RPF-III

PROFORMA FOR SUBMISSION OF FINAL REPORT OF RESEARCH PROJECTS

Part-I : General Information

800 Project Code :

8001 Institute Project Code No. : -

6002 8002 ICAR Project Code No.: 3030775014

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 : Bioecology and integrated management of root mealybug *Planococcus* sp. infesting black pepper

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 : 3 years

8051 Date of start : July 2003

8052 Date of completion : June 2006

806 Total cost : Rs. 10,75,346/-

807 Executive summary

Surveys conducted in 85 locations in major black pepper areas in Kerala and Karnataka indicated that infestation by root mealybugs on black pepper was more serious in Wyanad District in Kerala. Six species of root mealybugs were recorded to infest black pepper vines among which *Planococcus* spp. was more common. The nature of damage, life history, seasonal population, alternate host plants and natural enemies of root mealybugs was studied and methods were standardized for mass culturing of the pest in the laboratory. Various plant extracts, neem products, organic products, microbial pathogens and insecticides were evaluated against root mealybugs in laboratory bioassays. An integrated pest management strategy involving, planting of root mealybug-free rooted cuttings in the field, removal of weeds in interspaces of black pepper vines during summer, drenching imidacloprid 0.0125% or acetamaprid 0.0125% or carbosulfan 0.075% or chlorpyriphos 0.075% on affected vines or drenching tobacco extract 3% on mildly affected vines and adoption of control measures against *Phytophthora* and nematode infections, was suggested for the management of root mealybugs, based on various studies conducted in the project.

808 Key words

Black pepper, *Piper nigrum*, *Planococcus* sp., root mealybug, bio-ecology, management.

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 / Entomology
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 / Entomology
8114	Location	: Calicut, Kerala
8115	Institute Address	: Indian Institute of Spices Research Calicut-673 012, Kerala.

812 Co-Investigator

8121	Name	: M. Anandaraj
8122	Designation	: Principal Scientist
8123	Division/Section	: Crop Protection / Plant Pathology
8124	Location	: Calicut
8125	Institute address	: Indian Institute of Spices Research Calicut – 673 012, Kerala.

Part-III: Technical Details

820 Introduction and objectives

8201 Project objectives

1. Distribution of root mealybugs in major black pepper areas.
2. Bioecology of root mealybugs.
3. Integrated management of root mealybugs.

8202 Background information and importance of the project

Increasing reports on the incidence of root mealybugs infesting black pepper were received especially from Wyanad district in Kerala. An institute project was therefore undertaken to study various aspects of the nature of damage and management of the pest. Based on the preliminary information generated from the institute project a proposal was submitted to ICAR to sanction an ad-hoc research scheme which would provide information on all aspects of the pest such as distribution, nature of damage, life history, alternate hosts, seasonal incidence and natural enemies which would help to develop suitable management strategies against the pest.

The proposed scheme would enable the farmers to identify various symptoms of root mealybug infested vines so as to undertake timely control measures against the pest. The integrated technology that would be developed for the management of root mealybugs of black pepper would result in reducing the crop loss caused by the pest thus increasing the production and productivity of the crop.

821 Project technical profile

8211 Technical programme

1. Survey for distribution of root mealybugs in black pepper areas.
2. Bioecology of root mealybugs.
3. Standardization of techniques for mass culturing of root mealybugs.
3. Evaluation of plant products, natural enemies and insecticides against root mealybugs.
4. Development of IPM schedules against root mealybugs.

8212 Total man months involvement of component project workers

Scientific	: 15 man months
Senior research fellows	: 57 man months

822 Final report on the Project

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

a. Distribution of root mealybugs

Surveys were conducted in Idukki (15 locations), Kozhikode (20 locations), Wyanad (14 locations), Kannur (9 locations) and Kasaragod (9 locations) districts of Kerala and Dakshina Kannada (4 locations), Udupi (1 location), Uttara Kannada (4 locations) and Hassan (9 locations) districts of Karnataka to record the incidence of root mealybugs on black pepper. The pest infestation was observed in five locations in Idukki District (in Nedumkandam, Thookkupalam, Meppara, Kalthotty and Rajakkad), nine locations in Wyanad District (in Chundale, Meppadi, Kalpetta, Ambalavayal, Sultan's Battery, Cheeambam, Pulpally, Panamaram and Nadavayal) and two locations in Hassan District (in Rayarakoppalu and Belagodu).

