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CALICUT 673 012, KERALA, INDIA

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HISTORY

Research on spice crops in India was limited to standardisation of input requirements on a regional basis by the State Departments of Agriculture, till the end of the Fourth Five Year Plan. The establishment of the All India Coordinated Spices and Cashewnut Improvement Project (AICSCIP) by the Indian Council of Agricultural Research (ICAR) in 1971 with its Coordinating Cell at Kasaragod was the first step towards a concerted programme of research on spices. With the increasing importance of spices as a major source of foreign exchange and the crucial role it played in the economy of many states, the ICAR established a Regional Station of the Central Plantation Crops Research Institute (CPCRI) at Calicut during 1975 for conducting research on crop production, protection and technological aspects of black pepper, ginger, turmeric, cinnamon, clove, nutmeg and allspice. The Regional Station during its year of establishment had a staff strength of three scientists and its administrative office and laboratories were housed in rented buildings. Subsequently they were shifted to the new campus at Chelavoor within the Calicut Corporation during 1980. The new campus has an area of 14 ha and is 10 kms away from Calicut on the Calicut-Wynad road. The experimental farm is situated at Peruvannamuzhi in Quilandy taluk of Calicut district. The farm has an area of 98 ha and is 51 kms north-east of Calicut.

A significant land mark in the history of spices research in the country was the upgrading of the Regional Station at Calicut as the National Research Centre for Spices (NRCS) during the Seventh Plan period. The CPCRI Research Centre at Appangala conducting research on cardamom was also merged with the NRCS which came into existence in April 1986. The Cardamom Research Centre, Appangala with an area of 14 ha is located 8 kms away from Madikeri on the Madikeri-Bhagamandala road in Kodagu district.

Consequent to the establishment of the National Research Centres for Spices and Cashewnut, the AICSCIP was bifurcated by the end of the

Sixth Plan and the headquarters of the Coordinated Project on Spices was shifted to NRCS, Calicut. The Project has at present three centres on black pepper (Panniyur, Kerala; Sirsi, Karnataka and Chintapalli, Andhra Pradesh), three on small cardamom (Pampadumpara, Kerala; Yercaud, Tamil Nadu and Mudigere, Karnataka), four on ginger and turmeric (Vellanikkara, Kerala; Jagtial, Andhra Pradesh; Pottangi, Orissa and Solan, Himachal Pradesh), four on minor spices (Coimbatore, Tamil Nadu; Guntur, Andhra Pradesh; Jobner, Rajasthan and Jagudan, Gujarat) and one on large cardamom (Gangtok, Sikkim).

OBJECTIVES

The objectives of 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 resistance in black pepper and cardamom and evolve drought resistant/tolerant varieties in these crops
* Standardise input technologies in relation to nutrients, spacing and standards for increasing 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
* Establish demonstration plots, impart training to extension workers and publish extension literature for transfer of spices production technology

STAFF AND BUDGET

The sanctioned staff at NRCS includes 39 scientific, 30 technical, 18 administrative, 4 auxillary and 62 supporting; the actual staff in position was 25, 16, 18, 4 and 56 respectively, in the various categories. The annual sanctioned budget for 1986–'87 for NRCS was Rs. 52,10,000.

Staff position

Category	Calicut		Appangala		Total	
	Sanc-tioned	In posi-tion	Sanc-tioned	In posi-tion	Sanc-tioned	In posi-tion
Scientific	31	21	8	4	39	25
Technical	25	13	5	3	30	16
Administrative	14	16	4	2	18	18
Auxillary	3	3	1	1	4	4
Supporting	39	33	23	23	62	56
Total	112	86	41	33	153	119

RESEARCH PROGRAMMES

In a major reorientation of the various research programmes on spices during 1986, special emphasis was laid on interdisciplinary approach for fulfilling the mandate given to the Research Centre and 28 projects in progress were regrouped into 11 mega projects. An ad-hoc research scheme on 'Collection, conservation and cataloguing of genetic resources of *Piper nigrum* and related species' is also in progress since November 1985. At various centres under the AICSIP about 50 experiments on different spice crops are in progress.

This being the first annual report of the National Research Centre for Spices, after it became independent from CPCRI, the important research accomplishments of the Research Centre during the past decade (1975–'85) of its existence are given below.

RESEARCH ACCOMPLISHMENTS

Crop improvement

i) *Collection, conservation, evaluation and cataloguing of genetic resources in spices*

The urgent need to collect and catalogue indigenous germplasm in black pepper, cardamom, ginger, turmeric and tree spices has been realised. Accordingly systematic surveys for genetic resources in these crops was initiated from 1976 onwards. At present the NRCS maintains a live herbarium in spices which is perhaps the largest in the world.

Germplasm accessions in spices at NRCS

Crop	Location	Exotic	Indige-nous	Wild	Total
Black pepper *(Piper nigrum)*	Calicut	2	236	78	316
Cardamom *(Elettaria cardamomum)*	Appangala	–	221	–	221
Related species of cardamom	Appangala	–	13	–	13
Ginger *(Zingiber officinale)*	Calicut	4	113	3	120
Turmeric *(Curcuma longa* and *C. aromatica)*	Calicut	6	166	12	184
Nutmeg *(Myristica fragrans, M. beddomei* and *M. malabarica)*	Calicut	–	301	2	303
Clove *(Eugenia caryophyllus)*	Calicut	2	150	–	152
Cinnamon *(Cinnamomum verum, C. malabathrum* and *C. aromaticum)*	Calicut	14	152	4	170

The present collections available in different crops have been assembled through exchange programmes and random surveys within India. The germplasm in black pepper, ginger and turmeric fairly represent all the available genetic resources within the country and outside. However, in tree spices expect for cinnamon, the genetic variability collected so far is very narrow and there is an urgent need to introduce materials from the centres of origin.

ii) *Breeding for yield*

In order to select uniform and high yielding genotypes within popular cultivars of black pepper, a secondary selection programme has been initiated for yield in Karimunda and Kottanadan.

In cardamom, clones giving high yield and quality capsules have been identified at Mudigere, Pampadumpara and Appangala and are being multiplied.

Based on the comparative yield trial of 85 accessions of ginger, some of the high yielding cultivars such as Karakkal (22.5 t per ha) and Bahreica (23.5 t per ha) have been identified in addition to the already established varieties like Maran, Rio de Janeiro and Nadia.

In turmeric, among the 174 indigenous and 6 exotic types, 9 accessions were selected based on a preliminary evaluation and were compared for their yield in a multilocation trial for three years. Among them, PCT-8 with an yield potential of 43.5 t of green rhizome per ha and curcumin content of 8.7% has been recommended for release recently.

In ginger and turmeric, crop breeding programmes are hampered by the absence of seed set. In ginger, cytological studies indicated chromosomal sterility. However, biometrical methods to predict the final yield based on certain morphological characters have been worked out.

In nutmeg, evaluation of mother trees based on number of nuts and weight of mace per tree have been completed and elite mother trees identified. The scions from these are being maintained.

iii) *Breeding for disease and pest resistance*

In order to identify resistant/tolerant genotypes, all the accessions of black pepper and seedling progenies obtained from open pollinated and irradiated seeds and hybrids are being screened against *Phytophthora*, nematodes and 'pollu' beetle. Seven genotypes tolerant to *Phytophthora* and one resistant to *Meloidogyne incognita* have been identified and are under field evaluation. Among the tolerant lines identified in seedling progenies, 22 are under field evaluation. Further programmes are aimed at evolving and isolating multiple resistant lines to this major disease and pests.

Mutation breeding programmes in cardamom initiated at Appangala helped to isolate 12 seedlings resistant/tolerant to 'katte' virus and are under multiplication.

In ginger, clonal propagation through tissue culture has been initated and studies are in progress for *in vitro* screening for resistance to *Pythium* and *Pseudomonas*.

iv) *Breeding for quality*

Evaluation of quality of spices is one of the major programmes of the Research Centre aimed to evolve quality based cultivars. In black pepper, over 60 cultivars have been evaluated for their quality components viz., oleoresins, piperine, volatile oil and starch content. Most of the cultivars have 3–6% essential oil, the maximum being in Thommankodi with 5.98%. Oleoresin percentage ranged from 5.5–17.28%, the maximum being in Kottanadan followed by Aimpirian with 15.7%. Piperine content ranged from 1.86% in Narayakodi to 7.6% in Kumbhakodi and 7.58% in Kottanadan.

Analysis of quality of 184 turmeric accessions revealed that curcumin content was highest in Edapalayam (10.9%); CV. Kahikuchi had the highest oil content (9.6%) and CV. Amrithapani the highest oleoresin content (19.8%).

Gas chromatographic analysis of essential oils of ginger and turmeric were carried out and 19 and 14 compounds respectively, were obtained. Out of these. 14 compounds in ginger and 8 compounds in turmeric were identified.

A comparative study on quality aspects of Indian and Sri Lankan accessions of cinnamon showed that they contained a range of 0.72-2.73% and 0.82-3.85% of leaf oil, 1.14-3.0% and 0.31-3.56% of bark oil and 1.21-17.05% and 2.62-12.45% oleoresins, respectively. Ten lines selected for their high quality parameters are now under field evaluation.

Crop management

A rapid multiplication method in black pepper has been developed to facilitate the distribution of planting materials to the farmers in the shortest time.

A comparison of different standards for black pepper indicated that its yield can be increased by 100 per cent by trailing them on non living standards like RCC and granite posts. However, overhead shade is essential for the optimum growth of vines. Application of phosphorus as mussoriephos at 80 g P_2O_5 per vine per year was found to be superior based on availability in soil and yield responses.

A ratio method of estimation using a visual scoring for yield as ancillary variable, was evolved to enable yield estimation of black pepper gardens with increased precision for a given cost. The method is nearly four times more efficient than simple average estimation.

Use of neem cake (200 kg per ha) increased the nutrient availability in soils, reduced rhizome rot disease and increased the yield of ginger.

In nutmeg, vegetative propagation method by epicotyl grafting was found to be highly successful and is being used for quick multiplication of planting material.

Crop protection

Phytophthora palmivora 'MF-4' (morphological form 4) has been identified as the causal agent of quick wilt disease of black pepper. A stem inoculation technique has been developed to assess the relative degree of resistance/tolerance of black pepper cultivars to *Phytophthora*. A technique of root inoculation with zoospores has been developed for mass screening of black pepper seedling progenies. A positive correlation of disease incidence with total rainfall, higher RH (91-99%) and

lower ambient (19-23°C) and soil temperatures (20-23°C) has been established. Metalaxyl (Ridomil - Ziram) a systemic fungicide, both as foliar spray and as soil drench gave effective control of *Phytophthora* infections. Soil application of Ridomil 5 G granules (20 g per vine) was equally effective in checking the disease. A survey conducted in Calicut district for three years showed an annual loss of 1.68 lakh black pepper vines due to quick wilt disease and the consequent yield loss was 120 t of black pepper.

'Katte' virus of cardamom has been identified as the one that belongs to poty 'Y' virus group. Yield loss due to 'katte' was 38 per cent during the first year of disease incidence and 62 and 68 per cent one and two years after infection, respectively. Eradication of 'katte' disease affected clumps reduced the disease spread. Based on detailed studies on epidemiology and virus-vector relationships an effective disease management programme has been formulated.

Cylindrocladium quinquiseptatum has been reported for the first time in India as the causal agent of leaf rot of clove.

Surveys carried out in major black pepper growing tracts of Kerala indicated that the root system of slow wilt affected vines showed varying intensities of infestation by three plant parasitic nematodes viz., *Radopholus similis, Meloidogyne incognita* and *Trophotylenchulus piperis*. *Trophotylenchulus* has been reported for the first time in India and also on black pepper. A new species *T. piperis* has been erected. Studies conducted so far clearly showed that *R. similis* could reproduce a majority of the symptoms of slow wilt disease. The infestation of this nematode in black pepper vines was severe in Cannanore, Calicut and Idukki districts and its population was maximum during September-October. In slow wilt affected gardens, both soils as well as tissues of affected plants were low for nitrogen and potash contents. Application of phorate 10 G (3 g ai per vine) twice a year reduced the nematode population.

'Pollu' beetle *(Longitarsus nigripennis)* is the most serious pest, causing about 40 per cent loss of black pepper berries. A positive and significant correlation existed between rainfall and population density of 'pollu' beetle and a significant negative correlation between temperature and population. Shade intensity had a positive influence on pest incidence. The insect attacks leaves, growing tips, emerging spikes and berries. Spraying endosulfan or quinalphos (0.05% each) during July and October can effectively control 'pollu' beetle. This spray will also take care of top shoot borer incidence. A GLC meothod for the estimation of residues of endosulfan in black pepper has been standardised.

Infestation of ginger by shoot borer *(Dichocrocis punctiferalis)* was found to cause a significant yield loss when damage to pseudostems exceeded 50 per cent. Malathion (0.1%) was found effective in controlling the shoot borer of ginger. A sequential sampling plan has been evolved to monitor the pest population in the field as guidance for undertaking control measures.

Transfer of technology

A High Production Technology in black pepper is being demonstrated in fifty one holdings comprising of 13,400 vines in Calicut district. A High Production Technology for cardamom has been evolved and is also being implemented in selected plantations through the Cardamom Board. Forty families at Chelavoor and 60 families at Peruvannamuzhi have been adopted by the Research Centre as a part of the Lab to Land programme and all the necessary inputs and technology for improving the economic status of the families are provided. Training programmes to extension officials on spice production technology are being conducted every year. Extension literature on various crop production programmes is being published periodically.

RESEARCH HIGHLIGHTS 1986

The salient features of research results obtained in various on going research projects on spices for 1986 are given below.

Black pepper

Surveys were organised to collect black pepper germplasm in Kerala, Karnataka, Tamil Nadu, Assam and Meghalaya. A total of 80 collections of cultivars and 194 collections representing different wild *Piper* spp. were made from these areas out of which 17 are from Miker hills of Assam and Khasi hills of Meghalaya. Based on studies of herbarium of *Piper* spp. available at the Research Centre, two new taxa were recorded and were reported as *Piper silentvalleyensis* and *Piper nigrum* var *hirtellosum.*

A new comparative yield trial consisting of six selections from Pepper Research Station, Panniyur, three intercultivar hybrid lines, four cultivars tolerant to *Phytophthora*, one nematode tolerant line and six cultivars was initiated. Over 400 intercultivar hybrid lines were being multiplied for screening against *Phytophthora* and nematodes.

In the spacing trial, both Panniyur-I and Karimunda planted at a spacing of 2.5 × 2.5 m gave the highest yields of 734.1 g and 757.6 g per vine, respectively, whereas Aimpirian gave the highest yield at a spacing of 2.5 × 1.5 m (199.5 g per vine).

Studies conducted on different methods of drying of black pepper showed that blanching slightly reduced the quantity of essential oils and oleoresin compared to sundrying. Both blanching and sundrying were found to improve the appearance of the product. Fifty one Karimunda selections were evaluated for chemical quality. Piperine, essential oil and oleoresin contents ranged from 5.44–7.13%, 5–9% and 7.22–14.38%, respectively.

Studies on the epidemiology of *Phytophthora* leaf infection in black pepper indicated a positive correlation with rainfall, relative humidity and number of rainy days and a negative correlation with sunshine hours and temperature. About 26,750 seedling progenies raised from open pollinated seeds of 18 cultivars and irradiated seeds of six cultivars were screened for tolerance/resistance to *P. palmivora*. Of them, 435 seedlings did not take up infection. Out of 70 hybrid lines screened, one was found tolerant. Fifteen tolerant lines from cultivars and hybrids and 15 promising cultivars were planted in a garden where severe infection of *P. palmivora* was noticed earlier. Field control trials conducted for three years conclusively showed the efficacy of the systemic fungicide metalaxyl (Ridomil-Ziram) in controlling quick wilt disease. Studies on *in vitro* compatibility of this fungicide with the insecticides endosulfan and quinalphos showed a compatible reaction and the insecticides were found to have a fungitoxic effect on the growth and sporulation of *P. palmivora*.

