RPF III
FINAL REPORT

Part 1: GENERAL INFORMATION

800 Project Code :
8001 Institute Project Code No. : Ent. X (813)
8002 ICAR Project Code No. : Not allotted

801 Name of the Institute and Division :
8011 Name and Address of Institute : Indian Institute of Spices Research
Post Box No. 1701, Marikunnu P.O.
Calicut-673012, Kerala.
8012 Name of Division/Section : Division of Crop Protection/Entomology

8013 Location of Project : Indian Institute of Spices Research, Calicut

802 Project Title : **Bionomics of major pests of black pepper and evolving integrated control measures against them**

803 Priority Area : Research
8031 Research Approach:

Applied Research	Basic Research	Process/Technology development	Transfer of Technology
01	02	03	04

804 Specific area : Spices-Entomology

805 Duration of Project :
8051 Date of start : 1978
8052 Date of completion : 1997

806 Total Cost / Expenditure Incurred: Rs. 2,50,000/- (Original Cost: Rs. 1,84,125/-)
(Give reasons for variation, if any from original estimated cost)
The project was originally proposed for 5 years but was extended up to 1996–97 to work on the leads that were obtained during the initial stages of the project. Moreover, there was increase in salary of scientific, technical and supporting personnel due to recommendations of Pay Commissions.

807 Executive Summary

Studies on seasonal population of pollu beetle at Koothali (Kozhikode District) indicated that populations of adult beetle were observed in the field throughout the year but were higher during August to December. Sex ratio ranged from 1:1.1 to 1:1.5 (female : male) during the year. The economic threshold of damage caused by pollu beetle to black pepper berries was determined as occurrence of 2 beetles per 100 leaves during July. A method was developed for determination of sex in pollu beetle based on the presence of sclerotized spine attached to the mid-ventral wall of the genital chamber in the abdomen of females. The reproductive structures of male and female beetles were described. Studies on reproductive physiology indicated that fat content in females declined during breeding season and increased during the non-breading season indicating that the pest undergoes reproductive diapause when oviposition sites are not available on the vines. Four black pepper accessions (Accs. 816, 841, 1084 and 1114), one wild *Piper nigrum* accession (Acc. No. 2070) and six related species of *Piper* namely*, P. attenuatum, P. barberi, P. chaba, P. colubrinum, P. hymenophyllum* and *P.longum* were resistant to pollu beetle. Laboratory bioassays with three compounds with suspected antifeedant properties, isolated from *P. attenuatum* indicated that antifeedant activity was significantly higher in crotepoxide. Seed kernel extracts of *Anonna squamosa* and *Azadirachta indica* and leaf extracts of *Strychnos nux-vomica* and *Chromolaena odorata* exhibited significant antifeedant activity against pollu beetle in laboratory bioassays. Among the various neem-based products, Repelin, Neemark, Neemgold and Neemazal were promising. Trials conducted in Kozhikode and Kottayam districts in Kerala indicated that spraying of endosulfan 0.05% or quinalphos 0.05% twice a year during June-July and September-October was effective for the management of pollu beetle. Spraying of endosulfan 0.05% during June-July followed by three sprays during August to October with a neem product such as Neemgold 0.6%, or Neemazal-F 0.05% or four sprays of neem products alone during June-July to September-October was effective for the management of the pest. Methods were standardized for estimation of endosulfan and quinalphos residues in black pepper. Surveys carried out in black pepper areas in Kerala indicated that the top shoot borer (*Cydia hemidoxa*) was a major insect pest on young black pepper vines (1-2 years) causing up to 100% terminal shoot damage. The pest infestation caused up to 57% reduction in growth when the vines were infested thrice during June-December. The damage caused by top shoot borer was observed in the field throughout the year but was higher during July to December. *Hexamermis* sp (Mermithidae) and *Apanteles cypris* Nixon (Braconidae) were identified to be major natural enemies of top shoot borer larvae. Spraying monocrotophos 0.05% during July and September on tender terminal shoots was the most effective that was on par with methyl parathion 0.05% and quinalphos 0.05% for the management of the pest.

Keywords: Black pepper, insect pests, pollu beetle, top shoot borer, bio-ecology, management.

