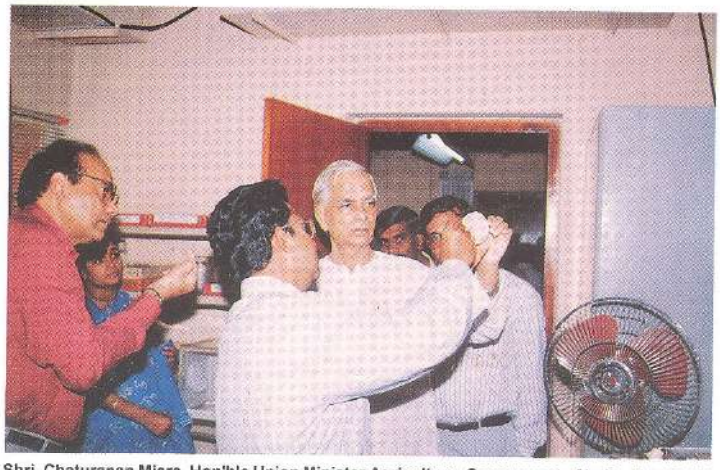
ANNUAL REPORT
1996-97

PROJECT DIRECTORATE OF BIOLOGICAL CONTROL
BANGALORE



Shri. Chaturanan Misra, Hon'ble Union Minister Agriculture, Government of India, New Delhi showing his keen interest in the work done on the utility of insect kairomones in biocontrol

Shri. Manoranjan Bhakta, Member of Parliament and Chairman for Social Audit, Government of India, New Delhi examining the parasitoids through the image analyser

Dr. R.S.Paroda, Secretary, DARE and Director General, ICAR, New Delhi discussing with the Project Director and Scientists of PG lab regarding large scale utilisation of the natural enemies of maize stem borer

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COVER PAGE	Effect of antagonist, *Trichoderma harzianum* (PDBCTH2) on *Sclerotium rolfsii* (sunflower isolate)
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CONTENTS

1. परियोजना निदेशकीय प्रतिवेदन

परियोजना निदेशालय जैविक नियंत्रण (परि. निदे. जै. नि.), भा.कृ.अनु.प., नई दिल्ली के अन्तर्गत 1993 मे 16 केन्द्रों के साथ स्थापित किया गया ।

1.1 विधिक आदेश

★ प्रमुख हानिकारक कीट रोगों, सुत्रकृमियों एवं खरपतवारों के नियंत्रण के लिए कुशल तकनीकों को विकसित करना ।

★ विभिन्न जैव कारक, प्राकृतिक शत्रुओं की मात्रा और इनके द्वारा कीट संख्या नियमित करने एवं इन प्राकृतिक शत्रुओं का राष्ट्रीय संग्रहण करना ।

★ राष्ट्रीय स्तर पर निस्पंदन एजेंसी के रूप में राष्ट्रीय जैविक नियंत्रण कारकों को उपोद्घात, आदान प्रदान एवं संरक्षण कार्य करना

★ राष्ट्रीय स्तर पर जैविक नियंत्रण संबंधी अनुसंधान को समवर्गीय बनाना एवं जैविक अनुसंधान के संबंध में अंतराष्ट्रीय एजेंसीयों के साथ संयोजन करना ।

★ जैविक दमन के लिए राष्ट्रीय सूचना प्रणाली को विकसित करना, जैविक नियंत्रण की नवीनतम तकनीकों की सूचनाओं का प्रसार करना एवं प्रशिक्षण प्रदान करना ।

1.1.1. संगठन

विधिक आदेश की भली भाँति एवं सफलता पूर्वक करने हेतू परि.निदे.जै.नि. के मुख्यालय में निम्न प्रयोगशालाओं और एक समवर्गीय, प्रशिक्षण एवं प्रलेखन इकाई में कार्य हो रहा है ।

★ जैवसिद्धान्त, प्राकृतिक शत्रुओं को उपोद्घात एवं संगरोध प्रयोगशाला

★ कीटों को अधिक संख्या में गुणन करने की प्रयोगशाला

★ कीट रोग प्रयोगशाला

★ भक्षक कीट व्यवहार प्रयोगशाला

★ जैव प्रौद्योगिकी प्रयोगशाला

इस परियोजना निदेशालय के 6 केन्द्र भा. कृ.अनु.प. के संस्थानों के अंतर्गत तथा अन्य 10 केन्द्र राज्य कृषि विश्व विद्यालयों के अन्तर्गत आते हैं, ये निम्नलिखित हैं

के.रो.फ.अनु.सं.	:	केन्द्रीय रोपण फसल अनुसंधान संस्थान, कयान्गुलम
कें.त.अनु.सं.	:	केन्द्रीय तम्बाकू अनुसंधान संस्थान, राजाहमुन्दरी
भा.कृ.अनु.सं.	:	भारतीय कृषि अनुसंधान संस्थान, नई दिल्ली
भा.बा.अनु.सं.	:	भारतीय बागवानी अनुसंधान संस्थान, बेंगलोर
भा,ग.अनु.सं.	:	भारतीय गन्ना अनुसंधान संस्थान, लखनऊ
ग.प्र.सं.	:	गन्ना प्रजनन संस्थान, कोयम्बतूर
आ.कृ.वि.वि.	:	आसाम कृषि विशवविद्यालय, जोरहट
आ.एन.जी.रा.कृ.वि.वि.	:	आचार्य एन जी रंगा कृषि विश्वविद्यालय, हैदराबाद
गु.कृ.वि.वि.	:	गुजरात कृषि विश्वविद्यालय, आनन्द
के.कृ.वि.वि.	:	केरला कृषि विश्वद्यालय, थ्रिसूर
म.फु.कृ.वि.वि.	:	महात्मा फुले कृषि विद्यापीठ, कृषि विद्यालय, पुणे
प.कृ.वि.वि.	:	पंजाब कृषि विश्वविद्यालय, लुधियाना
शे,क.कृ.वि.वि.	:	शेर ए कश्मीर कृषि विज्ञान एवं प्रशिक्षण विश्वविद्यालय, श्रीनगर
त.ना.कृ.वि.वि.	:	तमिलनाडू कृषि विश्वविद्यालय, कोयम्बतूर
डा.वाइ.एस.प.ब.व.वि.वि.वि.	:	डा.वाई.एस.परमार बागवानी एवं वन विज्ञान विश्वविद्यालय, नौनी, सोलन
गो.व.प.कृ.प्र.वि.वि.	:	गोविन्द वल्लभ पन्त कृषि विज्ञान एवं प्रशिक्षण विश्वविद्यालय, पंतनगर

1.1.2 परि.निदे.जै.नि. में उपलब्ध सुविधायें

उपकरण

परियोजना निदेशालय की प्रयोगशालों में आधुनिकतम तकनीक वाले उपकरण जैसे, तापक्रम, आर्द्रता एवं प्रकाश काल को सुनियोजित करने वाले पर्यावरणिक कक्ष, काल्पनिक विश्लेषक प्रणाली साँफ्टवेयर के साथ, विडियों कैमरा, विडियों द्वारा चलित

इकाई एवं अपेक्षित विश्लेषण के लिए कंपयूटर, पराप्रर्शीति अपकेन्द्रित मशीन, स्वचलित एलीसा रीडर, खमीर उठाने वाली मशीन, इलेक्ट्रोफोरेसिस एवं वैद्युत केन्द्रीकरण इकाई, प्रतिदीप्ति के साथ क्रमावस्था विषमता सूक्ष्मदर्शी, डीप फ्रीज (-85 डिग्री से.ग्रे.) माइक्रोटोम, पत्ती का क्षेत्र विश्लेषक, एन्टीनोग्राम, कम्पयूटर द्वारा नियंत्रित मौसम संबंधी उपकरण, आहार एनकेपसुलेशन मशीन, कीट सक्रियता मापक, एल.सी.डी. प्रक्षेपक यंत्र, फ्रीज ड्रायर, एच.पी.एल.सी. एवं अन्य उपकरण जो कि जैविक नियंत्रण के अनुसंधान कार्यों के लिए अति आवश्यक है, प्रयोगशालाओं में उपलब्ध हैं ।

पुस्तकालय

पुस्तकालय में 1400 पुस्तकें, 858 ग्रंथ पत्रिकायें, 22 विवरण पत्रिकायें, कई अन्य पुस्तक प्रकाशन एवं अनेक पुनः मुद्रित प्रकाशन जो कि जैविक नियंत्रण के संबंध में प्रकाशित किये गये, उपलब्ध हैं । अल्पकाल में उचित एवं योग्य आँकड़े तथा जानकारी प्राप्त करने के लिए सी.डी. रोम (जिसमें एक घनी तश्तरी है, जो केवल एकत्रित आँकड़ों को पढ़ने का कार्य करती है) कैबपेस्ट सी.डी. सूचिबद्ध आँकड़ों के साथ उपलब्ध है । संधिपाद प्राणियों की अनुक्रमणिका सूची (ए.एन.आइ.-सी.डी.) में फरवरी 1997 तक के नये संधिपाद प्रणियों के नाम जाँचने के लिए सी.डी रोम के साथ हाल ही में लगायी गई है ।

तकनीकी प्रलेखन

प्रतिलिपि चित्रक, विद्युत टंकक, कम्पयूटर, रंगीन लेजर मुद्रक, पुस्तक जिल्द बनाने वाली मशीन, फैक्स, टेलेक्स एवं ई-मेल आदि उपकरण उपलब्ध हैं, जो लिखित प्रमाण शीघ्र संकलित करने के साथ ही साथ शीघ्र सूचना के आदान-प्रदान करने में सहायक है । कंप्यूटर में उपलब्ध सॉफ्टवेयर वैज्ञानिकी तथ्य विश्लेषण एवं आरेख-रेखाचित्र बनाने में सहायक है ।

राष्ट्रीय कीट निर्देशित संग्रहण

परियोजना निदेशालय में प्रमाणिक रूप से पहिचाने गये कीटों की 3441 जातियाँ संग्रहित हैं जो कि 216 कुटुंबों से संबंधित हैं एवं 16 गणों के अन्तर्गत आते हैं । ये संग्रहित कीट निर्देश अनेक फसल कीटों, परजीवी कीटों, भक्षक कीटों का निम्न गणों में प्रतिनिधित्व करते हैं - हायमेनोप्टेरा, कोलियोप्टेरा, हेमिप्टेरा, आर्थोप्टेरा, स्ट्रेपसीप्टेरा, न्यूरोप्टेरा,

डिप्टेरा, लेपिडोप्टेरा आदि संग्रहित हैं । कीट एवं प्राकृतिक शत्रुओं का संग्रहण सूची-पत्र कम्पयूटीकृत अवस्था में एवं मुद्रित अवस्था में परि.निदे.जै.नि. में उपलब्ध है ।

परि.निदे.जै.नि.इस अवस्था मे है कि साझा कार्यक्रम जो जैविक नियन्त्रण संबंधी सभी कार्य आपसी लाभ, विशेष रूप से लाभदायक कीटो के आदान प्रदान, योजनाये बनाने एव आधुनिक रूप से प्रशिक्षण देने मे पूर्ण सक्षम है ।

1.1.3. 1996-1997 की प्रमुख उपलब्धियाँ

1.1.3.1 उपोद्धात, संगरोध सुरक्षा व्यवस्था एवं मूल अनुसंधान

21 पोषक कीट, 19 भक्षक कीट, 32 कीट परजीवी (ट्राइकोग्रामा किलोनिस की 8 प्रजातियों सहित) 3 कीट विषाणु, 2 कीट परजीवी सूत्रकृमि एवं 13 कीट रोग शत्रु परि.निदे.जै.नि. में पाले गये ।

इस वर्ष के दौरान, 29 पोषक कीट, 54 कीट परजीवियों एवं 18 भक्षक कीटों की प्रजातियाँ कई अनुसंधान संगठनों एवं क्षेत्रीय केन्द्रो को भेजे गये । लीरीयोमाइजा ट्राईफोली कीट का कीट परजीवी डीगलीफस बीगेनी अभी केलीफोर्निया से लाया गया । ऐलीयूरेडीकस डीसपेरसस के जैविक नियंत्रण के लिए ऐनकारसिया हाइटीएन्सिस को विदेश से मँगाने की मंजूरी ली गयी, जल्दी ही यह कीट परि.निदे.जै.नि.के परजीवी कीटों में शामिल हो जायेगा ।

बैंगलोर के आसपास कपास, अरण्डी, टमाटर, फलियों एवं कद्दू प्रजाति वाली फसलों में ली.ट्राइफोली के प्रकोप का क्षेत्र सर्वेक्षण किया गया ।

विभिन्न फसल जैव प्रणाली के अन्तर्गत परि.निदे.जै.नि. ने बैंगलोर के आसपास 6 सिरफिड, ।। कोक्सीनेलिड्स, । केमिएमिड एवं एक हेमेरोबीड को माँहू के भक्षक कीट के रूप में अभिलेखित किया ।

स्वदेशी कोक्सीनेलीड पर जैव सिद्धान्त का अध्ययन किया जा रहा है । भारतीय कीट समूह की एक विस्तृत सूची बनाने की प्रक्रिया चल रही है । परि.निदे.जै.नि. में परिमाणिक रूप से पहिचाने गये कीटों को सूचिबद्ध किया गया है और यह प्रकाशन के

लिए तैयार है । कोक्सीनेलिड्स को पहिचानने का कार्य शुरु किया जा चुका है । (परि.निदे.जै.नि.)

ए. क्रेसीवोरा का प्रयोगशाला में गुणन करने के लिए पोषक पौधे के रूप में लोबिया को सर्वोत्तम पाया गया । बैंगलोर के आसपास एफिडोफेगस सिरफीड को प्रत्येक मौसम में अलग रूप से, प्राप्त हुए । आइसीओडान स्कुटेलेरीस सभी फसलों में सभी मौसम में अधिक संख्या में प्राप्त हुए । पेरागस येरब्युरिएन्सिस एवं पे. सेराटस भी, सिर्फ मौसम के शुरु में छोड़कर, ग्रीष्म एवं खरीफ फसलों में लगातार प्राप्त हुए । डाएडीआप्सीस एग्रोटा एवं बीटासिरफस फ्लेचरी सितम्बर अक्टूबर माह में पाया गया । बी.लिंगा लोबिया में कभी नहीं पाया, जबकि अरहर की फसल में यह पाया गया । (परि.निदे.जै.नि.)

6 एफिडोफेगस सिरफीडस के जैव मापक अध्ययन किये गये । यह देखा गया कि डा. एग्रोटा के लारवों ने सबसे अधिक कीट उपभोग किये इसके उपरान्त बे. लिंगा एवं आइ. स्कुटेलेरीस क्रमशः उपभोग करते है । प्रयोगशाला में आई. स्कुटेलेरीस को पालना अनुकूल पाया गया ।

कोक्सीनेलीड कीट भक्षक कोक्सीनेला सेपटमपंकटेटा, को. ट्रान्सवरसेलिस एवं कीलोमिनस सेक्समेकुलेटा का पोषक कीट के रूप में 6 माँहू प्रजातियों का अध्ययन किया गया, ये केवल यू.कम्पोजीटे को छोड़कर माँहू की सभी प्रजातियों का भक्षण करते हैं । को. सेपटमपंकटेटा एवं को. ट्रान्सवरसोलिस पोषक कीट का भक्षण करते है, किन्तू अण्डे नहीं देते । ऐ. नेरी पोषक कीट को सेक्समेकुलेटा के विकास के लिए अनुकूल पाया गया । ऐ. क्रेसीवोरा सभी कोकसीनेलिड्स के लिए उत्तम पाया गया । कोक्सीनेलीड्स ग्रब के द्वारा ऐ. क्रेसीवोरा पोषक के उपभोग की दर प्रति ग्रब प्रतिदिन अधिक है और उसकी अण्डा देने की दर बढ़ी पायी गई । (परि.निदे.जै.नि.)

सीरोप्लेस्टोड्स कजानी पर चार शिकारी कीट एवं फेरीसीया विरगेटा पर एक शिकारी कीट पाया गया । फे. विरगेटा कीट के पाँच नये पोषक पौधे दर्ज किये गये । (परि.निदे.जै.नि.)

ट्राइकोग्रामा किलोनिस के मादा परजीवी, 'वाई' आकार की घ्राणमापक परखनली में हेलीकोवर्पा आरमिजेरा के शल्क निचोड़ का घ्राणआकर्षक परीक्षण करने पर इसकी गंध

की सकारात्मक प्रतिक्रिया पायी गयी, यह प्रतिक्रिया 44 से 80% तक विभिन्न सान्द्रताओं पर निरीक्षण की गयी । गँदे की कली की गंध ट्रा. किलोनिस मादा परजीवी को आकर्षित करती है । जब कोरसेरा सिफेलोनिका के अण्डे पोषक के रूप में उपयोग किये गये तो ट्रा. किलोनिस द्वारा सूर्यमुखी की विभिन्न जातियों में परीजीवित करने की क्षमता बहुत कम पायी गयी । ट्रा किलोनिस, पोषक है. आरमीजेरा एवं पोषक पौधे लोबिया की विभिन्न जातियों के त्रिकोणिय पारस्परिक संबंधों का परीक्षण करने पर परजीवी कीट का प्रभाव विभिन जातियों/संकर पर विभिन्न पाया गया । परजीवी कीटों का अधिकतम प्रभाव बी.जी. 256 (10.83%) प्रजाति पर पाया गया । (परि.निदे.जै.नि.)

अम्लीय जल अपघटित एल्फा ट्रिप्टोफॉन, क्राइसोपरला कारनीया के प्रौढ़ को आकर्षित करने के लिए अनुकूल.पाया गया । एल्फा ट्रिप्टोफॉन को तीन दिन संग्रहण के उपरान्त कपास के पौधो पर प्रयोग करने से अंडों की संख्या अधिक प्राप्त हुई । आक्सीकृत एल्फा ट्रिप्टोफॉन में हाइड्रोजन पेराआक्साईड, आक्सीकृत कारक के रूप में उत्तम पाया गया । वायू टनल परीक्षण में वेलाइन ट्रिप्टोफॉन मिश्रण, क्रा. कारनीया के पौढ़ को आकर्षित करने के लिए अनुकूल पाया गया । पिंजड़े में किये गये परीक्षण में, कपास पर, हेलीकोवर्पा आरमीजेरा प्रौढ़ कीट के पंख शल्को के साइक्लोहेक्सेन निचोड़, क्रा.कारनीया के लारवों को प्रभावी रूप से आकर्षित करता है ।

स्पोडोप्टेरा लिट्यूरा के लारवों को, अर्द्धसंश्लेषित आहार में पातगोभी की पत्तियों का पीसा आटा मिलाने से लारवों को भक्षण-आकर्षण के लिए अनुकूल पाया गया । ओपीसीना ऐरेनोसेला कीट को प्राकृतिक आहार पर पाले जाने की अपेक्षा अर्द्ध-संश्लेषित आहार पर पाला गया, किन्तु प्यूपों की संख्या कम प्राप्त हुई । (परि.निदे.जै.नि.)

क्रा. कारनीया के अधिक संख्या में लारवों एवं प्रौढ़ प्राप्त करने के लिए हाइड्रोलाइजड सोयाबीन आहार को अनुकूल पाया गया । क्रिप्टोलीमस मोन्ट्रोजेरी, किलोमिनस सेक्समेकुलेटा, काइलोकोरस नीगरीटा, कोक्सीनेला सेपट्मपंकटेटा, होरमोनिया आक्टोमेक्युलेटा एवं नीफस स्पे. को प्रयोगशाला मे सूअर के यर्कत पर पाला गया ।

हे. आरमीजेरा एवं स्पो. लिट्यूरा, एन.पी.वी. उत्पादन के लिए एवं न्यूकिलयस संवर्धन भेजने के लिए निरंतर पाले गये । प्रयोगशाला में, 200 हे.एन.पी.वी. एवं 500

स्पो.एन.पी.वी. का उत्पादन किया गया । ग्रेनुलोसिस विषाणु, प्लूटेला जाइलोसटेल्ला के प्रति पहली बार घातक पाया गया । पातगोभी एवं सरसों के बीजांकुरों पर पी. एक्स.जी.वी. का विवो गुणन उत्पादन सफलतापूर्वक किया गया । (परी.निदे.जै.नि.)

पी.एक्स जी वी के संक्रमण के कारण पहले शरीर का भार बढ़ना एवं शरीर फुलने के लक्षण तथा रोग बढ़ने पर हरे रंग से कुछ पीला रंग पाया गया । वसा शरीर के ऊतकों में अनुकूल प्रोटीन पायी गई । जी.वी. केप्सूल ओवोसिलिन्ड्रिकल आकार के होते हैं, जिसमें एक या कभी कभी दो न्यूक्लियोकेप्सीडस एक केप्सूल में पाये जाते हैं । (परि.निदे.जै.नि.)

सर्वभक्षी शलभ कीटों, स्पो.लिट्यूरा एवं है. आरमीजेरा के उपभोग के लिए अर्द्धसंश्लेषित आहार को ठोसपन प्रदान करने के लिए महँगे अगार आगार पदार्थ के बदले में उसका प्रतिस्थापी सस्ता सागो (टेपीओका आधारित उत्पाद) प्रयोग करने से कीट के विकास एवं वृद्धि के संतोषजनक परिणाम मिले । आहार की सहवर्तिता अगार अगार के समतुल्य पायी गई । आगार आगार के अपेक्षा सागो लगभग ९० गुणा सस्ता है, इसको आहार में, प्रयोग करने से पोषक कीट आहार एवं प्राकृतिक शत्रुओं के उत्पादन की मूल्य उत्पाद लागत कम की गई । (परि. निदे.जै.नि.)

प्लूटेला जाइलोसटेल्ला से एन पी वी एवं स्पाइलोसोमा आँबलीकुआ पर कवकीय रोगाणु पृथक किये गये । बेसीलस थयूरिजेन्सिस की दो जातियों, कुरसटेकी एवं इजराएलेन्सिस को हेलीकोवर्पा आरमीजेरा के लारवे के अंतिम निरूप के प्रति प्रभावी पाया गया । (भा.कृ.अनु.सं.)

कोरसेरा सिफेलोनिका के लारवों को विलोभक तकनीक के प्रयोग करने से स्टेइनरनीमा एवं हेटरोरहब्डीटीस स्पे. को प्रथक किया गया । को. सिफेलोनिका लारवों पर स्टेइनरनीमा एवं हेटरोरहब्डीटीस स्पे. का इन वाइवो संवर्धन गुणन किया गया एवं इनविट्रो के प्राकृतिक माध्यम में सोया आटा, कॉर्न तेल, यीस्ट एवं पोषक तत्व मिलाने से जीवाणु सुत्रकृमि को प्रमुखता देते है । सूत्रकृमियों को पोलीयुरीथेन फाँमचिप्स पर कोनीकल फलास्क में पोषित किया गया । स्पोडोप्टेरा, कोरसेरा, होलोट्रिकीया (श्वेत ग्रब्ज), प्लुटेला जाईलोसटेल्ला, काइलो पारटीलस के लारवों के प्रति हेटरोरहब्डीटीस का परीक्षण किया गया एवं इसको प्रभावी पाया गया । यह मक्का के पोधो में काइलो पारटीलस के प्रति

1000 संक्रमित ज्यूवेनाइल्स प्रति मि.ली. की मात्रा छिड़कने पर अत्यन्त प्रभावी पाया गया । (परि.निदे.जै.नि.)

पादप परजीवी सूत्रकृमियों मीलोइडोगाइने इनकोग्नीटा, मी. जेवेनीका, मी. ऐरिनेरिया एवं रोटाईलेन्कुलस रेनीफोरमीस को टमाटर, लोबिया, चना, भिण्डी एवं बैगन पर पोषित किया गया । सूत्रकृमि भक्षक कवक पेसीलोमाइसस लाइलेसीनस, ट्राइकोडर्मा हारजीएनम एवं अन्य दो कवकों को पृथक किया गया । पास्टेइयूरीआ पेनेट्रेन्स जीवाणु को भी पृथक किया गया तथा मीलोइडोगाइने एवं. मी. जेवेनीका के साथ टमाटर के पोधो पर संवर्धन किया गया । (परि.निदे.जै.नि.)

कवक संवर्धन ट्राइकोडर्मा हरजीएनम (परि.निदे.जै.नि. 2), ट्रा. कोनीनगी (आई टी सी सी 2170), ट्रा. हेरजीएनम (आई टी सी सी 2395), ट्रा. वीरीडे (परि.निदे.जै.नि. 4) एवं ग्लॉयोक्लेडियम विरेन्स (आई टी सी सी 4177) - को मिलॉयडोगाइने इनकोगनीटा एवं मी . जेवेनीका के प्रति प्रबल जैव नियंत्रण कारकों के रूप में प्रयोग किया गया । (परि.निदे.जै.नि.)

एस. रोल्फसाई के उपनिवेशन त्रिज्यक के विस्तार को 0 से 60.7% तक कम किया गया । अधिकतम नियंत्रण, ट्रा. हेरजीएनम के पृथककरित पी.डी.बी.सी. टी.एच. 2, पी.डी.बी.सी. टी.एच. 8, पी.डी.बी.सी. टी.एच 7 एवं आई.टी.सी.सी. 2895 द्वारा किया गया जिनसे विस्तार 60.7, 55.1, 59 एवं 50.6% क्रमशः एस. रोल्फसाई के उपनिवेशन के त्रिज्यक की कमी पाई गई । सभी प्रतिरोधी, दृढपटल के उत्पादन को पर्याप्त रूप से कम किया गया जिसका विस्तार 31.8 से 97.8% था । दृढपटल उत्पादन की अधिकतम कमी पी डी बी सी टी एच 8 (97.8%) के द्वारा, उसके बाद पी डी बी सी टी एच 2 (93.9%) एवं पी डी बी सी टी एच 7 (93.8%) के द्वारा पायी गयी । पी डी बी सी टी एच 8, पी डी बी सी टी एच 2, पी डी बी सी टी एच 7, टी. स्यूडोकोनिन्गी एवं गलायोक्लोडियम डेलीक्यूसेन्स के द्वारा सौ प्रतिशत अवरोधन पाया गया । टी. हारजीएनम (पी डी बी सी टी एच । से 4), टी. वीरीडे (पी डी बी सी टी वी । से 4) एवं पी. फलूआरसेन्स (पी डी बी सी पी एफ । से 4) के द्वार गुलाब के ग्रे मोल्ड रोग को पैदा करने वाला बोट्रीटीस सिनेरीया की वृद्धि को सफलतापूर्वक नियंत्रित करता है ।

पार्थेनियम को, साधरणतया पाउड्री मिलड्यू रोग (आडियम पार्थेनी) से प्रभावित पाया गया, जिनका-अगस्त अप्रैल माह में अत्यधिक विस्तार पाया गया तथा जो पौधे प्रारंभिक अवस्था में संक्रमित होते है, उनमें बीज नहीं बनते और जो पोधे अत्यधिक संक्रमित थे, मृत पाये गये । (परि.निदे.जै.नि.)

प्रयोगशाला में, पार्थिनियम के प्रति कवक रोग फ्यूजेरियम सेमीटेक्टम एवं पेसटालोटिया स्पे. को प्रभावी पाया गया । स्केलेरोटियम रोल्फसाई को पार्थिनियम विल्टड पोधों से पृथक किया गया, जो कि ग्रीनहाउस दशा में अत्यधिकि प्रभावी रोग पाया गया । यह रोग खरपतवार में, कॉलर रॉट रोग उत्पन्न करता है और विशेषत: पौधे के विकास की प्रारंभिक अवस्था में संक्रमित होने पर पौधा मर जाता है । पार्थेनियम पौधो से स्कलेरोटीनीया स्केलेरोटीऔरम भी पाया गया । पार्थेनियम की पत्तियों के धब्बों एवं ब्लास्टस से एक अनिभिज्ञात जीवाणु पृथक किया गया । पोषक के विशेषत: रोगों पर प्रयोग जारी है । खरपतवार कवक, ग्लाँयोक्लेडियम वायरेन्स एवं ग. डेलीक्यूसेन्स को पार्थेनियम के प्रति प्रयोगशाला दशाओं में सफलतापूर्वक प्रदर्शित किया गया । (परि.निदे.जै.नि.)

