RPF-III

PERFORMA FOR SUBMISSION OF FINAL REPORT OF RESEARCH PROJECTS

Part-I : General Information

800 Project Code :

8001 Institute Project Code No. : Biocontrol I.2 (813)

8002 ICAR Project Code No.: -

801 Name of the Institute and Division

8011 Name & address of Institute : Indian Institute of Spices Research
Calicut – 673 012, Kerala.

8012 Name of Division / Section : Crop Protection / Entomology

8013 Location of the Project : Calicut, Kerala.

802 Project title : Biological control of insect pests of spice crops

803 Priority area : Crop Protection

8031 Research approach :

Applied Research	Basic Research	Process or Technology Development	Transfer of Technology
✓	✓	✓	✓

804 Specific area : Spices-Entomology

805 Duration of Project : 13 years

8051 Date of start : April 1992

8052 Date of completion : March 2005

806 Total cost / Expenditure incurred : Rs. 15,96,135

807 Executive summary

The natural enemies of major insect pests of spice crops were documented. The potential biocontrol agents identified include the coccinellid predator *Chilocorus circumdatus* and the hymenopterous parasitoid *Encarsia lounsburyi* on scale insect, the entomophagous fungus *Metarrhizium anisopliae* on root mealybug and the hymenopterous parasitoid *Apanteles cypris* on top shoot borer infesting black pepper. The entomophagous nematode *Hexamermis* sp. and the hymenopterous parasitoid *Apanteles taragamae* were identified to be potential biocontrol agents of shoot borer infesting ginger. Technologies were developed for the integrated management of *pollu* beetle of black pepper and shoot borer and rhizome scale of ginger and turmeric. The pollu beetle can be managed by shade regulation and spraying endosulfan 0.05% during July and three rounds of neem product (Neemgold 0.6%) during August, September and October. The shoot borer on ginger and turmeric can be managed by spraying a *Bacillus thuringiensis* product such as Dipel 0.3% at monthly intervals during July to October. The shoot borer can also be managed on ginger by pruning of infested shoots at fortnightly intervals during July–August and spraying malathion 0.1% during September–October. The rhizome scale can be managed during storage by dipping seed rhizomes in quinalphos 0.075% and storing in dried leaves of *Strychnos nuxvomica* or *Glycosmis pentaphylla*.

808 Key words

Biological control, integrated pest management, spice crops, insect pests.

Part-II : Investigator Profile

(Please identify clearly changes, if any in Project personnel)

810 Principal Investigator

8101	Name	: S. Devasahayam
8102	Designation	: Principal Scientist
8103	Division / Section	: Crop Protection
8104	Location	: Calicut, Kerala
8105	Institute Address	: Indian Institute of Spices Research Calicut-673 012, Kerala.

811 Co-Investigator

8111	Name	: K. M. Abdulla Koya
8112	Designation	: Scientist (Selection Grade)
8113	Division / Section	: Crop Protection
8114	Location	: Calicut, Kerala
8115	Institute Address	: Indian Institute of Spices Research Calicut-673 012, Kerala.

812 Co-Investigator

8121	Name	: T. John Zachariah
8122	Designation	: Senior scientist
8123	Division / Section	: Crop Production
8124	Location	: Calicut, Kerala
8125	Institute Address	: Indian Institute of Spices Research Calicut-673 012, Kerala.

813 Co-Investigator

8131	Name	: T. K. Jacob
8132	Designation	: Senior Scientist
8133	Division / Section	: Crop Protection
8134	Location	: Peruvannamuzhi, Kerala
8135	Institute Address	: Indian Institute of Spices Research Calicut-673 012, Kerala.

Part-III: Technical Details

820 Introduction and objectives

8201 Project objectives

To develop biological control technologies for the integrated management of major insect pests of black pepper, ginger and turmeric.

8202 Background information and importance of the project

Infestation by insect pests is a major factor responsible for the low productivity of spice crops in the country. A number of insect pests have been recorded on various spice crops among which pollu beetle (*Longitarsus nigripennis*), scale insects (*Lepidosaphes piperis* and *Aspidiotus destructor*), top shoot borer (*Cydia hemidoxa*), root mealybug (*Planococcus* sp.) on black pepper, shoot borer (*Conogethes punctiferalis*) and rhizome scale (*Aspidiella hartii*) on ginger and turmeric are important. All the major insect pests are controlled at present by application of insecticides alone. Since spices are high-value and export-oriented in nature, it is imperative that the residues of pesticides are kept below permissible levels in the produce. Hence, development of integrated pest management schedules in which biological control forms a major component is important. The technologies that would be developed would depend on insecticides to a lesser extent only and thus help in increasing the productivity of the crop with minimum damage to the ecosystem.

