ANNUAL REPORT
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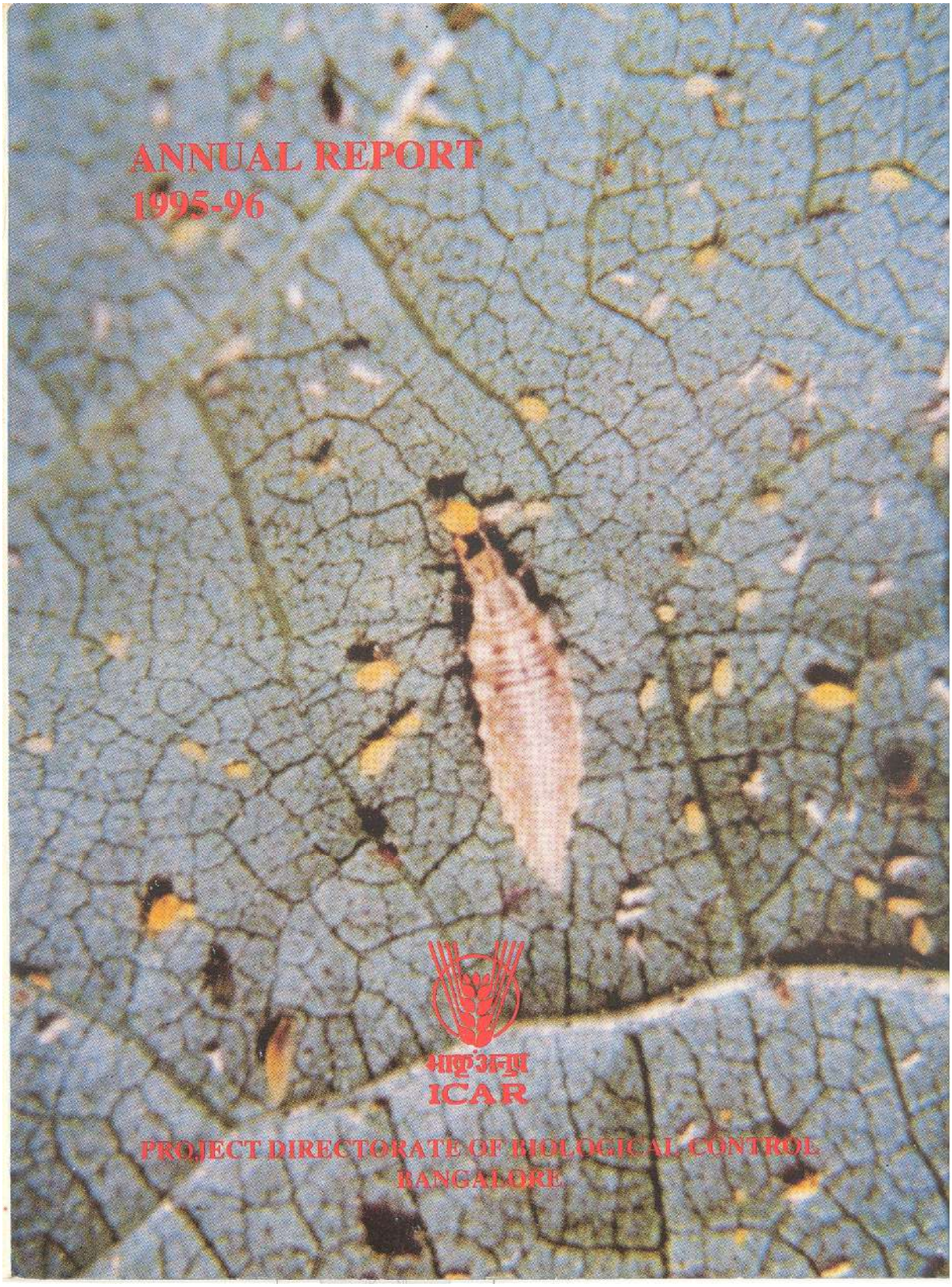

भाकृअनुप
ICAR

PROJECT DIRECTORATE OF BIOLOGICAL CONTROL
BANGALORE

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1995-96

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परियोजना निदेशकीय प्रतिवेदन

परियोजना निदेशालय जैविक नियंत्रण, भा.कृ.अनु.प, नई दिल्ली के अन्तर्गत 1993 में 16 समवर्गीय केन्द्रों के साथ स्थापित किया गया।

1.1 विधिक आदेश

* प्रमुख हानिकारक जीवों एवं खरपतवारों के नियंत्रण के लिए जैविक नियंत्रण की कुशल तकनीकों को विकसित करना।
* राष्ट्रीय स्तर पर जैविक नियंत्रण संबंधित अनुसंधान को समवर्गीय बनाना तथा जैविक अनुसंधान के संबंध में अंतराष्ट्रीय एजेन्सी के साथ मिलकर संयोजन करना।
* राष्ट्रीय स्तर पर निस्पंदन एजेन्सी के रूप में जैविक नियंत्रण कारको का उपोद्घात, आदान-प्रदान एवं संरक्षण संबंधी कार्य करना।
* जैविक नियंत्रण के संबंध में उचित सूचना एवं प्रशिक्षण देना।

1.1.1 संगठन

विधिक आदेश को भली भांति एवं सफलता पूर्वक करने हेतू परि.निदे. जै.नि. के मुख्यालय में पाँच प्रयोगशालायें ओर एक समवर्गीय, प्रशिक्षण एवं प्रलेखन इकाई में कार्य हो रहा है।

* जैव-सिद्धांत, जीव सूची-पत्र बनाना, प्राकृतिक शत्रुओं का उपोद्घात एवं संगरोध प्रयोगशाला
* कीटों को अधिक संख्या में गुणन करने की प्रयोगशाला
* जीव रोग प्रयोगशाला
* भक्षक कीट व्यवहार प्रयोगशाला
* अनुवांशिक सुधार एवं कृत्रिम आहार 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 है, ये निम्नलिखित है -

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, बैंगलोर
भा.ग.अनु.सं.	:	भारतीय गन्ना अनुसंधान संस्थान, लखनऊ
ग.प्र.सं.	:	गन्ना प्रजनन संस्थान, कोयम्बतूर
आ.कृ.वि.वि.	:	आसाम कृषि विश्वविद्यालय, जोरहट
आ.प्र.कृ.वि.वि.	:	आन्ध्रा प्रदेश कृषि विश्वविद्यालय, हैदराबाद
गु.कृ.वि.वि.	:	गुजरात कृषि विश्वविद्यालय, आनन्द
के.कृ.वि.वि.	:	केरला कृषि विश्वविद्यालय, 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
डा.वाई.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. मे उपलब्ध सुविधायें

उपकरण

परि.निदे.जै.नि. मे उत्तम प्रकार के उपकरण एवं साज सामान की उपलब्धता के लिए प्रयास किये जाने से संस्थान मे अमीनो अम्ल संश्लेषक, कीट एन्टीनोग्राम, पूर्ण स्वचालित माइक्रोटोम, तीव्र गति से छवि लेने वाले द्विनेत्रीय सूक्ष्मदर्शी के साथ जोडकर फोटो लेने वाला उपकरण, खमीर उठाने वाली मशीन (क्षमता 2 लीटर), आति संवेदक विद्युत तराजू, स्वचालित मौसम जलवायु का आँकड़ा रखने वाला यन्त्र एवं कम्पूटर आदि प्राप्त हो चुके हैं। अन्य आवश्यक उपकरण जैसे क्षेत्र में जैविक नियंत्रण के संबंध में परीक्षण एवं जाँच हेतू पिंजडे बनाये गये हैं।

पुस्तकालय

पुस्ताकलय में 1357 पुस्तकें, 655 ग्रंथ पत्रिकाऐं, 17 विवरण पत्रिकाऐं, 75 तकनीकी प्रलेख एवं वार्षिक प्रतिवेदन, 50 समाचार पत्रिकाऐं एवं कई अन्य पुस्तक प्रकाशन तथा अनेक पुनःमुद्रित प्रकाशन

परियोजना निदेशकीय प्रतिवेदन

परियोजना निदेशालय जैविक नियंत्रण, भा.कृ.अनु.प, नई दिल्ली के अन्तर्गत 1993 में 16 समवर्गीय केन्द्रों के साथ स्थापित किया गया।

1.1 विधिक आदेश

- प्रमुख हानिकारक जीवों एवं खरपतवारों के नियंत्रण के लिए जैविक नियंत्रण की कुशल तकनीकों को विकसित करना।
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- राष्ट्रीय स्तर पर निस्पंदन एजेन्सी के रूप में जैविक नियंत्रण कारको का उपोद्घात, आदान-प्रदान एवं संरक्षण संबंधी कार्य करना।
- जैविक नियंत्रण के संबंध में उचित सूचना एवं प्रशिक्षण देना।

1.1.1 संगठन

विधिक आदेश को भली भांति एवं सफलता पूर्वक करने हेतू परि.निदे. जै.नि. के मुख्यालय में पाँच प्रयोगशालायें ओर एक समवर्गीय, प्रशिक्षण एवं प्रलेखन इकाई में कार्य हो रहा है।

- जैव-सिद्धांत, जीव सूची-पत्र बनाना, प्राकृतिक शत्रुओं का उपोद्घात एवं संगरोध प्रयोगशाला
- कीटों को अधिक संख्या में गुणन करने की प्रयोगशाला
- जीव रोग प्रयोगशाला
- भक्षक कीट व्यवहार प्रयोगशाला
- अनुवांशिक सुधार एवं कृत्रिम आहार 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 है, ये निम्नलिखित है -

के.रो.फ.अनु.सं	:	केन्द्रीय रोपण फसल अनुसंधान संस्थान, कयान्गुलम
कें.त.अनु.सं.	:	केन्द्रीय तम्बाकू अनुसंधान संस्थान, राजाहमुन्दरी

जो कि जैविक नियंत्रण के संबंध में प्रकाशित किए गए, उपलब्ध हैं। अल्प काल में उचित एवं योग्य आँकड़े एवं जानकारी प्राप्त करने हेतू सी.डी.रोम(जिसमें एक घनी तश्तरी है जो केवल एकत्रित आँकड़ो को पढ़ने का कार्य करती है) उपलब्ध है, जिसमें सितंबर 1996 तक के सभी आँकड़े उपलब्ध हैं।

तकनीकी प्रलेखन / सूचनायें

प्रतीलिपि चित्रक, विद्युत टंकक, कम्प्यूटर, लेज़र मुद्रक, लेमिनेटिंग मशीन, पुस्तक जिल्द बनाने हेतू मशीन, फैक्स, टेलेक्स एवं ई-मेल आदि उपकरण उपलब्ध हैं जो लिखित प्रमाण शीघ्र संकलित करने के साथ ही साथ शीघ्र सूचना का आदान-प्रदान करने में सहायक हैं। कंप्यूटर में उपलब्ध सॉफ्टवेयर वैज्ञानिक तथ्य विश्लेषण एवं आरेख-रेखाचित्र बनाने में सहायक हैं।

राष्ट्रीय कीट निर्देशित संग्रहण

परी.निदे.जै.नि. में प्रमाणिक रूप से पहचाने गये कीटों की 3597 जातियाँ जो कि 1063 वंश, 205 कुटुंबों से संबंधित हैं। ये संग्रहित कीट निर्देश अनेक फसल कीटों, परजीवी कीटों, भक्षक कीटों आदि का निम्न गणों में प्रतिनिधित्व करते हैं-हायमिनोप्टेरा, कोलियोप्टेरा, हेमिप्टेरा, आर्थोप्टेरा, स्ट्रेप्सीप्टेरा, थाइसेनोप्टेरा, न्यूरोप्टेरा, डिप्टेरा, लेपिडोप्टेरा आदि संग्रहित हैं।

परि.निदे.जै.नि. इस अवस्था में है की साझा कार्यक्रम जो जैविक नियंत्रण संबंधी सभी कार्य आपसी लाभ, विशेष रूप से लाभदायक कीटों के आदान-प्रदान, योजनायें बनाने एवं आधुनिक रूप से प्रशिक्षण देने में पूर्ण सक्षम है।

1.1.3 प्रमुख अनुसंधान उपलब्धियाँ

भूमिका, संगरोध एवं मौलिक अनुसंधान

इस वर्ष के दौरान, परजीवियों की अनेक प्रजातियों (संख्यायें) जैसे ट्राइकोग्रामा (42), केम्पोलेटिस क्लोरिडे (2), टेलिनोमस रिमस (1) एवं पोषक संवर्धन कीटों की प्रजातियाँ स्पोडोप्टेरा लिट्युरा (5), कोरसेरा सिफेलोनिका (6) एवं हेलिकोवर्पा आरमीजेरा (1) समवर्गीय केंद्रो एवं अन्य अनुसंधान संगठनों को भेजे गए।

