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TIONAL RESEARCH CENTRE FOR SPICES

CALICUT 673 012, KERALA, INDIA

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Calicut 673 012, Kerala, India

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Director's introduction

HISTORY

Though spice crops are cultivated in a limited area in India they are a major source of foreign exchange among agricultural commodities and play a crucial role in the economy of many states. The establishment of a Regional Station of the Central Plantation Crops Research Institute (CPCRI) by the Indian Council of Agricultural Research (ICAR) at Calicut during 1975 for conducting research on spice crops such as black pepper, ginger, turmeric, cinnamon, clove, nutmeg and allspice was a major step towards a concerted programme of research on spices. The upgrading of the Regional Station at Calicut as the National Research Centre for Spices (NRCS) during 1986 was a significant landmark in the history of spices research in the country. The Research Centre of CPCRI at Appangala conducting research on cardamom was also merged with the NRCS. Consequent to the establishment of the National Research Centres for Spices and Cashewnut, the All India Coordinated Spices and Cashewnut Improvement Project (AICSCIP) which was established during 1971 was bifurcated into individual projects on spices and cashewnut during 1985 and the headquarters of the All India Coordinated Research Project on Spices (AICRPS) was shifted to Calicut during the subsequent year. The project has 15 centres (located in different agroclimatic regions in 9 states) functioning under it.

OBJECTIVES

The objectives of the NRCS are to

* Evolve high yielding varieties in black pepper having multiple resistance to *Phytophthora,* nematodes and 'pollu' beetle

* Develop integrated field control measures against wilt diseases of black pepper

* Characterise drought tolerance in black pepper and cardamom and evolve drought resistant|tolerant varieties

* Standardise input technologies in relation to nutrients, spacing and standards for increasing the productivity of black pepper
* Evolve high yielding varieties of ginger resistant to rhizome rot and bacterial wilt diseases
* Monitor pesticide residues in spices with special reference to black pepper and cardamom
* Multiply planting materials of elite clones through tissue culture
* Transfer of spices production technology.

LOCATION

The laboratories and administrative offices of the NRCS are situated at Chelavoor, 10 kms away from Calicut on the Calicut-Wynad road in an area of 14 ha.The experimental farm is situated at Peruvannamuzhi, 51 kms away from Calicut in an area of 98 ha. At Calicut, research is being conducted on all spice crops mentioned earlier excepting cardamom. Research on cardamom is being conducted at the Cardamom Research Centre, Appangala which is situated 8 kms away from Madikeri on the Madikeri-Bhagamandala road in Kodagu district in an area of 14 ha.

STAFF AND BUDGET

The staff strength (in position) of the NRCS at Calicut and Appangala during the year included 28 scientific, 18 technical, 18 administrative, 4 auxillary and 56 supporting. The annual budget of the Research Centre for 1987-88 was Rs. 55,00,000.

RESEARCH PROGRAMMES

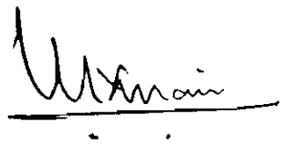
In a major reorientation of research programmes on spices during 1986, special emphasis was laid on interdisciplinary work for fulfilling the specific objectives of the NRCS. Consequently all the research projects under progress were regrouped into 12 mega projects. Since infection by diseases is a major limiting factor for the productitvity of black pepper, studies on quick and slow wilt diseases of black pepper have been given the maximum priority. Collection, conservation, evaluation and documentation of genetic resources in spices and evolving high yielding varieties by selection and hybridization have been given the next priority. About 45 experiments are being conducted on spice crops such as black pepper, cardamom, ginger, turmeric, cumin, coriander, fennel, fenugreek and large cardamom in various centres of the AICRPS. An ad hoc research scheme on black pepper and cardamom is also in progress at the Research Centre.

TRANSFER OF TECHNOLOGY

Since the productivity of most of the spices is very low, the transfer of technology developed, to appropriate agencies has been an important activity of the Research Centre. Various training programmes on cultivation of spice crops have been organised for research workers, officials of agricultural and horticultural departments and developmental agencies and farmers. Literature of extension value on cultivation of spice crops have also been published and distributed. Planting materials of black pepper, cardamom, ginger, turmeric and tree spices have been supplied to farmers and other agencies.

ABOUT THIS REPORT

The report has been organised according to the various priority areas identified. A chapter on Research Highlights during the year has been included at the beginning of the report. Detailed reports on various projects in progress and projects concluded and general information regarding the Research Centre have been given in the succeeding pages.



Calicut
11 February 1989

(MK NAIR)
Director

PROJECTS IN PROGRESS

BLACK PEPPER

Surveys were conducted in Kerala, Karnataka and Tamil Nadu for collection of germplasm and 145 collections of cultivars and 70 collections of wild relatives of black pepper were made. These included 19 collections apparently tolerant to drought from Cannanore district and 54 collections that performed well under shade from coffee and cardamom estates in Kodagu district. In the germplasm, Coll. 933 (Aimpiriyan) was the highest yielder (5.7 kg|vine-green). Morphological and anatomical characters of 43 cultivars and 7 wild accessions were studied. A comprehensive descriptor for black pepper was prepared. Evaluation of 100 Karimunda accessions indicated that Acc. 27 was the highest yielder (1.7 kg|vine-green); among the 49 Kottanadan accessions, Acc. 2559 was the highest yielder (2.49 kg).

In the fertiliser trial which was concluded, application of 140:55:270 g NPK|vine resulted in an optimum yield response. In the spacing trial with three varieties, the highest yield (5740 kg|ha-green) was obtained in Karimunda under a spacing of 2 x 1 m accommodating 5000 vines|ha. Studies with slow release fertilisers indicated that the urea N in ureaform was higher and persisted for a longer period.

Among the 100 Karimunda accessions evaluated for quality parameters, Acc. 79, 21 and 149 had the highest piperine (7.7%), oleoresin (14.5%) and essential oil (5.5% v|w) contents, respectively. Analysis of 37 accessions of cultivars indicated that piperine, oleoresin and essential oil contents ranged between 3.5-7.0%, 6.7-16.9% and 3.2-4.2% v|w, respectively.

Two hundred and forty seven accessions of cultivars were screened against the 'pollu' beetle *Longitarsus nigripennis* using a rapid screening technique. Eighteen cultivars which remained free of infestation would be screened again. Wild relatives of black pepper viz., *Piper attenuatum, P. hymenophyllum, P. longum, P. betel* and *P. colubrinum* were not preferred by the pest.

Surveys conducted in five districts in Central and Southern Kerala indicated that infestation by the top shoot borer *Cydia hemidoxa* ranged between 12-40 and 54-90 per cent in older and younger vines, respectively. Endosulfan, methyl parathion, quinalphos, dimethoate, monocrotophos and phosphamidon (0.05% each) were effective in controlling the pest infestation in field trials.

Studies on population dynamics of gall thrips *Liothrips karnyi* indicated that the pest population was high during July to September. The life history and predatory potential of *Montandoniola moraguesi* (Anthocoridae), a common predator of gall thrips was studied. Spraying of monocrotophos 0.05% was the most effective among the six insecticides tested in field trials.

Surveys conducted in Wynad and Idukki districts indicated that *Lepidosaphes piperis* and *Aspiaiotus destructor* were the common species of scale insects infesting black pepper; the percentages of infestation by these species were 19 and 7 in Wynad and 32 and 15 in Idukki districts, respectively. *Cybocephalus* sp. (Nitidulidae) was recorded to be predaceous on *L. piperis*.

Application of Ridomil 5 G (20 g|vine) was effective in controlling quick wilt. The fungicide was compatible with endosulfan, quinalphos, furadan and phorate which are commonly used for the control of 'pollu' beetle and nematodes. A technique was standardised for mass screening of seedling progenies against *Phytophthora palmivora*. M_2 seedling progenies of Panniyur-I, Karimunda and Kottanadan were screened against the fungal pathogen and 90 remained healthy. Among the 75 hybrids screened, 6 showed a tolerant reaction; none of the 49 Karimunda selections screened were tolerant. The seedlings and hybrids that remained healthy would be screened again.

Surveys conducted in Uttara Kannada district indicated that *Meloidogyne incognita* and *Radopholus similis* were the major species of endoparasitic nematodes associated with roots of black pepper occurring in 62.5 and 58.5 per cent of gardens surveyed, respectively. *Trophotylenchulus piperis* occurred in 12.5 per cent of the gardens surveyed. One hundred and twenty hybrid lines and 5000 seedlings of various cultivars were screened against *M. incognita* and *R. similis*. Eight hybrids and 10 seedlings which were resistant to *M. incognita* and *R. similis* respectively, would be screened again. Pathogenicity trials conducted in large tubs under simulated field conditions proved that *R. similis* in combination with *M. incognita* could induce the typical symptoms of slow wilt. Application of phorate resulted in reduction in population of nematodes and foliar yellowing in field trials.

Large scale demonstration of improved technology in 51 farmers fields in 3 villages resulted in an increase in 209 and 303 per cent in yield of the experimental vines in 2 villages.

CARDAMOM

In the germplasm, the highest yield (368.75 g|plant-green) was recorded in APG-88. One hundred and sixty accessions of cultivars and 14 species of allied genera were screened against 'katte' virus and all of them were susceptible.

All the M_2 and M_3 seedlings obtained from selfing 'katte' escapes were also susceptible to the virus. Thirty one 'katte' escapes were collected from hot spot areas of Kerala and Karnataka.

In tissue culture, methods were standardised for the transfer of cardamom cultures to soil. About 450 cultures were transferred to soil from 2900 cultures produced in 18 lines.

In the system of planting and fertiliser trials, the yield was higher (376.5 kg/ha-dry) in the trench system of planting when compared to the pit system. The highest yield (496.5 kg/ha-dry) was recorded in plots where 160:160:320 kg NPK/ha was applied in the trench system of planting.

Analysis of 37 accessions for their chemical quality indicated that oleoresin and essential oil contents ranged from 3.6-3.7% and 4.4-8.4% v/w, respectively.

Pythium vexans and *Rhizoctonia solani* caused damping off in primary seedlings and rhizome rot in later stages. Studies on epidemiology of rhizome rot indicated that rainfall had a positive influence on the incidence of the disease. *P. vexans* was reisolated from 2 year old dried infected soil and plant samples indicating the possible carry over of the pathogen to the next season through plant debris.

Substantial increases in yield were obtained in various research-cum-demonstration plots located in different ecological situations. An yield of 933 kg/ha (dry) was obtained in the second year of planting in the plot where cardamom was grown in valleys.

GINGER AND TURMERIC

In the turmeric germplasm, Cls. 20 was the highest yielder (15.73 kg/3 sq m bed) among the *longa* types; among the *aromatica* types, Ammicad was the highest yielder (9.35 kg). In the multilocation trial with 12 selections, PCT-13 was the highest yielder (22.7 kg/3 sq m bed) at Peruvannamuzhi: the selections PCT-10, 13 and 14 yielded significantly higher than the local variety.

In tissue culture, ginger plantlets with multiple shoots and abundant roots were obtained that were transferred to soil.

Studies on the effect of systemic fungicides on growth of *Pythium aphanidermatum* (the causal organism of rhizome rot of ginger) *in vitro* indicated that Terrazole was the most toxic. In studies under pot culture, application of Ridomil 5 G (2.5 g/3 kg of soil) was the most effective fungicide against the disease. In field trials the incidence of the disease was minimum when seed

ginger was treated with Ridomil-Ziram (100 μg/l). The crude toxin produce by *Pseudomonas solanacearum* (the causal organism of bacterial wilt of ginger was isolated and used to screen the germplasm in tissue culture. *Ageratun conyzoides* and *Eupatorium odoratum* were infested with *P. solanacearum* i ginger and turmeric fields respectively.

I. Quick and slow wilt diseases of black pepper

(General Leader : YR Sarma)

Path II.1(813). Epidemiological studies on quick wilt disease of black pepper

(M Anandaraj and *N Ramachandran)*

Meteorological parameters such as rainfall, ambient temperature, relative humidity and soil temperature (at 5, 15 and 30 cm depths) were recorded at Peruvannamuzhi (Calicut district) and Chemberi (Cannanore district). At Peruvannamuzhi, infection of runner shoots by *Phytophthora palmivora* was first noticed on 20 June 1987. Removal of infected leaves and drenching with copper oxychloride 0.2% and spraying with Bordeaux mixture 1% checked the spread of the disease. However, sporadic infection of runner shoots was noticed up to 25 August 1987. There was no incidence of foot rot during the year at both the locations.

Monitoring of field soils for the presence of *P. palmivora* by baiting was carried out at monthly intervals at Peruvannamuzhi. Positive baiting was obtained in August, September and December.

For studies on the effect of age of vines to infection by *P. palmivora*, vines of age groups 1, 2, 3, 4 and 5 years grown in cement tubs were inoculated with the pathogen. The inoculum consisted of 1 cm diameter sporulating culture discs of *P. palmivora* MF_4. For each age group there were four treatments viz., 8, 16 and 24 discs/plant and control; four plants were taken for each treatment. The soil in the tubs was kept moist by daily irrigation. One plant in the age group of 4 years has succumbed to the disease so far. The population of *P. palmivora* in different treatments was also monitored at monthly intervals by baiting.

Path II.2(813). Screening germplasm material for reaction to quick wilt of black pepper

(YR Sarma, M Anandaraj and *N Ramachandran)*

A technique was developed for mass screening of seedling progenies against *P. palmivora.* In this method the seedlings are raised in contaminated soil and the susceptible ones succumb to the infection within a month.

M_2 *seedling progenies of Panniyur-I, Karimunda and Kottanadan* were screened and 90 seedlings which remained healthy were maintained for further screening. Six out of 75 hybrid lines and none of the 49 Karimunda selections screened showed a tolerant reaction.

Among the 26 disease escapes from previous screening, 5 showed a tolerant reaction. The available tolerant types were multiplied and 25 types have been handed over to Nematology Section for screening against nematodes.

Path II.3(813). Disease management in quick wilt affected black pepper gardens

(N Ramachandran, M Anandaraj and *YR Sarma)*

The field experiment initiated during 1986 to evaluate the efficacy of Ridomil 5 G granules in controlling *P. palmivora* infection was continued at Chemberi. The treatments included, two doses of Ridomil 5 G viz., 10 and 20 g/vine applied once during June, besides Bordeaux mixture and untreated control. The intensity of foliar and collar infection was recorded. The disease was less severe during the year and good control was obtained with Ridomil 5 G (20 g/vine). Black pepper samples were collected from vines treated with Ridomil 5 G at different time intervals for estimating the fungicide residues.

In the plot where the effect of different levels of phosphorous on the incidence of quick wilt is being studied, soil samples were collected for estimating the phosphorous-fixing capacity of the soil. Based on this, the doses of phosphorous applied were, 0, 75, 125, 173 and 275 g of super phosphate/ vine. So far the disease was not noticed in the plot.

Studies were continued on the physical and chemical compatibility of Ridomil with the insecticides, endosulfan and quinalphos and nematicides, furadan and phorate. The fungicide was compatible with these chemicals.

Nema II (813). Role of nematodes in the incidence of slow wilt disease of black pepper

a. Survey and screening of black pepper germplasm against root knot and burrowing nematodes

(KV Ramana and *C Mohandas)*

1. Survey of pant parasitic nematodes associated with black pepper

Forty eight each of soil and root samples collected from 24 gardens in Uttara Kannada district were analysed for plant parasitic nematodes. The analysis indicated that *Meloidogyne incognita* and *Radopholus similis* were the

major endoparasitic nematodes associated with roots of black pepper. *M. incognita* was the most widely distributed species occurring in 62.5 per cent of the gardens and 41.6 per cent of the root samples examined. *R. similis* was found in 58.3 per cent of the gardens and 39.5 per cent of the root samples examined. *Trophotylenchulus piperis* was recorded in 12.5 per cent of the gardens and 6.2 per cent of the samples examined. High populations of *M. incognita* (> 1000 nematodes|g of root) and *R. similis* (> 250 nematodes|g of root) were present in 18.8 and 12.5 per cent of root samples, respectively. Concomitant infestations by these two nematodes were recorded in 31.3 per cent of the root samples.

