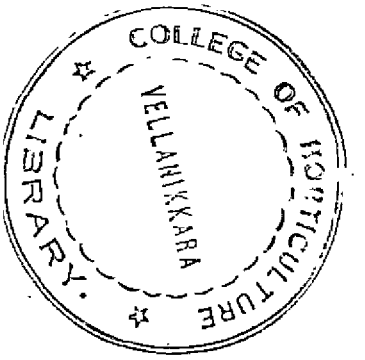
NUTRITIONAL STATUS OF SOIL AND PLANT IN RELATION TO THE INCIDENCE OF CHENTHAL DISEASE OF CARDAMOM



By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Nutritional status of soil and plant in relation to the incidence of Chenthal disease of cardamom" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "Nutritional status of soil and plant in relation to the incidence of Chenthal disease of cardamom" is a record of research work done independently by Shri. K.N. Dileep Kumar, under my guidance and supervision and that it has not previously formed the basis of award of any degree, diploma, fellowship or associateship to him.

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(K.N. DILEEP KUMAR)

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INTRODUCTION

Cardamom (Elettaria cardamomum L.Maton), popularly known as "Queen of Spices" is cultivated mostly in evergreen forests. In India its cultivation is mainly confined to the Western Ghats comprising the states of Kerala, Karnataka and Tamil Nadu. The crop is of great importance as a foreign exchange earner and India has an unique position in the Trade of this spice. India used to account for 70 per cent of total world production and 60 per cent of total world trade during the period 1978-79. