

**RPF - III**

**PROFORMA FOR SUBMISSION OF  
FINAL REPORT OF RESEARCH PROJECTS**

**Part - I: GENERAL INFORMATION**

- 800 Project Code** :
- 8001 Institute Project Code No. : Ent. XIII (813)
- 8002 ICAR Project Code No. :
- 801 Name of the Institute and Division** : Indian Institute of Spices Research  
Crop Protection
- 8011 Name and address of Institute: : Indian Institute of Spices Research  
Marikunnu P.O, Kozhikode-673012
- 8012 Name of Division/Section : Crop Protection/Entomology
- 8013 Location of the Project : IISR, Kozhikode.
- 802 Project Title** : Screening of germplasm accessions of  
spices and evaluation of antibiotics  
resistance to major insect pests.
- 803 Priority Area** : Spices
- 8031 Research Approach:

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

- 804 Specific area** : Entomology
- 805 Duration of Project** :
- 8051 Date of start of project : 2006
- 8052 Date of completion of project : 2013
- 806 Total cost / Expenditure incurred** : **Rs. 69,16,140/-**

(Give reasons for variation, if any from original estimated cost)

The project was originally proposed for 5 years. Based on RAC recommendations to biochemically characterize the moderately resistant and highly susceptible accessions of ginger and turmeric to shoot borer, the IRC in 2011 approved the extension of the project for 2 more years. Dr. C.M. Senthil Kumar, Senior Scientist also joined the project during the extended period of the project. The hike in salary estimates due to 6<sup>th</sup> CPC and joining of a new scientist, coupled with the extension of the project for 2 years led to variation from the original cost.

## 807 Executive Summary:

Screening of 113 black pepper cultivars and 76 hybrids available in the Germplasm Conservatory at the Experimental Farm of IISR at Peruvannamuzhi, showed that none of them were resistant to pollu beetle (*Lanka ramakrishnai* Prathapan & Viraktamath) attack.

Biochemical characterization of susceptible and resistant black pepper accessions to pollu beetle indicated that total essential oils and phenols in berries and leaves of three black pepper resistant accessions (816, 841 and 1114) and one susceptible variety (Panniyur-1) were not statistically significant. The surface wax in immature berries in the resistant accessions varied from 0.48-0.69 µg/g and in susceptible variety it was 0.29 µg/g and was significantly different.

Four hundred and ninety two accessions of ginger (*Zingiber officinale* Rosc.) available in the Germplasm Conservatory including popular cultivars and high yielding varieties were screened in the field against the shoot borer (*Conogethes punctiferalis* Guen.) at the Experimental Farm of IISR at Peruvannamuzhi. All the accessions were susceptible to the pest infestation. The accessions were rated for their resistance/susceptibility and none were highly resistant, whereas, 49, 251, 130 and 62 accessions were rated as moderately resistant, moderately susceptible, susceptible and highly susceptible, respectively, to the pest. Among the popular cultivars, Jorhat, Rio-de-Janerio, Thingpui and Burdwan were rated as moderately resistant. Among the high yielding varieties released by IISR, Rejatha was moderately resistant. There was no phylogenetic influence on the resistance of the accessions to the pest and 66.7% of the moderately resistant accessions under consideration belonged to Kerala where the highest area is under the crop in India.

Nine hundred and fifteen accessions of turmeric (*Curcuma longa* L.) that included popular cultivars and improved varieties available at the Germplasm Conservatory at the Experimental Farm of Indian Institute of Spices Research (IISR), Peruvannamuzhi, were screened in the field against the shoot borer. All the accessions were susceptible to the pest infestation. Rating of accessions in relation to the level of pest infestation indicated that none of the accessions were rated as resistant, whereas, 34, 412, 456 and 13 accessions were rated as moderately resistant, moderately susceptible, susceptible and highly susceptible, respectively, to the pest.