821 Project technical profile

8211 Technical programme

(Indicate briefly plan of procedure, techniques, instruments and special materials, organisms, special environments etc.)

a. Documentation of natural enemies of insect pests of major spice crops.
b. Studies on bioecology of major natural enemies.
c. Evaluation and development of biocontrol and integrated pest management technologies.

8212 Total man months involvement of component project workers

a) Scientific : 69 months
b) Technical : 48 months
c) Supporting : 40 months

822 Final report on the Project

Detailed report containing all relevant data with a summary of results (not exceeding 2-5 pages)

Documentation of natural enemies of insect pests of spice crops

The natural enemies of insect pests of black pepper, ginger, turmeric, cinnamon and clove were documented.

Table 1. Natural enemies of insect pests of spice crops

Crop / Insect pest	Natural enemy	Order / Family
Black pepper		
Longitarsus nigripennis	Genus et sp. indet.	Mermithidae
	Genus et sp. indet.	Araneae
	Oecophylla smaragdina	Formicidae
Lepidosaphes piperis and	Genus et sp. indet.	Heteroptera
Aspidiotus destructor	Genus et sp. indet.	Coleoptera
	Genus et sp. indet.	Coleoptera
Pseudococcus sp.	*Leptacis* sp.	Platygasteridae
Planococcus sp.	*Blepyrus insularis*	Encyrtidae
	Genus et sp. indet.	Hymenoptera
	Genus et sp. indet.	Coleoptera
	Genus et sp. indet.	Diptera
Protopulvinaria longivalvata	*Cocophagus ceroplastae*	Aphelinidae
Ginger and Turmeric		
Conogethes punctiferalis	*Hexamermis* sp.	Mermithidae
	Bracon sp.	Braconidae
	Apanteles taragammae	Braconidae
Aspidiella hartii	*Cocobius* sp.	Aphelinidae
	Genus et sp. indet.	Coleoptera
	Genus et sp. indet.	Formicidae
Lasioderma serricorne	*Anisopteromalus calandrae*	Pteromalidae
Clove		
Pulvinaria psidii	*Megommata* sp.	Cecidomyiidae
Cinnamon and Cassia		
Conopomorpha civica	*Elasmus* sp.	Elasmidae
	Sympiesis dolichogaster	Eulophidae

Seasonal incidence of natural enemies of top shoot borer

The seasonal incidence of hymenopterous parasitoids such as *Apanteles cypris* and *Goniozus* sp. parasitising top shoot borer larvae infesting black pepper was studied at Peruvannamuzhi. Both the parasitoids occurred in the field during September to November. Peak parasitism by *A. cypris* (20.0%) and *Goniozus* sp. (6.7%) occurred during October.

Seasonal incidence of natural enemies of scale insects

The seasonal incidence of coccinellid predators such as *Cybocephalus* sp. and *Chilocorus circumdatus* and hymenopterous parasitoid such as *Encarsia lounsburyi* on scale insect infesting black pepper was studied at Kalpetta. Populations of *Cybocephalus* sp and *E. lounsburyi* occurred almost throughout the year with higher populations during May and September–October, respectively. The population of *C. circumdatus* was relatively lower when compared to the other two natural enemies and was higher during January–February.

Evaluation of microbial pathogens against *pollu* beetle

A commercial formulation of *Bacillus thuringiensis* (Dipel) was evaluated against adult *pollu* beetle in laboratory bioassays at 0.05% to 1.00% concentrations. However, significant mortality of beetles was not observed in any concentration even after 10 days of treatment.

Laboratory bioassays were conducted to evaluate the pathogenecity of *Beauvaria bassiana*, *B. brongniartii*, *Metarhizium anisopliae and Verticillium chlamydosporium* obtained from various sources against adult *pollu* beetle. The beetles were allowed to crawl over the fungal cultures for 24h. Observations taken after 7 days indicated that 30% and 20% of beetles took up infection of *B. brongniartii* and *B. bassiana,* respectively, and died.