कॉफी बेरी बेधक हाइपोथेनिमस हेम्पी कीट के नियंत्रण हेतू मैक्सिकों से मंगाएँ गए परजीवी कीट सिफेलोनोमियाँ स्टेफेनोडेरिस एवं प्रोरोप्स नेसुटा को प्रयोगशाला में सफलतापूर्वक पाला गया। संगरोध प्रयोगशाला में परीक्षण एवं जाँच के उपरांत प्रकोपित क्षेत्रो में इन परजीवियों को छोड़ा गया।

भक्षक कीट क्राइसोपरला कारनिया के डिंभक पर गंधग्राहक का अध्ययन स्पष्ट दर्शाता है कि हे. आरमिजेरा के शल्क-हेक्सेन का निचोड़ अपनी ओर आकर्षित करता है। यह शल्क-हेक्सेन निजोड़ 7° सेग्रे. पर 7 दिन तक बिना अपनी गुणता खोये संग्रहित किया जा सकता है।

एल-ट्राइप्टोफान, मादा क्राइसोपरला कारनिया को अंडे देने हेतू एक अच्छे प्रेरित का कार्य करता है।

के. क्लोरिडे एवं डाएडिग्मा अरगंटीओपिलोसा को पोषक कीट को. सिफेलोनिका के ऊपर सफलता पूर्वक पाला जा सकता है।

पोलिहेड्रल विषाणु के हे. आरमिजेरा एवं स्पो.लिट्यूरा के शरीर में समावेश द्वारा एनकेप्सूलेशन बाजार में कपडों में लगाने वाले माँड़ का सफलतापूर्वक प्रयोग किया जा सकता है, किन्तु जैल पदार्थ का ठोसपन इतना सुदृढ़ नहीं पाया गया। यह एनकेप्सूलेटड पदार्थ हे. आरमिजेरा एवं स्पो. लिट्यूरा के उपभोग के लिए तुरंत तैयार होता है।

व्यवसायिक फसलों के हानिकारक कीटों का जैविक नियंत्रण

पंजाब में, गन्ने की फसल में तना बेधक का नियंत्रण करने के लिए सीठी अलग करने के साथ ट्रा. किलोनिस परजीवी को 50000/ है. की दर से छोडने पर उत्तम परिणाम मिले हैं।

हैदराबाद में, जैविक समन्वियत कीट प्रबंध (बी.आई.पी.एम.) के अंतर्गत मूँगफली के साथ अन्य प्रपंची फसल उगाने से श्रेष्ठ परिणाम मिले हैं।

आई.पी.एम. के अंतर्गत तंबाकू की फसल में लगने वाले गुलाबी माँहू माइजस निकोटिने को नियंत्रित करने के लिए अरण्ड़ी की फसल को खेत के किनारों पर प्रपंची फसल के रूप में प्रयोग करने से प्राकृतिक शत्रुओं की सक्रियता को अच्छा आयाम मिला, इससे माँहू का 15.4 % तथा जिन क्षेत्रों में अरण्ड़ी नहीं बोया गया था वहाँ पर 21.4% माँहू कीट का प्रकोप था।

दलहन एवं तिलहन वाली फसलों के कीटों का जैविक नियंत्रण

पंजाब में, हे. एन.पी.वी. का 625 एल.ई. / है.की दर से ओर हे.एन.पी.वी. का 312.5 एल.ई + इंडोसल्फान 12.50 मिली. / है. की दर से एक साथ प्रयोग करने से हे.आरमिजेरा को सफलतापूर्वक कम किया गया है। सूत्रबद्द बेसिलस थ्यूरिनजेन्सिस 0.5 किग्रा. / है. की दर से अरहर मे फली बेधक के विरुद्द प्रयोग करने से संतोषजनक परिणाम मिले हैं। सूत्रबद्द बे. थ्यूरिनजेन्सिस, बायोबिट एवं बी.टी.के. II के प्रयोग करने से अरहर में हे. आरमिजेरा की संख्या कम पाई गई एवं डाइपल और बी.टी.के. II 1किग्रा. / है. की दर से प्रयोग चने में, आंध्रा प्रदेश में प्रभावी पाया गया। कोयम्बतूर में बे. थ्यूरिनजेन्सिस का 0.5 किग्रा. / है. की दर से प्रयोग करने से चने में हे. आरमिजेरा को नियंत्रित करने हेतू प्रभावी पाया गया।

डाइपल का 0.75 किग्रा. / है. की दर से किया गया छिड़काव अरण्ड़ी में लगने वाली सूंडी, एकिया जनेटा के नियंत्रण में अत्यधिक सफल पाया गया। बी. पोपिलिये एवं बिवेरिया ब्रोन्गनीआरटी का प्रयोग

मूँगफली की ग्रब्ज को नियंत्रित करने के लिए उत्तम पाया गया। मूँगफली को अकेले उगाने की अपेक्षा अंतर फसल के रूप में मक्का को साथ उगाने पर प्राकृतिक शत्रुओं सिरफिड, जेन्थोग्रामा स्कुटेलेरे एवं कोक्सीनेलीड स्कीमनस जातियों की संख्या अधिक पायी गयी।

अनाज वाली फसलों के कीटों का जैविक नियंत्रण

काकाजन (आसाम) एवं कोयम्बतूर (तमिलनाडु) में ट्रा. जपोनिकम एवं ट्रा. किलोनिस को 50000 / है. / सप्ताह की दर से छोडने पर धान के तना बेधक एवं पत्ती मोडक कीटों कों सफलतापूर्वक नियंत्रित किया गया। पंजाब में, इन्ही कीट परजीवियों के प्रयोग करने से पत्ती मोडक कीट द्वारा की गयी क्षति को काफी कम किया गया।

सूत्रबद्द बे. थ्यूरिनजेन्सिस का प्रयोग थ्रिसूर (केरला) एवं काकाजन (आसाम) में पत्ती मोडक को नियंत्रित करने हेतू उचित पाया गया।

कोयम्बतूर में, जैविक आधार पर आई.पी.एम. (बी.आई.पी.एम.) किए गए प्रयोग से धान के तना बेधक एवं पत्ती मोडक को नियंत्रित करने के लिए श्रेष्ठ पाया गया और अधिक उपज लेने हेतू जैविक कारकों के साथ सुरक्षित कीटनाशी का प्रयोग अतिउत्तम पाया गया।

रोपण फसल में लगने वाले कीटों का जैविक नियंत्रण

कायन्गुलम में, नारियल में लगने वाले कीट ओपीसीना ऐनोसेला को नियंत्रित करने के लिए परजीवी कीट गोनीओजस निर्फेंटिडिस 20.5 %, इलासमस निर्फेंटिहिस 49.4 % एवं ब्रेकीमेरिया नोसाटोई 31.9 % के अनुपात में छोड़ने से हानिकारक कीट को कम करने में सफल पाए गए।

क्षेत्र पिंजड़ों में किए गए परीक्षण में लेसविंग मुल्कुण को भक्षक कीट स्टीफेनिटीस टिपिका 70 से 100 % तक नष्ट कर सकते हैं।

नींबू प्रजाति के वृक्षों में लगने वाले कीट तितली के परजीवी एपेंटिलस पेपिलीओनिस, श्वेत मक्खी परजीवी एनकारसिया आजीमी एवं कोक्सीनीलिड भक्षक कीट, काइलोकोरस सरकुमडेटस के लिए कीटनाशी की सुरक्षित मात्रा सुनिश्चित करने के लिए परीक्षण किए गए। साइपरमिथ्रिन का हानिकारक प्रभाव 28 दिनों के बाद भी रहता है, जबकि फाँसेलोन, डाईमिथोएट, क्लोरपायरीफोस एवं सल्फर कीट परजीवी ऐ. पेपिलिओनिस के प्रति सुरक्षित पाए गए। डाईक्लोरवोस, फेनवालीरेट एवं डेल्टामिथ्रिन भक्षक कीट का. सरकुमडेटस के प्रति विषैलें पाए गए, जब की नीम के बीज का केरनेल निचोड, नीम का तेल, सल्फर, काँपर आक्जीक्लोराईड, डाइकोफोल और डाइमिथोएट सुरक्षित कीटनाशक पाए गए। साइपरमिथ्रिन कीट परजीवी ऐ. आजीमी के प्रति विषैला पाया गया।

सब्जियों एवं आलू के कीटों का जैविक नियंत्रण

बेंगलोर में, लेप्टोमेस्टिक्स निगरीकोक्सेलिस एवं ले. लाइसीए को सर्वप्रथम बैंगन के सफेद फूंगा पर पाया गया। टमाटर के फल बेधक के नियंत्रण के लिए ट्रा. प्रीटीओसम की 45000-90000 / है. की दर से प्रकोपित खेत में छोडने से उत्तम परिणाम मिलें हैं। पत्तागोभी में प्लूटेल्ला जाइलोस्टेल्ला की संख्या को सफलतापूर्वक नियंत्रण करने के लिए बीजरहित परिवर्तनीय बी.टी.के. को 300 ग्रा. ऐ.एस.पी. / है. का प्रयोग उचित पाया गया एवं उपज भी अधिक प्राप्त हुई। सोलन में ट्रा. प्रीटीओसम के द्वारा हे. आरमीजेरा के 45% अंडे परिजीवी पाए गए। बी.टी.के. की 1-1.5 किग्रा. / है. की दर से प्रयोग करने पर इसी प्रकार के परिणाम मिले हैं। आनन्द में, टमाटर के फल बेधक को नियंत्रित करने के लिए ट्रा. प्रीटीयोसम का प्रयोग उचित पाया गया।

पुणे में, उन गोदामों में आलू की सूंडी का कम प्रकोप पाया गया जहा कोपिडोसोमा कोईहेल्री एवं किलोनस ब्लैकबर्नी परजीवी कीट को छोडा गया था, खास तौर पर निचले स्तर पर। परजीवी कीट (को. कोईहेल्री) को एक हैक्टेअर में छोडने हेतू 304 रुपए की लागत आँकी गयी।

जलीय एवं थलीय खरपतवारों का जैविक नियंत्रण

जाइगोग्रामा बाईकोलोराटा द्वारा सूर्यमुखी के उपभोग से इन के वृषण सिकुडे एवं अंड़नाल पारदर्शी पाए गए। ये कीट अपना पूर्ण विकास सूर्यमुखी के नवीन अंकुरित पौधे पर ही कर सकते हैं। बेंगलोर के आसपास ये कीट उन सूर्यमुखी की फसल पर खाते हुए दिखाई दिए जहाँ पर सूर्यमुखी के खेतो से लगा पत्ती रहित पार्थेनियम खरपतवार खड़ा पाया गया एवं उस समय भी जबकि वर्षाकाल समाप्त हो गया हो। इस कीट में निष्क्रियता भोजन के अभाव में बढ़ जाती है। बी. विनोसोना कीट साईपीरस रोटून्डस खरपतवार को 75 % तक नष्ट करते है। उदयपुर में, पिचोला झील में जलकुंभी को नष्ट करने वाले कीट नीओकेटिना आइकोरनिया एवं नि. ब्रूकी स्थापित पाये गये एवं आसाम और गुजरात राज्यों में इन कीटो के द्वारा जलकुंभी को नियंत्रित किया जा चुका है।

(सुरेन्द्र पाल सिंह)
परियोजना निदेशक

1. PROJECT DIRECTOR'S REPORT

Project Directorate of Biological Control (PDBC) was established in 1993 under the Indian Council of Agricultural Research, New Delhi with 16 co-ordinating centres.

1.1 Mandate

* To evolve effective biological control methods for important pests and weeds

* To co-ordinate research on biological control aspects at the national level and to serve as a linkage with international agencies on biocontrol research

* To serve as a nodal agency for introduction, exchange and conservation of biological control agents at the national level

* To disseminate information and impart training in biological control

1.1.1 Organization

With a view to fulfill the mandates 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
* Genetic Improvement and Artificial Diets Laboratory

There are six ICAR Institutes 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
- APAU : Andhra Pradesh 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
- Dr.YSP UH&F : Dr. Y. S. Parmar University of Horticulture & Forestry, Nauni, Solan
- GBPUAS&T: Govind Ballabh Pant University of Agricultural Science & Technology, Pantnagar

1.1.2 Facilities at PDBC

Equipments

Efforts are underway to create excellent facilities at the PDBC. Amino acid analyser, insect antennogram, fully automatic microtome, time lapse micro photographic attachment for the stereo zoom bionocular microscope, fermenter (2 litre cap.), highly sensitive electronic balance, automatic weather recorder, etc. were acquired. Other requisite facilities like field cages were created.

Library

The library has a collection of 1351 books, 655 volumes of journals, 17 technical bulletins and 75 technical documents including annual reports, 50 newsletters and several miscellaneous publications including reprints on various aspects of biological control. For quick and efficient literature search CD-ROM (Compact Disc Read Only Memory) has been upgraded upto September, 1996.