1.1.3.2 गन्ने के हानिकाकरक कीटों का जौविक नियंत्रण

पंजाब के चार जिलों में पंजाब कृषि विश्वविद्यालय द्वारा काइलो औरीसीलीअस के प्रति ट्राइकोग्रामा किलोनिस के प्रयोग करने से, फसल में 53.8% की क्षति कम की गयी । सभी क्षेत्रों से परजीवी कीटों की पुन: प्राप्ति हुई, जिन क्षेत्रों में परजीवी छोड़े गये वहाँ 2.9 से 15.5 प्रतिशत जबकि अन्य क्षेत्रों में 0 से 0.9 प्रतिशत नियंत्रण पाया गया । जालांधर में, एस. एक्सरपटेलिस के प्रति ट्रा. जेपोनिकम प्रयोग करने से, फसल में 31.6 से 36.2 प्रतिशत की क्षति कम की गयी । अण्डा परजीवी टेलेनोमस डीगनाँइडस को अत्याधिक सफल परजीवी पाया गया । प्राकृतिक स्थिति में क्षेत्रों में 48.5% अण्डे एवं 25.4% एस. एवसरपटेलिस के लारवें परजीवित पाये गये । का. इनफसकेटेलस, का. आरीसीलीअस एवं एकीगोना स्टेनीएलस के लारवें क्रमश: 14.6, 23.7 तथा 15.1 प्रतिशत परजीवित पाये गये ।

केवल गन्ने की फसल की अपेक्षा, खेत में मिश्रित फसल के रूप में, गन्ने के साथ दलहनी फसलों (सोयाबिन, लोविया, चना एवं मटरा) के प्रयोग से अगोला बेधक के प्रकोप में,

कोई विशेष अन्तर दिखायी नहीं दिया । गन्ने की एक फसल की अपेक्षा मिश्रित फसलों में कीट भक्षक कीटों, मकड़ीयों एवं कोक्सीनेलीड्स की संख्या कम पायी गया । (ग.प्र.सं.) एस. इनफेरेन्स को, 10 से 20 प्रतिशत परजीवित गेलेरीय मीलोनेला पर पाला गया । जी.वी. पूरे वर्ष, 8.5 से 32.4 प्रतिशत सक्रियता स्तर पर सक्रिय रहा । प्रयोगशाला में किये गये जैवपरिक्षण में, बेयुवेरीया ब्रोनगनीआरटी की 10 बीजाणु/मि.ली. की दर से निवेशित करने से होलोट्रीचीया सरेटा के तीसरे निरूप ग्रब्ज के लिए 64% घातक सिद्ध हुआ । (ग.प्र.सं.)

1.3.3.3 कपास के हानिकारक कीटों का जैविक नियंत्रण

पंजाब कृषि विश्वविद्यालय में अनियंत्रित क्षेत्रो की अपेक्षा कपास की सूंडियों के प्रति, छिड़काव, आई पी एम एवं जैव नियंत्रण के परिणाम स्वरूप, उपज क्रमशः 40, 24 एवं 20 प्रतिशत बढ़ी तथा सूंडियों का प्रकोप कम किया जा सका । ट्रा. किलोनिस द्वारा हे. आरमीजेरा के अण्डे, सबसे ज्यादा लुधियाना में परजीवीत पाये गये इसके बाद संगरूर में परजीवित पाये गये तथा मुक्तसर जिले में सबसे कम परजीवीत अण्डे पाये गये । फरीदकोट एवं फिरोजपुर में अण्डे परजीवित नहीं पाये गये ।

त.कृ.वि.वि. में, कपास की फसल में बी आई पी एम के विकास के लिए, किये गये अध्ययन से स्पष्ट परिणाम मिलते है कि ए. आई. सी. आर. पी. एवं त कृ वि वि द्वारा माँहू एवं सूँड़ीयों के जैविक दमन के लिए निर्धारित विधियाँ किसानों के लिए अनुरूप है

गु. कृ.वि.वि. में, कपास 8 संकर प्रजाति पर सूँडियों एवं चूसने वाले कीटों के प्रति कीटनाशक प्रयोग एवं कीटनाशी रहित अनियंत्रित फसल में आई पी एम परीक्षण खरे उतरे एवं मूल्य वृद्धि लाभ अनुपात के तहत अधिकतम प्राप्त हुई । कपास में, ए. गोसीपी से से 2 ग्राम बेसीली (+), 1 ग्राम सिरेटीआ (-) एवं एक कवक प्रजाति गु.कृ.वि.वि. में प्रथक की गयी तथं इनकी रोगजनकता का परीक्षण किया जाना है ।

कपास में अन्तः फसल के रूप में मूँगफली उगाने एवं रासयनिक कीट नाशियों के प्रयोग न करने से लाभदायक कीटों की संख्या बहुत अधिक पायी गयी जिससे आई पी एम के प्रयोग के उत्कृष्ट परिणाम मिले । आई पी एम प्रक्रिया अपनाने से मूल्य वृद्दि लाभ अनुपात (10.07) सबसे अधिक मिला जबकि किसानों द्वारा अपनायी गई प्रक्रिया से 1.55

एवं कीटनाशियों के विवेचित इस्तेमाल से 1.59 मूल्य वृद्दि लाभ अनुपात पाया गया । (आ एन जी आर कृ वि वि)

1.1.3.4 तम्बाकू के हानिकारक कीटों का जैविक नियंत्रण

स्पो. लिट्यूरा के प्रति बे. थ्यूरिनजोन्सिस की 4 प्रजातियाँ भा.बा.अनु.स., बैंगलोर, 2 प्रजातियाँ भा.प.अनु.के., मुम्बई द्वारा नर्सरी तथा कवक कीट रोग नोमयूरेइया रीलेयी प्रयोगशाला में विकसित किये गये ।

(हैदराबाद प्रजाति) स्पो. लिट्यूरा के प्रति तिलहन अनुसंधान निदेशालय, हैदराबाद द्वारा विकसित की गयी तथा के.त.अनु.सं. द्वारा नर्सरी की गयी ।

1.1.3.4 दलहनी फसलों के हानिकारक कीटों का जैविक नियंत्रण

अरहर में, फलीभेदकों द्वारा हानि को, इन्डोसल्फान (100 मि.ली./है.) एवं बे. थ्यूरीनजेन्सिस के प्रयोग से कम किया गया (प.कृ.वि.वि.)

त.कृ.वि.वि. में, अरहर में हे. आरमीजेरा को सफलतापूर्वक नियंत्रित करने के लिए बे. थ्यूरीनजेन्सिस एग्री के अनेक सूत्रबद्द फार्मुले, अन्य सूत्रबद्द फार्मूलों से उत्कृष्ट पाये गये एवं उपज अधिक मिली तथा फली क्षति कम पायी गई ।

आ.एन.जी. आर कृ.वि.वि. में, फसल में फूल आने के समय हे.एन.पी.वी.की 250 एल.इ.प्रति हेक्टर की दर से और ट्रा. किलोनिस की 50000 प्रति है. की दर से तथा हे. एन.पी.वी. 125 एल.ई./है.की दर से शाम के समय 10 दिन के अन्तराल से चार बार प्रयोग करने से कीट लारवों की संख्या के नियंत्रण एवं फलीयों की क्षति रोकने के लिए उत्तम पाये गये तथा उपज भी अधिक मिली । बे. थ्यूरीनजेन्सिस, बाँयोबीट एवं बी. टी. के II के प्रयोग से कीट लारवों की संख्या को कम करने एवं अरहर की उपज अधिकतम लेने में सफलता मिली । हे.एन.पी.बी 125 एल ई प्रति है. तथा इन्डोसलफान 0.035% की दर से प्रयोग करने पर है. आरमीजेरा के लारवों की संख्या कम करने एवं उपज ज्यादा लने के लिए उत्तम पाया गया, हे.एन.पी.वी. की 250 एल.ई/है. की दर से चने

की फसल में प्रयोग करने से अनुकूल परिणाम मिले । बे.थूरिजेन्सिस के साथ डाइपेल एवं बी.टी. के. II को 1 किलोग्राम /है. की दर से चने में हेलीकोवर्पा के विरुद्ध प्रभावी पाया गया ।

1.1.3.6 धान के हानिकारक कीटों का जैविक नियंत्रण

धान के पत्ती मोडक कीट को नियंत्रित करने के लिए बी.टी. सूत्रबद्ध को सर्वोत्तम पाया गया । (के.कृ.वि.वि.)

क्षेत्र में ट्रा. किलोनिस एवं ट्रा. जेपोनिकम को 100000/है.की दर से छोड़ने पर पत्ती मोडक कीट का प्रकोप कम किया गया । कीटनाशी के छिड़काव एवं 100000/है. की दर से परजीवी छोड़ने पर तना बेधक द्वारा उत्पन श्वेत बालियों के प्रकोप के प्रतिशत को कम किया गया । (प.कृ.वि.वि.)

आ.कृ.वि.वि. में ट्रा. जेपोनीकम (फली तना बेधको के प्रति) को धान रोपण के 30 दिन पश्चात 50000 प्रौढ़/है./सप्ताह की दर से 5 बार छोड़ने पर खरीफ मौसम में 10.66% और रबी मौसम में 5.71% डेडहर्ट की कमी पायी गई । नियंत्रण में 5.7% की अपेक्षा, बाँयोबिट, डेलफीन एवं बी. टी. के 1 द्वारा पत्ती मोडक द्वारा की क्षति को क्रमशः 1.35%, 1.34% एवं 1.93% तक करता है ।

ट्रा. जेपोनिकम कीट परजीवी को बी.टी.के साथ प्रयोग करने से डेडहर्ट को सफलतापूर्वक नियंत्रित किया गया । रासायनिक छिड़काव से पत्ती मोडक कीट को कम किया गया, किन्तु कीट परजीवियों एवं बी.टी. छिड़काव के समतुल्य पाया गया । कीटनाशी नियंत्रण के अपेक्षा ट्रा. जेपोनीकम तथा ट्रा. किलोनिस एवं बी. टी. छिड़काव के प्रयोग को सर्वोत्तम पाया गया (त.न.कृ.वि.वि.)

1.1.3.7 तिलहन फसलों के हानिकारक कीटों का जैविक नियंत्रण

श्वेत ग्रब्ज को नियंत्रित करने के लिए सूक्ष्मजीवी कीटनाशियों (एम. एनीसोप्लीए, बी. बेसीआना एवं पी. पोपीलीए) एवं कीटनाशियों क्लोरपाइरीफोस एवं क्विनेलफोस) का प्रयोग किया गया, एम. एनीसोप्लीए को सर्वोत्तम पाया गया । (गु.कृ.वि.वि.)

1.1.3.8 नारियल के हानिकारक कीटों का जौविक नियंत्रण

नारियल के स्टेफेनीटीस टीपीका कीट के भक्षक कीट के रूप में स्टेथोकोनस प्रेफेकटस, प्रमुख भक्षक कीट पाया गया । (के.कृ.वि.वि.)

दो केन्द्रो पर कीट परजीवियों के प्राकृतिक रूप से पाये जाने के अभिलेख यतन किये गये । ट्राइकोग्रामा एम्ब्रीओफेगम कीट परजीवी ओपीसीना ऐरेनोसेला कीट पर 10 दिन में जीवन चक्र पूर्ण करता है तथा प्रयोगशाला में परजीवित विस्तार 30 से 90% पाया गया । (के.रो.फ.अनु.सं.)

1.1.3.9 फलो वाली फसलों के कीटों का जैविक नियंत्रण

श्वेत मक्खी, ऐलीयूरोडीकस डीसपरसस के प्रति दो कोक्सीनेलीड्स, एक्सीनोसीमनस पुटेरूद्रीआही एवं क्रिप्टोलीमस मोन्ट्रोजेरी को प्रमुख भक्षक कीट पाया । को. मोन्ट्रोजेरी का एक लारवा, श्वेत मक्खी के 300 निम्फ का भक्षण करता है । धर्मपुरी (त.न.) जिले में, आम की तोतापुरी एवं सिन्दुरा प्रजातियों पर सफेद फूँगा की दो प्रजातियों, रेस्ट्रोकोकस आइसेरीआयडोन एवं फेरीसीया बीरगेटा पायी गयी । कस्टई एप्पल पर, स्कुटलीस्टा सीनीया द्वारा, पेरासेसीटीया नीग्रा को 40% परजीवित पाया गया, जबकि केरीया कम्युनिस, एनसिरटीड कीट परजीवियों द्वारा परजीवित पाये गये । औएनसीरट्स पेपिलीओनीस का अनार की तितली के अण्डों पर 12 से 15 दिन में पूर्ण विकास होता है । अनार की श्वेत मक्खी के कीट परजीवियों, एनकारसीया आजीमी के लिए 18 पादप उत्पाद एवं 6 कवकनाशी सुरक्षित पाये गये । काइलोकोरस सरकुमडेटस के लारवें, अंगुरलता के शल्क कीटों का औसतन 30.45 प्रतिदिन के हिसाब से उपभोग करते हैं, जबकि प्रौढ बीटल 50.24 शल्क प्रतिदिन उपभोग करता है । केस्थूर गाँव में, अमरूद के बाग में प्लेनोकोकस सीट्राई को, कि. मोन्ट्रोजेरी द्वारा नियंत्रण करने की सामर्थयता को प्रदर्शित किया गया । (भा.बा.अनु.सं.)

सोलन में, सेब के सेन जोज शल्क कीट को एफाइटीस प्रोकलीया समूह एवं एनकारसीया पर्नीसीओसी द्वारा क्रमशः 2.5 से 12% एवं 0से 1.9% अप्रैल से अक्टुबर में परीजीवित पाया गया, जबकि काइलोकोरस बीज़ुगस मई से सितम्बर तक विद्यमान पाये गये ।

शिकारी कीट के चौथे निरूप के लारवों एवं प्यूपो को उमाइजस स्केपोसस (थॉमसन) द्वारा परजीवित पाये गये । अतिपरजीवी एफाइटीस स्पे. हिस्पेनीकस पर विभिन्न तापक्रम के प्रभाव का जैविक अध्ययन किया जा रहा है ।

सोलन में, सेब के बागो में लोमश सेब माँहू की संख्या पूरे वर्ष कम पायी गयी, किन्तु कीट परजीवी एफीलीनस माली काफी सक्रिय पाया गया मौसस एवं परजीवियों की सक्रियता से माँहू को नियंत्रण करने में सफलता मिली । (डा.वाइ.एस.प.ब.वि.वि.वि.)
श्रीनगर में, सेन जोज शल्क की सघतना का प्रकोप 60 से 150 वर्ग से. सी. तथा 3 से 4.5% कीट परजीवित पाये गये ।

1.1.3.10 सब्जियों वाली फसलों के कीटों का जैविक नियंत्रण

रासायनिक प्रयोग के अपेक्षा, हे.एन.पी.वी. को 500 एल.ई/है. की दर से टमाटर की फसल में प्रयोग करने से टमाटर के फल केवल 19.58% संक्रमित पाये गये, इससे उत्कृष्ट परिणाम मिले । हे.एन.पी.वी. नियंत्रित क्षेत्रों में अधिकतम उपज प्राप्त हुई । (म.फु.कृ.वि.वि.)

भा.ब.अनु.स., बैंगलोर में, बैगन के तने एवं फल बेधक लियूसीनोड्स औरबोनेलीस पर डायडीग्मा एपोसटेटा पहली बार पाया गया । ट्राइकोग्रामा बेक्टरे को 2.5 लाख प्रति है. की दर से छोड़ने पर प्लूटेला जाइलोसटल्ला के लारवों की संख्या को सफलता पूर्वक नियंत्रित किया गया । ट्रा. बेक्टरे के विकास एवं दीर्घ आयु के लिए 20 से 25 डिग्री से.ग्रे. तापक्रम अनुकूल पाया गया । कीट एल.आरबोनेलीस एवं इसके कीट परजीवियों का जैविक अध्ययन किया गया । बैगन फल भेदक, ल्यूसीनोड्स औरबोनेलीस एवं भिण्डी फल भेदक, एरीआस वीटेल्ला को व्यवस्थित करने के लिए बीजाणु रहित उत्तपरिवर्ता बी.टी. कुरस्टेकी प्रजाति की सामर्थ्यता का परीक्षण एवं अध्ययन किया गया । एम बी टी का 300 या 200 या 100 ग्रा. ए.एस.पी/है.एवं इन्डोसलफॉन की 0.07% की दर से, एल. औरबोनेलिस को नियंत्रित करने के लिए अनुकूल पाया गया । पातगोभी में प्लूटेल्ला जाइलोसटेल्ला को नियंत्रित करने के लिए बी.टी. की 300 ग्रा. ए एस पी/है. की दर से प्रयोग करना सभी प्रयोगों से उत्कृष्ट पाया गया । बी. थ्यूरीजोन्सिस की मूल प्रजाति को महाराष्ट्र, तमिलनाडू, आन्ध्रप्रदेश, कर्नाटक, राजस्थान तथा अण्डमान एवं निकोबार द्वीप से एकत्र किया गया ।

ट्राइकोग्रामा परजीवी पालने के लिए अंतर्भूत मूल्य की सीमांत अधिकतम सापेक्ष मूल्य के सांमजस्य के प्रयोग से ट्रा.प्रेटीऔसम, हे. आरमीजेरा (0.18) पर, को. सिफेलोनीका (0.167) की अपेक्षा अधिक पाया गया । मई से जून में टमाटर की फसल में 50000 परिजीवित अण्डे प्रति है. की दर से चार बार में छोड़ने पर 42.8 से 66.7 प्रतिशत परीजीविकरण पाया गया । गैंदें को प्रपंचीफसल के रूप में प्रभावी नहीं पाया गया । (डा.वाई.एस.प.ब.व.वि.वि.वि.)

1.1.3.11 आलू के हानिकरक कीटों का जैविक नियंत्रण

खरीफ मौसम में, कोपीडोसोमा कोइहिल्री की 50000 प्रौढ़/है./ प्रत्येक बार, चार सप्ताह के अन्तराल से छोड़ने, किलोनीस ब्लैकबर्नी 15000 प्रौढ़/है./प्रत्येक बार, चार बारी एवं को. कोइहिल्री के विकल्प में ग्रेनुलोसिस विषाणु को 500 एल ई/है. दर से दो बार प्रयोग करने से आलू की मौथ के प्रकोप को क्रमशः 53.60% 47.65 एवं 43.20% सुविस्तृत किया गया, रवी मौसम में किए गये परीक्षण में, केवल कीट परजीवियों को. कोइहेल्री एवं कि. ब्लैकबर्नी तथा केवल ग्रेनुलोसिस विषाणु एंव जी.वी. के संयुक्त रूप से प्रयोग करने से आलू कन्द मौथ का समप्रभावी नियंत्रण पाया गया । (म.फु.कृ.वि.वि.)

म. फु.कृ.वि.में, अनेक पादप पर्ण अच्छादन परीक्षण केये गये, जिनमें से नीरगुड़ी सबसे अधिक प्रभावी पाया, इसके प्रयोग से केवल 5.65% कन्द संक्रमित तथा अन्य पादप पर्ण कस्टर्ड, लैन्टाना औसीयम एवं नीम आच्छादन प्रयोग करने से क्रमशः 19.66, 24.29 एवं 27.27% कन्द संक्रमण पाया गया । ऐपेन्टिलस स्पे., ब्रेकोन स्पे., एवं दो अन्य अनभिज्ञ हामनोप्टेरस कीट परजीवी, रवी एवं खरीफ दोनो मौसम में उपस्थित थे । पिछले वर्ष, एक अनभिज्ञात कोलियोप्टेरस बीटल पायी गयी थी, प्रतिदिन 22 अण्डे उपभोग करती है तथा एक पीढ़ी पूर्ण करने में 84 से 99 दिन का समय लेती है । कीट परजीवी को. कोइहेल्री एवं कि. ब्लैकबर्नी को पालने के लिए आलू कन्द की मौथ के एक दिन पुराने अण्डे अनुकूल पाये गये । लारवों की घातकता सुनिश्चित करने के लिए परीक्षण किये गये, स्पो. एन.पी.वी. 500 एल. ई/है. की दर से 0.005% फेलवेलीरेट (83.23%) एवं बेसीलस थ्यूरिनजिएन्सिस 1 ली./है. की दर से (86.67) नियंत्रण पाया गया ।

1.1.3.12 खरपतवारों का जैविक नियंत्रण

आर्थोग्लेमना टेरेब्रन्टिस माइट केरल में निर्धारित स्थान पर छोड़ने के बाद पूर्ण रूपेण

स्थापित हुआ तथा इसके द्वारा खरपतवार का आंशिक रूप से नियंत्रण पाया गया । सिरटोबेगस कीट का क्षेत्रों में छोड़ने एवं परिवीक्षण का कार्य के कृ.वि.वि. द्वारा किया जा रहा है ।

आसाम में, नीऔकेटीना आइकोरनीये एवं नि. बुकी को प्रकोपित क्षेत्रों में प्रयोग करने से जलकुम्भी को सफलतापूर्वक नियंत्रित किया गया एवं ये बिटीलस स्थापित हो चुकी है ये बीटल्स जिस मूल स्थान पर छोड़ी गयी थी, वहाँ से उड़कर एवं नदी के पानी के बहाव के साथ करीब 300 कि.मी. दूर गोहाटी तक प्रवासी हो चुकी है । (आ.कृ.वि.वि.)

पुणे में, निऔकेटीना विविल्स को 1.04 से 2.48 के औसत से जलकुंभी पर छोड़ने पर 30-52% जलकुंभी की पत्तियों को क्षतिग्रस्त करता है (म.फु.कृ.वि.वि.)

गु. कृ. वि.वि. द्वारा नि. आइकोरनीये एवं नि. बुकी विवल्स को जलकुंभी के प्रति छोड़ने पर पर्यावरण के लिए अनुकूल पाया गया ।

पार्थेनियम बीटल के प्रौढ़, जाइगोग्रामा बाइकोलोराटा द्वारा पी. हीस्टेरोफोरस पर केवल एक दिन उपभोग करने के उपरान्त सूर्यमुखी पर उपभोग करने पर अण्डे देने में असमर्थ पाये गये तथा कीट के नवजात लारवों द्वारा सूर्यमुखी फसल का उपभोग नहीं किया । खेतों में, सूर्य मुखी के पौधों पर उपभोग के लिए पार्थेनियम की पत्तियों या परागकणों के अपरिष्कृत जलीय निचोड़ को जिन पौधे पर निरूपित किया गया था, केवल उन्ही पोधे पर नये उद्गमित प्रोढ़ों को उपभोग के लिए आकर्षित पाया गया । सूर्यमुखी एवं पार्थेनियम के उपभोग करने के बाद प्रौढो की अण्डनाल का विकास 5वें दिन एक समान पाया गया । सूर्यमुखी का लगातार उपभोग करने के कारण अण्डनाल पुटक अपभ्रंश पाया गया । जब प्रौढ़ को सूर्यमुखी पर उपभोग करने के बाद पार्थेनियम पर अंतरित किया गया, तब अण्डनाल पूर्वविकसित पायी गयी । क्षेत्रों से एकत्र किये गये जा. बाईकोलोराटा प्रौढ़ को अनुमनित आयु एवं उनके शरीर के विकास के आधार पर एक अनुक्रमणिका तैयार की गयी, तथा 95% से अधिक प्रौढ़ जो 0 से 6 दिनों के समूह के थे, सूर्यमुखी पौधो से एकत्र किये गये । 10 दिनों से ज्यादा आयू के प्रौढ़ किसी भी प्रतिदर्श

में नहीं मिले, जो इसका प्रतीक है कि भक्षक उद्दीपक की उपस्थिति होते हुए भी, जा. बाइकोलोरोटा प्रोढ़ों को फसल पर रखने में असमर्थ है । बैंगलोर एवं आसपास के क्षेत्रों में, इस बीटल के कारण पार्थेनियम खरपतवार को व्यापक रूप से पत्ती रहित पाया गया । अब यह खरपतवार, उन क्षेत्रों में पाया गया जहाँ की भूमि अपभ्रंशित है । बैंगलोर में पार्थेनियम के परागकणो की वार्षिक सघनता वातावरण में 66.18% से 20.59% तक कम हुई । सिपेरस रोटन्डस की वृद्धि को बेक्ट्रा बेनोसाना के द्वारा पर्याप्त रूप से नियंत्रित किया गया । सि. रोटन्डस के प्रमुख प्राकृतिक शत्रु बे. वेनोसाना की अधिक गुणन की नई तकनीक विकसित की गयी। (भा.ब.अनु.सं.)

पार्थेनियम पर जाइगोग्रामा बाइकोलोराटा, मध्य पहाड़ियों (1300 मी. की ऊँचाई) तक व्याप्त पाया गया । मध्य अक्टुबर में उद्गमित प्रौढ़ प्रजनन एवं मार्च के अन्त में बीटल्स द्वारा पत्तियों पर उपभोग आरंभ किया । (डा.वाई.एस.प.ब.व.वि.वि.)

(एस.पी.सिंह)

1. PROJECT DIRECTOR'S REPORT

The Indian Council of Agricultural Research established Project Directorate of Biological Control (PDBC) in 1993 with 16 co-ordinating centres.

1.1 Mandate

* To evolve effective biological suppression for important crop pests, diseases, nematodes and weeds.
* To quantify the natural enemy biodiversity and its role in regulation of pest population and serve as a national repository of natural enemies.
* To serve as a nodal agency for introduction, exchange and conservation of biological suppression agents at the national level.
* To co-ordinate research on biological suppression aspects at the national level and to serve as a linkage with international agencies.
* To develop state of the art national information system on biological suppression (NISBS), disseminate information and impart training on latest technology in biological suppression.

1.1.1 Organization

With a view to fulfil the mandate effectively and efficiently, the PDBC is functioning at its headquarters in Bangalore with the following five laboratories and a Co-ordination, Training and Documentation unit.

* Biosystematics, Cataloguing, Introduction and Quarantine Laboratory
* Mass Production Laboratory
* Pathology Laboratory
* Entomophagous Insect Behaviour Laboratory
* Biotechnology Laboratory

There are six ICAR Institute based centres and ten State Agricultural University based centres. They are

- CPCRI : Central Plantation Crops Research Institute, Kayangulam
- CTRI : Central Tobacco Research Institute, Rajahmundry
- IARI : Indian Agricultural Research Institute, New Delhi

- IIHR	:	Indian Institute of Horticultural Research, Bangalore
- IISR	:	Indian Institute of Sugarcane Research, Lucknow
- SBI	:	Sugarcane Breeding Institute, Coimbatore
- AAU	:	Assam Agricultural University, Jorhat
- ANGRAU	:	Acharya N.G. Ranga Agricultural University, Hyderabad
- GAU	:	Gujarat Agricultural University, Anand
- KAU	:	Kerala Agricultural University, Thrissur
- MPKV	:	Mahatma Phule Krishi Vidyapeeth, College of Agriculture, Pune
- PAU	:	Punjab Agricultural University, Ludhiana
- SKUAS & T	:	Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar
- TNAU	:	Tamil Nadu Agricultural University, Coimbatore
- YSPUH & F	:	Dr. Y. S. Parmar University of Horticulture & Forestry, Nauni, Solan
- GBPUA & T	:	Gobind Ballabh Pant University of Agriculture & Technology, Pantnagar

1.1.2 Facilities at PDBC

Equipments

Since its inception efforts are underway to create excellent facilities at the PDBC and its coordinating centres. Presently the laboratories at PDBC are fairly well equipped with modern scientific equipments. The laboratories were further augmented with scientific instruments like amino acid analyser, insect antennogram, fully automatic microtome, time lapse micro photographic attachment for the stereo zoom binocular microscope, fermentor (2 l cap.), highly sensitive electronic balance, automatic weather recorder, etc. Other facilities like field cages were created. The centres have acquired need based equipments and other facilities.