A survey conducted in Kerala and Karnataka indicated the positive role of *Radopholus similis* in causing slow wilt disease. This was further confirmed by pathogenicity studies conducted under simulated field conditions. None of the varieties, cultivars and open pollinated seedling progenies showed resistance to *R. similis*. Application of phorate 10 G (3 g a i per vine) once during May-June and again during September-October was effective in controlling the disease.

Larvae of *Lestodiplosis* sp. (Cecidomyiidae) were recorded for the first time to be predacious on the juvenile stages of leaf gall thrips *Liothrips karnyi*.

Cardamom

Two more collections were added to the existing germplasm at Appangala. Accession no. 20 gave the maximum yield of 261.9 g of green capsules per clump. Fifty six clonal materials of 'katte' escapes were collected from Uttara Kannada and Chikmagalur districts. Out of 297 M_2 seedlings screened, 158 did not contract 'katte' disease.

Evaluation of quality of popular cardamom varieties showed that 'Valayar' contained the highest quantity of essential oil (8.3% V/W) followed by 'Mysore' (8.0%). Among the 34 accessions evaluated, accession no. 37 contained 10% (V/W) essential oil followed by accession nos. 49 and 5 (9%).

Studies on the interaction of *Pythium* sp. and the nematode *Meloidogyne incognita* in rhizome rot showed that the fungus alone could cause 100 per cent infection and the severity of the disease did not increase in nematode-fungus combinations.

Ginger

In tissue culture, callus formation was observed when tender explants and vegetative buds were cultured in MS basal medium supplemented with 0.2 mg/l kinetin, 0.24 mg/l NAA and 0.16 mg/l 2,4-D. The vegetative buds developed into plantlets when cultured in MS medium supplemented with 0.2 mg/l of NAA, 1 mg/l of kinetin and 0.2 mg/l of BAP.

Evaluation of quality of 14 cultivars at different maturity periods indicated that dry recovery, starch and fibre contents increased with maturity. Correlation matrix between different quality parameters was worked out and based on this, the cultivars Maran, Ernad Chernad, Rio de Janeiro, Nadia and Karakkal were superior for yield, essential oils and oleoresin.

Seed treatment with Apron 35 SD (1g ai per kg of rhizome) was effective in controlling rhizome rot caused by *Pythium aphanidermatum* in pot culture experiments.

Pot culture studies conducted to assess the role of *Mimegralla coeruleifrons* in the incidence of rhizome rot conclusively proved that *Pythium* sp. is the causal agent for the disease and the maggots are secondary saprophytic feeders.

Turmeric

The high yielding turmeric selection PCT-8 with an yield potential of 43.5 t of green rhizomes per ha and a curcumin content of 8.7% has been released as 'Suvarna' and the seed materials of the same were supplied to State Seed Farms and Agricultural Universities of Andhra Pradesh, Tamil Nadu and Kerala for further multiplication and distribution.

Tree spices

A field experiment was initiated to evaluate the performance of epicotyl grafts of nutmeg produced with scions collected from six high yielding trees. One hundred and eighty seedlings from elite lines of cinnamon were planted for evaluating their yield. About 2800 clove seedlings were raised during the year for distribution.

PROJECTS IN PROGRESS

1. 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 and incidence of quick wilt were monitored at Peruvannamuzhi (Calicut district), Kannara (Trichur district) and Chemberi (Cannanore district). At Peruvannamuzhi, infection of runner shoots by *Phytophthora palmivora* was noticed during the last week of July. The infected shoots were removed to check the further spread of the disease. At Kannara, the foliar infection was noticed during the third week of June but its severity was less compared to that during 1984 and 1985. The incidence of the disease was recorded at weekly intervals at Kannara. Analysis of the data indicated a positive correlation between rainfall, relative humidity and disease incidence. A negative correlation was found between temperature, sunshine hours and disease incidence.

In the trial to study the effect of age of the host plant on infection, the fifth batch of 20 black pepper cuttings was planted in cement tubs installed in the field at Peruvannamuzhi.

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

(YR Sarma, M Anandaraj and N Ramachandran)

About 5500 seedlings raised from open pollinated (OP) seeds of 18 cultivars were screened adopting root inoculation technique. Twenty five seedlings which did not take up infection have been transplanted into separate bags and will be further tested. M-2 seedling progenies (15,250) of Panniyur-1 raised from seeds irradiated at 500, 1000, 1500 and 2000 r were screened using root inoculation technique. About 210 seedlings that did not take up the infection will be tested further. No specific indication was noticed on infection in relation to various doses of radiation. Six thousand M-1 seedlings raised from irradiated seeds of cultivars Panniyur-I, Karimunda, Narayakodi, Kalluvally, Balankotta and Aimpirian were screened and 200 of them did not take up

infection. All the 11 Kottanadan selections obtained from Palode were susceptible. Of the 70 hybrid lines screened, one (No. 119-81-4) gave a tolerant reaction. All the 20 cultivars screened were susceptible.

A cultivar from Thottilpalam (Calicut district) which was reported to be surviving inspite of severe disease incidence in the area was collected. A few vines surviving in severely disease affected gardens at Czuali and Koralai (Cannanore district) were located.

Fifteen tolerant lines from cultivars (OP) and hybrids along with 15 promising cultivars have been planted for field evaluation (eight cuttings per type) at Sirsi (Uttara Kannada district) in an areca-pepper mixed plantation, a hot spot area for quick wilt.

Preliminary studies on growth *in vitro* of 10 isolates of *Phytophthora palmivora* showed considerable variation. These isolates were inoculated on excised leaves of cultivar Karimunda to study their pathogenic variability. However, the results were not consistent.

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

(N Ramachandran, YR Sarma and M Anandaraj)

Field experiments to control quick wilt were continued for the third consecutive year at Thiruvambady (Calicut district) and Kannara. Application of three systemic fungicides viz., Ridomil, Aliette and Terrazole and Bordeaux mixture was undertaken in the first fortnights of June and September. Ten plants each of four replications at Kannara and six replications at Thiruvambady were maintained for each treatment. The incidence and intensity of disease were recorded at weekly intervals at Kannara, where foliar infection was noticed this year also although to a lesser extent. At Thiruvambady, where only collar infection was noticed the death of the vines was recorded (Table 1).

Table 1. *Efficacy of systemic fungicides in the control of quick will of black pepper*

Location	Treatments				
	Ridomil	Aliette	Terrazole	Bordeaux mixture	Control
Kannara	5.0	10.0	30.0	20.0	27.5
Thiruvambady	1.6	10.0	11.6	13.3	20.0

Values indicate cumulative vine death (%) during 1934-'83

A new experiment was started using a granular formulation of Ridomil and Bordeaux mixture in a severely disease affected garden at Chemberi. Ridomil 5 G granules were applied at two doses (10 and 20 g per vine) during June and the incidence of foliar infection was recorded at fortnightly intervals (Table 2).

Table 2. *Efficacy of Ridomil 5 G granules in the control of quick wilt of black pepper*

Treatments	Vine death (%)
Ridomil 10 g/vine	13.3
Ridomil 20 g/vine	6.6
Bordeaux mixture	30.0
Control	40.0

The compatibility of Ridomil with two insecticides viz., endosulfan and quinalphos, which are commonly used against 'pollu' beetle in black pepper was studied. The insecticides were toxic to *Phytophthora palmivora* both *in vitro* and *in vivo*. Using their fungitoxicity, interaction ratios were worked out taking different ratios of binary mixtures of fungicies and insecticides; both the insecticides were found to be compatible with Ridomil.

The effect of undergrowth of grass and *Mimosa* sp. on the incidence of quick wilt was studied at Chemberi. The incidence of the disease was less in plots with undisturbed undergrowth (Table 3).

Table 3. *Effect of undergrowth (grass and* Mimosa *sp.) on the incidence of quick wilt of black pepper*

Treatments	No. of plants observed	Vine death (%)
With undergrowth		
Block A	94	4.2
Block B	56	8.9
Without undergrowth		
Block A	89	10.1
Block B	88	13.6

Nema II. 1 (813). Role of nematodes in the incidence of slow wilt disease of black pepper
Survey and screening of black pepper germplasm against root-knot and burrowing nematodes
(KV Ramana and C Mohandas)

1. Survey on plant parasitic nematodes associated with black pepper

Thirty each of soil and root samples collected from 16 gardens in Dakshina Kannada district were analysed for plant parasitic nematodes. The percentage of gardens infested with *Meloidogyne incognita*, *Radopholus similis* and *Trophotylenchulus piperis* was 87.5, 75.0 and 43.7 respectively. Forty eight each of soil and root samples from 24 gardens in Uttara Kannada district were collected and processed for identifying plant parasitic nematodes.

2. Screening of black pepper germplasm

a. Against *M. incognita*

A total of 120 intercultivar hybrids and 1000 open pollinated seedlings of various cultivars were inoculated with *M. incognita* for testing their reaction to the nematode. None of the open pollinated seedlings showed a tolerant reaction. The intercultivar hybrids are being maintained for recording the final observation.

b. Against *R. similis*

Fifty Karimunda selections and 1000 open pollinated seedlings of various cultivars were inoculated with *R. similis* for testing their reaction to the nematode. All the open pollinated seedlings were susceptible. The Karimunda selections are being maintained for recording the final observation.

Two experiments were initiated to standardise a technique for screening the germplasm against *R. similis*. In Experiment I, the effect of different inoculum levels of *R. similis* at different time intervals after inoculation was studied. Single node rooted cuttings of Panniyur-I were planted in polythene bags containing 1.5 kg fumigated soil. Two months after planting they were inoculated with a pure culture of *R. similis* at the rate of 10,50,150 and 250 nematodes per plant in four replications along with uninoculated controls. Growth parameters and root lesion indices were recorded 2,3,4,5 and 6 months after inoculation. Root lesion index progressively increased with the increase in initial inoculum and time of recording. The maximum root lesion index (4.5) was recorded 6 months after inoculation at the highest level of inoculum. More than 70 per cent reduction in the root weight

over control was recorded in plants inoculated with 50, 150 and 250 nematodes per plant 6 months after inoculation. The study indicated that an inoculum level of 250 nematodes per plant and recording root lesion index at 6 months after inoculation was optimum for screening the germplasm for reaction to *R. similis*.

In Experiment II, the relative susceptibility of black pepper to *R similis* in relation to the age of the vine was studied. The first batch of 10 single node rooted cuttings of Panniyur-I (2 months old) was planted in cement tubs (one cutting per tub) containing soil mixture sterilised with 2% formalin.

Nema II. 2 (813). Role of nematodes in the incidence of slow wilt disease of black pepper
Population fluctuations and pathogenicity of root-knot and burrowing nematodes

(C Mohandas and KV Ramana)

1. Pathogenicity experiment

a. Inoculation with *Radopholus similis* alone

Growth characteristics such as number of primary branches and disease symptoms such as foliar yellowing and defoliation were recorded on the experimental vines. Vines inoculated with 1000 or more *R. similis* showed yellowing even 4 months after inoculation. During the year foliar yellowing and defoliation further progressed and a few vines showed wilting. Inoculated vines had a few branches at base, compared to control. There was remission in the yellowing symptoms after the onset of monsoon during July (Table 4).

Table 4. *Effect of* **Radopholus similis** *on foliar yellowing in black pepper*

Period of observation	Treatments				
	T_1	T_2	T_3	T_4	T_5
November 1985	0	0.0	0.4	1.1	0.9
February 1986	0	0.6	0.7	1.1	1.1
July 1986	0	0.1	0.3	0.7	0.4
November 1986	0	0.4	1.4	1.6	1.6
January 1987	0	0.3	1.3	1.9	1.7

T_1 = control; T_2 = 10 nematodes/vine; T_3 = 100 nematodes/vine; T_4 = 1000 nematodes/vine; T_5 = 10,000 nematodes/vine

Yellowing is measured on a scale of 0-3 where 0=no yellowing; 1=mild yellowing; 2=50 per cent yellowing; 3= completely yellow

Table 5. *Effect of* **Radopholus similis** *and* **Meloidogyne incognita** *on foliar yellowing in black pepper*

Period of observation	Treatments										
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}
November 1985	0	0.0	1.0	0.5	0.8	0.8	0.5	1.0	0.3	0.0	0.5
February 1986	0	0.0	1.3	0.8	1.0	0.8	1.0	1.3	0.7	0.0	1.0
July 1986	0	0.3	1.3	0.2	0.8	0.3	0.5	0.3	0.5	0.2	0.3
November 1986	0	0.2	1.2	0.5	0.8	1.0	1.0	0.5	0.7	0.0	0.7
January 1987	0	0.0	2.0	1.0	1.3	1.3	1.5	0.7	1.2	0.0	0.7

T_1 = control; T_2 = *M. incognita* 1000/vine; T_3 = *R. similis* 1000/vine; T_4 = *M. incognita* 500/vine + *R. similis* 500/vine; T_5 = *M. incogniat Similis* 500/vine 20 days after; T_6 = *M. incognita* 1000/vine ; *R. similis* 1000/vine, 20 days after; T_7 = *M. incognita* 500/vine + *R. incognita* 500/vine, 20 days after; T_8 = *R. similis* 1000/vine + *M. incognita* 1000/vine, 20 days after; T_9 = *R. similis* 500/vine + *M. incognita* 500/vine; T_{10} = *M. incognita* 500/vine; T_{11} = *R. similis* 500/vine

b. Inoculation with *R. similis* and *Meloidogyne incognita*

Vines inoculated with *R. similis* alone or in different combinations with *M. incognita* developed foliar yellowing (Table 5) and defoliation; there was also considerable reduction in number of primary branches. Vines inoculated with *M. incognita* did not exhibit marked yellowing, defoliation or reduction in number of primary branches.

The two experiments indicate that *R. similis* alone could produce the symptoms of slow wilt in black pepper.

c. Inoculation with *M. incognita* **alone**

Recording of disease symptoms on the experimental vines indicated that yellowing (Table 6) and defoliation were marked in vines which received higher inoculum levels (10,000 and 100,000 nematodes). Three vines which received an inoculum level of 10,000 nematodes succumbed during the year.

Table 6. *Effect of* **Meloidogyne incognita** *on foliar yellowing in black pepper*

Period of observation		Treatments				
		T_1	T_2	T_3	T_4	T_5
July	1985	0	0.3	0.6	2.0	1.9
February	1986	0	0.6	0.9	2.1	1.4
May	1986	0	0.3	1.0	2.4	2.0
July	1986	0	0.6	0.7	2.3	1.1
November	1986	0	0.4	0.6	2.4	1.6
January	1987	0	0.3	0.6	2.4	1.3

T_1 = control; T_2 = 100 nematodes/vine; T_3 = 1000 nematodes/vine; T_4 = 10,000 nematodes/vine; T_5 = 100,000 nematodes/vine

The results indicate that *M. incognita* when inoculated on very young vines can reduce the growth and vigour and cause yellowing and defoliation and even mortality at higher levels of inoculum.

2. Control

a. Nematicidal trial

The results of the experiment conducted at Vittal indicated that application of Thimet at 3 g ai per vine was superior to all other treatments in controlling slow wilt. The number of diseased vines which recovered after the application of the nematicide was maximum in this treatment. Application of Bavistin alone or in combination with Thimet was not effective.

b. Effect of antagonistic plants

Black pepper seedlings and antagonistic plants viz., *Zinnia* sp. and *Tagetes* sp. were raised together in pots. After a month a set of four plants was inoculated with *R. similis* and another set kept free of nematodes. Root lesion index taken four months after inoculation indicated that the antagonistic plants had no effect on the infestation and multiplication of *R. similis* on black pepper. Similar experiments conducted with *M. incognita* indicated that the root-knot index was reduced when black pepper and *Tagetes* sp. were raised together (Table 7).