Technical Documentation/Communication

Photostat copiers, electronic typewriters, computers, laser printer, laminating machine, binding machine, Fax, Telex and E-Mail are ready 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 3,597 authentically identified species belonging to 1,063 genera under 205 families. 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 research achievements

Introduction, Quarantine and Basic Research

Forty five shipments of parasitoids, which comprise different species of *Trichogramma* (42), *Campoletis chlorideae* (2), *Telenomus remus* (1), and 12 shipments of host cultures which include *Spodoptera litura* (5), *Corcyra cephalonica* (6), and *Helicoverpa armigera* (1) were sent to the coordinating centres and other research organisations.

Cephalonomia stephanoderis and *Prorops nasuta*, the parasitoids of the coffee berry borer, *Hypothenemus hampei* were introduced from Mexico successfully reared in the laboratory, quarantine screened and field released.

Olfactometer studies indicated greater response of *Chrysoperla carnea* larvae to the hexane scale extract of *Helicoverpa armigera*. The extract is amenable for storage up to 7 days at 7°C with no reduction in the activity.

L-tryptophan was observed to be a good oviposition stimulant for females of *Chrysoperla carnea*.

Campoletis chlorideae and *Diadegma argenteopilosa* could be reared successfully on the laboratory host *Coreyra cephalonica* with good biological characteristics.

Commercial laundry starch could be used for encapsulation of the polyhedral viral inclusion bodies of *H. armigera* and *S. litura* but solidification of the gel material was found to be poor. The encapsulated material was readily consumed by *H. armigera* and *S. litura* larvae.

Biological suppression of insect pests of commercial crops

Detrashing was found to be a good cultural practice in combination with release of *Trichogramma chilonis* @ 50,000/ha for the control of stalk borer in Punjab.

At Hyderabad, cotton BIPM excelled in combination with suitable intercropping of groundnut.

IPM of tobacco pink aphid, *Myzus nicotianae* included castor as border trap crop which could serve as a recluse for encouraging natural enemy activity. Plants infested with aphids in castor bordered tobacco were 15.14 per cent and unbordered crop 21.4 per cent.

Biological suppression of insect pests of pulses and oilseed crops

In Punjab, *Ha*NPV @ 625 LE/ha and *Ha*NPV @ 312.5 LE + endosulfan 12.50 ml/ha gave moderate control of *H. armigera* on chickpea. Dipel and BTK-II @ 1 kg/ha were effective in chickpea in Andhra Pradesh. In Coimbatore, *B.t.* 0.5 kg/ha was found effective against *H. armigera* in chickpea. *B.t.* formulation @ 0.5 kg/ha proved effective in pigeonpea against pod borer complex. *Bacillus thuringiensis* (*B.t.*) formulations - Biobit and BTK II were found to reduce larval population of *H. armigera* in pigeonpea.

Spray application of Dipel at 0.75 kg/ha was found to be highly effective in the control of semilooper, *Achaea janata* on castor. Application of *B. popilliae* and *Beauveria brongniarti* was significantly better in controlling whitegrub on groundnut. Populations of syrphid, *Xanthogramma scutellare* and coccinellid, *Scymnus* sp. were found more in groundnut intercropped with maize than in monoculture of groundnut.

Biological suppression of cereal crop pests

Trichogramma japonicum and *T. chilonis* released @ 50,000/ha/week for the control of rice stem borer and leaf folder could bring about effective check of both the pests at Kakajan (Assam) and Coimbatore (Tamil Nadu). In Punjab, the damage by the leaf-folder was reduced by the same treatment.

Bt formulations proved effective in suppression of leaf-folders in trials at Thrissur (Kerala) and Kakajan (Assam).

Biocontrol based IPM (BIPM) was found best in controlling rice stem borer and leaf folder in Coimbatore and was found superior to need based insecticidal application with significantly higher yields than other treatments.

Biological suppression of tree crop pests

Release of *Goniozus nephantidis* @ 20.5%, *Elasmus nephantidis* @ 49.4% and *Brachymeria nosatoi* @ 31.9% of host population gave significant reduction of coconut caterpillar, *Opisina arenosella* at Kayangulam.

Mirid predator, *Stephanitis typica* effected 70-100% mortality of lacewing bug under controlled conditions in field cages.

Safety of different pesticides to citrus butterfly parasitoid, *Apanteles papilionis;* pomegranate whitefly parasitoid, *Encarsia azimi* and coccinellid predator, *Chilocorus circumdatus* were tested. Cypermethrin remained detrimental even beyond 28 days whereas phosalone, dimethoate, chlorpyriphos, and sulphur were safe against *A. papilionis.* Dichlorvos, fenvalerate and deltamethrin were toxic to *C. circumdatus,* and neem seed kernel extract, neem oil, sulphur, copper oxychloride, dicofol and dimethoate were safe. Cypermethrin was toxic to *E. azimi* adults.

Biological suppression of vegetable and potato crop pests

In Bangalore, *Leptomastix nigricoxalis* and *L. lyciae* were recorded for the first time on brinjal mealybug, *Coccidohystrix insolita*. Release of *Trichogramma pretiosum* @ 45000-90000/ha was effective in the field against *Helicoverpa armigera* on tomato. In Solan, field release of *T. pretiosum* provided 45% parasitisation of *H. armigera*. *Btk* was equally effective at 1.0 -1.5 Kg/ha. *T. pretiosum* was also effective at Anand in controlling fruit borer on tomato. Sporeless mutant *Btk* at 300 g ASP/ha effectively suppressed *Plutella xylostella* larval population on cabbage with resultant increase in yield at Bangalore.

The infestation of potato tuber moth in Pune was found lower in the country stores (arnies) where releases of *Copidosoma koehleri* and *Chelonous blackburni* were made. These parasitoids could not move in search of the host up to a depth of 1 metre and the parasitization was more at lesser depths. The cost of host and parasitoid (*C. koehleri*) production was worked out and it was found that the release cost was Rs.304/release/ha. Dithane M-45 was found safe for *C. koehleri*.

Biological suppression of aquatic and terrestrial weeds

Zygogramma bicolorata adults fed on sunflower were found to have shrunken testes, and thin transparent ovarioles. They could complete development when fed at seedling stage of plant. Around Bangalore, feeding on sunflower was noticed where a defoliated stand of parthenium was observed in adjacent field and not in field located away from weed stand and also during periods of no rainfall. Absence of food increased number of diapausing adults. *Bactra venosona* eggs placed in field caused 75% damage on *Cyperus rotundus*. *Neochetina eichhorniae* and *N.bruchi* adults were found established on water hyacinth in lake Pichola, Udaipur. Successful control of water hyacinth was achieved in Assam and Gujarat with *N. eichhorniae* and *N. bruchi*.

S. P. Singh

1.2.1 Basic research

Introduction of natural enemies

Two parasitoids *viz.*, *Cephalonomia stephanoderis* and *Prorops nasuta* (Bethylidae) were introduced from Mexico against a major pest of coffee called berry borer, *Hypothenemus hampei* (Ferrari). Rearing procedures were perfected using borer infested berries. Parasitoids were released at a ratio of 1:5-1:10 (parasitoid : host) to infested berries and placed in ventilated plastic boxes. Parasitoids emerged from 21 days after setting up the cultures and continued to emerge up to 80 days. Higher humidity level (70-90%) gave good emergences with temperature being 28-30°C. *Cephalonomia stephanoderis* was fed on honey for a short period while *P. nasuta* was provided with berry borer stages alone. Field releases of both the parasitoids were made in Kodagu and parasitoids could be recovered, thereafter.

Supply of parasitoids, predators and host cultures to various centres

During 1995-96, Project Directorate of Biological Control supplied cultures of *Trichogramma brasiliensis, T. pretiosum, T. chilonis, T. japonicum, T. achaeae, T. embryophagum, Trichogrammatoidea armigera, Campoletis chlorideae* and *Telenomus remus* in 45 shipments numbering 1,71,160 (Table 1). Besides this, 12 shipments of host cultures i.e. *Corcyra cephalonica, Spodoptera litura,* and *Helicoverpa armigera* were also sent (Table 1).

Survey of natural enemies and fungal antagonists of major crop pests

Parasitoids of lepidopterous pests

Field surveys conducted during 1995 in and around Bangalore and Mysore revealed that coconut black headed caterpillar, *Opisina arenosella* was parasitized by two larval parasitoids *viz.*, *Apanteles taragamae* (8%) and *Goniozus nephantidis* (10%) and a pupal parasitoid *Brachymeria* sp. (10%). Old world bollworm, *Helicoverpa armigera* was found parasitized by endoparasitoids *viz.*, *Campoletis chlorideae* and *Diadegma argenteopilosa* to the extent of 12 and 10%, respectively.

Table 1. Supply of parasitoids, predators and host cultures

Name of species	No. of shipments supplied	Quantity
a) Prasitoids		
Trichogramma brasiliensis	7	1,71,160
T. pretiosum	5	
T. chilonis	14	
T. japonicum	10	
T. achaeae	2	
T. embryophagum	3	
Trichogrammatoidea armigera	1	
Campoletis chlorideae	2	
Telenomus remus	1	
Total	45	
b) Hosts		
Corcyra cephalonica eggs	6	25 cc
Spodoptera litura pupae/ larvae (L)/eggs (E)	5	70 L/2000 E
Helicoverpa armigera eggs	1	1000
	12	

Predators of important aphid pests

Surveys conducted to identify indigenously available predators of *Aphis craccivora, A. gossypii, A. nerii, Brevicoryne brassicae* and *Dactynotus compositae* revealed the association of five species of coccinellids, four species of syrphids, one species each of chamaemyiid and hemerobid with *A. craccivora*.

Anatagonistic fungi of plant pathogens

Surveys conducted in and around Bangalore (Rajankunte, Doddaballapur, Hessaraghatta, etc.) to identify the antagonistic fungi in rhizosphere/non-rhizosphere soil samples revealed the presence of *Trichoderma* spp., *Gliocladium* spp., *Penicillium* spp. and *Aspergillus* spp.

Population dynamics of *Aphis craccivora, A. gossypii* and their natural enemies

Population dynamics of *A. craccivora* and its natural enemies was studied in February and July planted cowpea. High population was recorded in February planted crop between March end and May begining which varied from 152.2-349.7 aphids/plant. Three coccinellids *viz., Cheilomenes sexmaculata, Scymnus* sp. and one unidentified were found regulating the aphid population. Similarly, high population of *A. craccivora* in July sown crop was observed during second week of September to 1st week of October and the population ranged from 60.2-189.3 aphids/plant. Four species of syrphids were recorded.

Aphis gossypii, population reached a peak during third week of June to first week of August with av. population/plant of 150.2 and 740.7, respectively. Two syrphid and three coccinellid species were active from second week of aphid appearance.

Rearing/culturing techniques for hosts and natural enemies

Standardisation of mass rearing technology for the American serpentine leaf-miner, *Liriomyza trifolii* and its parasitoids

A method has been developed to mass produce the leaf-miner. Beans or cowpea were grown in leaf-miner free cages in a net house in polythene bags (15 x 20 cms) with 10-15 plants/bag in vermiculite. Beans/cowpea plants 11-13 days old,were placed in a screen oviposition cage (30 x 30 x 30 cms) with a transparent front/top. The flies were provided with 2% honey. Fifty to hundred flies were released in a mass rearing oviposition cage for overnight. The seedlings were replaced with fresh ones every day and the seedlings

were shifted to net houses. The seedlings after 8-10 days (when the leaf-miner larvae were in 3rd instar) were shifted to larval/pupal recovery units in net houses.

The larval/pupal recovery units consists of a funnel supported with a stand and enclosed with a lid. The narrow end of the funnel is placed in a glass/plastic vial. The seedlings containing third instar larvae were placed above the wire mesh in the enclosure and the lid is placed with plants. Six polythene bags in slanting position were found ideal for each enclosure. The larvae wriggle out of the mine and pass through the funnel and finally get collected directly into the vial. Some of the larvae pupate over the leaf surfaces and are collected manually by a wet brush. The vial containing larvae/pupae are replaced with empty vial every day. The pupae collected each day are kept for adult emergence. Pupae can be stored in lower compartments of refrigerator for the augmentation of continuous adult supply for oviposition.

The above methodology was standardised by selecting known number of plants for culturing. Two polythene bags containing 15 seedlings of beans and cowpea were required every day for the mass multiplication and regular culture of *L. trifolii*. Two bags of beans and two bags of cowpea need to be sown and two bags of bean seedlings and two bags of cowpea seedlings exposed to the leaf-miner adults for oviposition to maintain the culture continuosly.

Survey was conducted for leaf-miner infestation on beans, castor, cucurbits, drumstic, weeds and other crops around Bangalore. From the infested leaves of castor, three species of indigenous parasitoids were collected. One parasitoid could be multiplied successfully which appears to be *Chrysonotomyia ? appanni*.