PART - II: INVESTIGATOR PROFILE

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

810 Principal Investigator (1983–84; 1990–97); Co-Investigator (1984–89)

8101	Name	:S. Devasahayam
8102	Designation	:Senior Scientist
8103	Division / Section	:Crop Protection / Entomology
8104	Location	:Indian Institute of Spices Research
8105	Institute Address	:IISR, Marikunnu P.O., Calicut – 673 012

811 Principal Investigator (1978–83)

8111	Name	: S. K. Banerjee
8112	Designation	: Scientist S-2
8113	Division/Section	: Crop Protection / Entomology
8114	Location	: Indian Institute of Spices Research
8115	Institute Address	: IISR, Marikunnu P.O, Calicut – 673 012

812 Principal Investigator (1984–90); Co-Investigator (1980–83)

8121	Name	: T. Premkumar
8122	Designation	: Scientist S-2
8123	Division/Section	: Crop Protection / Entomology
8124	Location	: Indian Institute of Spices Research
8125	Institute Address	: IISR, Marikkunnu, P.O., Calicut-673 012

813 Co-Investigator (1979–80)

8121	Name	: S. S. Singh Gautam
8122	Designation	: Scientist S-1
8123	Division/Section	: Crop Protection / Entomology
8124	Location	: Indian Institute of Spices Research
8125	Institute Address	: IISR, Marikunnu P.O., Calicut – 673 012

814 Co-Investigator (1983–84; 1990–94)

8121	Name	: K. M. Abdulla Koya
8122	Designation	: Scientist (SG)
8123	Division/Section	: Crop Protection / Entomology
8124	Location	: Indian Institute of Spices Research
8125	Institute Address	: IISR, Marikunnu P.O., Calicut – 673 012

814 Co-Investigator (1984–86)

8141	Name	: R. Balakrishnan
8142	Designation	: Senior Scientist
8143	Division/Section	: Social Sciences / Statistics
8144	Location	: Indian Institute of Spices Research
8145	Institute Address	: IISR, Marikunnu P.O., Calicut – 673 012

815 Co-Investigator (1987–89)

8131	Name	: Jose Abraham
8132	Designation	: Senior Scientist
8133	Division/Section	: Social Sciences / Statistics
8135	Location	: Indian Institute of Spices Research
8135	Institute Address	: IISR, Marikkunnu, P.O., Calicut-673 012

816 Co-Investigator (1990–93)

8141	Name	: T. John Zachariah
8142	Designation	: Senior Scientist
8143	Division/Section	: Crop Production / Biochemsitry
8144	Location	: Indian Institute of Spices Research
8145	Institute Address	: IISR, Marikunnu P.O., Calicut – 673 012

PART - III: TECHNICAL DETAILS

820 Introduction and Objectives:

8201 Project objectives:

The project was proposed to study the bionomics of major insect pests of black pepper and evolve integrated control measures against them.

8202 Background information and importance of the project:

The pollu beetle (*Longitarus nigripennis*) and top shoot borer (*Cydia hemidoxa*) are considered as important insect pests of black pepper. However, the nature of damage, incidence of these pests in various regions, seasonal population and other aspects of bionomics are not available. Schedules for the management of these pests in the field are also not available. Hence developing integrated management schedules, based on need-based application of insecticides, utilization of resistant sources, plant products and biocontrol agents would enhance the productivity of the crop and would also help in obtaining a produce free of pesticide residues.

821 Project Technical Profile

8211 Technical Programme

1. Biology and bionomics of major insect pests (pollu beetle and top shoot borer) of black pepper.
2. Screening black pepper cultivars to locate sources of resistance against pollu beetle.
4. Screening recent formulations of insecticides and natural products and developing schedules for management of pollu beetle and top shoot borer.
5. Documentation of natural enemies and identification of suitable biocontrol agents against pollu beetle and top shoot borer.

8212 Total man months involvement of component project workers
Scientific: 185 man months

822 Final Report on the Project

Pollu Beetle (*Longitarsus nigripennis*)

a. ***Seasonal population***
The seasonal population of pollu beetle was studied at Koothali (Kozhikode District). Weekly counts of pollu beetle were undertaken on 100 leaves in each of the 15 vines. Populations of adult beetle were observed throughout the year but were higher during August to December. The adult populations during different months during 1985 were 64, 58, 49, 18, 9, 11, 28, 109, 133, 137, 112 and 106 during January to December. During 1986 the cumulative monthly populations during January to December were 46, 26, 17, 7, 5, 3, 4, 5, 9, 26, 67 and 167 respectively.