Library

The library has a collection of 1,400 books, 858 volumes of journals, 22 bulletins and several miscellaneous publications including several reprints on various aspects of biological control. For quick and efficient literature search, CD-ROM (Compact Disc Read Only Memory) is provided with CABPESTCD abstracts upgraded up to February, 1997. Arthropod name index (ANI-CD) has also been added recently.

Technical Documentation

Photostat copiers, elèctronic typewriters, computers, laser printer, laminating machine, binding machine, Fax, Telex and E-Mail are available for efficient and quick compilation and documentation work as well as for quick communication. The computer facility includes software for scientific data analysis and graphics.

National Insect Reference Collection

The PDBC has 3,441 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 PDBC is in a position to collaborate on all aspects of biological control for mutual benefit, particularly on exchange of beneficial organisms, preparation of projects and advance training.

1.1.3 Major achievements during 1996-97

1.1.3.1 Introduction, Quarantine handling and basic research

Twenty one host insects, 19 predators, 32 parasitoids (including eight strains of *Trichogramma chilonis*), three insect viruses, two entomophilic nematodes and 13 cultures of disease antagonists were maintained (PDBC).

29 shipments of host insects, 54 of parasitoids and 18 of predators were supplied to various research organisations and field centres. *Diglyphus begini*, a parasitoid of *Liriomyza trifolii* was imported from California. Import permit for obtaining *Encarsia haitiensis* for the biological suppression of *Aleurodicus dispersus* is awaited (PDBC).

Field surveys conducted at Bangalore revealed the infestation of *L. trifolii* on cotton, castor, tomato, beans and cucurbits.

Six syrphids, eleven coccinellids, a chamaemyiid and a hemerobiid were recorded feeding on aphids around Bangalore in different crop ecosystems (PDBC).

Biosystematic studies on Indian predatory Coccinellidae were initiated. Preparation of an annotated checklist to the Indian fauna is in progress. A catalogue of authentically identified material at PDBC has been prepared and is ready for publication. Identification service for coccinellids has been initiated (PDBC).

Cowpea emerged as the most favourable host plant for *A. craccivora* multiplication in the laboratory. Aphidophagous syrphids have remarkable variation in their seasonal occurrence around Bangalore. *Ischiodon scutellaris* commanded the dominant position throughout the crop season. *Paragus yerburiensis* and *P. serratus* were also continuously observed on the summer and kharif crops, except during the beginning of the season. *Dideopsis aegrota* and *Betasyrphus fletcheri* were present only during September - October. *B. linga* was never recorded on cowpea crop, though present on pigeon pea plants (PDBC).

Biological parameters of six aphidophagous syrphids were studied. It was found that the larva of *D. aegrota* was the most voracious feeder followed by *B. linga* and *I. scutellaris*. *I. scutellaris* was considered to be the most suitable for laboratory rearing.

Out of six species of aphid hosts, coccinellid predators - *Coccinella septempunctata*, *C. transversalis* and *Cheilomenes sexmaculata* accepted all the hosts except *Uroleucon compositae*. *C. septempunctata* and *C. transversalis* fed on this host could not produce eggs. *C. sexmaculata* developed faster on *A. nerii* than other hosts and its wide acceptability of other hosts was evident. *A. craccivora* was found to be the most preferred host for all the coccinellids. A high rate of consumption per grub per day and higher fecundity was observed when the coccinellids fed on *A. craccivora* (PDBC).

Four new predators on *Ceroplastodes cajani* and one on *Ferrisia virgata* were recorded. Five new host plants were also added on to the existing record of host plants of *F. virgata* (PDBC).

Trichogramma chilonis females responded positively to the olfactory stimulus of *Helicoverpa armigera* scales in Y-tube olfactometer. The response varied from 44 to 80% at different concentrations. Marigold bud wash attracted the *T. chilonis* female parasitoids in the olfactometer. Parasitization efficiency of *T. chilonis* was very poor on different varieties of sunflower when *C. cephalonica* eggs were used as hosts. Tritrophic interaction between *Trichogramma chilonis*, *H. armigera* and different varieties of chickpea revealed that parasitization efficiency varies on different varieties/hybrids. Maximum parasitization was observed on variety BG256 (10.83%) (PDBC)

The acid hydrolysed á-Tryptophan was found to be highly attractive to the adults of *Chrysoperla carnea* in wind tunnel tests. More number of eggs were laid on the cotton plants treated with á-Tryptophan stored for three days. Hydrogen peroxide also acted as a good oxidising agent in oxidising á-Tryptophan. Valine - Tryptophan combination also attracted more adults of *C. carnea* in wind tunnel tests. Hexane extract of scales of *Helicoverpa armigera* moths acted as a good pre-conditioning agent for larva of *C. carnea* under caged conditions on cotton. Cyclohexane based formulation of wing scale extract of *H. armigera* though effective as reinforcing agent for the larva of *C. carnea* was phytotoxic to cotton plants on repeated applications.

Cabbage leaf powder was found to be a suitable phago-stimulant in the semi-synthetic diet for the rearing of *Spodoptera litura*. Use of semi-synthetic diet prolonged the developmental period of *Opisina arenosella* in comparison to natural diet. *Plutella xylostella* and *S. litura* could be reared on semi-synthetic diets, with poor pupal recovery (PDBC).

A soybean hydrolysed diet was found to be very effective with respect to increased pupation and adult emergence in *C. carnea*. A pig liver diet could be used for rearing *Cryptolaemus montrouzieri, Cheilomenes sexmaculata, Chilocorus nigrita, Coccinella septempunctata, Harmonia octomaculata* and *Nephus* sp. in the laboratory.

H. armigera and *S. litura* were continuously reared for NPV production and supply of nucleus cultures. Two hundred LE of *Ha*NPV and 500 of *Sl*NPV were produced. Natural mortality of the diamondback moth, *Plutella xylostella* due to granulosis virus was observed for the first time. Attempt for *in vivo* mass multiplication of *Px*GV using cabbage/mustard seedlings was successful (PDBC).

'Sago' a tapioca based product has been found as a cheap substitute for costly agar agar used in semi-synthetic diet for *S. litura* and *H. armigera*. The consistency of the diet was on par with agar-agar diet. 'Sago' is about 90 times cheaper than agar-agar, thus the cost of production of host diet and natural enemy production could be reduced (PDBC).

NPV on *Plutella xylostella* and fungal pathogen on *Spilosoma obliqua* were isolated. Two varieties of *Bacillus thuringiensis* i.e. *kurstaki* and *israelensis* were found to be effective against the last instar larvae of *Helicoverpa armigera* (IARI).

Steinernema and *Heterorhabditis* spp., were isolated by baiting technique using *Corcyra cephalonica* larvae. *Steinernema* and *Heterorhabditis* spp., were mass cultured *in vivo* on *Corcyra cephalonica* and *in vitro* on an artificial medium consisting of soy flour, corn oil, yeast, nutrient broth with bacterium added prior to nematode. Nematodes were maintained on polyurethane foam chips (autoclaved) in conical flasks. *Heterorhabditis* was tested against *Spodoptera, Corcyra, Holotrichia, Plutella xylostella* and *Chilo partellus* larvae and was proved to be effective. In pot culture studies, it was found effective against *Chilo partellus* at 1000 infective juveniles/ml used as spray on maize plants (PDBC).

Plant parasitic nematodes, *Meloidogyne incognita, M. javanica* and *M. arenaria* and *Rotylenchulus reniformis* were cultured in tomato, cowpea , blackgram, okra and brinjal. Nematophagous fungi *Paecilomyces lilacinus, Trichoderma harzianum* and two unidentified fungi were isolated. *Pasteuria penetrans* bacterium also was isolated and cultured in tomato plants with *Meloidogyne incognita* and *M. javanica* (PDBC).

Fungal culture filtrates of *Trichoderma harzianum* (PDBC 2), *T. koningii* (ITCC 2170), *T. harzianum* (ITCC 2395), *T.viride* (PDBC 4) and *Gliocladium virens* (ITCC 4177) could be used as potential biocontrol agents against *Meloidogyne incognita* and *M. javanica* (PDBC).

Reduction in colony diameter of *Sclerotium rolfsii* was observed with *T. harzianum* isolates PDBCTH 2, PDBCTH 8,PDBCTH 7 and ITCC 2895 which gave 60.7, 55.1, 53.9 and 50.6% reduction in colony diameter in dual culture. All antagonists reduced sclerotia production drastically which ranged from 31.8 to 97.8%. Culture filtrates of all antagonists inhibited sclerotial germination. Hundred per cent inhibition was observed with PDBCTH 8,PDBCTH 2,PDBCTH 7 , *T. pseudokoningii* and *Gliocladiun deliquescens*. *T. harzianum* (PDBCTH 1 to 4), *T. viride* (PDBCTV 1 to 4) and *P. fluorescens* (PDBCPF 1 and 2) significantly reduced the linear growth of *Botrytis cinerea*, the causal organism of grey mould of rose, in dual culture. Three isolates, viz.,PDBCTH 2,PDBCTV 4 and PDBCPF 2 showed 78.9,89.8 and 67.1% reduction in leaf blight, respectively (in vitro) (PDBC).

The most common disease afflicting parthenium was powdery mildew (*Oidium parthenii*) which was widespread during August-April and seed setting was observed to be very poor in plants infected early and complete demise of the heavily infected plants occurred (PDBC).

The pathogenicity of *Fusarium semitectum* (=*F. pallidoroseum*) and *Pestalotia* sp. has been proved in the laboratory against Parthenium. *Sclerotium rolfsii*, isolated from wilted parthenium plants, was highly pathogenic to the weed under greenhouse conditions. The pathogen caused collar rot and ultimately death of the weed plants especially at early stages of growth. *Sclerotinia sclerotiorum* was also obtained from parthenium plants. An unidentified bacterium was isolated and purified from leaf spots and leaf blights found on parthenium. Its pathogenicity has been proved and identification is due. Phyllody, incited by mycoplasma-like organisms (MLO's) was widespread and affected the seed production of parthenium. Further experiments will be continued only on host specific pathogens.The mycoherbicidal properties of *Gliocladium virens* and *G.deliquescens* have been demonstrated against parthenium under laboratory conditions (PDBC).

1.1.3.2 Biological suppression of sugarcane pests

Trichogramma chilonis was released by PAU against *Chilo auricilius* in four districts of Punjab and resulted in 53.8 per cent reduction in pest damage to the crop. The parasitoid

was recovered at all the locations and the per cent parasitization varied from 2.9 to 15.5 per cent in release fields as compared to 0 to 0.9 per cent in the control. Releases of *T. japonicum* made at Jallandhar against *S. excerptalis* resulted in 31.6 to 36.2 per cent reduction in pest damage to the crop. The parasitization of the eggs by *Telenomus dignoides* was very high in release and control plots at both the locations. 48.5% parasitism of eggs and 25.4% larvae of *S. excerptalis* were observed in the natural field conditions. The larval parasitism in case of *C. infuscatellus, C. auricilius* and *Acigona steniellus* was 14.6, 23.7 and 15.1 per cent respectively.

Sugarcane-pulse intercrop field experiment involving soyabean, cowpea, black gram and green gram showed that the incidence of shoot borer did not differ signifcantly from pure crop fields. Predator population comprising spiders and coccinellids was also significantly lower in some inter-crop combinations than in single crop (SBI).

S. inferens could be reared on *Galleria mellonella* with 10 - 20% parasitism. GV was active throughout the year with activity levels of 8.5 - 32.4%. In laboratory bioassay, third instar grubs of *Holotrichia serrata* suffered 64.0% mortality when inoculated with 10^9 spores/ml of *Beauveria brongniartii* (SBI).

1.1.3.3. Biological suppression of cotton pests

The incidence of the bollworms on boll basis was less in PAU spray schedule, IPM and Biocontrol as compared to the control and the increase in yield was 40.0, 24.0 and 20.0 percent, respectively over control. It was found that parasitism by *T. chilonis* on *H. armigera* was maximum in Ludhiana followed by Sangrur, and minimum parasitism was recorded in Mukatsar. No parasitism was observed in Faridkot and Ferozepur.

The studies on development of BIPM for cotton crop conducted by TNAU showed that both AICRP and TNAU methods of protection were on par with farmers' method with reference to the suppression of aphids and bollworms.

Studies conducted at GAU revealed that IPM modules gave significantly better protection from bollworms and sucking pests to Hybrid Cotton-8 over insecticidal treatments as well as untreated checks and yielded more with higher ICBR. At GAU, two gram +ve Bacili, one gram -ve *Serratia* and one fungus strain were isolated from *A. gossypii* in cotton and their pathogenicity is yet to be confirmed.

In cotton, IPM practice excelled due to the significant role played by the beneficial insects which could be increased through intercropping with groundnut and avoiding chemical insecticide applications. The incremental cost benefit ratio (ICBR) in IPM was found to be high (10.07) compared to Farmers' practice (1.55) and judicious usage of insecticide, (1.59) (ANGRAU).

1.1.3.4 Biological suppression of tobacco pests

Bt strains from IIHR, Bangalore (4 nos.) and BARC, Bombay (2 nos.) and fungal pathogen *Nomuraea rileyi* (Hyderabad strain) from Directorate of Oilseeds Research, Hyderabad were evaluated against *S. litura* in laboratory and nursery by CTRI.

1.1.3.5 Biological suppression of pulse crop pests

Significantly lower damage by pod borers was recorded in the pigeonpea plots treated with endosulfan (100 ml/ha) and the treatment was superior to *Bt* formulations (PAU).

However, at TNAU, *Helicoverpa armigera* on pigeonpea could be controlled effectively with the various formulations of *Bt*. Agree was found superior to other formulations with regard to the yield and incidence of pod damage.

At ANGRAU, spray application of *Ha*NPV @ 250 LE/ha alone and also release of *Trichogramma chilonis* @ 50,000/ha along with spray application of *Ha*NPV @ 125 LE/ ha for four rounds during evening hours at 10 days interval starting from flower initiation was found to be effective in suppressing the larval population as well as pod damage and increased the yields. *Bt* formulations, Biobit and BTK-II were found to be better in reducing the larval population as well as increasing the yields on pigeonpea. Spray application of *Ha*NPV @ 125 le/ha + endosulfan 0.035% was found to be effective in reducing the larval population of *H. armigera* and increasing the yields followed by *Ha*NPV @ 250 le/ha on chickpea. Among the *Bt* formulations, Dipel and BTK-II at 1.0 kg/ha were found to be effective against *Helicoverpa* in chickpea.

1.1.3.6 Biological suppression of rice pests

Bt formulations were superior to control in managing leaf folder on rice (KAU).

The incidence of the leaf folder was lowest when *T. chilonis* and *T. japonicum* were released at the rate of 1,00,000/ha. The per cent white ears due to stem borer was lowest in insecticidal spray followed by release of 1,00,000/ha of the parasitoids (PAU).

The investigations carried out by AAU revealed that five releases of *T. japonicum* (against stem borers) @ 50,000 adults/ha/week starting from 30 days of transplanting brought about 10.66% reduction in per cent dead heart occurrence in biocontrol plots during kharif and 5.71% reduction during rabi. Biobit, Delfin and *Btk*1 could reduce the leaf folder damage (1.35%, 1.34% and 1.93%, respectively) as compared to control (5.70%).

With regard to white ear damage, all the treatments (egg parasitoids alone or in combination with *Bt)* were superior to untreated check in reducing the stemborer damage at 110-DAT. Leaf folder damage was less in chemical sprayed plot but on par with parasitoid and *B.t.* sprayed plots. The yield in *T. japonicum+T. chilonis+Bt* sprayed plots was superior to other biocontrol treatments and on par with pesticide treated plots (TNAU).

1.1.3.7 Biological suppression of oilseed crop pests

Treatments with microbial insecticides (*M. anisopliae,B. bassiana* and *P. popilliae)* and insecticides (chlorpyriphos and quinalphos) against whitegrub were significantly superior to control. *M. anisopliae* proved to be the best (GAU).

1.1.3.8 Biological suppression of coconut pests

Stethoconus praefectus was found to be the dominant predator of *Stephanitis typica* on coconut (KAU).

Attempts were made to record the natural occurrence of *Trichogramma embryophagum* which could complete its life cycle in 10 days on *Opisina arenosella* and the parasitization range was 30-90 per cent under laboratory conditions (CPCRI).

1.1.3.9 Biological suppression of fruit crop pests

The two coccinellids *Axinoscymnus puttarudriahi* and *Cryptolaemus montrouzieri* were found to be important predators on the spiralling whitefly, *Aleurodicus dispersus*. A single larva of *C. montrouzieri* fed on 300 nymphs. In Dharmapuri district (TN) *Rastrococcus iceryoides* and *Ferrisia virgata* were recorded on the mango varieties, Totapuri and Sindura. On custard apple, the pteromalid *Scutellista cyanea* had caused up to 40% parasitism on *Parasaissetia nigra*, while *Kerria communis* was found to be attacked by two encyrtid parasitoids. Development of *Ooencyrtus papilionis* was completed in 12-15 days on the eggs of pomegranate butterfly. Eighteen plant products and six fungicides were found to be safe to the pomegranate whitefly parasitoid, *Encarsia azimi*. A mean of 30.45 grapevine scales/day was consumed by the larvae of *Chilocorus circumdatus*, while the adult consumed 50.24 scales per day. The efficacy of *C. montrouzieri* in controlling *Planococcus citri* was demonstrated in a guava orchard at Kesthur village (IIHR).

Parasitisation of the San Jose scale on apple at Solan by *Aphytis proclia* group and *Encarsia perniciosi* varied (from 2.5-12.0% and 0-1.9%, respectively) during April -

October, while predation by *Chilocorus bijugus*, also existed from May to September. The IV instar larvae and pupae of the predator were parasitized by the eulophid *Oomyzus scaposus* (Thomson). The hyper-parasitoid completed its life cycle in 15-16 days. The detailed biological studies and the effect of different temperatures on the parasitoid of *Aphytis* sp. near *hispanicus* were conducted.

Woolly aphid population in apple orchards at Solan was very low throughout the year, but *Aphelinus mali* was quite active. The weather coupled with the parasitoid maintained a check on population build-up of the aphid (YSPUH&F).

At Srinagar, San Jose scale incidence varied from 60-150/cm^2 and 3-4.5% parasitization was recorded.

1.1.3.10 Biological suppression of vegetable crop pests

The percent fruit infestation on tomato crop when *Ha*NPV was used @ 500 le/ha was 19.58% which was on par with chemical treatment and was superior to control. Yield was also maximum in HaNPV treated plots (MPKV).

At IIHR, *Diadegma apostata* was recorded for the first time from brinjal shoot and fruit borer, *Leucinodes orbonalis*. A release rate of 2.5 lakh adults of *Trichogramma toidea bactrae* per hectare reduced the *Plutella xylostella* larval population significantly. For development and longevity of *T. bactrae*, 20° and 25°C were found to be suitable. Studies on the biology of *L. orbonalis* and its parasitoids were made. Studies were carried out to test the efficacy of the sporeless mutant of *Bacillus thuringiensis* var. *kurstaki* for the management of the brinjal fruit borer, *Leucinodes orbonalis* and the bhendi fruit borer, *Earias vittella*. Five sprays of MBt @ 300 or 200 or 100 ASP/ha and endosulfan @ 0.07% were suitable for the management of *L.orbonalis*. The dose 300g ASP/ha of *Bt* was found to be superior over the other treatments for the management of *P. xylostella* on cabbage. Native strains of *B. thuringiensis* were collected from Maharastra, Tamil Nadu, Andhra Pradesh, Karnataka, Rajasthan and Andaman & Nicobar islands.

Marginally higher value of true intrinsic rate of increase was recorded for *Trichogramma pretiosum* reared on *H. armigera* (0.18) as compared to that on *C. cephalonica* (0.167). In tomato crop, four releases of the parasitoid in May-June @ 50,000 parasitised eggs/ha provided 42.8-66.7 per cent parasitization. Marigold as trap crop did not provide any added advantage (YSPUH&F).

1.1.3.11 Biological suppression of potato pests

During kharif, four weekly releases of *Copidosoma koehleri* @ 50,000 adults/ha/ release, *Chelonus blackburni* @ 15,000 adults/ha/release for four times and *C. koehleri* alternated with granulosis virus @ 500 le/ha twice could suppress the tuber moth infestation to the extent of 53.60%, 47.65% and 43.20%, respectively. During rabi season trial, the parasitoids, *C. koehleri* and *C. blackburni* alone and in combination with granulosis virus and GV alone were found equally effective in controlling the potato tuber moth (MPKV).

Amongst the various plant foliage covers tried by MPKV, Nirgudi was found to be the most effective showing 5.65% tuber infestation followed by custard (19.40%), lantana (19.66%) *Ocimum* (24.29%) and neem (27.27%). *Apanteles* sp. and *Bracon* sp. and two unidentified hymenopterous parasitoids were present in the field during both kharif and rabi seasons. An unidentified beetle recorded during the last year could consume 22 eggs/day and it took 84-99 days for completing one generation. It was observed that one day old eggs of PTM were suitable for rearing *C. koehleri* and *C. blackburni*. The larval mortality recorded in different treatments - *Sl*NPV @ 750 le/ha (83.33%), *Sl*NPV @ 500 le/ha (76.67%), *Sl*NPV @ 500 le/ha + 0.005% fenvalerate (83.33%) and *Bacillus thuringiensis* @ 1 L/ha (86.67%) were on par with fenvalerate (0.01%) (96.67%).

1.1.3.12 Biological suppression of weeds

The mite, *Orthogalumna terebrantis* has established all over the release sites in Kerala giving partial suppression of the weed. Field release and monitoring of the *Cyrtobagous* population was also continued by KAU.

Successful control of water hyacinth has been achieved by the field release of *Neochetina eichhorniae* and *N. bruchi* in Assam and the beetles have established. The beetles have migrated aerially and through connected rivers to Guwahati about 300 km from the original release site (AAU).

Neochetina sp. damaged 30-52 per cent leaves of water hyacinth with an average population of 1.04 to 2.48 weevils/plant at Pune (MPKV).

The weevils released by GAU have adapted well to the new environment, when released against water hyacinth.

Adults of the parthenium beetle, *Zygogramma bicolorata* that had fed even for one day on *P. hysterophorus* were incapable of ovipositing after feeding on sunflower and young larvae could not feed on the crop. Under field conditions, newly emerged adults were only attracted to feed on plants that were either treated with crude aqueous extract of leaves or pollen grains of parthenium. The development of ovarian follicles in sunflower and parthenium fed adults were similar up to the fifth day. Continuous feeding on sunflower was found to cause degeneration of ovarian follicles. When adults that had fed on sunflower were transferred to parthenium they were noticed to develop fully mature ovaries. An index has been prepared for estimating the age of field collected adults of *Z. bicolorata*, by rating the development of their anatomical features and more than 95% of the adults collected from sunflower plants belonged to the age group of 0-6 days. Adults older than 10 days could not be collected from any of the samples, indicating that the adults of *Z. bicolorata* are not capable of remaining continuously on the crop, even in the presence of phagostimulants. The beetle was observed to cause extensive defoliation of parthenium in Bangalore and surrounding areas, encouraging the growth of vegetation formerly suppressed by this weed. Pure stands of the weed are now seen only in areas where the soil is disturbed. The density of parthenium pollen, which predominated in the Bangalore atmosphere and accounted for 66.18% of the total annual pollen catch has declined to 20.59%. Release of *Bactra venosana* was found to cause significant reduction in the growth of *Cyperus rotundus*. A method was developed to mass multiply *B. venosana* on artificial diet (IIHR).

Zygogramma bicolorata has spread on parthenium in mid hills (ca 1300 m altitude). Adults formed from grubs hatching by mid October entered into reproductive diapause and beetles started feeding on the foliage by end of March (YSPUH&F).

1.2 Introduction, Quarantine, Handling and Basic research

1.2.1 Introduction of natural enemies

1.2.1.1 Importation of natural enemies of *Liriomyza trifolii* and laboratory studies on them

The exotic parasitoid *Diglyphus begini* was received during February,97 from California. It was successfully quarantined and seven generations were reared. A small net house trial using tomato seedlings is in progress to assess the efficiency of the parasitoid.

1.2.2 Biosystematic studies on coccinellids

Literature on various aspects of Coccinellids such as taxonomy, biology, host range, distribution, susceptibility to insecticides and other relevant information was collected with a view to construct a national biodiversity database for coccinellids.

Preparation of an annotated checklist to the Indian fauna of predatory coccinellids was started. The information provided in the check list includes the generic names with original citation and synonyms, method of type fixation and all the species with original reference and synonyms, geographical distribution, type locality and type depository.

The unidentified collections of Coccinellids at PDBC were sorted out and taxonomic studies have been initiated on these collections.

1.2.3 Shipments sent

During the reporting period, 34 cultures of various host insects and 86 cultures of natural enemies being maintained were sent to co-ordinating centres and other research organisations as nucleus cultures to facilitate their multiplication and establishment there.

1.2.4 Survey for natural enemies

1.2.4.1 Collection of *Campoletis chlorideae* and *Eriborus argenteopilosus* from different locations

Surveys conducted in Bangalore and Arsikere area of Karnataka in lablab, sunflower, gram and cotton ecosystem revealed that the per cent parasitism by *C. chlorideae* and *E. argenteopilosus* ranged from 0.5 to 10.1 and 1.0 to 9.6 during September - December. Maximum per cent parasitism by *C. chlorideae* was observed in gram ecosystem, whereas *E. argenteopilosus* was more dominant in lablab ecosystem. Parasitism by these parasitoids was not observed on *Helicoverpa armigera* infesting cotton. Parasitisation by *C. chorideae* and *E. argenteopilosus* was not observed on sunflower and gram, respectively, during the specific period.

1.2.4.2 *Macroplectra nararia*, a new limacodid pest of coconut around Bangalore

The limacodid, *Macroplectra nararia* has recently been observed to defoliate coconut trees in Bangalore. Detailed laboratory studies were conducted on this pest in the laboratory.

The moth is pale brown with setaceous antennae in female and pectinate antennae in male. Last abdominal segment in female moth is yellowish orange in colour. Mating occurs on the first day after adult emergence and oviposition commenced the following day. Eggs are translucent, pale yellow and are laid on the leaves. The young larvae scrape away the green tissues but as they grow they feed on the complete leaf except the midrib

portion. The fully grown caterpillars are dark brown with bright lemon yellow markings and bear series of tubercles with short spines. It pupates in a hard shell like brown cocoon. The grown up larvae were found to feed on other plants in the vicinity like *Mangifera indica*, *Ricinus communis* and *Vigna unguiculata*. In the laboratory, a single female laid 30 - 130 eggs singly or in groups of 8 - 20, overlapping each other. Hatching occurred in 5 - 7 days. Larval period lasted for about 35 to 55 days and pupation occurred between the leaves. Pupal period lasted for 15 to 20 days. Adults lived for 3 to 8 days. In addition to earlier recorded pentatomid predator and braconid parasitoid, an unidentified tachinid parasitoid was found to parasitise the late larval instars. The per cent parasitism in the field in the months of December, January, February and March was 3.8, 4.2, 8.7 and 2.2, respectively.