Total fibre and lignin contents in mature shoots and total carbohydrates, lignin and proteins in mature leaves were estimated in moderately resistant and susceptible accessions of ginger and turmeric to shoot borer. Lignin, total proteins, total phenols, carbohydrates and fibre contents in immature leaf tissues and immature shoots were also determined in

susceptible and moderately resistant accessions. Epicuticular wax was estimated in immature leaf tissues. The results were not statistically significant between the accessions

Analyses of N, P, K, Ca, Mg, Fe, Mn, Zn and Cu contents of immature leaves of susceptible and moderately resistant accessions of ginger and turmeric to shoot borer recorded no statistically significant differences, except in case of copper content which was significantly higher in moderately resistant turmeric accessions (21.3 mg/kg of dried leaves) compared to that of susceptible turmeric accessions (16.5 mg/kg).

The life cycles of shoot borer were studied on moderately resistant and highly susceptible accessions of ginger and turmeric. However, the differences in days taken to complete each stage and larval and pupal weights were not statistically significant.

**808 Key words:** ginger, turmeric, black pepper, pollu beetle, shoot borer, antibiosis, resistance, biochemical characterization.

## **PART - II: INVESTIGATOR PROFILE**

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

- 810 Principal Investigator :**
- 8101 Name : Dr. T.K. Jacob
- 8102 Designation : Principal Scientist
- 8103 Division/Section : Crop Protection/Entomology
- 8104 Location : IISR, Kozhikode
- 8105 Institute Address : Indian Institute of Spices Research  
Marikunnu P.O, Kozhikode
- 811 Co-Investigator:**
- 8111 Name : Dr. S. Devasahayam
- 8112 Designation : Head, Crop Protection
- 8113 Division/Section : Crop Protection
- 8114 Location : IISR, Kozhikode
- 8115 Institute Address : Indian Institute of Spices Research  
Marikunnu P.O, Kozhikode
- 812 Co-Investigator:**
- 8121 Name : Dr. C.M. Senthil Kumar
- 8122 Designation : Senior Scientist
- 8123 Division/Section : Crop Protection/Entomology
- 8124 Location : IISR, Kozhikode
- 8125 Institute Address : Indian Institute of Spices Research  
Marikunnu P.O, Kozhikode

## **PART - III: TECHNICAL DETAILS**

### **820 Introduction and Objectives:**

#### **8201 Project Objectives:**

##### **Objectives:**

1. To identify the black pepper accessions resistant to pollu beetle and turmeric and ginger accessions to shoot borer.
2. To evaluate the antibiosis resistance in the germplasm accessions of black pepper to pollu beetle and turmeric and ginger accessions to shoot borer.
3. To biochemically characterize susceptible and resistant ginger and turmeric accessions to shoot borer

#### **8202 Background information and importance of the project**

Collection and maintenance of spices germplasm is one its main mandates of Indian Institute of Spices Research. Newer collections are added to the germplasm every year. The germplasm collections are regularly screened against major insect pests in the field for identifying resistant accessions against major insect pests. These accessions are also characterized for identification of antibiosis resistance / tolerance which could be more reliable for breeding purposes that confer prolonged / permanent resistance in the plants. Antibiosis factors prolong the generation time, reduces the reproductive potential and lead to increased mortality in pest populations and provide clues for the effective control of the pests. The present project was formulated with the aim of screening the germplasm and identifying antibiosis resistance in black pepper to pollu beetle and ginger and turmeric accessions to shoot borer.

The pollu beetle is a major pest of black pepper especially in the plains. The ginger shoot borer is polyphagous and serious pest of ginger and turmeric in all tracts of the crops. Effective control of the pests is therefore very important for preventing crop losses. Breeding programmes for evolving resistant varieties of black pepper, ginger and turmeric to major pests based on antibiosis factors would provide ecologically sound, effective control of the pests.

