basumati No.1, the incidence of leaf folder

Table 22. Efficacy of entomofungal pathogens against sucking pests (kharif – 2003-04)

Treatments	Mean number of hoppers/hill					Rice bugs/hill
	Pre-count & 1st spray	10 days after 1st spray	20 days after 1st spray & 2nd spray	10 days after 2nd spray	Post-counts (pooled mean)	
B. bassiana	(1.79) 2.72	(2.36)ab 5.24	(2.28)a 4.92	(1.91)a 3.24	(2.21)a 4.47	(0.89)a 0.30
M. anisopliae	(1.76) 2.64	(1.88)bc 3.16	(2.34)a 4.96	(1.99)a 3.48	(2.09)a 3.87	(0.92)a 0.36
Chemical control	(1.79) 2.72	(1.46)c 1.72	(2.50)a 5.84	(2.11)a 3.96	(2.09)a 3.84	(1.00)a 0.52
Control	(2.41) 5.36	(2.47)a 5.64	(2.72)a 7.16	(2.25)a 4.6	(2.50)a 5.8	(0.90)a 0.32

Table 23. Effect of fungal pathogens on sucking pests and leaf folder of rice at TNAU

Treatments	Pre-treatment		10 DAT						Grain yield kg/ha
	GLH	WBPH	GLH		WBPH		LF		
			H	M	H	M	H	M	
B. bassiana 10^{13} spores/ha	8.0	1.0	11.2^{b}	4.2^{a}	0.2^{a}	0.1	19.2^{b}	6.2	3920^{a}
M. anisopliae 10^{13} spores/ha	9.0	0.2	9.6^{b}	3.8^{a}	0.6	0.4	17.6^{b}	3.0	3413^{b}
Chemical schedule (For the state)	11.3	0.8	0.8^{a}	0.0^{b}	-	-	0.8^{a}	0	3856^{a}
Untreated check	10.1	0.4	8.7^{b}	0.2^{b}	-	-	1.2^{a}	-	3210^{c}
	NS	NS			NS	NS			

Data are means of five values; H- Healthy; M-Mycosed individuals. Means followed by similar letters in a column are not different statistically (P= 0.05) by DMRT

Table 24. Evaluation of fungal pathogens on sucking pests of rice at AAU

Treatment	Pre count of jassids before 1st spray	Post treatment Mean no. of jassids/ hill	Pre count before 2nd spray	Post treatment Mean no. of Jassids/ hill	Yield (kg/ha)
Beauveria bassiana (10^{13} spores/ha)	16.8	13.0	10.5	9.2	3499
Metarhizium anisopliae (10^{13} spores/ha)	14.4	14.2	11.2	10.5	3635
Chloropyriphos 20 EC @ 1.0 lit/ha	15.5	5.4	6.2	4.4	4251
Untreated check	17.2	15.6	13.5	10.2	3528
CD (P=0.05%)		1.54		1.80	446.3

(2.42%) and stem borer (4.12%) was slightly lower in plots receiving recommended practices than in organic farming (3.86 and 4.21%, respectively). The yield in organic farming was lower (24.32 q/ha) than that obtained with recommended practices (38.25 q/ha), but the cost-benefit ratio was higher (1: 17.31).

Rates of egg parasitism in *S. incertulas* was very high in organic farming. *Trichogramma chilonis* (3.83 %), *T. japonicum* (19.28 %) and *Telenomus dignoides* (42.34 %) together caused 65.45 per cent parasitism. Overall, organic farming helped in the conservation of natural enemies.

KAU

Field trials at Mannuthy for two seasons did not show any significant difference in pest incidence and grain yield between organic farming and chemical control. But the populations of spiders and coccinellids were significantly higher in organically farmed plots than in chemical control. Per centage incidence of leaf blight was lower (8.72) in organic farming than in chemical control (17.15) during kharif, but did not vary in rabi crop.

Biological suppression of oilseed crop pests

BIPM of *S. litura* in irrigated groundnut (TNAU)

In a field at Aliyar Nagar, leaf-folder damage and population of *S. litura* were significantly less and seed yield significantly higher in BIPM plots than in chemical control plot. The C:B ratio in BIPM was 1:1.82 over chemical control.

Evaluation of *Nomuraea rileyi* against *S. litura*/ *H. armigera* on groundnut (TNAU)

In a field trial, aqueous and oil-based formulations of *Nomuraea rileyi* were evaluated against *S. litura* / *H. armigera* on groundnut. Totally three applications were given. The incidence of *S. litura* was significantly lower in insecticide-treated plots (larval population of 0.02 - 0.8 post-application) than in *N. rileyi* treated plots (2.2 - 3.2 larvae/10 plants). In the case of *H. armigera* also, insecticidal control (0.02 - 3.2 larvae / 10 plants) was better than *N. rileyi* treatment (0.8 - 6.2 larvae / 10 plants) after 9-10 DAT. Mycosed cadavers were significantly more in fungus-treated plots than insecticide-treated and control plots. The foliar damage was lowest in insecticide-treated plots, followed by fungus-treated plots. The yield was higher in insecticide application (1672 kg/ ha) than fungus application (1466-1515 kg/ha) and untreated check (1385 kg/ha).

Biological control of the aphids, *Lipaphis erysimi* and *Brevicoryne brassicae* (PAU)

Insecticide application (oxy-methyl demeton) for the control of mustard aphid, *Lipaphis erysimi*, was superior to two releases of *Ischiodon scutellaris*, two sprays of *Verticillium lecanii* @ 10^8 conidia/ml, and combination of *I. scutellaris* and *V. lecanii*. The highest yield (7.48q/ha) was obtained with chemical control and it was significantly higher than all other treatments. The yield from the plots treated with *V. lecanii* + releases of *I. scutellaris* (6.25q/ ha) was on par with *V. lecanii* alone (6.11q/ha) and significantly better than control (4.61q/ha) and *I. scutellaris* releases alone (4.69q/ha).

Biological suppression of coconut pests

Field evaluation of *Trichogramma embryophagum* against *Opisina arenosella* (PDBC)

Trichogramma chilonis and *T. embryophagum*, found efficient in the lab, were evaluated in the field at the release rates of 1000, 2000, 3000 and 4000 / palm at weekly interval and were continued for 4 weeks starting from 24th January to 28th February 2004.

The sentinel cards of *Corcyra* eggs were parasitized by up to 2.0% only by *T. chilonis*. However, the larval population/20 leaflets was significantly lower on parasitoid-released palms (1–4 with *T. chilonis* and 0–2 with *T. embryophagum*) than in control (17 / 20 leaflets) (Fig. 9). The population of *O. arenosella* was reduced by 76.4-100.0% during the 1st generation. The experiment is in progress.

Evaluation of method of release of *Goniozus nephantidis* against *O. arenosella* (KAU)

In a field trial at Thrissur during October, 2003-January, 2004, the parasitoid *Goniozus nephantidis* was evaluated against *O. arenosella* (six releases at fortnightly intervals). After the 3rd, 4th, 5th and 6th releases, the pest population came down and was significantly lower in the parasitoid-released palms than in control palms. Efficacy of releases at 4-5' height or at the crown did not differ significantly.

Field evaluation of *Cardiastethus exiguus* against *O. arenosella*

In a field trial at Allalasandra, releases of *C. exiguus* on *O. arenosella* infested coconut reduced the pest population by 34.6% (PDBC). At Thrissur in Kerala, three releases of *C. exiguus* @ 50 and 100 / tree at 5 days interval were evaluated against *O. arenosella*. There was a significant reduction in the pest population after the II and III releases compared to control, though the efficacy of release rates did not differ significantly.

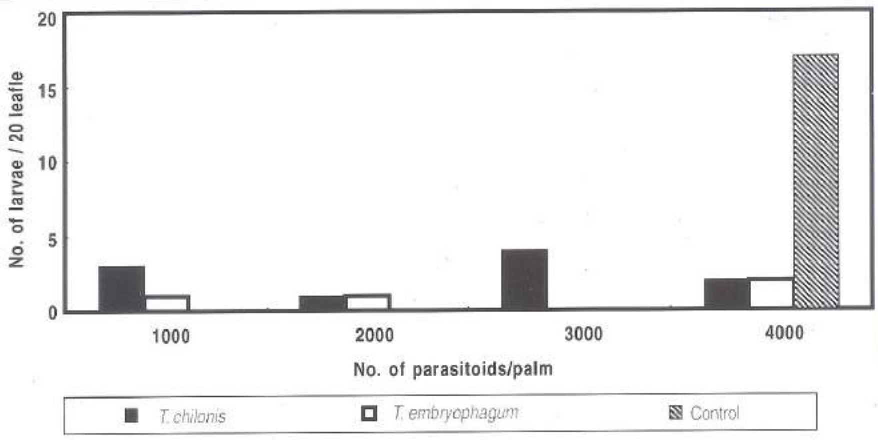

Fig. 9. Relative larval population of *O. arenosella* in *T. chilonis* and *T. embryophagum* released and control palms during 1st generation

Biological suppression of tropical fruit crop pests

Evaluation of *Trichogramma chilonis* against pomegranate fruit borer, *Deudorix isocrates* (IIHR)

In a field experiment at IIHR during May–September 2003, six releases of *T. chilonis* @ one lakh/ ha per release at weekly intervals were made against *D. isocrates* from the time of fruit set onwards. Mean fruit damage was marginally reduced in *T. chilonis*-released plants (15.31%) as compared to check (20.47%).