Mass production technology for aphidophagous syrphids

Five pairs of syrphid adults were released in a cage of 30 x 30 x 30 cm and provided with honey, protinex, water and castor pollen. Mating occurred five days after emergence of adults and lasted for 35-55 minutes. Mated females were isolated and kept in a glass jar containing aphid infested cowpea plants. Eggs are laid singly and are attached to the plant surface by

the posterior ventral position. Plant parts with eggs were cut and kept in a glass petri dish. Eggs hatched in three days. The resulting larvae were released in a larval rearing unit, containing 16 cowpea plants sown in sand and infested with *A. craccivora*, at the rate of two larvae/plant. This way 32 larvae were reared in one rearing unit. Dead aphids were replaced with new aphid stock.

Suitable culture media for antagonistic fungi

The cultures of *Trichoderma viride* and *T. harzianum* which are being maintained in our laboratory as reference species have been studied for their growth characteristics on different commonly available culture media *viz*., Potato Dextrose Agar (PDA), Potato Dextrose Broth (PDB), Czapek Dox Agar (CDA), Richard's Synthetic Agar (RSA) and Malt Extract Agar (MEA). Among all the media tested, PDA as well as PDB supported the growth of the fungi as evidenced by the production of biomass and observance of maximum sporulation. The cost of the ingredients needed for the preparation of PDA/PDB is very low and therefore, for mass production of *Trichoderma* spp. these media can be effectively used.

Biology and developmental studies on natural enemies

Studies on sex ratio of *Campoletis chlorideae* and *Diadegma argenteopilosa* and their interaction

Effect of mating age on sex ratio was studied by taking different combinations of *C. chlorideae* and *D. argenteopilosa* adults. It was found that two days old male and female of *C. chlorideae* produced a sex ratio of 1.07:1 (M:F). Different combinations of young and old *D. argenteopilosa* produced good sex ratio which varied from 1:0.2 to 1:1.3 (M:F). Effect of male to female ratio on parasitization and sex ratio in *C. chlorideae* was studied. The male to female ratio of 1:1 parasitised 51% of *S. litura* and the sex ratio was 1.8:1 and male to female ratio 2:1 parasitised 40% and the sex ratio was 1:1. Interaction studies were conducted between *C. chlorideae* and *D. argenteopilosa* to find out the dominant one. *C. chlorideae* and *D. argenteopilosa* were found to dominate when *S. litura* was exposed first to each of the parasitoids.

Biology of *Cotesia flavipes* on *Chilo partellus*

Chilo partellus larvae of uniform size were provided to mated females of the parasitoid *Cotesia flavipes* to study the ovipositional and other aspects of the life cycle of the parasitoid. The parasitised larvae (n= 45) were maintained on artificial diet and were observed for cocoon formation. Once the cocoons were formed they were removed from the diet and kept in separate vials. Observations on the days taken to form cocoons, days for parasitoid emergence, number of cocoons formed, number of adults emerged and sex ratio of the emerged parasitoids were taken.

The egg and larval period together of the parasitoid was 14.56 days (range 13-17 days) when they formed cocoons outside the host larva. The pupal period was 8.36 days (7-11 days). The number of cocoons from each host larva was 36.73 (5-80) with a per cent adult emergence of 76.82. The sex ratio was female biased with 3.82 females for every male parasitoid emerged.

Effect of multiple oviposition by *Cotesia flavipes* on parasitoid emergence

Chilo partellus larvae of uniform size were provided to mated females of *Cotesia flavipes* and the larvae removed after 1, 2, 3, 4, and 5 ovipositional attempts by the parasitoid. Five such larvae were used for each number above. The number of adults emerging and the sex ratio of the emerged parasitoids was observed.

Cotesia flavipes does repeatedly parasitize *C. partellus* larvae. Though, the number of adults from those larvae oviposited on 5 times was maximum, the sex ratio was only 1:1 while that oviposited 4 times produced 50.6 adults with sex ratio biased towards females. The larvae oviposited on 3 times produced lesser number of adults (23.0) but the sex ratio was greatly biased towards females (5.76). Three to four ovipositional attempts results in good adult emergence with favourable sex ratio.

Effect of host larval weight on parasitisation and adult emergence of *Cotesia flavipes*

Chilo partellus larvae were individually weighed and presented to mated females of *Cotesia flavipes* in a patch of diet. After 24 hours of exposure, the larvae (n=35) were removed and reared individually till parasitoid cocoons were formed. Per cent larvae from which parasitoid cocoons were formed was also noted. Number of parasitoids emerged from these cocoons were noted for each larva and the sex ratio worked out.

There was no great influence of the host larval weight on the total emergence of parasitoids or on the number of females among them. The r values recorded were 0.1313 and 0.2183, respectively, which were not significant.

Effect of rearing of *Cotesia plutellae* on *P. xylostella* for several generations

Studies were conducted to understand the effect of rearing *C. plutellae* on *P. xylostella* over generations. The egg plus larval period was 7.52 days and the pupal period 3.76 days over all the generations with a decrease in the periods from around 12 and 6 days during December to 7 and 3 days during March as the temperature rose. The mean longevity for male and female was 16.30 and 17.36 days and it can be seen that over generations with an increase in temperature from December-March the longevity was reduced.

The per cent parasitism and adult emergence over 5 generations revealed that adult emergence from cocoons was good but the per cent of exposed larvae forming cocoons was only 9.26 over the five generations with the third generation recording a maximum of 19.93% and an adult emergence of 17.83% for the number of larvae exposed.

The study revealed that the parasitoid is able to do well during December-January with the adults living longer and also producing higher parasitism.

Rearing of *Campoletis chlorideae* on different hosts

Corcyra cephalonica was tried as an alternate laboratory host for rearing *C. chlorideae* in the laboratory at 27°C and 70% RH. The parasitoid completed its development in 20.5 (av.) days and the adults lived for 19.5 (av.) days and the sex ratio was 1:1.2 (F:M). The average fecundity of the parasitoid was 54 and the quality of the parasitoid reared on *C. cephalonica* was very good (Table 2).

Table 2. Biology of *Campoletis chlorideae* on different hosts

Host insect	Larval age (days)	Total period (days)			Longevity (days)		Fecundity	Sex ratio
		Egg	Larva	Pupa	Male	Female		(F:M)
Corcyra cephalonica	13	8-9	8-10	18-22	20-23	18-21	54.0	1: 1.2
Helicoverpa armigera	3	6-7	7-8	16-17	17-18	19-21	68.0	1: 1.7
Spodoptera litura	3	5-6	7-8	15-17	16-17	20-22	60.0	1: 3.3

Response of natural enemies to kairomonal substances

Orientation behaviour of *Chrysoperla carnea* larvae to the kairomones

Orientation behaviour of *C. carnea* studied using a 'Y' olfactometer revealed that larvae were more attracted to the scale extracts of *Helicoverpa armigera* compared to abdominal scale extracts or egg washings of *Corcyra cephalonica*. Highest attraction was found to a 40 mg scale extract followed by 120 mg scale extract with no attraction at a concentration of 160 mg.

Behaviour of *C. carnea* larvae to the kairomones in an insect activity meter

In an insect activity meter, it was found that the larvae were highly responsive with high turning movements and feeding attempts on wax droplets treated with the scale extract rather than to the filter papers treated with extracts.

Behaviour of *C. carnea* adults to kairomones in a wind tunnel olfactometer

Kairomone substances *viz.*, L-tryptophan and honey solution showed higher response than untreated control. Higher number of adults were attracted to 15-day old tryptophan, followed by 7-day old tryptophan and honey.

Behaviour of *C. carnea* adults to kairomones in insect activity meter

Adults of *C. carnea* starved for 24 days were studied for their response to 50% honey solution , honey dew from mealybug and L-tryptophan. The adults unexposed to the kairomones made long distances and their walking speed was less. The distance travelled in L-tryptophan was less as compared with honey dew. Similarly, the number of adults responsive were very low compared to honey and honey dew.

Orientation behaviour of adult *C. carnea* to kairomone substances

A 15-day old L-tryptophan attracted significantly more adults compared to 7-day old L-tryptophan, 50% honey solution and pure honey. Number of eggs laid were more in this treatment.

Artificial diets for host insects

Development of diets for *Plutella xylostella*

Attempts were made to develop artificial diets for *P. xylostella*. The evaluation of diet based on cabbage and cauliflower leaf powder showed that the survival rate was very poor.

Evaluation of diet for *Opisinia arenosella*

Opisinia arenosella was reared on a experimental diet for two generations. The freshly hatched larvae were allowed to feed on coconut leaves for 12 days and then transferred to the diet. About 1500 larvae were transferred to the diet and 340 pupae were collected. Simultaneously, the culture was maintained on coconut leaves at the production level of 400

eggs/day and about 944 pupae were collected. The larval period was observed to be prolonged when reared on artificial diet as compared to the natural host.

Evaluation of diet for *Spodoptera litura*

Spodoptera litura was reared on three experimental diets based on the leaf powders of castor, cauliflower, and cabbage and compared with the control diet (Table 3). Immediately, after hatching, the larvae were fed on castor leaves for 9 days and then transferred to the above mentioned diets. The observations on egg, larval, pupal and preoviposition periods, adult longevity, pupal weight, sex ratio, fecundity, hatching percentage and adult emergence were recorded for 3 generations. The adult emergence percentage was comparatively higher in the diet no.III, based on cabbage leaf powder. The composition of this diet seems suitable for continuous rearing of *S. litura* in the laboratory.

Table 3. Biology of *Spodoptera litura* after two generations of rearing on the artificial diets

Duration (Days)	Control	Diet-I Castor leaf powder basis	Diet-II Cauliflower leaf powder basis	Diet-III Cabbage leaf powder basis
Egg period	4	5	4	4
Larval period	19-24	30-42	20-23	21-25
Pupal period	10	10	8	9
Adult longevity	9	13	14	10
Pupal weight (g) (♂)	0.40-0.41	0.29-0.38	0.40-0.50	0.39-0.49
(♀)	0.34-0.51	0.25-0.39	0.40-0.52	0.36-0.53
Sex ratio (♂:♀)	2:46	3:34	25:28	13:44
Adult emergence (%)	90	50	81.81	91.67

Artificial diets for natural enemies

The diet based on *Spodoptera litura* was evaluated begining from two days old larvae of *Chrysoperla carnea*. Six generations were reared on the diet and highest pupation recorded around 88% and adult emergence of 77%. Adults developed were normal with high fecundity (Table 4).

Table 4. Evaluation of *Spodoptera* diet for mass rearing of two day old larvae of *C. carnea*

Generation	Larval duration (days)	Per cent pupation	Cocoon weight (mg)	Per cent adult emergence
III	29.2 (27-53)	60.0	38.0	34.0
IV	25.0 (20-36)	60.0	39.3	28.0
V	24.0 (28-45)	26.8	37.0	17.3
VI	20.1 (8-32)	59.5	39.0	28.5
VII	26.6 (11-38)	60.0	38.0	15.5
VIII	22.0 (11-35)	88.5	40.0	76.9
IX	19.7 (14-41)	87.3	38.3	66.6

Figures in parentheses are ranges

A new diet was formulated based on bee powder for rearing adults and larvae of *Cheilomenes sexmaculata*. Though, the adults survived for 74- 130 days, there was no egg laying. Another diet was tried for *C. sexmaculata* based on the dried aphid powder. Adults could survive for 40-44 days but, no egg laying was observed.

Mealy bug based diet was tried for the larvae of *Cryptolaemus montrouzieri*. Around 33% pupation was observed with 26 % adult emergence. Another diet based on the mealybugs was also tried for the adults of *C.montrouzieri*. Longevity of the adults varied from 11- 201 days with no oviposition.The diets were enriched with vitamin E and protinex to increase the oviposition, but no improvement in oviposition was noticed.

For rearing the adults of *Chilocorus nigrita*, a diet based on *Aspidiotus* sp. was developed. Around 30% pupation was noticed with 24% adult emergence. The same diet was tried for the adults of *C. nigrita*. The adults could survive for 66-163 days, but did not exhibit any egg laying.

Mealy bug based diet was tried for rearing the larvae of *Scymnus coccivora*. Fifty four per cent pupation was observed with 24 % adult emergence. Protinex based diets were tried for mass rearing the adults of *Scymnus coccivora*. No egg laying was observed, though, the adults could survive 10-22 days.

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

This study was initiated in 1989-90 and is still being continued. During the year, 8 exposures were given at the dosage of 0.052% of endosulfan and 32 generations were completed. It has reached 229th generation at the present dosage. The details of percentage mortality after 6 hr of exposure and parasitisation are given in the Table 5.

Table 5. Exposure of *Trichogramma chilonis* adults to endosulfan

Generation	Mortality after 6 hrs exposure	Parasitism (%)	Concentration of endosulfan (%)
205	90	05	0.052
208	85	10	0.052
214	80	40	0.052
220	70	100	0.052
221	50	50	0.061
225	15	95	0.061
228	01	100	0.061

At F 221 generation the test insects were shifted to 0.061% when 50% mortality (after 6hrs) and 50% parasitisation occurred. By F 228 generation, mortality reduced to 1% after 6 hrs. and parasitism improved to cent per cent. The experiment will be continued till resistant/tolerant strain is obtained at field recommended dosage of endosulfan (0.07%).