2. Screening of germplasm

a. Against *M. incognita*

One hundred and twenty inter cultivar hybrids and 5000 open pollinated seedlings of various cultivars were inoculated with *M. incognita* for testing their reaction to the nematode. Eight hybrid lines which showed a resistant reaction were multiplied for further testing. One hundred Karimunda selections were inoculated with *M. incognita* and were maintained for recording the final observation.

b. Against *R. similis*

One hundred and twenty inter cultivar hybrids, 40 Karimunda selections and 500 open pollinated seedlings of various cultivars were tested for their reaction to *R. similis*. Ten open pollinated seedlings which did not take up the nematode infestation were multiplied for further testing. One hundred Karimunda selections inoculated with *R. similis* were maintained for recording the final observation.

3. Susceptibility of black pepper to *R. similis* in relation to its age

To test the relative susceptibility of vines to *R. similis* in relation to its age, rooted cuttings of Panniyur-I were planted in field tubs in four batches to obtain different age groups viz., 3, 6, 9 and 12 months old at the time of inoculation. Out of 10 vines under each age group, 5 were inoculated with *R. similis* (250 nematodes|vine). The experiment is in progress.

Nema II(813). Role of nematodes in the incidence of slow wilt disease of black pepper

b. Population dynamics and pathogenicity of root knot and burrowing nematodes

(*C Mohandas* and *KV Ramana*)

1. Pathogenicity experiments

Three experiments initiated during 1983 and 1984 to study the pathogenicity of *M. incognita* and *R. similis* individually and in different combinations on black pepper were concluded. Final observations on various characteristics such as height of vine, number of primary branches, weight of shoot and root, foliar yellowing, extent of defoliation and root damage due to nematode infestation were recorded. Soil and root samples were collected and estimation of nematode population is in progress. The experiments indicated that vines inoculated with *R. similis* alone or in combination with *M. incognita* showed foliar yellowing, defoliation, stunting and die back symptoms characteristic of slow wilt.

2. Control trials

a. Nematicidal trials

Thimet, Bavistin and neem cake were applied twice during the year to the experimental vines as per treatment schedules. Soil and root samples were collected at the time of application of chemicals and nematode populations were estimated. The data indicated that among the three chemicals tested, Thimet was superior in reducing the population of *R. similis* and foliar yellowing.

b. Mode of application of nematicide

An observational trial was undertaken to study the effect of nematicide in reducing the nematode population at different distances from the point of application. Thimet (30 g/vine) was applied in one spot 15 cms away from the base of the vine. Nematode populations were estimated at 15, 30, 45 and 60 cms away from the spot of application at fortnightly intervals. The results showed that the reduction in nematode population at different distances were not significant indicating that broadcasting of nematicide in the basins is more effective than application at a specific spot.

c. Effect of Vesicular Arbuscular Mycorrhizae (VAM)

Cultures of *Glomus fasciculatus* and *G. epigenum* were mass cultured on sorghum. An experiment to study the effect of these VAM on *R. similis* and *M. incognita* was initiated.

II. Collection, conservation, evaluation and documentation of genetic resources in spices

(General leader : PN Ravindran)

Gen I(813). Collection, conservation, cataloguing and evaluation of black pepper germplasm

(PN Ravindran, MK Nair, K Nirmal Babu and *AAM Syed)*

1. Collection of germplasm

a. Cultivars

Surveys were organised to various areas in Idukki, Wynad, Calicut, Cannanore, Kodagu and Shimoga districts in Kerala and Karnataka and 145 collections were made, including 21 Kottanadan lines from CPCRI Research Centre, Palode (Table 1).

Table 1. Collection of black pepper germplasm (cultivated)

Area	No. of collections	Remarks
Kodagu district	54	Collected from coffee and cardamom estates which performed well under shade
Shimoga district	26	
Idukki district	13	
Wynad district	6	
Peruvannamuzhi, Calicut district	6	
Cannanore district	19	Collected from drought affected areas during April and May
CPCRI Research Centre, Palode	15	Kottanadan lines
CPCRI Research Centre, Palode	6	Open pollinated Kottanadan lines

b. Wild relatives of black pepper

Collections of wild *Piper nigrum* and related taxa were made from Idukki, Wynad, Kodagu, Shimoga and Kanyakumari districts. Seventy collections were made which included *P. nigrum, P. longum, P. attenuatum, P. hymenophyllum, P. galeatum* and *P. argyrophyllum.*

2. Maintenance and evaluation of germplasm

The germplasm collections were maintained in the rapid multiplication shed (1-2 vines|accession) and in the nursery (10-20 cuttings|accession). Among these, 236 cultivated types and 110 wild types are planted in the field.

The performance of some accessions planted at CPCRI Research Centre, Kannara is given in Table 2.

Table 2. Performance of some black pepper accessions at Kannara

Collection No.	Cultivar	Yield (kg|vine-green)
933	Aimpiriyan	5.7
1080	Unnamed	5.1
898	Kuttiyanikodi	4.9
942	Unnamed	4.7
1086	Unnamed	4.7
1107	Kalluvally	4.5
807	Arakulam *munda*	4.1

An alternate location for the maintenance of germplasm is being developed at Appangala (NRCS, Cardamom Research Centre).

3. Characterisation of germplasm

Morphological and anatomical characters of 43 cultivars and 7 collections of wild *P. nigrum* were recorded. Twenty two characters were recorded from the cultivars, which included morphological and anatomical characters of leaf, spike and berry. Floral biology of eight cultivars was studied. A comprehensive descriptor for black pepper was prepared.

4. Screening of germplasm for pests and diseases

Various accessions of cultivars were screened against the fungal pathogen *P. palmivora,* the nematodes *M. incognita* and *R. similis* and the 'pollu' beetle *Longitarsus nigripennis* (Refer Path II.2(813), Nema II(813) and Ent XV(813).

Gen II(813). Collection, conservation, cataloguing and evaluation of germplasm in ginger and turmeric

(MJ Ratnambal, PS Ravindran and *K Nirmal Babu)*

I. Ginger

1. Germplasm

One hundred and eighty three accessions were maintained in the germplasm.

II. Turmeric

1. Germplasm

In the germplasm 251 accessions were maintained. In addition 13 related species of *Curcuma* and 41 seedling progenies of *C. aromatica* and *C. domestica* comprising of 111 plants were planted in the field At CPCRI Research Centre, Palode 112 types were maintained. Cataloguing of 10 cultivars was completed. Flowering was observed in 57 accessions. However, seed set was obtained only in nine types (five in *C. aromatica* and four in *C. domestica*). In seedling progenies, 26 have flowered. Cls. No. 20 was the highest yielder (15.73 kg|3 sq m bed) among the *longa* types. Among the *aromatica* types, the cultivar Ammicad was the highest yielder (9.35 kg|3 sq m bed). At Palode, the yiedl varied from 0.3 to 8.5 kg|3 sq m bed.

2. Multilocation trial

In the multilocation trial with 12 selections, PCT-13 was the highest yielder (22.7 kg|3 sq m bed) followed by PCT-14 (21.9 kg) at Peruvannamuzhi. At Palode, PCT-13 was the highest yielder (4.1 kg|3 sq m bed). The selections PCT-10, 13 and 14 yielded significantly higher compared to the local variety at Peruvannamuzhi. The increase in yield in these selections was 37.9, 59.4 and 53.7 per cent, respectively when compared to control. At Palode, the yield of all the selections including control (local variety) was very poor. At Jagtial, the PCT selections did not show an appreciable increase in yield when compared to the local variety (Table 3). The trial was laid out at Peruvannamuzhi, Palode and Jagtial during the year also.

A new multilocation trial with 11 selections which included 3 from Peruvannamuzhi, 2 each from KAU and TNAU and 4 from Pottangi was initiated at NRCS, Peruvannamuzhi, Kerala Agricultural University, Mannuthy, Tamil Nadu Agricultural University, Coimbatore, High Altitude Research Station, Pottangi and Himachal Pradesh Agricultural University, Solan.

The high yielding selection PCT-8 was multiplied on a large scale for distribution.

Table 3. Yield data of 12 turmeric selections under multilocation trial (1986-87)

Selection	Mean yield (kg|3 sq m bed)		
	Peruvannamuzhi	Palode	Jagtial
PCT-2	11.24	4.42	11.76
PCT-5	14.35	3.99	6.10
PCT-10	19.65	2.40	6.10
PCT-11	14.82	3.36	5.92
PCT-12	13.52	3.11	6.09
PCT-13	22.72	4.10	8.62
PCT-14	21.90	3.14	7.92
PCT-15	14.02	2.48	5.85
PCT-16	16.89	1.87	6.55
PCT-17	14.48	2.42	5.30
PCT-18	14.89	1.92	5.59
PCT-19	12.25	4.21	6.01
Local	14.25	3.18	17.54
Grand mean	16.00	3.12	7.04
CD at 5%	2.76	1.51	1.54

Gen VI(813). Collection, conservation, cataloguing and evaluation of germplasm in tree spices

(B Krishnamoorthy and *J Rema)*

1. Cinnamon

Cataloguing of accessions as per the standard descriptor was completed. The accessions were classified based on the colour of the young flushes into four categories viz., pure purple, purple dominated with green, green dominated with purple and pure green. Analysis of quality parameters showed that plants with purple pigmented flushes contained more of bark oil. Of the 165 air layers prepared from 9 selected lines, only 34 were successful. Vegetative characters were recorded for progenies of the elite lines.

2. Nutmeg

Cataloguing of accessions (for plants which had flowered) was carried out. In the progeny trial plot, among the 18 plants that flowered, 16 were males and 2 females. About 1300 seedlings were raised for the production of epicotyl grafts.

3. Clove

Forty four plants have started to yield during the year. Clove seeds were collected from Kallar, Burliar and Nagercoil and about 4000 seedlings were raised. Studies on germination and viability were carried out.

4. Allspice

Studies conducted to induce rooting in stem cuttings using NAA, IAA, IBA, Ethrel, GA and Vipul were not encouraging. Sprays for induction of flowering in adult trees also did not give encouraging results.

Gen IX(813). Collection, conservation, cataloguing and evaluation of cardamom germplasm

(Regy Lukose and *MN Venugopal)*

1. Evaluation of germplasm

The yield of plants was recorded in the six entry trial, multilocation trial (MLT) and germplasm assemblage. There was no significant difference between the treatments in the six entry trial, while in the MLT no significant difference between the highest yielder and control was observed. In the germplasm assemblage the highest yield (368.75 g|plant-green) was obtained in APG-88; APG-87 yielded 256.25 g. Growth parameters were recorded in the plants of the germplasm assemblage. The number of tillers was highest (32.62) in APG-28 followed by that in APG-39 (30.87). The number of panicles was highest (26.85) in APG-87.

2. Screening for 'katte' disease

To screen the germplasm against 'katte' disease, 168 accessions, 14 species of allied genera and 14 'katte' escapes were inoculated with viruliferous aphids at the rate of 15-20|plant. A local severe strain was used as the inoculum source. After three rounds of screening all the accessions were found to be susceptible to the virus. *Alpinia galanga, Hedychium coronarium, H. flavescence, Zingiber zerumbet* and *Aframomum malegueta* were found to be immune to 'katte' virus and *Alpinia mutica* was selectively resistant.

III. Evolving high yielding varieties by selection and hybridisation

(General Leader : MK Nair)

Gen VIII(813). Breeding for high yield and resistance to *Phytophthora* in black pepper

(MK Nair, PN Ravindran, K Nirmal Babu, MJ Ratnambal, PS Ravindran, B Krishnamoorthy and *AAM Syed)*

1. Production, multiplication and evaluation of hybrids

About 3000 hybrid seeds obtained from crosses involving 26 cultivars in various combinations were sown. About 1000 hybrid seedlings from these were transplanted into individual polybags. Crosses involving Cholamundi, Malamundi, Narayakodi, Perambramundi, Coll. 1132, Cheriakaniakkadan and Cheppukalamundi as female parents and Panniyur-I, Karimunda, Aimpiriyan and *P. colubrinum* as male parents were made.

Five hundred lines of inter cultivar hybrids were planted in the multiplication sheds for rapid multiplication and maintenance in the nursery. One hundred and thirty five hybrid lines were planted in the screening trial plots for field maintenance and preliminary evaluation.

2. Comparative yield trials

Two comparative yield trials were under progress. In the first wherein three elite lines are being compared against two standard cultivars, the vines have started bearing. The yield was very low in general, the highest being in Aimpiriyan (790 g/vine-green) followed by Panniyur-I (760 g). The second trial wherein some tolerant and promising lines are being tested was also maintained. In the hybrid evaluation trial about 10 per cent of the vines have flowered.

3. Evaluation of Karimunda selections

Among the 100 Karimunda accessions planted in 1983, Acc. 27 yielded the highest (1.7 kg/vine-green). However, the highest recorded yield was 3.3 kg/vine (green) from one vine in Acc. 32. Among the Karimunda selections planted in 1984, the highest yielder was Acc. 114 (1.025 kg/vine-green).

Analysis of quality of 88 Karimunda selections showed that piperine, oleoresin and essential oil contents varied from 3.65-7.76%, 7.7-14.1% and 3.0-5.5% v|w, respectively.

4. Evaluation of Kottanadan selections

The Kottanadan selections were planted in 1984 at CPCRI Research Centre, Palode. Out of 49 accessions and 2 controls from which data was recorded this year, Acc. 2559 yielded the highest (2.49 kg|vine-green) compared to the controls, Panniyur-I (2.06 kg) and unselected Kottanadan (2.13 kg).

5. Screening against *P. palmivora* and nematodes

Various inter cultivar hybrid lines, open pollinated seedling progenies of cultivars and Karimunda accessions were screened against *P. palmivora, M. incognita* and *R. similis* (Refer Path II.2(813) and Nema II(813).

Gen V (813). Breeding cardamom for high yield and resistance to 'katte' disease

(Regy Lukose and *MN Venugopal)*

1. Comparative yield trial

Growth parameters such as number of tillers, yielding tillers and panicles and yield were recorded in the plants of the comparative yield trials (CYT) I, II and III. Among the Cl. 37 plants, Sel. 561 (interse) yielded the highest (440.07 g|plant-green). Growth parameters such as number of tillers and leaves were recorded in the plants of CYTs IV and V. In these trials significant difference between treatments was found in the case of number of leaves per plant; there was no significant difference between treatments in the case of number of tillers.

2. Hybridisation

Ninety two seeds were produced by crossing Hy-836 and 1271|2-6 against EB and Wy-213.

3. Screening against 'katte' disease

For raising M_1 population 25,195 seeds from 15 selected clumps from the 16 entry trial were irradiated by r rays (12 and 16 Kr) and the seeds were sown in GI trays filled with autoclaved soil. Germination counts were taken 50 and 60 days after sowing. The germination percentages were 16.2 and 12.3 for the seeds irradiated with 12 and 16 Kr, respectively. Abnormalities such as chlorosis and crinkling of leaves were noticed in these seedlings. About 4350 of these seedlings were transferred to polybags for screening against 'katte' virus.

Two batches of M_2 and M_3 seedlings obtained from selfing the 'katte escapes' were screened against 'katte' virus by inoculating viruliferous aphids carrying a local severe strain at the rate of 10|plant. After four inoculations at 45 day intervals all the seedlings were found to be susceptible to the virus. The first inoculation of 4352 M_1 seedlings was completed and the inoculants are under observation.