Evaluation of *Bacillus thuringiensis* against pomegranate fruit borer (IIHR)

Commercial formulations of *Bacillus thurinigiensis* var. *kurstaki*, *viz.*, Dipel (6.7%), Halt (8.3%), Biolep (10.0%) and Delfin (16.6%), were more effective in that order in reducing fruit damage due to *D. isocrates* compared to control (25.4%). But deltamethrin application was more effective (4.5%) than *Bt* products.

Integration of *T. chilonis* with *Bt* for the control of ber fruit borer, *Meridarches scyrodes* (IIHR)

In a field trial during July - October 2003, five releases of *T. chilonis* (from the time of fruit set onwards at weekly intervals @ one lakh/ ha per release) in combination with application of *Bt* @ 1 kg/ha were more effective in reducing the mean fruit damage (29.52 %) than *Bt* application (34.0%), parasitoid release (48.7%) and control (88.0%).

Biological suppression of pink mealybug, *Maconellicoccus hirsutus*, on sapota (IIHR)

Releases of *Cryptolaemus montrouzieri* @ 20/plant twice on 23rd April and 9th May 2003 on sapota severely infested with *M. hirsutus* reduced the mealybug population from a mean of 54.20/plant (4 shoots) on April 22nd to 1.50/plant by 15th June. The plants were completely free from mealybugs in the first week of July 2003.

Colonization of *Encarsia guadeloupae* on spiralling whitefly

IIHR

Inoculative releases of *Encarsia guadeloupae* were made at two locations, namely, Haniyur and Mathkur (Bangalore North), where the whitefly was severe on guava. The whitefly population declined sharply after the parasitoid release at both locations.

At Hessaraghatta, 648 adults of *E. guadeloupae* were released on heavily infested papaya in January–February 2003. The parasitism ranged from 20.0 to 62.0% during March-May 2003 and reached 85.0% in January 2004. The papaya plants were found to be completely free from spiralling whitefly in March 2004.

MPKV

At Pune, inoculative release of *E. gaudeloupae* was made on 17th February, 2004 in a guava orchard infested with spiralling whitefly where activity of the parasitoid was absent. Parasitism by *E. guadeloupae* was 12.9% at 45 days after release of the parasitoid, which indicated its establishment.

TNAU

The population of *Aleurodicus dispersus* varied from 60.2 to 480.2/100 leaves/tree at two locations surveyed during October 2003-January 2004, the maximum being in November 2003. Parasitization by *E. guadeloupae* ranged from 1.3 to 14.8, the maximum being in November 2003.

KAU

The highest parasitism was recorded in chillies during February, 2004 (55.77%) and December, 2003 (50.55%). Parasitism was maximum on guava (22.50 %) and brinjal (15.63 %) during November 2003 and January, 2004, respectively. In tapioca, wild tapioca, ceara rubber and poinsettia, parasitism was less than 10 % during November, 2003-February, 2004.

Efficacy of *Beauveria bassiana* against mango nut weevil (IIHR)

Five spore concentrations of *B. bassiana* ($1x10^{10}$, $1x10^9$, $1x10^8$, $1x10^7$ and $1x10^6$) were evaluated against the mango nut weevil in the laboratory and found effective, the highest concentration producing 100.0% mortality.

Demonstration of biological control of mealybugs and scale insects in guava, grapes and sapota

Releases of *C. montrouzieri* on severe infestations of striped mealybug, *Ferrisia virgata*, on guava (at Haniyur), *Planococcus citri* on acid lime (at Tirumalapura in August 2003) and mealybugs on grapes (at Ajwara village near Chikkalapura) effectively controlled the mealybugs.

MPKV

The efficacy of *C. montrouzieri* against grapevine mealybugs was demonstrated over one hectare area at Narayangaon village (Dist-Pune). There was considerable reduction in mealybug population after *C. montrouzieri* releases. After three releases, the mealybug population was 3.67 as against 23.33 / bunch in control.

Biological suppression of temperate fruit crop pests

Quantification of natural incidence of parasitoids of San Jose scale on apple

SKUAS&T

In Budgam, Srinagar, Pulwama and Baramullah districts, parasitism of San Jose scale ranged from 7.84 to 12.65 %.

YSPUH&F

The population of San Jose scale at Nauni (ca. 1250 m altitude) in Solan and Mashobra (ca. 2300 m altitude) in Shimla was negligible in well-established orchards having old trees (>20 year age). However, in young plantations, 9.4 and 9.2 per cent of the plants were infested by the scale at Nauni and Mashobra with live-scale insect density of 0.2-47.8 and 1.2-28.5 cm^{-2} of the bark, respectively, on moderately to heavily infested plants.

At Nauni, from April to September, there were two overlapping generations. Parasitization by *Aphytis* sp. (*proclia* group) was 0.2-14.4%, while that by *Encarsia perniciosi* was 1.8-14 per cent with a total parasitization of 1.8-28.4 per cent. At Mashobra, overwintering generation commenced larviposition in April and till September, two overlapping generations were completed. Both *Aphytis* sp. and *E. perniciosi* were present (0.8-1.8 and 0-1.5 per cent parasitism, respectively), with overall parasitization of 1.7-2.3 per cent. The predatory coccinellid, *Chilocorus infernalis*, was active during November-February, and the grubs (II and III instars) were noticed by March-end.

Current status of San Jose scale and woolly aphid and their natural enemies on apple

SKUAS&T

San Jose scale and woolly apple aphid populations in three districts were monitored. *Chilocorus infernalis* and *Coccinella* sp. (predators) and *Aphytis proclia* and *Encarsia* sp. (parasites) were recorded. Woolly apple aphid prevalence was very low. *Aphelinus mali*, an eulophid endoparasite, and predators, *C. infernalis*, *Episyrphus balteatus*, *Coccinella septempunctata* and *Chrysoperla* sp., were recorded.

YSPUH&F

At Nauni, aerial population of the aphid was hardly present on 2 per cent plants in April when *C. septempunctata* (both adult and eggs) was active on apple plants. Thereafter, the per cent infested plants varied from 8.4 to 11.4 and colonies on such infested plants were small (1-3.3 mm) and fewer in number (up to 10/plant). In May and September, *Aphelinus mali* was recorded in low numbers.

At Mashobra, aphid infestation on young plants as small aerial colonies appeared on 1.3 per cent plants with a mean number of 2 colonies per infested plant in April. *C. septempunctata* was noticed on infested plants (1.4 beetles/plant). The infestation had increased to 21.8 per cent in May and number of colonies per infested plant was 1-28 (mean 6.5), but predator activity was low. The infestation declined by July-August and started building up in September (7.5 per cent plants with 1-6 (mean 2.3) colonies). In October, infested plants were maximum (10.4%) with 1-35 (mean 6.1) colonies/infested plant. In autumn and winter, no predator activity prevailed. The infestation declined to 9.3 per cent in November and to 4.1 in February, the number of colonies being 1-13 (4.1) and 1-5 (1.7) per infested plant.

Studies on predators of phytophagous mites on apple (YSPHUH & F)

European red mite (ERM) was more prevalent in unsprayed apple orchards in June and July 2003 and was low during the third week of June at Thanedhar in Shimla district (0-50 eggs and 0-1 motile stages with a mean of 13.9 and 0.4/leaf, respectively) and so was the predator population (0-2, mean 0.4 predatory mites/leaf). In the insecticide treated location, the mite count was 19-113 (71.3) eggs, but without adult mites, there was no predator activity. In Kinnaur district, in addition to ERM, *Tetranychus urticae* was also encountered in some locations, the latter being mainly present on trees where Rajmash beans were intercropped. The predator complex included thrips, anthocorid bugs, staphylinids, *Stethorus*, chrysopid larvae, and predatory mites (stigmaeid and phytoseiid mites).

Biological suppression of vegetable crop pests

BIPM in Tomato (MPKV)

In a field trial at Umbare village (Dist. Pune), BIPM practices including five releases of *T. pretiosum* and four sprays of *Ha*NPV were significantly more effective in reducing the larval population of *H. armigera* and fruit damage than farmers' practice. The yield was significantly higher with BIPM (237.7 q / ha) than with farmers' practice (156.6 q / ha).

Fixing the dose of NPV for the management of *Helicoverpa armigera* on tomato (TNAU)

In a field trial at Keeranur, the per cent decrease in larval incidence over control was significantly higher with the regular dose of *Ha*NPV (1.5 x 10^{12} POB/ha), followed by half the recommended dose (0.75 x 10^{12} POB/ha).