Evaluation of plant products against *pollu* beetle

Three plant products namely, neem extract (Source: M/s Synthite Chemicals), seed kernel extract of *Melia composita* and *Capsicum* seed extract (Source: M/s Synthite Chemicals) were evaluated in laboratory bioassays adopting no choice feeding tests at 0.15 to 5% concentrations to determine their antifeedant activity against adult *pollu* beetle. The bioassay indicated that among the products, *Capsicum* extract and seed kernel extract of *M. composita* were more promising causing above 50% feeding deterrence at 0.1% and 0.5% concentrations, respectively, and above 90% feeding deterrence at 1% and 2% concentrations, respectively.

The persistence of antifeedant activity of *Capsicum* extract containing various concentrations (0.05% to 1.00%) of capsaicin was studied against adult *pollu* beetle in greenhouse bioassays. The tests indicated that *Capsicum* extract containing 1%

capsaicin caused >90% and >50% feeding deterrence up to 14 and 21 days respectively, after treatment.

Capsicum extract was also evaluated in the field at Peruvannamuzhi for its efficacy in the management of *pollu* beetle. The extract was sprayed at 1% concentration at fortnightly intervals during July to October along with a wetting agent (Sandovit 0.1%). The present recommendation of spraying endosulfan 0.05% during July and October was also carried out. The trials indicated that *Capsicum* extract was not effective in reducing the damage caused by *pollu* beetle to black pepper berries and the incidence of infested berries was on par with that of control.

Demonstration of management of *pollu* beetle with neem-based insecticide

The efficacy of spraying neem-based insecticide (Neemgold) for the management of *pollu* beetle was demonstrated in a farmers field at Thiruvambady (Kozhikode District, Kerala). The treatments included spraying 2 rounds of endosulfan 0.05% (July and October); 1 round of endosulfan 0.05% (July) + 3 rounds of Neemgold 0.6% (August-October); 2 rounds of quinalphos 0.05% (July and October); 1 round of quinalphos 0.05% (July) + 3 rounds of Neemgold 0.6% (August-October) and 4 rounds of Neemgold 0.6% (July-October). The trials indicated that all the treatments were effective and were on par with each other and superior to control, for the management of the pest.

Determination of pesticide residues in black pepper

The pesticide residues in black pepper, in which the recommended spraying schedules of endosulfan and neem-based insecticide were adopted, were determined at Quality Evaluation Laboratory, Kochi. Spraying 2 rounds of endosulfan 0.05% (July and October); 1 round of endosulfan 0.05% (July) + 3 rounds of Neemgold 0.6% (August-October) and 4 rounds of Neemgold 0.6% (July-October) resulted in 0.041 ppm, 0.009 ppm and non deductible levels of endosulfan residues, respectively, on black pepper berries at harvest. These residue levels were below the permissible level of 0.1 ppm fixed by the importing countries indicating that the recommended management schedule against *pollu* beetle does not result in pesticide residues in the product.

Evaluation of fungal pathogens against root mealybug

Cultures of various fungi namely, *Beauvaria bassiana, Paecilomyces lilacinus, Verticillium chlamydosporium*, *V. lecanii, Metarrhizium anisopliae*, *Aspergillus rugulosus*, *Paecilomyces lilacinus*, *Fusarium oxysporum*, *Penicillium citrinum*, *P. fumiculosum*, *Fusarium* sp., *Scopulariopsis* sp., *Aureobasidium* sp., *Humicola* sp., and *Scolecobasidium* sp. collected from various spice ecosystems were multiplied and laboratory bioassays conducted to evaluate their pathogenicity against root mealybug.

The bioassays indicated that among the various fungi, *M*. *anisopliae* and *A. rugulosus* were more effective resulting in 80% and 63%, reduction in population, respectively, 30 days after spray, indicating their potential in the management of the pest.

Four isolates of entomopathogenic nematodes (*Heterorhabditis* sp.) were evaluated for their pathogenecity against root mealybug in laboratory bioassays. The study indicated that the isolates caused 10% to 32% mortality of the pest.