Thirty one natural 'katte' escapes were collected from hot spot areas of Kerala and Karnataka. Sub cloning of 48 'katte' escapes collected earlier was done and the clones are under multiplication.

IV. Rhizome rot of ginger and turmeric

(General Leader : GN Dake)

Path III(813). Rhizome rot of ginger and turmeric

(GN Dake, N Ramachandran, YR Sarma, M Anandaraj, S Edison, KV Ramana and *C Mohandas)*

I. Ginger

1. Effect of systemic fungicides on growth of *Pythium aphanidermatum in vitro*

The efficacy of five systemic fungicides viz., Aliette, metalaxyl, oxadixyl, Previcur-N and Terrazole was evaluated *in vitro* against *P. aphanidermatum*, the causal organism of rhizome rot. The concentrations tested were 0.01-10.0 μg|ml of metalaxyl and Terrazole, 100-1000 μg|ml of Aliette and 0.01-100 μg|ml of oxadixyl and Previcur-N.

The required quantity of chemicals were added to cornmeal agar of 50 ml in each concentration and dispensed into three petriplates. The petriplates were inoculated with 3 mm discs of 3 day old culture of the fungus on carrot agar. The inoculated plates were incubated at 24 $\pm$ 1°C for 48 hrs. The radius of the fungal colonies was measured after 24, 48 and 72 hrs. Linear regression analysis of the probit values of inhibition percentages and the log values of 100 x concentrations was carried out to obtain the dose response slopes and ED 50 and ED 90 values (Table 4).

Table 4. Effect of systemic fungicides on growth of *P. aphanidermatum* in corn meal agar *in vitro*

Fungicide	ED 50	ED 90
Aliette	293.70	934.10
Metalaxyl	0.74	9.50
Oxadixyl	27.18	179.60
Previcur-N	4.44	305.56
Terrazole	0.25	1.14

Terrazole was the most toxic and had the lowest ED 50 and ED 90 values followed by Metalaxyl. The slope values of these fungicides were 1.94 and 1.15, respectively. The correlation coefficient of the fungicides varied from 0.91 to 0.99.

2. Evaluation of systemic fungicides for efficacy on rhizome rot

The efficacy of systemic fungicides viz., metalxyl (Apron 35 WS, Ridomil 5G and Ridomil-Ziram), Aliette, oxadixyl, Previcur-N and Terrazole in controlling rhizome rot was evaluated under green house conditions. The fungicides were tried as seed treatment plus drenching or spraying and soil application and drenching alone. Four pieces of seed ginger (cv. Maran) subjected to different treatments were sown in each bucket containing 3 kg of nursery mixture infested with 500 ml of mycelial suspension of *P. aphanidermatum* (the inoculum was grown in carrot broth, which was blended with 1000 ml of water). For each treatment 10 buckets were maintained. An untreated control was maintained by dipping seed rhizomes in water for 30 minutes. A second application of chemicals in the form of drenching was done 27 days after sowing with 500 ml/bucket of fungicide solution. Application of Ridomil 5G granules was carried out again after 60 days.

The experimental plants were observed at 10 day intervals from the third week of July to the first week of October and the percentage of infection was recorded. The crop was harvested in February 1988 and the yields were recorded (Table 5).

Among the various treatments, application of Ridomil 5G @ 2.5 g/bucket (40 ppm concentration) was the best. A single application prevented the infection for 2 months, gave the best control of the disease and also higher yields. This was closely followed by Ridomil 5G applied @ 5 g/bucket.

3. Field trial for control of rhizome rot

The trial was laid out in split plot design constituting application of neem cake and without neem cake as main treatments and seed treatment with the fungicides Aliette, Difolatan, Dithane M-45, Ridomil-Ziram and untreated control as sub treatments with four replications. The treated seed ginger was sown in a sick plot developed at Chelavoor by adding mycelial suspension of *P. aphanidermatum* to the field. Observations on germination and disease incidence were recorded (Table 6).

Table 5. Efficacy of systemic fungicides in the control of rhizome rot of ginger

Treatment	Concentration of chemicals	Infection of tillers (%)	Yield (g/bucket)
Control	—	25.9	21.50
Dithane M-45 (seed treatment + drenching)	0.3%	16.3	44.90
Ridomil 5G (soil application twice)	2.5 g/bucket*	2.1	248.60
,,	5 g/bucket	4.0	173.88
,,	10 g/bucket	1.6	130.50
Apron 35 WS (seed treatment + drenching with 100 ppm)	250 μg/ml	15.0	72.30
,,	500 μg/ml	15.7	66.70
,,	1000 μg/ml	4.4	122.50
,,	2450 μg/ml	2.6	158.30
Ridomil-Ziram 78 (seed treatment + drenching with 100 ppm)	250 μg/ml	14.3	67.90
,,	500 μg/ml	16.8	37.60
,,	1000 μg/ml	8.9	80.80
Ridomil-Ziram 78 (drenching alone)	100 μg/ml	7.5	93.20
Aliette (seed treatment + spraying)	1000 μg/ml	38.1	10.90
,,	2000 μg/ml	28.9	8.30
,,	3000 μg/ml	19.5	9.60
Aliette (drenching alone)	1000 μg/ml	19.2	22.60
Terrazole (seed treatment + drenching)	1000 μg/ml	6.9	103.70
,,	2000 μg/ml	9.0	56.50
,,	3000 μg/ml	16.3	18.40
Oxadixyl (seed treatment + drenching)	1000 μg/ml	20.6	40.10
,,	2000 μg/ml	14.5	74.00
,,	3000 μg/ml	11.3	69.50
Previcur-N (seed treatment + drenching)	1000 μg/ml	11.6	41.80
,,	2000 μg/ml	6.2	113.90
,,	3000 μg/ml	2.6	110.30

*Each bucket contained 3 kg of soil

Table 6. Field trial for control of rhizome rot of ginger

Treatment		Germination (%)	Disease incidence (%)	Yield (kg/3 sq m bed)
Untreated control	WNC	97.3	4.3	2.120
	NC	97.8	4.6	2.450
Difolatan 0.25%	WNC	97.2	3.1	3.276
	NC	96.6	3.1	3.962
Dithane M-45 0.3%	WNC	98.4	3.2	2.997
	NC	97.5	3.5	3.612
Ridomil-Ziram 100 μg/ml	WNC	98.4	1.4	3.326
	NC	97.8	0.4	4.600
Aliette 3000 μg/ml	WNC	98.4	8.3	1.871
	NC	98.1	8.9	3.575

WNC = Without neem cake

NC = With neem cake (1 kg/bed)

The incidence of the disease was minimum in seed ginger treated with Ridomil-Ziram followed by Dithane M-45. No significant difference was observed between main treatments.

4. Field trial for control of bacterial wilt

A field trial was laid out in a sick plot at Peruvannamuzhi in a split plot design having two main treatments viz., with bleaching powder (25 g/bed of 3 sq m) and without bleaching powder and with four sub treatments viz., seed treatment with streptocycline at 200, 500 and 1000 ppm for 30 minutes and untreated control. The experiment was replicated four times. Bleaching powder was applied 1 week before sowing. Observations on germination and disease incidence were recorded. The incidence of the disease was observed from the first week of July and continued until September.

Seed ginger treated with Streptocycline at all concentrations provided good control up to 2 months compared to untreated control. After this the plants were affected by the disease and 90 per cent mortality was observed by the end of the September.

5. Standardisation of techniques for screening ginger against *Pseudomonas solanacearum*

Twenty four hour old cultures of *P. solanacearum* multiplied on yeast dextrose carbonate (YDC) agar were used as inoculum. Ginger sprouts (1 month old) were inoculated with bacterial suspension of OD 620 nm (0.550) by three methods viz., brushing the pseudostem base with gentle pressure (with a tooth brush dipped in bacterial suspension) and pouring 100 ml of bacterial suspension around it, pouring bacterial suspension over the pseudostem, placing a cotton swab soaked in bacterial suspension at the collar region and pouring the remaining quantity around it. Apart from these methods, 10 bits of infected pseudostems were mixed in soil around the pseudostems and an uninoculated control was also maintained. Four hours prior to inoculation the pots were watered to field capacity to distribute the inoculum uniformly in the soil. Thereafter they were watered regularly to maintain humidity and moisture. Observations on initiation of infection revealed that the method in which soil was mixed with chopped bits of infected pseudostems of ginger was ideal for screening under pot culture.

II. Turmeric

1. Bacterial wilt

The incidence of bacterial wilt caused by *P. solanacearum* was noticed in a few beds of germplasm maintained at Peruvannamuzhi farm. Studies on symptomatology in the field and pathogenicity under green house conditions were carried out.

III. Colateral hosts of *P. solanacearum*

Common weeds such as *Eupatorium odaratum* and *Ageratum conyzoides* were found to be infected with *P. solanacearum* in turmeric and ginger fields, respectively.

Biotech II(813). *In vitro* selection for resistance to soft rot and bacterial wilt in ginger

(MJ Ratnambal, GN Dake and *MSK Shetty)*

1. Tissue culture

Healthy sprouting buds of ginger were inoculated in MS basal medium with different combinations of NAA, kinetin, 2, 4-D and BAP. Two types of calli viz., friable and rosette types were noticed when the explants were inocul-

ated with basal agar medium supplemented with 0.08-1 mg|1 kinetin, 0.8-1 mg|1 2,4-D and subsequent sub culturing in the same medium every 2 weeks. The calli were multiplied and maintained.

The friable type of calli were transferred to MS basal medium supplemented with 20 g|1 sucrose, 0.1 mg|1 NAA, 0.5 mg|1 kinetin, 0.1 mg|1 BAP and 6% agar. The pH of the culture medium was 5.6. The calli were maintained at a temperature of 25 ± 2°C with a 10 hr light period. Plant regeneration from the calli was noticed after 4 weeks of sub culturing. The plantlets were maintained in the same medium with subsequent sub culturing.

The rosette type of calli produced only roots in the medium mentioned above and also in MS medium with 0.4 mg|1 NAA, 0.5 mg|1 kinetin and 0.4-0.8 mg|1 2,4-D. The rate of root formation was more in the latter medium.

The explants developed into multiple shoots (12-20 nos.) with abundant roots when they were inoculated in MS basal medium supplemented with 0.1-0.5 mg|1 NAA, 0.5-1 mg|1 kinetin and 0.1-0.5 mg|1 of BAP and subsequently sub cultured in MS liquid medium supplemented with NAA (0.1-0.3 mg|1), kinetin (0.5-0.7 mg|1) and BAP (0.3-0.8 mg|1). Well developed shoots with healthy roots were transplanted in polythene bags with soil mixture and later transferred to pots.

2. Isolation of toxin produced by *P. solanacearum*

One week old culture of *P. solanacearum* grown in YDC broth was centrifuged at 20,000 rpm for 30 minutes. The supernatant liquid was collected and concentrated by flash evaporation. Absolute alcohol was added to the concentrated cell free culture fluid to precipitate and stored in refrigerator at 4°C overnight. The precipitated solution was centrifuged at 6000 rpm for 10 minutes. The pellet was dissolved in distilled sterile water and passed through a 20 x 2.5 cm column of Dowex-50 (200-400) mesh H^+ form and Dowex-1 (200-400) mesh formate form to remove charged compounds. The elute was collected and used for bioassay.

The elute was diluted serially with sterile distilled water to test its bioassay. One set was sterilised at 121°C for 30 minutes and then tested for bioassay. The cut shoots of 1 month old ginger sprouts were immersed in crude toxin in a test tube. Distilled (sterile) water was used as control. Observations on wilting of cut shoots and time taken for the same were recorded (Table 7).

Table 7. Bioassay of cut shoots of ginger in crude toxin solution produced by *Pseudomonas solanacearum*

Concentration of toxin (%)	Time taken for expression of flacidity (minutes)	
	Unsterilised	Sterilised
10	33	32
20	26	24
30	21	19
40	17	15
50	15	15
Control (water)	—	—

The crude toxin was effective even after sterilisation at 121°C for 15 minutes and could be added in the culture medium before sterilisation.

The crude toxin isolated from *P. solanacearum* was incorporated in the culture medium in different concentrations. The explants were inoculated in this medium to see the effect of the toxin on ginger buds.

V. Studies on quality analysis

(General Leader : A Gopalam)

Phy III(813). Quality evaluation in black pepper

(A Gopalam and *T John Zachariah)*

Evaluation of quality of 100 Karimunda accessions was carried out. Piperine, oleoresin and essential oil contents ranged from 3.4-7.7%, 7.7-14.5% and 3.3-5.5% v|w, respectively. Acc. 79, 21 and 149 had 7.7% piperine, 14.5% oleoresin and 5.5% v|w essential oil, respectively.

Among the four Kottanadan accessions evaluated, significant variation in chemical quality was not observed. Piperine, oleoresin and essential oil contents ranged from 6.3-7.5%, 18.8-19.9% and 3.2-3.6% v|w, respectively.

Thirty seven accessions of cultivated germplasm maintained at CPCRI Research Centre, Kannara were analysed for their chemical quality. Piperine, oleoresin and essential oil contents ranged from 3.5-7.0%, 6.7-16.9% and 3.2-4.2% v|w, respectively.

The chemical and aroma quality of Panniyur-I grown in different altitudes and rainfall levels in Kodagu district was analysed. Piperine and oleoresin contents were higher at higher altitudes, whereas essential oil content was considerably low. The aroma quality of essential oil from higher altitudes was also superior.

The chemical quality as influenced by different methods of drying viz., Wynad method, blanching and solar drying were compared with sun drying. Essential oil and oleoresin levels were low by blanching as compared to other methods. Piperine levels in Karimunda were high by blanching. The appearance of the product was superior by blanching and Wynad method of drying.

Phy IV(813). Quality evaluation in tree spices

(A Gopalam)

Analysis of essential oil of leaf and bark of 10 selected cinnamon lines was carried out by gas chromatography. Gas chromatographic profile of leaf oils indicated that eugenol content varied from 12.6-60.0%, the highest being in Acc. 312. Cinnamic aldehyde varied from 6.50-14.11%, the highest being in Acc. 65.

Phy VIII(813). *Quality evaluation in cardamom*

(T John Zachariah and *A Gopalam)*

Thirty seven accessions (which included three popular cultivars viz., Malabar, Mysore and Valayar) were evaluated for their chemical quality. The oleoresin content ranged from 3.6-3.7%, the highest being in Acc. 34. Essential content ranged from 4.4-8.4% v|w, the highest being in Acc. 135. Among the popular cultivars, Valayar had the highest essential oil and oleoresin contents.

1:8 cineole and α -terpinyl acetate were estimated by gas chromatography. 1:8 cineole ranged from 7-46%, the highest being in Acc. 84; α -terpinyl acetate ranged from 25-65%, the highest being in Acc. 105.

VI. Nutritional requirement and crop management

(General leader : K Sivaraman)

Agr VI(813). Studies on the impact of input technology on the yield performance and quality attributes of black pepper

(K Sivaraman and *AK Sadanandan)*

1. NPK trial

A new trial was started during the year to study the response of black pepper vines to applied nitrogen and potassium from early stages of planting and also to find out whether there is a response for magnesium and calcium in combination with various doses of NPK. Rooted cuttings of Karimunda were planted in the field and the first dose of fertilisers was applied during September as per the treatment schedule.

The yield data collected over a period of 5 years in the NPK experiment which was concluded were statistically analysed to work out the optimum dose of fertiliser requirement under Peruvannamuzhi conditions. Application of 140, 55 and 270 g NPK/vine per year increased the availability of nutrients both in soil and leaf and optimum yield response was also obtained.

2. Spacing trial

The trial was started in 1983 to find out the optimum spacing requirement of three cultivated varieties viz., Panniyur-I, Karimunda and Aimpiriyan. Observations on yield were recorded (Table 8).