Further reduction in dose of NPV resulted in inferior control. The fruit damage was significantly lower with application of NPV in full dose (14.8%) than other treatments. The cumulative yield was significantly higher with application of NPV at full or half the dose and decreased with reduction in the dosage of NPV.

BIPM for brinjal fruit and shoot borer (TNAU)

In a field trial at Kuruchi, larval population of *Leucinodes orbonalis* was significantly lower with BIPM (3.28/10 plants) compared to farmers' practice (11.21 / 10 plants). The per cent incidence of fruit borer with respect to fruit damage was lower in BIPM than farmers' practice. The per cent shoot damage was lower with BIPM (4.82%) than farmers' practice (13.06%). The total marketable fruit yield was higher in BIPM package (19.51 t/ha) than in insecticide control ((1317 t/ha).

Effectiveness of microbial pesticides and a summer oil against *Pieris brassicae* on kale / knol-khol (SKUAS&T)

In a field trial evaluating the use of *Beauveria bassiana, Bacillus thuringiensis, Metarhizium anisopliae, Heterorhabditis indica,* D.C.Tron Plus, neem, and dichlorvos against *Pieris brassicae*, dichlorvos (0.05%) proved most effective causing 100 % mortality after 10 days and *H. indica* @ 2 billion/ha was the least effective.

Investigations on potential biocontrol agents of *Diaphania indica* infesting cucurbits (IIHR)

Survey for natural enemies of *D. indica*

During surveys for natural enemies of *D. indica*, a gregarious braconid parasitoid, *Dolichogenidea stantoni*, was identified for the first time. Each parasitized larva of *D. indica* yielded a mean of 16.3 cocoons and 13.4 adults. Adult emergence was 14.3-100 % under field conditions and the sex ratio was female biased (1: 4.20).

Biology of *Dolichogenidea stantoni*

The biology of *D. stantoni* was studied in the laboratory on *D. indica*. Two- to three-day-old mated females of *D. stantoni* were allowed to parasitise 4-6 days old larvae of *D. indica*. The exposed larvae were maintained separately on cucurbit leaves. The larval period was 8-10 days. The parasitoid larvae pupated outside in white silken cocoons and the pupal period lasted 5-6 days. *D. stantoni* took 13-16 days to complete one life cycle (from egg to adult) at 25°C. The adults lived for 8-10 days on honey.

Biology and predatory potential of *Orius* spp. against thrips infesting chilli (IIHR)

During surveys for the natural enemies of thrips infesting chilli and other crops, *Orius maxidentex* (marigold), *Orius tantillus* (maize) and *Orius* spp. (crossandra and niger) were collected.

Biology of *Orius maxidentex* on thrips

Orius maxidentex adults collected from maize were released in a ventilated plastic jar containing marigold flowers infested with thrips. The eggs were laid on the flower parts. The nymphs hatched in 3-5 days. The nymphal period ranged from 12 to 14 days at 25°C. The adult longevity was 20-30 days. On marigold thrips, the male survived for 18 days and the female for 29 days. A single pair consumed 316 thrips during 29 days. The fecundity was about 24.

Biological suppression of potato pests (MPKV)

In a field trial at Pune, BIPM practices including *V. lecanii* spray and *Copidosoma koehleri* releases (four releases @ 1250 mummies/ha at weekly interval) were significantly more effective than farmers' practice in suppressing aphid and potato tuber moth population and also recorded 47 % higher yield of healthy marketable potato (209.0 q / ha) than farmers' practice (141.5 q / ha).

Biological suppression of weeds

Monitoring, evaluation and impact assessment of *Neochetina eichhorniae, N. bruchi* and *Orthogalumna terebrantis* against *Eichhornia crassipes*

AAU

Successful control of water hyacinth has been achieved by the exotic weevils *N. eichhorniae* and *N. bruchi*. At Disangmuck (Sibsagar) and Alengmara (Jorhat), 900 ha and 700 ha of water bodies, respectively, were cleared off by the weevils and the control achieved was 95%.

ANGRAU

Releases of *N. eichhorniae* and *O. terebrantis* were made in seven water bodies (in Ibrahim Bagh, Hyderguda, Hassan Nagar and Talabkatta near Hyderabad) and observation on establishment is in progress.

GAU

The weevils have established in all the released locations (Karjani, Boriavi, Lambhwel, Khodiar, Vidyanagar, and Anand).

MPKV

In August-September 2003, about 2000 adults of *Neochetina* spp. and 5000 mites were released in a pond. Gradual increase in the weevil and mite populations in the pond was observed and the leaf damage due to the weevils was 25.56 scars / leaf (until mid-February, 2004).

PAU

Neochetina bruchi and *N. eichhorniae* were released @ 2000 per water body; while *O. terebrantis* was released @ 5000 per water body, during July, 2003. There was an increase in the number of weevils per plant during July-March at all locations (Phillaur, Ludhiana, Goraya and Phagwara). Mites did not increase after the release, probably due to severe winter.

Monitoring, evaluation and impact assessment of *Zygogramma bicolorata* against parthenium

ANGRAU

Releases of *Zygogramma bicolorata* in a wasteland with good parthenium stand was compared with plots free of *Z. bicolorata*. The number of flowers per plant was fewer (537.16) in unreleased plots compared to *Zygogramma*-released plots (853.98 in August and 907.21 in September as against 483.23 in unreleased plots). *Z. bicolorata* did not influence plant height.

TNAU

In a trial at Thondamuthur, *Zygogramma* excluded plots recorded increased biometric characters. The presence of *Zygogramma* in untreated plots lowered the germinating seedlings and plant biomass. Defoliation in *Zygogramma* included plot was higher compared to *Zygogramma* excluded plots.

GAU

Release of 500 adults of *Z. bicolorata* on parthenium during August 2003 resulted in voracious feeding on leaves and flowers. Oviposition and development of larvae were also observed (0.4 grubs/plant). Predation of grubs by birds such as myna was observed.

YSPUH&F

Recovery of beetles released in congress grass infested patches (with no beetle population) was poor. At Nauni, the field activity of the beetle commenced in third week of May and continued till September 2003, with a mean of 8.3 per cent plant infestation and a population 0.3 beetles. There was no apparent impact of the beetle on growth of the plant at this low population level.

Survey and quantification of natural enemies of *Mimosa rubicaulis* subsp. *himalayana* and *M. invisa* (AAU)

Mimosa rublicaulis himalayana (Family: Mimosaceae), a thorny creeper, has occupied most of the grazing areas of Kaziranga National park, Assam. At present, 50 hectares of grazing areas are occupied by this weed in different forest ranges like Kohora, Bagari, Armora, Agaratali, etc. Survey for the natural enemies of these weeds revealed the occurrence of *Lamnia biplagiata* (Coleoptera: Chrysomelidae) during March 2004.

5. TECHNOLOGY ASSESSED AND TRANSFERRED

Technology assessed

Mass production of natural enemies

Superior strains of *Trichogramma chilonis* selected for multiple insecticide- and high temperature-tolerance and high host-searching ability were assessed at different agro-climatic regions for the control of cotton bollworms.

Improved strain of *Metarhizium anisopliae* (Ma 4) identified for the control of sugarcane woolly aphid.

Invented a simple and noval design for small scale solid state mass production unit for antagonistic fungi.

Corcyra eggs for shipment

Consignments of tricho-cards

6. EDUCATION AND TRAINING

Training for PDBC staff

Ms. M. Pratheepa, Scientist SS, attended the Summer School training on "Design and Analysis of Experiments for Agricultural Systems Research" from 5th June to 25th June 2003 at Indian Agricultural Statistics Research Institute, New Delhi

Mr. Satendra Kumar, Technical Officer, attended a workshop-cum-training on "Gahan Hindi Prashikshan and Karyashalla" from 1st to 5th July 2003 at National Academy of Agricultural Research Management (NAARM), Hyderabad

Dr. R.J. Rabindra, Project Director, attended the 7th Executive Development Programme (EDP) in Agricultural Research Management from 18th July to 22nd July 2003 at NAARM, Hyderabad.

Dr. M. Nagesh, Senior Scientist, attended a training course on "Advances in Videography and Photography" from 26th August to 5th September 2003 at NAARM, Hyderabad.

Dr. S.K. Jalali, Senior Scientist visited Russia for a study tour on "Biological and Microbiological Control of Pests and Diseases" from 28th July to 6th August 2003.

Dr. P. Sreerama Kumar, Senior Scientist, attended a training course on "Microbial control of insect pests - constraints, current developments and perspectives in integrated pest management" from 1st to 22nd December 2003 at Division of Entomology, Indian Agricultural Research Institute, New Delhi.