Six species of root mealybugs namely, *Planococcus* sp*., P. citri* (Risso), *P. lilacinus* (Ckll.), *Dysmicoccus brevipes* (Ckll.) and *Ferrisia virgata* Ckll. were recorded infesting roots and basal portions of stems of black pepper vines in various locations surveyed. The identification of various species of root mealybugs was confirmed by Gillian Watson, University of California, Sacramento, USA.

b. Nature of damage caused by of root mealybugs

Colonies of root mealybugs were distributed on the main, secondary and tertiary roots and basal region of stems on rooted cuttings in the nursery and also on vines of all age groups in the field. In some locations in Wyanad, the root mealybugs were observed to be covered with fungal colonies. The pest infestation resulted in defoliation, yellowing and wilting of leaves and lateral branches and also mortality of vines in severe cases of infestation.

The fungal pathogen *Phytophthora capsici* and nematodes such as *Meloidogyne incognita* and *Radopholus similis*, were commonly associated with root mealybug infested vines. At Wayanad and Kozhikode districts, all the root mealybug infested vines examined (n=104) were also infested with *P. capsici* and nematodes or both. The infested vines exhibited symptoms such as root rotting, absence of feeder roots, yellowing, defoliation and wilting of leaves and mortality of vines that are characteristically associated with *P. capsici* and nematode infections.

c. Bioecology of root mealybugs

Life history

Studies on biology of two common root mealybug species namely, *Planococcus* sp. and *P. citri* were conducted by caging individual specimens in micro-cages fixed on pumpkins. There were three instars in the life history of *Planococcus* sp. and males were not recorded. Females were viviparous and the fecundity ranged from 22 to 322 eggs. The oviposition period ranged from 10 to 40 days and the pre-oviposition period ranged from 9 to 21 days. The eggs were oval and yellowish orange. The crawlers were light brown and generally settled after 2 days. All the instars were flesh coloured immediately after moulting (Table 1).

Table 1. Life history of *Planococcus* sp.

Stage	Duration (days)
I instar	7 – 12
II instar	4 – 06
III instar	5 – 09

There were three instars in the life history of *P. citri* females. The fecundity of females ranged from 31 to 310. The preoviposition period ranged from 3 to 15 days. The eggs were laid in a ovisac and were yellowish orange. The crawlers were light brown. In males there were two instars and pre-pual and pupal stages (Table 2).

Table 2. Life history of *Planococcus citri*

Stage	Duration (days)
Male	
I instar	5 – 13
II instar	5 – 12
Prepupal / Pupal stages	4 – 10
Female	
I instar	5 – 11
II instar	4 – 13
III instar	4 – 10

Seasonal incidence and alternate hosts

The seasonal incidence and alternate hosts of root mealybugs infesting black pepper was monitored in the field at Wayanad. The pest infestation was higher during the post monsoon season. Colonies of root mealybugs were observed on banana, colocasia and turmeric rhizomes and base of stems of coffee and *Erythrina* sp and roots of 11 weed plants especially during summer in black pepper gardens severely infested with the pest.

d. Mass culturing of root mealybug

Twelve fruits/vegetables/tubers, namely, orange, pumpkin, squash, ash gourd, bottle gourd, cucumber, water melon, colocasia, elephant foot yam, ginger, turmeric and potato were evaluated for their suitability for mass culturing of root mealybug. The number of adults obtained was maximum in squash (*Cucurbita moschata*) followed by pumpkin (*C. pepo*) which remained without rotting up to 88 and 83 days after inoculation, respectively. Inoculation of 50 adults per squash resulted in 654 and 1437 adults after 2 and 3 months, respectively; whereas, inoculation of 100 adults per squash resulted in 894 and 1065 adults after 2 and 3 months, respectively.

e. Evaluation of natural enemies against root mealybug

Occurrence of natural enemies

Larvae of *Spalgis* sp. (Lycaenidae) were observed to predate on root mealybug colonies present at the base of the black pepper stems in Wyanad and Kozhikode districts. *Aspergillus* sp. (Damatiaceae) was observed to grow in root mealybug cultures in the laboratory, but bioassays indicated that the fungus was not pathogenic.

Evaluation of bacterial isolates

Sixteen bacterial isolates (that were promising against *P. capsici* and nematodes) available in the Repository of Biocontrol Agents at Indian Institute of Spices Research, Calicut, were evaluated against root mealybug (*Planococcus* sp.) in laboratory bioassays. Among the various bacterial isolates evaluated, IISR-860 was the most promising reducing the population of root mealybug by 56.0%, 30 days after treatment. The reduction in population of root mealybug by the other isolates ranged from 0.0% to 39.3%.