#### **821 Project technical profile:**

##### **8211 Technical programme:**

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

The germplasm collections of black pepper, ginger and turmeric were field screened for identification of field resistant lines / accessions / hybrids. The life cycles of the pests

were studied in susceptible and resistant accessions. Biochemical parameters of resistant and susceptible accessions of ginger and turmeric such as leaf wax, fibre, total phenols, lignin and proteins were estimated following standard methods.

8212 Total man months' involvement of component workers

1. T. K. Jacob : 46 man months
  2. S. Devasahayam : 17 man months
  3. C. M. Senthil Kumar : 4 man months
- Total : 67 man months

## 822 Final Report on the Project

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

8221 Achievements in terms of targets fixed for each activity

### Target 1. Screening of black pepper germplasm against pollu beetle

**Achievement:** Screening of black pepper cultivars and hybrids during 2006-2011 in the Germplasm Conservatory at Experimental Farm of IISR at Pervannamuzhi, showed that none of them were resistant to pollu beetle attack. Among the cultivars, Acc. No. 1423 had the lowest berry damages of 2.7 and 0.0 per cent during 2008-09 and 2010-11, but had high percentage (> 30 per cent) pest attack during the rest of the study period (Table 1).

**Table 1. Screening of black pepper accessions against pollu beetle**

Year	Cultivars	Hybrids	% berries infested (range)
2006-07	66	76	1.6-52.6
2007-08	57	61	0-34.4
2008-09	113	72	1.8-44.4
2009-10	110	75	0-36.5
2010-11	36	15	0-51.6

### Target 2. Biochemical characterization of resistant and susceptible accessions of black pepper to pollu beetle

**Achievement:** Biochemical characterization of susceptible and resistant black pepper accessions to pollu beetle was carried out. The total essential oils and phenols were estimated in berries of three black pepper resistant accessions (816, 841 and 1114) and one susceptible variety (Panniyur-1) (Table 2). The total essential oil in dried immature berries of susceptible

(Panniyur-1) variety was 3.98% and in resistant accessions it ranged from 2.80% to 8.60%. The total phenol content in susceptible variety was 0.61 mg/g and it ranged from 0.74 to 1.01 mg/g in resistant accessions. The surface wax in immature berries in the resistant accessions varied from 0.48 to 0.69  $\mu\text{g/g}$  and in susceptible variety it was 0.29  $\mu\text{g/g}$ . The surface wax content of berries in resistant and susceptible accessions was significantly different.

**Table 2. Biochemical characterization of black pepper accessions against pollu beetle**

Parameter	Resistant (range)	Susceptible
Wax ( $\mu\text{g/g}$ fresh immature berries)	0.48-0.69	0.29
Essential oils (% dried immature berries)	2.80-8.60	3.98
Total phenols (mg/g dried immature berries)	0.74-1.01	0.61

### Target 3. Screening of turmeric germplasm against shoot borer

**Achievement:** Nine hundred and fifteen accessions of turmeric that included popular cultivars and improved varieties available in the Germplasm Conservatory at the Experimental Farm of IISR, Peruvannamuzhi were screened in the field against the shoot borer for four consecutive years during 2005-09. All the accessions were susceptible to the pest infestation. Rating of accessions in relation to the level of pest infestation indicated that none of the accessions were rated as resistant, whereas, 34, 412, 456 and 13 accessions were rated as moderately resistant, moderately susceptible, susceptible and highly susceptible, respectively, to the pest (Tables 3 & 4). The reaction of popular varieties/cultivars to shoot borer are presented in Table 5.