1.2.4.3 Record of predators of *Ceroplastodes cajani*

A survey revealed the presence of coccid *Ceroplastodes cajani* on pigeon pea cv. ES 90. The infestation ranged from four to eight per cent during February-April. The natural enemies recorded were an encyrtid, a pteromalid, a lycaenid *Spalgis epeus*, coccinellids, viz, *Rodolia* sp., *Pseudaspidimerus trinotatus (P. circumflexa)* and *Curinus coeruleus*. There are no earlier reports of predators of *C. cajani*, however both the encyrtid and pteromalid have been reported earlier.

Adults of *C.coeruleus* laid 90-130 eggs in the laboratory on the plant parts infested with *C.cajani* . The egg, 1st, 2nd, 3rd and 4th instar larvae, pre pupal and pupal stages were completed in 7-8, 3-4, 2-3, 3-4, 5-6, 2-3 and 6-7 days, respectively.

1.2.4.4 Records of host plants and predators of *Ferrisia virgata*

Studies were conducted on the natural enemy complex of white tailed mealybug *Ferrisia virgata*. Infestation by this mealybug was observed on *Spathodea campanulata*, *Gliricidia maculata*, *Cassia auriculata*, *Leucaena leucocephala*, *Bauhinia purpurea*, *Vigna unguiculata*, *Lablab niger*, *Arachis hypogea*, *Portulaca grandiflora* and two species of *Croton* during January to May. The natural enemies recorded on *B. purpurea* were *Cryptolaemus montrouzieri*, *Scymnus coccivora*, two unidentified species of *Scymnus* and a myrid bug. Natural enemies collected on *S. campanulata* were an unidentified encyrtid, an unknown pteromalid and predators *viz*., *Spalgis epeus*, *Cheilomenes sexmaculata* and *Mallada boninensis* on crotons. *S. campanulata*, *B. purpurea*, *G. maculata*, *C. auriculata*, *P. grandiflora* are new host plant records. Among predators, the mirid bug is a new record. On *B. purpurea*, *C. montrouzieri* dominated in January but its population came down by the end of February. Mirid bug was more prevalent in

March. Among the three *Scymnus* species commonly observed between March-April, *S. coccivora* was the most dominant. Association of *E. virgata* with spiralling whitefly *Aleurodicus dispersus* Russell on *B. purpurea* and *S. campanulata* was an interesting observation.

1.2.4.5 Predatory fauna of *Aphis craccivora*

Investigations were carried out to document the predators of *Aphis craccivora*, their activity period and their role in the suppression of *A. craccivora*. Surveys were undertaken at fortnightly intervals during 1994 - 96 in Bangalore district of Karnataka.

Survey conducted during summer (March - May) and kharif (August - October) seasons revealed that the population of *A. craccivora* reaches its peak during the last week of March to the first week of May (252.20 to 449.70 aphids per plant) and from second week of September to first week of October (160.20 to 289.30 aphids per plant), respectively. During January - March, *A. craccivora* was recorded on the inflorescence of *Gliricidia maculata* and during June - August, it appeared on the new flush of *G. maculata*, *Mimosa pudica*, *Cassia auriculata*, *Cassia tora*, *Portulaca oleracea*, *Crotolaria mucronata* and *Crotolaria juncea* and during November - March it was found to survive on *Vicia faba*.Predatory coccinellids started appearing two weeks after the appearance of aphid population and Syrphid population coincided with the peak aphid population. Among predators, eleven coccinellids, six syrphids, a chamaemyiid and a hemerobiid were recorded on *A. craccivora*. Predators recorded on weeds were *Cheilomenes sexmaculata*, *Scymnus* sp., *Paragus serratus* and *P. yerburiensis*. *Leucopis* sp. ? *formosana* was recorded only on *V. faba* and cowpea during winter. *C. sexmaculata*, *P. serratus* and *Ischiodon scutellaris* were the predominant predators occurring in both the seasons and were available throughout the year feeding on different species of aphids. *P. serratus* was the first syrphid species to appear (third week of March), immediately followed by *I. scutellaris*. The incidence of other syrphid species and hemerobiid was negligible. One species of *Scymnus* was abundant and helped in bringing down the population of the aphid on *G. maculata* during January - March and June - August and the aphids almost disappeared completely by the end of March and August due to the activity of this predator.

The predatory coccinellid and syrphid populations declined by the second week of May and first week of October in summer and kharif seasons, respectively. During February, about 8 - 10 per cent of *C. sexmaculata* and *C. septempunctata* were parasitised in prepupal stage by *Homalotylus flaminius* Dalman. Around 16 - 19 per cent of *I. scutellaris* pupae were also parasitised by an unknown pteromalid during the same period. Similarly, *P. serratus* was found to be parasitised to an extent of 16 - 59 per cent during December by an unidentified ichneumonid. In addition to these, braconid and eulophid parasitoids were found to parasitise syrphids and coccinellids during December to January.

1.2.4.6 Rearing/culturing techniques for host and natural enemies

1.2.4.6.1 Mass rearing of American serpentine leaf-miner, *Liriomyza trifolii* in the laboratory

A mass multiplication method developed during 1995-96 for *L. trifolii* using beans and cowpea seedlings was continued during this year also. French bean seedlings were found more suitable than cowpea.

1.2.4.6.2 Identification of suitable host plants for the mass rearing of *Liriomyza trifolii*

To find alternative suitable host plants for the mass rearing of *L. trifolii*, an experiment was conducted using two varieties of french beans and different cucurbits such as bottle gourd, pumpkin, gherkin, snake gourd and cucumber.

The seedlings of these host plants were sown in polythene bags with vermiculite medium. The seedlings were exposed to adult flies when enough leaf area was available on the seedlings. Known number of flies were used in each exposure on different host plants. It was found that french bean seedlings were more suitable than cucurbits.

1.2.4.7 Bioecological studies on natural enemies

1.2.4.7.1 Studies on biological parameters of cowpea aphid *Aphis craccivora* on cowpea, lablab and pigeon pea

Biological parameters of *Aphis craccivora* were studied on cowpea, lab-lab and pigeonpea seedlings in the laboratory. A cage was fabricated for this experiment. The cage was made using a polyethylene box which had a sliding lid provided with wire mesh for ventilation. Utilising a plastic piece with a central hole, the inner chamber was divided into two portions; an upper larger compartment and a lower smaller compartment. A piece of sponge was placed in the lower compartment. An excised seedling was inserted

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with its petiole passing through the hole in the partition. The sponge piece was kept continuously moist by placing the box in a container of water, to avoid the plant from drying up. Gravid adults were released on the seedlings and the set up was observed daily for recording pre-reproductive, reproductive and post-reproductive periods. Longevity and total progeny production were also recorded. The experiment was repeated on the vegetative and flowering stages of all the three host plants.

On the vegetative and flowering stages of the three host plants, four instars were observed. Longevity of the last instar was maximum in comparison to the earlier instars. The total nymphal period was completed in 13-16, 13-16 and 14-16 on the vegetative stage and 12-13, 13-15 and 13-14 days on the flowering stage of cowpea, lablab and pigeonpea, respectively. There were no significant differences between the host plants with reference to the pre and post-reproductive periods. But both the host plant and stage of the host plant had significant effect on the reproductive period of the aphid. Reproductive period and adult longevity were longer on cowpea while nymphal period was longer on lablab and pigeonpea. However, total developmental period did not differ significantly between the host plants. Fecundity and reproductive rate was higher when on the flowering stage of the host plant, while adult longevity was significantly more when on the vegetative stage. Both fecundity and longevity of adults were higher on cowpea, irrespective of the crop stage.

1.2.4.7.2 Species complex, population density and dominance structure of aphidophagous syrphids in cowpea ecosystem

During summer and kharif, five species of predatory syrphids, *viz.*, *Paragus serratus*, *P. yerburiensis*, *Ischiodon scutellaris*, *Dideopsis aegrota* and *Betasyrphus fletcheri* were identified to form the syrphid complex in cowpea ecosystem. During both the seasons, number of syrphid species involved in suppressing aphids was found to undergo remarkable variation (Table 1 & 2). During March - May only three species existed in nature, while during August - October five species were recorded. In the beginning of the season, only one species was involved in predation but its number continued increasing till the end of season.

Table 1. Species complex and population density of syrphids on *A. craccivora* on cowpea during summer

Month/ Week		Mean number of syrphid larvae per ten plants						Number of species recorded
		A	B	C	D	E	F	
March	I	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
	II	1 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1
	III	3 (50.00)	2 (33.33)	1(16.66)	0(0)	0 (0)	0 (0)	3
	IV	12(44.44)	6 (22.22)	9 (33.33)	0 (0)	0 (0)	0 (0)	3
	V	9 (29.03)	11 (35.48)	11 (35.48)	0 (0)	0 (0)	0 (0)	3
April	I	16 (42.11)	14 (36.84)	8 (21.05)	0 (0)	0 (0)	0 (0)	3
	II	12 (36.36)	11 (33.33)	10 (30.30)	0 (0)	0 (0)	0 (0)	3
	III	19 (44.19)	10 (23.26)	14 (32.56)	0 (0)	0 (0)	0 (0)	3
	IV	18 (33.33)	9 (16.66)	27 (50.00)	0 (0)	0 (0)	0 (0)	3
May	I	9 (13.04)	7 (10.14)	53 (76.81)	0 (0)	0 (0)	0 (0)	3
	II	3 (5.45)	4 (7.27)	48 (87.27)	0 (0)	0 (0)	0 (0)	3
	III	1 (6.67)	2 (13.33)	12 (80.00)	0 (0)	0 (0)	0 (0)	3
	IV	1 (10.00)	0 (0)	9 (90.00)	0 (0)	0 (0)	0 (0)	2

Figures in parentheses indicate per cent population composition of syrphids

A-*P. yerburiensis*, B-*P. serratus*, C - *I. scutellaris*, D - *D. aegrota*,E - *B. fletcheri*,F - *B. linga*

Out of five species of syrphids, *P. yerburiensis* was the earliest to appear during both the seasons. It remained active till the end of summer, but during kharif it was active till the end of September only. Its population ranged from 1 to 19 larvae per ten plants with peak in the third week of April and 1 to 4 larvae per ten plants with peak being in the first week of September. *P. serratus* was the second to appear followed by *I. scutellaris*. *I. scutellaris* remained active till the end of both the crop seasons and maintained relatively a higher population density, ranging from 1 to 53 and 3 to 16 larvae per ten plants with peaks during the first week of May and fourth week of September when it constituted 76.81 and 34.78 per cent of syrphid population, respectively. But as regards the dominance structure, its share in the community reached the highest level, that is 90 percent and 100 percent, at the end of both seasons, respectively.

Table 2. Species complex and population density of syrphids on *A. craccivora* on cowpea during kharif

Month/ Week		Mean number of syrphid larvae per ten plant						No.of species recorded
		A	B	C	D	E	F	
August	I	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
	III	(100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1
	III	2 (40.00)	0 (0)	3 (60.00)	0 (0)	0 (0)	0 (0)	2
	IV	1 (20.00)	1 (20.00)	3 (60.00)	0 (0)	0 (0)	0 (0)	3
	V	3 (37.50)	2 (25.00)	(37.50)	0 (0)	0 (0)	0 (0)	3
September	I	4 (26.66)	5 (33.33)	6 (40.00)	0 (0)	0 (0)	0 (0)	3
	II	2 (8.00)	6 (24.00)	12 (48.00)	5(20.00)	0 (0)	0 (0)	4
	III	2 (5.13)	8 (20.51)	15 (38.46)	11(28.21)	2 (5.13)	0 (0)	5
	IV	1 (2.17)	3 (6.52)	16 (34.78)	23 (50.00)	3 (6.52)	0 (0)	5
October	I	0 (0)	1 (3.57)	12 (42.86)	9 (32.14)	6 (21.43)	0 (0)	4
	II	0 (0)	0 (0)	6 (37.50)	7 (43.75)	3 (18.75)	0 (0)	3
	III	0 (0)	0 (0)	3 (50.00)	3 (50.00)	0 (0)	0 (0)	2
	IV	0 (0)	0 (0)	3 (100.00)	0 (0)	0 (0)	0 (0)	1

Figures in parentheses indicate per cent population composition of syrphids
A - *P. yerburiensis*, B - *P. serratus*,C - *I. scutellaris*,D - *D. aegrota*,E - *B. fletcheri*, F - *B. linga*

Among the remaining species *P. yerburiensis* occupied first position during second to fourth week of March and first three weeks of April during summer and second week of August during kharif, while *P. serratus* held second position during third week of March and first two weeks of April. During fifth week of March, *P. serratus* and *I. scutellaris* contributed equally (35.48% each), while in the last week of August, *P. yerburiensis* and *I. scutellaris* contributed equally (37.50% each) to the field population of syrphids. It was found that the peak *I. scutellaris* population coincided with pod formation which also coincided with peak aphid population, while both the species of *Paragus* were major predators during vegetative stage of the crop.

Other species like *B. fletcheri* and *D. aegrota* were minor and occurred only in kharif season and reached peak during fourth week of September and first week of October, when it contributed 50 and 21.43 percent to the syrphid community. *B. linga* occurred only on pigeonpea and *Gliricidia* during January to March.

1.2.4.7.3 Bio-ecology of six aphidophagous syrphids of *Aphis craccivora*

Surveys were undertaken in legume growing areas of Bangalore and surrounding villages. Aphid infested shoots were collected with immature stages of syrphids which were reared in the laboratory in acrylic sheet cages (30 x 30 x 30). A pair of freshly emerged male and female was introduced into the adult rearing cage containing castor pollen and cotton swabs soaked in 50 per cent honey and drinking water as food and *A. craccivora* infested seedlings in a box made of polypropylene for oviposition. Observations were made on oviposition, incubation, larva and pupal periods and longevity of adults. For studying feeding potential, one day old eggs laid in aphid colonies were removed with help of a fine camel hair brush and kept individualy in a glass petri dish containing cowpea leaf with known number of aphid nymphs. The first instar larvae were provided with only first and second instar nymphs, while second and third instar larvae were provided with fourth instar nymphs. Larvae were removed after every 24 hours and petri dishes were cleaned before providing next lot of aphids on fresh cowpea leaf. The number of aphids provided to each larva always exceeded the number consumed on the previous day. The predatory potential was ascertained in terms of number of aphids consumed per larva during each instar and total feeding potential was worked out on the basis of total number of aphids consumed per larva in its entire larval period.

Mating was observed both in flight and at rest. Repeated mating, each lasting for 50-65 minutes was observed in *Ischiodon scutellaris*, whereas in the case of *Paragus serratus* and *P. yerburiensis*, it lasted for 15-20 minutes and in *Dideopsis aegrota*, 20-30 minutes. The adults of *Betasyrphus* spp. failed to mate in confinement. Females of *Paragus* spp. started laying eggs after pre-oviposition period of 3-4 days whereas in *I. scutellaris* pre-oviposition period varied from 3-5 days. Eggs were laid singly or in a group of 3-6. The number of eggs laid by these species varied significantly. Maximum number of eggs were laid by *I. scutellaris* (107.9) followed by *P. serratus* (16.4) and *P. yerburiensis* (11.4). Incubation period in different species varied from 2-5 days. Immediately after hatching, larva started searching for aphids and in the absence of the latter, it fed on its own eggs. There was no marked preference for any specific instar nymph of aphid by particular stage of syrphid larvae. In the absence of earlier instar nymphs of aphids, freshly hatched larvae fed on gravid adults of aphid larger than its own size. There were three larval instars and larval period varied from 8 to 11 days. Cannibalism was highly prevalent in all the instars of larvae and among all the species of syrphids studied. Syrphid larvae started feeding right from the emergence and there was gradual increase in aphid consumption. Maximum number of aphids were consumed by the third instar larva. Among the six syrphids *D. aegrota* was the most voracious feeder and consumed 450.6 ± 16.39 aphids followed by *B. linga* (398.9 ± 7.96) and *I. scutellaris* (370.60 ± 7.74). The full grown larva pupated in sand or on the cowpea seedlings and preferred

loose absorbant cotton wool for pupation, when provided.Pupal period lasted for 8 to 11 days. Sex ratio of adults did not deviate much from the normal proportion of equal numbers of either sex. Sex ratio was 1.16 : 1 and 0.99 : 1 in *I. scutellaris* and *Paragus* spp., respectively.

1.2.4.7.4 Biotic potential of three coccinellids on various aphid host

Six species of aphids *viz.*, *Aphis craccivora*, *Aphis gossypii*, *Aphis nerii*, *Lipaphis erysimi*, *Rhopalosiphum maidis* and *Uroleucon compositae* were reared on cowpea, cotton, *Calotropis gigantea*, mustard and safflower, respectively. All the predators *viz.*, *Coccinella septempunctata*, *Coccinella transversalis* and *Cheilomenes sexmaculata* were field collected and were reared initially in the laboratory on their natural hosts. Developmental period of predators was recorded by releasing one pair of freshly emerged adults on each of the hosts. Plants were observed daily for egg laying. Preoviposition, egg incubation, larval and pupal periods were recorded on each host. Experiments were conducted to determine the rate of host consumption by grubs and adults of the predators by releasing them on known aphid population. Observations were recorded daily on number of host insects consumed by grubs, but as adults lived for many days, host consumption was recorded every five days and mean host consumption data was derived.

The results indicated that egg period lasted 3.0 to 3.8 days for the three coccinellids. The length of developmental period of the four larval instars of three species of coccinellids varied significantly with the host. *C. septempunctata* took less time on *A. craccivora* (8.50 days) than on *U. compositae* (13.0 days); *C. transversalis* (8.20 days) on *A. gossypii* than on *L. erysimi* (9.90 days). *C. sexmaculata* strongly preffered *A. nerii* and grubs were able to complete development in 5.20 days while on *L. erysimi* it took 12.50 days. Grubs of all the three coccinellids were able to complete development on all the aphid species provided. However, egg laying was not observed in *C. septempunctata* and *C. transversalis* when fed with *U. compositae*. Total developmental period of *C. septempunctata* ranged from 16.5 days to 21.4 days; of *C. transversalis* 15.2 to 18.0 days and of *C. sexmaculata* 12.2 to 20.4 days. *C. sexmaculata* could complete its development in the shortest time on all hosts (16.60 days) and was found to be a better predator. Its developmental period varied significantly with *C. septempunctata* (19.12 days). *A. nerii* and *A. craccivora* were found to be better hosts with regard to the developmental period of all the three coccinellid predators.

Host consumption rate by grubs of *C. septempunctata*, *C. transversalis* and *C. sexmaculata* ranged from 20.8 to 34.0, 21.0 to 34.9 and 20.1 to 38.5 aphids per day. Similarly, host consumption by adults ranged from 29.6 to 47.4, 31.0 to 47.7 and 33.1 to 41.7 aphids per day, respectively. *C. septempunctata* grubs preferred *L. erysimi* and *R. maidis* whereas *C. transversalis* preferred *A. gossypii* and *A. craccivora*. *C. sexmaculata* exhibited strong preference for *A. nerii* and *A. craccivora*. Similar trend of preference was observed in the adult stage of these predators.

Progeny production by *C. septempunctata* was high (374) on *A. craccivora* followed by 311 and 301 on *L. erysimi* and *A. gossypii*, while *C. transversalis* laid maximum number of eggs (292) when fed with *A. craccivora* followed by *A. nerii* (260) and *A. gossypii* (259).*C. sexmaculata* could produce 305 and 301 nymphs when fed on *A. craccivora* and *A. nerii*, respectively, confirming its preference for these hosts. Its progeny production was 290, 217, 202 and 179 on *A. gossypii*, *R. maidis*, *L. erisimi* and *U. compositae*, respecitvely. Longevity of *C. septempunctata* ranged from 41.0 to 99.0; *C. transversalis* 39.0 to 87.0 and *C. sexmaculata* 49.0 to 94.0 days on different hosts. *C. septempunctata* lived for a long time on all hosts but *C. transversalis* lived for a long time on *A. nerii* and *A. craccivora*, thus showing preference for those hosts. It can be concluded that *C. sexmaculata* is the best predator due to its short developmental time, higher fecundity and fairly high host consumption rate and longevity.

1.2.4.7.5 Effect of low temperature storage on *Eriborus argenteopilosus*

A laboratory study was carried out to determine the effects of cold storage on *E. argenteopilosus*.

Storage of pupa at 8° C for 7 and 14 days resulted in 100 and 30 per cent adult emergence, respectively, as compared with 100 per cent emergence in control. Emergence after 21 and 28 days of cold storage fell to 20 and 10 per cent, respectively. The life span of the adult was also greatly reduced when pupa had been stored for more than 14 days. Pupa stored at 14° C started emerging on 7th day of storage and per cent hatch was 100 in all the subtreatments. Percentage of female emerging from the pupa stored at 8° C was 30.

1.2.4.8 Studies on behavioural response of natural enemies and tritrophic interaction

1.2.4.8.1 Response of *Trichogramma chilonis* to *Helicoverpa armigera* scale extract

The response of *Trichogramma chilonis* adult parasitoids to the host derived olfactory stimuli namely scale extract of the wings of *Helicoverpa armigera* was studied in the laboratory in 'Y' tube olfactometer at a room temperature of 25 ±2°C and relative humidity ranging between 56 and 62%. Wing scale extract was prepared using hexane as a solvent. Four pairs of wings were kept in one ml of hexane for one hour. This extract was further diluted using hexane in 1:5, 1:2 and 1:25 ratio. In the olfactometer ten adult *T. chilonis* were presented with a choice of two ovistreams, one carrying odour of host scale extract and the other clean air. Observations were recorded on the response by the movement of the parasitoids towards the source of olfaction. The percent response to host scale extract

varied from 22.00 to 40.00 if both the sexes were taken into consideration. However, if only female *T. chilonis* were considered response ranged from 44 to 80%. Maximum response was observed to the extract obtained by keeping four pairs of wing in one ml of hexane. Equally good response was observed to the extract made from four pairs of wings in 2ml of hexane. This indicated that *Helicoverpa armigera* scale extract can be used for improving the parasitizing efficiency of the *T. chilonis*.

1.2.4.8.2 Kairomones as preconditioning agents for larvae of *Chrysoperla carnea*

Another experiment was conducted to find out the efficiency of the kairomones as preconditioning agent for the larvae of *Chrysoperla carnea*. The hexane extract of the wing scales of *Helicoverpa armigera* was prepared and sprayed on a petridish and allowed to dry. The eggs of *H. armigera* were glued to the potted cotton plants (@ 20 eggs per strip and 2 strips for each plant) using a double adhesive tape. Third instar larvae of *C. carnea* were released into the petridish treated with the kairomone, retained there for 30 minutes and released later on the potted plants with eggs. The number of eggs consumed was calculated after 24 hours. More number of eggs were fed by the preconditioned larvae as compared to control.

1.2.4.8.3 Kairomones as reinforcement agents for the larvae of *Chrysoperla carnea*

To utilise the kairomones as a reinforcement agent, the kairomones were tried on the potted cotton plants. Earlier the hexane extract was sprayed on the plants . But this could not be made into any formulation. Later cyclohexane was used as a solvent along with emulsifier (Tween20). The extract could be formed as an emulsifiable concentrate and sprayed on the plants. The cotton plants were artificially infested with the eggs of *H. armigera* and the efficacy of the larvae of *C.carnea* tested as described in the previous experiment. Though the number of eggs consumed was more, there was a slight phytotoxic symptom noticed on the plants with repeated spray. Efforts are on to select a new solvent with low phytotoxicity.

1.2.4.8.4 L-tryptophan as an ovipositional attractant for *Chrysoperla carnea*

Encouraged by the earlier results from the laboratory studies on the use of L-tryptophan as ovipositional stimulant, a cage experiment was conducted . Twenty potted cotton plants were selected at the early boll stage and kept in a cage. The kairomones such as L-tryptophan (3, 7 and 15 days old) and honey solutions were sprayed on the plants around 4 pm . The plants were allowed to dry . Twenty fertile females and ten males of *Chrysoperla carnea* were released in the evening and left overnight . The

number of eggs laid were examined carefully and counted on the next day. Each treatment was replicated ten times. The results showed that 3 day old L-tryptophan was very much attractive followed by 7 day old L-tryptophan. The honey solution did not record any egg laying probably because of the stickiness of the plants.

L-tryptophan is also very effective in the open conditions, registering more number of eggs compared to control.

1.2.4.8.5 Use of valine-tryptophan combination as an ovipositional attractant for *Chrysoperla carnea*

The kairomone substances valine and L-tryptophan alone and in combination, were sprayed on the filter paper and dried for half an hour. The treated paper was kept on the lid of acrylic sheet box (30 X 30 X 30 cm) , glued with the help of a double adhesive tape. Seventy adults of *C. carnea* were released into the box and the number of adults visiting the treated paper in half an hour was recorded at 5 minute intervals and the data was analysed in CRD analysis. Each treatment was repeated for 8 times. Preliminary results indicated that valine-tryptophan combination was as effective as tryptophan alone.

1.2.4.8.6 Response of *Trichogramma chilonis* to leaf extracts of different varieties of sunflower in Y-tube olfactometer

Studies were conducted in the laboratory to find out the response of *T. chilonis* to leaf extracts of sunflower varieties Morden, KBSH-1, 6D-I, CMS 234A, RHA 274 and BSH-I. However, during the period under report only one variety namely 6D 1 could be evaluated. On an average, 64% of the female *T. chilonis* responded to the leaf extract of sunflower variety 6D-1.

1.2.4.8.7 Response of *Trichogramma chilonis* to marigold bud extracts

Marigold is used as a trap crop for *H. armigera* management in tomato crop effectively besides releasing egg parasitoid *T. chilonis*. *Helicoverpa armigera* prefers to lay eggs on marigold bud. Hence it was felt necessary to study the response of *T. chilonis* to the volatiles released by the marigold buds. The studies were conducted in Y-tube olfactometer in laboratory condition. Two concentrations of marigold bud wash were obtained by soaking full grown semi opened marigold bud in 5 ml and 2.5 ml hexane respectively for one hour. Two ml of bud wash was placed on filter paper disc and used as a source of olfaction. Ten adult parasitoids were used in each replication for a test duration of half an hour. Observations were taken on initial time (IT) taken by the parasitoids to enter respective arms, final time (FT) taken to reach the source of olfaction and per cent response. The response to bud wash (one bud/2.5 ml hexane) ranged from

20-50% and the mean value was 38.57 if both the sexes are considered. However, the mean response of female *T. chilonis* parasitoid was very high (77.14%). Similarly, the overall response to one bud/5ml of hexane varied from 20 to 50% with an average response of 36% while mean response to control was only 10%. If the response is calculated on the basis of female parasitoids, it is 72%. This revealed that volatiles released by marigold buds can improve the host searching efficiency of *T. chilonis*.

1.2.4.8.8 Parasitization efficiency of *Trichogramma chilonis* on *Corcyra cephalonica* on different varieties/hybrids of sunflower

Three hybrids, namely, Morden, KSBH-1 and BSH-1; and three varieties, namely, 6D-1, CMS-234A and RMA-274 were evaluated in polyhouse using one day old *Corcyra cephalonica* eggs. One day old adults of *T. chilonis* were released from central point to give equal opportunity to parasitize *Corcyra* eggs placed on plants of different varieties/ hybrids. On all varieties per cent parasitization was extremely poor, indicating that *Corcyra* eggs are not preferred in field condition.