Ms. M. Pratheepa, Scientist SS, attended a training programme on "GIS Application in Agriculture" from 15th to 24th December 2003 at NAARM, Hyderabad

Training programmes organized by PDBC

Two months training on biological control of crop pests and weeds was organized for eight scientists from State Agricultural universities from 6th October to 6th December 2003

Hands' on training programme organized for six months on fungal pathogens for the control of sugarcane woolly for a technical officer from Sugarcane Breeding Institute, Coimbatore from 1st March to 31st August 2003

Organized a refreshers course training for 37 scientists in seven batches each for a period of six days

Forty-one scientists were trained representing from KVKs, SAUs & Departments of Agriculture & Horticulture on biological control of insect pests on cotton, pigeon pea, chickpea, tomato, cabbage, groundnut, apple and mango

Organizing ten tailor made training programmes on mass production and quality control aspects for 34 trainees representing states like Andhra Pradesh, Kerala, Nagaland, Meghalaya, Karnataka and Maharashtra

Training Programme on Mass Production of Entomophilic nematodes

7. AWARDS AND RECOGNITIONS

Dr. R.J. Rabindra and Dr. S. Ramani have been recognized as guides for Post-Graduate Research by the University of Agricultural Sciences, Bangalore, and Dr. (Ms.) Chandish R. Ballal and Dr. M. Nagesh as guides for Post-Graduate Research by Mysore University, Mysore.

PDBC presented awards to Mr. T. Bhaskaran and Mr. P. Ravindran, Technical Staff for their valuable contribution in their service on ICAR Foundation Day.

PDBC Director presenting best service awards to PDBC Staff on the occasion of ICAR Foundation Day

8. LINKAGES AND COLLABORATION IN INDIA AND ABROAD INCLUDING EXTERNAL PROJECTS

NATP-funded project entitled "Team of Excellence for Human Resource Development in Biological Control" has been extended up to 31-12-2004. The project is operative at PDBC, Bangalore, and the clients are scientists from various State Agricultural Universities, traditional universities and ICAR Institutes. This project will have linkages with all the institutes interested in biocontrol of crop pests and weeds.

NATP-funded project entitled "Development of bio-intensive IPM modules in chickpea against *Helicoverpa armigera*, wilt and dry root rot" is operative at Indian Institute of Pulses Research, Kanpur, and PDBC, Bangalore, is one of the co-operating centres.

NATP-funded project entitled "Control of leaf curl viral disease in cotton and development of protocols for mass multiplication of predators, parasites and insect pathogens" is operative at Central Institute for Cotton Research, Nagpur, and PDBC, Bangalore, is one of the co-operating centres.

NATP-funded project entitled "Development of an integrated pest management package for the eriophyid mite, *Aceria guerreronis* (Keifer) of coconut in the southern states" is operative at Tamil Nadu Agricultural University, Coimbatore, and PDBC, Bangalore, is one of the co-operating centres.

NATP funded project entitled "Development of IPM modules for oilseeds and nutritious cereals-based production system" (closed on 31-12-2003) was operated at National Centre for Integrated Pest Management, New Delhi, with PDBC, Bangalore, as one of the co-operating centers.

NATP funded project entitled "Validation and promotion of IPM Technology in selected crops in different agro-ecological regions" has been extended up to 31-12-2004 and is operative at National Centre for Integrated Pest Management, New Delhi, and PDBC, Bangalore, is one of the co-operating centers. The clients are the staff from various co-operating centers of the project and Plant Protection Officers from KVKs. This project will have linkages with all the institutes interested in biocontrol of pests of cotton, pigeon pea, chickpea, groundnut, tomato, cabbage, mango and apple.

Based on the linkage developed, the Coconut Board has given further financial assistance in the second phase for bioefficacy and biosafety tests for the mycoacaricide developed for coconut mite.

A linkage has been developed with Ministry of Agriculture, DARE, for mass production of quality biocontrol agents / biopesticides with financial assistance in four centres (UAS, Dharwad; Agricultural Research Station, Sri Ganganagar; PAU, Ludhiana; GAU, Anand) with PDBC, Bangalore, as the lead centre.

A linkage has been developed with Ministry of Agriculture, DAC, under Technology Mission on Cotton for development and evaluation of location-specific IPM modules and development of efficient strains. The project is operative at Central Institute for Cotton Research, Nagpur, with PDBC, Bangalore, as one of the co-operating centres.

ICAR Cess-funded project entitled, "Development of commercial formulations of antagonistic fungi (*Paecilomyces lilacinus* and *Pochonia chlamydosporium*) for biological control of *Meloidogyne incognita* and *Rotylenchulus reniformis*" is operative at PDBC, Bangalore.

ICAR Cess-funded project entitled, "Evolving and testing superior stains of *Steinernema* sp. and *Heterorhabditis* sp. against *Spodoptera litura* in field" is operative at PDBC, Bangalore.

DBT-funded project entitled, "Isolation, purification and characterization of novel insecticidal toxins from *Photorhabdus luminescens* and *Xenorhabdus* spp. of bacteria from entomopathogenic nematodes" is operative at PDBC, Bangalore.

9. AICRP / COORDINATION UNIT / NATIONAL CENTRES

With a view to fulfill the mandate given, the Project Directorate has divided the workload among six ICAR Institute-based and ten State Agricultural University (SAU)-based co-ordinating centres based on infrastructural facilities and expertise available as follows:

Headquarters

Project Directorate of Biological Control, Bangalore	Basic Research

ICAR Institute-based centres

Regional Station (CPCRI), Kayangulam	Coconut
Central Tobacco Research Institute, Rajahmundry	Tobacco, soybean
Indian Agricultural Research Institute, New Delhi	Basic Research
Indian Institute of Horticultural Research, Bangalore	Fruits & vegetables
Indian Institute of Sugarcane Research, Lucknow	Sugarcane
Sugarcane Breeding Institute, Coimbatore	Sugarcane

State Agricultural University-based centres

Assam Agricultural University, Jorhat	Sugarcane, pulses, rice and weeds
Acharya N.G.Ranga Agricultural University, Hyderabad	Sugarcane, pulses, cotton, oilseeds, coconut & weeds
Govind Ballabh Pant University of Agriculture and Technology, Pantnagar	Plant diseases - antagonists
Gujarat Agricultural University, Anand	Cotton, pulses, oilseeds, vegetables & weeds
Kerala Agricultural University, Thrissur	Weeds, rice, fruits & coconut
Mahatma Phule Krishi Vidyapeeth, Pune	Potato, weeds, rice, vegetables, sugarcane, cotton, pulses, fruits
Punjab Agricultural University, Ludhiana	Sugarcane, cotton, weeds, oilseeds, rice, & vegetables
Sher-E-Kashmir University of Agricultural Sciences & Technology, Srinagar	Temperate fruits & vegetables
Tamil Nadu Agricultural University, Coimbatore	Rice, cotton, pulses, oilseeds, coconut, fruits and weeds
Dr.Y.S.Parmar University of Horticulture & Forestry, Solan	Temperate fruits vegetables, oilseeds, weeds

10. LIST OF PUBLICATIONS

Research papers

Project Directorate of Biological Control, Bangalore

Baitha, A., Jalali, S.K., Rabindra, R.J., Venkatesan, T. and Rao, N.S. 2003. Parasitising efficiency of egg parasitoid, *Trichogramma japonicum* at four temperature regimes. *Annals of Plant Protection Sciences*, **11**: 185-188.

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11. LIST OF APPROVED ONGOING PROJECTS

Basic Research

Project Directorate of Biological Control, Bangalore

1. Biosystematic studies on predatory coccinellids
2. Biosystematic studies on Indian Tachinidae
3. Introduction and studies on exotic natural enemies of some important crop pests and weeds
4. Development of interactive identification key for important families of insect parasitoids and predators
5. Rearing and evaluation of natural enemies with special reference to scelionid, braconid, ichneumonid and anthocorid groups
6. Development of mass production techniques for dipteran (Diptera: Cecidomyiidae) and acarine (Arachnida: Acarina) predators for use in biological control programmes
7. Herbivore-induced plant synomones and their utilization in enhancement of the efficiency of natural enemies
8. Host-derived kairomones to enhance the efficiency of natural enemies
9. Development and use of insect viruses for the management of major pest complex of cruciferous crops
10. Development of improved formulations of NPV for management of *Helicoverpa armigera* and *Spodoptera litura* in tomato
11. Biocontrol of insect pests using entomopathogenic fungi and development of mycoinsecticides
12. Mass production, formulation and field testing of entomopathogenic nematodes against important lepidopteran pests
13. Biological suppression of plant parasitic nematodes exploiting antagonistic fungi and bacteria in specific cropping systems
14. Identification of pathogens of phytophagous mites and assessment of their potential in microbial control
15. Development and evaluation of improved strains of trichogrammatids, *Cheilomenes sexmaculata* and *Chrysoperla carnea* tolerant to insecticides, temperature and high host searching ability
16. Development and formulation of artificial diets for the rearing of coccinellids and anthocorids
17. Development and evaluation of artificial diets for *Opisina arenosella* and *Plutella xylostella* and studies on host-parasitoid interrelations
18. Software development for identifying and suggesting biosuppression measures for different crop pests using personal computer
19. Developing a database on microbial biocontrol agents