Evaluation of *Bacillus thuringiensis* strains against *Chrysoperla carnea*

Several commercial strains of *B. thuringiensis* were evaluated for their safety against *Chrysoperla carnea*. Assays were done on the neonate larvae both for contact and systemic action. None of *B.t* strains were toxic to *C. carnea* larvae in all the assays.

Encapsulation study on nuclear polyhedrosis virus (NPV)

The success in encapsulating the polyhedral inclusion bodies of nuclear polyhedrosis virus of both *Helicoverpa armigera* and *Spodoptera litura* in calcium alginate as a means to increase their persistence and efficiency as biopesticides has prompted further study to encapsulate the PIBs of *H. armigera* using commercial laundry starch (Revive). Though preliminary success was achieved in encapsulating the PIBs of NPVs of *H. armigera* and *S. litura* in laundry starch, attempt in solidifying the gel material in laundry starch failed. Attempts are being made to use soluble corn starch. The feeding of virus encapsulated calcium gel material by the larvae of both *H. armigera* and *S. litura* has been confirmed. Studies in quantifying the amount of encapsulated materials in terms of polyhedral inclusion bodies has revealed that last instars of both *H. armigera* and *S. litura* consumed more capsules than fourth and fifth instars.

Molecular epidemiology for *Ha*NPV

Conserved sequence of 'polyhedrin' as well as 20-40 primer needed for DNA probing have also been identified. DNA has been isolated from the *Ha*NPV for further study on the molecular epidemiology using PCR.

Mass production of pathogens

Production of NPVs of *H. armigera* and *S. litura* using their respective live host is a continuous process; 3000, 2000, and 750 larvae of *H. armigera* were reared, inoculated, and virosed, respectively. A total of 500 LE virus was produced. In case of *S. litura* 3000, 1500, and 750 larvae were reared, inoculated and virosed, respectively.

Supply of insect pathogens

Supply of nucleus culture of NPVs of *H. armigera* and *S. litura* to various govt. and private organizations for mass propagation of the viruses was made. Distribution of virus suspension for lab. and field use on crops like pulses and tomato were made by way of supplying to Tamil Nadu Biocontrol Centre, Sankarapuram, Basarass Biocontrol Research Laboratory, and to Dr. M. S. Swaminathan Research Foundation, Madras.

1.2.2 Biological suppression of sugarcane pests

Field evaluation of exotic strains of *Cotesia flavipes* (Indonesian strain) against stalk and internode borers

Studies conducted on relative efficacy of different doses of *C. flavipes* at IISR, Lucknow indicated 8.14, 13.32 and 30.0 per cent parasitisation of stalk borer larval parasitoid released @ 800, 1200 and 2000 mated females/ha, respectively against 6.6 per cent in check. In other treatments, the stalk borer (*Chilo auricilius*) infestation remained higher than the check. In case of internode borer, all the parasitoid treatments indicated lower infestation than check. A block trial conducted on efficacy of *C. flavipes* (Indonesian strain) @ 2000 mated females/ha revealed 29% reduction in the internode borer infestation and 1.7% reduction in stalk borer infestation.

Field evaluation of *T. chilonis* for the control of *Chilo auricilius* in Punjab

Field experiments conducted at nine locations *viz.*, Lodhipur, Barowal, Bahar-Muzara, Mehli, Ropar, Barnala, Morinda, and Kheri in Punjab an evaluation of *T. chilonis* resulted in 52.0, 45.2, 54.7, 56.9, 34.6, 51.8, 57.0 and 83.3 percent reduction in the incidence of stalk borer (Fig.1).

Seasonality/efficacy of the indeginous parasitoids of *Chilo infuscatellus*

Chilo infuscatellus contributed 60-90% to the total population of sugarcane shoot borers at Sardarnagar and inflicted 1.2-12% damage. *Cotesia flavipes* and *Stenobracon* sp. were observed parasitising *C. infuscatellus* larvae at low level. At Pravaranagar, *C. infuscatellus* infestation ranged between 2.7-12% during April-February. Prevalence of *Sturmiopsis inferens* was noticed in April-May while *Cotesia flavipes* was seen during August-February. *Trichogramma eldanae* was evaluated against the shoot borer at Pravaranagar. Six releases made at weekly interval @ 50,000 adults/ha in December planted crop (30 DAP) revealed 1.5% borer damage in released block as against 66% in untreated check.

The activity of shoot borer parasitoids was observed at four different locations i.e. Kovaipudur, Kuniamuthur, Perur and Telungupalayam at Coimbatore during April-December, 1995. The data presented in Fig.2 about

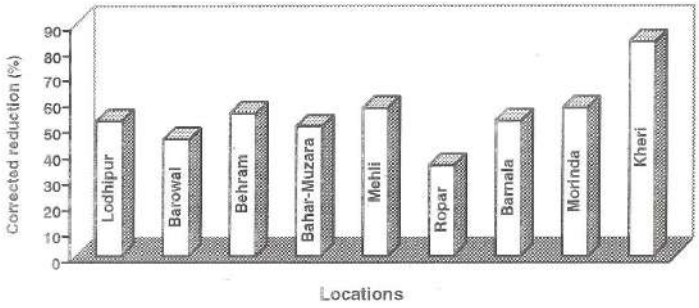

Fig.1 Evaluation of *Trichogramma chilonis* against *Chilo auricilius*

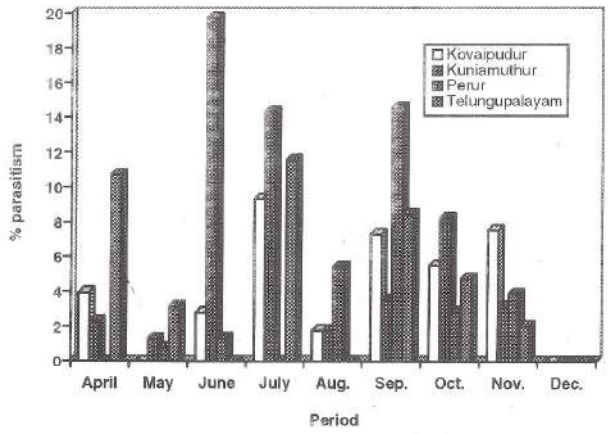

Fig. 2 Seasonal incidence of shoot borer parasitoids at Coimbatore

seasonal fluctuation in per cent parasitism of *C. infuscatellus* by *S. inferens* revealed highest parasitism (19.7%) during June and lowest (0.0%) during December at Kuniamuthur. However, similar trend was not observed at other locations. *Cotesia flavipes* activity was restricted to April-July, 1995 and was far below the levels exhibited by *S. inferens*.

Comparative efficacy of two strains of *Cotesia flavipes* (Indian and Indonasian) for the control of sugarcane stem borers i.e. *Acigona steniellus* and *Chilo auricilius* conducted at Nawanshahr (Punjab) revealed slightly better performance of indigenous strains as indicated by the incidence of *A. steniellus* in different plots. The incidence of *C. auricilius* was 9.6% where indigenous strain was released in comparison to 17.2% where Indonasian strain was released as against 18.2% in check plot. This showed that the indigenous strain of *C. flavipes* played a better role in suppressing the incidence of borers in sugarcane.

Effect of cultural practice and use of parasitoids on the incidence of *Chilo auricilius* in Punjab

Detrashing and release of *T. chilonis* at village Sanawa (Nawanshahar) recorded as low as 2.4% incidence of *C. auricilius* (Table 6).

Table 6. Effect of cultural practice and use of parasitoid on the cane damage by *Chilo auricilius*

Treatment	No. of *T. chilonis* releases(May-Aug)	Canes damaged (%)*
Detrashing	-	3.4
Trichogramma chilonis	7 @ 50000/ha/ release	3.8
Detrashing + *T. chilonis*	7 @ 50000/ha/ release	2.4
Control	-	9.8

* Based on 5 units of 100 canes each observed during October, 1995
Pre treatment incidence was below 1% cane damage in all treatments

Seasonal occurrence of granulosis virus (GV) on *C. infuscatellus*

Seasonal occurrence of GV on shoot borer at four locations i.e. Kovaipudur, Kuniamuthur, Perur and Telungupalayam in Coimbatore from April-December, 1995 revealed that highest infection was recorded during November and December at Kuniamuthur (21.7%) and Telunguplayam (20%) and Perur (17.7%) with the exception of June at Kovaipudur (54.55%).

Biological suppression of leafhopper, *Pyrilla perpusilla*

Sugarcane leafhopper, *P. perpusilla* population reached its peak in September. Parasitism by *Epiricania melanoleuca* was at its peak (4.55/leaf) during September when *P. perpusilla* population was highest at Sardarnagar in Gorakhpur, U.P. Further, 2000 cocoons of *E. melanoleuca* released at Kunshmi Farm (Gorakhpur) could check the pyrilla buid up effectively. Similarly, studies conducted at Nawanshahr (Punjab) showed that parasitoid cocoons when released @ 5000/ha with the start of activity of the pyrilla, proved effective in checking the population of the pest (Table 7).

Table 7. Effectiveness of *Epiricania melanoleuca* against *Pyrilla perpusilla* in sugarcane

Treatment/dose	Observation	Mean population/leaf						
		Pyrilla perpusilla			*Epiricania melanoleuca*			
		E	N	A	E	C	A	PN
E. melanoleuca	Pre-release	0.5	1.8	2.3	0.3	0.8	0.4	0.1
5000/ha	Post-release	0.6	3.6	5.4	1.4	5.1	0.5	0.8
Control	Pre-release	0.4	2.1	2.1	0.1	0.3	0.2	0.1
	Post-release	1.3	11.3	8.0	0.4	2.0	0.2	0.2

* Av. of five units of 10 leaves each: E = Egg cluster, N= Nymphs, A= Adult, C= Cocoon, PN= Parasitised host nymph

Biological suppression of scale insect, *Melanaspis glomerata*

Maximum parasitism of *M. glomerata* was observed during October at Paravaranagar in adsali and ratoon crops (21.6 and 18.1%, respectively). The peak parasitism by *A. mayurai* at Nellore was 9.24% during July.

1.2.3 Biological suppression of cotton pests

Development of biocontrol based IPM for cotton pests

In a field trial laid out at Regional Research Station, Lam (Guntur), APAU; IPM treatment (intercropping with groundnut 1:2, seed treatment with carbofuran, inundative release of *Chrysoperla carnea* and *Trichogramma chilonis*, NSKE 5% spray, *Ha*NPV + endosulfan and *B.t.* (Dipel) @ 2.0 kg/ha) was found effective against whiteflies, jassids and boll worms. The incremental cost benefit ratio (ICBR) was 1:2.15 in IPM practice as compared to 1:0.89 in farmers' practice and 1:0.67 in judicious usage of insecticides treatment.

At Coimbatore three methods of pest management *viz.*, AICRP (need based oxydemeton-methyl sprays and *Ha*NPV) , TNAU (need based application of insecticides or *Ha*NPV) and Farmers (6-8 rounds of insecticidal applications only) were compared. AICRP and TNAU methods were found superior to farmers' method for suppression of leafhopper, aphids and bollworms. AICRP method recorded highest yield (10.34 kg/plot of 60 m^2) of Kapas which was on par with TNAU treatment (9.91 kg/plot of 60 m^2) and were superior to farmers' method of protection (7.07 kg of Kapas).

Experiments conducted in farmers' fields at Barnala (Sangrur Distt., Punjab) revealed that PAU method (6 insecticidal sprays) and biocontrol method (one insecticidal spray, 9 releases of *Trichogramma chilonis* @ 2.0 lakhs/ha and one spray of NPV 200LE/ha) were found effective in reducing bollworm complex to the extent of 18.7% and 36.8%, respectively as compared to 44.6% in farmers practice (8 insecticidal sprays) and 53.1% in the untreated control.

In Gujarat Agricultural University, Anand, IPM (Blanket application of methyl-o-demeton 0.05%), 3 releases of *Chrysoperla* @ 50,000 larvae/ha/week, 8 releases of *Trichogramma chilonis* each @ 1,50,000/ha/week and need based application of endosulfan 0.07% and monocrotophos 0.04% (alternatively after 8th release of *T. chilonis*) gave significantly better protection to buds (14.87%) and bolls (19.38%) when compared with need based application of insecticides (monocrotophos

0.036%, methyl-o-demeton 0.030% and endosulfan 0.070% alternatively) which recorded 27.97% and 31.32% bud and boll damage, respectively. The per cent bud damage and boll damage in control was 29.28 and 35.46, respectively. The combined application of *Chrysoperla* and insecticides gave significantly better protection against aphid, jassid and whitefly.

Influence of cotton hybrids on the rate of parasitism by *T. chilonis*

Interaction studies in case of *T. chilonis* revealed that maximum boll worm eggs were parasitized on Hybrid 8 as compared to other hybrids, suggesting the influence of genotypes on parasitism.