1.2.4.8.9 Tritrophic interaction among *Trichogramma chilonis, Helicoverpa armigera* and different varieties of Chickpea

.Tritrophic interaction between egg parasitoid, *T. chilonis,* host insect *Helicoverpa armigera* and different varieties of chickpea was studied in polyhouse condition. Each variety was replicated 10 times with two plants/replication. Ten eggs (one day old) of *H. armigera* were placed near flowerbuds on each plant. One-day-old post-mated adult parasitoids were released. Observations were recorded on per cent parasitization of *H. armigera* on different varieties. The data presented in Table 3 revealed that per cent parasitization varied from 4.72 to 10.83 (pooled data). Consistently higher parasitization was obtained on variety BG256. Other three varieties, namely, JG 315, ICCV 10 and Avrodhi registered 4.72, 5.82 and 5.83 per cent parasitization, respectively.

Table 3. Tritrophic interaction between *Trichogramma chilonis, Helicoverpa armigera* and chickpea varieties

Variety	Mean per cent parasitization of *H. armigera*			
	Expt. 1	Expt.2	Expt.3	Expt.4
JG 315	5.83	1.83	6.67	4.72
ICCV 10	5.83	7.50	4.16	5.82
Avrodhi	4.16	5.83	7.50	5.83
BG256	10.83	11.67	10.00	10.83
CD (P=0.05)	NS	7.54	NS	4.56

1.2.4.9 Artificial diets for natural enemies

1.2.4.9.1 Synthesis of new diet for *in vitro* rearing of *Chrysoperla carnea*

Among the several diets tested for *in vitro* rearing of *C. carnea*, hydrolysed soybean diet was found to be the best one with reference to increased pupation (85%) and adult emergence (71%) as compared to *C. cephalonica* eggs which resulted in 86% pupation and79% adult emergence. As the above diet was found to be effective *C. carnea* was reared continuously for five generations. Besides these, *C. carnea* was also reared for five generations on *Spodoptera litura* abdomen powder diet.

1.2.4.9.2 Development of *C. carnea* on hydrolysed soybean diet and *Spodoptera* abdomen powder diet

The efficacy of hydrolysed soybean diet was further confirmed by rearing *C. carnea larvae* for 6 generations and the per cent pupation and adult emergence were 85,71(F1), 63,31(F2), 84, 48 (F3), 80,69 (F4), 75,63 (F5), 82,67 (F6), respectively. *C. carnea* was reared on *S.litura* abdomen powder as a standard semi-synthetic diet for 5 generations and the per cent pupation and adult emergence were 8, 56 (F1), 51,24 (F2), 62,45 (F3), 26,6 (F4), 64,43 (F5), respectively.

1.2.4.9.3 Rearing of *Mallada boninensis* on hydrolysed soybean diet

Mallada boninensis was also reared on hydrolysed soybean diet (0.2 gm) and the pupation and adult emergence were 63% and 33%, respectively.

1.2.4.9.4 *In vitro* rearing of coccinellids on pig liver based diet

Among different combinations of pig liver based diets, pig liver (5 gm) + yeast hydrolysed (1 gm) + yeast extract (0.4 gm) + ground nut oil (0.4 ml) was found to be the best. *Cheilomenes sexmaculata, Cryptolaemus montrouzieri, Harmonia octomaculata* and *Nephus* sp. were found to complete the life cycle and the per cent pupation and adult emergence was 15,10; 45,26; 43,8; 17,8; 43,35; 27,24, respectively. Besides these cattle liver was evaluated for rearing *C. montrouzieri*. Pupation was 4% and adults failed to emerge.

Pig liver diet was also tried for rearing adults of *H. octomaculata, C. sexmaculata* and *C. montrouzieri* and the longevity and fecundity were 148 (days) 3.0 eggs/female, 52 (days) 0.0 eggs, 69 (days) 2.0 eggs/female, respectively. Eggs were laid on cotton treated with hexane extract of *Maconellicoccus hirsutus* ovisac.

1.2.4.10 Artificial diets for host insects

1.2.4.10.1 Synthesis of diets for *Plutella xylostella*

The following semi-synthetic diets were tested for rearing *P. xylostella*. The diets were prepared using the ingredients listed below. Glass tubes (3" x 1") with the test diets were used in the experiment. Two day-old larvae were released into the tubes.

Ingredient	Diet-I	Diet-II
Soybean flour	20.0 gms	-
Kabuligram flour	-	20.0 gms
Cabbage/cauliflower leaf powder	30.0 gms	30.0 gms
Ascorbic acid	0.8 gms	0.8 gms
Sorbic acid	0.25 gms	0.25 gms
MPHB	0.5 gms	0.5 gms
Yeast tablets	2.5 gms	2.5 gms
Multivitaplex	1 capsule	1 capsule
Vitamin E	1 capsule	1 capsule
Streptomycin sulphate	0.07 gms	0.07 gms
Sucrose	2.0 gms	2.0 gms
Filter paper (powdered)	5.0 gms	5.0 gms
Wesson's salt mixture	2.0 gms	2.0 gms
Water	100 ml	100 ml
Agar agar	3.2 gms	3.2 gms
Water	100 ml	100 ml
Formalin 1.0%	0.25 ml	0.25 ml

For the evaluation of the diets 200 larvae were transferred to the diet. 30 per cent pupation was recorded and they could be continuously reared for two generations.

1.2.4.10.2 Evaluation of diet for *Opisina arenosella*

Opisina arenosella was reared on the semi-synthetic diet formulated by Jayanth and Nagarkatti (1981) for two generations. On this diet, 22.6 per cent pupation was obtained. The larval developmental period was longer on this semi-synthetic diet in comparison to natural diet.

1.2.4.10.3 Evaluation of diet for *Spodoptera litura*

S. litura was reared on three experimental diets containing leaf powders of castor, cauliflower and cabbage. Cabbage leaf powder diet was selected for the continuous rearing of *S. litura* in the laboratory. The data revealed that *S. litura* culture could be maintained at an average production level (56.6%).

1.2.4.10.4 Evaluation of diet for *Spodoptera exigua*

The larvae of *Spodoptera exigua* were collected from tomato, cabbage and cauliflower fields and were reared on the existing diet formulated by Nagarkatti and Sathyaprakash (1976). *S. litura* and *H. armigera* were reared for 4 generations. 29.6 per cent pupation was obtained.

1.2.4.11 Evaluation of endosulfan resistant / tolerant strain of *T. chilonis*

This study was started in 1989-90 and is being continued. In the resistance / tolerance study 21 generations were passed and during the year, 8 exposures were given at the dosage of 1.75ml of endosulfan / litre of water and reached 254th generation at the present dosage level of 1.75ml/litre. From F 234 to 254 generations, the test insects were exposed to 1.75 ml/l. Initially 95% mortality (after 6hrs.) and very low parasitisation (2%) occurred. By F254 generation mortality reduced to 50% after 6 hrs. and parasitism improved to 95 per cent. Then the test insects were shifted to 2 ml/litre(255th generation)and the mortality was 50% and the parasitisation was 50%. The experiment will continue till resistant / tolerant strain is obtained at field recommended dosage of endosulfan (0.07%).

1.2.4.12 Studies on insect pathogens

1.2.4.12.1 Survey for insect pathogens

During a field survey, a Granulosis virus was isolated from the diamondback moth, *Plutella xylostella*. Conserved sequence of polyhedrin were identified and 20-40 primers needed for DNA probing retrieved from the computer base genome.

1.2.4.12.2 Mass Production

During the period under report 1000, 750, 500 *H. armigera* larvae were reared, inoculated and virosed respectively and 200 LE of NPV produced. In case of *S. litura*, 2000, 1500 and 750 larvae were reared, inoculated and virosed respectively. 500 LE of NPV was obtained.

Mass multiplication of recently isolated GV from *P. xylostella* was attempted using mustard seedlings and was successful.

1.2.4.12.3 *In vitro* mass multiplication of NPV with a cheap and simple artificial diet

An attempt has been made to replace Agar Agar with 'Sago' - a tapioca based product in the semi-synthetic diet for rearing *H. armigera* and *S. litura*. Both the species fed on the modified diet and their growth and development were comparable to those reared on the regular diet. Observations revealed that 'sago' could give a consistency on par with Agar Agar. Sago is about 90 times cheaper than Agar Agar and the cost of preparation of one litre of the diet could be reduced by 35%.

1.2.4.12.4 Gross and histopathology of granulosis virus of *Plutella xylostella*

Very recently, a granulosis virus was reported by us to infect *P. xylostella* (Px) in India. Pathogenecity studies using neonate larvae showed that *P. xylostella* GV was highly pathogenic to DBM causing more than 90% mortality in 3-4 days. *Px*GV infection initially caused swelling of the body with increase in body weight as the disease progressed accompanied by colour changes varying from pale green to pale yellow green and pale yellow at the time of GV induced deaths. Histopathological studies using general purpose staining technique of *Px*GV revealed that GV infection takes place mostly in the fat body. Fat body cells of GV infected DBM larvae showed hypertrophy of nuclei. Electron microscopic study revealed that the GV capsules, which were ovocylindrical in shape enclosed one or rarely two enveloped nucleocapsids in a capsule. *P. xylostella* GV was not cross infective to *H. armigera, S. litura* and *S. exigua*. Mass multiplication of this virus in DBM larvae reared on mustard seedlings as well as on artificial diets is under progress.

1.2.4.12.5 Screening of polyflavanoids for the UV- protection of *Sl*NPV

There was significant reduction in the inactivation of *Sl*NPV with the naturally occurring flavanoids from mango and guava.

1.2.4.12.6 Maintenance of varieties of *Bacillus thuringiensis* at IARI, New Delhi

Survey and collection of diseased specimens of insects were continued to identify the insect pathogens. *Plutella xyllostella*, and *Spilosoma obliqua* larvae with disease symptoms were collected from the field. Isolation and identification of these pathogens is in progress.

Entomopathogen Repository

At the division of Entomology, IARI, New Delhi, Entomopathogen Repository has been established. This repository aims at collection and preservation of various insect pathogens and maintenance of consolidated "Gene Pool" of the diverse entomopathogens. During the period under report repository has been enriched by addition of three new fungal pathogens. These are *Achromonium zylaenicum, Fusarium* sp. and *Paecilomyces* sp.

Bioassay

Bioassay studies were undertaken with two varieties of *Bacillus thuringiensis* (laboratory grown culture) var. *kurstaki* and *israelensis* to test comparative efficacy against last instar larvae of *Helicoverpa armigera*. Good mortality of the insect in both these treatments was noticed, however, statistically there was no significant difference in the mortality between treatments.

1.2.4.12.6.1 Basic studies on Baculovirus of *Achaea janata, Agrotis ipsilon* and *Chilo partellus*

The culture of *Chilo partellus* was maintained on semi-synthetic diet as well as cut pieces of jowar plants throughout the year.

1.2.4.13 Studies on fungal antagonists

1.2.4.13.1 Survey and collection of soil samples

Soil samples were collected from sunflower, chickpea, cotton, rice, rose, grapes, coconut, arecanut, tomato, cauliflower and beans from the fields in and around Bangalore.

1.2.4.13.2 Isolation and maintenance of antagonists and fungal pathogens

Trichoderma viride (9 isolates) and *T. harzianum* (8 isolates) were isolated from soils collected from different crops. Fungal antagonists like *T. viride* (ITCC 1433), *T. harzianum* (ITCC 2895), *T. hamatum* (ITCC 2084), *T. koningii* (ITCC 2170), *T. pseudokoningii* (ITCC 3694), *T. polysporum* (ITCC 3761), *G. virens* (ITCC 4177), *G. deliquescens* (ITCC 3450), *G. roseum* (ITCC 4176) and *G. catenulatum* (ITCC 3058) were obtained from Indian Type Culture Collection, IARI,N.Delhi.

Fungal pathogens of sunflower(*Sclerotium rolfsii, Sclerotinia sclerotiorum*& *Alternaria helianthi*), chickpea (*Fusarium oxysporum* f.sp.*ciceri*) ,rice (*Rhizoctonia solani*) and cotton (*Fusarium oxysporum* f.sp.*vasinfectum* and *Macrophomina phaseolina*) were isolated.

All fungal antagonists and pathogens were subcultured at regular intervals in Potato Dextrose Agar slants and preserved at 4° C in refrigerator.

1.2.4.13.3 Biological control of *Sclerotium rolfsii*

Ten *Trichoderma* and 3 *Gliocladium* isolates were tested against *S. rolfsii* in dual cultures. All antagonistic fungi were grown in PD broth and the culture fitrate was used to test its effect on sclerotial germination.Results obtained in these preliminary studies are presented in Tables 4 and 5.

1.2.4.14 Studies on entomophilic nematodes

1.2.4.14.1 Survey for entomophilic nematodes

One hundred and fifty soil samples were collected from Bangalore and surrounding areas, Chickballapur, Hassan and Dharwar, seven from Trivandrum and seven from Kanpur for collection of entomopathogenic nematodes. *Steinernema /Heterorhabditis* were isolated by baiting technique using *Corcyra cephalonica* larvae in laboratory.

Table 4. *In vitro* antagonism of different fungal antagonists against *S.rolfsii.*

Sl.No	ANTAGONISTS	Colony diameter of the pathogen (in cms) *	Per cent reduction in colony	No.of sclerotia produced* diameter	%reduction
1.	*T. viride* (ITCC 1433)	6.1	31.5	62.1	92.2
2.	*T. viride* (PDBCTV 4)	5.7	36.0	108.0	86.4
3.	*T. harzianum* (ITCC 2895)	4.4	50.6	123.8	84.4
4.	*T. harzianum* (PDBCTH 2)	3.5	60.7	48.8	93.9
5.	*T. harzianum* (PDBCTH 7)	4.1	53.9	49.5	93.8
6.	*T. harzianum* (PDBCTH 8)	4.0	55.1	17.5	97.8
7.	*T. hamatum* (ITCC 2084)	5.4	39.3	126.3	84.1
8.	*T. koningii* (ITCC 2170)	5.5	38.2	105.5	86.7
9.	*T. pseudokoningii* (ITCC3694)	6.9	22.5	151.6	81.0
10.	*T. polysporum* (ITCC 3761)	8.0	10.1	542.8	31.8
11.	*G. virens* (ITCC 4177)	5.4	39.3	212.3	73.3
12	*G. deliquescens* (ITCC3450)	5.5	38.2	250.0	68.6
13	*G. roseum* (ITCC 4176)	6.1	31.5	122.7	84.6
14.	*G. catenulatum* (ITCC 3058)	8.9	00.0	329.0	58.7
15.	Control	8.9	00.0	796.0	00.0

* The average of four replications.

Table 5. Effect of culture filterates of fungal antagonists on sclerotial germination of *S. rolfsii*

Sl.No	ANTAGONISTS	% reduction in sclerotial germination
1.	*T. viride* (ITCC 1433)	71.5
2.	*T. viride* (PDBCTV 4)	43.0
3.	*T. harzianum* (ITCC 2895)	100.0
4.	*T. harzianum* (PDBCTH 2)	61.5
5.	*T. harzianum* (PDBCTH 7)	100.0
6.	*T. harzianum* (PDBCTH 8)	100.0
7.	*T. hamatum* (ITCC 2084)	21.5
8.	*T. koningii* (ITCC 2170)	35.0
9.	*T. pseudokoningii* (ITCC3694)	100.0
10.	*T. polysporum* (ITCC 3761)	50.0
11.	*G. virens* (ITCC 4177)	23.0
12.	*G. deliquescens* (ITCC3450)	100.0
13.	*G. roseum* (ITCC 4176)	35.0
14.	*G. catenulatum* (ITCC 3058)	75.0
15.	Control	00.0

1.2.4.14.2 Mass culturing of isolated nematodes

Steinernema & *Heterorhabditis* sp.were mass cultured *in vivo* on *Corcyra cephalonica* larvae and *in vitro* on an artificial medium consisting of soy flour, corn oil, yeast, nutrient broth with bacterium added prior to nematode. Nematodes were maintained on polyurethane foam chips (autoclaved) in conical flasks.

1.2.4.14.3 Utilization and testing bioefficacy

Nematodes extracted from foam chips were utilized for laboratory and green house tests. *Heterorhabditis* was tested against *Spodoptera, Corcyra, Holotrichia, Plutella xylostella,* and *Chilo partellus* larvae and it proved to be effective. In pot culture, it proved effective against *Chilo partellus* at 1000 infective juveniles/ml used as spray on maize plants.

1.2.4.15 Studies on nematophagous fungi and bacteria

1.2.4.15.1 Survey and collection of soil for isolating nematophagous fungi and bacteria

One hundred and fifty soil samples and nematode infested materials were collected from in and around Bangalore and from Hassan, Dharwad, Trivandrum and Kanpur.

1.2.4.15.2 Culturing of plant parasitic nematodes, nematophagous fungi and bacteria

To maintain pure cultures of plant parasitic nematodes, the infested plant materials were collected from field , root systems were processed and following nematode species were collected. *Meloidogyne incognita, M. javanica, M. arenaria* and *Rotylenchulus reniformis* were inoculated in tomato, cowpea , blackgram, bhendi and brinjal.

The following fungi were isolated from *Meloidogyne incognita* egg masses, viz. *Paecilomyces lilacinus, Trichoderma harzianum* and two unidentified fungi. The unidentified fungi were sent to ITCC , New Delhi for identification. *Pasteuria penetrans* bacteria was isolated from infected root knot nematode larvae.

P. lilacinus fungus culture is being maintained in PDA medium and in sorghum grains. All nematophagous fungi were subcultured at regular intervals in PDA slants and preserved in refrigerator at 4°C. *Pasteuria penetrans* culturing was done in tomato seedlings with *Meloidogyne incognita* and *M. javanica.* The infected tomato roots were dried and powdered and kept for further studies.

1.2.4.15.3 Nematotoxic effect of different fungal filtrates against root knot nematodes

Eight *Trichoderma* spp. and two *Gliocladium* spp. were tested against *M. incognita* and *M. javanica* under lab conditions.

Significant nematode mortality was recorded in all the culture filtrates. The culture filtrate of *Trichoderma harzianum* (PDBC 2) and *T. koningii* (ITCC 2170) recorded 100% mortality within 24 hours exposure. *T. harzianum* (ITCC 2395), *T.viride* (PDBC 4) and *Gliocladium virens* (ITCC 4177) were found to be effective in 48 hours exposure. *T. viride* (PDBC 11) and *T. harzianum* (PDBC 7) were found to be less effective in killing *Meloidogyne incognita* and *M. javanica* juveniles.

The results indicated that *T. harzianum* (PDBC 2), *T. koningii* (ITCC 2170), *T. harzianum* (ITCC 2395), *T. viride* (PDBC 4) and *Gliocladium virens* (ITCC 4177) could be used as potential biocontrol agents against *Meloidogyne incognita* and *M. javanica.*

1.2.4.16 Studies on weed pathogens

1.2.4.16.1 Field survey, isolation and purification of weed pathogens

During the period under report, field surveys for parthenium diseases were concentrated in and around Bangalore, which is one of the most severely affected regions in India. The samples were brought to the laboratory for isolation and purification of the pathogens.

The procedure suggested by Hanlin (1982), with suitable modifications, was used for isolation and purification of fungi and bacteria from diseased samples. Infected lesions were cut into small pieces (1 Sq.cm.) and surface-disinfested by submersion in a bleach: ethanol: water (10:10:80) solution for 2 minutes. The sterilized pieces were dried between two sterile filter papers and placed on a suitable agar medium such as potato dextrose agar (PDA) amended with streptomycin sulphate (for suspected fungi) or nutrient agar (NA) (for bacteria). The plates were incubated at room temperature for obtaining growth. Single hyphal tip and single spore isolation techniques were employed to get pure cultures of fungal isolates. Transfers of each isolate were made onto agar plates containing suitable media.

All the fungal and bacterial cultures in axenic form were maintained in a refrigerator at ca. 4°C . Sub-culturing was done as and when needed. The obligate parasites were maintained in the greenhouse in the host plants.

1.2.4.16.2 Description of *Parthenium* diseases encountered

Fusarial disease

Fusarium semitectum (= *F. pallidoroseum*) was isolated from parthenium plants showing wilting and other symptoms like leaf spots. Its pathogenicity has been confirmed and further studies on the potential use of this pathogen as a biocontrol agent are on.

Collar rot / wilt

Sclerotium rolfsii was obtained from wilted and dead parthenium plants. The pathogen caused collar rot and wilt when young plants were inoculated in the greenhouse and complete mortality was noticed.

Pestalotia leaf spot

Pestalotia sp. was obtained from leaf spots collected from different areas and each culture is being maintained as a separate isolate for further studies.

Sclerotinia disease

Sclerotinia sclerotiorum - incited rot in parthenium was noticed in Hebbal area and the pathogen was isolated and the pathogenicity was proved.

Powdery mildew

Powdery mildew caused by *Oidium parthenii* was seen extensively during August-April in almost all the areas surveyed. Warm nights followed by cool nights are favourable for the disease. A temperature range of 23-30°C is most conducive for this malady. In an affected plant all the aerial parts are covered with the mycelium. The leaves become yellow with advancement in disease resulting in the drying-up and ultimate death. Seed setting is drastically reduced. The disease is being maintained in the greenhouse.

Bacterial leaf spot / blight

A bacterium causing leaf spot and leaf blight has been isolated from parthenium. The pathogenicity was enhanced when leaves of the host were pre-treated with wax solvents like 0.001 M potassium hydroxide (KOH) or sodium hydroxide (NaOH) before inoculation. Identification of the bacterium is to be done.

Phyllody

This disease was generally observed during September- January. But infected plants are seen almost throughout the year. The disease is characterized by witches' brooms. Early infection results in excessive branching, shortened internodes, greatly reduced leaf size and transformation of florets into phylloid structures. The affected plants give a bushy dwarf appearance. Later infection results in normal growth but there will be transformation of calyx and corolla into green leaf-like structures. Seed formation is absolutely nil. The causal agents, namely, mycoplasma-like organisms (MLO's) are transmitted by grafting as well as by the leafhopper, *Hishimonus phycitis*. Because of the involvement of a vector in the perpetuation of the disease, further work on the exploitation of this for the control of parthenium is not being taken up for the time being.

1.2.4.16.3 Mycoherbicidal properties of *Gliocladium* spp.

The culture filtrates of *Gliocladium virens* and *G. deliquescens* showed adverse effect on seed germination of parthenium under *in vitro* conditions. Seeds were treated with the culture filtrates and sown on sterile filter paper discs kept in petri dishes. Germination percentage was recorded when all the seeds in control had germinated. Hundred per cent inhibition in germination was observed due to treatment with the filtrates. Same results were obtained in soil medium also.

1.3 BIOLOGICAL SUPPRESSION OF SUGARCANE PESTS

Sugarcane Breeding Institute, Coimbatore

1.3.1 Parasitoid cultures

Two generations of *Sturmiopsis inferens* were reared on *Galleria mellonella* with parasitisation levels of 10-20%. In the first generation 61 s and 51 s were recovered whereas in the second generation 68 s and 63 s were recovered.

1.3.2 Host cultures

A laboratory culture of *Corcyra cephalonica* was established for multiplying *Trichogramma chilonis*. *C. cephalonica* was multiplied on a mixture of pearl millet and groundnut. Two generations of the host were completed in which 10 and 15 cc of eggs, respectively, were produced. The culture of *Galleria mellonella* was continuously maintained on artificial diet and the larvae were used for the multiplication of *S. inferens* and entomophilic nematodes.

1.3.3 Seasonal fluctuations of natural enemies of shoot borer at Coimbatore

The activity of shoot borer parasitoids and GV was monitored at Coimbatore during 1996-97 by collecting larvae from the field every month and examining them in the laboratory. *Sturmiopsis inferens* was the only parasitoid active on the borer. Its activity was restricted to a few months in 1996 (April-July). The highest parasitism level (5.6%) was observed in January 1997. Natural parasitism by *Cotesia flavipes* was nil during the study period.

Further, shoot borer GV was found active throughout the period. The infection level ranged from 8.5 to 32.4 per cent.

1.3.4 Seasonal fluctuations of natural enemies of shoot borer in sugar factory areas

In the two sugar factory areas viz., Thiruthani Co-operative Sugars, Thiruthani and Andhra Sugars, Tanuku, surveyed for natural enemies activity during May-July 1996, *S. inferens* and *C. flavipes* were not recorded. Virus infection in shoot borer larvae ranged from 4.2 to 13.0 per cent.

1.3.5 Evaluation of GV under field conditions

In a field trial (one acre field) conducted near Coimbatore, the incidence of shoot borer was 30.1 per cent in control plot and 38.2 per cent in treatment before imposing the treatment. The shoot borer incidence noticed after the first round of application of virus was 9.3 and 19.5 per cent in treated and control plots. After the second round of application, the incidence of shoot borer was low both in treated and control plots (2.5 and 3.6%, respectively). The larvae collected 15 days after second round of virus application showed 66.7 per cent infection in treated plot as against 14.3 per cent in control plot.

1.3.6 Virulence of GV stored for sixteen years

The GV stored at 4°C for 16 years was tested for its virulence by bioassay studies. The mortality of shoot borer larvae varied from 11.6 to 27.1 per cent.

1.3.7 Evaluation of different formulations of *Bacillus thuringiensis*

Two experiments were conducted under pot culture conditions. In the first experiment, formulations of *Bt* were sprayed before the release of neonate larvae and in the second experiment, the spraying was done after the release of the larvae. Mortality of larvae due to the four formulations of *Bt*, viz., Dipel, Delfin, Biobit and Spicurin varied from 20 to 80 per cent in the first experiment and 20 to 60 per cent in the second experiment.

1.3.8 Evaluation of the fungus *Beauveria brongniartii* against white grub

The fungus was evaluated under laboratory conditions against third instar grubs of *Holotrichia serrata* F. and the results showed that the fungus caused 64 per cent mortality when applied at 10^9 spores/ml.

In pot culture studies, the fungus was evaluated at four different doses, viz., 0.75 x 10^9, 10^{10}, 10^{11} and 10^{12} spores/pot. The mortality of grubs observed at these doses were 0.0, 24.0, 29.0 and 40.0 per cent, respectively.

A field experiment was conducted at Thalavadi with three treatments. The treatment area was 120 square metres/treatment. The treatments consisted of 1.6×10^{10} and 1.6×10^{11} spores/square metre. The fungus inoculum was mixed with farm yard manure and applied at the sides of the row near the root zone. The plots were irrigated immediately after the treatment. Grubs were collected from the plots 30 days after treatment and observed in the laboratory for mortality. The mortality observed was 14.0 per cent in 1.6×10^{9} spores/sq.m and 48.0 per cent in 1.6×10^{10} spores/sq.m. as against 4.0 per cent in control.

Punjab Agricultural University, Ludhiana

1.3.9 Field evaluation of *Trichogramma chilonis* for the control of sugarcane stalk borer *Chilo auricilius*

Five experiments for the evaluation of *Trichogramma chilonis* (Sugarcane strain) for the control of stalk borer, *C. auricilius* were carried out at Phagwara (Dist. Kapurthala). Jasso Mazara (Dist. Nawanshahr). Appra and Teng (Dist. Jalandhar) and Khudi Kalan (Dist. Sangrur). The plot size was 1.0 ha at all the places except that it was 8.0 ha at Khudi kalan and the variety used was CoJ 64. The releases of seven-day-old parasitized host eggs were made @ 50,000/ha at 9-12 days interval from July to October. The recovery tests were carried out at four locations by exposing 10 cards with eggs of *Corcyra cephalonica* for 48 hrs. The data on the incidence of stalk borer recorded on the basis of 500 canes during November, 1996 revealed that the incidence of *C. auricilius* in release fields varied from 7.8 to 10.6 per cent as compared to 17.0 to 23.0 per cent in the control plots. The reduction in damage over control varied from 46.2 per cent at Phagwara to 58.8 per cent at Appra. The overall incidence of *C. auricilius* was 9.3 per cent in the release fields as compared to 20.1 per cent in control resulting in 53.8 per cent reduction in damage. The parasitoid was recovered at all the locations, while at Appra, it was recovered in the control plots also. The parasitization varied from 2.9 to 15.5 per cent in the release fields as compared to 0 to 0.9 per cent in the control plots.