Seasonal incidence of natural enemies of shoot borer

The seasonal incidence of natural enemies of shoot borer of ginger was studied at Peruvannamuzhi. *Hexamermis* sp. parasitized larvae of shoot borer during July to November with a peak parasitisation of 72% during August. The hymenopterous parasites (*Bracon* sp. and *Apanteles taragamme*) were observed during October to December with a peak parasitisation of 28% during November.

Studies on host plant-insect pest-natural enemy interactions in ginger and turmeric indicated that the incidence of shoot borer was not significantly different on ginger and turmeric when these crops were grown individually and as mixed crops. The incidence of parasitism by hymenopterous parasitoids on shoot borer was also not significantly different in these crops.

Field evaluation of *Bacillus thuringiensis* against shoot borer

Two commercial formulations of *Bacillus thuringiensis* (Bioasp and Dipel) that were promising in laboratory bioassays were evaluated against shoot borer of ginger and turmeric in the field at Peruvannamuzhi for two crop seasons during 1995 and 1996. The treatments included four sprays (during July, August, September and October) with Bioasp (at 0.25%, 0.50% and 0.75% concentrations), Dipel (at 0.1%, 0.2% and 0.3% concentrations) and malathion 0.1% (present recommendation). An untreated control was also maintained. The percentage of tillers infested by the pest was recorded during November and the data subjected to combined analysis of data. The trials indicated that in both ginger and turmeric, all the treatments were effective in controlling the pest infestation when compared to control. However, spraying of Dipel 0.3% was the most effective treatment.

Integrated management of shoot borer

Cultural methods such as pruning of infested shoots, pruning of infested shoots and spraying of insecticide and spraying of insecticide alone were evaluated in the field for 2 years during 1998 and 1999 for the management of shoot borer on ginger. The trials indicated that pruning of infested shoots during July–August (at fortnightly intervals) and spraying of insecticide (malathion 0.1%) during September–October (at monthly intervals) resulted in significantly lower incidence of shoot borer and higher yields. The economics of various management schedules were also calculated and the adoption of pruning and spraying resulted in a Cost : Benefit ratio of 1 : 4.6 which

was higher than pruning alone and spraying alone. By adopting this integrated strategy two insecticide sprays could be avoided, thus causing less harm to the ecosystem.

Evaluation of neem product for the management of shoot borer

A commercial neem product (Nimbicidine) and neem oil was evaluated at 0.5%, 0.75% and 1.0% concentrations in the field at Peruvannmuzhi for 2 years during 2001 and 2002 for the management of shoot borer on ginger and turmeric. The neem products were sprayed at 15 day intervals on the experimental plants during July to October. A treatment involving spraying of malathion 0.1% at monthly intervals during July–October was also maintained. The trials indicated that, on ginger, spraying of Nimbicidine 1.0% and neem oil 1.0% were effective and was on par with malathion 0.1% and the percentage of shoots infested by the pest was significantly less in these treatments when compared to all other treatments including control. However, on turmeric, none of the treatments were effective in reducing the damage caused by the shoot borer.

During 2003, the commercial neem product (Nimbicidine) and neem oil were evaluated at 1% concentration (that were promising during the previous year) in the field at Peruvannmuzhi for the management of shoot borer on ginger. The neem products were sprayed at 15-day intervals on the experimental plants during July to October. A treatment involving spraying of malathion 0.1% at monthly intervals during July–October was also maintained. However, both the neem formulations were not effective in reducing the pest infestation on the crop and the percentage of shoots infested by the pest was on par with control.

An integrated strategy such as adoption of cultural methods (pruning and destruction of freshly infested shoots at fortnightly intervals during July to August) and spraying of neem products (Neem oil and Nimbicidine-1% concentration each at 15 day intervals during September to October) were evaluated in the field at Chelavoor during 2003 for the management of shoot borer on ginger. Treatments involving pruning and destruction of freshly infested shoots at 15 day intervals during July to August and spraying of malathion 0.1% at monthly intervals during September to October and spraying of malathion 0.1% at monthly intervals during July–October were also maintained. However, the treatments involving pruning of infested shoots and spraying of neem products were not effective in reducing the pest damage on ginger.

Evaluation of repellent plants for the management of shoot borer

Plants of saw-toothed coriander (*Eryngeum foetidum*) and galangal (*Kaempferia galanga*) were raised along with ginger in the field at Chelavoor to study the repellent action of these plants against oviposition by the shoot borer. However, these plants were not effective in preventing oviposition by the shoot borer and the percentage of infested shoots were not significantly reduced in plots where these crops were grown.