Table 8. Yield of black pepper as influenced by varieties and spacing

Variety	Spacing (m)			
	3.0x3.0 (1100)	2.5x2.5 (1600)	2.5x1.5 (2600)	2.0x1.0 (5000)
Panniyur-I	942	2405	3312	3110
Karimunda	978	2169	3374	5740
Aimpiriyan	681	645	1955	2259

Values indicate mean yield in kg/ha (green)
Values in parenthesis are number of vines/ha

The highest yield was obtained in Karimunda (5740 kg|ha) under a spacing of 2 x 1 m accommodating 5000 vines|ha. The performance of Karimunda was superior than the other varieties in the closer spacings.

3. Management trial

The trial was started in 1984 to compare the performance of two varieties under four live standards and two spacings. Among the standards, *Erythrina indica* performed better in terms of height and girth attained.

An observation trial on irrigation requirement of black pepper was laid out during the year. *E. indica* seedlings were planted; planting of experimental vines will be taken up during 1988.

4. Standard and spacing trial

Application of manures and fertilisers and plant protection measures were taken up. Banana, planted for the initial maintenance of shade was uprooted and subabul was planted to maintain shade. Congosignal grass was grown as cover crop which helped in reducing soil temperature during summer resulting in increased productivity of vines.

Among the live standards, vines trained on *Glyricidia maculata* registered the lowest yield for both the varieties when compared to *E. indica* and *Garuga pinnata*. Among the non living standards, RCC post was superior to granite post registering the highest yield of black pepper. The optimum spacing for both Panniyur-I and Karimunda was 3 x 2 m irrespective of the type of standards used.

SSc I(813). Mineral nutrition studies in black pepper

a. Nitrogen management through slow release nitrogen fertilisers

(AK Sadanandan)

Slow release nitrogenous fertilisers (urea, ureaform, neem coated urea, coir dust coated urea and urea pellet) were applied to the experimental vines. Soil samples were drawn 5, 10, 30 and 90 days after application of fertilisers and analysed for soil pH, organic carbon and urea N. Morphological observations on growth of vines were recorded.

Soil pH was highest throughout the period (5th to 90th day) in plots in which urea was applied. This may be attributed to the rapid hydrolysis of urea to ammonia carbonate. The organic carbon status of the soil was highest in plots treated with neem coated urea. On the 5th day after the application of fertilisers, neem coated urea treatment registered highest urea N, while on the 10th day and thereafter up to the 90th day, ureaform maintained its superi-

ority in contributing urea N compared to other treatments. Plots treated with urea registered lowest urea N among all the treatments, which may be due to hydrolysis of urea to ammonium carbonate. The height and number of leaves and laterals produced by the vines was highest in plots treated with ureaform.

Agr XIII(813). Systems of planting-cum-fertiliser levels in cardamom under rainfed conditions

(VS Korikanthimath)

Fertilisers were applied as per the treatment schedule and shade was regulated during April-May. Data on growth and yield were recorded. Soil moisture was determined by gravimetric methods during April.

1. Growth characters

The highest value for various growth characters was observed in the trench system when compared to pit system of planting. The corresponding values were : height of the plant -- 172.2, 165.3 cm; number of bearing tillers per plant -- 9.95, 9.18; number of leaves per plant -- 183.7, 167.8 and number of panicles per plant -- 19.7, 18.8. The highest value for various growth characters was observed in plots in which application of 160:160:320 kg NPK/ha was carried out. These values and those of control were: height of the plant -- 184.9, 152.0 cm; number of bearing tillers per plant -- 12.9, 5.3 and number of leaves per plant -- 242.0, 116.0.

2. Soil moisture

Soil moisture was higher (15.9%) in the trench system of planting when compared to that in pit system (14.6%).The trenches could conserve more soil moisture and supplement the plants even during the dry spells.

3. Yield

The yield of cardamom (dry) was higher (376.5 kg/ha) in the trench system of planting when compared to the pit system (337.0 kg). The application of 160:160:320 kg NPK/ha resulted in the highest yield of 496.5 kg/ha in trench system as against 455.6 kg in pit system followed by application of 120:120:240 kg NPK/ha (465.5 kg in trench and 437.0 kg in pit system, respectively). The lowest yield was observed in control (no fertiliser) (134.6 kg/ha in trench and 123.9 kg in pit system, respectively (Table 9).

Table 9. Yield of cardamom as influenced by systems of planting and fertiliser levels -- Table of means A x B means (last column -- A means and last row -- B means)

Systems of planting	NPK fertiliser levels (kg/ha)					
	0:0:0	40:40:80	80:80:160	120:120:240	160:160:320	Mean
Pit	123.88	277.52	388.92	437.00	455.57	336.58
Trench	134.62	369.32	416.72	465.45	496.47	376.52
Mean	129.25	323.42	402.82	451.22	476.02	

SE/Plot	88.00
Gen. Mean	356.55
CV (%)	24.68
CD for A	57.102
CD for B	90.286
CD for A x B	127.683

Values indicate yield of dry cardamom (kg/ha)

A positive correlation between yield of cardamom and number of bearing tillers per plant (0.9662**), number of green leaves per plant (0.9177**) and number of panicles (0.9503**) was observed. The regulation of overhead shade had a profound influence on the response of cardamom to the added fertilisers.

VII. Water management, stress and production physiology in spices

(General leader : A Ramadasan)

Phy V(813). Characterisation of drought tolerance in black pepper

(A Ramadasan)

A preliminary study on 10 cultivated types of 1½ year old vines of black pepper viz., Karimunda, Aimpiriyan, Kottanadan, Kalluvally, Kuthiravally, Narayakodi, Thommankodi, Arakulam munda, Neelamundi and Panniyur-I raised in cement pots (75 x 50 cm) in forest soil was completed. The characters studied were stomatal resistance, transpiration, leaf water potential, soil moisture and epicuticular wax content. A fairly good relationship between depleting soil moisture and stomatal resistance, leaf water potential and transpiration was observed. Further work is in progress.

VIII. Pest management

(General leader : T Premkumar)

Ent XV(813). Bionomics of major pests of black pepper and evolving integrated control measures against them

(T Premkumar, S Devasahayam and *Jose Abraham)*

I. 'Pollu' bettle *Longitarsus nigripennis*

1. Screening of germplasm

Two hundred and forty seven accessions of cultivars from the germplasm collection maintained in the nursery were screened for their reaction to 'pollu' beetle using a rapid screening technique. Second and third leaves from the tip of the vines were severed along with the petiole which were dipped in water in a specimen tube. These tubes were kept in insect proof cages. Beetles collected from the field were then released into the cages and the feeding marks on the leaves were recorded after 24 hrs. Panniyur-I, a known *highly susceptible variety was used as a check. An index of preference for* each accession was worked out using the formula:

$$\text{Index of preference} = \frac{\text{Number of feeding marks on the accession} \times 100}{\text{Number of feeding marks on Panniyur-I}}$$

Based on the index the accessions were classified into various categories. Among the 287 accessions screened, 145 had an index of 50 and of the 145 accessions, 18 had an index of 0 (they were not fed by the beetles). These accessions would be screened again.

Screening of wild relatives of *P. nigrum* showed that *P. attenuatum. P. hymenophyllum, P. longum. P. betel* and *P. colubrinum* were not preferred by the pest.

2. Economic threshold of pest infestation

The progress in the incidence of berry damage was recorded from 2 plots with 25 vines each to calculate the economic threshold of pest infestation. Twenty five spikes were randomly selected from each vine and the incidence of infested berries was recorded at weekly intervals. The rate of increase of infested berries in the two plots was steady up to November and thereafter the increase was only marginal.

II. Top shoot borer *Cydia hemidoxa*

1. Survey for pest incidence

A survey was conducted in 50 locations in Quilon, Alleppey, Pathanamthitta, Kottayam and Idukki districts of Kerala to record the incidence of the pest. The pest was present in all the areas surveyed and the infestation ranged from 12-40 per cent. Thirty nine young vines (3-4 years old) in 23 locations were also observed for pest incidence and the infestation varied from 54-90 per cent.

2. Field control trial

A field trial with six insecticides (endosulfan, quinalphos, methyl parathion, dimethoate, monocrotophos and phosphamidon -- 0.05% each) was laid out at Channal (Calicut district) for the control of the pest. Two sprayings of the insecticides were given. The results indicated that all the insecticides were effective in controlling the pest infestation and there was no significant difference between the treatments (Table 10).

Table 10. Effect of different insecticides in the control of top shoot borer

Inecticide	New shoots damaged (%)
Endosulfan 0.05%	22.2 (28.10)
Quinalphos 0.05%	18.9 (25.76)
Methyl parathion 0.05%	18.2 (25.28)
Dimethoate 0.05%	21.6 (27.70)
Monocrotophos 0.05%	18.1 (25.17)
Phosphamidon 0.05%	19.4 (26.15)
Control	64.9 (53.56)
CD (5% level)	7.43

Figures in parenthesis are transformed values

Ent. VIII(813). Bioecology and control of marginal gall forming thrips *Liothrips karnyi* Bagnall infesting black pepper

(S Devasahayam)

1. Seasonal population of gall thrips

Studies on the seasonal population of gall thrips conducted at Kalpetta (Wynad district) indicated that the pest population was high during July to September and low during February to April. The pest population was at its peak during July and minimum during March.

Studies on the increase in the number of gall thrips within a leaf in relation to its age indicated that maximum number of individuals occurred in galls that were about 2 months old. Galls that were more than 7 months old did not contain gall thrips.

2. Seasonal population of natural enemies

Studies on the seasonal population of three common predators of gall thrips were also conducted at Kalpetta. The population of *Montandoniola moraguesi* (Anthocoridae) and *Androthrips flavipes* (Phlaeothripidae) was high during July to September and November; the population of *Rhodesiella* sp. (Chloropidae) was high during September and November. *Lestodiplosis* sp. (Cecidomyidae) was observed in low numbers during August to October.

3. Predatory potential of natural enemies

The life history and predatory potential of *M. moraguesi* was studied under laboratory conditions. The eggs of the predator were oviposited into the leaf tissues within the galls. The duration of the five nymphal instars and the prey consumed during each stage was determined.

4. Other fauna in thrip galls

Studies on the sequential occurrence of various other arthropodan fauna in thrip galls in relation to its age and population of gall thrips were conducted throughout the year at Kalpetta.

5. Field control trial

A field trial for the control of gall thrips was conducted at Kuppadi (Wynad district) with six insecticides viz., endosulfan, quinalphos, monocrotophos, phosphamidon, dimethoate (0.05% each) and malathion (0.1%). Spraying of various insecticides was carried out during July during emergence of new flushes. The trial indicated that at the end of 15 days after treatment, monocrotophos, dimethoate and endosulfan were effective; at the end of 30 days after treatment, monocrotophos alone retained its efficacy in controlling the pest infestation.

Ent IX(813). Studies on coccids infesting black pepper

(KM Abdulla Koya)

1. Survey for pest incidence

Surveys were conducted at Pampadumpara, Thookupalam, Ramakkalmedu, Koombanpara, Ayyappankovil Mannankandam, Kanhikuzhi, Vellathooval, Kumali, Amaravathy, Attapallam, Chackupallam and Vazhathoppu areas of Idukki district and Kuppadi, Pulpally, Chulliode, Ambalavayal, Krishnagiri, East Nadavayal, Panamaram and Kalpetta areas of Wynad district of Kerala and various species of scale insects and mealy bugs infesting black pepper were collected. The scale insects collected included *Lepidosaphes piperis, Marsipococcus marsupiale, Aspidiotus destructor, Pseudaulacaspis* sp. and *Icerya aegyptiaca*; the mealy bug collected was identified as *Pseudococcus longispinus*. The infestation by scale insects was scattered and that by mealy bugs was negligible. The percentages of infestation by scale insects were 49.8 and 33.3 in Idukki and Wynad districts, respectively and that by mealy bugs were 6.7 and 0.4, respectively.

2. Bioecology of the pest

The nature of damage caused by scale insects was studied. Laterals of vines severely infested by *L. piperis* dried up completely. *L. piperis* infested leaves, laterals, runners, main stem and berries. *A. destructor* infested leaves and berries.

Attempts were made to study the life history of *L. piperis*. The crawlers were picked from the infested vines and released on leaves of uninfested rooted cuttings. The crawlers fixed themselves on the stem after wandering for 1 or 2 days.

The seasonal abundance of *L. piperis* was recorded at monthly intervals at Kuppadi (Wynad district). A reduction in the intensity of infestation was observed after the monsoon period.

3. Natural enemies

Adults and larvae of *Cybocephalus* sp. (Nitidulidae) were recorded to be predaceous on *L. piperis*. An unidentified hymenopteran parasite was also recorded; a single parasite emerged from a scale insect. Both the specimens were recorded from Peruvannamuzhi.

IX. Disease management

(General leader : MN Venugopal)

Path IX(813). Investigations on the rhizome rot disease of cardamom
(MN Venugopal)

1. Pathogenicity

A trial under pot culture was conducted to study the pathogenicity of *Pythium vexans* and *Rhizoctonia solani* on primary and secondary seedlings and grown up plants. The results indicated that both the fungi were pathogenic to cardamom and caused damping off disease in primary seedling stage and rhizome rot in other stages. *R. solani* was less virulent and the percentage of infection was less in older plants. Visible water soaked symptoms appeared 8 and 5 days after inoculation with *R. solani* and *P. vexans*, respectively.

2. Epidemiolgy

Pre and post planting monitoring of 16 plantations (up to 3 months) indicated that nurseries formed an important source of disease introduction. Studies on the incidence and spread of the disease in relation to rainfall, RH and temperature indicated the influence of rainfall on the disease incidence; more than 80 per cent of the total infections occurred during the monsoon period (June-October).

P. vexans was reisolated from 1 and 2 year old dried samples of soil and plant that were stored under laboratory conditions. Attempts to reisolate *P. vexans* from 4, 6, 8 and 10 month old partly decayed and dried rhizome bits yielded positive results. This indicated the possible carry over of the fungus to the next season through infected plant debris.

Various stages of rhizome rot infected plants were examined to study the pattern of symptoms. Eighty two per cent of the infected plants had symptoms of damage by root grubs or by an unidentified soil pest. When such infested seedlings were used as inoculants against *P. vexans* and *R. solani*, the incidence of rhizome rot was to an extent of 80 and 68 per cent, respectively. This indicated that damage to root, rhizome or sucker made the plants more vulnerable to rhizome rot infection.

3. Standardisation of inoculation techniques

Attempts were made to standardise inoculation techniques with *P. vexans* as the test pathogen. Mycelial mat, mycelium suspension, infected rhizome bits and inoculated rhizome bits were used as inoculum source. Inoculation in the form of mycelial mat at suckering stage under saturated moisture conditions gave a higher percentage (68) of infection.

Nema I(813). Investigations on plant parasitic nematodes associated with cardamom

(Santosh J Eapen)

Three new trials were initiated during the year.

1. Pathogenicity trial

Monoclonal cardamom suckers raised under nematode free conditions were planted in 50 cement pots (1 m diameter and 1 m depth) containing formalin (2%) treated soil. The randomized experiment consists of 5 treatments viz., inoculation with 0, 100, 1000, 10000 and 100000 nematodes/pot with 10 replications. Cultures of root knot nematode *(M. incognita)* were established using egg masses of infested cardamom roots collected from the field. For mass multiplication of the inoculum, they were periodically transferred to tomato plants planted in sterile soil. The inoculation will be taken up next year.

2. Field control trial

Three plots were identified for conducting the field trial. The base population level of nematodes in these plots was determined through random sampling.

3. Screening of germplasm

About 150 monoclonal suckers (P1) were planted in fumigated soil for conducting a preliminary trial to standardise screening techniques.