**Table 3. Reaction of turmeric accessions to shoot borer**

Category of resistance	Range of shoot damage (%) (Criteria for classification)	No. of accessions
Resistant	0	0
Moderately resistant	< 13.57 (less than mean - 2 SD)	34
Moderately susceptible	13.58 - 28.95 (mean - 2 SD to mean)	412
Susceptible	28.96 - 44.33 (mean to mean + 2 SD)	456
Highly susceptible	> 44.34 (more than mean + 2 SD)	13

Mean = 28.95; SD=7.69

**Table 4. List of turmeric accessions exhibiting moderately resistant reaction to shoot borer**

Category of resistance	Accession no.
Moderately resistant	954, 619, 1026, 422, 435, 589, 687, 579, 964, 1028, 751, 693, 592, 1036, 1039, 483, 749, 438, 931, 972, 684, 413, 433, 419, 615, 930, 580, 381, 594, 1010, 911, 985, 1034, 932

The accessions are arranged in ascending order of per cent shoot damage

**Table 5. Resistance/susceptibility of popular cultivars and high yielding varieties of turmeric to shoot borer (*C. punctiferalis*)**

Moderately resistant	Moderately susceptible	Susceptible	Highly susceptible
Roma (930), Suroma (931), Rasmi (932)	Alleppey 1 (1), Amalapuram (2, 3), Co-1 (219), IISR Prabha (360), Prathiba (361), Alleppey Supreme (585), Duggirala (63), Jobedi (10), Amruthapani Kothapeta (07), Ranga (933), Tekurpet (224)	Sugandham (37), Kedaram (126), Mydukar (138), Avanigadda (276), Erode (198), Shillong (117), Gorakhpur (16), Lakadong (312), Vontimitta (40), Mananthavady (32), Maran (98), Kalimpong (111), Nandyal (34), Dughi/Dhagi (11)	Kasturi (28), Idukki-2 (74)

Numbers in parentheses indicate accession numbers

#### **Target 4. Screening of ginger germplasm against shoot borer**

**Achievement:** Four hundred and ninety two accessions of ginger available in the Germplasm Conservatory including popular cultivars and high yielding varieties were screened in the field against the shoot borer for four years at the Experimental Farm of IISR at Peruvannamuzhi. All the accessions were susceptible to the pest attack. The accessions were rated for their resistance/susceptibility and none were highly resistant, whereas, 49, 251, 130 and 62 accessions were rated as moderately resistant, moderately susceptible, susceptible and highly susceptible, respectively, to the pest (Table 6). Among the popular cultivars, Jorhat, Rio-de-Janerio, Thingpui and Burdwan were rated as moderately resistant and among the high yielding varieties released by IISR, Rejatha was moderately susceptible to the pest (Table 7). There was no phylogenetic influence on the resistance of the accessions to the pest and 66.7% of the moderately resistant accessions under consideration belonged to Kerala.

**Table 6. List of ginger accessions exhibiting moderately resistant reaction to shoot borer**

Category of resistance	Mean % damaged shoots	Accessions
Moderately resistant	<12.47	031, 247, 409, 431, 430, 631, 293, 227, 298, 586, 587, 575, 151, 577, 472, 565, 203, 065, 491, 588, 630, 252, 281, 174, 444, 178, 269, 291, 026, 073, 083, 171, 579, 059, 341, 422, 447, 485, 164, 372, 581, 610, 613, 053, 432, 246, 435, 530, 260.

The accessions are arranged in ascending order of maximum per cent shoot damage.

**Table 7. Resistance/susceptibility of popular cultivars and high yielding varieties of ginger to shoot borer (*C. punctiferalis*)**

Moderately resistant	Moderately susceptible	Susceptible	Highly susceptible
Jorhat (291), Rio-de-Janerio(059), Thingpui (073), Burdwan (247)	Rejatha (035), Assam (187), Maran (295), Nadia (027), Himachal (294), Burdwan (006), Tura (097), Ernanan (013), Wyanad Kunnamagalam (079), China (009), Vengara (076), Burdwan-1 (007), Burdwan-2 (008), Wayanad Local (251)	Mahima (117), Thodupuzha (204, 217, 200, 205), Varada (064), Jorhat (249)	Thodupuzha (208), Wyanad Local (078), Jamaica (428), Kurumaput Local (023)

Numbers in parentheses indicate accession numbers

**Target 5. Biochemical characterization of moderately resistant and highly susceptible accessions of ginger and turmeric**

**Achievement:** Total fibre and lignin contents in mature shoots, total carbohydrates, lignin and proteins in mature leaves were estimated in both moderately resistant and susceptible accessions of ginger and turmeric to shoot borer. Lignin, total proteins, total phenols, carbohydrates and fibre contents in immature leaf tissues and immature shoots were also determined in susceptible as well as in moderately resistant accessions. Epicuticular wax was estimated in immature leaf tissues. The results are presented in tables 8, 9, 10 and 11.