b. ***Economic threshold of damage***
For working out the economic thresholds of pollu beetle infestation, observations on the incidence of spike and berry damage were recorded at weekly intervals from July onwards on three cultivars (Panniyur-1, Karimunda and Arakulam munda) at Koothali and Ingapuzha (Calicut district). The rate of increase of pest infestation on the berries was positive up to September during 1986 and up to November during 1987 and declined thereafter. The weekly average of number of berries damaged per spike followed a sigmoid curve. Spraying of endosulfan 0.05% was undertaken in one plot during July and October. Taking into consideration the input cost, yield loss and beetle population, the economic threshold was worked out as occurrence of 2 pollu beetles per 100 leaves during 4^{th} week of July which is capable of causing economic damage.

c. ***Reproductive biology***
A method was developed for the determination of sex in pollu beetle based on the presence of sclerotized spine attached to the mid-ventral wall of the genital chamber in the abdomen of female. Male and female beetles were dissected and the reproductive structures studied. The typical feature in the male reproductive system was presence of a single testis formed by fusion of four lobes. An accessory gland was also present. In females the ovary was composed of five to six ovarioles indicating its prolonged oviposition period. A spermatheca was also present. The sex ratio, dry weight and water and fat contents which are important indices of the reproductive and physiological condition of field populations of male and female beetles were monitored at bimonthly intervals throughout the year. Sex ratio was fairly constant throughout the year with a preponderance of males, the female : male ratio ranging from 1:1:1 to 1:1:5. Dry weight of females was higher than males throughout the year. Fat and water contents were higher in females almost throughout the year. Fat content in females declined during breeding season and increased during the non-breading season indicating that the pest undergoes reproductive diapause when oviposition sites are not available on the vines.

d. ***Screening of germplasm***

Observations were initiated during 1988 to record the incidence of pollu beetle infested berries on 250 black pepper accessions (cultivated) maintained in the germplasm at Peruvannamuzhi.. Ten spikes from four vines of each accession were randomly selected and the total number of berries and berries infested were recorded and the per cent berry damage was worked out. The accessions were classified into 4 groups: No infestation (8 accessions), <1% infestation (50 accessions), 1%-5% infestation (66 accessions) and >5% infestation (32 accessions). During 1989, the observations were recorded on 234 black pepper accessions and eight accessions were free of infestation, 31 accessions had <1% infestation, 67 accessions had 1%-5% infestation and 27 accessories had >5% infestation. During 1990 the incidence of 'pollu' beetle infested berries was recorded on 185 accessions and the pest infestation ranged from 0.0% to 36.8%; 30 accessions were designated as relatively resistant to the pest. During 1991, screening of the 30 relatively resistant accessions indicated that 7 of them continued to be resistant during the year. During 1992 seven of the promising accessions were further screened and four of them (Accs. 816, 841, 1084 and 1114) remained resistant (<1% berry damage) and were designated as resistant to pollu beetle in the field.

During 1993-1994, 24 wild accessions of *Piper nigrum* maintained in the germplasm at Peruvannamuzhi were screened against pollu beetle in the field and Acc. 2070 was designated as resistant to pollu beetle. Screening (leaf damage) of 16 related species of *Piper* in laboratory no choice tests indicated that eight species namely, *P. colubrinum*, *P. betle, P. hymenophyllum, P. attenuatum, P. barberi, P. mullesua, P. arboretum, P.longum* and *P. chaba* were resistant to pollu beetle. Screening (berry damage) of seven *Piper* species in no choice tests indicated that six species namely, *P. colubrinum*, *P. hymenophyllum, P. attenuatum, P. barberi, P.longum* and *P. chaba* were resistant.

e. ***Studies on anti-feedants from wild* Piper *spp.***

Laboratory bioassays with three compounds with suspected antifeedant properties, namely, crotepoxide, pipoxide and pipoxide chlorhydrin isolated from *P. attenuatum* indicated that antifeedant activity was significantly higher in crotepoxide and pipoxide chlorhydrin; 62% feeding deterrence was observed crotepoxide at 500 ppm in no choice tests. Various combinations of the compounds did not enhance the antifeedant activity significantly.

f. ***Evaluation of plant extracts and neem products***

Seed kernel extracts of *Anonna squamosa* and *Azadirachta indica* and leaf extracts of *Strychnos nux-vomica* and *Chromolaena odorata* exhibited significant antifeedant activity against pollu beetle in laboratory bioassays. Among the various neem-based products, NSKE, Neem Oil, Repelin, Neemark, Neemgold and Neemazal were promising.

g. ***Evaluation of insecticides and neem-based products***

Various insecticides were evaluated for the management of pollu beetle. At Koothali (Kozhikode District) seven insecticides were evaluated for three years and among the treatments, endosulfan 0.05% was the most effective when sprayed twice a year during June-July and September-October, followed by quinalphos 0.05% and methyl parathion

0.05%; however, these treatments were on par with fenvalerate 0.01%, carbaryl 0.1%, and monocrotophos 0.05%. Trials conducted at Kozhikode (Thiruvambadi) and Kottayam (Chempakara) districts with three promising insecticides for three years indicated that spraying of endosulfan 0.05% or quinalphos 0.05% twice during June-July and September-October was effective for the management of pollu beetle. Trials with endosulfan 0.05% adopting different spray schedules indicated that two sprays during July and October was the most effective and economical.