Samples of soil and roots were collected at monthly intervals from the field since November, 1987 at different distances from the base of the plant and at different depths to study the population dynamics of root knot nematodes of cardamom.

X. Refinement of experimentation techniques in spices

(General leader : Jose Abraham)

Stat III(813). Optimum size and shape of plots and blocks for experiments in black pepper

(Jose Abraham)

A compact block of 288 (12 x 24) vines was selected at the NRCS Farm at Peruvannamuzhi and the field lay out was prepared. Data on height and diameter of the canopy were recorded and the vines were scored for yield by the visual scoring technique. The analysis of data will be carried out after recording the yield during harvest.

XI. Transfer of technology network

(General leader : AK Sadanandan)

Extn. I(443). Training of extension and research workers and farmers

(KM Abdulla Koya, MN Venugopal and *VS Korikanthimath)*

The Research Centre organised nine training courses during the year at Calicut and Appangala on different aspects of spices production technology (Table 11). The training courses were attended by research and extension workers, officials of agriculture, horticulture and forest departments and progressive farmers. Special training on production and processing of ginger was also imparted to two officials from Nepal sponsored by USAID for 1½ and 3½ months respectively, at Calicut.

Table 11. Training courses conducted at NRCS, Calicut and Appangala

Sl. No.	Course	Duration and venue	No. of trainees	State/Union territory
1.	Spices cultivation	2 days Calicut	11	Andaman Islands
2.	Spices cultivation	1 day Calicut	1	Madhya Pradesh
3.	Management of spices	2 days Calicut and Appangala	1	Andhra Pradesh
4.	Rapid multiplication of black pepper	2 days Calicut	11	Karnataka
5.	Spices production technology (excluding cardamom)	5 days Calicut	25	Various States
6.	Cardamom production technology	3 days Appangala	6	Karnataka
7.	'Katte' disease management	1 day Appangala	2	Karnataka
8.	Techniques in cardamom nursery	1 day Appangala	10	Karnataka
9.	Cardamom post-harvest technology	1 day Appangala	1	Karnataka

At Appangala, apart from the regular training courses, seven 1 day training courses on cardamom was imparted to 169 persons including progressive farmers and agricultural officers.

Extn IV(443). Research-cum-demonstration plots

(AK Sadanandan and *VS Korikanthimath)*

I. Black pepper

A field trial was laid out with 13 cultivars (11 vines per cultivar and planted in a spacing of 3 x 2 m) at Peruvannamuzhi to study their relative performance. Banana (cv. Poovan) and Subabul were planted in the inter space for providing shade to the vines.

Panniyur-I and Karimunda were planted in a 20 year old coconut and arecanut garden at Pattampara (Calicut district) to demonstrate black pepper based cropping systems. Banana was grown as a shade crop. Among the two varieties planted in 1986, 15 and 27 per cent of vines of Panniyur-I and Karimunda respectively, flowered during the first year.

II. Cardamom

The national average yield of cardamom is about 60 kg|ha as against a production potential of 850-1000 kg|ha. Hence research-cum-demonstration plots were laid out to study the feasibility of increasing the yield per unit area and to convince the farmers about the advantages of adopting scientific methods of cultivation.

1. Cultivation of cardamom in valleys

This area offers a great scope for realising higher yields by virtue of retention of moisture almost throughout the year. Cl. 37 seedlings were planted during 1985 at Silver oak estate in a spacing of 2 x 1 m and a maiden crop of 933 kg|ha (dry) was obtained during the second year of planting.

2. Effect of plant population density in gentle slopes

The trial was laid out at Madabane estate with a conventional spacing of 1.8 x 1.8 m and a closer spacing of 1.8 x 0.9 m. During 1986-87 a maiden crop of 735 kg|ha (dry) was obtained in the closer spacing as against 410 kg under the conventional spacing.

3. Performance of cardamom in gentle slopes

Two demonstration plots, one each at Halery and Cananoad were maintained under irrigated conditions. At Halery, the trial was initiated during 1983 by planting with Cl.37 seedlings. An average yield of 541.6 kg|ha (dry)

was obtained during 1985-88 (mean of 3 years). At Canancad, the trial was started during 1982 and an average yield of 675 kg|ha (dry) was obtained during 1984-88 (mean of 4 years).

4. Performance of cardamom in slopes

Cardamom was planted at Suntikoppa estate at a spacing of 2 x 1 m during 1983-84 by providing inward bench terracing to conserve soil moisture and minimise soil erosion. An average yield of 423.33 kg|ha (dry) was obtained during 1985-88 (mean of 3 years).

5. Performance of cardamom in reclaimed marshy area

The trial was undertaken at Suntikoppa estate to study the feasibility of cultivation of cardamom in low lying marshy lands unfit for cultivation of any other crop. Adequate drainage was provided in the plot and fast growing shade tree species were established. An average yield of 805 kg|ha (dry) was obtained during 1985-87 (mean of 2 years).

6. Mixed cropping with coffee

Studies were initiated to find out the production potentialities of cardamom mix cropped with arabica and robusta coffee. At Suntikoppa estate, cardamom (Cl. 37) was planted at a spacing of 5.4 x 0.9 m and arabica coffee (S-795) at 1.8 x 1.8 m. An average yield of 242.5 and 293.6 kg|ha (dry) of cardamom and coffee respectively, was obtained during 1983-87 (mean of 4 years) under rainfed conditions. Under irrigated conditions the average yield was 404 and 314 kg|ha respectively, during 1984-87 (mean of 3 years). At Canancad, cardamom (Cl. 37) was planted at a spacing of 1.8 x 1.2 m inbetween rows of coffee (Terdinia) planted at 2.7 x 2.7 m. An average yield of 287.5 and 2000 kg|ha (dry) of cardamom and coffee respectively, was obtained during 1986-88 (mean of 2 years).

Farmers, trainees, research workers and officials were taken to the above plots to convince them about the production potentialities of cardamom by adopting scientific methods of cultivation.

Extn I(813). a. Increasing production and productivity of black pepper through large scale demonstration of improved technology in farmers fields

(AK Sadanandan, M Anandaraj and *Jose Abraham)*

The objective of the field demonstration was to convince the farmers that by adopting the improved technology developed at the Research Centre the productivity of black pepper can be increased. Fifty one plots in an area of 80 ha were selected for the study. A survey of the area selected for the

demonstration revealed that 12 per cent of the farmers did not use manures for black pepper and 14 per cent applied inorganic fertilisers. As regards to pesticide use, 18 per cent used fungicides against quick wilt while 50 per cent used insecticides against 'pollu' beetle. However, mulching of vines was practised by very few.

The following technologies were demonstrated:

1. Rejuvenation of gardens using high yielding vines
2. Balanced nutrient management
3. Shade regulation and mulching
4. Adoption of timely plant protection measures
5. Phytosanitary measures for checking incidence of quick wilt.

An Advisory Committee consisting of representatives of NRCS, Department of Agriculture and other Developmental Agencies was set up for the implementation of the programme. The farmers were also trained at the Research Centre on various aspects of cultivation. Inputs such as rooted high yielding black pepper cuttings, neem cake, bone meal, inorganic fertilisers, fungicides, insecticides and sprayers, besides technical literature were supplied. The organic manures and the labour involved were met by the farmers themselves. The ratio of commitment from NRCS:farmers was 1:2.

Impact of the programme

In spite of the prevalent drought during the year, the mean yield of black pepper in the experimental vines at Pannikottur and Peruvanna villages was 1.1 kg|vine (dry) which was 209 per cent more over control. At Puthupadi, the mean yield of the experimental vines was 1.51 kg|vine (dry) which was 303 per cent more over control (Table 12).

Table 12. Impact of field demonstration on yield of black pepper

Locality	Yield (kg|vine-dry)		
	Pre experimental	Farmers production	Experimental
Peruvanna	0.232	0.356	1.10(209)
Puthupadi	0.660	0.375	1.51(303)

Figures in parenthesis are percentage increase in yield over farmers practices

Analysis of soils in the demonstration plots revealed a substantial increase in the build up of soil nutrients due to addition of inputs. The occurrence of quick and slow wilt was only 0.3 and 1.0 per cent respectively. Infestation

of 'pollu' beetle was brought under complete control. The loss of vines due to drought was 2.0 per cent. In addition, 10-15 per cent mandays of employment was also generated.

Extn I(813) b. Increasing productivity of cardamom through large scale demonstration of improved technology in farmers fields

(VS Korikanthimath and *MN Venugopal)*

A High Production Technology (HPT) programme was initiated in 42 plots in key cardamom growing zones to motivate the farmers to increase the per unit production to a level of 800-1000 kg/ha by utilising the technology available at the Research Centre. The data collected on the pre planting status (bench mark survey) of the plots selected revealed that the yield level ranged from as low as 10 kg to as high as 125 kg/ha, with the average being 54.2 kg/ha.

Planting of cardamom in the demonstration plots was taken up during 1986. The establishment of plants was above 90 per cent. During periodical visits the farmers were briefed about carrying out various cultural operations, fertiliser and plant protection measures as per the calendar of operations. The maiden crop is expected during 1988.

All India Coordinated Research Project on Spices (Summary Report)

(Project Coordinator : S Edison)

The All India Coordinated Research Project on Spices (AICRPS) initiated as a combined project on spices and cashewnut during 1971 was bifurcated into two independent projects during 1985 and its headquarters shifted to NRCS, Calicut during the subsequent year. The project has 15 coordinating centres located in 9 states and about 45 research experiments are being conducted on crops such as black pepper, cardamom, ginger, turmeric, coriander, cumin, fenugreek, fennel and large cardamom. The project has a provision of Rs. 105 lakhs during the VII Plan. The major objectives of the project are:

* Evolving high yielding varieties resistant|tolerant to diseases and pests
* Sandardisation of agrotechniques for the crops under different agroclimatic conditions
* Evolving control measures for major diseases and pests
* Working as an inter-face and feed-back between the Agricultural Universities, NRCS and ICAR.

A brief account of research achievements made by the coordinating centres during 1986-87 is given below.

BLACK PEPPER

1. Chintapalli

Twenty eight cultivars were maintained in the germplasm. A CYT with nine cultivars from NRCS was laid out.

2. Panniyur

Seven cultivars were added to the germplasm; 70 cultivars and 117 wild types were maintained in the germplasm. Morphological characters of berry and spike and yield were recorded for the 50 cultivars that have begun to yield. Intervarietal crossing involving seven parental combinations was carried out for evolving high yielding varieties. The yield of promising varieties (developed from intervarietal crossing carried out earlier) was recorded. A comparative

yield trial (CYT) involving seven promising cultivars and a multilocation trial (MLT) involving nine cultivars was in progress. A new CYT with four cultures from Panniyur, three selections from NRCS and few local checks was initiated.

An irrigation-cum-fertiliser trial on Panniyur-I and Karimunda was initiated.

Studies on epidemiology of quick wilt carried out over a period of 10 years indicated that a significant and positive correlation existed between disease incidence and rainfall, number of rainy days and relative humidity; the correlation between disease incidence and maximum temperature and sunshine hours was significant and negative. A multiple linear regression equation based on disease incidence and weather parameters was developed which was a suitable model for prediction of the disease. Field trials for the control of quick wilt involving application of Bordeaux mixture, copper oxychloride, Ridomil, Captafol and Aliette were in progress. Application of neem cake and lime reduced collar infection of vines in farmers' fields.

3. Sirsi

Thirteen cultivars were added to the germplasm; 52 accessions including cultivated and wild types were maintained in the germplasm. A CYT involving four cultures from Panniyur, three selections from NRCS and a few local checks was initiated.

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Field trials for the control of quick wilt involving application of Bordeaux mixture, copper oxychloride, captafol, Ridomil and Aliette were initiated. Trials involving application of neem cake, lime and Thimet for the control of slow wilt were in progress.

CARDAMOM

1. Mudigere

Eighty four accessions were maintained in the germplasm. In the preliminary evaluation of clonal progenies of 25 accessions, K-4 had the highest number of suckers (18|clump); NPK-618 yielded the highest (327 g|clump-green), followed by NPK-469 (286 g). The yields in CL-683, CL-679 and CL-726 were 58.6, 50.6 and 23.0 per cent more over the control P-1, respectiveiy. Studies on the comparative performance of clonal and seedling progenies indicated that there were not much differences between the two. In the MLT of selected clones, no significant difference was observed among the entries for yield. In hybridisation trials, 40 promising selections were identified.

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In the old NPK trial, application of N at 50 kg/ha was optimum for sucker production. A new NPK trial was in progress. The deficiency symptoms of trace elements such as Mn, Zn, Cl, Cu, and Mo were studied under hydroponics.

The performance of 12 clones under moisture stress and the physiological changes occurring in them was studied. The Relative Water Content (RWC), Leaf Area Index (LAI) and Dry Matter Production were determined during the period under stress. Clone P-6 had a higher RWC compared to the overall mean during the drier months.

Seedlings raised from seeds treated with EMS, seedlings raised from P-1 and disease free clumps collected from heavily infested gardens were screened against the 'katte' virus.

Sampling procedures for estimating the population of thrips on plants were standardised. The biology of thrips was studied. In control trials with 10 insecticides, though all were effective, Nuvacron and Thimet were the best. Trials to determine the number of sprays required for controlling thrips were in progress.

2. Pampadumpara

Twenty nine cultivated and 18 wild types were maintained in the germplasm. Biometrical characters and yield were recorded for the cultivated types. The yield was highest in PV-2 (242 g/plant-dry). In the MLT, the highest yield (115.9 g/plant-dry) was obtained in PV-1. In the trial on selection of high yielding plants from the existing population, the yield was highest in PV-77, S-1 and PV-440 among the 19 Vazhakka, 22 Malabar and 24 Mysore types, respectively.

Trials to study the effect of soil stirring and leaf mulching and NPK were in progress.

Trials for the control of 'azhukkal' disease with fungicides were in progress. Healthy plants collected from 'katte' disease affected areas succumbed to the disease on artificial inoculation with viruliferous aphids.

Trials to determine the optimum dose of decamethrin (Decis) for the control of thrips and also the efficacy of MIT 505 (Ethion) in the control of thrips and shoot borer were in progress.

3. Yercaud

Twenty three accessions were maintained in the germplasm; 101 clonal units were collected from surveys conducted in Kolli hills. Forty five clonal progenies of three high yielding clumps of Malabar type were under evaluation.

In the MLT, APG-7 yielded the highest (260.8 kg|ha-green), followed by local Malabar (170 kg) among the eight entries evaluated. Hybridisation was initiated in the Malabar types based on the shape of the capsule and 1085 crosses were made.

GINGER

1. Pottangi

Eighty four collections in the germplasm were evaluated and among them Jamaica yielded the highest (2.61 kg|2m² bed) followed by Wynad local (1.74 kg). Recovery of dry ginger was maximum (34%) in PGS-16.

In trials on intercropping (with the ginger cultivar PGS-35) with niger, french bean, black gram and horse gram, the highest yield (5.5 t|ha) and income was obtained in the pure crop followed by intercropping with french bean (4.69 t|ha of ginger and 0.43 t|ha of french bean). In another trial, removal of mother rhizomes before harvest affected the growth of plants and resulted in reduced yields.

2. Solan

Thirty two collections in the germplasm were evaluated for yield, ginger oil and crude fibre content. The yield was highest (6.95 kg|4 x 1 m bed) in SG-666, followed by SG-638 (5.8 kg). SG-568 and Nadia had the highest (2.5%) ginger oil content; crude fibre content was highest (9.12%) in SG-551.

In the trial with different mulches, mulching with pine needless combined with application of farm yard manure yielded the highest (9.57 kg|plot). In another trial, seed rhizomes weighing 20-25 g promoted better growth of plants and resulted in higher yields.