**Table 8. Biochemical characterization of ginger accessions against shoot borer (Immature leaf and shoot)**

Biochemical parameter	Immature Leaf*		Immature shoot*	
	Mod. Res.	Susceptible	Mod. Res.	Susceptible
Epicuticular wax (mg/200cm <sup>2</sup> leaf)	18.0-24.7 (22.9)	20.0-27.0 (23.6)	-	-
Lignin (%)	27.1-41.05 (33.0)	29.9-42.3 (35.5)	35.4-43.0 (41.7)	42.4-43.5 (42.9)
Carbohydrates (mg/100 mg dried tissue)	8.9-16.6 (13.4)	15.8-23.9 (19.3)	18.1-27.6 (21.4)	15.9-25.4 (19.2)
Fibre (%)	20.0-24.0 (21.7)	23.0-26.7 (24.7)	22.6-32.6 (28.0)	22.0-30.6 (26.4)
Phenols (mg/100 mg dried tissue)	0.2-0.5 (0.34)	0.3-0.6 (0.44)	0.2-0.4 (0.3)	0.1-0.2 (0.2)
Protein (mg/100 mg dried tissue)	2.0-2.9 (2.6)	2.4-3.2 (2.8)	1.6-1.9 (1.7)	1.2-1.8 (1.6)

\*The differences in parameters studied were not statistically significant between susceptible and resistant accessions. Figures in parentheses show mean values

**Table 9. Biochemical characterization of ginger accessions against shoot borer (Mature leaf and shoot)**

Biochemical parameter	Mature Leaf*		Mature shoot*	
	Mod. Res.	Susceptible	Mod. Res.	Susceptible
Lignin (%)	10.1-18.9 (15.4)	11.1-18.1 (14.7)	8.6-17.6 (13.1)	17.5-17.6 (17.6)
Carbohydrates (mg/100 mg dried tissue)	6.2-13.1 (9.8)	6.9-16.3 (12.3)	-	-
Fibre (%)	-	-	24.6-34.3 (30.2)	19.3-27.7 (23.7)
Protein (mg/100 mg dried tissue)	1.5-4.6 (2.7)	1.3-2.7 (1.7)	-	-

\*The differences in parameters studied were not statistically significant between susceptible and resistant accessions. Figures in parentheses show mean values

**Table 10. Biochemical characterization of turmeric accessions against shoot borer (Immature leaf and shoot)**

Biochemical parameters	Immature Leaf*		Immature shoot*	
	Mod. Res.	Susceptible	Mod. Res.	Susceptible
Epicuticular wax (mg/200 cm <sup>2</sup> leaf)	4.50-4.53 (4.5)	4.50-4.53 (4.5)	-	-
Lignin (%)	36.8-42.3 (39.3)	36.5-42.0 (39.6)	43.1-43.8 (43.7)	42.7-44.4 (43.6)
Carbohydrates (mg/100 mg dried tissue)	15.2-17.3 (16.5)	15.1-18.3 (16.1)	13.0-23.9 (17.0)	12.1-18.4 (15.7)
Fibre (%)	18.7-22.0 (20.2)	15.0-22.0 (19.0)	24.3-30.3 (27.3)	25.7-37.0 (31.4)
Phenols (mg/100 mg dried tissue)	0.8-1.5 (1.0)	1.1-1.5 (1.4)	0.12-0.14 (0.14)	0.11-0.15 (0.14)
Protein (mg/100 mg dried tissue)	2.2-2.6 (2.3)	1.8-2.0 (1.9)	1.5-1.9 (1.6)	1.5-1.8 (1.6)