Genetic studies for various biological traits in *Chrysoperla carnea*

Studies conducted on the genetics of *C. carnea* revealed the presence of wide genetic variability for most of the biological traits including tolerance to pesticides. High heritability coupled with genetic advance observed for the characters *viz.*, post oviposition period, fecundity and oviposition period suggested that phanotypic selection could be effective for the improvement of these traits.

***Chrysoperla carnea* role in the control of *H. armigera* in cotton hybrid 6**

During 1995 season, observations were made on the occurrence of *C. carnea* and its impact on the suppression of *Helicoverpa armigera* in insecticide free Hybrid 6 at Raval village. The observation indicated that during September *H. armigera* was totally under control in the presence of *C. carnea*. The predator was abandantly found (11.47 eggs/plant) and the fertility of the eggs was almost 100%. No other egg or larval predators/parasitoid of *H. armigera* existed during the course of observation, indicating the role of *C. carnea* in the suppression of *H. armigera*.

1.2.4 Biological suppression of tobacco pests

Evaluation of different *Bt* formulations at CTRI, Rajahmundry revealed that Dipel with and without boric acid, Bactospeine, Delfin at 0.5 kg/ha and *Ha*NPV @ 250 LE/ha were effective against *Helicoverpa armigera* on tobacco and superior to endosulfan 0.05%. In nurseries, the same

treatments of *Bt* were effective against *Spodoptera litura*. IPM schedule consisting of release of second instar *Chrysoperla carnea*/plant (30 DAT) + one spray of nicotine sulphate 0.04% spot (45 DAT) + one spray of NSKS 0.5% (55 DAT), and one spray of acephate (65 DAT) was found effective to check infestation of *Myzus nicotianae* on planted crop. There was no detrimental effect on syrphids, coccinellids and chrysopids.

1.2.5 Biological suppression of pulse crop pests

In a field experiment at APAU, Hyderabad four sprays of *Ha*NPV (250 LE/ha) alone or four rounds *T. chilonis* (50,000/ha) and with 4 spray application of *Ha*NPV (125 LE/ha) performed significantly better.

Bacillus thrungiensis formulations *viz. Btk*-I, *Btk*-II, Dipel, Delfin, Biobit and Agree evaluated against *H. armigera* on pigeonpea at APAU indicated the superiority of all the formulations over control. Agree, Biobit, and *Btk*-II were better than others in terms of per cent pod damage and were on par with endosulfan 0.07% spray. In another trial, application of *Btk*-I, *Ha*NPV (250LE/ha), *Btk*-II, *Ha*NPV (125 LE/ha) + endosulfan (0.035%) were better in reducing the pod damage and were on par with the endosulfan (0.07%). Highest yield was recorded in Dipel treatment followed by *Ha*NPV + endosulfan.

At PAU, Ludhiana *Ha*NPV (125 LE/ha) alone and combined with endosulfan gave moderate control of *H. armigera* and reduced pod damage in chickpea.

All the *Bt* formulations such as Biobit, Agree, Biotox, Biolep, *Btt*, Bioasp, Delfin and Centari recorded lowest pod damage compared to untreated control. No significant difference was observed between various *Bt* formulations.

In yet another field trial conducted at TNAU, Coimbatore *Bt* (500g/ha) + *Ha*NPV (250 LE/ha) was found to be superior treatment and recorded highest yield.

1.2.6 Biological suppression of rice pests

At AAU, Jorhat field evaluation of *Trichogramma japonicum* and *T. chilonis* at 50,000/ha/week were done against yellow stem borer and leaf-folder, respectively. Percentage dead heart due to stem borer ranged from 2.1-5.3% and 4-7.6% in treated and untreated plots, respectively. Yield increase was 158-250 kg/ha. Leaf folder damage was 2.7% as against 7.65% in control. Yield increase was 139-308 kg/ha as a result of the biocontrol.

At TNAU, Coimbatore, three releases of parasitoids were made at 1 lakh/ha at weekly interval followed by spray of *Bt* at 1kg/ha. Parasitoid release was superior to check and chemical control with regard to dead hearts. Leaf-folder incidence was significantly reduced 60, 70, 80, 90 days after release of parasitoids and was better than farmers' method and control.

1.2.7 Biological suppression of oilseed pests

Microbial control of castor semilooper, *Achaea janata*, spray application of Dipel at 0.75 kg/ha was highly effective 5 and 10 days after treatment followed by Dipel 0.5 kg/ha with or without endosulfan 0.035% and endosulfan alone 0.07 % in trials conducted at APAU, Hyderabad. *Bacillus popilliae* and *Beauveria brongniarti* @ 10 and 15 kg/ha, respectively controlled white grubs on groundnut at Anand. Population of jassids and whitefly were significantly low in groundnut with maize as intercrop and the natural enemy population was higher.

1.2.8 Biological suppression of coconut pests

Effect of *Apanteles taragamae* on *Opisina arenosella* caterpillars at Kayangulam revealed that 53-54% parasitism was found where 3-6 parasitoids were released.

Stethoconus praefactus, a mirid predator released at 5, 10, 15 and 20 individuals/cage resulted in 70-100% mortality of the bug. At Thrissur, *S. praefectus* was found to be the most important natural enemy.

1.2.9 Biological suppression of fruit crop pests

Biological control of the mango mealybug, *Rastrococcus invadens*

The mealybug was observed on three-year old mango plants at IIHR Farm, Bangalore in February, 1995. The infestation was mainly found on the leaves and occasionally on the fruits.

The coccinellid predator, *Cryptolaemus montrouzieri* was found feeding on *R. invadens*. The larvae of *C. montrouzieri* were released @ 25/plant (15/plant in the middle of February and 10/plant on 1st March, 1995). The data on the population of mealybug were recorded on five mealybug infested plants. In each plant five infested leaves were chosen and the number of mealybugs counted at fortnightly interval. Similar observations were made on mango plants located one km away from the released plants. Just prior to the first release of predator, a mean population of 241.4 mealybugs/leaf was observed. Following the releases, the mealybug population came down to 167.0 on 28th February. Almost all the mealybugs were cleared in the first week of April followed by the second release made in the first week of March. In the unreleased plot, the mealybug population had built up steadily to 424.5 mealybugs/leaf in the first week of April. The mealybug ceased to be a problem from April onwards in the released plot whereas it posed a severe problem in the unreleased plot.

Safety of pesticides to citrus butterfly parasitoid, *Apanteles papilionis*, pomegranate whitefly parasitoid, *Encarsia azimi* and the coccinellid predator, *Chilocorus circumdatus*

Apanteles papilionis

Potted citrus plants were sprayed with 24 pesticides and the adults of *A. papilionis* were exposed to the treated leaves. All the synthetic insecticides proved highly toxic even six hours after exposure. Neemark proved highly toxic causing 100% mortality 24 hours after exposure on the day of spraying among botanicals. The remaining pesticides (fungicides, acaricides, antibiotic and *B. thuringiensis*) were found safe to the parasitoid (Table 8).

Table 8. Toxicity of different pesticides to *Apanteles papilionis*

Treatment/conc.	Adult mortality (%) (hours after exposure)			
	1	3	6	24
Monocrotophos 0.05%	0	80	100	100
Phosalone 0.07%	0	60	100	100
Carbaryl 0.1%	0	100	100	100
Dimethoate 0.05%	0	100	100	100
Chlorpyrifos 0.05%	100	100	100	100
Fenvalerate 0.01%	20	80	100	100
Deltamethrin 0.01%	0	100	100	100
Cypermethrin 0.05%	0	100	100	100
Sulphur 0.2%	0	0	0	100
Dicofol 0.05%	0	0	0	0
Copper oxychloride 0.2%	0	0	0	0
Neem seed extract 2%	0	0	0	0
Neem oil 2%	0	0	0	0
Neem cake 2%	0	0	0	0
Nimbicidin 2%	0	0	0	0
Neemark 2%	0	0	0	100
Neemguard 2%	0	0	0	0
Repelin 2%	0	0	0	0
Pongamia oil 2%	0	0	0	0
Pongamia seed extract 2%	0	0	0	0
Mahua oil 2%	0	0	0	0
Castor oil 2%	0	0	0	0
Bacillus thuringiensis	0	0	0	0
Streptomycin sulphate	0	0	0	0

In another study on the residual toxic of ten pesticides to the adult parasitoid, leaves from treated plants were removed and exposed to the parasitoids at weekly interval. Neemark proved non-toxic to *A. papilionis* one day after treatment. There was no mortality of the adult parasitoids when exposed to leaves treated with phosalone, dimethoate, chlorpyriphos and

sulphur on 14th day. Cypermethrin remained toxic to *A. papilionis* even beyond 28 days.

The cocoons of *A. papilionis* were sprayed with monocrotophos 0.05%, carbaryl 0.1%, chlorpyriphos 0.05%, deltamethrin 0.01%, sulphur 0.2%, copper oxychloride 0.2%, Neem oil 2%, Neemguard 2%, Pongamia oil 2%, Mahua oil 2% and *Bacillus thuringiensis*, and the adult emergence from the treated cocoons was counted. Chlorpyriphos proved most toxic and no adult emergence was observed while in water spray 100% adult emergence was noticed. Fenvalerate, deltamethrin, carbaryl, copper oxychloride and cypermethrin were other toxic pesticides.

Chilocorus circumdatus

Fourteen pesticides *viz.*, monocrotophos 0.05%, phosalone 0.07%, carbaryl 0.1%, dimethoate 0.05%, cypermethrin 0.05%, sulphur 0.2%, dicofol 0.05%, Neem seed extract 2%, Neem oil 2.0%, methyl demeton 0.05%, quinalphos 0.05%, fenvalerate 0.01%, deltamethrin 0.01% and phosalone 0.05% were tested against the adults of *C. circumdatus*. The adults were exposed to the treated citrus leaves and mortality was recorded at 1, 3, 6 and 24 hrs after exposure.

The results indicated that fenvalerate 0.01%, deltamethrin 0.01% and phosalone 0.07% gave quick knock down effect on the coccinellid beetle causing 100% mortality within an hour of exposure. The remaining insecticides also proved toxic to the adults at 24 hrs of exposure. However, the adults were not affected by neem seed kernel extract, neem oil, sulphur, and dicofol. Other study on the residual toxicity of five commonly used pesticides in citrus ecosystem revealed dichlorvos to be least persistent causing no mortality 1 day after exposure. The adults were not affected with dimethoate, when exposed seven days after treatment. Monocrotophos and cypermethrin were more persistent causing mortality even after 28 days.

Encarsia azimi

The study on the residual toxicity to *E. azimi* included eight commonly used insecticides. Dichlorvos (0.1%) was found non-toxic to the adult parasitoids one day after treatment. There was no mortality of parasitoids

with endosulfan on 7th day of treatment. Monocrotophos, deltamethrin and phosalone were found non-toxic 14 days after application. However, cypermethrin alone proved detrimental.

Seasonal incidence of the pomegranate whitefly and its natural enemies

The activity of the whitefly *Siphoninus phyllireae* and its natural enemies was observed from February, 1995 to March, 1996. The whitefly infestation was found more from February to May and less in the remaining months.

Only the aphelinid, *Encarsia azimi* was found emerging from the pomegranate whiteflies. Regular sampling yielded large number of the aphelinid parasitoids up to May. Parasitism by *E. azimi* was initially low in February (40%) and progressively increased in the subsequent months upto June (92.36%). In other months, whitefly infestation itself was low and no activity of the parasitoid was observed.

Studies on the parasitoids of pomegranate butterfly *Deudorix* (=*Virachola*) *isocrates*

Deudorix isocrates is a serious pest of pomegranate. A search was made for its natural enemies in pomegranate orchards around Rahuri in September, 1995. The eggs of *D. isocrates* were found parasitized (70%) by *Ooenyrtus papilionis* (Encyrtidae).

***Aulacaspis tubercularis* and its natural enemies on mango**

The diaspine scale, *A. tubercularis* was observed on five year old Totapuri plants at IIHR Farm in September, 95. The scale population and its natural enemies were monitored from September, 1995 to January, 1996. Observation recorded on scale and its natural enemies revealed that higher population of scale was found in September and early part of October, and it drastically reduced thereafter. A mean population of 39 cm^2 in September was reduced to 3/cm^2 in January. During this period, a total of eight natural enemies; two parasitoids and six predators were found attacking the mango scale. The parasitoids included an aphelinid, *Pteroptrix koebelei* and an undetermined pteromalid. The former was abundant during September - December and the later was observed only on one occasion in the first week of November,

1995. The parasitism went up to 96.6% and the parasitoids was found mainly responsible for the suppression of *A. tuberculariis*. The predators included *Chilocorus circumdatus*, *C. nigrita*. *Scymnus* sp., *Mallada boninensis*, *Triommata coccidivora* and an undetermined coccinellid. *C. circumdatus*, *C. nigrita* and *Scymnus* sp. were found in adult and larval stages feeding on all the stages of the scales from September to December.