Thirty two cultivars were screened against rhizome rot and two of them (SG-666 and SG-503) were found resistant. Trials involving seed treatment with Captaf, Captafol, Dithane M-45 and hot water for the control of rhizome rot were initiated.

3. Vellanikkara

In the MLT with 10 promising types, the highest yield (5.981 kg,2 sq m) was obtained in Nadia, followed by Bajpai (5.950 kg). Recovery of dry ginger was highest in Bajpai and Narasapattam (24%).

Field trials conducted for the control of rhizome rot involving application of Captaf, Captafol, Dithane M-45 and Chestnut compound indicated that there was no significant difference among the treatments. In trials on seed treatment with Captaf, Captafol, Dithane M-45 and hot water for the control of the disease, none of the treatments affected germination.

TURMERIC

1. Jagtial

Evaluation of 50 collections available in the germplasm was initiated.

2. Pottangi

Evaluation of 150 collections indicated that the yield was highest in PTS-55 and Amritapani (9 kg|3 m^2). Recovery of dry ginger was highest (33%) in PTS-48.

In trials on intercropping (with the turmeric cultivar PTS-24) with niger, french bean, black gram and horse gram the highest yield (21.86 t|ha) and income was obtained in the pure crop followed by intercropping with niger (20.12 t|ha of ginger and 0.09 t|ha of niger).

3. Solan

Evaluation of 46 collections indicated that the yield was highest (10.9 kg|plot) in ST-291.

Ten cultivars were screened under field conditions against the leaf rot pathogen *Taphrina maculans* and all of them were susceptible.

4. Vellanikkara

Thirty types were evaluated in two field trials; Chayapasupu and 321 Ethamukala yielded the highest (8.60 and 8.65 kg|2 m^2 respectively) in these trials.

A new MLT with 12 high yielding types obtained from different centres was initiated at Vellanikkara, Solan, Jagtial and Coimbatore.

CORIANDER

1. Coimbatore

One hundred and twenty accessions were maintained in the germplasm and growth and yield characters were recorded. In the initial evaluation trial (IET) with 18 accessions, the highest yields were obtained in Acc. 335 (575 kg|ha) and JC-111 (260.5 kg) during *rabi* and *kharif* seasons, respectively. In the CYT with 17 entries, analysis of pooled data for 5 years (1982-87) indicated that the highest yielder was Co-2 (369.8 kg|ha), followed by Acc. 695 (337.5 kg).

One hundred and twenty lines were screened against grain mould and all were susceptible. *Fusarium* sp., *Alternaria* sp., *Curvularia* sp. and *Helminthosporium* sp. were isolated from diseased samples. The incidence of wilt and powdery mildew was recorded in the accessions under the CYT and IET.

The incidence of wilt was higher during *rabi* and Co-1 was least infested. Powdery mildew was absent during *kharif* and a severe outbreak was observed during *rabi*. UD-373 and UD-374 appeared to be more tolerant to the disease.

2. Guntur

One hundred and twenty accessions were evaluated for yield; the yield was highest (438 kg|ha) in Gadwal followed by Cuddapah (428 kg). In the IET of 18 promising lines, the highest yield (321 kg|ha) was obtained in Adoni, followed by AS-176 (300 kg). In the CYT of 19 entries, CS-2 was the higher yielder (352 kg|ha), followed by Co-2 (336 kg).

In the trial to determine the response of coriander to phosphorous, the highest yield (339 kg|ha) was obtained in the treatment where 40 kg P_2O_5|ha was applied. However, the differences among the treatments were not significant. In the companion cropping trial, the highest income (Rs. 8379|ha) was obtained by sowing coriander along with half the seed rate of mustard.

3. Jagudan

Three hundred and one entries were maintained in the germplasm and growth and yield characters were recorded. Among the 13 entries evaluated, the highest yield was obtained in GAU Coriander-2 (1495 kg|ha) followed by CS-2 (1458 kg). The percentage of volatile oil was highest (0.2%) in the former.

4. Jobner

One hundred and ninety five accessions were maintained in the germplasm. In the MLT with 18 entries, the yields were higher in UD-374 (5.65 q|ha) and UD-41 (5.35 q|ha) and were significantly superior to the local Check (5.28 q|ha).

Trials with growth regulators and cow dung slurry on germination indicated that treatment with the latter enhanced germination.

Among the 63 germplasm entries screened against stem gall disease in the field, 23 were free from the disease.

CUMIN

1. Jagudan

One hundred and fifty seven entries were maintained in the germplasm and observations on growth and yield were recorded. Evaluation of eight entries indicated that MC-43-73 yielded the highest (808 kg|ha) followed by UC-208 (784 kg).

Among the 30 entries evaluated against wilt, EC-109635 was moderately tolerant. In the trial with different oil cakes and fungicide, none of the treatments were effective in controlling wilt. Trials on the effect of crop rotation on yield and incidence of wilt were under progress.

2. Jobner

Eighteen lines were maintained in the germplasm under muslin cloth chamber. UC-198 and UC-199 performed better among the 12 entries evaluated. Plants from F_2 generation of UC-19 x UC-198 and M_2 generation of U-19 treated with gamma rays were evaluated for yield and resistance to wilt.

In the fertiliser trial, application of 30 kg N|ha (after first weeding and hoeing) and 20 kg P_2O_5|ha (during sowing) resulted in higher yields. Control of weeds by herbicides or by hand weeding was essential for realising higher yields.

In the trial with different oil cakes (neem, cottonseed, castor and mustard) in combination with Bavistin and Captan, none of the treatments were effective in controlling wilt. However, increase in the dosage of oil cakes resulted in higher yields. Experiments on the effect of crop rotation on yield and incidence of wilt were in progress. The pathogenicity of *Fusarium oxysporum cumini* was established. Attempts were made to isolate the toxin from the culture filtrate of the fungus.

FENNEL

1. Jagudan

One hundred and eighty two lines were maintained and observed for growth and yield characters. In the MLT with seven lines (with PF-35 as a check), Gujarat Fennel-1 yielded the highest (1881 kg|ha) which was 15.4 per cent higher than the check.

2. Jobner

One hundred and twelve lines were maintained in the germplasm and observed for growth and yield characters. In the MLT with six lines, the highest grain yield was obtained in UF-90 (10.34 q|ha) followed by UF-101 (9.12 q|ha). Analysis of essential oil contents in seeds of six promising varieties indicated that it ranged from 0.3 - 0.8% and was highest (0.8%) in UF-112.

In fertiliser trials application of N at 90 kg|ha increased the grain yield. Picking of umbels at full length size of fruits was ideal for obtaining a better quality of seed.

FENUGREEK

1. Coimbatore

Sixty accessions were maintained and various biometrical characters recorded. In the CYT with 14 entries, pooled yield data for 6 years (1981-87) indicated that Co-1 performed better than others yielding 350.2 kg|ha followed by Acc. 1084 (249.5 kg).

In trials against root rot involving application of organic amendments, treatment with the antogonistic fungus *Trichoderma viridae* and the fungicide carbeadazin 0.1%, the treatments reduced the disease incidence appreciably and increased yields. None of the entries in the CYT, IET and germplasm were resistant to the disease.

2. Guntur

Sixty entries in the germplasm were evaluated; the highest yield was obtained in Methi-3 (568 kg|ha) followed by Bolpur local (518 kg). In the CYT with eight entries, the highest yield was obtained in Co-1 (512 kg|ha), followed by GF-1 (462 kg).

3. Jagudan

One hundred and seventy entries were maintained in the germplasm and observations on growth and yield were recorded. In the MLT, none of the 11 entries tested showed significant differences in seed yield; however, the grain yield was highest (1846 kg|ha) in Co-2 (TG-1084).

4. Jobner

Evaluation of 24 entries in the IET indicated that UM-67 yielded the highest (8.43 q|ha) followed by UM-9 (6.58 q). Sixty five M_5 progenies and selections from the germplasm were evaluated for yield and reaction to powdery mildew. Grain yield was highest (11.12 q|ha) in 30 kr-107, followed by 20 kr-11 (10.43 q). Seven entries were resistant to powdery mildew disease. In the MLT with 10 entries, UM-118 and UM-117 were superior and tolerant to root rot; the latter was tolerant to powdery mildew also.

Among the 34 entries screened against root knot nematode, UM-34 and UM-35 were resistant.

LARGE CARDAMOM

1. Gangtok

Four types were collected and added to the 21 existing types in the germplasm. Evaluation of six cultivars in a CYT was in progress.

Surveys were initiated to study the incidence and extent of damage by viral diseases. A new fungal leaf spot disease was identified. Evaluation of fungicides against the disease is in progress.

Collection, conservation and cataloguing of genetic resources of *Piper nigrum* L. (black pepper) and related species

*(Romeo Alex** and *VV Radhakrishnan*)*

1. Collection of germplasm (cultivars)

Black pepper growing areas in five districts of Kerala and Karnataka were surveyed for collection of germplasm and 158 collections were made. These were planted in the nursery at the NRCS Farm, Peruvannamuzhi (Table 13). In addition, specimens were also collected for preparation of herbarium.

Table 13. Collection of black pepper germplasm (cultivated)

Area	No. of collections	Promising cultivars collected
Idukki district	25	Jeerakamundi, Marampadathi, Aimpiriyan, Thevanmundi, Irumaniyan
Cannanore district	19	Valiakaniakkadan, Chettikodi, Karimunda, Arakulam munda
Calicut district	7	Kalluvally, Karimunda, Arakulam munda, Perumkodi
Palode (Trivandrum district)	14	Kottanadan types
Sagar (Shimoga district)	26	Sagar, Sidhapur local, Doddigya, Masur local

2. Collection of wild *Piper* spp.

Surveys were organised to forest ranges of Nelliampathy, Idukki and Wynad in Kerala, Kanyakumari district of Tamil Nadu and Kodagu and Sagar areas in Karnataka and 123 collections were made. These were planted in the nursery Peruvannamuzhi (Table 14). Specimens for herbarium were also collected wherever possible.

* Research fellow

Table 14. Collection of wild *Piper* spp.

Area	No. of collections	Species collected
Nelliampathy (Palghat district)	39	*P. nigrum, P. longum, P. attenuatum P. mullesua*
Idukki district	10	*P. nigrum, P. galeatum*
Wynad district	12	*P. attenuatum, P. trichostachyon*
Kodagu district	8	*P. hymenophyllum, P. attenuatum, P. trichostachyon*
Sagar (Shimoga district)	16	*P. betel, P. nigrum, P. attenuatum*
Nagercoil(Kanyakumari district)	24	*P. hymenophyllum, P. nigrum, P. attenuatum, P. longum, P. argyrophyllum*
North eastern hill region	14	*P. nigrum, P. betel*

3. Establishment of germplasm conservatories

Two germplasm conservatories were established, one each for the cultivated and wild types. As many of the wild species are adapted to the humid, forest conditions at high elevations their establishment was found to be difficult. An alternate site for maintenance of the germplasm has been selected at Appangala (NRCS Cardamom Research Centre) in Kodagu district. At present 120 accessions of *Piper* spp. have established in the wild germplasm conservatory; 236 cultivated types were planted in the germplasm field.

4. Study of herbaria

A herbarium of *Piper* spp. is being established at the Research Centre. The collections were identified and classified and were found to consist of the following species: *Piper attenuatum, P. galeatum, P. hookeri, P. hymenophyllum, P. longum, P. mullesua, P. trichostachyon, P. schmidtii* and *P. silentvalleyensis*. Taxonomic descriptions of these species were made.

5. Anatomical studies on *Piper* spp.

Stem, leaf and root anatomy of *P. nigrum, P. longum, P. attenuatum* and *P. hymenophyllum* was studied. Epidermal morphology and stomatal characters of various species were also studied. Stomatal ontogeny was studied in relation to *P.longum, P.attenuatum, P.nigrum, P. colubrinum* and *P.hymenophyllum.*

Tissue culture for rapid clonal multiplication of elite plants (cardamom)

(KV Saji * and *Regy Lukose)*

1. Clonal multiplication of elite lines

About 2900 cultures were produced from 18 lines and out of these, 450 were transferred to soil using the following method which was standardised during the year. *In vitro* plants were transferred to White's liquid medium supplemented with NAA for rooting. They were then transferred to autoclaved soil-vermiculite mixture (1:1 v|v) in polybags kept in the laboratory under controlled light, temperature and humidity conditions. Hoagland's solution was supplied at 3 day intervals instead of watering. These plants were transferred to the cage house after 10 days. Out of 450 plants, about 40 died due to poor rooting and establishment while the rest are growing satisfactorily in the cage house and in the field.

2. Comparative yield trials

A CYT was laid out during October in a CRD with 12 plants per plot with 8 replications for assessing the field performance of tissue cultured seedlings over seedlings and suckers using Cl.37 materials. Another CYT was laid out during December using monoclonal tissue cultured material (P_1), monoclonal suckers multiplied in field (P_1) and seedlings of P_1 Mudigere, in a RBD with seven replications and nine plants per plot.

3. Callus cultures

Callus cultures were established from different origins viz., rhizome and apical meristem. Work is in progress to regenerate plantlets from the callus.

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* Research fellow

PROJECTS CONCLUDED

Path II.4(813). Crop loss survey on quick wilt of black pepper

(M Anandaraj, R Balakrishnan, RN Brahma and *Jose Abraham)*

OBJECTIVES

1. To estimate the crop loss due to quick wilt of black pepper caused by *P. palmivora* ME_4.
2. To identify the constraints in the cultivation of black pepper.

TECHNICAL PROGRAMME

1. Collection of basic data on cultivation of black pepper from agricultural census records.
2. Classification and selection of villages and black pepper gardens.
3. Survey of selected gardens and enumeration of data on the incidence of quick wilt for consecutive years.
4. Compilation and analysis of data.

MATERIALS AND METHODS

1. Survey

The survey was conducted in Calicut and Cannanore districts of Kerala, which are important black pepper growing areas. The design of the survey was that of stratified multistage. In Calicut district, the villages were classified into three categories viz., those with large, medium and small sized black pepper gardens. The first two categories were selected for the survey; three villages in the first stratum and four in the second were selected (Table 15). In Cannanore district, the villages were classified into four strata based on the population of vines available viz., I. > 1,00,000 vines II. 30,000 to 1,00,000 vines III. 10,000 to 30,000 vines IV. < 10,000 vines. From each stratum four villages were selected at random (Table 16).

Table 15. List of villages surveyed in Calicut district for estimation of crop loss caused by quick wilt

Stratum	Village
I	Naripetta
	Peruvanna
	Pudupady
	Tiruvampadi
II	Chengroth
	Puttur
	Kumaranellur

Table 16. List of villages surveyed in Cannanore district for estimation of crop loss caused by quick wilt

Stratum	Village
I	Panapuzha
	Pariyarum
	Panniyur
	Eruvassy
II	Kadannapally
	Panoor
	Pattiam
	Sreekandapuram
III	Kandamkunnu
	Eruvetti
	Peralam
	Taliparamba

In Calicut district five clusters were chosen in each selected village, each comprising of five contigous survey sub-divisions; four clusters were chosen in each selected village in Cannanore district. The selected gardens were visited for three consecutive years (1982, 1983 and 1984) in Calicut district and two years (1985 and 1986) in Cannanore district. Data on total number of vines present, number of vines affected by quick wilt, cultural practices followed and incidence of other pests and diseases were recorded. For estimating the yield, the visual scoring method of Balakrishnan and Jose Abraham (1986) was adopted. For this purpose neighbouring vines of the same cultivar and similar canopy to that of the wilted vines were selected.

2. Estimation procedures

The estimates on mean number of vines lost, loss in production and percentage disease incidence were obtained by standard methods (Sukhatme and Sukhatme, 1976). For computing the number of vines lost and the total loss in yield, the data from Agricultural Census Records (1981-82) of Directorate of Statistics, Government of Kerala, were used.