\*The differences in parameters studied were not statistically significant between susceptible and resistant accessions. Figures in parentheses show mean values

**Table 11. Biochemical characterization of turmeric accessions against shoot borer (Mature leaf and shoot)**

Biochemical parameters	Mature Leaf*		Mature shoot*	
	Mod. Res.	Susceptible	Mod. Res.	Susceptible
Lignin (%)	26.4-48.7 (39.5)	23.9-39.1 (33.9)	10.6-35.6 (23.1)	28.1-32.8 (30.5)
Carbohydrates (mg/100 mg dried tissue)	7.6-19.7 (14.2)	8.8-12.8 (10.6)	-	-
Fibre (%)	16.3-25.4 (19.7)	18.1-23.6 (20.2)	23.0-32.7 (28.6)	21.2-31.8 (25.7)
Protein (mg/100 mg dried tissue)	1.1-7.8 (3.7)	1.1-3.0 (2.3)	-	-

\*The differences in parameters studied were not statistically significant between susceptible and resistant accessions. Figures in parentheses show mean values

**Target 6. Studies on leaf nutrient contents of resistant and susceptible accessions of turmeric and ginger to shoot borer**

**Achievement:** Analyses of N, P, K, Ca, Mg, Fe, Mn, Zn and Cu contents of immature leaves of susceptible and moderately resistant accessions of turmeric and ginger to shoot borer were carried out to find out their roles in imparting resistance/susceptibility in host plants to the borer. The results are presented in Tables 12 and 13. The levels of nutrients (N, P, K, Ca, Mg, Fe, Mn, Zn and Cu) in immature leaf tissues of moderately resistant and highly susceptible accessions of ginger to shoot borer did not record any statistically significant differences. The levels of nutrients in immature leaf tissues of moderately resistant and highly susceptible accessions of turmeric to shoot borer also did not record any statistically significant differences, except the copper content which was significantly higher in moderately resistant accessions (21.3 mg/kg of dried leaves) compared to that of susceptible accessions (16.5 mg/kg of dried leaves).

**Table 12. Analyses of nutrients in moderately resistant and susceptible accessions of turmeric to shoot borer**

Nutrient	Moderately resistant (mg /kg tissue)	Susceptible (mg /kg tissue)
N	1.5 – 1.9 (1.73)	1.65 – 2.22 (1.94)
P	0.13 – 0.16 (0.15)	0.12 – 0.16 (0.14)
K	4.32 – 4.35 (4.33)	4.32 – 4.33 (4.33)
Ca	0.22 – 0.60 (0.39)	0.29 – 0.67 (0.48)
Mg	0.40 – 0.47 (0.44)	0.20 – 0.28 (0.24)
Fe	97 – 199 (152.33)	65 – 156 (110.50)
Mn	84 – 92 (88.0)	31 – 90 (60.50)
Zn	23 – 41 (29.0)	6 – 10 (8.00)
Cu	20 – 22 (21.33)	16 – 17 (16.50)

**Table 13. Analyses of nutrients in moderately resistant and susceptible accessions of ginger to shoot borer**

Nutrient	Moderately Resistant (mg/kg tissue)	Susceptible (mg/kg tissue)
N	2.19 – 3.88 (3.05)	2.40 – 3.53 (2.92)
P	0.12 – 0.18 (0.15)	0.13 – 0.17 (0.16)
K	2.86 – 4.35 (4.04)	3.03 – 4.34 (4.03)
Ca	0.16 – 0.66 (0.34)	0.15 – 0.56 (0.32)
Mg	0.26 – 0.54 (0.39)	0.27 – 0.55 (0.41)
Fe	164 – 488 (328.24)	187 – 774 (335.21)
Mn	54 – 186 (85.18)	54 – 221 (85.57)
Zn	17 – 49 (31.12)	17 – 160 (43.71)
Cu	15 – 29 (19.88)	10 – 21 (18.14)