Evaluation of microbial pathogens

Four isolates of microbial pathogens namely, *Nomurae rileyii*, *Verticillium lecanii*, *Metarrhizium anisopliae* and *Aspergillus* sp. and four commercial products of microbial pathogens namely, *Paecilomyces* sp., *Beauveria bassiana*, V*. lecanii*, and *M. anisopliae* were evaluated in laboratory bioassays for their efficacy against root mealybug (*Planococcus* sp.). The trials indicated that none of the isolates of microbial pathogens were effective against root mealybug and the reduction in population of ranged from 24.0% to 32.0 in various treatments 30 days after spray. None of the commercial products of microbial pathogens were also effective against root mealybug and the reduction in population of ranged from 9.6% to 13.3% in various treatments 30 days after spray.

The effect of application of biocontrol consortium (*Pseudomonas* spp.) for the management of *Phytophthora* and nematodes on black pepper on the population of root mealybugs was also studied in field at Peruvannamuzhi. However, none of the treatments were effective in reducing the percentage of vines colonized by root mealybugs.

g. Evaluation of eco-friendly products against root mealybug

Evaluation of plant extracts

Alcoholic and water extracts of 8 and 10 plant species, respectively, collected from Kozhikode District were evaluated in various concentrations against root mealybug (*Planococcus* sp.) in laboratory bioassays. The trials indicated that among the various treatments, alcoholic extracts of six plant species (*Azadirachita indica*, *Clerodendron infortunatum*, *Glycosmis pentaphylla*, *Ocimum basilicum, Pongamia glabra* and *Vitex negundo*) could result in over 50% reduction in population of root mealybug 30 days after treatment. Among them, *A. indica* and *V. negundo* were more effective resulting in over 75% reduction in root mealybug population 30 days after treatment. Among the water extracts, none of the treatments were effective and maximum reduction in population of root mealybug population (27%) 30 days after treatment was observed in *Samadera indica* and *Strychnos nuxvomica* .

Evaluation of neem products

Three commercial products of neem, neem oil and neem seed kernel extract were evaluated at two concentrations against root mealybug (*Planococcus* sp.) in laboratory bioassays. The trials indicated that among the neem products, Nimbicidine was the most

promising resulting in over 50% reduction in population of root mealybug 30 days after treatment. The reduction in population in the other treatments ranged from 17.8% to 43.8%.

Evaluation of organic products

Seven organic products namely, kerosene, garlic extract, custard apple seed extract, tobacco extract, neem oil + garlic extract + soap emulsion, tobacco extract + soap emulsion and kerosene + soap emulsion were evaluated against root mealybug (*Planococcus* sp.) in laboratory bioassays. The trials indicated that among the organic products, tobacco extract 3% and custard apple seed extract 2% were more promising resulting in 88% and 85% reduction in population of root mealybug, respectively, 30 days after treatment. The reduction in population of root mealybug in the other treatments ranged from 12.6% to 64.8%.

In the second experiment various concentrations (1%, 3% and 5%) of paraffin base oil (Agrospray Oil) were prepared and evaluated against root mealybug (*Planococcus* sp.) in laboratory bioassays. The trials indicated that among the various treatments Agrospray Oil 3% was the most effective resulting in 85.3% reduction in population 7 days after the third spray.

h. Evaluation of insecticides against root mealybug

Various experiments were undertaken in the laboratory to identify insecticides that are promising against root mealybug (*Planococcus* sp.) for evaluation in the field later. In the first experiment 11 insecticides namely, acephate, carbosulfan, chlorpyriphos, quinalphos, dimethoate, carbaryl (0.075% each), fenvalerate, imidacloprid, lamda-cyhalothrin, acetamiprid and thiomethoxam (0.025% each) were evaluated in laboratory bioassays for their efficacy against root mealybug. The insecticides were prepared at the desired concentrations and sprayed on pumpkins and 30 adult females of root mealybug were introduced 1 day after spraying and the females were removed after 7 days. The population of root mealybug in various treatments was counted 15 and 30 days after treatment. The results of the first experiment indicated that all the insecticides except fenvalerate and thiomethoxam could cause above 90% reduction in root mealybug population 15 and 30 days after treatment.

In the second experiment the root mealybug was inoculated 30 days after spray and the population of root mealybug in various treatments was counted 15 and 30 days after

treatment and the per cent reduction over control was determined. The results of the second experiment indicated that among the various insecticides acephate, carbosulfan, chlorpyriphos, dimethoate, carbaryl, imidacloprid, lamda-cyhalothrin and acetamiprid could cause above 90% reduction in root mealybug population at 15 and 30 days after treatment.