Pseudococcus longispinus and its natural enemies on guava

The long tailed mealybug, *P. longispinus* was observed in July-September 1995. Three predators *viz.*, *Scymnus* sp., *Triommata coccidivora* and *Cheilomenes sexmaculata* were found feeding on the mealybug.

Planococcus citri

The first incidence of *P. citri* was observed in sapota in biocontrol plot in January, 1996. The encyrtid, *Coccidoxenoides perigrinus* was observed emerging from *P. citri*. By the middle of February, 96 the mealybug had disappeared due to the activity of *C. perigrinus*.

The appearance of *P. citri* was also observed on sapota plants in Entomology plot in the first week of March, 96. Samples were collected regularly and the populations of the mealybug and the number of parasitoids emerged were recorded. The mealy bug population had declined from 112.41 (11th March) to 2.16/shoot (4th April). The decline in the mealybug population was attributed mainly to the activity of the encyrtid parasitoid *L. dactylopii*. The emergence of the parasitoid was observed from all the samples and number of parasitoids emerged ranged from 42.38-5.30/4 shoots.

Recovery of natural enemies from _Planococcus citri_ infesting pomegranate

Pomegranate fruits were found covered with the mealybugs in the first week of March, 1996 at IIHR Farm. Five mealybug infested fruits from each plant were collected and kept in cages to record the activity of natural enemies. Sampling was done on five selected mealybug infested plants. All the samples yielded the encyrtids, *Leptomastix dactylopii* and *Coccidoxenoides peregrinus* in large numbers. The drosophilid predator,

Cacoxenus perspicax was collected in negligible numbers. The recovery of *L. dactylopii* in 1996 revealed that the exotic parasitoid (released in 1983) has permanently established at IIHR Farm. Though *L. dactylopii* and *C. perigrinus* were found together, the latter played a dominant role in suppressing *P. citri*. The mealybug ceased to be a problem by the last week of March and in subsequent months in pomegranate orchards.

Seasonal incidence of woolly aphid (WA), *Eriosoma lanigerum* and its natural enemies

Seasonal incidence of the WA in terms of average colony size, number of aphid colonies and coverage of the aphid (in cm) on the marked twigs was recorded throughout the year at weekly interval at Nauni, Solan. The parasitoid, *Aphelinus mali* was introduced in 1991. The WA population was negligible (0-0.1 cm coverage/replicate) from April, 1995 till mid June and so was the natural enemy activity. During this period, max. and min. temperature fluctuated between 23.4-37.4°C and 9.1-26.3°C and rainfall varied from 0 to 19.6 mm. Increase in the colony number began in the third week of June and by mid July the av. coverage was 4 cm. The natural enemies' (chrysopids, syrphids and *A. mali*) activity commenced, simultaneously. Population of the WA was at peak in August (>10 colonies/replicate, each colony 0.5-0.6 cm and coverage being above 6 cm) and remained high till mid September, 1995. *A. mali* population was high during the period. The mean max. and min. temperature during end of June to mid September was 24.7-29.0°C and 18.3-23.8°C and the rainfall was 1121 mm out of 1498 mm. WA coverage began declining in second half of September and was nil by December on the aerial portion of the tree. During the period, mean temperature declined (max. 28.3 to 16.8°C and min. 18 to 3.8°C). However, the parasitoid activity continued. Population remained low (coverage <0.5 cm) till March end (1996). Emergence of adults of *A. mali* from the mummified WA commenced in the first week of March, 96 when colony size of the aphid (third instar and adults) was 0.1 to 0.38 cm. Overall emergence from the overwintering lot was 77.4 per cent and female:male sex ratio was 1.5:1.

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

Among predators, adults of *Pharoscymnus flexibilis* and *Sticholotis marginalis* were common in mid hills. Their progeny was rarely seen on trees. Wherever dense scale population existed, *Chilocorus bijugus* adults were often noticed. Their grubs were encountered on dense population of the San Jose scale (SJs) in July-August in Shimla and Solan districts. However, parasitism was of common occurrence. In surveys undertaken in selected orchards at Naggar (Kullu), Nauni (Solan) and Kotkhai (Shimla), parasitism by *Aphytis* sp. (the *proclia* group) was a regular feature. Samples of scale infested twigs containing all stages of the San Jose scale were collected at monthly interval and observations on parasitisation were recorded. Average parasitization at Solan and Kotkhai was 6.1 and 6.7 per cent, respectively. Higher av. parasitization was noticed at Naggar. These observations revealed that in samples collected from Naggar and Kotkhai the cumulative parasitization was more during October to December, while at Nauni, the parasitization was more in January-March. Out of 8608 scale insects, 1.2 per cent (II instar) and 22.2 per cent (III instar - adult) scales were parasitized by *Aphytis* sp.; the overall parasitization being 0.4 and 7.2 per cent, respectively. Hyper-parasitization of the *Aphytis* sp. was observed at Kullu by an encyrtid endoparasitoid and one sample of *Encarsia* sp. was also obtained as a parasitoid of *Aphytis* sp. Hyperparasitization (on basis of the SJs population) was 2.2, 1.4, 1.0, 0.5 and 1.3 per cent in September, October, December (1995), February and March (1996), respectively. In all these samples, parasitization by *Encarsia perniciosi* was rarely observed.

Studies on *Aphytis* sp. (*proclia* group) parasitizing the San Jose scale

Aphytis sp. (the *proclia* group), reared on San Jose scale and collected from the Kullu valley, was exclusively thelytokous. Comparison of characters reveals the species to be close to *hispanicus*, which as per literature is a palaearctic species. It has preference to parasitize third instar (adult) female, and rarely laid an egg on late second instar female scales.

Newly emerged adult female made random search to locate host for feeding and it fed on male (II instar, prepupa and pupa) as well as female scales (II and III instar). Preoviposition period lasted for about 2 days at 25°C and adult provided with honey containing equal amount of Protinex

survived for 6-9 days. For egg laying, the female selected appropriate adult female scale, thrusted its ovipositor into the scaly armature and laid an egg on the dorsum of the body. Rarely two eggs per scale body were noticed. The time taken for one oviposition was 160 to 294 seconds.

The pearly translucent oval egg was glued on to the tergum. It hatched in 2-3 days at 25°C. The egg on an average was 0.134 mm long and 0.088 mm broad with a distinct pedicel at the anterior end. The newly hatched larva was more or less globular. The first instar lasted for 1-2 days.

The body size of first instar larva varied from 0.1-0.31 mm x 0.11-0.22 mm. The second instar larva grew from 0.28 to 0.53 mm in length and from 0.25 to 0.36 mm in breadth. The third instar larva increased from 0.55 to 0.76 mm in length and 0.38 to 0.52 mm in width and became full fed (III instar) in 7-10 days. The prepupal stage was of 2-3 days while pupal duration lasted for 5-6 days. Hence, one generation (egg to adult emergence) was completed in 17-22 days. Adult longevity was 6-9 days.

In the laboratory, the parasitoid completed a maximum of 12 generations. Duration of development was 17-19 days during April- third week to September when temperature fluctuated between 20-34°C and seven generations were completed in this period. The duration of development got prolonged to 23-27 days in March-April and September-October when diurnal temperature was in the range of 18-30°C. In October-November and mid-February to March-end the duration was 31-43 days at a temperature regime of 12-26°C.

1.2.10 Biological suppression of vegetable crop pests

Identification of natural enemies of vegetable crop pests

The survey conducted in and around Hessaraghatta for natural enemies of important vegetable crop pests resulted in two new records of *Leptomastix nigricoxalis* and *L. lyciae* on brinjal mealybug, *Coccidohystrix insolita*. A parasitisation level of 51% by *Cotesia plutellae* on *Plutella xylostella* indicates that the parasitoid is a potential one.

Seasonal incidence of *Pieris* spp on cauliflower and their natural enemies

At Solan, *Pieris rapae* adults were seen on wings in cauliflower fields during March and egg laying commenced from 12th standard week and pupal formation from 17th standard week. The pest could infest 44.7% of the plants. Larval parasitism by *Cotesia glomerata* was observed to range from 30.6 to 70.8% and by *Hyposoter ebenicus* was very low (6%). Disease incidence up to 12% was observed. Hyperparasitoid, *Baryscapus (=Eutetrastichus)* could parasitise 18.8% cocoons of *C. glomerata*.

Evaluation of *Trichogramma pretiosum* against *Helicoverpa armigera*

At IIHR, Bangalore seven releases of *T. pretiosum* were made on variety Roopali for control of *H. armigera* and 60.63% of egg parasitism was obtained in the treated plot. The borer damage was 2.5% and 14.7% in the treated and control plot, respectively.

Release of *T. pretiosum* @ 50,000 parasitised eggs at weekly interval to control *H. armigera* on tomato (variety Naveen) at Solan resulted in 40-45% parasitism of *H. armigera* eggs.

Release of *T. pretiosum* @ 50,000/ha on tomato at Gujarat resulted in 47.34% parasitism as compared to 8.34 in control. The fruit damage in the treated and control plots was 5.69% and 24.23%, respectively. The larval population was also significantly lower in the treated plot (0.32/plant) in comparison to the control plot (0.6/plant).

Evaluation of *T. pretiosum* and *Bt* on *H. armigera* on tomato

Bacillus thuringiensis var *kurstaki* (Delfina) sprayed @ 1 and 1.5 kg/ha was found to be effective in providing 63.7% larval mortality of *H. armigera* on tomato at Solan. Combined treatment of *Bt* at 1 kg/ha and *T. pretiosum* @ 50,000 parasitised eggs/ha showed significant effect only after the third combined treatment where the larval population was 6.7/80 plants as against 35.3/80 plants in control. This indicates the effectiveness of alternate treatments involving *T. pretiosum* and *Bt* var *kurstaki*.

Field evaluation of *Trichogrammatoidea bactrae* against *Plutella xylostella*

Release of *T. bactrae* against *P. xylostella* at 3 dosages (*viz.*, 3, 6 and 9 lakh adults/ha) at Bangalore on cabbage resulted in very low parasitism rates and there was no significant difference in the yield data between the treated and control plots. However, in the treated plot, the damage due to *P. xylostella* remained low.

Field evaluation of *Trichogramma chilonis* against *Earias vittella* on okra

T. chilonis could parasitize 80-100% *E. vittella* eggs in the laboratory. But even at large dosages like 2,50,000 adults/ha at Bangalore no parasitism could be recorded under field conditions.

Effect of different temperatures on *Trichogrammatoidea bactrae*

Developmental period of *T. bactrae* at 35°C was very short (7 days), but per cent emergence and survival was very low at this temperature. At 30°C, 90% emergence was recorded.

Efficacy of sporeless mutant *Btk* against *Plutella xylostella* on cabbage

M*Btk* @ 300 g ASP/ha effectively suppressed *P. xylostella* population. The highest yield of marketable cabbage was also obtained from M*Btk* treatment (38.25 t/ha) while Dipel 8L treatment yielded 36.00 t/ha, endosulfan treatment 31.7 t/ha and control 20.05 t/ha. When M*Btk* spray was alternated with NSKE 4% an yield of 32.8 t/ha was obtained.

Combined efficacy of sporeless mutant *Btk* with *Trichogrammatoidea bactrae* against *Plutella xylostella* on cabbage

M*Btk* @ 300 g/ha with *T. bactrae* @ 4 lakhs/ha and NSKE + *T. bactrae* (4 lakhs/ha) suppressed *P. xylostella* population on cabbage at Hessaraghatta effectively (1.28 and 2.01, respectively) while in the control the population was 28.50. M*Btk* @ 300 g/ha with *Trichogramma* provided the highest yield of 33.2 t/ha followed by NSKE + *Trichogramma* treatment (30.1 t/ha). Treatment with M*Btk* @ 150 g/ha + *Trichogramma* and control recorded lower yields of 26.75 t/ha and 20.65 t/ha, respectively.

Analysis of constitutive polypeptides of NPV isolated from *H. armigera* by SDS - PAGE

The isolate specific polypeptides of *Ha*NPV (IIHR isolate) was studied by SDS-PAGE. A total of 16 viral polypeptides could be identified. Among these, the molecular weights of eleven polypeptides match with obtained earlier for *Ha*NPV. Five polypeptides were specific to IIHR isolate and the most abundant was that of polyhedrin (30 kD).

1.2.11 Biological suppression of potato pests

Effectiveness of bioagents in comparison with the recommended insecticides for the suppression of potato pests

Release of parasitoids *viz.*, *Chelonus blackburni* and *Copidosoma koehleri* alone or in combination with the alternate sprays of granulosis virus recorded 6.3 to 7.95% infestation while *Bacillus thuringiensis* and endosulfan treatments recorded 9.38 and 8.79% infestation, respectively. The infestation in these treatments were significantly lower than noticed in untreated control.