NATP-Funded Projects at Project Directorate of Biological Control, Bangalore

1. Team of Excellence for Human Resource Development in Biological Control
2. Validation and Promotion of IPM Technology in Selected Crops in Different Agroecological Regions
3. Development of IPM modules for oilseeds and nutritious cereals based production systems
4. Development of bio-intensive IPM modules in chickpea against *Helicoverpa armigera*, wilt and dry root rot (RPPS-7)
5. Control of leaf curl viral disease in cotton and development of protocols for mass multiplication of predators, parasitoids and insect pathogens
6. Development of integrated pest management package for the eriophyid mite (*Aceria guerreronis* Keifer) of coconut in the southern states
7. Improvement of formulation technology for entomopathogenic nematodes
8. Isolation of baculoviruses from larval Arctiidae (Lepidoptera) and standardization of mass production techniques of promising entomopathogenic strains

Other sources

1. Mass Production of Quality Bioagents/Biopesticides (DAC)
2. Development of efficient strains of biocontrol through molecular manipulations / techniques (DAC)
3. Evolving and testing superior strains of *Steinernema* sp. and *Heterorhabditis* sp. against *Spodoptera litura* in field (ICAR Cess)
4. Isolation, purification and characterization of novel insecticidal toxins from *Photorhabdus luminescens* and *Xenorhabdus* spp. of bacteria from entomopathogenic nematodes (DBT)
5. Developing a mycoacaricide for suppressing the coconut mite – Phase II (CDB)

Indian Agricultural Research Institute, New Delhi

1. Basic studies on and maintenance of *Bacillus thuringiensis* strains
2. Studies on formulations of microbial pesticides based on baculoviruses and *Bacillus thuringiensis*
3. Supply of improved formulations of *Bt* and NPV to PDBC for confirmatory screening tests

Applied Research

G.B.Pant University of Agriculture and Technology, Pantnagar

1. Evaluation of seed biopriming with *Trichoderma harzianum* (TH) and *Pseudomonas fluorescens* (PsF) and TH enriched FYM technologies
2. Evaluation of *Trichoderma* spp. against soil-borne diseases in pigeon pea
3. Evaluation of *Trichoderma* spp. against soil-borne diseases in chickpea
4. Management of foliar diseases using TH and/or PsF
5. Shelf-life of *Trichoderma* and / or *Pseudomonas* formulations with different moisture levels

Biological suppression of crop pests and weeds

Centre	Crop	Experiments
Regional Station (CPCRI), Kayangulam	Coconut	Evaluation of method of release of *Goniozus nephantidis* against *O. arenosella*; Field evaluation of *Cardiastethus exiguus* against *O. arenosella*
CTRI, Rajamundry	Tobacco	Biological Control of *Helicoverpa armigera* on tobacco; Identification and utilization of biocontrol agents for the management of *Spodoptera exigua*
	Soybean	Evaluation of BIPM package on soybean
IIHR, Bangalore	Fruits	Evaluation of *Trichogramma chilonis* against pomegranate fruit borer *Deudorix isocrates*; Integration of *T. chilonis* with *Bt* for the control of pomegranate fruit borer *Deudorix isocrates*; Colonization of *Encarsia guadeloupae* on spiralling whitefly in guava orchards; Efficacy of different formulations of *Verticillium lecanii* against the mealybugs, *Planococcus citri* and *Maconellicoccus hirsutus*; Field efficacy of *Metarhizium anisopliae* against mango hoppers; Evaluation of *Bacillus thuringiensis* against pomegranate

		fruit borer; Survey for natural enemies of fruit flies on guava and mango; Demonstration of biological control of mealybugs on grapes; Evaluation of Bt formulations against citrus leaf miner; Evaluation of Bt formulations against pomegranate fruit borer
	Vegetables	Biological control of insect pests of okra; Investigations on the potential of selected biocontrol agents against *Diaphania indica* infesting cucurbits; Evaluation of *Orius* spp. against thrips infesting chilli; Evaluation of *Verticillium lecanii* against thrips infesting chilli
IISR, Lucknow	Sugarcane	Survey and surveillance of woolly aphid and its natural enemies; Survey for current status of sugarcane woolly aphid and its natural enemies including status of alternate host plants; Maintenance and supply of *Epiricania melanoleuca* for use against *Pyrilla perpusilla and* Field evaluation of *Trichogramma japonicum* against *Scirpophaga excerptalis*
SBI, Coimbatore	Sugarcane	Survey and surveillance of woolly aphid and its natural enemies; Survey for current status of sugarcane woolly aphid and its natural enemies including status of alternate host plants; Influence of crop management practices on sugarcane woolly aphid and its natural enemies; Evaluation of potential natural enemies
AAU, Jorhat	Sugarcane	Survey and surveillance of woolly aphid and its natural enemies; Survey for current status of sugarcane woolly aphid and its natural enemies including status of alternate host plants; and Field evaluation of *Trichogramma chilonis* against *Chilo tumidicostalis*
	Pulses	Survey for natural enemies of pigeon pea seed weevil, *Apion clavipes*
	Rice	Isolation of fungal pathogens from rice ecosystem; Search for *Trichogramma* spp. and other egg parasitoids of rice hispa; Development of biointensive IPM for rice stem borer and disease management; Evaluation of *Trichogramma japonicum* against rice leaf folder; Evaluation of fungal pathogens on sucking pests of rice
	Weeds	Monitoring, evaluation and impact assessment of *Neochetina eichhorniae*, *N. bruchi* and *Orthogalumna terebrantis* against *Eichhornia crassipes;* Survey and quantification of natural enemies of *Mimosa rubicaulis* subsp. *himalayana* and *M. invisa*

ANGRAU, Hyderabad	Sugarcane	Survey and surveillance of woolly aphid and its natural enemies; Survey for current status of sugarcane woolly aphid and its natural enemies including status of alternate host plants; Influence of crop management practices on sugarcane woolly aphid and its natural enemies; Evaluation of potential natural enemies; Method of mass production of *Dipha* and *Micromus*
	Cotton	BIPM for Bt cotton
	Vegetables	BIPM for brinjal fruit and shoot borer
GAU, Anand	Cotton	BIPM for Bt cotton; Standardization of release technology for *Trichogramma chilonis* for bollworms; Influence of cotton cultivars/hybrids on the parasitization efficiency of *Trichogramma chilonis*
	Pulses	Biological control of pigeonpea cyst nematodes and disease complex; Microbial control of *H. armigera* and *Adisura atkinsoni* on lablab
	Oilseeds	Biological control of the aphids *Lipaphis erysimi* and *Brevicoryne brassicae* (*L. erysimi* on mustard)
	Weeds	Monitoring, evaluation and impact assessment of *Neochetina eichhorniae*, *N. bruchi* and *Orthogalumna terebrantis* against *Eichhornia crassipes;* Monitoring, evaluation and impact assessment of *Zygogramma bicolorata* against parthenium
KAU, Thrissur	Rice	Isolation of fungal pathogens from rice ecosystem; Evaluation of *Trichogramma japonicum* against rice leaf folder; Evaluation of fungal pathogens on sucking pests of rice; Impact of organic farming on conservation and augmentation of natural enemies of rice pests
	Coconut	Evaluation of method of release of *Goniozus nephantidis* against *O. arenosella;* Field evaluation of *Cardiastethus exiguus* against *O. arenosella*
	Fruits	Colonization of *Encarsia guadeloupae* on spiralling whitefly in guava orchards
	Weeds	Monitoring, evaluation and impact assessment of *Neochetina eichhorniae*, *N. bruchi* and *Orthogalumna terebrantis* against *Eichhornia crassipes;* Monitoring, evaluation and impact assessment of *Cyrtobagous salviniae* against *Salvinia molesta*