In the third experiment the promising insecticides namely, acetamaprid, imidacloprid and lamda-cyhalothrin were evaluated at 0.0125%, 0.075% and 0.005% each and carbosulfan and chlorpyriphos were evaluated at 0.05% each. The root mealybug was inoculated 1 day after spraying, and the population of root mealybug in various treatments was counted 15 and 30 days after treatment. The results of the third experiment indicated that all the insecticides evaluated could cause above 90% reduction in root mealybug population at 15 and 30 days after treatment.

In the fourth experiment the promising insecticides namely, acetamaprid, imidacloprid and lamda-cyhalothrin were evaluated at 0.0125%, 0.075% and 0.005% each and carbosulfan and chlorpyriphos were evaluated at 0.05% concentrations. The root mealybug was inoculated 30 days after spraying, and the population of root mealybugs in various treatments was counted 15 and 30 days after treatment. The results of the fourth experiment indicated that all the insecticides evaluated except carbosulfan and chlorpyriphos could cause above 90% reduction in root mealybug population 15 and 30 days after treatment.

i. Management of root mealybugs in the field

The promising insecticides namely, imidachloprid 0.0125%, acetamaprid 0.0125% and carbosulfan 0.075% were evaluated in the field along with the present recommendation of chlorpyriphos 0.075% at Peruvannamuzhi to select a insecticide which is promising in the field and which can be utilized in developing integrated schedules against root mealybugs. The trials were laid out in a randomized block vines with four replications. The insecticides were drenched on affected vines and the population of root mealybugs on the experimental vines was recorded 1 and 2 months after treatment.

The trials indicated that all the insecticides were significantly effective and were on par in reducing the population of root mealybugs up to 60 days after treatment. At 30 days after treatment, there was no population of root mealybugs in all the treatments. At 60 days after treatment there was no population of root mealybug in vines treated with

acetamaprid and imidacloprid, whereas in vines treated with carbosulfan and chlorpyriphos, there was a mild build up of pest population 60 days after treatment which was however, on par with acetamaprid and imidacloprid.

In the second trial, three natural products, namely, custard apple seed extract 2%, neem leaf extract 1% and tobacco extract 3% that were promising in laboratory bioassays were evaluated in the field against root mealybugs along with the present recommendation of chlorpyriphos 0.075% at Peruvannamuzhi. The trials were laid out in a randomized block vines with four replications. The natural products and insecticides were drenched on affected vines thrice at 21 day intervals and the population of root mealybugs on the experimental vines was recorded 21 days after each treatment.

The trials indicated that at 21 days after I treatment, only tobacco extract was promising in reducing the population of root mealybugs among the various natural products. At 21 days after II treatment, neem leaf extract and tobacco extract were promising in reducing the population of root mealybugs. At 21 days after III treatment all the natural products were effective significantly effective in reducing the population of root mealybugs. Among the natural products custard apple seed extract 2% and tobacco extract 3% were on par with each other.

j. Integrated management of root mealybugs

The following integrated schedule was suggested for the management of root mealybugs based on various studies conducted in the project:

- Planting of root mealybug-free rooted cuttings in the field.
- Removal of weeds in interspaces of black pepper vines during summer.
- Drenching imidacloprid 0.0125% or acetamaprid 0.0125% or carbosulfan 0.075% or chlorpyriphos 0.075% on affected vines.
- Drenching tobacco extract 3% on affected vines in case the infestation is mild.
- Adoption of control measures against *Phytophthora* and nematode infections.

8221 Achievements in terms of targets fixed for each activity

Sl. No.	Target	Achievement
1.	Distribution of root mealybug	The distribution of root mealybug on black pepper was studied by conducting surveys for the incidence of the pest in various locations Kerala and Karnataka.
2.	Studies on bioecology of root mealybug	The nature of damage, life history, alternate hosts, seasonal incidence and natural enemies of root mealybugs were studied..
3.	Evaluation and development of integrated pest management technologies against root mealybug.	Various plant products, microbial pathogens and insecticides were evaluated for their efficacy against root mealybug. Integrated management technologies for the management of the pest were developed.

8222 Questions answered

a. What are areas where root mealybug infestations are observed on black pepper vines ?
b. What is the nature of damage, life history, seasonal population, alternate hosts and natural enemies of root mealybugs infesting black pepper?
c. What is the effect of various plant products, microbial pathogens and insecticides on root mealybugs?
d. What are the technologies to be adopted for the management of root mealybug ?

8223 Process/Product/Technology developed

a. Integrated management of root mealybugs infesting black pepper.