Trials conducted for two years at Peruvannamuzhi (Kozhikode District) with neem products and insecticide indicated that one spray with endosulfan 0.05% (during July) and three sprays with Neemgold 0.6% or Neemazal-F 0.05% or Neemark 1% (during August, September, October) or four sprays with Neemgold 0.06% or Neemazal-F 0.05% was as effective as spraying of endosulfan 0.05% twice a year during June-July and September-October. Colorimetric and GLC methods of estimation of quinalphos and endosulfan I, endosulfan II and endosulfan cyclic sulphate residues in black pepper were standardized.

Top Shoot Borer (*Cydia hemidoxa*)

a. ***Incidence and nature of damage***

Surveys carried out in black pepper areas in Kerala indicated that the top shoot borer was a major insect pest on young black pepper vines (1-2 years). The percentage of infestation recorded in different districts were: Trivandrum: 53%, Quilon: 30–61%, Alleppey, Pathanamthitta, Kottayam and Idukki: 54–90%, Calicut: 13–100%, Wayanad: 15–75%, Cannanore: 21–100% and Kasaragod: 36–100% The pest infestation caused up to 57% reduction in growth when young vines were infested thrice during June-December. The damage caused by top shoot borer was observed in the field throughout the year but was higher during July to December.

b. ***Natural enemies***

Hexamermis sp (Mermithidae) and *Apanteles cypris* Nixon (Braconidae) were identified to be major natural enemies of top shoot borer larvae. The other natural emeies recorded included *Goniozus* sp. (Bethylidae) and *Trombidium* sp. (Trombidiidae).

c. ***Evaluation of insectidcides***

Six insecticides were evaluated at Tamasserry (Calicut District) for the management of top shoot borer during 1987–1988; the insecticides were sprayed on tender terminal shoots during July and September. Combined analysis of two years data indicated that spraying monocrotophos 0.05% was the most effective that was on par with methyl parathion 0.05%, quinalphos 0.05% phosphamidon 0.05%, dimethoate 0.05% and endosulfan 0.05%.

8221 Achievements in terms of targets fixed for each activity

Targets	Achievements
Seasonal abundance of pollu beetle	Populations of pollu beetle were observed in the field throughout the year but were higher during

	August to December. Sex ratio was fairly constant through out the year ranging from 1:1.1 to 1:1.5 (female : male).
Reproductive biology of pollu beetle	The morphology of female and male internal reproductive systems of pollu beetle was described. A method was developed for determination of sex of adult beetle.
Economic threshold of damage caused by pollu beetle	The economic threshold of damage caused by pollu beetle to black pepper berries was determined as a population level of 2 beetles per 100 leaves during July
Evaluation of insecticides and spraying schedules against pollu beetle	Spraying endosulfan 0.05% or quinalphos 0.05% during July and October was effective for the management of pollu beetle.
Evaluation of natural products against pollu beetle	Leaf extracts of *Chromolaena odoratum* and *Strychnos nuxvomica* and seed kernel extract of custard apple possessed significant antifeedant activity against pollu beetle in laboratory bioassays. In the field, Neemgold 0.6% and Neemazal-F 0.05% were promising in reducing the damage caused by pollu beetle.
Screening black pepper germplasm against pollu beetle.	Four black pepper cultivars (Accs. 816, 841, 1084 and 1114), one wild *P. nigrum* (Accn. 2070) and six related species of *Piper* (*P.attenuatum*, *P. barberi, P.chaba, P. colubrinum, P. hymenophyllum, P. longum*) were identified to be relatively resistant to pollu beetle.
Studies on anti-feedants isolated from resistant lines	Three compounds with suspected antifeedant properties, were isolated from *P. attenuatum* and tested for their antifeedant activity against 'pollu' beetle; antifeedant activity was significantly higher in crotepoxide and 62% feeding deterrence was observed at 500 ppm.
Development of procedures for determination of pesticide residues in black pepper	Colorimetric and GLC methods of estimation of quinalphos and endosulfan I, endosulfan II and endosulfan cyclic sulphate residues in black pepper were standardized.
Nature of damage caused by top shoot borer	Infestation by top shoot borer caused up to 57% reduction in growth on young vines when they were infested thrice during June-December.
Incidence and seasonal abundance of top shoot borer	The incidence of top shoot borer was observed on young vines in all major black pepper areas in Kerala and the pest incidence ranged from 13% to 100% in various districts. The damage caused by top shoot borer was observed in the field