Curcuma zeodaria (a related species resistant to shoot borer) was planted along with ginger in the border of the beds in the field at Chelavoor to evaluate its efficacy as a repellent crop for the prevention of infestation by shoot borer on ginger. However, the the trials indicated that *C. zeodaria* was not effective in preventing the infestation of shoot borer on ginger.

Determination of pesticide residues in ginger

The recommended package of practices for the management of shoot borer on ginger involving spraying of malathion 0.1%, monocrotophos 0.05% and endosulfan 0.05% at monthly intervals during July–October (4 sprays) and pruning of infested shoots during July – August and spraying of insecticides during September–October (2 sprays) was adopted. The residues all the insecticides were below 0.001 ppm in dried ginger rhizomes at harvest under both the schedules of spraying which is well below the permissible values fixed by the importing countries.

Integrated management of rhizome scale

Six insecticides namely, malathion, methyl parathion, quinalphos, phosphamidon, dimethoate and monocrotophos (0.075% each) and four plant / organic products namely, Neemgold 0.5%, Nimbicidine 0.5%, neem oil 1% and fish oil rosin 3% were evaluated for the management of rhizome scale of ginger in storage for 2 years during 1999 and 2000. The trials indicated that among the various chemicals, dipping seed rhizomes in quinalphos 0.075% prior to storage was significantly the most effective treatment for the management of the pest resulting in maximum seed recovery, minimum scale population and maximum sprouts on the seed rhizomes. Dipping seed rhizomes in methyl parathion also resulted in higher seed recovery, lower scale population and higher sprout formation.

The trials also indicated that discarding of severely infested rhizomes was also important since none of the insecticide treatments was effective in obtaining a high recovery of rhizomes that were severely infested with rhizome scales..

Dried leaves of *Chromoleana odorata*, *Glycosmis pentaphylla*, *Melia composita*, and *Strychnos nux-vomica* were evaluated as storage material for the management of rhizome scale on ginger during storage for 2 years during 2001 and 2002. The trials indicated that, dipping of seed rhizomes in quinalphos 0.075% and storing in dried leaves of *S. nux-vomica* and *G. cochinchinensis* was more effective for obtaining higher recovery of rhizomes, higher number of sprouts and lesser incidence of rhizome scale.

Dried leaves of *Strychnos nux-vomica* and *Glycosmis pentaphylla* that were promising as storage materials for the management of rhizome scale of ginger were evaluated alone and along with sawdust (1:1 proportion) after dipping of seed

rhizomes in quinalphos 0.075% for 2 years during 2003 and 2004. The trials indicated that, storage of seed rhizomes in *S. nux-vomica* and sawdust in 1:1 proportion was more effective for obtaining a higher recovery of rhizomes (74.5%), whereas, storage in *S. nux-vomica* alone resulted in higher number of sprouts (60.5 sprouts per 1000 g) and lower population of rhizome scale (0 rhizome scale population).

8221 Achievements in terms of targets fixed for each activity

Sl. No.	Target	Achievement
1.	Documentation of natural enemies of major insect pests of spice crops	The natural enemies of major insect pests of black pepper, ginger, turmeric, clove and cinnamon were documented.
2.	Studies on bioecology of major natural enemies	The seasonal incidence of major natural enemies of scale insect and top shoot borer of black pepper and shoot borer of ginger and turmeric was studied.
3.	Evaluation and development of biocontrol and integrated pest management technologies	Technologies were developed for the integrated management of *pollu* beetle of black pepper, shoot borer and rhizome scale of ginger and turmeric.

8222 Questions answered

a. What are the natural enemies of major insect pests of spice crops?
b. What are the potential biocontrol agents of major insect pests of spice crops?
c. What are the technologies to be adopted for the management of major insect pests of spice crops?

8223 Process/Product/Technology developed

a. Integrated management of *pollu* beetle of black pepper and shoot borer and rhizome scale of ginger and turmeric.

8224 Practical utility (not more than 150 words)

The technologies developed for the management of *pollu* beetle of black pepper, shoot borer and rhizome scale of ginger and turmeric would result in increasing the productivity of these crops with minimum pesticide residues in the produce and minimum damage to the eco-system.