The following integrated schedule was suggested for the management of root mealybugs infesting black pepper in the field based on various studies conducted in the project:

- Planting of root mealybug-free rooted black pepper cuttings in the field.

- Removal of weeds in interspaces of black pepper vines in the field during summer to reduce the population build-up of root mealybugs on alternate host plants.
- Drenching insecticides such as imidacloprid 0.0125% or acetamaprid 0.0125% or carbosulfan 0.075% or chlorpyriphos 0.075% on affected vines. At least 5–10 litres of insecticide solution should be drenched per vine depending upon its age. The insecticide should be slowly poured around the base of the vine so that it percolates down into the soil.
- Drenching tobacco extract 3% on affected vines (5–10 litres per vine) in case the infestation is mild.
- Adoption of control measures such as drenching potassium phosphonate 0.3% or metalaxyl-mancozeb 0.125% against *Phytophthora* and application of phorate 10 G 30 g per vine or carbofuran 3 G 100 g per vine against nematode infections during April-May and September-October.

8224 Practical utility (not more than 150 words)

The study established the distribution and nature of damage caused by root mealybugs to black pepper. The various symptoms of root mealybug infested vines were clearly established. The technology developed for the management of root mealybugs of black pepper would result in reducing the crop loss caused by the pest thus increasing the production and productivity of the crop.

8225 Constraints, if any : Nil

823 Publications and material development :
(One copy each to be supplied with this pro forma)

8231 Research papers

1. Bhat, A. I., Devasahayam, S., Hareesh, P., Preethi, N. and Tresa, T. 2003. *Planococcus citri* (Risso)-an additional mealybug vector of badna-virus infecting black pepper (*Piper nigrum* L.) in India. Entomon 30: 1–6.

Papers presented in Seminars / Symposia (Abstracts)

1. Tresa, T., Preethi, N., Devasahayam, S. and Koya, K. M. A. 2004. Evaluation of plant materials for the multiplication of root mealybug (*Planococcus* sp.) infesting black pepper (*Piper nigrum*) in the laboratory. In: Abstracts of Papers, Symposium on Commercialization of Spices, Medicinal and Aromatic Crops, 1–2 November 2004, Calicut.

8232 Popular articles

1. Devasahayam, S. 2006 Root mealybugs : a major pest of black pepper. The Hindu 10 August 2006, p. 16.

8233 Reports

1. IISR 2004 Annual Report for 2003-04, Bioecology and integrated management of mealybug *Planococcus* sp. infesting black pepper, Indian Institute of Spices Research, Calicut, 9 pp.
2. IISR 2005 Annual Report for 2004-05, ICAR Ad-hoc Scheme, Bioecology and integrated management of mealybug *Planococcus* sp. infesting black pepper, Indian Institute of Spices Research, Calicut, 10 pp.
3. IISR 2006 Annual Report for 2005-06, ICAR Ad-hoc Scheme Bioecology and integrated management of mealybug *Planococcus* sp. infesting black pepper, Indian Institute of Spices Research, Calicut, 10 pp.
4. IISR 2006 Final Report, ICAR Ad-hoc Scheme, Bioecology and integrated management of mealybug *Planococcus* sp. infesting black pepper, Indian Institute of Spices Research, Calicut, 25 pp.

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

1. Symposium on Commercialization of Spices, Medicinal and Aromatic Crops, 1–2 November 2004, Calicut.
2. National Seminar on Insect Growth Regulators and Natural Products in Insect Pest Management, 11 January 2005, Calicut.

824 Infrastructural facilities developed

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

Various field and laboratory note books and 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

Since root mealybugs are hypogeic in nature, attempts should be made to develop a suitable technology for ensuring that the applied chemical reaches the desired area under the soil and the efficacy of the applied chemical can be increased. Since the probability of occurrence of predators and parasitoids on root mealybugs are remote due to its habitat attempts should be made to identify potential microbial pathogens that can be incorporated in IPM schedules.

Part-IV : Project Expenditure
(Summary)
2003–2006

830 Total Recurring Expenditure

8301	Salaries SRFs	Actual (Rs) Rs. 5,09,491
8302	Recurring	Rs. 2,88,291
8304	Institutional charges	Rs. 65,328
8305	Total	Rs. 8,63,110
831	**Total Non-Recurring Expenditure** (Equipments)	Rs. 2,12,236
Total	(830 and 831)	**Rs. 10,75,346**

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. M. Anandaraj

Signature & Comments of
Head of the Division/ Section

Signature & Comments of
Director