MPKV Pune	Sugarcane	Survey and surveillance of woolly aphid and its natural enemies; Survey for current status of sugarcane woolly aphid and its natural enemies including status of alternate host plants; Influence of crop management practices on sugarcane woolly aphid and its natural enemies; Evaluation of potential natural enemies; Method of mass production of *Dipha* and *Micromus;* Evaluation of fungal pathogens against sugarcane woolly aphid and Biointensive pest management practices for sugarcane scales
	Cotton	BIPM for Bt cotton
	Fruits	Colonization of *Encarsia guadeloupae* on spiralling whitefly in guava orchards; Demonstration of biological control of mealybugs on grapes
PAU, Ludhiana	Sugarcane	Maintenance and supply of *Epiricania melanoleuca* for use against *Pyrilla perpusilla*
	Cotton	Standardization of release technology for *Trichogramma chilonis* for bollworms; Influence of cotton cultivars / hybrids on the parasitization efficiency of *Trichogramma chilonis*
	Rice	Isolation of fungal pathogens from rice ecosystem; Evaluation of *Trichogramma japonicum* against rice leaf folder; Impact of organic farming on conservation and augmentation of natural enemies of rice pests
	Vegetables	BIPM in Tomato; Fixing the dose of NPV for the management of *Helicoverpa armigera* on tomato
	Weeds	Monitoring, evaluation and impact assessment of *Neochetina eichhorniae, N. bruchi* and *Orthogalumna terebrantis* against *Eichhornia crassipes*
SKUAS & T, Srinagar	Fruits	Quantification of natural incidence of parasitoids of San Jose scale on apple, in order to fix the release rates; Current status of San Jose scale, woolly aphids and their natural enemies on apple; Microbial control of white grubs on turf
	Vegetables	Effectiveness of various microbial pesticides and summer oil against *Pieris brassicae* on kale/knol khol; Evaluation of some fungal biocontrol agents for the control of cabbage aphid (*Brevicoryne brassicae*); Attempts to isolate nuclear polyhedral viruses from tent caterpillar and *Pieris brassicae*
TNAU, Coimbatore	Sugarcane	Survey for current status of sugarcane woolly aphid and its natural enemies including status of alternate host plants; Influence of crop management practices on sugarcane

		woolly aphid and its natural enemies; Evaluation of potential natural enemies and fungal pathogens against sugarcane woolly aphid
	Cotton	BIPM for Bt cotton
	Pulses	Biological control of pigeonpea cyst nematodes and disease complex; Microbial control of *H. armigera* and *Adisura atkinsoni* on lab-lab
	Rice	Evaluation of fungal pathogens on sucking pests of rice
	Oilseeds	Long-term control of *Amsacta albistriga* on groundnut by generating epizootics of NPV
	Coconut	Field evaluation of *Trichogramma embryophagum* against *Opisina arenosella*
	Fruits	Colonization of *Encarsia guadeloupae* on spiralling whitefly in guava orchards
	Vegetables	BIPM for brinjal fruit and shoot borer
	Weeds	Monitoring, evaluation and impact assessment of *Zygogramma bicolorata* against parthenium
Dr.YSPUH & F, Solan	Oilseeds	Biological control of the aphids *Lipaphis erysimi* and *Brevicoryne brassicae* (*B. brassicae* on cole crop)
	Fruits	Evaluation of *Trichogramma chilonis* against pomegranate fruit borer *Deudorix isocrates;* Quantification of natural incidence of parasitoids of San Jose scale on apple in order to fix the release rates; Current status of San Jose scale, woolly aphids and their natural enemies on apple; Studies on predators of phytophagous mites on apple
	Vegetables	BIPM in Tomato; Effectiveness of various microbial pesticides and summer oil against *Pieris brassicae* (Lepidoptera: Pieridae) on kale/knol khol; Evaluation of some fungal biocontrol agents for the control of cabbage aphid (*Brevicoryne brassicae*)
	Weeds	Monitoring, evaluation and impact assessment of *Zygogramma bicolorata* against parthenium

12. CONSULTANCY, PATENTS, COMMERCIALIZATION OF TECHNOLOGY

- Consultancy service provided for
  - EAG and GC-MS analyses of samples received from various organizations
  - Supply of quality biocontrol agents to different research and development departments of central and state governments
- Patent applied for
  - A simple and novel design for small-scale solid state mass production unit for antagonistic fungi on 30th September 2003

Supply of NPV formulations

Consultancy for GC-MS analysis

13. MEETINGS HELD AND SIGNIFICANT DECISIONS MADE

Eighth Research Advisory Committee Meeting held on 14th and 15th October 2003

Recommendations

1. The need for training in Biosystematics in internationally acclaimed centres of excellence was emphasized. The Chairman, RAC, remarked that the economic benefit should be the criterion for selection of groups for taxonomic / biosystematic studies.
2. The need for importation of natural enemies was emphasized and as a first step it was suggested that a project proposal on importation of parasitoids of *Helicoverpa armigera* and *Liriomyza trifolii* be prepared for submission to ICAR under Cess Fund Project.
3. Exploration of Southeast Asian countries may be considered to import effective natural enemies of sugarcane woolly aphid.
4. Since *Telenomus* has been found to be promising against *Spodoptera litura*, a programme may be included for multi-location testing under the AICRP during 2004-05.
5. The PDBC may develop linkages with the Directorate of Oilseeds Research for better utilization of *Bt* products developed for the management of castor semilooper.
6. As whitegrubs are a serious problem on ginger in Sikkim, a suitable strain of EPN may be developed for field testing at Gangtok.
7. For formulations of *Paecilomyces lilacinus*, *Trichoderma*, *Metarhizium anisopliae*, etc., optimum moisture content for enhanced shelf life must be identified.
8. Since *Spodoptera exigua* is emerging as an important pest, attempts should be made to standardize techniques for its mass production. *Nosema* infection, if any, in nucleus colony of insects must be eliminated following standard procedures.
9. Information on biopesticide producers and farmers adopting biocontrol technologies may be included in information systems on biocontrol.
10. Research efforts on developing biocontrol strategies for pigeon pea may be strengthened through the AICRP programme in view of the crop's importance.
11. Research on biocontrol-based IPM of brinjal shoot borer may be intensified.
12. Strains of *Trichoderma* with enhanced chitinase and glucanase activity may be identified. The plant pathologists involved should be adequately trained in this area.
13. All the microbial biocontrol agents available at PDBC may be freeze-dried and maintained in a repository.
14. The work on *Amsacta albistriga* NPV under the lateral funded project of NATP is interesting. Efforts to induce NPV epizootics for long-term management of *Amsacta albistriga* are promising. The work can be intensified with the help of various stakeholders like Department of Agriculture, Farmers' Self Groups and NGOs.
15. Greater attention should be paid for developing biocontrol strategy for sugarcane woolly aphid.
16. Under ICAR Adhoc Programme on woolly aphid, IARI, G. B. Pant University and other institutions from the states where the sugarcane woolly aphid is present may be included as a part of network programme.
17. A national workshop on biocontrol of *Helicoverpa armigera* may be organized along with the next work group meeting at PDBC. Possibility of conducting an international workshop in the year 2006 may also be explored.
18. Improved methods of release of *Trichogramma* may be developed.
19. Efforts to collect natural enemies from areas of low

pesticide use, particularly northeastern region and biodiversity-rich areas should be made. A cess-fund project may be proposed on this aspect.

20. Efforts should be intensified to increase the potential of *Dipha aphidivora* and *Micromus* for the management of sugarcane woolly aphid.

21. In order to conserve valuable natural enemy fauna, the possibility of establishing conservation reserves in different states through centrally sponsored programmes may be explored.

22. Concerted efforts are necessary for development of refined formulations and placement of entomofungal pathogens and antagonistic organisms.

23. The identification guide to coccinellids should be printed as soon as possible. A proposal may be sent to the Council for additional budget allocation for printing.

24. The Chairman, RAC, suggested that Proceedings of the AICRP Biocontrol Workers' Group Meeting may be sent to all the RAC members.

25. A strong linkage should be developed with NCIPM and biocontrol technologies developed by PDBC should be passed on to NCIPM for validation.

26. An interactive workshop with Scientists of NCIPM, Directors of Research and Plant Protection scientists of various agricultural universities and selected ICAR centers with strong biocontrol programmes may be organized in order to promote biocontrol as a component of IPM.

27. PDBC should increase its efforts in developing biocontrol technologies for the management of plant diseases and nematodes as part of IPM package.

28. Voluntary centers may be identified based on their strength in different areas of biocontrol for strengthening research activities in the AICRP programme.

Quinquennial Review Team- PDBC and AICRP (Biocontrol)

The Indian Council of Agricultural Research constituted the Quinquennial Review Team (QRT) to review the work done at the Project Directorate of Biological Control, Bangalore, during the period 1997-2002 vide order F.No.16-21/02-IA.IV dated 28-10-2002.

The QRT consisted of the following experts:

Dr. C.P.S. Yadava, Former Vice-Chancellor, Rajasthan Agricultural University, Bikaner (Chairman); Dr. B. Senapati, Vice-Chancellor, Orissa University of Agriculture & Technology, Bhubaneswar (member); Dr. B.L. Jalali, Former Director of Research, Chaudhary Charan Singh Haryana Agricultural University, Hissar (member); Dr. S. Lingappa, Director of Research, University of Agricultural Sciences, Dharwad (member); and Dr. J.G. Patel, Principal, C.P. College of Agriculture, Sardar Krishinagar, Banaskantha (member).

The first meeting of the team was held at ICAR, New Delhi, on 24th July 2003 and was chaired by Dr. G. Kalloo, DDG (CS & Hort.). The team visited 13 of the 17 centres including the Project Directorate of Biological Control, Bangalore, in a phased manner. During the visits, the members interacted with the Heads of the Departments/ Divisions, Directors of Research, Directors of Extension, Vice-Chancellors of State Agricultural Universities and Directors of the ICAR Institutes. An effort was also made to interact with producers of biocontrol agents in commercial insectaries in India to have feedback on research needs and constraints in popularizing biocontrol. The final report was submitted to the Council as per the format after discussion with the Institute Management Committee.