Table 7. *Effect of antagonistic plants on root-knot index in black pepper caused by* **Meloidogyne incognita**

Treatments	Root-knot index
M. incognita	3.5
M. incognita + *Zinnia* sp.	3.5
M. incognita + *Tagetes* sp.	2.8
Zinnia sp.	0.0
Tagetes sp.	0.0
Control	0.0

Table 8. *Seasonal fluctuation in population* of* **Radopholous similis** *in black pepper*

Month	Year		
	1983	1984	1985
January	650	420	787
February	492	225	612
March	325	285	370
April	125	65	82
May	60	25	62
June	162	275	163
July	210	400	229
August	463	172	233
September	712	985	908
October	805	602	710
November	625	555	687
December	600	712	770

* In per gram of root

3. Population dynamics of *R. similis*

The population dynamics of *R. similis* was studied for a period of three years (1983-'85) at Koothali (Calicut district). Maximum number of *R. similis* recorded was 3750 per gram of root. The nematode population was minimum during April and May and maximum during September and October (Table 8). The occurrence of high and low nematode populations during a particular season appears to be influenced by rainfall. During 1983 there was no rain from January to March and maximum rainfall occurred in August. The nematode population during this year reached its peak during October. During 1984 and 1985 there was isolated rain during January to May and maximum rainfall occurred during June. The peak nematode population during these years occurred during September.

Rainfall probably has an indirect effect on the increase in the nematode population by reducing the soil temperature and helping the host plant to put forth new roots, which provide more feeding sites for nematodes. Rainfall also increases soil moisture which helps the nematodes to migrate from infested roots to healthy roots through water films in between soil particles.

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, K Nirmal Babu, MK Nair and AAM Syed)

Surveys were organised in Wynad, Central and South Kerala and Coorg areas for the collection of cultivated germplasm; 72 collections were made from these areas (Table 9). Collection of wild black pepper was made from Begur, Thirunelli, Naduvattom, Gudalur and Gudalur-Wynad border, Silent Valley and Nelliampathy areas of Kerala and Tamil Nadu and Bhagamandala and Virajpet areas of Karnataka; 177 collections comprising of nine species were made during these trips. The Khasi hills of Meghalaya and Miker hills of Assam were surveyed and 17 collections were made (Table 10).

Studies were conducted on the herbarium of *Piper* spp. collected so far. Two new taxa were recorded and these are being reported as *Piper silentvalleyensis* sp nov and *P. nigrum* var *hirtellosum* var nov. The former is a bisexual species having erect flexuous spikes and minute pungent berries. The latter differs from *P. nigrum* in having hirtellous spikes.

Sixty new accessions were planted in the field. The accessions that flowered this year were described using a minimum descriptor. The germplasm collection (400 nos) was also maintained in the nursery. Cuttings were supplied to Pathology, Nematology and Entomology Sections for screening against pests and diseases.

At Peechi, most of the 100 accessions in the germplasm started bearing. During the 1985-'86 season (1st years' harvest) the highest yield was recorded in Coll. 865 (Bilimalligesara)-4.816 kg green berries per vine followed by Coll.812 (T-L.Ottaplackal)-2.975 kg. Longest spike was recorded in Coll. 1080 (unnamed collection). Maximum number of berries was recorded in Coll. 865 ard maximum berry weight in Panniyur-I.

Table 9. *Collection of black pepper germplasm (cultivated)*

Areas	No. of collections	Important cultivars collected
Wynad district	18	Cheppukulamundi, Nedesankodi, Cheruvally, Jeerakamundi, Kalluvally
Trivandrum and Quilon districts	26	Murithothan, Karuvilanchi, Chinkupazhuppan, Kuthiravally, Kumbhanadan, Vellaramundi, Rannichola
Coorg district	22	Arikotta, Vadakkan, Pirimunda, Valiakarimunda, Arimulaku, Kallubalancotta
Thottilpalam (Calicut district)	5	Unnamed local
Meghalaya	3	Unnamed local
Panniyur	6	Selections received from Pepper Research Station

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

(MJ Ratnambal, K Nirmal Babu and PS Ravindran)

1. Ginger

In the evaluation trial the yield was low due to incidence of soft rot and bacterial wilt. In the multiplication plot the cultivar Maran gave the highest yield (10.7 kg per 3 sq m bed).

Sixty four accessions were received from High Altitude Research Station, Pottangi (Orissa), 25 from NEH Region and two from Andhra Pradesh. A total of 165 accessions were planted.

In tissue culture, callus formation was noticed when tender explants and tender vegetative buds were cultured in MS basal medium supplemented with 0.2 mg/l kinetin, 0.24 mg/l NAA and 0.16 mg/l 2,4-D. Vegetative buds developed into plantlets when cultured in MS medium supplemented with 0.2 mg/l of NAA, 1 mg/l of kinetin and 0.2 mg/l of BAP. The lateral buds got activated and developed into complete clonal plantlets after 30 days of sub-culturing. When the clonal plantlets were sub-cultured in MS liquid medium with 0.8 mg/l NAA,

0.6 mg/l kinetin and 0.2 mg/l of BAP, the formation of well developed root system and proliferation of tillers (upto five numbers) were noticed.

Quality analysis of 14 cultivars at different maturity periods (150, 180, 210 and 240 days after planting) showed that dry recovery, starch and fibre contents increased with maturity. Dry recovery was maximum (22.2 %) in Nadia. Starch content was maximum (49.7 %) in Karakkal. The fibre content at full maturity varied from 4.85 (Jamaica) to 6.9 % (Sleeva Local). At 150 th day, maximum essential oil content (4.0 %), was noticed in Ernad Chernad and highest oleoresin content (10.4 %) in Vengara selection. The percentage of gingerol, the pungent principle of oleoresin, varied from 9.10 in Vengara selection to 28.05 % in Jugijan at different maturation periods. Protein content was maximum at 180th day in almost all the cultivars, the maximum being 14.81% in Vengara selection and thereafter decreased rapidly by 210th day and then stabilized.

Table 10. *Collection of black pepper germplasm (wild* **Piper** *spp.)*

Areas	No. of collections	Species collected
Tholpetti range, Thirunelli forest and Wynad ghats	23	*P. attenuatum, P. argyrophyllum, P. galeatum, P. hymenophyllum, P. nigrum* and *P. trichostachyon*
Bhagamandala and Virajpet ghats	18	*P. attenuatum, P. mullesua, P. argyrophyllum, P. trichostachyon,* and *P. nigrum*
Silent Valley	50	*P. attenuatum, P. argyrophyllum, P. hymenophyllum, P. mullesua, P. trichostachyon, P. nigrum* and *P. nigrum* var *hirtellosum*
Thirunelli, Naduvattom, Gudalur and Nilambur	50	*P. schemidtii, P. galeatum, P. longum, P. nigrum, P. attenuatum, P. argyrophyllum, P. hymenophyllum and P. mullesua*
Nelliampathy	36	*P. attenuatum, P. galeatum, P. nigrum, P. argyrophyllum, P. mullesua* and *P. trichostachyon*
Khasi hills (Meghalaya) and Mikir hills (Assam)	17	*P. nigrum, P. betel, P. longum* and few other *Piper* spp.

Table 11. *Correlation matrix in ginger*

	Maturity	Dry recovery	Essential oil	Oleoresin	Gingerol	Starch	Protein	Fibre
Maturity	I	0.8907**	-0.8134**	-0.3515**	0.2699	0.8868**	-0.7083**	0.8668**
Dry recovery		I	-0.7238**	-0.3901**	0.3412*	0.8128**	-0.6940**	0.8305**
Essential oil			I	0.4045**	-0.3249*	-0.6903**	0.6254**	-0.7119**
Oleoresin				I	-0.3835**	-0.1046	0.2743*	-0.3821**
Gingerol					I	0.1365	-0.2613	0.2276
Starch						I	-0.6495**	0.7710**
Protein							I	-0.5997**
Fibre								I

* Significant at 5% level
** Significant at 1% level

Correlation matrix between different quality parameters were worked out (Table 11). The analysis showed that with the advent of maturity the percentage of dry recovery and starch and crude fibre content increased and the correlation between percentage dry recovery and starch and crude fibre was statistically significant. The levels of essential oil, oleoresin and protein content decreased significantly as maturity progressed. Dry recovery was negatively correlated with essential oil, oleoresin and protein contents indicating the loss of volatiles and proteinaceous components during rhizome development. Essential oil was positively correlated with starch because the starch build up during maturation evidently reduces the essential oil levels. Oleoresin was negatively correlated to gingerol and starch was negatively correlated with protein. The study also indicated that for yield of rhizome as well as for essential oils and oleoresin, the cultivars Maran, Ernad Chernad, Rio de Janeiro, Nadia and Karakkal were superior among the 14 cultivars studied.

2. Turmeric

At Peruvannamuzhi, maximum yield was observed in Cls. No. 5B (19.2 kg per 3 sq m bed) followed by Cls. No. 4 (16.5 kg) among *longa* types. Among *aromatica* types, the cultivar Kasturi yielded the maximum (12.1 kg) followed by GL. Puram I (11.9 kg). Among the related species of *Curcuma*, a maximum yield of 21.6 kg was recorded in *C. amada*. At Palode, *Cll 316 Gorakpur yielded the maximum (10.0kg).*

In the multilocation trial, maximum yield was recorded in PCT 13 (18.6 kg per 3 sq m bed) at Peruvannamuzhi and in PCT 11 (8.4 kg) at Palode. A new multilocation trial has been laid out with the inclusion of PCT 2 and PCT 5 at Peruvannamuzhi, Palode, Jagtial (Andhra Pradesh) and Goa.

One hundred and ninety three accessions including 18 from NEH region and one each from Tamil Nadu and Andhra Pradesh were planted at Peruvannamuzhi. At Palode, 113 accessions were planted.

Morphological characters like height and girth of pseudostems, number of tillers and leaves and length and breadth of last fully opened leaf were recorded in 73 accessions for cataloguing and description. Cataloguing was completed in 90 accessions.

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

(B Krishnamoorthy, AAM Syed and T John Zachariah)

1. Cinnamon

One hundred and eighty seedlings from elite lines were planted in the field in a RBD for evaluation of yield.

2. Nutmeg

A field trial with epicotyl grafts (produced with scions collected from six high yielding parent trees) was laid out in a RBD along with a seedling progeny as control. Nutmeg grafts were also planted at Chelavoor campus. About 8400 seedlings were raised for the production of epicotyl grafts. Grafting of nutmeg *in situ* was also attempted. In the nutmeg progeny trial, 64 plants have flowered so far, out of which 33 are males and 31 females. Attempts were made to evolve a chemical marker for easy identification of male and female plants at seedling stage.

A high variability in yield was observed among the 88 trees maintained at Kannara. Based on their yield they were categorised into three groups viz., high (> 1000 fruits — 5 nos), medium (500–1000 fruits — 10 nos) and low (< 500 fruits — 22 nos). The hundred seed weight varied from 402 to 1074 g, and the weight of mace per 100 fruits varied from 54 to 289 g.

3. Clove

About 2800 seedlings were raised from seeds collected from Nagercoil area. Ten more plants in the germplasm have flowered making the total number of plants flowered so far to 22. Twenty four seedlings from five parent trees of Kallar and Burliar were planted at Chelavoor.

4. Allspice

Rooting of allspice cuttings by polybag method using various growth regulators was attempted. However, the rooting was extremely poor.

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

(Thimmappiah and Regy Lukose)

Two collections viz., one with bold capsule and the other with trigonal capsule were made from Karnataka.

In the multilocation trial laid out during 1984 with seven entries and a control, the differences in yield were not significant between treatments. In the 24 entry trial, Vazhukka yielded 149.3 g green capsules per clump when compared to 95.0 g in control; however, the differences in yield were not significant between the treatments. The differences in yield, height, number of tillers and number of panicles were not significant in the six entry trial laid out during 1984. The maximum yield (223.0 g) was recorded in control. In the germplasm assemblage the yield was maximum in Acc. No. 20 (261.9 g).

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, AAM Syed, PS Ravindran and MJ Ratnambal)

A new comparative yield trial was laid out at Peruvannamuzhi consisting of six selections from Pepper Research Station, Panniyur, three inter-cultivar hybrid lines, four cultivars tolerant to *Phytopthora palmivora*, one nematode tolerant line, four promising cultivars and two popular cultivars. A similar trial planted at Peechi in 1985 was also maintained. A trial was laid out in a farmer's field at Sirsi, which is a hot spot area for quick wilt. In this trial, cultivars and inter-cultivar hybrids tolerant to *P. palmivora* and promising cultivars were planted in an areca-pepper garden (Refer Path II.2 (813).

Ripe seeds from Panniyur-I, Karimunda, Kalluvally, Narayakkodi and Aimpiriyan were irradiated at 1-4 kr with gamma rays and the seedlings were raised for screening against *P. palmivora* (Refer Path II. 2 (813).

Over 400 intercultivar hybrid lines were planted in the nursery for rapid multiplicalion. The earlier batch of hybrid lines were multiplied and given to Pathology and Nematology Sections for screening against quick wilt and nematodes. Forty four of these lines were planted in a preliminary evaluation plot. About 600 lines were transplanted to polybags for multiplication. The plants in the Karimunda selection trial planted in 1983 have started bearing. The highest yield was recorded in Sel. 96 (1.215 kg green berries per vine) followed by Sel. 63 (1.195 kg). Forty accessions of Karimunda were analysed for quality parameters.

The plants in the Kottanadan selection trial at Palode and the comparative yield trial and the preliminary yield trial at Peruvannamuzhi have come to flowering during the year.

Intercultivar hybridisation was continued and 800 spikes in various combinations were crossed. The crossing block was strengthened by the addition of nine more cultivars.

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

(Thimmappaiah and Regy Lukose)

Two clonal trials were laid out. In one of them, 40 selections from a Cl. 37 population and two controls were included. The selections were made from the Cl. 37 populations whose yields varied from 1.267 to 3.012 kg per clump. In another trial, selections from 16 ET along with 11 'katte' escapes, five hybrids, one extra bold mutant and eight controls were included.

Vegetative characters such as number of tillers, height of the tallest tiller, number of leaves and length and breadth of the median leaf were recorded in CYT's I, II and III. In CYT I, significant differences between treatments were found in the case of height of the tallest tiller, number of leaves and breadth of the median leaf. In CYT II, the differences in the number of tillers, height of the tallest tiller and length of the median leaf were significant. In CYT III, the differences in the height of the tallest tiller and length and breadth of the median leaf were significant.

Five out of 21 seedlings of PV type that were treated with chemical mutagens did not take up 'katte' disease. Out of 297 M-2 seedlings, 139 took up 'katte' infection after the first round of inoculation, the percentage of infection varying from 12.5 to 78.3. Fifty six clonal material of 'katte' escapes were collected from North Kanara and Chickmagalur districts and planted in the field.

IV. Rhizome rot of ginger and turmeric

(General leader : GN Dake)

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

(GN Dake and CKP Prasad)

1. Efficacy of metalaxyl (Apron 35 SD) as seed dresser in ginger against *Pythium* spp.

The seed ginger (cv. Maran) was treated with three rates of metalaxyl (Apron 35 SD) viz., 1, 2, and 3 g ai per kg rhizome. The rhizomes were moistened with water and the fungicide was added to them. The treated rhizomes were then dried under shade and sown in infested soil which was prepared by mixing with the mycelial suspension of *P. aphanidermatum* and small pieces of rhizomes. An untreated control was also maintained. In each treatment 60 bits were planted. Observations were recorded on germination and disease incidence (Table 12).