1.3.10 Effectiveness of *Trichogramma japonicum* for the control of sugarcane top borer *Scirpophaga excerptalis*

The experiments for the control of sugarcane top borer, *S. excerptalis* were carried out at Nagar and Moai (Dist. Jalandhar). *T. japonicum* was released six times during April to June @ 50,000/ha, coinciding with the availability of the eggs. The egg masses of the top borer were collected in the first fortnight of July to find out the extent of parasitism. The larvae of the top borer were also collected to observe the extent of larval parasitization. The incidence of top borer was recorded before the start of releases and in the month of July on the basis of 500 canes per ha.

The pre-release incidence of the pest at Nagar (Dist. Jalandhar) was very low (0.8 to 1.0%). The post release incidence of top borer was 7.8 per cent in the release field as compared to 11.4 per cent in control resulting in 31.6 per cent reduction in damage. The natural parasitization of eggs by *Telenomus* sp. was quite high (56.3 and 57.0%) in release and control plots. However, parasitization by *T. japonicum* was not observed in the control fields, while it was 14.3 per cent in release fields. Three larval parasitoids, viz., *Rhaconotus scirpophagae, Isotima javensis* and *Glyptomorpha nicevillei* were recorded from the release and control fields. The parasitization by these larval parasitoids was almost the same in the release (23.3%) and control plots (23.1%).

At Moai, the pre-release incidence of the top borer was 0.2 to 0.6 per cent, which gradually increased to 13.8 per cent in the control plots. However in release fields, it was only 8.8 per cent resulting in 36.2 per cent reduction in damage over the control. The natural parasitization of eggs by *Telenomus dignoides, Trichogramma chilonis* and *T. japonicum* was 31.9, 10.6 and 4.3 per cent and 30.5, 1.7 and 5.1 per cent in release and control plots, respectively. The larval parasitization by the three species stated above was 13.9 per cent in the release fields as compared to 13.7 per cent in the control.

1.3.11 Indigenous parasitoid complex of sugarcane borers and the extent of parasitism in nature during 1996-97

The life stages of different sugarcane borers, viz., eggs, larvae and pupae were collected from fields during their activity period. These were brought to the laboratory and reared till emergence of parasitoids or their transformation into the next stage of the host.

Four species of parasitoids, viz., *Trichogramma chilonis* (6.4%), *T. chilotraeae* (10.3%), *Cotesia flavipes* (8.8%) and *Bracon sp.* (5.8%) were recorded on *Chilo infuscatellus*. No pupal parasitoid was observed during the period of investigation.

On *Chilo auricilius*, three larval parasitoids namely, *C.flavipes* (7. 0%), *Glyptomorpha nicevillei* (3.7%) and *Sturmiopsis inferens* (13.0%) were recorded, while no pupal parasitoid was observed.

On *Scirpophaga excerptalis*, three egg parasitoids, *Telenomus* sp. (44.6%), *Trichogramma chilonis* (2.2%) and *T. japonicum* (1.7%) and three larval parasitoids, viz., *R. scirpophagae* (9.7%), *Isotima javensis* (7.4%) and *G. nicevillei* (8.3%) were recorded.

In case of *Acigona steniellus*, only *T. chilonis* (8.0%) was recorded. Three larval parasitoids namely *G. nicevillei* (1.1%), *R. signipennis* (1.4%) and *C. flavipes* (12.6%) and two pupal parasitoids, *Xanthopimpla* sp. (4.7%) and *Tetrastichus* sp. (1.2%) were also recorded.

On cumulative basis, a reasonably high parasitism of eggs (48.5%) and larvae (25.4%) of *S. excerptalis* was observed in nature during 1996. The larval parasitism in case of *C. infuscatellus*, *C. auricilius* and *A. steniellus* was 14.6, 23.7 and 15.1 per cent, respectively.

1.4 BIOLOGICAL SUPPRESSION OF COTTON PESTS

Tamil Nadu Agricultural University, Coimbatore

1.4.1 Development of biocontrol based IPM for cotton crop

In cotton three methods of management practices, viz., AICRP, TNAU and Farmers' method were compared at Sarkarsamakulam in farmers' field. AICRP method was a combination of need based application of oxy-demeton methyl, release of *Chrysoperla carnea* @ 50,000/ha on 50 and 70 DAS and the parasitoid *T. chilonis* @ 1 lakh/ha on 80,90,100,110 DAS based on 5 moths trapped/pheromone baited trap and need based application of HaNPV on 80,90 and 110 DAT @ 450 LE/ha (7 second instar larvae/20 plants). TNAU method involved the use of need based application of *Ha*NPV on 80,90 and 110 DAS and release of *C. carnea* @ 50,000 on 50 and 70 DAS and release of *T.japocicum* @ 1.5 lakh/ha on 80,90,100 and 110 DAS and the farmers' method consisted of insecticidal application only (5 rounds). The results of the trial showed that both AICRP and TNAU methods of protection were on par with farmer's method regarding suppression of aphids and bollworms. The yield of seed cotton in TNAU and AICRP methods were on par with farmer's method.

Acharya N.G. Ranga Agricultural University, Hyderabad

1.4.2 Development of biocontrol based IPM for cotton pests

A field trial was laid out at Regional Agricultural Research Station, Lam (Guntur) with L-604 variety in an area of 4000 m^2. There were four treatments, viz., IPM, conventional method of control (Farmers' practice), judicious usage of insecticides and control.

In IPM treatment, cotton was intercropped with cluster beans and cowpea and soybean, while sole cotton crop was sown for other treatments.

The IPM treatment plot received seed treatment with carbofuran, application of granular insecticide (carbofuran) @ 1.0 a.i./ha at 15 days after sowing, inundative releases of *Trichogramma chilonis* @ 1,50,000 and *Chrysoperla carnea* @ 50,000/ha at 60 days after sowing and spray application of NSKE 5% at 115 days, *Ha*NPV + endosulfan at 125 days and Dipel @ 2.0 kg/ha at 140 days after sowing.

In conventional method of control (farmers' practice), the following insecticidal treatments were alternated at weekly interval for 16 times. The spray treatments included were oxydemeton methyl, monocrotophos, endosulfan + sesamum oil, chlorpyriphos + sesamum oil, monocrotophos + dipel, endosulfan + Dithane M-45, profenphos, endosulfan + *Ha*NPV, Dipel, Acephate. The remaining plot received sprays of oxydemeton methyl, monocrotophos, endosulfan + sesamum oil, chlorpyriphos + sesamum oil, monocrotophos + Dipel, endosulfan + Dithane M-45, endosulfan + *Ha*NPV and Dipel for 12 times on need basis. The control plot received no spray applications.

The observations on the population of sucking pests, viz., jassids, aphids and white flies were recorded on 10 plants selected at random from lower, middle and upper regions of the plant. The data on the incidence of *H. armigera* and natural enemies were recorded from 10 plants from each treatment.

Population of sucking pests remained lower when judicious use of insecticides and IPM were followed than that in conventional method.

The egg population of *H. armigera* in IPM and control plots was lower than that on other treatments. The build up of larval population was very slow in IPM practice and high in Farmer's practice. The larval population in Farmer's practice and control was more. Lowest damage to squares and bolls was recorded in IPM treatment and it was found to be superior to the rest of the strategies.

The presence of predatory fauna (coccinellids, spiders and chrysopids) was significantly high in IPM treatment.

The cotton yield obtained through IPM strategy (18.3 q/ha) was low when compared to that of conventional method of control (farmers' practice) (23.8 q/ha). However the incremental cost benefit ratio (ICBR) was high in IPM practice (10.07), as compared to Farmers' practice (1.55) and judicious use of insecticide (1.59). The IPM practice thus excelled due to the significant role played by the beneficial insects which could be increased through intercropping and avoiding insecticidal treatment.

Punjab Agricultural University, Ludhiana

1.4.3 Development of bio-control based IPM for cotton pests

An experiment for the control of cotton bollworms was carried out at Regional Research Station, Bathinda. There were four treatments, viz., biocontrol (12 releases of

T. chilonis during July-August), IPM (releases of *T.chilonis* during July-August and need based insecticidal spray), PAU spray schedule and control. The plot size was 0.4 ha for each treatment. In all the treatments including control, two insecticidal sprays were given for the control of sucking pests. The incidence of bollworms on the bolls and locules was recorded in the first week of November. The final yield from each plot was also recorded.

The incidence of bollworms on boll basis was the lowest (11.7%) in PAU spray schedule. The incidence in the IPM and biocontrol plots was 23.5 and 27.8 per cent, respectively, as compared to 32.2 percent in the control. The incidence on locule basis was again lowest (5.9%) in the PAU spray schedule followed by IPM (15.3%) and biocontrol (16.7%) as compared to 18.9 per cent in control. The highest yield was obtained in PAU spray schedule (14.67 q/ha) followed by IPM (13.10 q/ha) and biocontrol (12.62 q/ha). The increase in yield over control was 40.0, 24.0 and 20.0 per cent in PAU spray schedule, IPM and biocontrol, respectively. The lower yields obtained were due to unavoidable delay in spraying insecticides against sucking pests.

Gujarat Agricultural University, Anand

1.4.4 Development of BIPM for cotton pests

To evaluate the efficacy of IPM module against pest complex in hybrid Cotton-8, an experiment was laid out at Agronomy Farm, B. A. College of Agriculture, Gujarat Agril. University, Anand.

The bud and boll damage was significantly lower in IPM module I and II than control and insecticidal treatments. The IPM modules gave significantly better protection to buds and bolls.

The bollworm damage to locules was also significantly low in IPM blocks. The damage due to *E. vittella* in the IPM-1, IPM-2, insecticides and control plot was found to be 7.13, 6.73, 12.40 and 19.90 per cent, respectively. Similarly damage due to *P. gossypiella* in the above treatments was 21.71, 19.37, 23.67 and 30.35 per cent, respectively. Observations on *Helicoverpa armigera* showed that the pest incidence was low. Only 47 larvae were collected during the whole season.

The population of sucking pests was also significantly low in IPM modules as compared to control. The releases of *Chrysoperla carnea* gave significantly better protection against aphid, jassid and whitefly.

Since IPM plots received less insecticide load, many of the bio-agents were conserved. Noteworthy among them were bollworm parasites, *Rogas aligharensi, T. chilonis* and *Agathis* sp. which caused 38.15, 24.45 and 5.15 per cent parasitism, respectively in IPM module I and 42.95, 23.71 and 6.0 per cent parasitism, respectively, in IPM module II. Mean population of the predators, *C. carnea, C. sexmaculata, Geocoris* sp. and staphylinids was 38, 50.30, 17.80 and 15.20/50 plants in IPM module I and 37.50, 62.50, 15.30 and 13.60/50 plants in IPM module II, respectively.

On the other hand, population of these natural enemies was greatly hampered due to application of chemical insecticides. The per cent parasitism by *R. aligharensi, T. chilonis* and *Agathis* sp. was found to be 15.63, 7.29 and 2.67 per cent, respectively. The count of *C. carnea, C. sexmaculata, Geocoris* and staphylinids was 13.40, 23.00, 10.70 and 8.60 per 50 plants, respectively, in insecticide treated plots. The yield in IPM-1 and IPM-2 was 33.05 q/ha and 33.47 q/ha which was significantly superior to control (23.94 q/h). (Table 6)

Table 6. Economics and ICBR of 1996-97

Treatment	Yield kg/ha	Increase in yield over control	Gross income	Cost of treatment	Net income	ICBR
IPM-I	3305	911	15943.00	2071.36 @ Rs.350/ 20 kg	13871.64	1:6.70
IPM-II	3347	953	16678.00	2656.36 @ Rs.350/ 20 kg	14021.64	1:6.28
Insecticide	2728	334	5845.00	3468.00 @ Rs.350/ 20 kg	2377.00	1:0.69
Control	2394	-	-	-		--

1.5 BIOLOGICAL SUPPRESSION OF TOBACCO PESTS

Central Tobacco Research Institute, Rajahmundry

Bt strains from IIHR, Bangalore (4 nos.) and BARC, Bombay (2 nos.) and fungal pathogen *Nomuraea rileyi* (Hyderabad strain) from Directorate of Oilseeds Research, Hyderabad were evaluated against *S. litura* in laboratory and nursery by CTRI.

1.6 BIOLOGICAL SUPPRESSION OF PULSE CROP PESTS

Tamil Nadu Agricultural University, Coimbatore

1.6.1 Studies on the effect of *Bt* formulations against pod borers in pigeonpea

A field experiment was conducted in Coimbatore with Co5 variety during Kharif'96 season. The result indicated that *Bt* formulations were significantly superior to control. However the efficacy of *Bt* was higher when combined with endosulfan (0.07%). Among the formulations, Agree was found to be superior to other formulations with regard to yield as well as in reducing the podborer damage but on par with endosulfan (0.07%) alone.

1.6.2 Effect of *Trichogramma chilonis* and *Ha*NPV and their combinations on *Helicoverpa armigera* on pigeonpea intercropped with sorghum.

Result of the above trial in Coimbatore showed that release of *T. chilonis* either @50,000 (or) 1,00,000/ha was inferior and on par with control, where as spraying *Ha*NPV @ 125LE/ha along with *T. chilonis* @ 50,000/ha was as effective as that of spraying *Ha*NPV @ 250 LE/ha in reducing the pod borer damage and recording higher yield. Spraying endosulfan (0.07%) was superior to all other treatments in increasing the yield.

Acharya N.G. Ranga Agricultural University, Hyderabad

1.6.3 Effectiveness of *Trichogramma chilonis* and NPV against *Helicoverpa armigera* in pigeonpea intercropped with sorghum.

A field experiment to evaluate the effectiveness of *Trichogramma chilonis* and *Ha*NPV against *Helicoverpa armigera* on pigeonpea intercropped with sorghum was conducted. Ranipal 0.1% and jaggery 0.5% were added to NPV before spraying.

During Kharif 1996, pre-treatment larval population showed no significant differences among treatments, whereas subsequent 3 spray applications showed significant differences. Among the treatments, spray application of *Ha*NPV @ 250 LE/ha alone reduced the larval population to zero and was significantly better than other treatments. *Ha*NPV 250 LE/ha + *T. chilonis* significantly reduced the larval population but was on par with *Ha*NPV 125 LE/ha alone and *Ha*NPV 125 LE/ha + *T. chilonis* @ 50,000/ha. However pod damage was noticed in the treatments with no significant differences in percentage pod damage.

With regard to yield, there was no significant difference among the treatments. Comparatively better yields were recorded with spray application of endosulfan 0.07% (186gm/5 plants) followed by *Ha*NPV @ 250 LE/ha (185gm/5 plants).

1.6.4 Evaluation of *Bacillus thuringiensis* formulations against *Helicoverpa armigera* in pigeonpea

A trial was laid out during Kharif 1996 with various formulations of *Bt*, viz.,.BTK-I, BTK-II, Dipel, Delfin, Biobit, Agree at 1.0 kg/ha.

The data showed that all the treatments were superior over control in reducing the *H. armigera* population 10 days after the first round of spray application. Similar trend was observed in the subsequent three applications made at 10 days interval. In all, the *B.t.* formulations, viz., Agree, Biobit and BTK-II performed better in reduction of larval population. The mean percent pod damage recorded at harvest was found to be non significant in all the treatments. Lowest pod damage was registered with Dipel (46.26%) followed by Delfin (46.19%), and proved to be better in suppression of larva. With regard to yield, Biobit (85 gm/5 plants), BTT (81.67 gm/5 plants) and Delfin (93.99 gm/5 plants) were found better.

1.6.5 Effectiveness of *Ha*NPV and *Bt.* formulations against *Helicoverpa armigera* in chickpea

A field trial was conducted at APAU, Hyderabad with chickpea (variety : Annegiri) comprising 11 treatments including certain *B.t.* formulations, viz., *Ha*NPV @ 250 LE/ha, *Ha*NPV @ 125 LE/ha, endosulfan 0.07%, endosulfan 0.035%, BTK-I, BTK-II, BTT and Dipel @ 1.0 kg/ha, *Ha*NPV @ 125 LE/ha + endosulfan 0.035%, *Ha*NPV@ 250 LE/ha + BTK-II @ 1.0 kg/ha and untreated control, replicated thrice with a plot size of 50 m^2. All the treatments were given in the evening hours starting from the incidence of *H. armigera* in the field. Jaggery 0.5% and Ranipal 0.1% were added to *Ha*NPV treatments before application. Spray application of these treatments were given for four and three rounds,respectively, starting from the incidence in the experimental plots. The observations were recorded on the population of larvae and the number of pods damaged by the larvae from 10 plants/treatment selected at random before and 10 days after each application. The yield at harvest was recorded.

The results indicated that initially the larval population was very high and 10 days after first round of spray application the larval population was significantly reduced over control in all the treatments. Among the treatments, BTK-I, *Ha*NPV @ 250 LE/ha and endosulfan 0.07% performed better in reducing larval population. In the subsequent two sprays made at 10 days interval also BTK-I, BTK-II and HaNPV @ 250 LE/ha were found to be superior in reducing *H. armigera* population.

With regard to per cent pod damage all the treatments were significantly superior to control. BTK-I (5.21%), BTK-II (5.25%) and *Ha*NPV @ 250 LE/ha + BTK I (5.02%) were found better and were on par with endosulfan.

In respect of yield, significant differences were recorded between the treatments. Highest yield was with Dipel (113.11gm/5 plants), followed by BTK I (85 gm/5 plants).

Considering the overall performance of the treatments, spray application of *Ha*NPV @ 125 LE/ha + endosulfan 0.035% was superior to all in reducing pest population as well as increase of yield. Among the *Bt* formulations, Dipel and BTK-II at 1.0 kg/ha were found to be the best.

Punjab Agricultural University, Ludhiana

1.6.6 Effectiveness of *Bt* formulations against pod borer complex of pigeon pea

The pigeon pea crop in Punjab is damaged by *Helicoverpa armigera, Grapholita critica, Lampides boeticus, Exelastis atomosa* and *Melanagromyza obtusa.* An experiment for the pod borer complex was conducted at farmer's field in village Jangpur (Dist. Ludhiana). Three *Bt* formulations, viz., Biobit, Delfin and Dipel 8 L were tested at two dosages, i.e., 500 and 1000 g or ml per ha along with standard insecticide (Thiodan 35 EC. 1000 ml/ha) and control. Three sprays were given at 10 days interval. The experiment was conducted in a randomized block design with three replications. The total pods from 5 plants selected at random were counted and the infested pods were also counted to work out per cent pod damage.

The pod damage in all the treated plots was significantly lower than control (27.0%). The lowest damage (0.17%) was recorded in Thiodan and it was significantly lower than all other treatments. Among the *Bt* formulations, the damage was lowest (6.0%) in Delfin (1.0 kg/ha) and it was on par with all other *Bt* formulations and their dosages. The number of pods varied from 78.68 to 200.51 per 5 plants but the differences were non-significant.

1.7 BIOLOGICAL SUPPRESSION OF RICE PESTS

Tamil Nadu Agricultural University, Coimbatore

1.7.1 Studies on the effect of release of *Trichogramma japonicum* and *Trichogramma chilonis* against stem borer and leaf folder

A field trial was laid out to control stem borer and leaf folder and the results indicated that the *T. japonicum* released plot with *Bt* spray was superior to other treatments

and on par with the plots sprayed with chemicals with respect to reduction in occurrence of dead hearts. All the treatments were superior to control in reducing the production of white earheads by stemborer on 110-DAT. Leaf folder damage was less in chemical sprayed plot but on par with parasitoid released plots along with *Bt* spray. The yield in *Tj.+T.c+Bt* sprayed plot was significantly superior and on par with chemical sprayed plots.

Kerala Agricultural University, Thrissur

1.7.2 Evaluation of *Bacillus thuringiensis* for the management of rice leaf folder

An experiment was conducted during June - October '96 to find out the efficacy of different formulations of *B. thuringiensis* in reducing the population of rice leaf folder in a randomised block design (RBD) with eight treatments and three replications. The rice variety Jaya was used during Kharif, 1996. The peak damage of the pest was noticed during the flag leaf stage. Spraying was done when the ETL level was one larva/hill. The various *Bt* formulations used were Dipel, Biolep, Biotox, Delfin, Agree 50 WP and BTT. Monocrotophos spray was used as a standard check.

Decrease in percentage of leaf damage was higher in Dipel treated plot (0.350 percent) followed by Biotox (0.321) and Monocrotophos (0.109). However all the *B.t.* treatments were on par with each other and monocrotophos but significantly different from control, with the decrease of leaf damage percentage.

BTT was found to be the best among the *B.t.* formulations with a high percentage of filled grains (84 percent). Other *B.t.* treatments, Dipel, Biolep, Delfin and Agree 50 WP, were found to be on par with each other and monocrotophos.

BTT recorded an yield of 3.433 t/ha which was on par with the yield obtained in monocrotophos treated plot (3.58 t/ha). However all the treatments except Agree 50WP were on par with each other and significantly superior to control.

Punjab Agricultural University, Ludhiana

1.7.3 Efficacy of *Trichogramma chilonis* and *Trichogramma japonicum* for the control of leaf folder and stem borer on rice

The experiment for the control of leaf folder and stem borer in rice was conducted in farmer's field at Khudi Kalan (Dist. Sangrur). Three dosages i.e. 50,000, 75,000 and

1,00,000/ha of the two egg parasitoids, *T. chilonis* and *T. japonicum* were tested along within secticidal spray of monocrotophos (Monocil 36 SL) and control. Percent leaves folded and the percent white ears were recorded near crop maturity from three sites in each plot on the basis of 25 plants selected at random. At maturity, the yield was recorded on the basis of 1x1m area at three places in a plot.

The mean incidence of the leaves folded was significantly lower in all the treatments as compared to control. The incidence of the leaf folder was lowest (8.3%) in the insecticidal spray and it was significantly lower than all other treatments. Among the three dosages of the parasitoid, the higher dose (1.0 lakh/ha) was the best. The per cent white ears due to stem borer were again lowest (12.6%) in the insecticidal spray and it was significantly lower than that in all other treatments except the higher dosages of the parasitoids. The damage in both the lower dosages of the parasitoids (21.3 and 23.4%) was on par with control (26.3%). The highest yield (60.38 q/ha) was obtained with insecticidal spray and it was significantly higher than all other treatments. The yield with the higher dosages of egg parasitoids (55.24 q/ha) was significantly higher than lower dosages and control, which were on par with each other.

Assam Agricultural University, Jorhat

1.7.5 Field evaluation of *Trichogramma japonicum* against stem borer and *T. chilonis* against rice leaf folder

Field experiments to evaluate the effectiveness of *Trichogramma japonicum* against yellow stem borer and *T. chilonis* against rice leaf folder were conducted at Dewangaon about 20 kms away from AAU, Jorhat campus. The inundative releases of *T. japonicum* and *T. chilonis* were made @ 50,000/ha/week.

The parasitoids were released 30 days after transplanting. Observations on the occurrence of dead heart and white earhead were taken on parasitoid released plot, unreleased plot as well as in the chemical control plot. During rabi 1996, the percentage of dead heart in the released plot and unreleased plot initially did not exhibit any difference(in the first two weeks after release) but from the third week onwards significantly good reduction of dead heart could be observed in the released plot in comparison to unreleased plot. The percentage dead heart in the third week after release ranged from 2.91% to 5.36% in comparison to the unreleased plot (8.62% to 9.83%). The percentage white earhead population was also low (2.39%) in the released plot in comparison to unreleased plot (6.32%).

Similarly during kharif 1996, the release of *T. japonicum* was assessed in the same experimental location. The result revealed that the percentage dead hearts ranged from 2.13% to 11.58% in the released plot against 7.48% to 16.63% in the unreleased plot. Significantly good reduction of dead heart could be achieved from the 2nd week after release. The percentage dead heart in the released plot was 5.02% against 15.70% in the unreleased plot in the third week after release. Hence a reduction of dead heart infestation to the extent of 65% was achieved with biocontrol plots. The white earhead population was low (2.85%) in comparison to unreleased plot (5.82%).

The percentage leaf folder damage during rabi 1996 ranged from 1.39% to 4.78% in *T. chilonis* released plot against 2.87% to 9.28% in the unreleased plot. Similarly during kharif 1996, the leaf folder population was high prior to field release of the parasitoid and ranged from 7.65% to 11.38%.

Field recoveries of *Trichogramma japonicum*

In order to recover *T. japonicum* from the field, adult moths of yellow stem borer were collected and used to obtain egg masses. The egg masses along with the leaves were stapled on the leaves of rice plant in the parasitoid released plots. The egg masses were allowed to remain in the field for 24 hrs for parasitisation. The egg masses were then kept in the laboratory for the emergence of parasitoid. The recovery of *T. japonicum* during rabi 1996 was 33.3% and 26.6% during kharif 1996.

1.7.6 Management of leaf folders with *Bt* formulations.

The experiment was conducted during Rabi 1996 in farmer's field located at Kakajan (Assam). The treatments were applied based on ETL (one damaged leaf per hill) during both vegetative and flowering stages of the crop. The various formulations used were Biobit, Delfin, *Bt* K I, *Bt* K II, Biotox (all at 1 kg/ha) and untreated check, replicated thrice with a plot size 40 M^2. Per cent infestation of leaf folder prior to the application of *Bt* ranged from 7.80% to 10.58%. Among the treatments Biobit, Delfin and *Bt* KI could reduce the leaf folder damage (1.35%, 1.34% and 1.93%) as compared to control (5.70%). The remaining *Bt* formulations did not give encouraging results in reducing leaf folder incidence.

Experiments were conducted in the laboratory to examine the effect of certain insecticides on the egg parasitoid *Trichogramma japonicum* and identify some safer pesticides which may be used for the management of rice stem borer and their natural enemies.

The insecticides used in the present study were chloropyriphos, quinalphos, monocrotophos and phosphamidon. In addition to these insecticides, dimethoate, cypermethrin, fenvalerate and two neem formulations - Neemazol F and Fortune Aza along with Biolep and Bioasp were also tested.

Freshly laid eggs of *Corcyra cephalonica* (0 - 24 hrs old) were glued on paper cards (size 4 x 0.7 cm) @ 100 eggs/card. The egg cards were then exposed to ultra violet rays for sterilization. The egg cards were then placed on petridish (diameter 15 cm) and sprayed with insecticide in a Potter's tower (1ml/spray). Egg cards used as control were sprayed with filtered water. After drying the cards 10 newly emerged adult parasitoids of *T. japonicum* were released in each glass vial and plugged with cotton. A fine streak of honey (50%) was provided as diet. The adult mortality was recorded at different time intervals (1,2,4,6,12,24 and 48 hours). The effect of insecticides on the parasitising ability of *T. japonicum* was also evaluated. One gravid female of *T. japonicum* was exposed for 24 hrs to strips of insecticide treated host egg card kept in glass vial (5 x 1.5 cm). A streak of 50% honey solution was also provided as diet. The rate of parasitisation was recorded on the basis of per centage of host eggs which had attained black colour.

Quinalphos was most toxic followed by chlorpyriphos and cypermethrin while fenvalerate and monocrotophos were comparatively less toxic.