Staff Research Council Meeting

The Staff Reseach Council Meeting was held on 22nd January 2004 under the Chairmanship of Dr. R.J. Rabindra, Project Director, in the presence of Dr. O.P. Dubey, ADG (PP), ICAR, New Delhi. The specific recommendations/comments for taking further action are as follows:

1. The PDBC website should be revised with the latest information
2. NPV production protocols may be published for the benefit of stakeholders
3. The mass production laboratories must be strengthened to increase production activity
4. ISO certification may be thought of and a quality control laboratory may be set up to promote the availability of quality products for biocontrol
5. Impact analysis of the technologies developed and transferred should be made on priority basis. The Director, NCAAP, may be consulted for the protocols.
6. All scientists working on microbials should address the issue of shelf life more vigorously

RAC Members interacting with QRT Chairman

QRT members visiting the exhibition

QRT members having a look at biopesticide formulations

14. PARTICIPATION OF SCIENTISTS IN CONFERENCES, MEETINGS, WORKSHOPS, SYMPOSIA, ETC., IN INDIA AND ABROAD

Project Directorate of Biological Control, Bangalore

Deputation Abroad

Dr.S.K.Jalali, Senior Scientist, visited Russian Academy of Agricultural Sciences, Russia, on a study tour on "Biological and microbiological control of pests and diseases" from 28th July to 6th August 2003, under ICAQR-RAAS Work Plan for 2002-03

Programmes attended by scientific personnel within India

Scientist	Name of the Symposium/Workshop/Meeting	Place & Duration
Dr. R.J. Rabindra	Annual Group Meeting of the All India Coordinated Cotton Improvement Project	3-4 April, 2003, TNAU,Coimbatore
	National Seminar on Alien Invasive Weeds in India	27-29 April, 2003 AAU, Jorhat
	Classical Biological Control of *Mikania micrantha* with *Puccinia spegazzinii*	27-28 June, 2003 NBPGR, New Delhi
Dr. R.J. Rabindra, Dr.K. Narayanan. Dr.N.S. Rao, Dr.B.S.Bhumannavar, Dr.N.Bakthavatsalam, and Dr.T.Venkatesan	XII Biocontrol Workers' Group Meeting on biological control of crop pests and weeds	3-5 July, 2003 GAU, Anand
Dr. R.J. Rabindra	National Symposium on Frontier Areas of Entomological Research	5th November 2003 IARI, New Delhi
	Research Advisory Committee meeting	28th November 2003 NCIPM, New Delhi

	Biodiversity, Biosignalling and Biotechnology in Insect Plant Interactions: Changing Trends in Entomological Research	29th November 2003 Loyola College, Chennai
	National Symposium on Green Pesticides for Insect Pest Management	5-6 February 2004 Loyola College, Chennai
	National Conference on Role of Biopesticides, Bioagents and Biofertilisers for Sustainable Agriculture and Horticulture	14th February 2004 AIBA, New Delhi
	National Conference on Organic Farming for Sustainable Production	23rd March 2004 IARI, New Delhi
Dr. N.S. Rao	IPM strategies on rice, cotton, redgram and bengal gram	2-3 December 2003 RARS, Guntur
	Steps and procedural formalities for production of video film on Betacam SP format	26-27 December 2003, NAARM, Hyderabad
Dr. N.S. Rao & Dr.P.SreeramaKumar	National Conference on Transgenics in Indian Agriculture	9-10 March 2004 NASC, New Delhi
Dr.N.S.Rao	National Conference on "Seed: A Global Perspective"	26-28 March 2004 NASC, New Delhi
Dr. S. Ramani	International Symposium on Ecology of Biological Invasions	4-6 December 2003 University of Delhi, New Delhi
Dr. M. Nagesh	APNL Biotechnology Meet on Plant Parasitic Nematodes in A.P. and Project Screening for Funding	12-13 October 2003 Osmania University, Hyderabad
	XIII Biennial Group Meeting: AICRP on Plant parasitic nematodes with integrated approach for their control	23-24 December 2003 JLNKVV, Jabalpur
Dr. (Ms.) K.Veenakumari	National Convention on Sexual Harassment and Gender Justice	2-3 May 2003 Taj Residency, Bangalore
Dr.T.Venkatesan	National Symposium on Frontier Areas of Entomological Research	5-7 November 2003, IARI, New Delhi
Dr. P. SreeramaKumar	International workshop on coconut mite	5-6 April 2003 Hotel Atria, Bangalore
	Classical biological control of *Mikania micrantha* with *Puccinia spegazzinii*: Implementation phase	27-28 June 2003 NBPGR, New Delhi
Mr.S. Gunneswara Rao & Dr. P. Venkateswarlu	XII Biocontrol Workers' Group Meeting on biological control of crop pests and weeds	3-5 July, 2003 GAU, Anand

Dr. M. Mani, Dr.A.Krishnamoorthy & Dr.C.Gopalakrishnan	XII Biocontrol Workers' Group Meeting on biological control of crop pests and weeds	3-5 July, 2003 GAU, Anand
Dr. K. L. Srivastava	National Symposium on Frontier Areas of Entomological Research	5-7 November 2003, IARI, New Delhi
Dr. Arun Baitha	XII Biocontrol Workers' Group Meeting on biological control of crop pests and weeds	3-5 July, 2003, GAU, Anand
Dr. J. Srikanth	National Seminar on Use of Appropriate Varieties and Management Practices for Improving Recovery of Sugarcane	19-20, January 2004, SBI, Coimbatore
	XII Biocontrol Workers' Group Meeting on biological control of crop pests and weeds	3-5 July, 2003 GAU, Anand
Dr. A. Basit and Dr. D.K. Saikia	XII Biocontrol Workers' Group Meeting on biological control of crop pests and weeds	3-5 July, 2003AAU, Anand
Dr.A.Ganeswara Rao and Dr.S.J.Rahman	XII Biocontrol Workers' Group Meeting on biological control of crop pests and weeds	3-5 July, 2003 GAU, Anand
Dr. D.N.Yadav, Dr.B.H.Patel and Mr.J.J.Jani	XII Biocontrol Workers' Group Meeting on biological control of crop pests and weeds	3-5 July, 2003 GAU, Anand
Dr.(Ms.) S. P.Beevi & Dr.(Ms.) K.R. Lyla	XII Biocontrol Workers' Group Meeting on biological control of crop pests and weeds	3-5 July, 2003 GAU, Anand
Dr.S.A.Ghorpade and Dr.D.S.Pokharkar	XII Biocontrol Workers' Group Meeting on biological control of crop pests and weeds	3-5 July, 2003 GAU, Anand
Dr. K.S. Brar, Dr. Maninder, S, Mr. Jagmohan Singh, and Ms. Neelam Joshi	XII Biocontrol Workers' Group Meeting on biological control of crop pests and weeds	3-5 July, 2003AAU, Anand
Dr.R. Balagurunathan and Dr. N. Sathiah	XII Biocontrol Workers' Group Meeting on biological control of crop pests and weeds	3-5 July, 2003 GAU, Anand
Dr. P. R. Gupta and Dr. Anil Sood	XII Biocontrol Workers' Group Meeting on biological control of crop pests and weeds	3-5 July, 2003 GAU, Anand
	Seventh International Symposium on Temperate Zone Fruits in the Tropics and Subtropics	14-18 October, 2003, Dr.YSPUH & F. Solan,

15. WORKSHOPS, SEMINARS, SUMMER INSTITUTES, FARMERS' DAY, etc.

Organized

- Brainstorming session on Entomopathogenic nematodes: 22-01-2003
- Ninth Institute Management Committee meeting: 10-02-2003
- Inception Workshop of the ICAR-CABI collaborative project entitled, "Classical biological control of *Mikania micrantha* with *Puccinia spegazzinii*: Implementation phase" at NBPGR, New Delhi: 27-28th June 2003.
- Twelfth Biocontrol Workers' Group Meeting, Gujarat Agricultural University, Anand: 3rd to 5th July 2003
- Group meeting of Antagonistic Organisms in Plant Disease Management: 10th & 11th July 2003
- Eighth Research Advisory Committee meeting, PDBC, Bangalore: 14 & 15th October 2003
- Brainstorming session on the Management of black headed caterpillar of coconut at PDBC, Bangalore: 16-10-2003
- Institute Joint Staff Council Meeting: 17-03-2004

Celebrated

Anti-Terrorism Day on 21st May 2003

ICAR Foundation Day on 16th July 2003

Delegates of the Brainstorming session on Entomopathogenic nematodes

Delegates of the 12th All India Biocontrol Workers Group Meeting held at Anand

16. DISTINGUISHED VISITORS

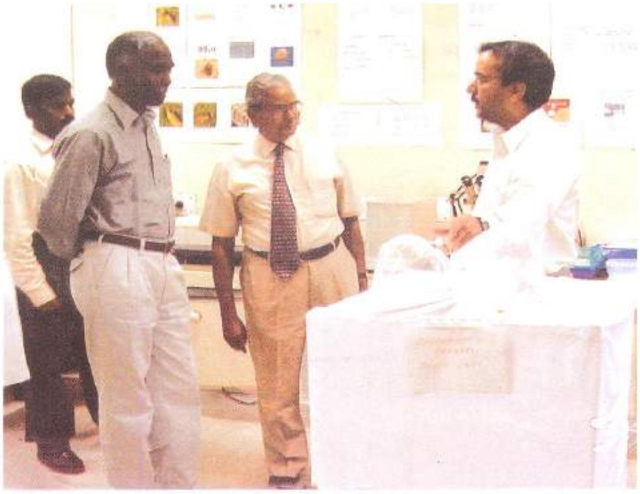
Project Directorate of Biological Control, Bangalore

Dr. (Mrs.) Manju Sharma, Secretary, Department of Biotechnology, Government of India, New Delhi, on 9th April 2003

Dr. M.V. Rao, Former Special Director General, ICAR, New Delhi on 29th August 2003.