Table 12. *Effect of seed treatment with Apron 35 SD on germination and rhizome rot of ginger*

Treatments	Germination (%)	Disease incidence (%)
1 g ai/kg rhizome	100	0
2 g ai/kg rhizome	65	0
3 g ai/kg rhizome	15	0
Control	100	60

Seed treatment with Apron 35 SD @ 1 g ai per kg rhizome was effective in controlling rhizome rot caused by *P. aphanidermatum* in pot culture. However, the germination was delayed for 15-30 days in treated seed compared to untreated control. Examination of ungerminated treated seed rhizomes revealed that the buds of treated seed (2 and 3 g ai per kg) were damaged.

In vitro studies indicated that the growth of *P. aphanidermatum* was totally inhibited at 10 ppm concentration of Ridomil (technical grade) compaped to 37 mm growth in unamended cornmeal agar plates incubated at 23°C for 24 hr.

2. Fabrication and testing a device for Aerated Steam Treatment of ginger seed rhizomes

An unit for Aerated Steam Treatment was fabricated and ginger seed rhizomes (cv. Maran) were treated at 40, 45 and 50°C for 1, 1½ and 2 hrs of exposure. Two kg of seed ginger was used for each treatment and sown in five beds of 1 × 1 m size. The germination count was recorded on the 50th day after sowing (Table 13).

Table 13. *Effect of Aerated Steam Treatment on germination of seed ginger*

Temperature	Duration			
	1 hr	1½ hr	2 hr	Control
40°C	91.25	87.50	68.75	97.50
45°C	70.00	60.00	22.50	100.00
50°C	8.75	3.75	3.75	97.50

Values indicate percentage germination

Treatment at 40°C for 1 and 1½ hrs gave 91 and 88 per cent germination respectively. As the temperature and duration was increased the percentage of germination decreased.

Studies *in vitro* indicated that the growth of *P. aphanidermatum* was inhibited when it was subjected to 45°C whereas it ranged from 26 to 29 mm at 35°C. The inoculated culture plates were first subjected to these temperatures for 30 min and were then incubated at 25°C for 24 hr.

3. Standardization of screening technique against *Pseudomonas solanacearum*

Twenty four hour old cultures of *P. solanacearum* multiplied on Yeast Dextrose Carbonate (YDC) Agar were used as inoculum. The plants were inoculated with three levels viz., 0.8×10^9, 1.5×10^9 and 3.3×10^9 colony forming units (cfu) per ml of bacterial suspension. The inoculation was done by two methods viz., pricking the pseudostem and pouring 100 ml of bacterial suspension around it in each pot and pouring the bacterial suspension over the pseudostem at the base level of ligules. Four hours prior to inoculation the pots were watered to field capacity in order to distribute the inoculum uniformaly throughout the soil. The plants inoculated with 3.3×10^9 cfu per ml could produce the symptoms after 20–22 days irrespective of the method of inoculation.

4. Screening of germplasm against bacterial wilt of ginger

The seed ginger of four cultivars (Maran, Himachal Pradesh, Nadan and Rio de Janeiro) and four wild types (Indonesia, Tamaraserry,

Kanyakumari and Zerumpet) were multiplied for screening under artifical inoculation.

5. Multiplication of disease escapes

The disease escapes of ginger collected from wilt affected plots during 1985 were multiplied in fumigated soil for testing their reaction to *P. solanacearum.*

6. Studies on toxin production by *P. solanacearum*

One week old culture of *P. solanacearum* grown in YDC broth was centrifuged at 20,000 rpm for 10 min and the supernatant liquid was tested for toxicity on tomato cut-shoots. The cut-shoots of tomato seedlings were immersed in culture filtrate, sterile YDC broth (without inoculation) and sterile distilled water. The epinesty of leaves was observed only in cut-shoots immersed in culture filtrates.

7. Field control trials

a) Effect of seed treatment on rhizome rot of ginger

The seed was treated with Captan (0.2% ai), Captafol (0.2% ai), Dithane M-45 (0.3%) and hot water (at 42°C for 30 min); seed treated with streptocycline 200 ppm alone served as control. The treated material was sown in 3 × 1 m beds with three beds in each treatment replicated four times. Observations on germination and disease incidence were recorded (Table 14).

Table 14. *Effect of seed treatments on rhizome rot of ginger*

Treatment	Germination (%)	Disease incidence (%)
Captan	87.01	10.02
Captafol	85.74	3.32
Dithane M-45	94.91	7.86
Hot water	89.08	6.05
Control	95.15	3.84

There was no significant difference among the various treatments with respect to germination and disease incidence. No conclusion could be derived from the trial since the incidence of the disease was low in the control plots. However, germination was high in seed treated with Dithane M-45 and control when compared to other treatments.

b) Effect of field application of fungicides on rhizome rot of ginger

The experiment was laid out in a split plot design with organic and inorganic manures as main treatments and Captan 5 G, Captafol 5 G, Dithane M-45 0.3 %, cheshnut compound and control as sub-

treatments with four replications. The material was sown in 3 × 1 m beds with eight beds per treatment. The fungicides were applied at the time of sowing and the second dose after the 60th day. Observations on germination and disease incidence were recorded (Table 15).

Table 15. *Effect of field application of fungicides on rhizome rot of ginger*

Main treatments	Sub treatments					
	Captan 5 G	Captafol 5 G	Dithane M-45	Cheshnut compound	Control	Mean
Organic & inorganic manure in 50 : 50 proportion	2.97 (89.91)	3.55 (91.33)	3.28 (93.39)	4.98 (90.56)	5.50 (90.57)	4.05 (91.15)
Organic manure alone (cowdung)	5.28 (92.22)	9.15 (93.26)	3.73 (92.88)	9.46 (91.13)	9.69 (94.44)	7.46 (92.78)

Values indicate percentage disease incidence
Values in parentheses are germination percentages

The differences with regard to incidence of disease were not significant for any of the treatments. Minimum disease incidence was noticed in plots treated with Dithane M-45 (3.50 per cent) followed by Captan (4.12 per cent) compared to 7.99 per cent in untreated control.

8. Field control trial on bacterial wilt of ginger

A field control trial was laid out in a bacterial wilt sick plot in a split plot design with two main treatments viz., with bleaching powder and without bleaching powder and four sub-treatments viz., seed treatment with streptocycline 200 ppm, plantomycin 200 ppm, hot water treatment (45°C for 30 min) and untreated control. The experiment was replicated four times. Observations on germination and disease incidence were recorded (Table 16).

Table 16. *Field control trial on bacterial wilt disease of ginger*

Main treatments	Sub treatments				
	Streptocycline 200 ppm	Plantomycin 200 ppm	Hot water treatment 45°C for 30 min	Control	Mean
Bleaching powder	96.66	96.87	87.49	97.49	94.63
Without bleaching powder	96.45	95.66	87.28	94.37	93.44
Mean	96.55	96.26	87.38	95.93	

Values indicate germination percentages

There were no significant differences in main and sub plot treatments with regard to germination and disease incidence. Though seed treatment with streptocycline 200 ppm delayed disease development, it did not reduce the final incidence.

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

(KM Abdulla Koya)

1. Biology of *Eumerus pulcherrimus*

Studies on the biology of *E. pulcherrimus* indicated that it completed its life cycle in 30–35 days. The egg, larval and pupal periods ranged between 3–4, 13–16 and 12–15 days, respectively.

2. Seasonal population

The population of *Mimegralla coeruleifrons* was high during October and low during April.

3. Survival during 'off season'

M. coeruleifrons was found to breed on decaying fallen banana flowers during the 'off season'. Maggots and pupae were observed in decaying rejected ginger bits. Adults were also observed in small numbers. When *M. coeruleifrons* was reared on different materials such as banana flowers, smashed ginger, decaying leaves, banana roots and cowdung, the life cycle was prolonged. However, the maggots could not survive on cowdung alone.

4. Natural enemies

Two species of parasites recorded from pupae of *M. coeruleifrons* were identified as *Spalanigia gemina* (Pteromalidae) and *Trichopria* sp. (Diapriidae), the former being recorded for the first time.

5. Other maggots

The other maggots collected from diseased ginger rhizomes were identified as *Deriops* sp. (Lonchaedae), *Bradysia* sp. (Sciaridae), *Atherigona* sp. (Muscidae) and *Adoxomyia heminopla* (Stratioidae).

6. Role of maggots in rhizome rot

a) Pot culture experiments

Pot culture experiments involving i) release of adult insects alone ii) inoculation with *Pythium* sp. +release of adult insects and iii) inoculation with *Pythium* sp. alone were conducted under green house conditions with 15 plants per treatment. All plants inoculated with

Pythium sp. showed the symptoms of disease one week after inoculation. However, the plants on which adult insects alone were released remained healthy and did not contain any maggots, whereas all the ginger rhizomes under treatment (ii) contained maggots, the number varying from 12 to 20 in different samples. The results conclusively proved that *Pythium* sp. is the causal agent for the disease and maggots are secondary saprophytic feeders.

b) Field experiments

The field trial was laid out at Chelavoor in a CRD with eight treatments replicated four times. The treatments were i) fungicide + cage + insects ii) cage + insects + fungus iii) fungicide alone iv) insects alone v) fungicide + cage vi) cage alone vii) fungicide + insecticide and viii) insecticide + fungus. The ginger beds under treatments (i), (ii), (v) and (vi) were covered with 1×1×1 m nylon mesh cages. The treatment with fungicide and insecticide was carried out from July to October at monthly intervals and release of adult insects was done at fortnightly intervals up to November. Inoculation with *Pythium* sp. was carried out during August. The initial stand of the crop was taken during July and observations on the incidence of disease and maggots were recorded during December (Table 17).

Table 17. *Field experiment to determine the role of rhizome maggots in rhizome rot of ginger*

Treatments	Germination (%)	Clumps diseased (%)	Diseased clumps with maggots (%)
Cage + insects + fungicide	98.4	0.0	0.0
Cage + insects + *Pythium* sp.	100.0	26.5	58.8
Fungicide alone	96.8	0.0	0.0
Insects alone	87.5	0.0	0.0
Fungicide + cage	100.0	0.0	0.0
Cage alone	96.8	0.0	0.0
Fungicide + insecticide	95.3	0.0	0.0
Insecticide + *Pythium* sp.	100.0	65.6	50.0

V. Studies on quality analysis

(General leader : A Gopalam)

Phy III (813). Quality evaluation in black pepper

(A Gopalam and T John Zachariah)

Fifty one Karimunda selections were evaluated for chemical quality constituents. Piperine content ranged from 5.44 to 7.13%, the maximum being in Sel. 84. Oleoresin content varied from 7.22 to 14.38%, the maximum being in Sel. 61. Essential oil content ranged from 5 to 9% (v/v), the maximum being in Sels. 98 and 61.

Thirty cultivars were also evaluated for chemical quality constituents. Piperine content varied from 1.95 to 7.73%, the maximum being in Acc.No. 1305. Oleoresin levels varied from 6.0 to 16.67%, the maximum being in Acc.No. 1297. Essential oil content varied from 3.0 to 6.5%, the maximum being in Acc.No. 1297.

The effect of coating mineral oil on quality of black pepper was studied. Black pepper samples were sprayed with oil and water (1 : 3 v/v) and thoroughly mixed. Another sample was prepared by hand smearing it with oil. Compared to untreated control, hand smeared samples had more oleoresin and essential oil. Piperine levels were not altered in either of the treatments.

The chemical quality of black pepper as influenced by different methods of drying was studied. Oleoresin and essential oil levels increased in Wynad method of drying whereas by blanching there was a decrease in these constituents.

Phy IV (813). Quality evaluation in spices

(A Gopalam and T John Zachariah)

The influence of different methods of processing on the curcumin content in turmeric was studied. As compared to control, boiling rhizomes with 5% cowdung slurry and 0.5 and 1.0% alkali did not influence the colour value. In cultivars Chayapasupu and Duggirala, samples treated with cowdung slurry had more curcumin content. In the cultivar Kasturi, cowdung slurry and 1% alkali treatments did not affect the curcumin levels.

The lead and curcumin content in trade samples of turmeric was also determined in five samples collected from Duggirala and Erode. Lead was absent in all the samples and curcumin content was 3.6 $\pm$ 0.3% in Duggirala and 4.2 $\pm$ 0.6% in Erode.

Phy VII (813). Quality evaluation in cardamon

(T John Zachariah)

Oleoresin and essential oils were evaluated in 34 accessions and four popular cultivars. Among the accessions, Nos. 37 and 49 contained 6.9% oleoresin. Gas chromatographic analysis of volatile fatty acids indicated the presence of acetic, propionic, butyric, valeric and iso-valeric acids. Among the popular cultivars, Mysore had 3.91% oleoresin and 6.45% essential oil. In Valayar, the oleoresin and essential oil content was 4.21 and 6.00% respectively.

Immature and mature samples of Mysore, Malabar and Vazhuka cultivars were evaluated for their quality. The oleoresin content was found to decrease as the capsules mature whereas the essential oil content remained steady indicating that starch accumulation in mature samples decreases the levels of oleoresins.

VI. Nutritional requirement and crop management

(General Leader : K Sivaraman)

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

(K Sivaraman and AK Sadanandan)

A new NPK experiment with four levels of Nitrogen (50, 100, 150 and 200 g per vine per year) and four levels of Potassium (70, 140, 210, and 280 g per vine per year) with five side treatments was laid out in a RBD with three replications. The plot size was six vines for each treatment constituting 870 vines in the experiment including border rows. The standards *(Erythrina indica)* and black pepper cuttings were planted during the year. Banana was also planted to give uniform shade. Evaluation of soil fertility of the experimental site indicated medium availability of Nitrogen and low availability of Phosphorous and Potassium. Phosphorous fixing capacity of the soil was 305 kg per ha. The first dose of fertilizers was applied during August-September.

In the standard and spacing experiment replanted in 1983 with Panniyur-I and Karimunda, an analysis of the recurrence of quick and slow wilt showed that incidence of quick wilt after 3 years of replanting was very low (4.5 per cent) and foliar yellowing was negligible. Agro-technological measures for the management of the wilt disease was also developed from this experiment. In the varietal-cum-spacing trial started during 1983, *Albizzia* sp. was pruned periodically to regulate the shade. The yield of the vines was also recorded (Table 18).

Table 18. *Yield of black pepper as influenced by varieties and spacing*

Variety	Spacing (m)			
	3×3 (1100)	2.5×2.5 (1600)	2.5×1.5 (2600)	2×1 (5000)
Panniyur-I	430.4	734.1	707.6	577.5
Karimunda	710.3	757.6	513.8	635.9
Aimpiriyan	187.0	143.0	199.5	149.7

Values indicate mean yield in g/vine (green)
Values in parentheses are number of vines/ha

In Panniyur-I, the highest yield (734.1 g per vine) was recorded in the spacing 2.5 2.5 m followed by that in 2.5 × 1.5 m spacing. The highest yield (757.6 g per vine) in Karimunda was recorded in the spacing 2.5 × 2.5 m followed by that in 3 × 3 m spacing. In Aimpiriyan, the highest yield (199.5 g per vine) was recorded in 2.5 × 1.5 m spacing. The yield per unit area was highest in the closer spacing of 2 × 1 m.

In the management trial, *Erythrina indica* and *Glyricidia maculata* performed better than *Garuga pinnata* and *Acacia auriculiformis* when considering their growth and establishment.

SSc 1 (813). Mineral nutrition studies in black pepper

(AK Sadanandan)

1. Nitrogen management through slow release fertilizers

A field experiment was laid out in a RBD with six treatments and four replications with Panniyur-I. The fertilizer treatments were i) control ii) urea-form iii) urea iv) neem coated urea v) coir dust coated urea and vi) urea pellets. The nutrients were applied @ 100 g N per vine per year. Being the first year of planting one-third of the above dose of Nitrogen was applied in September. Banana (cv. Mysore Poovan) was planted as a shade crop along the border of each treatment. The plot size was six vines per treatment. Soil samples were collected after one month of fertilizer application for analysis.