RESULTS AND DISCUSSION

The mean number of vines lost in each survey sub-division and the estimated yield loss in Calicut and Cannanore districts are given in Tables 17 and 18, respectively. The average disease incidence in Calicut and Cannanore districts was 3.2 and 9.4 per cent, respectively. The estimated loss in yield in these districts was 119 and 905 metric tonnes, respectively. In earlier reports, vine deaths up to 30 per cent in individual gardens have been reported. During the present survey up to 95 per cent disease incidence was recorded in Cannanore district. Though the disease is serious, the farmers did not take up prophylactic measures; a few had sprayed Bordeaux mixture to the vines after noticing the disease. In some gardens where black pepper is cultivated as a monocrop, once the disease occurs the vines are removed and the area is planted with rubber, coconut etc. In most of the gardens black pepper is grown as a mixed crop along with arecanut and coconut. Cultural operations such as digging damaged the tender feeder root system of the vines which aggravated the severity of foot rot. Keeping the interspaces clean by regular digging and removal of weeds added to the quicker spread of the disease to adjacent vines. The spread was restricted in areas where grass|weeds were present in interspaces and in gardens where no tilling was done.

Table 17. Estimates of quick wilt disease incidence and loss in yield of black pepper in Calicut district

Year	Disease incidence (%)	No. of vines lost|survey sub-division	Total vines lost in the district ('000)	Loss in yield (mt)
1982	5.45	4.48(1.16)	346.68	209.7
1983	1.92	1.22(0.43)	105.96	72.6
1984	3.73	1.61(0.22)	132.87	86.6
Mean	3.70	2.35(0.42)	188.95	119.6

Figures in parenthesis are standard errors

Table 18. Estimates of quick wilt disease incidence and loss in yield of black pepper in Cannanore district

Year	Disease incidence (%)	No. of vines lost|survey sub-division	Total vines lost in the district ('000)	Loss in yield (mt)
1985	8.3	12.3(3.6)	1313.28	1288.6
1986	10.4	5.0(1.3)	719.57	521.2
Mean	9.4	8.7(2.5)	1016.42	904.9

Figures in parenthesis are standard errors

CONCLUSIONS

Quick wilt of black pepper caused serious economic losses. It was estimated that 119 and 905 metric tonnes of black pepper were lost every year in Calicut and Cannanore districts, respectively. Since black pepper is cultivated as a subsidiary crop, neither fertiliser application nor prophylactic measures for controlling the disease were undertaken.

PUBLICATIONS

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Ent VII(813). Studies on rhizome maggots in ginger and their role in rhizome rot

(KM Abdulla Koya)

OBJECTIVES

The project was undertaken to study the bioecology of rhizome maggots infesting ginger and to determine their role in rhizome rot.

TECHNICAL PROGRAMME

1. Survey of major ginger growing areas in Kerala for collection and identification of rhizome maggots.

2. Studies on nature and extent of damage caused by rhizome maggots and microorganisms associated with rhizome rot.

3. Bioecology of major species of rhizome maggots.

4. Role of rhizome maggots in rhizome rot.

MATERIALS AND METHODS

1. Survey

Surveys were conducted in ginger growing areas in Wynad, Cannanore, Pathanamthitta, Idukki, Kottayam and Ernakulam districts during November 1984 and Quilon, Trivandrum, Malappuram, Palghat, Trichur and Calicut districts of Kerala during September to December, 1985 to record the incidence of rhizome maggots.During the survey, 195 gardens selected at random, were visited and 767 samples (healthy and diseased) were collected and brought to the laboratory. The maggots in the samples were extracted and cultured for identification; the pathogens were isolated on potato dextrose and corn meal agar media and identified. Observations on the incidence of rhizome rot and the maggots associated with them were also recorded in the field.

2. Bioecology of *Mimegralla coeruleifrons*

a. Life history

Females of *M. coeruleifrons* were collected from the field and released in cages of 1 x 1 x 1 m size containing glass troughs filled with soil for egg laying. The adults were fed with diluted honey soaked in cotton wool. The eggs were collected and placed in petri plates for hatching. Crushed ginger rhizomes were provided as food material for the hatching rhizome maggots. As the moulten skin of the maggots could not be traced out from the food material, the mouth hook was measured from the first day of hatching to pupation to determine the different instars. Measurements of egg, larva, pupa and adults were recorded. Studies on mating and oviposition were carried out in the field and under green house conditions. The alternate hosts and natural enemies were recorded. The mode of survival during the non crop season was studied.

3. Role of rhizome maggots in rhizome rot

a. Studies under pot culture

Ginger plants (cv. Maran) were raised in earthen pots of 25 cm diameter filled with 3 kg of sterilised soil. Seed ginger (25 g|pot) was sown after surface sterilisation with mercuric chloride 0.1%. The pots were maintained in insect proof cages of 1 x 1 x 1 m size. The treatments included, T_1 - release of adult *M. coeruleifrons*, T_2 - inoculation with *P. aphanidermatum* and release of adult *M. coeruleifrons* and T_3 - inoculation with *P. aphanidermatum*. The treatments were effected 2 months after sowing. The pots (15 numbers) under each treatment were enclosed in separate cages. The occurrence of the disease and the maggots in the rhizomes under various treatments was recorded. The experiment was conducted for two years (1985 and 1986).

b. Field trials

The field trial was laid out at Chelavoor in a CRD with eight treatments replicated four times. Ginger plants (cv. Maran) were raised in beds of 1 x 1 m size with 16 plants|bed. The treatments were T_1 - drenching fungicide + release of adult *M. coeruleifrons* under cage, T_2 - release of *M. coeruleifrons* under cage, T_3 - drenching fungicide, T_4 - release of *M. coeruleifrons* in open condition, T_5 - drenching fungicide under cage, T_6 - ginger plants kept under cage, T_7 - drenching fungicide + spraying insecticide and T_8 - spraying insecticide. As there was no natural infection in the experimental plot during 1985, the beds under treatments T_2 and T_8 were inoculated with *P. aphanidermatum* during 1986. The beds under treatments T_1, T_2, T_5 and T_6 were covered with nylon mesh cages of 1 x 1 x 1 m size immediately after sowing. The treatments with

fungicide (Dithane M-45 0.3%) and insecticide (methyl parathion 0.05%) were carried out at montly intervals from July to October. The number of diseased clumps and those containing maggots were recorded during November-December.

4. Life history of *Eumerus pulcherrimus*

Eggs of *E. pulcherrimus* collected from the field were utilised to study the life history. The eggs were kept in petri plates for hatching. Crushed diseased ginger rhizomes were provided as food for the hatching maggots. To study the natural enemies of *E. pulcherrimus*, pupae were collected from the field and kept in glass vials in the laboratory.

RESULTS AND DISCUSSION

1. Survey

The association of various rhizome maggots in healthy and diseased samples collected from different districts is furnished in Table 19. Maggots were present in 33.6 per cent of the diseased samples. Among the various species, *M. coeruleifrons* was the dominant one occurring in 26.4 per cent of the diseased samples. *E. pulcherrimus* was observed only in 1.0 per cent of the diseased samples. The combined infestation of both the species was observed in 5.9 per cent of the diseased samples. *Gymnonerius* sp. (Neriidae) was recorded from a single sample collected from Wynad district. Infestation by *M. coeruleifrons* occurred first and that by *E. pulcherrimus* occurred subsequently especially in rhizomes which were in an advanced stage of rotting. The diseased rhizomes yielded pathogens such as *P. aphanidermatum, P. solanacearum* and *Fusarium* spp. Maggots were not observed in healthy rhizomes and in those which had just taken up the disease indicating that the disease occurred first and the maggots infest the diseased rhizomes later.

2. Bioecology of *M. coeruleifrons*

a. Life history

Egg: Eggs were white, spindle shaped and sculptured with longitudinal lines, the posterior end being round and the anterior end pointed. Eggs hatched in 3-4 days. Hatching occurred through a longitudinal split of the egg shell that extended from the anterior end to three fourths of the egg. The process of hatching took 8-10 minutes.

Larva: Newly hatched larvae were transparent and pale white. Based on the change in the dimensions of the mouth hook, the number of instars was fixed as three. In the field the rhizome maggots were observed to tunnel inside the rhizomes and feed on the inner contents. In severely infested rhizomes only the outer skin remained after feeding.

Table 19. Distribution of rhizome maggots and pathogens associated with ginger rhizomes in Kerala

District	No. of samples examined		No. and percentage of diseased samples				Pathogens isolated from diseased samples
	Total	Diseased	With Mc alone	With Ep alone	With Mc and Ep	Without maggots	
Trivandrum	28	6	4 (66.7)	–	–	2 (33.3)	P, Ps
Quilon	34	10	3 (30.0)	1 (10.0)	–	6 (60.0)	Ps
Pathanamthitta	55	40	11 (27.5)	2 (5.0)	1 (2.5)	26 (65.0)	F, P, Ps
Kottayam	10	7	1 (14.3)	–	–	6 (85.7)	F
Ernakulam	15	13	2 (15.3)	–	–	11 (84.6)	P
Idukki	43	–	–	–	–	–	Nil
Palghat	43	12	6 (50.0)	–	5 (41.7)	1 (8.3)	P, Ps
Trichur	105	32	–	–	–	32 (100.0)	P, Ps
Malappuram	39	16	6 (37.5)	–	5 (31.3)	5 (31.3)	F, P, Ps
Calicut	200	3	–	–	–	3 (100.0)	P, Ps
Wynad *	162	126	33 (26.2)	–	3 (2.4)	89 (70.6)	F, P, Ps
Cannanore	33	23	10 (43.5)	–	3 (13.0)	10 (43.5)	P, Ps
Total	767	288	76 (26.4)	3 (1.0)	17 (5.9)	191 (66.3)	

* *Gymnonerius* sp. was recorded from a single sample

Mc = *Mimegralla coeruleifrons* F = *Fusarium* spp. Ps = *Pseudomonas solanacearum*

Ep = *Eumerus pulcherrimus* P = *Pythium* spp.

Pupa: Pupation occurred generally within the infested rhizome and rarely in the soil. The pupae were elongated; nascent pupae were pale brown which soon turned dark brown.

Adult: Males were slightly smaller than females. Females could be identified by the presence of a long tubular structure formed out of the last segment of the abdomen. The dimensions of various stages are given in Table 20.

Table 20. *Dimensions of egg, larval, pupal and adult stages of M. coeruleifrons*

Stage	Mean (mm)	Range (mm)	No. observed
Egg (length x width)	0.776 x 0.171	0.752-0.800 x 0.160-0.184	20
Larva (length)			
I instar	2.607	1.224-3.980	5
II instar	5.256	6.756-9.012	5
III instar	10.224	9.340-10.920	5
Mouth hook of larva (length)			
I instar	0.036	0.030-0.040	7
II instar	0.077	0.075-0.080	7
III instar	0.167	0.140-0.185	11
Pupa (length x width)	7.783 x 1.616	7.50-8.00 x 1.50-1.75	15
Adult male (length x width)	11.95 x 1.50	11.00-12.50 x 1.50	10
Adult female (length x width)	13.65 x 1.75	13.00-15.00 x 1.50-2.00	10
Adult male (wing span)	16.60	15.50-17.50	10
Adult female (wing span)	17.85	17.50-19.00	10

Mating and oviposition: Mating was preceded by a brief courtship. Mating pairs remained in copula up to 13 minutes. Copulation occurred 4-7 times at intervals of 4-46 minutes. The various stages in the mating behaviour were studied in detail. After mating the eggs were laid singly in the soil up to a depth of 1 cm around the base of the pseudostems. However, under laboratory conditions gravid females laid eggs even on the sides of the glass troughs.

b. Alterante hosts

The rhizome maggots were observed in rhizomes of diseased turmeric *(Curcuma longa)*, wild arrow root, *Colocasia* sp. and wild ginger *(Zingiber* sp.). They also bred on fallen and decaying banana flowers espectially during the non crop season (January-May).

c. Mode of survival during non crop season

The rhizome maggots bred on fallen and decaying banana flowers, rejected bits and roots of ginger during January-May. The duration of life cycle was prolonged on banana flowers in the laboratory (35-45 days). Adults were also observed in the field in moist and shaded areas during this period and exhibited normal activities such as mating, egg laying etc.

d. Natural enemies

Two parasites were recorded from the pupae and were identified as *Trichopria* sp. (Diapriidae) and *Spalangia gemina* (Pteromalidae), the latter being recorded for the first time. In the case of the former, 12-20 adults emerged out of a single pupa and in the latter a single parasite emerged from one pupa.

3. Role of rhizome maggots in rhizome rot

a. Trials under pot culture

The results of the trials are presented in Table 21.

Table 21. Trials under pot culture to determine the role of rhizome maggots *(M. coeruleifrons)* in rhizome rot of ginger

Treatment	No. of plants treated	No. of plants diseased		No. of plants healthy		No. of plants with maggots	
		1985	1986	1985	1986	1985	1986
T_1-Release of adult *M. coeruleifrons*	15	0	0	15	15	0	0
T_2-Inoculation with *Pythium* sp. + release of adult *M. coeruleifrons*	15	9	15	6	0	7	15
T_3-Inoculation with *Pythium* sp.	15	12	15	3	0	0	0

The ginger plants which were inoculated with adult *M. coeruleifrons* remained healthy and the rhizomes of these plants did not contain maggots. Rhizomes of plants which were inoculated with *Pythium* sp. + *M. coeruleifrons* took up the disease and only these contained maggots indicating that they could infect only diseased and rotting rhizomes.

b. Field trials

The data collected from the field trials are presented in Table 22. Here too the disease occurred only in treatments where *Pythium* sp. was inoculated and 58.8 and 50.0 per cent of the diseased clumps in treatments T_2 and T_8 respectively, contained maggots. The results of the field trials confirmed the findings of the trial under pot culture. On the ginger plants which were kept exposed, neither disease nor insect incidence was noticed, although they were exposed to the floating population of the adult insects. It was also observed that the maggots were not present in rhizomes which had just taken up the disease.

Table 22. Field trials to determine the role of rhizome maggots (*M. coeruleifrons*) in rhizome rot of ginger

Treatment	Germination (%)	Clumps diseased	Diseased clumps with maggots (%)
T_1-Cage + adult Mc + fungicide	98.4	0.0	0.0
T_2-Cage + adult Mc + *Pythium* sp.	100.0	26.5	58.8
T_3-Fungicide	96.8	0.0	0.0
T_4-Adult Mc	87.5	0.0	0.0
T_5-Fungicide + cage	100.0	0.0	0.0
T_6-Cage	96.8	0.0	0.0
T_7-Fungicide + insecticide	95.3	0.0	0.0
T_8-Insecticide + *Pythium* sp.	100.0	65.6	50.0

Mc = *Mimegralla coeruleifrons*
Fungicide = Dithane M-45 0.3%
Insecticide = Methyl parathion 0.05%

4. Bioecology of *E. pulcherrimus*

Females of *E. pulcherrimus* laid eggs singly on dried leaves and twigs around diseased ginger clumps in the field. Eggs were sometimes deposited near the rhizomes in the soil. The eggs were white; newly hatched larvae were dirty white and later turned brown. The egg, larval and pupal periods lasted for 3-4, 13-16 and 12-15 days, respectively. The maggots were mostly

seen in the rhizomes that were in an advanced stage of rotting. No parasite could be recorded even though 800 pupae were collected and observed in the laboratory.

CONCLUSION

Studies conducted under laboratory and field conditions on the role of rhizome maggots in rhizome rot of ginger and also observations made during the survey in various locations indicated that *M. coeruleifrons* was not a primary pest of the crop and could not infest healthy rhizomes. However rhizomes that were either infested by another sub terrannean pest or by pathogens resulting in rotting, were secondarily invaded by the maggots. The maggots were also found to breed in other decaying plant material indicating their saprophytic nature.