Dr. Nadykta Valdimir, Head, Dr. Ismailov Valdimir, Deputy Director and Dr. Kovalenkov Viacheslav, All Russia Research Institute of Biological Plant Protection, Krasnodar, Russia, from 13th to 22nd October 2003.

Dr. A.F.G. Dixon, UEA, United Kingdom, on 10th December 2003.



Dr. M. V. Rao visiting the Biotechnology Laboratory

17. PERSONNEL

Project Directorate of Biological Control, Bangalore

Dr. R.J. Rabindra	Project Director
Dr. P.L. Tandon	Principal Scientist
Dr. K. Narayanan	Principal Scientist
Dr. N.S. Rao	Principal Scientist
Mr. S.R. Biswas	Principal Scientist
Dr. S.S. Hussaini	Principal Scientist
Dr. B.S. Bhumannavar	Principal Scientist
Dr. N. Bakthavatsalam	Senior Scientist
Dr. (Ms.) Chandish R.Ballal	Senior Scientist
Dr. S. Ramani	Senior Scientist
Dr. S.K. Jalali	Senior Scientist
Dr. B. Ramanujam	Senior Scientist
Dr. Prasanth Mohanraj	Senior Scientist
Dr. M. Nagesh	Senior Scientist
Dr.(Ms.)K.Veena Kumari	Senior Scientist
Dr. T. Venkatesan	Senior Scientist
Dr. (Ms.) J. Poorani	Senior Scientist
Dr. P. Sreerama Kumar	Senior Scientist
Dr. K. Srinivasa Murthy	Senior Scientist
Mr. Sunil Joshi	Scientist SS (on study leave)
Mr. R. Rangeshwaran	Scientist SS (on study leave)
Ms.M.Pratheepa	Scientist SS

Central Plantation Crops Research Institute, Regional Station, Kayangulam

Dr. (Ms.) Chandrika Mohan	Senior Scientist

Central Tobacco Research Institute, Rajahmundry

Mr. S. Gunneswara Rao	Scientist SG
Dr. P. Venkateswarlu	Scientist SS

Indian Agricultural Research Station, New Delhi

Dr. K.L. Srivastava	Principal 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

Indian Institute of Sugarcane Research, Lucknow

Dr. Arun Baitha	Scientist SS

Sugarcane Breeding Institute, Coimbatore

Dr. J. Srikanth	Senior Scientist
Dr. N. Geetha	Senior Scientist

Assam Agricultural University, Jorhat

Dr. A. Basit	Principal Scientist
Dr. D.K. Saikia	Senior Scientist

Acharya N.G.Ranga Agricultural University, Hyderabad

Dr. A. Ganeswara Rao	Principal Scientist
Dr. S.J. Rahman	Senior Scientist

Govind Ballabh Pant University of Agricultural Sciences & Technology, Pantnagar

Dr. U.S. Singh	Professor

Gujarat Agricultural University, Anand

Dr. D.N. Yadav	Principal Research Scientist
Dr. B.H. Patel	Associate Research Scientist
Mr. J.J. Jani	Assistant Research Scientist

Kerala Agricultural University, Thrissur

Dr. (Ms.) S. Pathummal Beevi	Associate Professor
Dr. (Ms.) K.R. Lyla	Assistant Professor

Mahatma Phule Krishi Vidyapeeth, Pune

Dr. S.A. Ghorpade	Entomologist
Dr. D.S. Pokharkar	Assistant Entomologist

Punjab Agricultural University, Ludhiana

Dr. S. Maninder	Entomologist
Shri. Jagmohan Singh	Assistant Entomologist
Dr. Neelam Joshi	Assistant Microbiologist
Ms. Ramandeep Kaur	Assistant Entomologist

Sher-e-Kashmir University of Agriculture and Technology, Srinagar

Dr. Abdul Majeed Bhat	Associate Professor

Tamil Nadu Agricultural University, Coimbatore

Dr. R. Balagurunathan	Professor
Dr. N. Sathiah	Associate Professor

Y.S.Parmar University of Horticulture and Forestry, Nauni, Solan

Dr. P.R. Gupta	Senior Entomologist
Dr. Anil Sood	Assistant Entomologist

18. INFRASTRUCTURAL DEVELOPMENT

Equipments

No new equipment was procured during this period.

Library

The library at PDBC has a collection of 1,692 books, 1154 volumes of journals, 49 bulletins and several miscellaneous publications including several reprints on various aspects of biological control. Ten foreign and 14 Indian journals have been subscribed. CABPEST-CD has been upgraded up to May 2004. A new CD, Sasya Sahyadri – 2004, was procured.

Aris Cell

A LINUX server was installed for firewall to save the workstations from network viruses. Internet cable connectivity was changed from modem to router for high speed of 512 kbps and quicker connectivity.

National Reference Collection of Insects

The PDBC has 3,495 authentically identified species belonging to 216 families under 16 orders. The collection includes representatives of the orders Hymenoptera, Coleoptera, Hemiptera, Orthoptera, Strepsiptera, Thysanoptera, Neuroptera, Diptera, Lepidoptera, etc. encompassing crop pests, parasitoids and predators. The information is available in the form of a catalogue.

Buildings

No new buildings were constructed during this period.

Electroantennogram and GC-MS facility

19. TECHNOLOGY DEVELOPED FOR THE BENEFIT OF WOMEN IN AGRICULTURE

Technology available

Two off-campus training programmes, well suited for adoption by household womenfolk, particularly in rural areas, were organized. Thirty-four farm women were trained on village level production of *Trichogramma* and *Trichoderma* at Maliappanahalli village of Hoskote Taluk (Karnataka). Five trainees have indicated their interest in becoming entrepreneurs for commercial scale production of biocontrol agents.

One on-campus training programme was organized for 90 farm women in three batches on production and use of *Trichogramma* and *Trichoderma*. These women were from Doddaballapura, Devanahalli (Bangalore South District) and Hoskote, Anekal (Bangalore North District) and Ramanagara, Chennapatna and Kanakapura.

Training programmes organized

Training programmes were organized on various aspects of biological control of crop pests. During the year 2003-04, participation of women in different training programmes was as follows.

Institute training programmes on mass production of quality biocontrol agents (7-10 days duration)	14 participants
NATP Project "Team of Excellence for Human Resource Development in Biological Control"	
Six months duration	1 participant
Two months duration	1 participant
6-day refresher course	1 participant
NATP Project "Validation and Promotion of IPM Technology in Selected Crops in Different agro-ecosystems"	
10 days duration	5 participants

Impact analysis of the training programmes conducted showed that there was improved awareness among the women trained.

Training for rural farm women in production of Biocontrol Agents

ACRONYMS

AAU	Assam Agricultural University, Jorhat
ANGRAU	Acharya N. G. Ranga Agricultural University, Hyderabad
CPCRI	Central Plantation Crops Research Institute, Kayangulam
CTRI	Central Tobacco Research Institute, Rajahmundry
GAU	Gujarat Agricultural University, Anand
GBPUA & T	Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar
IARI	Indian Agricultural Research Institute, New Delhi
IIHR	Indian Institute of Horticultural Research, Bangalore
IISR	Indian Institute of Sugarcane Research, Lucknow
KAU	Kerala Agricultural University, Thrissur
MPKV	Mahatma Phule Krishi Vidyapeeth, Pune
PDBC	Project Directorate of Biological Control, Bangalore
PAU	Punjab Agricultural University, Ludhiana
SBI	Sugarcane Breeding Institute, Coimbatore
SKUAS & T	Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar
TNAU	Tamil Nadu Agricultural University, Coimbatore
Dr.YSPUH & F	Dr.Y.S.Parmar University of Horticulture and Forestry, Solan