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

(VS Korikanthimath)

The experiment was laid out during 1985 in a RBD with four replications and 10 treatment combinations comprising of two systems of planting (pit and trench) and five levels of fertilisers viz., 0 : 0 : 0, 40 : 40 : 80, 80 : 80 : 160, 120 : 120 : 240 and 160 : 160 : 320 kg of N, P and K per ha by using 'CL. 37' and following 2.0 × 1.0 m spacing and a plot size of 12.0 × 8.0 m.

Fertilisers were applied as per the treatment schedule and the shade was regulated during April-May. Data on the height, number of tillers and leaves on the plant were recorded. The height of the plant was maximum (177.0 cm) under the pit system of planting with application of 160 : 160 : 320 kg NPK per ha and the lowest (145.7 cm) in control. The number of tillers per plant was maximum (27.7) under the trench system of planting with application of 160 : 160 : 320 kg NPK per ha and lowest (12.9) in control. The number of leaves per plant

differed significantly under various fertiliser levels. Maximum number (209.1) of leaves was recorded in plots with 120 : 120 : 240 kg NPK per ha under trench system of planting and the lowest (114.4) in control. The overhead shade of trees regulated in the experimental plot was also found to affect the response of cardamom to added fertilizers.

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, AK Sadanandan and T John Zachariah)

1. Pot culture study

Three popular cultivars viz., Panniyur-I, Karimunda and Kalluvally were raised in cement pots of 45 × 60 cm size in a known quantity of forest soil. The epicuticular wax content (ECW) and specific leaf weight (SLW) of these vines growing under coir mat shade were determined after collecting the leaf samples one week after irrigation (Table 19).

Table 19. *Epicuticular wax content (ECW) and specific leaf weight (SLW) of one year old black pepper plants of three cultivars raised in shade*

Cultivar	ECW		SLW	
	Mean	CV%	Mean	CV%
Panniyur-I	10.03	19.29	10.45	16.00
Karimunda	10.59	16.73	11.78	12.53
Kalluvally	14.50	18.55	12.58	10.05

The preliminary data indicate that Kalluvally is superior to others in both the characters. The study of SLW in ten more cultivars under different moisture regimes was initiated.

2. Field study

Studies on the reaction of adult vines to stress in relation to depleting soil moisture was initiated in December.

Phy II (813). Leaf area and dry matter production in black pepper and cardamom in relation to different light regimes

(A Ramadasan)

The canopy area of adult vines of Panniyur-I raised on living and non-living standards ranged from 4.85 to 7.66 m^2.

VIII. Pest management

(General leader : T Premkumar)

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

(T Premkumar, S Devasahayam and Jose Abraham)

1. Seasonal fluctuation in population of 'pollu' beetle

The population of adult 'pollu' beetle *Longitarsus nigripennis* was recorded at weekly intervals at Koothali (Calicut district) on 100 leaves each of 15 vines. The cumulative monthly populations during January to December were 46, 26, 17, 7, 5, 3, 4, 5, 9, 26, 67 and 167 respectively. Studies on the sex ratio of field populations of adult 'pollu' beetles indicated that females out-numbered the males during the period February to June.

2. Screening of black pepper cultivars against 'pollu' beetle

Twenty six black pepper cultivars were screened for their relative susceptibility to adult 'pollu' beetle. Five rooted cuttings of each cultivar raised in polybags were placed in cages along with five cuttings of a susceptible check (Panniyur-I). Based on the number of feeding marks present on the leaves of Panniyur-I and other cultivars, the relative susceptibility was worked out. Acc. No. 1095 was the most susceptible and Acc. Nos. 1056, 1089, 1024 and 890 least susceptible

3. Economic thresholds for 'pollu' beetle infestation

For working out the economic thresholds for 'pollu' beetle infestation, observations on the incidence of spike and berry damage were recorded at weekly intervals from July onwards on three cultivars (Panniyur-I, Karimunda and Arakulam munda) at Koothali and Ingapuzha (Calicut district).

The analysis of data collected during the previous year indicated that the rate of increase of pest infestation on the berries was positive up to the second week of September and declined thereafter. The weekly average of number of berries damaged per spike followed a sigmoid curve.

4. Field control trials against top shoot borer

A trial was laid out at Puthupady (Calicut district) with six insecticides viz., endosulfan, quinalphos, methyl parathion, dimethoate, monocrotophos and phosphamidon (0.05% each) for the control of top shoot borer *Cydia hemidoxa*.

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

(S Devasahayam)

1. Incidence of gall thrips in black pepper areas

Surveys conducted in six locations in Coorg district and nine locations in Cannanore district indicated that the incidence of gall thrips was relatively higher at Appangala, Polibetta and Tithmathi in Coorg district (with up to 12.7 per cent leaf infestation) and negligible in Cannanore district.

2. Bioecology of gall thrips

a) Seasonal abundance

Studies on the seasonal abundance of gall thrips conducted at Kalpetta (Wynad district) indicated that the pest population was high during July-August and low during December-April. Studies on the increase in the number of individuals within a leaf in relation to its age indicated that maximum population occurred in leaves that were about 60 days old.

b) Natural enemies

Studies on the seasonal abundance of the common predators *Montandoniola moraguesi* and *Androthrips flavipes* conducted at Kalpetta indicated that the predator population was high during July-September and low during October-May. *A. flavipes* preferred eggs of gall thrips more than larvae and pupae. Adults and larvae of the predator fed on 4-8 eggs of gall thrips per day. Larvae of *Lestodiplosis* sp. (Cecidomyiidae) were recorded to be predacious on the juvenile stages of gall thrips for the first time.

c) Other fauna in thrip galls

Twenty four species of arthropods have so far been recorded to occur in thrip galls. The occurrence of these in relation to the age of the leaf and population of gall thrips was studied at Kalpetta.

d) Alternate hosts

Wild pepper vines (*Piper* sp.) in forest areas in Coorg district

were found to be infested with gall thrips. However, the correct identity of the vines and the gall thrips is to be confirmed.

3. Morphology of gall thrip infested leaves

The morphological aberrations caused by gall thrips infestation on leaves of three cultivars of black pepper (Panniyur-I, Karimunda and Arakulam munda) was studied. The galls were of the hypophyllous laminar fold/roll gall type. The margins of affected leaves were considerably thickened (540–1079) microns) when compared to that of normal leaves (210–329 microns). The other changes induced by gall thrip infestation included crinkling of leaf surface, reduction in leaf size, formation of depressions and necrotic patches within the galls and yellowing of the gall region.

4. Field control trial

Field control trials were conducted at Kuppadi (Wynad district) to test the efficacy of seven insecticides viz., endosulfan, quinalphos, dimethoate, formothion, monocrotophos, phosphamidon (0.05% each) and malathion (0.1%) in the control of gall thrips. Spraying of the test insecticides was carried out during July (during emergence of new flushes) and October. During July, the percentage of leaf galls on the vines was recorded 15 and 30 days after treatment. During October, the population of gall thrips within the galls was recorded 15 and 30 days after treatment.

All the insecticides were effective in controlling the pest infestation at the end of 15 days after treatment during July. Plots treated with dimethoate had the least percentage of pest infestation followed by those treated with monocrotophos. At the end of 30 days after treatment monocrotophos, formothion and dimethoate alone retained their efficacy in controlling the pest infestation. During October no conclusion as to the efficacy of various insecticides could be arrived at since the population of gall thrips was very low.

IX. Disease management

(General Leader : MN Venugopal)

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

(SS Ali and MN Venugopal)

1. Pathogenicity experiment

Root and soil samples were assessed for nematode populations and morphological characters of the plants were recorded. There was reduction in growth and yield of plants with increasing inoculum levels of nematodes. Maximum population was recovered in 100,000 nematode inoculum level but higher rates of multiplication occurred at lower inoculum levels. Maximum yield was recorded from control (nematode free) plants. Progressive reduction in yield was observed in all treatments with increasing levels of inoculation.

2. Demonstration trials

Application of furadan (100 g per plant) and neem oil cake (1 kg per plant) was carried out twice a year at Udaya estate. Harvest records collected till November 1986 indicated that the yield (total yield of 300 plants in each treatment) in plots treated with furadan and neemcake were 179.600 and 169.130 kg respectively, compared to 127.575 kg in control.

A new demonstration plot was also taken up at Prasanna estate. Nine hundred plants (three year old Malabar cultivar) were selected and the following treatments were imposed: i) furadan (50 g per plant) ii) neem oil cake (1 kg per plant) iii) furadan 25 g + neemcake ($\frac{1}{2}$ kg per plant) and iv) untreated control. The treatments were replicated thrice and aplication of nematicide and neemcake was undertaken twice a year. The harvest records indicated that the increase in yield in furadan, neemcake and furadan+neemcake treated plots was 47.6, 41.5 and 45.5 per cent respectively over untreated control.

3. Interaction of nematode and fungus in rhizome rot

An experiment was conducted to study the interaction of *Meloidogyne incognita* and *Pythium* sp. in rhizome rot affected seedlings.

Six to seven leaf stage seedlings of Mysore, Vazhuka and Malabar cultivars grown in pots were inoculated with i) *M. incognita* alone ii) *Pythium* sp. alone iii) nematode followed by fungus simultaneously iv) nematode followed by fungus after 14 days and vi) fungus alone with injury to roots. An uninoculated control was also maintained. The trial was undertaken in a RBD and each treatment was replicated six times. The fungus was inoculated at the rate of 40 mg mycelium in suspension per seedling and the nematode inoculum was 1000 juveniles per seedling. The results indicated that the fungus alone could infect the seedlings up to 100 per cent level within eight days of inoculation. The severity of the disease did not increase in nematode and fungus combinations.

4. Nematicidal trial

An increase in yield was observed in all nematicide and neem cake treated plants. Nematode population was significantly less in treated plants. Cardamom samples collected from the trial were sent to Nematology Division, Indian Agricultural Research Institute, New Delhi, for analysis of nematicide residues.

X. *Estimation of crop losses in spices*

(General Leader : Jose Abraham)

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

(M Anandaraj and Jose Abraham)

A survey on the incidence of quick wilt disease of black pepper was conducted in Cannanore district adopting a stratified two stage sampling procedure. Four clusters of five survey sub divisions were selected from each of 12 villages and enumerated consecutively for two years for recording the disease incidence and yield score (Table 20).

Table 20. *Incidence of quick wilt of black pepper in Cannanore district*

Stratum No.	Mean no. of diseased plants		Percentage incidence		Loss in yield (kg)/sub division	
	1985	1986	1985	1986	1985	1986
I	20.06	11.11	13.90	16.62	24.52	7.68
II	1.49	2.20	1.89	3.56	1.57	1.78
III	4.72	4.42	6.78	8.21	4.61	4.33
Pooled	10.15	6.10	8.97	9.25	9.97	4.49

Though the incidence of the disease remained same (about 9 per cent) during 1985 and 1986, the loss in yield during 1986 was reduced to almost half due to the reduction in the mean number of diseased vines and their relatively poor yield when compared to the previous year.

XI. Transfer of technology network

(General Leader : AK Sadanandan)

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

(KM Abdulla Koya, MN Venugopal and VS Korikanthimath)

Thirteen training courses ware organised during the year on different aspects of spices production technology (Table 21). The training programmes were attended by research workers, subject matter specialists and extension workers from universities and departments of agriculture and horticulture, farmers and students of different states.

Extn I (813). a. Increasing production and productivity of black pepper through large scale demonstration of improved technology in farmer's field

(AK Sadanandan, K Sivaraman, M Anandaraj, A Ramadasan and PN Ravindran)

The objective of the field demonstration was to convince the farmers that by adopting the improved production technology developed at the Research Centre an average yield of 1.5 to 2 kg per vine per year could be achieved.

A bench mark survey was initiated in three adjoining villages of the Experimental Farm of NRCS viz., Pannikotore, Peruvanna and Puthupady where 51 farmers were selected. The area of demonstration was 80 ha with 24,400 vines. The predominant cultivars cultivated in the area were Karimunda (49 per cent), Arakkulam munda (20 per cent) and Panniyur-I (16 per cent). In all the areas except at Puthupady black pepper was raised as a mixed crop in coconut gardens. Among the holdings, 35.5 per cent were marginal and 50 per cent small farmers. Fourteen per cent of the farmers applied inorganic fertilisers for black pepper; 50 per cent of the farmers used insecticides against 'pollu' beetle and 18 per cent used fungicides against wilt diseases.

The following technologies were demonstrated:

* Cultural operations like regulation of shade, mulching of basins and propping of vines.

Table 21. *Training courses conducted at NRCS, Calicut/Appangala*

Sl. No.	Name of the course	Duration and venue	No. of trainees	State
1.	Spices Production Technology	7–10 January, Calicut	2	Assam and Kerala
2.	Orientation Training to new ARS Recruitees	15–16 May, Calicut	5	CPCRI, Kasaragod
3.	Spices Cultivation	21 June, Calicut	11	Kerala
4.	Spices Cultivation with special reference to Rapid Multiplication and Breeding of Black Pepper	21–24 July, Calicut	3	Kerala
5.	Spices Cultivation with special reference to Black Pepper	22–24 September, Calicut	4	Kerala
6.	Training-cum-Discussion Seminar on Spices Production Technology	14–21 October, Calicut & Appangala	33	All States
7.	Spices Production Technology excluding Cardamom	18–22 November, Calicut	7	All States
8.	Cardamom Production Technology	3–5 September, Appangala	4	Karnataka
9.	'Katte' Disease Management	4–5 November, Appangala	2	Manipur and Maharashtra
10.	'Katte' Virus Transmission	31 July–2 August, Appangala	1	Kerala
11.	Cardamom Cultivation	31 October, Appangala	9	Kerala
12.	Nursery Management in Cardamon	20–22 November, Appangala	2	Madhya Pradesh
13.	Nursery Management and Cultivation in Cardamom	29 November, Appangala	16	Karnataka

* Nutrient management by the use of inorganic fertilizers besides organic manures (NPK–100:40:140; neemcake–1 kg, bone meal –½ kg and farm yard manure –5 kg per vine per year).
* Phytosanitary measures like uprooting wilt diseased vines and burning the pits.
* Rejuvenation of diseased gardens by replanting with rooted cuttings of Panniyur-I and Karimunda.

Seven leaders were selected among the 51 farmers and were given practical training in the adoption of improved technologies. The harvest data of 1985 showed that the average yield obtained in the demonstration plots prior to the transfer of technology was 447 g per vine. A tentative yield estimate based on visual grading of the vines indicated that it would be 1 to 1.5 kg per vine during the year. There was 88 per cent reduction in quick wilt incidence and 83 per cent reduction in the foliar yellowing of vines in the garden. 'Pollu' beetle was also completely controlled.

Extn I (813). b. Increasing productivity of cardamom through large scale demonstration of improved technology in farmer's field

(VS Korikanthimath and MN Venugopal)

A High Production Technology (HPT) programme was initiated in all the key cardamon growing zones to motivate the growers to increase the per unit production to a level of 800–1000 kg per ha by utilising the information available at the NRCS, Cardamom Research Centre, Appangala and UAS, Regional Research Station, Mudigere, Karnataka in collaboration with the Cardamom Board.

A series of meetings were held in various field units of the Cardamom Board to motivate the planters for adoption of the HPT programme. The meetings were held at Yeslur, Virajpet, Madikeri, Birunani, Bhagamandala and Somwarpet.

The planters were also brought to the Research Centre and taken round the various field experiments and demonstration plots, to convince them about the benefits of the programme. Training programmes were conducted for Assistant Directors and Field Officers of the Cardamom Board and Extension Assistants and Field Assistants who assist in the implementation of the HPT programme in all the cardamom growing zones of Karnataka. They were also briefed about the collection of data on the pre-planting history of the HPT demonstration plots, package of practices and calender of operations to

be followed in the plots and the cost accounting of various inputs and cultural practices to be carried out.