Biolep and Bioasp exerted minimum detrimental effect registering fairly high degree of parasitism (55.67 and 54.33 per cent, respectively) as compared to control (48.33%) but were statistically on par with control. Among the rest , Neemazol F, fortune Aza, Fenvalerate and monocrotophos recorded 37.67, 38.0, 30.0 and 28.33 per cent parasitism and were comparatively less toxic.

1.8BIOLOGICAL SUPPRESSION OF OILSEED CROP PESTS

Gujarat Agricultural University, Anand

Treatments with microbial insecticides (*M. anisopliae,B. bassiana* and *P. papilliae)* and insecticides (chlorpyriphos and quinalphos) against whitegrub were significantly superior to control. *M. anisopliae* proved to be the best (GAU).

1.9BIOLOGICAL SUPPRESSION OF COCONUT PESTS

Stethoconus praefectus was found to be the dominant predator of *Stephanitis typica* on coconut (KAU).

Attempts were made to record the natural occurrence of *Trichogramma embryophagum*. It completed its life cycle in 10 days on *Opisina arenosella* and the parasitization range was 30-90 per cent under laboratory conditions (CPCRI).

1.10 BIOLOGICAL SUPPRESSION OF FRUIT CROP PESTS

INDIAN INSTITUTE OF HORTICULTURAL RESEARCH BANGALORE

1.10.1 Studies on the parasitoids of pomegranate butterfly, *Deudorix isocrates*

Pomegranate orchards in and around Rahuri were surveyed for the collection of parasitoids of pomegranate butterfly, *Deudorix isocrates* during August, 96. The percentage of fruits bored by the butterfly was very low. The mean borer infestation was 10.07% in August.

Two egg parasitoids, viz., *Ooencyrtus papilionis* and *Telenomus* sp., two larval parasitoids *Apanteles* sp. nr. *sauros*, *Charops obtusus* and a pupal parasitoid, *Brachymeria lasus* were collected. A maximum of 26.00% eggs were parasitised in September, 96. Larval parasitism (16.67%) by *Apanteles* sp. was observed and pupal parasitism by *B. lasus* (1.67%) was recorded during September, 96.

Eggs of *Chilo partellus* and *D. isocrates* were exposed to *O. papilionis* in September, 96. There was no emergence of parasitoids from the eggs of *C. partellus*. The parasitoid completed its development on the eggs of *D. isocrates* in 12-14 days in the laboratory. During the study period mean maximum and minimum temperatures were 28.07 and 19.95 °C. The relative humidity in the morning and evening was 77.43 and 66.13, respectively.

1.10.2 Development of dimethoate resistant strain of *Leptomastix dactylopii* to dimethoate

L. dactylopii was maintained on ripe pumpkins infested with *Planococcus citri* in the laboratory. One-day-old adults were used as test insects. Six concentrations of dimethoate viz., 0.01%, 0.02%, 0.04%, 0.005%, 0.001% and 0.0025% were tested for their effect on the adult parasitoids. Glass vials (15 cm x 2.5 cm) with both ends open were sprayed inside with the pesticide at different concentrations. After drying, one end of the vial was covered with muslin cloth and 20 adults were released into the vial. The other end was closed later with muslin cloth. Adults were fed with 50% honey solution. Mortality was recorded at 1, 2, 3, 4, 5, 6 and 24 hrs after exposure. Each treatment was replicated three times and each replicate involved 20 parasitoids.

There was no adult mortality within an hour of exposure. At 2 hrs of exposure, dimethoate at 0.04% & 0.02% caused 65% & 45% mortality of *L. dactylopii*, respectively. There was progressive increase in mortality with increase in hours of exposure and concentration of dimethoate. Dimethoate at all the concentrations, was found to be highly toxic causing 80-100% mortality of *L. dactylopii*. At 3 hrs of exposure, dimethoate caused 35% mortality. The surviving adults were transferred and released into a cage containing the mealybug infested pumpkins. The progeny produced from the treated parasitoids will be further subjected to pesticide pressure to see the possibility of developing a resistant strain. Two generations were completed and the study will be continued in 1997-98.

1.10.3 Safety of plant products and fungicides to the pomegranate whitefly parasitoid, *Encarsia azimi*

E. azimi was found to be a principal aphelinid parasitoid of the ash whitefly, *Siphoninus phyllireae* on pomegranate.

Five plant products, viz., neem oil, mahua oil, pongamia oil, neem cake and neem seed kernel extract and thirteen formulations of neem, viz., Neem guard, Repellin, Nimbicidin, Neemark, Econeem, Bioneem, Neem rich I, Azadirachtin, Neem gold, neem Azal, Rakshak, Achook, neem rich I were included in the present study. Six commonly used fungicides and acaricides in pomegranate ecosystem, viz., Blitox, Kelthane, Kavach, Topsin, Dithane M45 and Sulphur were also tested against *E. azimi*. Carbaryl (0.10%) was used as standard check besides an untreated check. In all, 25 treatments were included in the present study.

The results showed that there was no mortality of adult parasitoids with all the treatments except the standard check 'Carbaryl' which had rapid knock-down effect causing 100% mortality within an hour of exposure.

1.10.4 Demonstration trial on the biocontrol of guava mealybug

Guava plants were found severely infested with the mealybug *Planococcus citri* in July'96. Release of *C. montrouzieri* was initiated on 19-7-1996 and continued up to 14-8-1996. The mealybug population had declined to 3.2 in the last week of August.

Besides the ladybird beetle released, the local natural enemies *Mallada astur, Leptomastix dactylopii* and *Spalgis epeus* were found in negligible numbers during July-August. Successful control of the mealybug was achieved in the second week of August'96. This success story was featured in the National News by DD and Grama mangala programme by Bangalore Doordarshan in August.

1.10.5 Seasonal incidence of the San Jose scale in relation to natural enemies

At Solan, San Jose scale population on two trees under observation was very high and dense. Parasitization by *Aphytis* was 4.5, 8.1, 4.1, 2.3, 12.0, 7.7 and 2.5%, respectively in April-October. Thereafter, scale population declined as the infested twigs had almost dried up. Adult females were 22.7, 37.2, 12.2, 55.8, 57.5, 76.9 and 11.5 per cent of the total scale population, respectively, during these months. Parasitization was noticed only on the third instar scales. In addition to *Aphytis*, parasitization was also noticed by *Encarsia pernicioci* which was not encountered last year, to the extent of 0.7, 1.9 and 1.7% in June, September and October, respectively.

On these infested trees, high activity of the coccinellid *Chilocorus bijugus* was observed. Beetles were first noticed in the beginning of May and their progeny was actively feeding on the scale in June-September. The late IV instar grubs and pupae were parasitized by the Eulophid, *Oomyzus scaposus* (Thomson). Majority of pupae(25-100%) collected from the field were found parasitized by it.

The adult parasitoid survived for 4-6 days in the laboratory and when offered III and IV instar grubs and pupae for parasitization, within 10 minutes the female exhibited positive tendency to parasitize. Its ovipositor was thrust into the tergum (usually of the abdomen) and rested for a few seconds to about half an hour. Only from those prepupae or pupae in which ovipositor remained for longer period (>20 minutes) parasitoids emerged. The period taken from egg laying to adult emergence was 15-16 days.

Besides *Chilocorus bijugus*, a few adults of *Sticholotis marginalis* were also seen feeding on the San Jose scale in May and August.

1.10.6 Biological studies on local *Aphytis* sp. (*proclia* group) parasitizing the San Jose scale

Although the local thelytokous species tentatively identified as *A.* sp. nr. *hispanicus* commenced oviposition after a pre-oviposition period of 1-3 days, development of oocyte in ovaries had begun in late pupal stage.In the adult female, each ovary had 2-6 (Usually 3) polytrophic meroistic ovarioles. The parasitoid laid eggs on the dorsum by drilling through the scaly armature. The mean time taken for oviposition was 229.4 (range 168-294) seconds. The life span of the adult was 4-8 (mean 5.9) days and on an average a female laid 17.5 (1-32) eggs in 3.2 (1-5) oviposition days. The species had a gross

reproductive rate of 27.44 female eggs/female while net reproductive rate was 17.47 female eggs/female. True generation time calculated from fertility table statistics was 24.7 days. The capacity to natural increase (r_c)and true intrinsic rate (r_m) were same (0.116). Population would multiply 1.123 times per day(finite rate of increase)and would get doubled in a period of 5.98 days.

Life span of the adult female fed on honey mixed with Proteinex (1:1 ratio) was adversely affected by increase in temperature and decrease in relative humidity. The mean longevity at 20, 25 and 30°C was 6.09, 4.54 and 3.83 days while at 20, 50 and 80% RH it was 2.15, 5.3 and 6.51 days, respectively. Without food, adult could survive only upto 48 hrs.

At 10, 15, 20, 25 and 30°C, egg to adult development occurred in 116.5, 62.5, 40.8, 19.6 and 16.1 days. At 8°C, only hatching of the egg took place. Minimum threshold of development for the egg, larval, prepupal and pupal stages was calculated to be 8.4°, 8.7°, 7.7° and 7.5°, respectively. Day-degree requirement of the parasitoid above minimum threshold for development from egg to adult stage was 357°D. Adult longevity was 89.4, 28.2, 19.6, 10, 8.4 and 4.5 days at 8,10,15,20,25 and 30°C and minimum threshold temperature for adult longevity was 7.5°C.

1.10.7 Seasonal incidence of wooly apple aphid *Eriosoma lanigerum* in relation to its natural enemies:

Since the introduction of *Aphelinus mali* at Nauni (Solan) in 1991, wooly aphid, is maintaining a low profile. In 1996-97, the aphid population (0.9-4.8 colonies/replicate; 0.215-1.337 cm coverage of the aphid) from April to mid June was higher as compared to that in last year; maximum and minimum temperature and relative humidity were in the range of 24.3-33.1°C, 11.1-19.5°C, and 27.1-65.1%, respectively, with a total rainfall of 42.2 mm during this period. However, activity of parasitoid and predators (primarily Chrysopids) had begun in May. Unlike last year, during June-September, no apparent flare-up of the population occurred, though temperature was favourable for aphid-population increase. It was primarily due to heavy rainfall due to which the relative humidity was also high (70.3-89.4%). Despite low population of the pest, *Aphelinus mali* remained quite active (1.4-6.9 mummified aphids per replicate). During late September- late March, mean colony count per replicate rarely exceeded and coverage of aphid was also quite low (0.11-0.35 cm). Even up to Jan. 9, 1997 a few mummified aphids could be seen in the orchard (0.1-1.4 mummies/replicate). However, thereafter no mummified aphid was visible up to March end. Nevertheless predator activity had started by then. This year weather coupled with parasitoid activity maintained a check on aphid population.

1.11 BIOLOGICAL SUPPRESSION OF VEGETABLE PESTS

Indian Institute of Horticultural Research, Bangalore

1.11.1 Evaluation of *Trichogrammatoidea bactrae* against *Plutella xylostella*

Cabbage (var. Maharani) was grown in 500 sq. m. area. Egg parasitoid *T. bactrae*, mass reared under laboratory conditions on eggs of *Corcyra cephalonica* was released @ 2.5 lakh adults/ha. Parasitoid release was initiated during primordial formation stage. Recovery of parasitoid was taken as establishment in the cropping system and the efficacy of parasitoid was determined based on the number of larvae present/plant compared to control (about 200 m away).

Parasitoid was recovered only after the second release onwards which ranged from 8 to 18%. Data on the number of larvae per plant showed a steady decline during release period over control. The larval population/plant ranged from 0.6 to 4.0 in parasitoid release plot compared to 1.2 to 13.0 in control plot. This significant reduction was mainly due to the activity of the parasitoid.

1.11.2 Studies on the effect of different temperatures on the development of *T. bactrae*

A study was conducted to determine the effect of various levels of temperature viz., 15°, 20°, 25°, 30°, 35° & 40°C on the development of the egg parasitoid, *T. bactrae*. No parasitoid could emerge at 40°C. At 35°C, 4.8% of the adults could emerge in 5 days but the emerged adults survived for less than a day. Developmental period of the parasitoid was 13, 10.2, 10.5 and 8 days at 15, 20, 25 and 30°C, respectively. Longevity of adults was reduced both at 15 and 30°C while it was maximum (7-8 days) at 20° and 25°C with a mean of 5.2 and 4.7 days, respectively. Adult emergence was very poor (30.4%) at 15°C whereas it was normal between 20 to 30°C. The study thus revealed that the parasitoid can do better at a temperature range of 20° to 25°C.

1.11.3 Studies on the biology and rearing of parasitoids of *Leucinodes orbonalis*

Attempts were made to rear *Pristomerus testaceous* and *Diadegma apostata* under laboratory conditions on brinjal shoot and fruit borer, *L. orbonalis*. Both *P. testaceous* and *D. apostata* mated immediately after emergence. Unmated females produced only males. Female parasitoids could parasitize the host larvae only from second instar stage. *P. testaceous* took 16 days for the completion of its life cycle at 25 ±2°C.

D. apostata parasitized all the instars. Total developmental period from oviposition to adult emergence was 14 days at 25 ± 2°C. Both the parasitoids survived for 8-12 days on honey solution. Longevity of the parasitoid was increased by keeping them at low temperature.

1.11.4 Comparative efficacy of sporeless mutant *Btk* @ 300g ASP/ha for the management of *Plutella xylostella* on cabbage

The trial was conducted in 600 m² area with four treatments, viz., MBt @ 300 g/ha, Dipel 8L @ 1 ml/lit., endosulfan @ 0.07% and control. The results indicated that MBt @ 300 g ASP/ha had effectively suppressed the *P. xylostella* larval population where the highest yield of marketable cabbage was obtained (40.00ha). The commercial *Btk* formulation Dipel 8L treatment yielded 33.04 t/ha of marketable cabbage, which was on par with the endosulfan treatment (30.50 t/ha). Control recorded the lowest yield (18.63 t/ha), which supported the highest *P. xylostella* population.

Mahatma Phule Krishi Vidyapeeth (Rahuri), Pune

1.11.5 Evaluation of *Trichogramma pretiosum* against *Helicoverpa armigera* on tomato

A field trial was laid out to study the efficacy of *T. pretiosum* against *H. armigera* on tomato under field conditions at Ganeshkhind (Pune).

The treatments were initiated at 50 per cent flowering of the crop. Observations on number and weight of healthy and infested fruits were recorded at each picking. The observations showed that all the treatments were significantly effective over control in reducing the fruit infestation and increasing the yield. Endosulfan (0.05%) treated plot recorded 17.24 per cent fruit infestation and was on par with *Ha*NPV (19.27%). *Ha*NPV @ 500 LE/ha resulted in a maximum of 456.56 qt. marketable fruits/ha which was followed by *T. pretiosum* released plot and endosulfan (0.05%) treated plot which were on par.

Sher-E-Kashmir University of Agricultural Sciences & Technology, Srinagar

1.11.6 Seasonal incidence of *Pieris* sp. on cabbage and their natural enemies

The experiment was carried out in a vegetable growing area near Srinagar. Eggs and larvae were collected from the field and observed for emergence of parasites in the laboratory. A larval parasite was recorded in the second week of October parasitizing to an extent of 8.3 per cent but no egg parasitoid was recorded. Some unidentified entomopathogens were observed on larvae collected during the second week of June causing mortality to an extent of 14.3 per cent.

1.11.7 Natural parasitization of *Helicoverpa armigera* eggs

Eggs of *Helicoverpa armigera* collected from different hosts (chickpea, sweetpea, sonchus, calendula, geranium and petunia) during March 21 to April 20, 1996, before transplantation of tomato in the field, were found free of parasites. First adult of *Trichogramma* seen on eggs of *H. armigera* was on April 17, 1996. Afterwards, eggs were collected only from tomato fields where no parasitoid release was made.

The first parasitization seen under field conditions on tomato was 18.2% on May 4, 1996. It increased to 50% by May 25. It was 70, 64.7 and 50% on June 7, 15 and 22, 1996, when egg density per plant was 1.6, 0.8 and 0.2, respectively. No fresh egg laying by the moth was noticed thereafter.

The parasitoids reared from these eggs were identified as *Trichogramma chilonis* and *T. achaeae* on the basis of body colour and male genitalia, the former being predominant over the latter.

1.11. Laboratory studies on *Trichogramma pretiosum* as egg parasitoid of *Helicoverpa armigera* and *Corcyra cephalonica*

In order to compare the ability of *T. pretiosum* reared on *Corcyra cephalonica* to parasitise the eggs of *H. armigera,* a laboratory study was undertaken. The trichogrammatids which were used for the experiment were originally obtained from *Corcyra cephalonica* and tested on *C. cephalonica* and *H. armigera* simultaneously. Each isolated female maintained with the male in glass tube continued to parasitise 1-6.9 and 1-8.6 eggs of *C.cephalonica* and *H. armigera* each day for 7 and 6 days, respectively. But with advancement in age, the number of eggs parasitised per day declined, the decline being non-significantly different for the first at least three days in both cases. However, advancement in age of parasitoid did not affect the emergence pattern of its progeny from the parasitised egg. The number of dead larvae in the parasitized eggs in both cases was low and did not vary significantly on day to day basis but number of dead pupae was higher on II day (2.3) in *C. cephalonica* and first four days (0.7-1.1) in *H. armigera* eggs when higher parasitisation occurred on these eggs. Total adults emerged per day declined from 8.6 to 5.4 and 9.7 and 2.0 on these two respective hosts during first five days of parasitisation. No statistically significant difference in-mean number of eggs parasitised/ female/day, eggs with the exit holes, dead larvae and pupae, fecundity and number of adults formed - was observed in respect of the individual parameter. Nevertheless, 5 of the 6 (all except the number of dead larvae) had a marginal edge in favour of *H. armigera*

as compared with *C. cephalonica*. Even sex-ratio of the parasitoid was narrower in the case of parasitoids reared on *H. armigera* in comparison to those on *C. cephalonica*. Hence *H. armigera* eggs were assumed to be readily acceptable for parasitisation by *T. pretiosum* reared on *C. cephalonica*.

When life table statistics were utilized for fertility analysis, higher value of r_m (the true instrinsic rate of natural increase) for the parasitoid reared on *H. armigera* (0.180) as compared with that of *C. cephalonica* (0.167) was attributable to higher net reproductive rate and lower generation time. Although each pair of adult parasitoid was maintained separately, the emerged progeny had male-biased sex-ratio.

1.11.9 Field releases of *Trichogramma pretiosum* in tomato field having marigold as trap crop

A field trial was laid out in which for every 16 rows of the hybrid tomato cultivar Naveen was planted a row of tall African marigold, (variety Golden Age) as trap crop, as per recommendations made by IIHR, Bangalore. The transplantation was done on April 20, 1996. Since the egg laying activity of *H. armigera* had begun before transplantation, *T. pretiosum* was released in the nursery-plot on April 12, 1996 which caused egg parasitisation to the extent of 40% (4 eggs parasitized out of 10) in the nursery itself. On April 19, *Bacillus thuringiensis* var. *kurstaki* (Agree 50% WP; Hindustan Ceiba Geigy Ltd.) was sprayed on nursery plants @ 1 kg/ha which killed all larvae up to II instar, sparing only some third instar larvae (total mortality 78.6%). *T. pretiosum* procured from Project Directorate of Biological Control,Bangalore was released in the plot four times @ 50,000/ha.

After a month of transplantation, per cent infested plants and egg density per plant were higher on tomato. On tomato egg laying was noticed on tender foliage only. This trend continued till June end. The egg density remained low throughout this period. Marigold as trap crop did not provide any added advantage in trapping *H. armigera*, may be the pest population was low.

1.12 BIOLOGICAL SUPPRESSION OF POTATO PESTS

Mahatma Phule Krishi Vidyapeeth, Pune

1.12.1 Efficacy of parasitoids and microbial agents (alone and in combination) in comparison with recommended insecticides for the control of potato tuber moth (PTM)

Copidosoma koehleri @ 50,000 adults/ha and *Chelonus blackburni* @ 15,000 adults/ha at weekly intervals for four times and release of *C. blackburni* alternated with two sprays

of GV @ 500 LE/ha were found best in reducing the infestation of potato tuber moth. The suppression of the pest in these treatments was 60.18, 53.60, 47.65 and 43.20 per cent, respectively, over control. Maximum yield was obtained from plots treated with granulosis virus (126.50 q/ha) which was statistically on par with all other treatments except control.

The results of the experiment during rabi season showed that all the treatments were significantly superior in controlling PTM over control. The treatment with releases of *C. koehleri* was found to be the most superior (4.67 per cent infestation). However, this was on par with *C. koehleri* + GV (4.90%), *C. blackburni* alone (5.00%). *C. blackburni* + GV (5.54%) and GV alone (7.84%). Thus, the parasitoids and GV alone and in combination, gave 51.21 to 70.93 per cent reduction of the pest over control. Maximum yield of 165.83 q/ha was obtained from the plots treated with *C. blackburni* + GV.

1.12.2 Effect of different plant foliage covers on infestation of potato tuber moth in country stores (Arni)

A laboratory experiment was conducted with a view to study the effect of different plant foliage covers on the infestation of PTM in local storage conditions. Five kg potato tubers were heaped and covered with mosquito curtain. Each heap was covered thoroughly with dried foliage of eight different trees. These heaps were artificially infested by releasing ten pairs of PTMs. Observations on healthy and infested tubers were recorded from each treatment after 75 days. Among the various plant foliage covers, nirgudi was the most effective showing 5.65 per cent tuber infestation, followed by custard (19.40%), lantana (19.66%), *Ocimum* (24.29%) and neem (27.27%). However, karanj was observed to be the least effective with 50.83 per cent tuber infestation. In the case of paddy straw, 37.70 per cent tubers were infested.

1.12.3 Survey for natural enemies of potato tuber moth in different seasons

To study and record the occurrence of natural enemies of potato tuber moth in different seasons under field and storage conditions, periodical survey was undertaken in potato growing areas of Maharashtra State during kharif and rabi seasons. The larval stages of PTM in foliage and infested tubers after harvest of the crop and from various godowns/Arnies were collected and reared for the emergence of natural enemies under laboratory condition.

It was observed that *Apanteles* sp. and *Bracon* sp. emerged from the foliage feeding larvae of tuber moth. Two hymenopterous parasitoids were also recorded from the infested tubers collected from the field. A beetle feeding on PTM eggs, which was reported last year, was further studied for its host preference, rate of consumption and bionomics.

A single adult consumed 22 PTM eggs per day. As regards host preference, the eggs of *P. operculella*, *H. armigera*, *C. cephalonica*, *Dysdercus* sp. and mealy bugs and honey agar diet were arranged in a circle and 47 adult beetles were released at the central point. Observations showed that 74.46 per cent beetles were attracted towards PTM eggs as against 10.67 and 2.12 per cent in case of *C. cephalonica* and *H. armigera*, respectively. Red cotton bug and mealy bug eggs did not attract any beetles.

1.12.4 Efficacy of different bioagents against *Spodoptera litura* on potato

With a view to study the efficacy of NPV, *Bt* and white muscardine fungus in comparison with chemical insecticides against *S. litura* on potato, a laboratory experiment was conducted with seven treatments replicating thrice. For this purpose, mass culture of *S. litura* was maintained on the foliage of potato for one generation and the 2nd instar larvae obtained from the subsequent generation were used for treatments. The larvae were exposed to treated leaves for 24 hrs and thereafter provided with fresh food daily. Ten larvae were released in each treatment. Larval mortality was recorded from each treatment and the percentage mortality data were subjected to statistical analysis.

All the treatments were significantly superior to control. Fenvalerate 0.01% proved most effective (96.67%) as against 33.33 to 86.67% with bioagents. *B. thuringiensis* gave 86.67% larval mortality and was statistically on par with *Sl*NPV @ 750 LE/ha, *Sl*NPV @ 500 LE/ha + fenvalerate 0.005% and *Sl*NPV @ 500 LE/ha. The crude suspension of white muscardine fungus was found to be the least effective.

1.13 BIOLOGICAL SUPPRESSION OF WEEDS

Indian Institute of Horticultural Research

1.13.1 Studies on the mortality factors affecting *Zygogramma bicolorata* in Bangalore

Egg mortality of *Z. bicolorata* ranged between 44.19 - 49.93%, of which infertility accounted for up to 29.50%. About 11.40 - 24.69% of the eggs remained unhatched. Among young larvae, mortality (9.62 - 20.77%) due to the inability of the larvae to complete moulting successfully was the major factor. Late larval mortality was relatively low (1.38 -9.24%). No natural enemies were recorded attacking early or late larval stages. However, mortality during the pupal stage was found to be high (39.30 -52.00%), mainly due to parasitism by *Chaetexorista* sp. and attack of the pathogen *Metarhizium anisopliae*. In spite of high mortality during egg, pupal and larval stages in that order, the insect continued to cause large scale defoliation.

1.13.2 Feeding potential of *Z. bicolorata* on different ages of sunflower

A total of 44.44% of all the adults used for the experiment were observed to feed on sunflower leaves, with a larger number (75%) of newly emerged adults accepting the crop, as compared to 30-day-old ones (15%). Survival of adults after feeding on sunflower was found to be negatively correlated with age. Thus, 0-day-old adults survived for 10-30 (mean 25.13) days on sunflower, whereas 30-day-old adults survived only for 5-8 (mean 6.00) days after feeding. Adults in the age group of 5-45 days laid up to 31 eggs per female, before they initiated feeding on sunflower. Most of the eggs were found to be deposited on the absorbant cotton wool used to plug the hole in the lid of the container, through which petiole of the sunflower leaf was inserted and thus kept moist. Oviposition was noticed only for the first 3 days, after the adults were released on sunflower, and no eggs were laid after they initiated feeding. However, newly emerged adults, that had not fed earlier on parthenium, were observed to lay up to 37 (mean 17.62) eggs after feeding on sunflower. Egg laying was observed from the 12th day after feeding initiation and continued till the females died about 25 days later. Adults that had fed continuously on parthenium were observed to lay about 239 eggs per female during the same period.

About 35% of the eggs laid by 0-day-old sunflower fed adults of *Z. bicolorata* were noticed to hatch. But larvae did not survive for more than one day, indicating that the insect is incapable of completing its development on the crop.

When 250 newly emerged adults were released on 10 sunflower plants in the pre-flowering stage, confined within field cages, feeding was noticed to commence in 2-3 days. However, only 14% of them were observed to survive by the 5th day, 4.4% by the 15th and none by the 25th day. Although the eggs laid on the crop were noticed to hatch, larval feeding was not observed. In open field studies newly emerged adults were observed to feed only on leaves treated with either crude aqueous extract or pollen grains of parthenium. Adults could be located on the treated leaves only up to the fifth day. The results of this study confirm that the insect is not attracted to sunflower leaves in the absence of foreign particles of parthenium origin, containing phagostimulants.

Since adults older than one month do not accept sunflower for feeding, the present studies establish that such adults were probably used for the host- specificity tests carried out during 1983. This is corroborated by the fact that adults of *Z. bicolorata* can survive for as long as seven months under laboratory conditions.

1.13.3 Effect of *Bactra venosana* on growth and regeneration capacity of *Cyperus rotundus*.

Studies were carried out to determine the impact of *B. venosana* on the regeneration capacity of *C. rotundus*. The experiment was conducted on one-month-old *C. rotundus*

plants raised in 120 x 120 cm zinc sheet trays of 5 cm depth. Strips of polythene sheet having eggs of *B. venosana* in the black head stage were released on the trays. The newly hatched larvae mined through the leaves and later entered the stem. Observations were recorded one month later, on the total number of plants damaged, the average weight of the tubers as well as the aerial part of the plant and the number of plants that produced sprouts.