Effectiveness of initial release of parasitoids under country storage (Arni)

Country stores where *Chelonus blackburni* and *Copidosoma koehleri* were released recorded 17.97 and 20.80% infestation, respectively which was significantly lower than that in the Arni where no releases were made (45.42%). Subsequent release of *C. blackburni* and *C. koehleri* could give 60.43 and 50.47% control, respectively.

Host searching capacity of *Chelonus blackburni* and *Copidosoma koehleri* in country store (Arni)

Both the parasitoids (*C. blackburni* and *C. koehleri*) were able to move in the country store and reach a depth 1 metre where infested tubers were placed. Nine cocoons of *C. blackburni* and 6 mummies of *C. koehleri* were recovered from the tubers kept at a depth of 1 metre in the `Arni'. Seventeen cocoons of *C. blackburnii* and 11 mummies of *C. koehleri* were recovered from the infested tubers kept at a depth of 50 cm. Both these observations revealed that the paraitoids were more at lower depth.

Studies on cost of production of *Copidosoma koehleri*

The cost of production of *C. koehleri* at present rates of ingredients is Rs.304/ha, which could be minimised further by large scale production.

Persistent toxicity of some pesticides to potato tuber moth parasitoids

Quinalphos 0.05% was highly toxic to *Copidosoma koehleri* resulting in 87.57% adult mortality followed by carbaryl (85.43%), dimethoate (78.81%), methyl demeton (74.74%), fenvalerate (62.35%) and endosulfan (68.51%).

Seasonal occurrence of natural enemies of potato tuber moth

Two parasitoids *viz., Apanteles* sp. and *Bracon* sp. and also two new unidentified hymenopterous parasitoids were recorded from foliage feeding potato tuber moth larvae in both kharif and rabi seasons. Besides these, a beetle has also been noticed in the samples collected from godowns which could feed well on the eggs of potato tuber moth. These beetles could consume on an average 22 eggs of potato tuber moth/day.

Efficiency of *Trichogramma chilonis* at different periods of storage

Cent per cent parasitisation was noticed in the treatment where *T. chilonis* was stored for 5 days at 10°C which was followed the treatment in which the parasitoids were stored for 15 days (94.5%), 10 days (89.0%) and 20 days (84.5%). About 50% of eggs of *Corcyra cephalonica* were found to be parasitised by *T. chilonis* stored for 25 days at 10°C.

1.2.12 Biological suppression of weeds

Parthenium

Feeding tests conducted at IIHR, Bangalore with *Zygogramma bicolorata* adults on sunflower revealed that feeding initiation was positively correlated with age of adult and survival negatively correlated. Five to forty five day old adults laid 11.2-21.8 eggs/female for 1-6 days after they are collected from parthenium and released on sunflower and no subsequent egg laying was observed. Adults not fed on parthenium laid viable eggs after feeding on

sunflower, however, number of eggs laid were non-significant. Development of indirect flight muscles, ovaries and testes was similar in 0, 5, and 10 days old adults fed on sunflower or parthenium. Sunflower fed adults had thin ovarioles, shrunken testes compared to those fed on parthenium. Trichomes on sunflower leaves were found to prevent feeding of newly hatched larvae. Under cage conditions it was found that *Z. bicolorata* completed development on sunflower with leaves of seedling stage plants. Further they were incapable of breeding continuously. Surveys in farmers' fields in Karnataka revealed no feeding of *Z. bicolorata* on sunflower. Feeding was observed only in fields where defoliated stand of weed was located adjacent to the crop. The beetle was capable of entering diapause once in life term even in the presence of abundant food. Diapausing adults had diffused ovarioles, testes, body cavity filled with fat globules, flight muscles as thin strands and gut devoid of any contents.

Cyperus rotundus

Bactra venosana was found to cause 75% damage to the weed in field. Damaged tubers were incapable of regeneration.

Water hyacinth

At AAU, Jorhat studies were taken up on biological suppression of water hyacinth with *Neochetina eichhorniae* and *N. bruchi*. The intensity of leaf damage ranged from 57-136% in different areas. At Pune the % damage ranged from 20-70.

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Singh, S. P., M.Sc.(Ag.), Ph.D	Project Director

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Bhumannavar, B. S., M.Sc.(Ag.)	Sr. Scientist (Agri. Ent.) & Lab Chief
* Ballal, C. R., M.Sc., M. Phil	Scientist (SS) (Agri. Ent.)
Ramani, S., M.Sc.(Ag.)	Scientist (SS) (Agri. Ent.)

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Joshi, Sunil, M.Sc.(Ag.)	Scientist (Agri. Ent.)
Pushpalatha, N. A., M.Sc.(Ag.), Ph.D	Scientist (Agi. Ento.)

Pathology Laboratory

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Kalidurai, M., M.Sc.(Ag.)	Scientist (Microbiology)
Sreerama Kumar, P., M.Sc.(Ag.)	Scientist (Pl. Path.)

Entomophagous Insect Behaviour Laboratory

Bakthavatsalam, N., M.Sc., Ph.D	Scientist (SS) (Agri. Ent.) & Lab. Incharge

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Biswas, S. R., M.Sc.	Sr. Scientist (Stat.)

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Dasan, C. B., B.Sc.(Ag.)	Technical Officer (T5)
Narayana Rao, M., Dip. in Cinematography (LCT), Dip. in Radio, TV & Audio Tech.	Technical Officer (T5) (Photography)

* On study leave

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Dr. N. S. Rao Sr. Scientist (Ent.)	Member	Mr. Ramakrishnaih Mali	Member (Elected)
Dr. N. Bakthavatsalam Scientist (SS)	Member (Elected)	Mr. S. R. Biswas Sr. Scientist (Stat.)	Member Secretary
Mrs. S. S. Kadam Technical Officer (T5)	Member (Elected)		

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Mr. S. K. Jalali Scientist (SS) (Ent.)	Member	Mr. Madan Paswan Jr. Clerk (Hindi Typist)	Member
Mr. S. Ramani Scientist (SS) (Ent.)	Member	Mr. S. R. Biswas Sr. Scientist (Stat.)	Member Secretary

BUDGET FOR THE YEAR 1995-96 (Rs. in lakhs)

Head	Plan	Non-plan	Total
Establishment	10.81	17.45	28.26
T.A.	1.50	0.75	2.25
Works	16.38	0.25	16.63
Other charges including equipments	53.19	5.00	58.19
Other items	1.30	0.0	1.30
Total	83.18	23.45	106.76

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30. Narayanan, K. and Vennila, S. 1996. Studies on the live larval sexing of some lepidopterans with particular reference top its impact on the *in vivo* multiplication of nuclear polyhedrosis virus of *Spodoptera litura* (F.) for its control. *J. Appl. Zool. Res.* **6:** (in press).

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44. Sohi, A. S., Brar, K. S., Singh, J., Shenhmar, M. and Brar, D. S. 1996. Host searching range of *Trichogramma chilonis* Ishii in cotton crop. *Insect Environ.* **1**(4):27.

45. Varma, G. C. and Shenhmar, M. 1994. Role of parasitoids and predators in the insect pest management. In *Biological Control of Insect Pests* (Geol, S. C. ed). *Uttar Pradesh Zoological Society* Muzaffarnagar, pp 1-6.

46. Yadav, D. N. 1996. Ecofriendly approaches for insect pest management. Paper presented at *Indian Science Congress* held at Patiala. January 3-8, 1996.

PARTICIPATION IN SEMINARS/MEETINGS/SYMPOSIA/WORKSHOPS

Dr. S. P. Singh attended the following :

Participated in the panel discussion on the topic `Role of Biocontrol agents in natural suppression of pests in vegetables' as a resource person at Directorate of Plant Protection, Faridabad.

Attended XXX All India Rice Research Group Meeting held at Directorate of Rice Research, Rajendranagar, Hyderabad from 9th to 12th April, 95 and Co-chaired a session in which Entomology programmes were discussed and finalised.

Participated in the second meeting of the Project Monitoring Committee of the Mission Mode Project on Development, Production and Demonstration of Biocontrol Agents under IPM at Department of Biotechnology, GOI, New Delhi on 22.8.95. The progress of the ongoing projects was reviewed and feasibility of funding new ones was discussed.

Attended workshop on `Biological Control as a Cornerstone of IPM for Sustainable Agriculture in Southeast Asia' held at Agriculture University, Serdang, Malaysia from 11th to 15th September, 95 and presented an invited paper entitled `Experiences in classical biological control in India'.

Attended 4th Meeting of the Task Force on Biological Control of Plant Pests, Diseases and Weeds held on 15th and 16th November, 95 in DBT Conference Room at New Delhi.

Participated in the Group Discussion of All India Coordinated Research Project on Tropical Fruits held at Punjab Agricultural University, Ludhiana from 27th to 29th November, 95. Chaired a session on `Pest Management'.

Attended National Symposium on Biotechnological Inputs in Insect-Plant Interactions held at Loyola College, Madras on 14th December, 95. Presented an invited paper entitled `Host plant-host-entomophage interactions: some biotechnological considerations'.

Participated in the 83rd session of the Indian Science Congress Association held at Punjabi University, Patiala from January 3-7, 1996 and presented an invited paper entitled `Prospects of Biological Control by AD 2000 and Beyond' on 6.1.96.

Attended second review meeting for *Heliothis* network project on 17th and 18th January, 96 at UAS Dharwad as resource person. Co-Chaired a session on IPM. Prepared a programme of work on Biointensive Integrated Pest Management.

Participated in the Task Force Meeting of Mission Mode Projects of Department of Biotechnology on 19th February, 96.

Others :

Dr. S. P. Singh, Dr. K. Narayanan, Dr. N. S. Rao, Mr. S. R. Biswas, Mr. B. S. Bhumannavar, Dr. N. Bakthavatsalam, Mr. S. Ramani, Dr. T. Venkatesan, Mr. Sunil Joshi and Dr. N. Pushpalatha attended the Fifth Biocontrol Workers' Group meeting from 2 -3 November, 1995.

Mr. S. Ramani attended the convention on coffee berry borer organised by the Coffee Board at Siddapur on June 10, 1995 and delivered a lecture on the "Biological control of the coffee berry borer" and participated in the discussion on the role of natural enemies.

Dr. K. Narayanan attended the workshop on "Biotechnology Genome -96" 27-30 th January, 1996 organized by Rotaract Club of Bangalore, Jayanagar, Bangalore.

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Shri G. S. Sahni, Secretary (ICAR) & Joint Secretary (DARE), Krishi Bhawan, New Delhi

Shri N. Rangasamy, Hon'ble Minister for Agriculture, Pondicherry.

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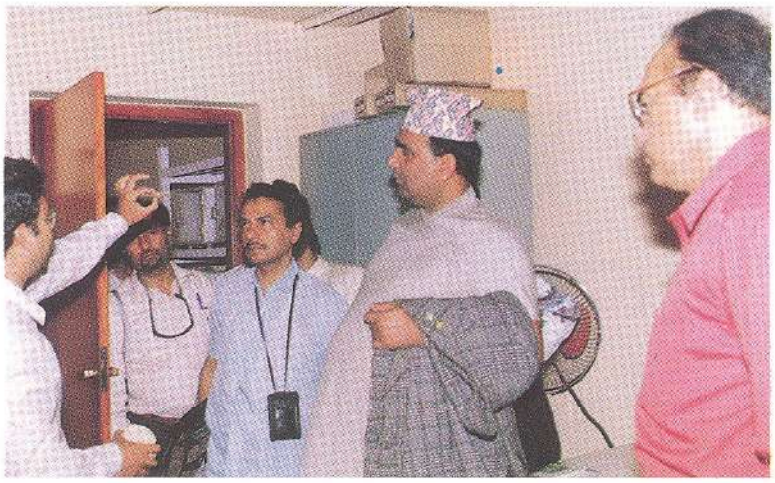
Dr. S. Lingappa, Professor and Head, Department of Entomology, UAS, Dharwad-580 005



Shri Radha Krishna Mainali, Hon'ble Minister of Agriculture, Govt. of Nepal being explained the research activities by Dr. S. P. Singh, Project Director, PDBC

Dr. Robart J. Williams, DDG (Scientific Services), CABI, UK visited for collaboration

Participants and invitees at Fifth Biocontrol Workers' Group Meeting

Productivity week celebrated by organising training on mass production of biocontrol agents

IMPRESSION ABOUT US!

"Very much impressed - KVKs should impart this information to farmers"

Shri Chaturanan Mishraji
Hon'ble Union Minister of Agriculture
Government of India

"It is always a pleasure to see the most impressive work and the facilities at this Project Directorate. Most important aspects on biological control 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 the success in their endeavour."

Dr. R. S. Paroda
Director General (ICAR) & Secretary (DARE)
Government of India

"A fascinating view of the wonderful work of biological control. I am most impressed with the practical achievements of the team. All best wishes for future success."

Dr. Robert J. Williams
DDG (Scientific Services)
CAB International, UK