The plantations of interested growers were visited by the scientists of this centre and the officials of Cardamom Board to find out the facilities available for adoption of the HPT programme and to explain the various schedule of operations to be carried out.

A proforma for collecting the information on the pre-planting history of the HPT plots, a package of practices and a calender of operations both under irrigated and rainfed conditions were prepared and distributed to the Extension Officers and farmers. An evalution committee has been constituted for monitoring the HPT plots to review the progress of work and to suggest corrective measures in the implementation of the programme. The details of the HPT programme are given in Table 22.

Table 22. *High Production Technology (HPT) programme in cardamom*

Unit	No. of farmers	Area (ha)	No. of seedlings used
Virajpet	13	15.50	77,500
Bhagamandala	7	37.70	188,500
Madikeri	12	27.70	138,500
Somwarpet	2	9.00	45,000
Yeslur	8	4.20	21,000
Total	42	94.10	470,500

CLOSED PROJECTS

Path VIII (813). Investigation on occurrence, transmission, epidemiology and characterization of Nilgiri necrosis disease of cardamom

(R Naidu)

OBJECTIVES

To understand the occurrence, mode of spread and the extent of damage caused by the disease and to work out suitable control measures against it.

TECHNICAL PROGRAMME

1. Survey on occurrence of the disease in Kerala, Karnataka and Tamil Nadu.
2. Studies on the role of insect vectors, seed and soil in the transmission of the disease.
3. Purification and electron microscopic studies of the virus involved in the disease.
4. Studies on epidemiology of the disease.
5. Development of suitable disease management practices.

SUMMARY OF RESULTS

1. The disease was prevalent in Kerala and Tamil Nadu only.
2. Nine plantations distributed in Nilgiris (4), Idukki (3) and Anamalai (2) were affected by the disease.
3. The intensity of the disease was less than 1 per cent in all the affected plantations.
4. The symptoms associated with the disease included irregular yellow patches on young leaves which developed into necrotic patches. The affected plants were stunted and the yield was drastically reduced.
5. Preliminary studies with electron microscopy indicated the association of flexous rod shaped virus particles measuring 570–700 nm in length and 10–12 nm thick.
6. The disease was mainly observed in plantations situated adjacent to tea plantations.
7. Studies on the spread of the disease indicated the involvement of an aerial insect vector; the disease was found to spread in a centrifugal fashion.
8. The cardamom aphid *Pentalonia nigronervosa* failed to transmit the disease.

9. Studies on transmission with infested seed and soil gave negative results.
10. Regular roguing of affected clumps resulted in reduction of the disease to a manageable level.

Stat II (813). Studies on the pre-harvesting forecasting of yield of black pepper based on biometrical observations

(R Balakrishnan and Jose Abraham)

OBJECTIVES

1. To identify simple observable biometrical characters related to yield of black pepper.
2. To evaluate the relationship between the biometrical observations and the yield of individual vines at different stages of the crop before harvest.
3. To indentify suitable regression models based on which yield can be predicted well in advance of the harvest of the crop.
4. To evolve sampling procedures for estimating yield of black pepper plantations with increased precision.

TECHNICAL PROGRAMME

1. Labelling of large number of individual vines for purposes of recording yield related biometrical observations and yield.
2. Recording of yield related characters like height of the bearing portion of the vines, number of spikes from one metre portion of the vines at breast-height, visual judgement of the yield potential of the vines, spike length and setting percentage at two pre-harvest stages viz., August and September and recording of yield from one metre portion as well as for the whole vine at the time of harvest.
3. Evaluating of regression models to predict yield based on suitable combinations of yield related characters and also to identify the usefulness of any one model for the prediction of yield well before harvest.
4. Identifying suitable index of yield potential that can be used as an ancillary variate to estimate the yield of black pepper plantations by ratio method or regression method of estimation.

MATERIALS AND METHODS

The study was conducted in a black pepper plantation at Calicut district (Amalgamated Estates, Puthupady) and a random mixture of three cultivars viz., Karimunda, Panniyur-I and Arakulam munda were

selected for observation. During 1983, 601 vines were labelled and during 1983, 527 vines were labelled. The total number of vines taken up for recording yield and related characters were as follows: Karimunda-345 and 291; Panniyur-I-187 and 142 and Arakulam munda-69 and 94 respectively for 1982 and 1983. Observations were recorded during the first week of August and September and at the time of harvest for both the years. Measurements on the height of bearing portion in metres, number of spikes in one metre portion of the vines at breast-height, length and visual scoring for setting percentage for 10 randomly selected spikes and a visual scoring for the yield potential of vines were recorded. At the time of harvest, the yield from one metre portion of the vine as well as for the whole vine was recorded. Driage percentage was also recorded. For recording the yield potential of the vines visually, the following method was adopted. For each vine, each metre of the bearing portion was visually categorised as poor, moderate or high yielding based on spike density in the canopy of the vine. Similarly, in the case of individual spikes they were given scores of 1, 2 or 3 based on the fruit set being poor, moderate or good and this score was multiplied by spike length to give a spike score.

Regression models of the following forms (product models) were evaluated for the pre-harvest and harvest data for both the years:

i) Yield = Plant height × No. of spikes in 1 m at breast-height

ii) Yield = Visual yield score × No. of spikes in 1 m

iii) Yield = Visual yield score × No. of spikes in 1 m for unit yield score

iv) Yield = Plant height × No. of spikes in 1 m × Spike score

v) Yield = Plant height × Yield from 1 m

vi) Yield = Visual yield score × Yield from 1 m

vii) Yield = Visual yield score × Yield from 1 m for unit yield score

RESULTS AND DISCUSSION

Table 23 gives the variation in some of the biometrical characters in the experimental material under study. It shows that sufficient range of variation was taken up for the study. Table 24 gives the mean yield per metre (in g) for the three visual categories of yield. The overall means indicated that the yields in these categories were in a geometric progression. Therefore, the portions on the plant classified as poor, moderate and high yielding were given numerical scores of 1, 2 and 4 respectively. Thus it was possible to give visual yield scores

for each vine by adding the corresponding numerical scores for each metre of the vine. A t-test indicated that the mean yield per metre under the classifications were uniform over the two years under study.

Table 23. *Variation in some biometrical characters of black pepper vines under study*

Character	Mean and variation	Arakulam munda	Karimunda	Panniyur-I
Spikes/	Mean	209.70	249.80	140.00
metre of	SD	133.90	147.60	87.10
canopy	Range	35-670	34-727	14-549
Yielding	Mean	163.40	200.00	120.40
laterals/metre	SD	104.80	118.30	73.40
canopy	Range	26-503	25-590	14-468
Spikes/50	Mean	28.00	29.30	25.00
nodes at	SD	6.30	5.80	6.20
random	Range	9-37	7-43	7-35
Mean	Mean	14.80	14.90	23.90
spike	SD	3.00	2.60	5.00
score	Range	9.0-22.4	7.5-26.1	7.4-39.4
Yield/	Mean	674.00	778.00	774.00
metre green	SD	474.00	436.00	472.00
pepper (g)	Range	100-3000	165-2340	75-2630

Table 24. *Mean yield of black pepper vines under three types of visual classifications*

Year	Varieties		High yielding	Moderate yielding	Poor yielding
1982	Karimunda	N	181.00	107.00	56.00
		$\bar{X}$	1087.45	512.36	293.30
		θ	367.10	153.40	81.10
	Panniyur-I	N	54.00	76.00	56.00
		$\bar{X}$	1305.00	692.00	384.00
		θ	488.00	208.00	156.00
	Arakulam munda	N	30.00	24.00	14.00
		$\bar{X}$	1035.00	500.00	227.00
		θ	500.00	174.00	102.00
1983	Karimunda	N	50.00	86.00	156.00
		$\bar{X}$	985.00	571.40	278.50
		θ	290.00	141.50	125.60
	Panniyur-I	N	15.00	21.00	106.00
		$\bar{X}$	1262.00	675.50	292.70
		θ	474.40	117.00	127.70
	Arakulam munda	N	15.00	21.00	106.00
		$\bar{X}$	935.70	539.50	246.00
		θ	173.80	119.40	111.30
Pooled (1983 & 1984)	Karimunda	N	231.00	193.00	212.00
		$\bar{X}$	1065.30	538.70	282.60
	Panniyur-I	N	69.00	97.00	161.00
		$\bar{X}$	1295.60	688.40	326.30
	Arakulam munda	N	45.00	45.00	72.00
		$\bar{X}$	1002.00	518.40	242.30
	Pooled data for two years	N	345.00	335.00	445.00
		$\bar{X}$	1103.00	579.30	291.90
		θ	550.40	177.80	195.80

N = Mean yield per metre in g

Tables 25-28 summarise the results of the regression analysis for yield prediction of individual vines. The regression coefficients were evaluated by appropriate linear transformtion. The analysis indicated that in models where yield score was considered as one of the predictor variables, consistently high R^2 values were obtained for both the years as well as for all the rounds of observations. However, when vine height was considered as one of the predictor variables, the R^2 values were not high probably because the spikes are in general not likely to be uniformly distributed over the entire canopy. The visual yield score was evaluted in such a way to take into account the variation in spike density in the canopy.

Table 25. *Regression models for yield prediction in black pepper based on biometrical observations*

First round	:	Observations pertaining to August.
Second round	:	Observations pertaining to September.
Third round	:	Observations pertaining to harvest.
X (1)	:	Height of the bearing portion of the vine in metres.
X (2)	:	Total visual yield score for the vine.
X (3)	:	No. of spikes in 1 metre portion of the vine at breast-height.
X (4)	:	Mean spike score.
X (5)	:	Yield of green pepper (g) from 1 metre portion of the vine at breast-height.
X (3)	:	No. of spikes in 1 metre for unit yield score.
X (5)	:	Yield of green pepper in g in 1 metre for unit yield score.
Y	:	Total vine yield in g (green pepper).
X (P)	:	Product of X (3) and X (4).

Table 26. *Estimates of regression parameters for product models (1982–1983)*

Round	Loge b_0	b_1	b_2	R^2	Residual M S S	Models
I	3.3720	0.8461	0.6667	62.62	0.1368	$Y=b_0 \times (1)^{b_1} \times (3)^{b_2}$
	5.4376	0.9330	0.0905	81.36	0.0682	$Y=b_0 \times (2)^{b_1} \times (3)^{b_2}$
	5.8690	1.0125	0.1094	81.25	0.0686	$Y=b_0 (2)^{b_1} (3)^{b_2}$
II	3.1739	0.8659	0.6935	62.18	0.1383	$Y=b_0 (1)^{b_1} (3)^{b_2}$
	5.5138	1.0180	0.0424	83.29	0.0611	$Y=b_0 (2)^{b_1} (3)^{b_2}$
	5.1938	1.0468	0.1107	83.48	0.0604	$Y=b_0 (2)^{b_1} (3)^{b_2}$
	0.7825	0.8793	0.7441	67.65	0.1184	$Y=b_0 (1)^{b_1} (P)^{b_2}$
III	3.0299	0.8557	0.7189	68.78	0.1142	$Y=b_0 (1)^{b_1} (3)^{b_2}$
	5.3701	0.9703	0.0885	84.51	0.0567	$Y=b_0 (2)^{b_1} (3)^{b_2}$
	5.5679	1.0616	0.0175	84.17	0.0579	$Y=b_0 (2)^{b_1} (3)^{b_2}$
	0.5656	0.8620	0.7735	78.36	0.0792	$Y=b_0 (1)^{b_1} (P)^{b_2}$
	0.8121	0.8682	0.9114	87.94	0.0441	$Y=b_0 (1)^{b_1} (5)^{b_2}$
	3.7561	0.6629	0.4140	89.29	0.0374	$Y=b_0 (2)^{b_1} (5)^{b_2}$
	3.0545	1.0310	0.4663	88.77	0.0411	$Y=b_0 (2)^{b_1} (5)^{b_2}$

Table 27. *Estimates of regression parameters for product models (1983–1984)*

Round	Log$e b_0$	b_1	b_2	R^2	Residual M S S	Models
I	5.0147	1.2024	0.2696	41.81	0.1851	$Y=b_0 \times (1)^{b_1} \times (3)^{b_2}$
	6.4100	0.7851	-0.0024	60.87	0.1245	$Y=b_0 \times (2)^{b_1} \times (3)^{b_2}$
	6.7146	0.7906	-0.0775	61.09	0.1238	$Y=b_0 \times (2)^{b_1} \times (3)^{b_2}$
II	4.5501	1.2243	0.3492	48.09	0.1651	$Y=b_0 \times (1)^{b_1} \times (3)^{b_2}$
	5.8830	0.9660	-0.0115	84.12	0.0505	$Y=b_0 \times (2)^{b_1} \times (3)^{b_2}$
	5.9401	0.9595	-0.0222	84.13	0.0505	$Y=b_0 \times (2)^{b_1} \times (3)^{b_2}$
	3.0612	1.2132	0.4208	55.47	0.1416	$Y=b_0 \times (1)^{b_1} \times (P)^{b_2}$
III	4.5028	1.2025	0.3623	55.38	0.1578	$Y=b_0 \times (1)^{b_1} \times (3)^{b_2}$
	5.8265	0.9551	0.0067	84.08	0.0506	$Y=b_0 \times (2)^{b_1} \times (3)^{b_2}$
	5.7560	0.9583	0.0217	84.11	0.0506	$Y=b_0 \times (2)^{b_1} \times (3)^{b_2}$
	3.0253	0.1806	0.4289	58.36	0.1324	$Y=b_0 \times (1)^{b_1} \times (P)^{b_2}$
	3.0309	1.2270	0.5235	63.51	0.1160	$Y=b_0 \times (1)^{b_1} \times (5)^{b_2}$
	5.5609	0.9190	0.0639	84.51	0.0493	$Y=b_0 \times (2)^{b_1} \times (5)^{b_2}$
	5.2656	0.9495	0.1073	84.80	0.0484	$Y=b_0 \times (2)^{b_1} \times (5)^{b_2}$

Table 28. *Estimates of regression parameters for product models (pooled for two years)*

Round	$Log_e b_0$	b_1	b_2	R^2	Residual M S S	Models
I	4.1695	1.2946	0.4148	47.16	0.1936	$Y=b_0 (1)^{b_1} \times (3)^{b_2}$
	6.1282	0.9533	-0.0393	70.47	0.1082	$Y=b_0 (2)^{b_1} \times (3)^{b_2}$
	6.0415	0.9268	-0.0104	70.24	0.1090	$Y=b_0 (2)^{b_1} \times (3)^{b_2}$
II	3.7691	1.2702	0.4917	52.56	0.1738	$Y=b_0 (1)^{b_1} \times (3)^{b_2}$
	5.6870	0.9977	0.0159	84.47	0.0569	$Y=b_0 (2)^{b_1} \times (3)^{b_2}$
	5.6207	1.0059	0.0294	84.47	0.0569	$Y=b_0 (2)^{b_1} \times (3)^{b_2}$
	1.9294	1.3094	0.5435	58.29	0.1528	$Y=b_0 (1)^{b_1} (P)^{b_2}$
III	3.6486	1.2672	0.5121	56.96	0.1577	$Y=b_0 (1)^{b_1} (3)^{b_2}$
	5.6264	0.9884	0.0324	85.06	0.0547	$Y=b_0 (2)^{b_1} (3)^{b_2}$
	5.6266	1.0068	0.0275	84.96	0.0561	$Y=b_0 (2)^{b_1} (3)^{b_2}$
	1.7332	1.2863	0.5705	65.15	0.1277	$Y=b_0 (1)^{b_1} \times (P)^{b_2}$
	1.8238	1.3695	0.6740	71.05	0.1060	$Y=b_0 (1)^{b_1} \times (5)^{b_2}$
	5.1795	0.9411	0.1135	86.22	0.0505	$Y=b_0 (2)^{b_1} \times (5)^{b_2}$
	4.5430	0.9958	0.2166	86.66	0.0489	$Y=b_0 (2)^{b_1} \times (5)^{b_2}$

The observations pertaining to August (I round) yielded two models which involved yield score and number of spikes from 1 metre portion at breast-height with high R^2 values in both the years. However, the regression parameters were not homogeneous. The observations pertaining to September (II round) and harvest (III round) yielded two models which again involve yield score and number of spikes from 1 metre portion with high R^2 values in both the years. The regression coefficients were homogeneous for both the rounds as well as for both the years. This may be due to the reason that spike production was nearly over by September and that we do not expect any significant addition of spikes beyond that period. Taking the high R^2 values into account, we infer that we may use the observations recorded in September to predict the yield of individual vines. However, standardisation of number of spikes or yield from 1 metre portion to unit yield score did not give any significant change in the regression parameters or R^2 values. This was done as the other variable in the product models was kept as total visual yield score; but this did not yield the expected gain probably because the yield score alone accounted for major portion of the variation that is due to the regression equations.