8225 Constraints, if any : Nil

823 Publications and material development :

(One copy each to be supplied with this pro forma)

8231 Research papers

1. Devasahayam, S. and Koya, K. M. A. 1993. Seasonal incidence of hymenopterous parasites of top shoot borer (*Cydia hemidoxa*) infesting black pepper. Journal of Entomological Research 17: 205–208.
2. Devasahayam, S. and Koya, K. M. A. 1994. Natural enemies of major insect pests of black pepper. Journal of Spices and Aromatic Crops 3: 50–55.
3. Devasahayam, S. and Koya, K. M. A. 1994. Seasonal incidence of *Hexamermis* sp. (Dor., Mermithidae) parasitising larva of top shoot borer *Cydia hemidoxa* Meyr. (Lep., Tortricidae) on black pepper. Journal of Applied Entomology 17: 31–34.

Papers presented in Seminars / Symposia (Full papers in Proceedings)

4. Devasahayam, S. 2000. Evaluation of biopesticides for the management of shoot borer (*Conogethes punctiferalis* Guen.) on ginger (*Zingiber officinale* Rosc.): In: Ramana, K. V., Eapen, S. J., Babu, K. N., Krishnamurthy, K. S. and Kumar, A. (Eds.). Spices and Aromatic Plants. Challenges and Opportunities in the New Century. Indian Society for Spices, Calicut. pp. 276-277.
5. Devasahayam, S. 2001. Integrated management of insect pests of spices. In: Ignacimuthu, S. and Sen, A. (Eds.) Strategies in Integrated Pest Management, Phoenix Publishing House Pvt. Ltd., New Delhi, pp. 86–93.
6. Devasahayam, S. 2002. Evaluation of biopesticides for the management of shoot borer (*Congethes punctiferalis* Guen.) on turmeric. In: Rethinam, P., Khan, H. H., Reddy, V. M., Mandal, P. K. and Suresh, K. (Eds.) Plantation Crops Research and Development in the New Millenium, Coconut Development Board, Kochi., pp. 489–490.
7. Devasahayam, S. and Koya K, M. A. 1998. IPM in spices-Challenges for the future. In: Reddy P P, Kumar N K K and Verghese A (Eds.) Advances in I P M for Horticultural Crops. Association for Advancement of Pest Management in Horticultural Ecosystems, Bangalore. pp. 157-164.
8. Sarma, Y. R., Ramana, K. V., Anandaraj, M. and Devasahayam, S. 2000. Biocontrol strategies in integrated pest and disease management of spice crops : Present status and future thrusts. In : Innovative Pest and Disease management in Horticultural and Plantation Crops, SPIC Science Foundation, Madras. pp. 1–13.

Papers presented in Seminars / Symposia (Abstracts)

9. Devasahayam, S. 1998. IPM in spices-Future thrusts and challenges. International Conference on Pest and Pesticide Management for Sustainable Agriculture, 11–13 December 1998, Kanpur.

10. Devasahayam, S. 2001 Biological control of insect pests of spices-Present status and strategies for the future. Seminar on Molecular Modalities in the Manipulation of Insect Natural Enemies. 14 July 2001, Chennai,

11. Devasahayam, S. 2001 Recent advances in biological control of insect pests of spices. National Symposium on Biological Control of Insect Pests, 7–8 February 2002, Chennai.

12. Devasahayam, S. 2005. Potential use of plant products for the management of insect pests of spices. In: Abstracts of Papers, National Seminar on Insect Growth Regulators and Natural Products in Insect Pest Management, 11 January 2005, Calicut.

13. Devasahayam, S. 2005. Prospects and emerging trends in biological control of insect pests of spice crops. In: Abstracts of Papers, Symposium on Biological Control of Pests of Horticultural Crops : New Thrusts, 19 March 2005, Bangalore.

14. Devasahayam, S. and Koya, K. M. A. 2000. Evaluation of entomopathogenic fungi against root mealybug infesting black pepper. ENTOMOCONGRESS 2000, 5–8 November 2000, Thiruvanandapuram.

16. Sarma, Y. R., Ramana, K. V., Dake, G. N., Venugopal, M. N., Ananadaraj, M., Devasahayam, S. and Eapen, S. J. 1996. Biocontrol strategies in pest and disease management of spice crops. Second International Crop Science Congress, 17–24 November 1996, New Delhi.