Release of *B. venosana* was found to cause significant reduction in the growth of *C. rotundus*. Up to 90% of the aerial parts of the attacked plants were found to be damaged. Tubers attacked by the insect were found to weigh 0.25g as compared to 0.45g for control, after one month. Only 25% of the damaged plants were observed to sprout after one month.

1.13.4 Standardisation of a method for mass rearing *Bactra venosana*

A method was developed to mass multiply *B. venosana*, under laboratory conditions on artificial diet. A wire-mesh frame wrapped in polythene sheet was used as oviposition cage. The top and bottom ends of the cage were covered with muslin cloth. Freshly emerged adults were released inside the cage, after providing 50% honey solution on cotton swabs.

The polythene sheets with eggs were collected once in two or three days and the egg masses were cut out along with the sheet on which they were laid. Newly hatched larvae were transferred to tender *C. rotundus* plants or containers with artificial diet. Various combinations of ingredients were tried out to find a suitable diet for rearing the larvae under laboratory conditions. A diet containing wheat germ and soybean flour is giving promising results. Comparative studies revealed that total developmental period, pupal weight and fecundity of insects reared on artificial diet were comparable with those reared on natural host plant.

1.13.5 Identification of key mortality factors of *Rhampus* sp., a leaf miner of *Mimosa pudica*

A curculionid leaf miner, *Rhamphus* sp. was recorded for the first time, attacking the leaves of *Mimosa pudica*, at Hessaraghatta, Bangalore. Observations were carried out on twigs of *M. pudica* collected from the field during August 1996 to February 1997. Leaves of the plant with eggs were collected and kept under observation for hatching. Equivalent numbers of the following stages, based on the numbers that survived the previous stage, were collected and observations continued. It was observed that death

during larval stage accounted for the maximum mortality of *Rhamphus* sp. However, the exact causal factor could not be identified. The larvae were observed to dry up inside the mine, and no parasitoids were observed to emerge.

Mahatma Phule Krishi Vidyapeeth, Pune

1.13.6 Effectiveness of *Neochetina* spp. in the suppression of water hyacinth

Studies were continued to find the efficiency of *Neochetina* spp. in the control of water hyacinth. The data on leaf area damage and average number of weevils/plant showed that the average score of leaf damage varied from 1.04 to 2.48 with a range of 30.20 to 52.40 per cent. During the period under observation, average number of weevils/plant was between 2.08 to 2.32 weevils. The existing weevil population was inadequate to control water hyacinth due to high growth rate of the weed and there was no complete foliage damage in the selected pond.

Kerala Agricultural University, Thrissur

1.13.7 Monitoring and evaluation of *Orthogalumna terebrantis*

Field release of *O. terebrantis* commenced during 1990 and during the last five years, the mite has established all over the release sites and some of the neighbouring locations.

Almost 100 per cent infestation was observed in all the *O. terebrantis* released locations. However, the brownish or yellowish streaks which are typical symptoms of the mite infestation are confined to the older leaves and older plants except in some of the shady areas.

1.13.8 Survey of the natural enemies of *Eichhornia crassipes, Mikania micrantha, Pistia stratiotes* and *Limnocharis flava*

The survey continued but no new natural enemies were found. *Prodenia* caterpillars continued to be the most common on *Limnocharis*.

Gujarat Agricultural University, Anand

1.13.9 Biological control of water hyacinth by release of *Neochetina eichhorniae, N. bruchi* and *Orthogalumna terebrantis*

The weevils have adapted to the new environment very well as evidenced by the presence of the larvae and adults in the bulbs as well as fresh damage observed on the leaves. The adult count varied from 1.42 to 2.90 per plant and damage holes from 39.85 to 105.10 per leaf.

Assam Agricultural University, Jorhat

1.13.10 Biological control of water hyacinth by release of *Neochetina eichhorniae* and *N. bruchi*

It was already reported in the last annual report regarding the control of water hyacinth in Disangmukh and Dikhowaukh areas of Sibsagar district in which about 5000 bighas of water hyacinth have been cleared off by this exotic insect species. The weevils further migrated through aerial migration and connected rivers to Guwahati, (about 300 km away from the initial release point AAU, Jorhat) and established in water hyacinth areas near Saraighat bridge. In some release areas namely, Lakhaibill and Alengmara stunted growth accompanied by less flowering was observed. The population build up and intensity of damage was recorded in some migratory areas of Assam.

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

1.13.11 Recovery of *Zygrogramma bicolorata* in Himachal Pradesh

Although *Zygogramma bicolorata* was released 1990-91 in Haryana (Kakka) and two districts of Himachal Pradesh (Paonta and Nahan in Sirmaur and Saproon in Solan), until now there had been no report of its recovery on parthenium. Only in June-July 1997, a few beetles were seen feeding on parthenium. Three females brought to the laboratory in August laid 243, 334 and 503 eggs in 9, 21 and 56 days of oviposition.

Females formed in September had a mean pre-oviposition period of 10 days and laid 520-1412 eggs till December. Eggs hatched in 2-6 days in August-September and 6-9 days in October-early November but those laid after November 10, failed to hatch, though the embryonic development had occurred to the advanced stage. Larvae became full fed in 7-13 days in August-September and in 18 days in October-November. Prepupal + pupal period was 11-14 days in August and 18-21 days in September-October. From 15 IV instar larvae which entered the soil for pupation, no adult emergence had occurred till February 1st week when soil was raked to determine the stage of development of the insect.

The adults formed from the grubs by mid-October and entered into reproductive diapause and were inactive till March. Adults which formed by mid-September laid very few eggs and entered reproductive diapause. These beetles resumed feeding by end of March.

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BUDGET FOR THE YEAR 1996-97 (Rs. in lakhs)

PDBC, Bangalore (Head quarters)

Head	Plan	Non-plan	Total
Establishment	38.43	19.54	57.97
T.A.	2.50	1.00	3.50
Works	24.84	0.00	24.84
Other charges including equipments	46.78	4.98	51.76
Vehicles	6.90	0.00	6.90
Total	119.45	25.52	144.97

Co-ordinating centres

Name of the centre	Amount sanctioned (Rs. in lakhs)	Total expenditure (Rs. in lakhs)
CPCRI, Kayangulam	*	
CTRI, Rajahmundry	*	
IARI, New Delhi	*	
IIHR, Bangalore	*	
IISR, Lucknow	*	
SBI, Coimbatore	*	
AAU, Jorhat	2.19	2.19
ANGRAU, Hyderabad	2.99	5.24
GAU, Anand	4.13	4.13
KAU, Thrissur	2.66	2.81
MPKV, Pune	2.15	2.15
PAU, Ludhiana	3.87	6.12
SKUAS&T, Srinagar	1.66	1.66
TNAU, Coimbatore	2.17	2.17
YSPUH&F, Nauni, Solan	2.29	4.54
GBPUA&T, Pantnagar	1.11	1.11

* Since the Project has been merged with Non-Plan no separate budget account has been maintained by ICAR Institute based centres

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Ganga Visalakshy, P. N., and Jayanth, K. P., 1996. Effect of inbreeding on the functional potential of *Pareuchaetes pseudoinsulata*. Paper presented in the Fourth International Workshop on Biological Control and Management of *Chromolaena odorata*, October 14-18, 1996, The Atria Hotel, Bangalore.

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Jayanth, K. P., and Ganga Visalakshy, P. N., 1996. Current status of Biological Control trials against *Chromolaena odorata* in India. Paper presented in *Fourth International Workshop on Biological Control and Management of Chromolaena odorata*, October 14-18, 1996, The Atria Hotel, Bangalore.

Jayanth, K. P., Ganga Visalakshy, P. N., Malvika Chaudhary and S. K. Ghosh 1996. The Parthenium beetle under attack by an indigenous parasitoid. *Insect Environment* **2**: 67-68.

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Krishnamoorthy, A., and Mani, M., 1996. Record of hyperparasitoids on the exotic parasitoid, *Leptomastix dactylopii* How. parasitising citrus mealybug, *Planococcus citri* (Risso) in India. *Entomon* **21**(1): 111-112.

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Mani, M., and Krishnamoorthy, A., 1995. Outbreak of *Aphis punicae* and its natural enemies on pomegranate in India. *Indian J. Plant Prot.*, **23**: 89-90.

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Mani, M., and Krishnamoorthy, A., 1995. Influence of different stages of oriental mealybug, *Planococcus lilacinus* (Ckll.) on the development, progeny production and sex ratio of the parasitoid, *Tetracnemoidea indica* Ayyar. *J. Insect Sci.* **8**(2): 1292-193.

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Mani, M., and Krishnamoorthy, A., 1996. New scale insect of ber and guava. *Indian Hort.*, **41**(3): 15.

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Mani, M., and Krishnamoorthy, A., 1997. Spiralling whitefly in horticultural Crops. *The Hindu*, dt. Jan. 23, 1997, p. 28.

Mohan, K. S., Asokan, R., and Gopalakrishnan, C. 1996. Isolation and field application of a nuclear polyhedrosis virus for the control of the fruit borer, *Helicoverpa armigera* (Hubner) on tomato. *Pest Management in Horticultural Ecosystems*, **2**(1): 1-8.

Sugarcane Breeding Institute, Coimbatore

Rami Reddy, P.V., and Srikanth, J., 1996. Effect of plant extracts on larval parasitoid *Cotesia flavipes* (Cameron) and its parasitisation efficacy. *Insect Environment* **2**(3):106-108.

Gujarat Agricultural University, Anand

Patel, I. S., and Yadav, D. N., 1996. Field evaluation of laboratory selected monocrotophos resistant strain of green lace wing, *Chrysopa scelestes* in integration with monocrotophos. *Ann. Pl. Protect. Sci.* 4 (2) : 1.

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Yadav,D.N., Prajapati, R.S. and Valand, S.M. 1996. Large scale demonstration of biocontrol based insect pest management in cotton in Gujarat. Lead paper presented in the National Seminar on Organic Farming held at University of Agricultural Sciences, Bangalore held from 9th to 11th, October, 1996

Yadav, D.N, Joshi, B.C and Parasara, U.A. 1996. Mass rearing technique for two chrysopid predators. Invited paper presented at the Symposium on Technological Advances in the Biological Control of Insects held at Loyola College, Entomological Research Institute, Madras, October 11th to 12th, 1996

Kerala Agricultural University, Thrissur

Lyla, K.R., Abraham,C.C., and Joy, P.J., 1996. Studies on fecundity and egg hatchability of *Pareuchaetes pseudoinsulata* Rego Barros (Arctiidae : Lepidoptera). Paper presented in the Fourth International Workshop on Biological Control and Management of *Chromolaena odorata,* October 14-18, 1996, The Atria Hotel, Bangalore.

Punjab Agricultural University, Ludhiana

Sharma, D.K., and Varma, G.C., 1996. Studies on feeding capacity of various predators of mustard aphid, *Lipaphis erysimi* (Kaltenbach). Paper presented during National Symposium on Aphidology, University of Gorakhpur, Gorakhpur, 29-31 Oct.1996

Sharma, D.K., and Varma, G.C., 1996. Studies on the effect of natural enemies on the population of *Lipaphis erysimi* (Kalt.) (Hemiptera:Aphididae) in nature on *Brassica juncea* Cross. *Ibid.*

Sharma, D.K., Varma, G.C., and Arora, B.S., 1996. Population build-up and interrelations of *Lipaphis erysimi* (Kaltenbach) (Aphididae:Hemiptera) and its predators and parasitoids on some Brassica crops. Ibid.

Shenhmar, Maninder and Brar, K.S., 1995, Biological control of mustard aphid *Lipaphis erysimi* (Kaltenbach) in the Punjab. *J. Biol. Control* 9(1): 9-12

Shenhmar, Maninder and Brar, K.S., 1996. Evaluation of parasitoids for the control of *Chilo infuscatellus* (Snellen) and *Scirpophaga excerptalis* (Fabricius) on sugarcane in Punjab, *Indian Sug.* **45** (2):121-123.

Shenhmar, Maninder and Varma G.C., 1995. Field evaluation of *Trichogramma japonicum* Ashmead for the control of rice stem borer *Scirpophaga incertulas* Walker *J. Biol. Cont.* 9(1):41-42

Shenhmar, Maninder, Brar, K.S., and Bakhetia, D.R.C., 1997. Management of sugarcane stalk borer, *Chilo auricilius* Dudgeon with egg parasitoid *Trichogramma chilonis* Ishii Third Agricultural Science Congress, Punjab Agricultural University, Ludhiana, 12-15 March 1997.

Singh, Jagmohan, Brar, K.S., Bakhetia, D.R.C., and Shenhmar, Maninder, 1997. Effect of storage on the emergence, sex ratio and parasitization efficiency of *Trichogramma chilonis* Ishii. Third Agricultural Science Congress, Punjab Agricultural University, Ludhiana, 12-15th March, 1997

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

Gupta P.R., and Inderjit Singh, 1996. Predation preference and reproductive performance of the coccinellid, *Chilocorus bijugus* Mulsant on San Jose scale. In : Biological and cultural control of Insect pests, an Indian Scenario,Ed. Dunston P. Ambrose,pp. 289-296, Adeline Publishers, Tirunelveli, T.N.

PARTICIPATION IN SEMINARS/MEETINGS/SYMPOSIA/WORKSHOPS

Dr.S.P.Singh, Project Director participated in

XVI Meeting of ICAR Regional Committee No.VIII held at University of Agricultural Sciences, Bangalore from 26th to 27th June, 1996 and presented a 'Status report on biological control'.

Conference on 'Challenges for Banana Production and Utilisation in 21st Century' and chaired a technical session - V: Nematodes, Insect pests and Diseases on 25th September, 96. A review paper was presented on 'Review of biological suppression of insect pests of banana'.

Fourth International Workshop on Biological Control and Management of *Chromolaena odorata* at Bangalore and chaired the 1st session of the workshop and presented a paper entitled 'A review of biological suppression work of *Chromolaena odorata* (Linnaeus) King and Robinson in India' on 14th October, 1996.

Deliberations of the Second International Crop Science Congress - "Crop Productivity and Sustainability - Shaping the Future" from 17th to 22nd November, 96 organised by the National Academy of Agricultural Sciences and ICAR, New Delhi. Presented an invited paper entitled 'Bio-intensive Integrated Pest Management' highlighting the progress made in biological control based IPM in India as well as future projections.

Regional Expert Consultation on the Application of Biotechnology in Plant Pest Management from 25.2.97 to 28.2.97 at IARI, New Delhi and presented a paper entitled 'Biotechnological approaches for the management of insect and nematode pests'.

Dr.P.L.Tandon, Principal Scientist (Entomology) attended

Fourth International workshop on Biological control and management of *Chromolaena odorata* held at Bangalore during October 14-16, 1996.

National symposium on Horticultural Biotechnology held at Bangalore during October 28-30, 1996

Seminar on "World Food Summit - Rome declaration on World Food Security and World Food Summit Plant of Action" held on 17.2.97 at Bangalore.

Dr.N.S.Rao, Senior Scientist (Entomology) attended

The symposium on Technological Advances in the Biological Control of Insects held at Loyola College, Entomological Research Institute, Madras, October 11th to 12th, 1996

Central Tobacco Research Institute, New Delhi

Mr.S.Gunneswara Rao, Scientist (Entomology)

Attended 3rd Conference of Applied Zoologists Research Association (AZRA) at Cuttack during 27-29th December, 1996 and presented a lead paper on " Problems and prospects of tobacco insect pest management with special reference to Biological Control".

Indian Institute of Horticultural Research, Bangalore

Mr.R.Asokan, Scientist (Entomology)

attended IV International Workshop on *Chromolaena odorata* held at Bangalore, from 14th to 19th, October, 1996.

Dr.K.P.Jayanth, Senior Scientist (Entomology)

participated in the National Symposium on Horticultural Biotechnology held at The Atria Hotel, Bangalore during 28-30 October, 1996

Dr. M. Mani, Senior Scientist (Entomology)

attended the Seminar on "Challenges for Banana Production and utilisation in 21st Century, 24-25, September, 1996, Thrissur.

Sugarcane Breeding Institute, Coimbatore

Dr.S.Easwaramoorthy, Senior Scientist (Entomology)

attended the 20th International Congress of Entomology at Florence, Italy from August 25th to 31st 1996, and 29th Annual Meeting of Society of Invertebrate Pathology and IIIrd International Colloquium on *Bacillus thuringiensis* at Cordoba, Spain from September 1st to 6th, 1996.

Mr.M.Shanmugasundaram, Technical Officer

underwent training in the Institute Fur Phytopathologie, Raisdorf, Kiel, Germany, for two months from 01-04-1996 to 31-05-1996 on *in vitro* production of entomopathogenic nematodes.

Gujarat Agricultural University, Anand

Dr.D.N.Yadav, Professor

has been awarded "Hariom Ashram sponsored Prof. J. P. Trivedi Award" for contribution in the field of Biological Control by the Gujarat Association of Agricultural Sciences.

Punjab Agricultural University, Ludhiana

Dr. Maninder, Entomologist

promoted as Entomologist on 30-01-1996

attended "National Beekeeping Experience Exchange Conference and annual workshop of AICP on Honey Bees, Research and Training" PAU, Ludhiana May 28-30, 1996.

VISITORS

Dr.R.S.Paroda, Director General, ICAR, New Delhi on 22-05-1996

Dr.R.M.Gumisimza and Dr.(Ms.) M.N.Makabay, Department of Agriculture, Uganda on 10-06-1996

Dr.A.K.Bandyopadhyay, Director, CARI, Port Blair on 15-06-1996

Dr.U.Venkateswarulu, Hon'ble Minister of State for Agriculture, Govt. of India, New Delhi, on 26-06-1996

Dr.M.A.Ruissen, Department of Phytopathology, Agricultural University, Wageningen, The Netherlands on 12-09-1996

Shri Chaturanan Misra, Hon'ble Minister of Agriculture, Govt. of India, New Delhi, on 14-09-1996

Dr.S.Shanthuram, USDA, APHIS, 4700- River Road, Riverdale, MD on 19-09-1996

Dr.R.N.Sharma, National Chemical Laboratory, Pune on 28-09-1996

Dr.V.B.Karmaker and Dr.Somsekhar Singh, Government of Madhya Pradesh, Indore on 08-10-1996

Dr.(Ms.) Larbi Fatma, Dr.Khaldi Gley and Dr.Abdelkader Hamdane, Ministry of Agriculture, Tunisia on 10-10-1996

Dr.(Ms.) Rachel E. McFadyen The Cooperative Research Centre for Tropical Pest Management, Brisbane, Australia on 19-10-1996

Dr.Stefan Neser and Dr.C.Zachariades, Plant Protection Research Institute, Pietermaritzburg, South Africa on 19-10-1996

Dr.Hampa Nagarajaiah, Retired Professor, Bangalore on 21-11-1996

Dr.M.Gopalan, Director, Centre for Plant Protection Studies, TNAU, Coimbatore on 19-12-1996

Dr.C.P.S.Yadava, Project Coordinator (White grubs), RAU, Udaipur on 19-12-1996

Prof.Yona Chen, Prof.Haim Rabinowitch and Dr.Uir Shani, Faculty of Agriculture, Food and Environmental Quality Sciences, Hebrew University of Jerusalem, Israel on 24-01-1997

Dr.M.Malipati, Victoria Institute for Horticulture, Melbourne, Australia on 26-02-1997

Shri Manoranjan Bhakta, Member of Parliament and Chairman for Social Audit, Government of India on 04-03-1997

Shri Palanisamy, Hon'ble Member of Legislative Assembly, Tiruturaipundi (TN) on 04-03-1997

Dr.A.K.Raheja, Asst. Director General (PP), ICAR, New Delhi on 19-12-1996 & 04-03-1997

Dr.S.N.Puri, Director, NCIPM, IARI Campus, New Delhi on 04-03-1997

QRT of PDBC, Bangalore comprising Dr.G.K.Veeresh, Vice Chancellor, UAS, Bangalore; Dr.A.N.Mukhopadhyay, Dean, GBPUAS & T, Pantnagar; Dr.O.P.Bhalla, Retired Head, Department of Entomology, YSPUH & F, Solan and Dr.S.Lingappa, Head, Department of Entomology, UAS, Dharwad on 05-03-1997

Dr.Don Griffiths , BMC Ltd., Essex, England on 31-03-1997

Central Plantation Crops Research Institute, Kayangulam

QRT of PDBC, Bangalore comprising Dr.G.K.Veeresh, Vice Chancellor, UAS, Bangalore; Dr.O.P.Bhalla, Retired Head, Department of Entomology, YSPUH & F, Solan and Dr.S.Lingappa, Head, Department of Entomology,UAS, Dharwad along with Dr.S.P.Singh, Project Director, PDBC, Bangalore on 20-01-1997

Sugarcane Breeding Institute, Coimbatore

QRT-PDBC team consisting of Dr.M.Gopalan, Director, Centre for Plant Protection Studies, TNAU, Coimbatore; Dr. S. Lingappa, Head, Department of Entomology, UAS, Dharwad and Dr. O.P. Bhalla, Retired Head, Department of Entomology, YSPUH & F, Solan, along with Dr. S.P.Singh, Project Director, PDBC, Bangalore on 22-01-1997.

Indian Agricultural Research Institute, New Delhi

QRT-PDBC team consisting of Dr. G.K.Veeresh, Vice-Chancellor, UAS, Bangalore; Dr.M.Gopalan, Director, CPPS, TNAU, Coimbatore; Dr. S. Lingappa, Head, Department of Entomology, UAS, Dharwad and Dr. O.P. Bhalla, Retired Head, Department of Entomology, YSPUH & F, Solan, along with Dr. S.P.Singh, PDBC, Bangalore on 19-09-1997.

Indian Institute of Horticultural Research, Bangalore

QRT-PDBC team consisting of Dr. G.K.Veeresh, Vice-Chancellor, UAS, Bangalore; Dr. S. Lingappa, Head, Department of Entomology, UAS, Dharwad and Dr. O.P. Bhalla, Retired Head, Department of Entomology, YSPUH & F, Solan, along with Dr. S.P.Singh, Project Director, PDBC, Bangalore on 04-03-1997.

Assam Agricultural University, Jorhat

QRT of PDBC, Bangalore comprising Dr.G.K.Veeresh, Vice Chancellor, UAS, Bangalore; Dr.O.P.Bhalla, Retired Head, Department of Entomology, YSPUH & F, Solan and Dr.S.Lingappa, Head, Department of Entomology,UAS, Dharwad along with Dr.S.P.Singh, Project Director, PDBC, Bangalore on 30-11-1997

Gujarat Agricultural University, Anand

QRT of PDBC, Bangalore comprising Dr.G.K.Veeresh, Vice Chancellor, UAS, Bangalore; Dr.M.Gopalan, Professor, Department of Entomology, TNAU, Coimbatore; Dr.O.P.Bhalla, Retired Head, Department of Entomology, YSPUH & F, Solan and Dr.S.Lingappa, Head, Department of Entomology, UAS, Dharwad on 28-12-1997

Dr.S.P.Singh, Project Director, PDBC, Bangalore on 19-02-1997

Dr.S.V.Sarode, Professor, Department of Entomology, PKVP, Akola on 19-02-1997

Dr.K.Nagarajan, Director, CTRI, Rajahmundry on 03-03-1997

Kerala Agricultural University, Thrissur

QRT-PDBC team consisting of Dr. G.K.Veeresh, Vice-Chancellor, UAS, Bangalore; Dr. S. Lingappa, Head, Department of Entomology, UAS, Dharwad and Dr. O.P. Bhalla, Retired Head, Department of Entomology, YSPUH & F, Solan, along with Dr. S.P.Singh, Project Director, PDBC, Bangalore on 21-01-1997.

Mahatma Phule Krishi Vidyapeeth, Pune

Dr. Y.S. Nerakar, Vice Chancellor, MPKV, Rahuri

Dr. Hubb.A.I. Stoelzer, Course Director, International Course on Integrated Pest Management, The Netherlands along with 20 trainees

Maged Abdel Rahman, Egyptian Consulate, Govt. of Egypt

Punjab Agricultural University, Ludhiana

QRT of PDBC, Bangalore comprising Dr.G.K.Veeresh, Vice Chancellor, UAS, Bangalore; Dr.A.N.Mukhopadhyay, Dean, GBPUAS & T, Pantnagar; Dr.M.Gopalan, Professor, Department of Entomology, TNAU, Coimbatore; Dr.O.P.Bhalla, Retired Head, Department of Entomology, YSPUH & F, Solan and Dr.S.Lingappa, Head, Department of Entomology, UAS, Dharwad along with Dr.S.P.Singh, Project Director, PDBC, Bangalore on 20-09-1997

Dr. J.N. Naresh, Head, Department of Entomology, CCS Haryana Agricultural University, Hissar

Dr. S.N. Puri, Director, NCIPM (ICAR), Lal Bahadur Shashtri Bhavan, IARI, Pusa, New Delhi 110 012

Dr. Ian Denholm, Insecticide Resistance Group, Biological and Ecological Chemistry Department, ICAR, Rothamsted, UK.

Mr Deepak R. Jadhev, Sr. Research Associate, Crop Protection Division, ICRISAT, ICAR, Rothamsted, U.K.

Tamil Nadu Agricultural University, Coimbatore

QRT of PDBC, Bangalore comprising Dr.M.Gopalan, Professor, Department of Entomology, TNAU, Coimbatore; Dr.O.P.Bhalla, Retired Head, Department of Entomology, YSPUH & F, Solan and Dr.S.Lingappa, Head, Department of Entomology, UAS, Dharwad along with Dr.S.P.Singh, Project Director, PDBC, Bangalore on 21-01-1997

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

QRT of PDBC, Bangalore comprising Dr.M.Gopalan, Professor, Department of Entomology, TNAU, Coimbatore; Dr.O.P.Bhalla, Retired Head, Department of Entomology, YSPUH & F, Solan and Dr.S.Lingappa, Head, Department of Entomology, UAS, Dharwad along with Dr.S.P.Singh, Project Director, PDBC, Bangalore on 21-09-1997

QRT members having deliberations with the Project Director and Scientists of PDBC

The Israeli team from the Faculty of Agriculture, Food and Environmental quality Sciences, Hebrew University of Jerusalem showing keen interest in chrysopid predator mass production

The Scientists from USDA having discussions on the use of microbial agents in pest management

IMPRESSIONS ABOUT US

"Very much impressed. DG be requested to have some arrangement with KVKs to impart this information to farmers."

19-09-1996. Shri Chaturanan Mishra, Hon'ble Union Minister of Agriculture, Government of India, New Delhi

"It is always a pleasure to see the most impressive work and the facilities at this Project Directorate. Most important aspects on biological control are being addressed on priority and excellent equipments and facilities are being developed under the leadership of Dr.S.P.Singh, scientists are highly dedicated and enthusiastic. My best wishes for success in their endeavour."

24-05-1996. Dr.R.S.Paroda, Director General, ICAR & Secretary, DARE, Government of India, New Delhi

" It is a pleasure to visit and observe the comprehensive research conducted here in the area of biological control of insects, diseases and weeds. A promising future awaits around the corner in applying results of this research. Wishing you a successful future. Good luck and thanks for your hospitality."

24-01-1997. Prof. Yona Chen, Dean, Faculty of Agriculture, Food & Environmental Quality Sciences and Dr.Uri Shani, Yotvata Research Farm, Hebrew University of Jerusalem, Israel.

" Though young still excellent work has been done by this institute. I congratulate all scientists, staff and technicians for this commendable job. They need all support from the Government of India. It was very educative to the non scientist members of the committee. I wish all the best for this institute.

04-03-1997. Shri Manoranjan Bhakta, Hon'ble Member of Parliament and Chairman of Social Audit Committee on IPM, Government of India, New Delhi

Tholasi Prints