**Target 7. Bionomics of shoot borer on moderately resistant and susceptible turmeric accessions**

**Achievement:** The life cycles of shoot borer were studied on moderately resistant and susceptible accessions. The average adult longevity, pupal period and fifth instar larval period were 2.9, 12.3 and 6.4 days, respectively on resistant accessions. Fourth and fifth instar and pupal weights were 0.144, 0.114 and 0.087 g, respectively on resistant accessions. The average adult longevity, pupal period and fifth instar larval period were 3.0, 11.3 and 6.8 days, respectively on susceptible accessions. Fourth and fifth instar and pupal weights were 0.14, 0.12 and 0.09 g, respectively on susceptible accessions. However, the differences in days taken to complete each stage and larval and pupal weights were not statistically significant on moderately resistant and susceptible accessions.

**Target 8. Bionomics of shoot borer on field resistant and susceptible ginger accessions:**

**Achievement:** The life cycles of shoot borer were studied on moderately resistant and susceptible accessions. The average adult longevity, pupal period and fifth instar larval period were 2.9, 12.4 and 7.5 days, respectively on resistant accessions. The fourth and fifth instar and pupal weights were 0.10, 0.10 and 0.07 g respectively. The average adult longevity, pupal period and fifth instar larval period were 2.8, 15.7 and 7.8 days respectively

on susceptible accessions. The fourth and fifth instar and pupal weights were 0.13, 0.11 and 0.07 g respectively. However, the differences in days taken to complete each stage and larval and pupal weights on resistant and susceptible accessions were statistically insignificant.

#### 8222 Questions –Answered

1. Whether any of the black pepper accessions screened were resistant to pollu beetle?

The screening of black pepper cultivars and hybrids showed that none of them were resistant to pollu beetle.

2. Whether any biochemical parameter contributes towards resistance to pollu beetle?

Higher epicuticular wax content in berries contributes towards resistance in pollu beetle.

3. Whether any accessions of ginger and turmeric are resistant to shoot borer?

In ginger and turmeric, none of the accessions were resistant to the shoot borer. Forty nine ginger accessions showed moderate field resistance to the pest. In the case of turmeric 34 accessions were rated as moderately resistant to the pest.

4. Whether any of the major biochemical parameters contribute towards the observed moderate resistance or high susceptibility in ginger and turmeric accessions to shoot borer?

The study of biochemical parameters in moderately resistant and highly susceptible accessions of ginger and turmeric to shoot borer has not shown statistically significant differences indicating biochemical parameters do not contribute towards the moderate resistance or high susceptibility of the accessions to shoot borer.

5. Whether leaf nutrients play any role in the moderate resistance or high susceptibility of ginger and turmeric accessions to shoot borer?

The levels of nutrients (N, P, K, Ca, Mg, Fe, Mn, Zn and Cu) in immature leaf tissues of moderately resistant and highly susceptible accessions of ginger to shoot borer do not record any statistically significant differences, ruling out their role in contributing resistance/susceptibility to shoot borer. However, in turmeric, copper content was significantly higher in moderately resistant accessions (21.3 mg/kg of dried leaves) compared to that of susceptible accessions (16.5 mg/kg of dried leaves).

6. Whether the observed field resistance in ginger and turmeric is due to antibiosis?

The study of life cycle of the shoot borer on moderately resistant and susceptible accessions of the crops did not record any significant host influence in the

development of the insect. Highly resistant accessions in both ginger and turmeric to the borer were absent.

#### 8223 Process/Product/Technology Developed

In turmeric, 34 accessions were identified as moderately resistant to the shoot borer. In ginger, 49 accessions were rated as moderately resistant to the pest.