	throughout the year but was higher during July to December.
Documentation of natural enemies of top shoot borer	*Hexamermis* sp (Mermithidae) and *Apanteles cypris* Nixon (Braconidae) were identified to be major natural enemies of top shoot borer larvae. No major natural enemy of pollu beetle was recorded.
Evaluation of insecticides against top shoot borer	Spraying monocrotophos 0.05% on tender terminal shoots of younger vines during July and September was the most effective that was on par with methyl parathion 0.05% and quinalphos 0.05% for the management of top shoot borer.

8222-Questions Answered

1. What is the nature of damage caused by top shoot borer and does it affect the growth of young vines?
2. During which season are higher populations of pollu beetle and top shoot borer observed in the field?
3. What are the characteristic features of the reproductive biology of pollu beetle in relation to feeding and breeding of pollu beetle?
4. What is the insecticidal schedule to be adopted for the management of pollu beetle and top shoot borer?
5. Are natural products effective for the management of pollu beetle?
6. Are there resistant sources in black pepper germplasm to pollu beetle?
7. What are the major natural enemies of top shoot borer?
8. Can residues of endosulfan and quinalphos be determined in black pepper?

8223-Process/ Product/ Technology/Developed

1. Four black pepper cultivars (Accs. 816, 841, 1084 and 1114), one wild *P. nigrum* (Accn. 2070) and six related species of *Piper* (*P.attenuatum, P. barberi, P.chaba, P. colubrinum, P. hymenophyllum, P. longum*) were identified to be resistant to pollu beetle.
2. *Hexamermis* sp. and *Apanteles cypris* were identified to be potential biocontrol agents of top shoot borer.
3. A technology for the management of pollu beetle by spraying insecticides and neem-based products was developed.
4. A technology for the management of top shoot borer by spraying insecticides was developed.

8224 Practical Utility

The technologies developed for the management of pollu beetle and top shoot borer would help in reducing the damage caused by these insect pests to black pepper. The resistant lines identified against pollu beetle can be utilized in hybridization programmes to develop improved varieties resistant to the pest and the promising natural enemies identified would help in developing biological control strategies against top shoot borer. Adoption of these technologies would help in increasing the productivity of the crop and would also help in obtaining a produce free of pesticide residues.

8225 Constraints, if any: Nil.

823 Publications

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. 1993. Effect of top shoot borer (*Cydia hemidoxa*) infestation on young vines of black pepper. Indian Journal of Agricultural Sciences 63: 762–763.
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.
4. 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.
5. Devasahayam, S., Koya, K. M. A. and Premkumar, T. 1994. Infestation of tea mosquito bug *Helopeltis antonii* Signoret (Heteroptera: Miridae) on black pepper. Entomon 11: 239–241.
6. Devasahayam, S., Premkumar, T. and Koya, K. M. A. 1988. Insect pests of black pepper (*Piper nigrum* L.) in India-a review. Journal of Plantation Crops 16: 1–11.
7. Devasahayam, S., Vidyasagar, P. S. P. V. and Koya, K. M. A. 1998. Reproductive system of pollu beetle (*Longitarsus nigripennis* Mots.), a major pest of black pepper. Journal of Entomological Research 22: 77–82.
8. Premkumar, T. and Devasahayam, S. 1989. Record of *Synegia* sp. (Lepidoptera: Geometridae) infesting black pepper (*Piper nigrum* L.). Journal of Bombay Natural History Society 86: 112–113.
9. Premkumar, T., Banerjee, S. K., Devasahayam, S. and Koya, K. M. A. 1986. Effect of different insecticides on the control of pollu beetle *Longitarsus nigripennis* Mots., a major pest of black pepper (*Piper nigrum* L.). Entomon 11: 219–221.
10. Devasahayam, S., Premkumar, T. and Koya, K. M. A. 1987. Record of *Sahyadrassus malabaricus* (Moore) damaging *Gliricidia maculata*, a standard of black pepper (*Piper nigrum*) in Kerala. Entomon 12: 391–392.