PUBLICATIONS

ABDULLA KOYA, K. M. Distribution of dipteran maggots associated with ginger (*Zingiber officinale* Rosc.) in Kerala. Accepted in *Journal of Plantation Crops*.

ABDULLA KOYA, K. M. Role of rhizome maggots *Mimegralla coeruleifrons* Macquart in rhizome rot of ginger. Submitted to *Tropical Pest Management*.

ABDULLA KOYA, K. M. Bioecology of *Mimegralla coeruleifrons* Macquart (Diptera: Micropezidae) associated with ginger *Zingiber officinale* Rosc. rhizomes. Accepted in *Entomon*.

GENERAL INFORMATION

Budget for 1987-88 (Calicut and Appangala)

Budget allocation

Non Plan	Rs. 35,00,000
Plan	Rs. 20,00,000
Total	Rs. 55,00,000

Actual expenditure

Non Plan	Rs. 34,91,764
Plan	Rs. 19,99,867
Total	Rs. 54,91,637
Receipts	Rs. 1,87,958

Library and documentation services

At Calicut, 114 books, 122 bound volumes, 190 reprints and 26 technical reports were added to the library; 54 foreign and 70 Indian journals were subscribed to during the year. At Appangala, 20 books and 5 technical reports were added to the library; 6 foreign and 13 Indian journals were subscribed to during the year.

The library provided information services to scientists and other research workers of the Research Centre and also to 15 centres of the All India Coordinated Research Project on Spices on various aspects of spice crops including minor spices through the 'Current Awareness Service on Spices and Condiments'. A bimonthly 'Library Accession List' was prepared and circulated to keep the research workers informed of the additions to the library.

Eight doctoral thesis on spices and condiments were obtained on loan and photocopies of the same were preserved in the library. Reprographic services were provided to research workers and other staff of the Research Centre and till date 36,000 copies of various documents have been taken either for distribution or for preservation in the library.

Publications

RESEARCH ARTICLES

ANANDARAJ, M. and BALAKRISHNAN, R. 1987. A sampling procedure to assess the yield loss due to 'koleroga' of arecanut palm (*Areca catechu* L.). *Journal of Plantation Crops* **15:** 66-68.

DEVASAHAYAM, S., PREMKUMAR, T. and ABDULLA KOYA, K. M. 1987. Record of *Sahyadrassus malabaricus* (Moore) damaging *Glyricidia maculata*. a standard of black pepper *Piper nigrum* L. in Kerala. *Entomon* **12:** 391-392.

GOPALAM, A. and RATNAMBAL, M. J. 1987. Gas chromatographic evaluation of turmeric essential oils. *Indian Perfumer* **31:** 245-248.

JOHN ZACHARIAH, T. and GOPALAM, A. 1987. Nature, production and quality of essential oils of pepper, ginger, turmeric, cardamom and tree spices. *Indian Perfumer* **31:** 188-205.

JOSE ABRAHAM, RAWTHER, T. S. S., JACOB, P. M. and ROBERT CECIL. 1987. Trend in yield of root (wilt) affected coconut palm (*Cocos nucifera* Linn.). *Journal of Plantation Crops* **15:** 38-41.

KORIKANTHIMATH, V. S. and VENUGOPAL, M. N. 1987. Dicotyledonous weeds of cardamom plantations. *Cardamom* **20** (7): 11-15.

RAMADASAN, A. 1987. Canopy development and yield of adult pepper vines in relation to light interception. *Indian Cocoa, Arecanut and Spices Journal* **11:** 43-44.

RAMADASAN, A. and JACOB MATHEW. 1987. Leaf area and dry matter production in adult coconut palms. *Journal of Plantation Crops* **15:** 59-63.

RAMANA, K. V. and MOHANDAS, C. 1987. Plant parasitic nematodes associated with black pepper (*Piper nigrum* L.) in Kerala. *Indian Journal of Nematology* **17:** 62-66.

RAMANA, K. V., MOHANDAS, C. and BALAKRISHNAN, R. 1987. Role of plant parasitic nematodes in the slow wilt disease complex of black pepper *(Piper nigrum* L.) in Kerala. *Indian Journal of Nematology* **17:** 225-230.

RAMANA, K. V., MOHANDAS, C. and RAVINDRAN, P. N. 1987. Reaction of black pepper germplasm to the burrowing nematode (*Radopholus similis*). *Journal of Plantation Crops* **15:** 65-66.

RAVINDRAN, P. N., NAIR, M. K. and ASOKAN NAIR, R. 1987. New taxa of *Piper* (Piperaceae) from Silent Valley Forest, Kerala. *Journal of Economic and Taxonomic Botany* **10:** 167-169.

SATHEESAN, K. V. and RAMADASAN, A. 1987. Curcumin and essential oil contents of three turmeric (*Curcuma domestica* Val.) cultivars grown in monoculture and as intercrop in coconut gardens. *Journal of Plantation Crops* **15:** 31-37.

POPULAR ARTICLES

GOPALAM, A. and JOHN ZACHARIAH, T. 1987. Processing of pepper -- a scientific way. *Cardamom* **20** (12): 45-46.

KORIKANTHIMATH, V. S. 1987. Impact of drought on cardamom. *Cardamom* **20** (6): 5-12.

KRISHNAMOORTHY, B. K. 1987. Nutmeg. *Planters Chronicle* March 1987, 83-84.

MOHANDAS, C. and RAMANA, K. V. 1987. Slow wilt disease of black pepper and its control. *Indian Cocoa, Arecanut and Spices Journal* **11:** 10-11.

PREMKUMAR, T. and DEVASAHAYAM, S. 1987. 'Pollu' beetle of black pepper. *Cardamom* **20** (12): 43, 44 & 46.

RAMADASAN, A. 1987. Pepper research in India -- at a glance. *Cardamom* **20** (12): 9-11.

SADANANDAN, A. K. 1987. High-tech black pepper production for spectacular yields. *Cardamom* **20** (12): 55-58.

SARMA, Y. R., PREMKUMAR, T., RAMANA, K. V., RAMACHANDRAN, N. and ANANDARAJ, M. 1987. Disease and pest management in black pepper nurseries. *Indian Cocoa, Arecanut and Spices Journal* **11:** 45-49.

PAPERS PRESENTED IN WORKSHOPS, SEMINARS AND SYMPOSIA

DEVASAHAYAM, S. Residual toxicity of certain insecticides to gall thrips (*Liothrips karnyi* Bagnall) on black pepper. National Symposium on Integrated Pest Control -- Progress and Perspectives, Trivandrum, 15-17 October 1987.

KORIKANTHIMATH, V. S. Alternate farming systems in Western Ghats with reference to Coorg district in Karnataka. National Symposium on Alternate Farming Systems, New Delhi, 21-23 February 1987.

KORIKANTHIMATH, V. S. Impact of rainfall on cardamom. National Seminar on Agrometeorology of Plantation Crops, Pilicode, 12-13 March 1987.

MOHANDAS, C. and RAMANA, K. V. Pathogenicity, seasonal prevalence and control of plant parasitic nematodes associated with black pepper. Third Group Discussion on Nematological Problems of Plantation Crops, Coimbatore, 29-30 October 1987.

PREMKUMAR, T., DEVASAHAYAM, S. and ABDULLA KOYA, K. M. Insect pests of spices in India. National Symposium on Spice Industries -- Present Scenario, Problems and Prospects, New Delhi, 9-10 April 1987.

RAMANA, K. V. and MOHANDAS, C. Nematodes of spices in India -- present status and future thrust areas. National Symposium on Spice Industries -- Present Scenario, Problems and Prospects, New Delhi, 9-10 April 1987.

RAMANA, K. V. and MOHANDAS, C. Nematological problems in black pepper (*Piper nigrum* L.). Third Group Discussion on Nematological Problems of Plantation Crops, Coimbatore, 29-30 October 1987.

SADANANDAN, A. K. and ROHINI IYER. Effects of amendments on nutrient availability, yield responses and incidence of rhizome rot of ginger. National Seminar on Recent Advances in Soil Research, Pune, 26-28 November 1987.

SIVARAMAN, K., SADANANDAN, A. K. and JOSE ABRAHAM. Effect of N, P and K on the nutrient availability in soil and yield response of black pepper. National Seminar on Recent Advances in Soil Research, Pune, 26-28 November 1987.

SANTHOSH J. EAPEN. Plant parasitic nematode problems in small cardamom. Third Group Discussion on Nematological Problems of Plantation Crops, Coimbatore, 29-30 October 1987.

Participation in workshops, seminars and symposia

Eighth Workshop of All India Coordinated Research Project on Spices, Lam, 30 January-1 February 1987
MK Nair, S Edison and VS Korikanthimath

National Seminar on Alternate Farming Systems, New Delhi, 21-23 February 1987
VS Korikanthimath

National Symposium on Plant Genetic Resources, New Delhi, 3-6 March 1987
MK Nair

National Seminar on Agrometeorology of Plantation Crops, Pilicode, 12-13 March 1987
VS Korikanthimath, MN Venugopal and N Ramachandran

National Symposium on Spice Industries -- Present Scenario, Problems and Prospects, New Delhi, 9-10 April 1987
MK Nair, KV Ramana and T Premkumar

Twelfth Peppertech Meeting of the International Pepper Community, Hamburg, Federal Republic of Germany, 4-11 May 1987
MK Nair

National Symposium on Integrated Pest Management -- Progress and Perspectives, Trivandrum, 15-17 October 1987
S Devasahayam

Third Group Discussion on Nematological Problems of Plantation Crops, Coimbatore, 29-30 October 1987
KV Ramana, C Mohandas and Santhosh J Eapen

National Seminar on Recent Advances in Soil Research, Pune, 26-28 November 1987
AK Sadanandan and K Sivaraman

Twelfth Meeting of the Indian Spices Development Council, Ernakulam, 17 February 1987
S. Edison

Symposium on Himalayan Horticulture, Tezpur (Assam), 28–30 October 1987
S. Edison

Membership of staff in committees

MK Nair

Research and Development Committee for Cardamom, Spices Board
Research Review Committee, Spices Board
Marketing and Development Committee for Spices, Spices Board
Special Committee on Personal Matters, Spices Board
ICAR Panel on Fruits, Plantation Crops and Medicinal and Aromatic Plants
ICAR Representative, Spices and Condiments, Sectional Committee
Editor, Journal of Plantation Crops

S Edison

Indian Spices Development Council
Research Review Committee, Indian Cardamom Research Institute
Expert Team for Evaluation of UPASI Tea Research Institute
PG Thesis Evaluation Committee, Tamil Nadu Agricultural University, Coimbatore

YR Sarma

Phytophthora Committee, International Society for Plant Pathology

T Premkumar

Assistant Editor, Journal of Plantation Crops

CALICUT

Dr BA Lasebikar, University of Ife, Nigeria

Sri C Narasimhachar, Executive Chairman, Karnataka Pradesh Karshak Samaj

Sri MS Shankarikoppa, Chairman, Expert Committee on Farmers Probelms, Government of Karnataka

Sri PK Thampan, Chief Coconut Development Officer, Coconut Development Board, Cochin

APPANGALA

Sri US Bagi, President, Belgaum Chamber of Commerce, Belgaum

Sri M Balaraman Nair, Director (Spices), Spices Board, Cochin

Dr GC Mishra, Director, Dudhva National Park, Uttar Pradesh

Dr SN Rai, Conservator of Forests, Sandal Research Centre, Bangalore

Sri H Shiva Swamy, Additional Director of Industries and Commerce, Bangalore

Sri Sunderlal Bahuguna, Member, ICAR Governing Body

Sri E Velappan, Director, Directorate of Cocoa, Arecanut and Spices Development, Calicut

CALICUT

MANAGERIAL

MK Nair Ph D	Joint Director|Scientist S-4 (up to 31-3-1987) Director Scientist S-5 (from 1-4-1987)
S Edison Ph D	*Project Coordinator (Spices)*|*Scientist* S-3

SCIENTIFIC

Genetics and Plant Breeding

PN Ravindran Nair M Sc	Scientist S-3
B Krishnamoorthy M Sc (Ag)	Scientist S-1
MJ Ratnambal Ph D	Scientist S-1
K Nirmal Babu M Sc, M Phil	Scientist S-1
J Rema M Sc (Hort.)	Scientist S-1 (joined on 14-8-1987)

Agronomy

K Sivaraman M Sc (Ag)	Scientist S-2

Soil Science

AK Sadanandan Ph D	Scientist S-2

Plant Physiology

A Ramadasan Ph D	Scientist S-4

Biochemistry

A Gopalam Ph D	Scientist S-2
T John Zachariah Ph D	Scientist S-1

Entomology

T Premkumar Ph D	Scientist S-2
S Devasahayam M Sc	Scientist S-2
KM Abdulla Koya M Sc (Ag)	Scientist S-1

Plant Pathology

YR Sarma Ph D	Scientist	S-3
GN Dake M Sc (Ag)	Scientist	S-2
N Ramachandran M Sc	Scientist	S-2
M Anandaraj M Sc	Scientist	S-2
CK Parthasarathy Prasad Ph D	Scientist	S-1

Nematology

KV Ramana Ph D	Scientist	S-2
C Mohandas Ph D	Scientist	S-2

Statistics

Jose Abraham MA, M Sc	Scientist	S-2

TECHNICAL

PS Sudarsanan	Superintendent (up to 14-6-1987) Asst. Administrative Officer (from 15-6-1987)	
NS Sekaran	Asst. Accounts Officer	
K Usha	Superintendent (from 22-9-1987)	
P Azgar Sherief	Sr. Library Assistant	T-4
NR Aditya Varma	Sr. Farm Assistant	T-4
MK Appaiah	Sr. Farm Assistant	T-4

APPANGALA

SCIENTIFIC

Genetics and Plant Breeding

Regy Lukose M Sc	Scientist	S-1

Agronomy

VS Korikanthimath M Sc (Ag)	Scientist-in-Charge|Scientist	S-2

Plant Pathology

MN Venugopal Ph D	Scientist	S-2

Nematology

Santhosh J Eapen M Sc	Scientist	S-1

PERUVANNAMUZHI

Month	Rainfall		Mean temperature (°C)		Mean relative humidity (%)	
	No. of rainy days	Rainfall (mm)	Maximum	Minimum	Maximum	Minimum
January	--	--	32.8	31.2	50.4	45.1
February	--	--	35.6	18.9	44.5	39.2
March	--	--	37.2	19.9	44.2	41.1
April	4	22.6	38.3	24.4	43.7	42.0
May	8	174.2	37.1	23.5	50.5	48.3
June	25	719.4	30.8	24.7	81.8	75.3
July	19	702.6	30.1	24.5	79.8	78.1
August	24	588.0	29.0	23.5	89.3	88.5
September	9	319.4	30.5	22.4	71.4	70.3
October	22	551.2	29.0	22.3	62.6	62.3
November	13	351.7	27.1	19.9	53.6	51.5
December	4	213.0	28.1	19.6	50.0	48.5
Total	128	3642.1				

APPANGALA

Month	Rainfall		Mean temperature (°C)	
	No. of rainy days	Rainfall (mm)	Maximum	Minimum
January	--	--	27.6	13.8
February	--	--	28.7	12.5
March	--	--	35.5	14.7
April	4	47.0	32.6	18.2
May	11	122.2	30.1	22.4
June	23	247.3	30.3	18.1
July	26	292.7	24.7	18.6
August	26	424.9	23.9	21.5
September	19	161.0	25.6	19.0
October	12	190.0	26.4	18.7
November	10	131.5	26.0	27.3
December	3	12.0	26.3	16.4
Total	134	1628.6		