While the product models involving yield score and number of spikes or yield from 1 metre portion is useful in predicting the individual vine yield, we may make use of these two characters for estimating the total yield of a population of vines by suitably incorporating them in a sampling scheme. For this purpose two indices of yield potential were identified which have high correlation with yield. The indices were:

i) Index I = Visual yield score × Yield per metre at breast-height for unit yield score.

ii) Index II = Visual yield score × Number of spikes per metre for unit yield score.

When the functional relationship between the primary variable (yield) and the ancillary variable (Index I or Index II) is linear, two methods viz., ratio method and regression method are commonly adopted to estimate the mean or total value of the primary variable in the population with increased precision. When the quantity $r\,C(Y)/C(X) > 0.5$ (where r is the correlation coefficient between primary and the ancillary variable and C(Y) and C(X) are the C.V.s of the primary and ancillary variables respectively) the ratio and regression methods would be more efficient than simple random sampling. In the present study this was found to be so. For any plantation of size N, if X(N) is the population mean of the ancillary variate and $\bar{y}(n)$ and $\bar{x}(n)$ are the means of the primary

and ancillary variates estimated from a sample of size n, then the estimate of the population mean of the primary variable is given by :

Y(R) : Ratio estimate $= \overline{y}(n) / \overline{x}(n) \times \overline{X}(N)$ of $\overline{Y}(N)$

Y(1) : Regression estimate of $\overline{Y}(N) = y(n) + \hat{\beta} (\overline{X}(N) - \overline{x}(n))$

where $\hat{\beta}$ is the estimated regression of the primary variate on the ancillary variate. The relative efficiencies of the ratio and the regression estimation methods were evaluated using standard procedures. It was estimated that by using Index I as ancillary variate in ratio or regression method the relative efficiency worked out to be 3.85. When Index II was used as the ancillary variate in regression method, the relative efficiency was estimated to be 2.95. However, Index II was only marginally efficient over simple random sampling when used in ratio method of estimation, the relative efficiency being 1.22.

However it may not be possible to have an exact idea on the population value of X(N) and it has to be estimated only by selecting a sample. In otherwords, one may select a larger sample of size n vines and record the ancillary variate (Index I or Index II) and from this larger sample select a sub-sample of n vines to record the actual vine yield in addition to the index values. This procedure know as double sampling is widely used in crop surveys.

A perusal of the regression models involving yield score as a predictor variable suggested that a major portion of the variation in the equations is accounted for by this variable. It is also obvious that for a vine with zero visual yield score the vine yield would also be nil. In view of these reasons a linear regression equation passing through the origin was fitted to the data explaining the relationship between visual yield score and whole vine yield. Tables 29 and 30 present the results of this study. It was found that the regression coefficients were uniform over the cultivars as well as over the years.

In view of the good linear relationship between yield score and total vine yield, this character can be efficiently utilized to estimate the total yield of black pepper plantations by the technique of double sampling.

In conclusion it should be pointed out that visual scoring for yield of black pepper is a simple technique that can be adopted with very little training and has a good scope of being incorporated in large scale surveys for yield estimation. It is also expected that this

Table 29. *Relationship between yield score and yield in black pepper*

Year	Variates	Means	Correlation coefficient	Regression coefficient	Residual MSS
1982–83	Yield score	8.2245	0.9009	0.335 kg	0.4763
	Yield (kg)	2.7355			
1983–84	Yield score	11.3681	0.8885	0.310 kg	0.6065
	Yield (kg)	3.5949			
Pooled	Yield score	9.6958	0.8962	0.320 kg	2.8713
	Yield (kg)	3.1377			

CV (Yield) = 53.97%
CV (Yield score) = 51.11%

Table 30. *Regression of plant yield (in kg) on visual yield score in different cultivars*

Year	Karimunda	Panniyur	Arakulam munda
1982–83	0.320	0.400	0.310
1983–84	0.295	0.345	0.305
Pooled	0.305	0.360	0.305

The regression lines are through the origin

character when used as an ancillary variate in a double sampling scheme would result in fifty per cent cost reduction as compared to simple random sampling for a given level of precision.

PUBLICATIONS

BALAKRISHNAN, R. and JOSE ABRAHAM (1987). A technique for estimating yield in black pepper *(Piper nigrum* L.) . *Journal of Plantation Crops* **14**: 115-118.

MISCELLANEOUS REPORTS

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

1. Collection of germplasm

In January 1986, a collection trip was organised to Wynad forests and nearby areas. During this survey 23 wild and 18 cultivated black pepper types were collected. The wild collections include *P. nigrum*, *P. hymenophyllum*, *P. trichostachyon*, *P. argyrophyllum*, *P. galeatum* and *P. attenuatum*. Materials were collected both for planting and for herbarium. The cultivated types collected include Cheppukulamundi, Balankotta, Kalluvally and a few unnamed local types.

In March 1986, a collection tour was organised to Kodagu district of Karnataka and 18 wild and 22 cultivated types were collected.

In April 1986, a collection trip was undertaken to Silent Valley forests for the collection of wild types. Fifty collections of wild *P. nigrum* and related species were made. A new variant of *P. nigrum* was also collected which is being reported as new variety (*P. nigrum* var. *hirtellosum* var. nov.)

In September 1986, a collection tour was organised to the forests of Wynad district and adjoining areas. Fifty collection of wild *Piper* spp. were made from Thirunelly, Naduvattom, Gudalur and Nilambur areas (details of the materials collected have been given in Tables 4 and 5).

2. Study of herbaria

A study of the herbarium specimens of *Piper* spp. collected earlier as well as in the current year was carried out. A trip was also undertaken to Botanical Survey of India, Regional Station at Coimbatore (Madras Herbarium) in order to study the herbarium specimens available there. The herbarium at NRCS Calicut consists

of collections belonging to the following species: *P. attenuatum*, *P. argyrophyllum*, *P. galeatum*, *P. hookeri*, *P. hymenophyllum*, *P. longum*, *P. mullesua*, *P. trichostachyon* and *P. schemidtii*. Two new taxa were recorded during this study and these are being reported (*P. silentvalliensis* and *P. nigrum* var. *hirtellosum* var. nov.). Taxonomic descriptions of all the above species were also made.

3. Planting and maintenance

All the collections were planted in the nursery for rooting. The earlier collections are under multiplication and are being planted.

All India Coordinated Research Project on Spices

(Project Coordinator : S Edison)

The erstwhile All India Coordinated Spices and Cashew Improvement Project functioning since 1971 with its headquarters at the CPCRI, Kasaragod was bifurcated into two independant projects for spices and cashewnut during 1985. The headquarters of the All India Coordinated Research Project on spices has been shifted to the NRCS, Calicut from April 1986. This project has 15 coordinating centres and about 50 research experiments are being conducted on the nine crops listed under it.

The major objectives of the project are:

i) evolving high yielding varieties resistant/tolerant to diseases and pests

ii) standardisation of agro-techniques for the crops under different agroclimatic conditions

iii) evolving control measures for major pests and diseases

iv) working as an inter-face and feed-back between the Agricultural Universities, CPCRI/NRCS and ICAR.

The crops dealt by the various centres and their locations are given below :

1. Black pepper

i) Panniyur (KAU) since 1971
ii) Sirsi (UAS) since 1981
iii) Chintapalli (APAU) since 1981

2. Cardamom

iv) Pampadumpara (KAU) since 1971
v) Mudigere (UAS) since 1971
vi) Yercaud (TNAU) since 1981

3. Ginger and Turmeric

vii) Solan (YSPUHF) since 1971
viii) Pottangi (OUAT) since 1975
ix) Vellanikkara (KAU) since 1981
x) Jagtial (APAU) since 1986

4. Cumin, Coriander, Fennel and Fenugreek

xi) Jobner (MLSU) since 1975
xii) Jagudan (GAU) since 1975

5. Coriander and Fenugreek

xiii) Coimbatore (TNAU) since 1975
xiv) Guntur (APAU) since 1975

6. Large cardamom

xv) Gangtok (NEH) since 1986

A brief account of the salient research achievements made by the different centres is summarised below :

BLACK PEPPER

1. Panniyur Centre

The centre has added 85 wild accessions to the germplasm during the year. The cultivar Kuthiravally performed consistantly well during the past six years with an yield of 2.32 kg dry pepper per vine. The stability parameters were worked out and this cultivar was fouud to be the most suitable cultivar followed by Panniyur-I.

The data from the long term NPK fertiliser experiment conducted from 1974-1982 were analysed and accordingly application of 50:50:150 g of NPK per vine per year has been recommended. However, it was confirmed that under North Kerala conditions, 60 g of N in the case of Panniyur-I, was necessary. The hybridization programme with eight parental combinations yielded 256 spikes, all pollinated.

Field trials for the control of quick wilt disease was under progress; the current recommendation is to spray the vines with 1% Bordeaux mixture and apply 10% Bordeaux paste in the collar region, besides drenching the soil with Bordeaux mixture during May-June, July-August and if necessary during September-October.

2. Sirsi Centre

A survey conducted in Uttara Kannada district forests yielded 15 additional cultivars for the germplasm. A field trial for the control of quick wilt disease was laid out.

3. Chintapalli Centre

Nine cultivars obtained from NRCS, Calicut were added to the germplasm. A new experiment to assess the performance of the cultivars was laid out in a CRD. The observational trial to identify the most suitable cultivar as an inter crop for coffee plantations was under progress.

CARDAMOM

1. Mudigere Centre

Seventy four accessions were maintained in the germplasm during the year. The selections received from Chandrapur and Handi estates were vegetatively multiplied for further evaluation. The CYT of promising types indicated that CL 726, CL 679 and CL 683 were the best, yielding 193.4, 136.5 and 133.4 g per clump per year. These yields were significantly superior to the three check clones viz., P-1, P-3 and P-5. A trial on the comparative performance of clonal and seedling progenies initiated during 1983 indicated that there were not much differences among the two types of progenies. In the diallel experiment, the combination of Bold Capsule x Long Panicle was superior than the other combinations; however, the highest yield was recorded in the cross Multiple Branching x Early Bearing which yielded 905.9 g per clump.

The deficiency symptoms caused by N, P, K, Ca, Mg, S and B were recorded through sand culture technique. The deficiencies of N, P, K and Ca were noticed when their respective contents in leaf were reduced to 48.8, 75.0, 76.8 and 23.4% respectively, as compared to control.

'Katte' disease escapes were collected from severely diseased gardens and maintained for testing against the disease by artificial inoculation by using the viruliferous aphid vector. A field experiment to study the effect of methods of eradication of 'katte' was laid out at the RARS Farm, Mudigere and in two farmers fields at Halikote and Byrapura.

In a pot culture experiment to evolve drought resistant varieties, a negative correlation between relative water content (RWC) and proline accumulation was observed; these factors were recorded at weekly intervals. A field experiment to identify drought tolerant varieties was laid with 12 clones identified based on the above experiment.

Studies on control of cardamom thrips indicated that Nuvacron 40 EC, Rogor 30 EC, Thimet 10 G, Dimecron 100 EC, Ekalux 25 EC, Anthio 25 EC, Metacid 50 EC, Metasystox 25 EC and Zolone 35 EC were equally effective in reducing the pest damage; plots treated with Nuvacron had the least percentage of infection.

2. Pampadumpara Centre

A total of 71 accessions including wild species were maintained in the germplasm. The multilocation field trial initiated during 1984 with seven types viz., P-1, P-3, P-5, PV-1, PR-107, CL-37, APG-7 along with

a local check was under progress at Pampadumpara, Mudigere and Yercaud centres. The NPK factorial experiment using uniform monoclonal planting material was also under progress and the plants are expected to yield next year.

Field trials for the control of Azukal disease conducted during 1984–86 indicated that a spray with 1% Bordeaux mixture coupled with soil drenching with the same was significantly superior over all the other treatments. The causal organism of the disease was authentically identified as *Phytophthora meadii* by the Commonwealth Mycological Institute, U. K. The disease symptoms could be artificially produced during the rainy periods when the RH was around 80 %. Studies on artificial inoculation for 'katte' disease indicated that the disease symptoms can be obtained on the susceptible seedlings of all the three popular varieties viz., Malabar, Mysore and Vazhukka after 28 to 45 days of inoculation; the highest percentage of infection was obtained when the seedlings were at the third leaf stage.

3. Yercaud Centre

A total of 23 accessions were maintained in the germplasm. Evaluation of 12 types under the CYT indicated that the highest yield was obtained in Malabar (180 g per clump) followed by Mysore (100 g). The 3^3 NPK factorial experiment was initiated during the year. A detailed survey for micronutrient requirements in cardamom plantations and collection of germplasm with specific reference to identifying drought tolerant types was initiated in collaboration with the Department of Horticulture and Plantation Crops, Government of Tamil Nadu.

LARGE CARDAMOM

1. Gangtok Centre

This centre started functioning during 1986–87 and the programmes identified include, collection and evaluation of germplasm with special reference to identiying types tolerant to Chirkey and Foorkey diseases and a CYT of high yielding clones. The IARI Regional Station at Kalimpong has been identified for collaborative work on screening for various diseases in large cardamom.

GINGER AND TURMERIC

1. Vellanikkara Centre

In turmeric, 59 accessions were evaluated and the highest yield was obtained from the selection 'Indonesia' (21.9 kg per 3 sq m bed); this

was followed by the selections 321 Ethamukula and NBPGR-1 which yielded 21.76 and 21.45 kg, respectively. In the multilocation trial, the highest yield was recorded in the selection CL 15 B (14.64 kg per 3 sq m bed) followed by CL 21A and CL 3D (13.67 and 11.22 kg, respectively). A new type of dry rot has been noticed in turmeric at this centre.

The evaluation of germplasm of ginger was continued and 17 selections were evaluated. The highest yield was recorded in M-233 (13.71 kg per 3 sq m bed) but this was highly susceptible to a disease of unknown etiology. In the field control trial against soft rot, no conclusive result could be obtained although the highest germination percentage was recorded when the rhizomes were treated with Captaf-5 G.

2. Pottangi Centre

Evaluation of 150 selections in the turmeric germplasm was carried out and the highest yield was recorded in CLS-3 (13.35 kg per 3 sq m bed) followed by CLS-2 and selection No. 316 Gorakhpur (11.4 and 10.45 kg, respectively). In the multilocation trial conducted at Pottangi during 1982-86, the selection PTS-10 performed better and yielded 20.68 tonnes per ha; this selection has been proposed for recommendation for release as a variety during the next Spices Workshop.

In ginger, among the 85 entries tested during the year, selection S-641 gave the highest yield (3.075 kg per 2 sq m bed) followed by Jugijan and Kunduli Local (2.8 and 2.7 kg, respectively). However, the performance of the elite selections in multilocation trial conducted during 1983-86 revealed that the selection PGS-35 gave highest yield (16.55 t per ha) and this variety has been proposed for recommendation for release during the next Spices Workshop. Twenty mutants were screened for soft rot and preliminary observations indicated that 12 lines were free from the incidence of the disease under natural conditions. The manurial trial did not give any significant difference in the yield to various NPK treatments; however the treatment 125 : 70 : 150 of NPK at a seed rate of 21 q per ha gave the highest yield of 6.65 t per ha. The experiment on mulching and intercropping did not yield any significant result but intercropping with french bean followed by a pure crop was found better.