#### 8224 Practical Utility:

The identification of several moderately resistant accessions of ginger and turmeric to shoot borer would lead to future development of shoot borer tolerant cultivars by utilizing these lines in breeding programmes. The significantly higher surface wax content in immature berries of black pepper can be utilized as marker for identifying black pepper lines resistant to pollu beetle in crop breeding.

8225 Constraints, if any: Nil

#### 823 Publications and Material Development

(One copy each to be supplied with this proforma)

#### 8231 Research papers published

1. Devasahayam S, Jacob, T.K, Abdullah Koya, K.M., and Sasikumar, B. 2010. Screening ginger (*Zingiber officinale* Rosc.) germplasm for resistance to shoot borer (*Conogethes punctiferalis* Guen.) (Lepidoptera: Pyralidae) *Journal of Medicinal and Aromatic Plant Sciences*, 32, 137-138.
2. Devasahayam, S., Jacob, T.K., Abdulla Koya, K.M., Sasikumar, B and Prasath, D. 2013. Screening of turmeric (*Curcuma longa* L.) germplasm for resistance to shoot borer (*Conogethes punctiferalis* Guen.) (Lepidoptera: Pyralidae). *Entomon* (In press).

#### Book chapters

1. Devasahayam, S., Eapen, S.J., Jacob, T.K., and Pervez, R. 2012. Pests. In: *Zingiberaceae Crops - Present and Future-Cardamom, Ginger, Turmeric and Others.* (Eds.) Singh, H.P., Parthasarathy, V.A., Kandiannan, K., and Krishnamurthy, K.S. Westville Publishing House, New Delhi, pp 332-347.
2. Devasahayam, S., Eapen, S.J., Jacob, T.K., and Pervez, R. 2012. Insect and nematode pests. In: *Piperaceae Crops-Production and Utilization-Black Pepper, Betelvine and Others.* (Eds.) Singh, H.P., Parthasarathy, V.A., Srinivasan, V. and Saji, K.V. Westville Publishing House, New Delhi, pp. 145-161.

### 8232 Popular articles

1. Jacob, T.K. 2012. Black pepper-technologies and disease management. *Planters Chronicle* (November 2012), 40-44.
2. Devasahayam, S and T.K. Jacob. 2012. Masala faslon ko hanee puhchaney waley keet evam un ka pardandhan. *Masala Mehak*, 1, 41-47.

### 8233 Reports:

1. Indian Institute of Spices Research, Kozhikode. Annual Reports, 2006-07, 2007-08, 2008-09, 2009-10, 2010-11, 2011-12, 2012-13.
2. Indian Institute of Spices Research, Kozhikode. Research Highlights, 2006-07, 2007-08, 2008-09, 2009-10, 2010-11, 2011-12, 2012-13.

### 8234 Seminars, conferences and workshops (relevant to the project)

1. National Workshop on Zingiberaceous Spices, 19-20, March, 2008, Kozhikode.
2. National Seminar on *Piperaceae*, 21-22 November, 2008, Kozhikode.
3. Brain storming session on Plant Protection in Spices and Plantation Crops. Spices Board, 20 June 2012, Kochi.
4. National Workshop on Strategies and Action Plan for Plant Health Management in XII Five Year Plan, 7-8 February 2013, Thiruvananthapuram.
5. Symposium on Spices and Aromatic Crops, 30-31 October, 2009, Nagaland.
6. State-level Workshop on Package of Practices of KAU, 24 February 2010, Trichur.

### 824 Infrastructural facilities developed (including location of registers, note books, etc.)

Project Register No. 59 contains summary of the work done under the project. Field Note Book No.1 and Entomology File numbered 1 contains all raw data generated during the investigations. All these documents are available in the Entomology Laboratory.

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

The moderately resistant accessions in ginger and turmeric to shoot borer identified in the project could be utilized for the development of pest resistant/tolerant cultivars in these crops. Screening of new seedling progenies against the shoot borer would be undertaken in future.