11. Sasikumar, B., Chempakam, B., Remashree, A. B., Devasahayam, S., Dhamayanthi, K., Ravindran, P. N. and Peter, K. V. 1998. Characterization of two interspecific hybrids of *Piper*. Journal of Horticultural Science and Biotechnology 74: 125–131.
12. Vidyasagar, P. S. P. V., Devasahayam, S. and Koya, K. M. A. 1988. Sexing live adults of the pollu bettle *Longitarsus nigripennis* Mots. (Chrysomelidae: Coleoptera). Current Science 57: 869.

8232 Popular articles

1. Devasahayam, S. 1984. Pests. In: Muliyar, M. K.. (Ed.) Pepper. Package of Practices (Extension Pamphlet No. 7). Central Plantation Crops Research Institute, Kasaragod. pp. 11–12.
2. Devasahayam, S. 1986. Insect pests. In: Muliyar, M. K., and Nambiar, K. K. N. (Eds.) Pepper Package of Practices (Extension Pamphlet No. 7). Central Plantation Crops Research Institute, Kasaragod. pp. 8–9.
3. Devasahayam, S. 1992. Insect pests of black pepper and their control. Planters Chronicle. 87 (3): 153, 155.
4. Devasahayam, S. 1994. Management of insect of back pepper. Spice India 7 (9): 27–29.
5. Premkumar, T. and Devasahayam, S. 1988 Pollu beetle of black pepper. Cardamom 20 (12): 43, 44 & 46.
6. Premkumar, T. and Devasahayam, S. 1988. Management of insect pests for higher yields in black pepper. Indian Cocoa, Arecanut and Spices Journal 11: 121–122.
7. Premkumar, T. and Devasahayam, S. 1989 Pollu beetle of black pepper. Spice India 2 (6): 16 & 17.
8. Premkumar, T. and Devasahayam, S. 1989. Control of pests of black pepper. Indian Farming 38 (10): 33, 34 & 45.

8233 Reports

1. Annual Reports 1979-1997.
2. Research Highlights 1979-1997.

8233 Seminars, conferences and workshops (relevant to the project) in which the scientists have participated

1. Symposium on Plantation Crops (PLACROSYM II), 26–29 June 1979, Ootacamund.
2. National Seminar on Strategies of Pest Management, 21–23 December 1981, New Delhi.
3. National Symposium on Spice Industries–Present Scenario, Problems and Prospects, 9–10 April 1987, New Delhi.
4. Advances in IPM for Horticultural Crops. Association for Advancement of Pest Management in Horticultural Ecosystems, Bangalore.
5. National Seminar on Biological Control in Plantation Crops, 27–28 June 1991, Kottayam.

6. Group Meeting of Entomologists Working in Coordinated Projects of Horticultural Crops, Indian Council of Agricultural Research, 28–29 January 1991, Lucknow.
7. Seminar on Intercropping Pepper in Coffee Plantations, 24 February 1992, Mysore.
8. National Seminar on Black Pepper and Cardamom, 17–18 May 1992, Calicut.
9. Indo-UK Workshop on Current Approaches to Pheromone Technology, 29 December–1 December 1995, Madras.
10. International Conference on Pest and Pesticide Management for Sustainable Agriculture, 11–13 December 1998, Kanpur.

824 Infrastructural facilities developed

facilities for screening black pepper cultivars against pollu beetle were developed.

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

The sources of resistance identified against pollu beetle can be utilized in crop improvement programmes for developing improved varieties resistant to the pest. The natural enemies identified against top shoot borer could be utilized in developing biological control strategies against the pest.

PART- IV PROJECT EXPENDITURE (Summary) 1978 - 1997

830 Total Recurring Expenditure

8301	Salaries	: Rs. 2,35,000
8302	Consumables	: Rs. 5,000
8303	Travel	: Rs. 5,000
8304	Miscellaneous	: Rs. 5,000
8305	Sub-Total	: **Rs. 2,50,000**

831 Total Non- Recurring Expenditure : Nil

832 Total (830 & 831) : Rs. 2,50,000

Signature of Principal / Co-Investigators

S. Devasahayam / S. K. Banerjee / T. Premkunar / S. S. Singh Gautam

K. M. Abdulla Koya / Jose Abraham / R. Balakrishnan / T. John Zachariah

Signature & Comments of the Head of Division/Section

Signature & Comments of the Director