3. Solan Centre

Thirty nine germplasm accessions were evaluated and Sel. ST 55 gave the highest yield (6.2 kg per 4 sq m plot). In the multilocation trial with 10 varieties, selection ST 315 gave the highest yield (6.17 kg per plot).

In ginger, 44 selections were evaluated of which the clone SG 547 gave the highest yield of 215 g per plant followed by clones SG 638 and SG 647, yielding about 200 g. In the multilocation trial, clone SG 312 gave the highest yield of 5.64 kg per 4 sq m plot. Seed treatment with Blitox-50 (0.3%) helped disease free storage of ginger. Seed rhizomes of 20 g size were found to do better at Pottangi and Solan centres.

4. Jagtial Centre

This centre started functioning during 1986 at the Regional Agricultural Research Station for the Telangana zone under the APAU. A multilocation trial was initiated on turmeric at this centre and 12 improved selections of PCT lines were supplied from NRCS, Calicut. A field trial was laid out including a local variety viz., Armoor as check; the yield data will be available during 1987.

MINOR SPICES (Cumin, Coriander, Fennel and Fenugreek)

1. Jobner Centre (Cumin, Coriander, Fennel and Fenugreek)

Eighty eight cumin lines were maintained under muslin cloth chamber. The initial evaluation of the germplasm was conducted at Jobner and Mandore with 28 and 26 accessions respectively. In the CYT, UC 19 gave the highest yield at Jobner and Mandore; the incidence of cumin wilt was least in UC-19. The selection UC 198 contained higher total oil whereas Sel-CS-2 had higher essential oil content. Top dressing with 30 kg N gave the highest yield of 6.6 q per ha.

Evaluation of 24 entries in coriander indicated that highest yield was obtained from UD 270 with 13.54 q per ha followed by UD 41 (10.54 q). In the MLT conducted at Jobner, Borkhera and Aklera, the selections UD-21 and UD-1 yielded higher at Jobner and UD-20, UD-21 and CS-5 at Borkhera whereas at Aklera, the types UD-1, UD-373 and UD 20 were the best performers. It was further confirmed that 50 per cent leaf plucking done 75 days after sowing can give economic returns under irrigated conditions; however this will reduce the grain yield. In a quality evaluation experiment at Jobner, it was found that the mid-flowering stage serves as the critical phase for evaluating the constituents like protein, sugar and chlorophyll. The total essential oil of coriander seed ranged from 0.1 to 0.4 %.

A total of 88 lines of fennel was maintained and evaluated at Jobner. Grain yield was higher in UF 32 (11.04 q per ha).

The initial evaluation of fenugreek showed that the highest yield was obtained from UM 67; this selection had less incidence of

powdery mildew besides being a late maturity type. In the CYT, higher yield was observed in NLM with 13.55 q per ha. The experiment on mutation breeding to evolve resistant lines to powdery mildew showed that the treatment 30 Kr-1 for M_5 generation was the best to reduce the wilt infection and also give higher yields. The selection UM-32 gave higher grain yield of 7.3 q per ha and leaf cutting had decreased the grain yield based on three years data. It was necessary to give eight irrigations to fenugreek at Jobner to realise higher yields of 13.34 q per ha and the fertiliser dose at 30 N and 45 P was found to be the best.

2. Jagudan Centre (Cumin, Coriander, Fennel and Fenugreek)

A total of 301 germplasm entries of coriander were maintained. The CYT with seven entries gave non significant results. However, the entry J-Coriander-3 gave the maximum yield of 15.56 q per ha based on analysis of four years data. The variety GAU-1 gave an higher seed yield of 1.93 q per ha and this was coupled with leaf cutting.

The MLT with fennel conducted for three years indicated that the variety Gujarat Fennel-1 gave the maximum yield (17.3 q per ha) and this selection (VC-14-3-3) has been proposed for recommendation during the next Spices Workshop. The experiment on leaf cutting of fenugreek conducted for three years showed that a maximum net profit of Rs. 2,300 per ha was recorded with the variety UM-1 with no cutting; even a single cutting of green leaves adversely affected the grain yield.

3. Coimbatore Centre (Coriander and Fenugreek)

The coriander variety Co-2 continued to perform better and yielded 540 kg per ha and was superior to the other selections/accessions. A total of 145 accessions were evaluated and 24 types were promising based on the umbel characters and yield. The initial evaluation trial with 18 entries conducted for three years showed that the grain yield was maximum in entry No. Co-2 which yielded 411.5 kg per ha. The CYT with 16 entries showed that the highest yield of 3.68 q per ha was obtained in accession No. 695 followed by Co-2. An early coriander culture viz., No. 287 was found suitable for rainfed cultivation in the southern districts of Tamil Nadu; it had 66 days duration in kharif and 79 days duration in rabi.

The fenugreek germplasm of 128 accessions was under evaluation. The CYT on fenugreek with 14 entries showed that Co-1 gave the highest yield of 2.73 q per ha.

The powdery mildew disease of coriander was controlled by spraying twice with Karathane 0.1% or Bavistin 0.1% or Wettable Sulphur 0.25%, the spray being given at the time of initiation of disease and repeated 10 days after. The root rot of fenugreek was controlled by a drenching with Bavistin 0.1% or Brassicol 0.1%.

4. Guntur Centre (Coriander and Fenugreek)

The germplasm of 108 accessions was evaluated and the maximum yield was obtained in selection ATP-116 (9.02 q per ha). The initial evaluation trial with 18 promising lines showed that the highest yield was obtained in AC-176 (7.99 q per ha). The CYT indicated that CS-4 gave the highest yield (9.75 kg per ha); however, the crop was susceptible to moisture stress and resulted in early maturity and subnormal yields. Basal application of 40 kg P in addition to 30 kg N and 20 kg K gave a higher grain yield of 8.84 q per ha at Guntur.

The Guntur Centre has identified coriander varieties suited to different conditions viz., CS-2 for mid season (grain type); CS-4 for late season (grain and leaf); CS-6 for early season and CS-7 for late season (grain and leaf).

GENERAL INFORMATION

Budget for 1986-87 (Calicut and Appangala)

Budget Allocation

Non-Plan	Rs. 32,10,000
Plan	Rs. 20,00,000
Total	Rs. 52,10,000

Actual Expenditure

Non-Plan	Rs. 32,03,994
Plan	Rs. 19,99,938
Total	Rs. 52,03,932*
Receipts	Rs. 1,66,690**

* This does not include the expenditure in respect of Appangala booked by CPCRI, Kasaragod up to 31-8-86 under non-plan

** This does not include receipts in respect of Appangala booked by CPCRI, Kasaragod up to 31-8-1986

Library and documentation services

The Library at NRCS, Calicut has 2407 books, 1143 bound volumes, 1131 reprints and 237 technical reports. The centre is subscribing to 70 Indian and 54 foreign journals.

The library continued to provide information services to the scientists and research scholars of this centre and also to 14 centres of the All India Coordinated Spices Improvement Project on various aspects of spice crops including minor spices through "Current Awareness Service on Spices and Condiments". The "Library Accession List" was also prepared for each month and circulated to keep the scientists informed of the additions to the library.

Photocopying facilities were also provided to the scientists working in the centre.

Publications

RESEARCH ARTICLES

1. ABDULLA KOYA, K. M., BALAKRISHNAN, R., DEVASHAYAM, S. and BANERJEE, S. K. 1986. A sequential sampling strategy for the control of shoot borer *(Dichocrocis punctiferalis* Guen) in ginger *(Zingiber officinale* Rosc.) in India. *Tropical Pest Management* **32:** 343-346.

2. BALAKRISHNAN, R., ANANDARAJ, M., NAMBIAR, K. K. N., SARMA, Y. R., BRAHMA, R. N., and GEORGE, M. V. 1986. Estimates on the extent of loss due to quick wilt disease of black pepper *(Piper nigrum* L.) in Calicut district, Kerala. *Journal of Plantation Crops* **14:** 15–18.

3. DEVASAHAYAM, S. 1986. Some observations on insects visiting cashew inflorescences. *Cashew Bulletin* **23** (5): 7–11.

4. DEVASAHAYAM, S. and RADHAKRISHNAN NAIR, C. P. 1986. The tea mosquito bug *Helopeltis antonii* Signoret on cashew in India—a review. *Journal of Plantation Crops* **14:** 1–10.

5. DEVASHAYAM, S., ABDULLA KOYA, K. M. and PREMKUMAR, T. 1986. Infestation of tea mosquito bug *Helopeltis antonii* Signoret (Heteroptera: Miridae) on black pepper and allspice in Kerala. *Entomon* **11:** 239–241.

6. GOPALAM, A. and RAVINDRAN, P. N. 1986. Indexing quality parameters in black pepper cultivars. *Indian Spices* **28** (1–2): 7–11.

7. JOHN ZACHARIAH, T., GOPALAM, A., KRISHNAMOORTHY, B. and RAVINDRAN, P. N. 1986. Steroid degradation compound associated with sex expressien in nutmeg *(Myristica fragrans* L.). *Proceedings, Indian National Science Academy* **B 52:** 685–688.

8. KORIKANTHIMATH, V. S. and NAIDU, R. 1986. Influence of stage of harvest on the recovery percentage of cardamom. *Cardamom Journal* **14** (2): 5–8.

9. KORIKANTHIMATH, V. S. and VENUGOPAL, M. N. 1986. Some weeds of cardamom estates. *Indian Weed Science* **17** (1): 43–44.

Participation in symposia, seminars, workshops and meetings

Second group discussion on Nematological problems of plantation crops, Central Coffee Research Institute, Balehannur, 24-25 April 1986
KV Ramana, C Mohandas and SS Ali

Eleventh technical meeting of the International Pepper Community, Rotterdam, The Netherlands, 19-25 May 1986
MK Nair

Workshop on Impact of drought on plantation crops, C P C R I, Kasaragod, 26-27 May 1986
MK Nair, S Edison, A Ramadasan, AK Sadanandan, A Gopalam, M Anandaraj, K Sivaraman, T John Zachariah and VS Korikanthimath

Summer institute on Analysis of food additives, contaminants, toxicants and adulterants in various food products, G B Pant University of Agriculture and Technology, 5-24 June 1986
A Gopalam

Ninth NARP-KAEP zonal (North zone) workshop, Regional Agricultural Research Station, Pilicode, 7 August 1986
MK Nair, S Edison, YR Sarma, KV Ramana and K Sivaraman

Workshop on Beneficial microbes in tree crop management, CPCRI, Kasaragod, 8-9 September 1986
MK Nair and S Edison

National seminar on Recent advances in soil science research, TNAU, Coimbatore, 23-25 September 1986
AK Sadanandan and K Sivaraman

National science seminar, New Delhi, 1 October 1986
MK Nair

Meeting of the Indo-US sub-commission on germplasm exchange, CPCRI, Kasaragod, 7 October 1986
S Edison

PLACROSYM VII, Coonoor, 16-19 October 1986

MK Nair, YR Sarma, AK Sadanandan, T Premkumar and A Gopalam

NARP-KAEP workshop, Regional Agricultural Research Station, Ambalavayal, 22 October 1986

A Ramadasan, S Edison, YR Sarma, AK Sadanandan, T Premkumar, K Sivaraman and CK Parthasarathy Prasad

NARP workshop, Regional Agricultural Research Station, Mudigere, 17 November 1986

S Edison

Workshop on Role of slow release fertilisers in plantation crops, CPCRI, Kasaragod, 25-26 November 1986

AK Sadanandan, K Sivaraman and VS Korikanthimath

National conference on Plant parasitic nematodes of India: Problems and progess, IARI, New Delhi 17-20 December 1986

KV Ramana

Membership of staff in committees

MK Nair

Institute Management Committee

Technical Advisory Committee, Special Agricultural Development Unit, Trivandrum

Spices and Condiments Sectional Committee

Editor, Journal of Plantation Crops

S Edison

Indian Spices Development Council

Selection Committee for new coordinating centre (AICSIP) in Andhra Pradesh

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

1. Dr KL Chadha, Horticulture Commissioner, Government of India
2. Dr MRN Rao, Director, Department of Agriculture, Andamans
3. Dr GL Kaul, Deputy Director General (Horticulture), ICAR, New Delhi
4. Dr RS Paroda, Director, National Bureau of Plant Genetic Resources, New Delhi

APPANGALA

1. Dr K Mohan Naidu, Director, Sugarcane Breeding Institute, Coimbatore
2. Dr V Ranganathan, Joint Director, UPASI Tea Research Station, Valparai, Tamil Nadu
3. Dr GL Kaul, Deputy Director General (Horticulture), ICAR, New Delhi
4. Sri RN Hegde, Manager (Technical), NABARD, Bombay
5. Sri L Markando Singh, District Officer (Horticulture and Soil Conservation), Manipur

CALICUT

MANAGERIAL

MK Nair Ph D	Joint Director/Scientist	S-4
S Edison Ph D	Project Coordinator/Scientist (Spices)	S-3

SCIENTIFIC

Genetics and Plant Breeding

PN Ravindran Nair M Sc (Ag)	Scientist	S-2
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

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-3

Biochemistry

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

Entomolgy

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

Nematology

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

Statistics

Jose Abraham M Sc	Scientist S-1

APPANGALA

MANAGERIAL

R Naidu Ph D	Scientist-in-charge/Scientist S-2 (relieved on 2-8-1986)
VS Korikanthimath M Sc(Ag)	Scientist-in-charge/Scientist S-2 (w. e. f. 1-8-1986)

SCIENTIFIC

Genetics and **Plant Breeding**

RSN Pillai Ph D	Scientist S-2	(relieved on 5-4-1986)
Thimmappaiah M Sc	Scientist S-2	(relieved on 4-9-1986)
Regy Lukose M Sc	Scientist S-1	(joined on 16-7-1986)

Plant Pathology

MN Venogopal Ph D	Scientist S-2

Nematology

SS Ali Ph D	Scientist S-1	(relieved on 16-12-1986)

PERUVANNAMUZHI FARM

Month	Rainfall		Mean temperature (°C)		Mean Relative Humidity (%)	
	No. of rains days	Rainfall (mm)	Maximum	Minimum	Maximum	Minimum
January	Nil	Nil	32.3	21.3	55.1	44.4
February	Nil	Nil	35.2	20.8	52.8	40.9
March	4	16.9	37.6	20.0	53.7	35.5
April	4	43.0	38.1	25.7	55.9	44.6
May	8	54.0	35.5	24.8	62.1	54.1
June	18	1340.5	30.7	25.1	80.9	75.4
July	21	592.5	28.7	24.4	83.2	77.1
August	16	605.5	24.5	18.8	82.6	77.3
September	17	457.0	26.0	20.1	83.9	75.4
October	16	333.8	34.4	27.5	72.2	64.7
November	11	256.8	31.0	22.9	74.0	61.3
December	1	26.0	31.6	25.0	68.8	58.3
Total	116	3726.0				

APPANGALA

Month	Rainfall		Mean temperature (° C)	
	No. of rainy days	Rainfall (mm)	Maximum	Minimum
January	Nil	Nil	24.5	16.8
February	1	12.7	26.2	17.5
March	3	15.5	28.2	20.4
April	5	120.4	28.8	22.0
May	6	88.0	28.1	22.6
June	24	622.5	24.5	17.7
July	30	470.8	24.4	18.7
August	20	826.0	23.5	18.9
September	20	200.3	25.7	18.1
October	11	97.4	28.0	18.7
November	9	139.6	25.8	16.7
December	3	40.0	26.6	15.5
Total	132	2633.2		