17. Sarma, Y. R., Ramana, K. V., Dake, G. N., Venugopal, M. N., Ananadaraj, M., Devasahayam, S. and Eapen, S. J. 1996. Biological control of pests and diseases of spice crops. National Seminar on Biotechnology of Spices and Aromatic Crops, 24–25 April 1996, Calicut.

8232 Popular articles

18. Devasahayam, S., Anandaraj, M. and Ramana, K. V. 1998. Ecofriendly management of pests and diseases of spice crops. The Botanica 48: 95–102.

19. Devasahayam, S. and Koya, K. M. A. 1999. Integrated management of insect pests of spices. Indian Journal of Arecanut, Spices and Medicinal Plants 1: 19–23 .

20. Devasahayam, S. and Koya, K. M. A. 2002. Integrated management of insect pests of spices. In: Selvan, M. T. (Ed.) Souvenir, National Consultative Meeting for Accelerated Production and Export of Spices. Directorate of Arecanut and Spices Development, Calicut. pp. 72–74.

8233 Reports

Nil

8234 Seminars, conferences and workshops (relevant to the project) in which the scientists have participated :

1. Workshop on Conservation of Invertebrates, 19–20 October 1995, Calicut.
2. National Seminar on Biotechnology of Spices and Aromatic Crops, 24–25 April 1996, Calicut.
3. International Conference on Pest and Pesticide Management for Sustainable Agriculture, 11–13 December 1998, Kanpur.
4. Indo-UK Workshop on Inovative Integrated Crop Protection Practices, 18 December 1999, Madras.
5. ENTOMOCONGRESS 2000, 5–8 November 2000, Thiruvananthapuram.
6. International Symposium on Plantation Crops, 14–17 December 2000, Hyderabad.
7. V National Conference of Applied Zoology Research Association, 27–29 December 2000, Chennai.
8. National Symposium on Pest Management Strategies : Current Trends and Future Prospects, 1–2 February 2001, Chennai.
9. Seminar on Molecular Modalities in the Manipulation of Insect Natural Enemies, 14 July 2001, Chennai.
10. National Symposium on Biological Control of Insect Pests, 7–8 February 2002, Chennai.
11. National Seminar on Insect Growth Regulators and Natural Products in Insect Pest Management, 11 January 2005, Calicut.
12. Symposium on Biological Control of Pests of Horticultural Crops : New Thrusts, 19 March 2005, Bangalore.

824 Infrastructural facilities developed

(Details of field, laboratory, note books and final material and their location)

A biological control laboratory with controlled temperature conditions was set up for rearing of insect pests and their natural enemies. The data sheets are available in the Entomology Section.

825 Comments / Suggestions of Project Leader regarding possible future line of work that may be taken up arising out of this Project.

Many natural enemies that are potential biocontrol agents were identified especially against scale insects, root mealybug, and top shoot borer of black pepper and shoot borer of ginger and turmeric. Studies are be undertaken to develop technologies for their mass culture and their effectiveness in the field may be evaluated and incorporated in integrated pest management schedules.

Part-IV : Project Expenditure
(Summary)
1992–2005

830 Total Recurring Expenditure

		Actual (Rs)
8301	Salaries	
	i) Scientific	11,19,795
	ii) Technical	1,86,500
	iii) Supporting	1,59,850
	Sub-Total	14,66,135
8302	Consumables	
	i) Chemicals	26,000
	ii) Glasswares	22,000
	iii) Others	-
	Sub-Total	48,000
8303	Travel	27,000
8304	Miscellaneous (other costs)	55,000
8305	Sub-Total (Recurring)	15,96,135

831 Total Non-Recurring Expenditure **-**
(Equipments and works)

Total (830 and 831) **15,96,135**

Part-V : Declaration

This is to certify that the final report of the Project has been submitted in full consultation with the project workers as per the approved objectives and technical programme and the relevant records, note-books, materials are available for the same.

Signature of Project Investigator

1. S. Devasahayam

Signature of Co-Investigators

1. K. M. Abdulla Koya

2. T. John Zachariah

3. T. K. Jacob

Signature & Comments of
Head of the Division/ Section

Signature & Comments of
Director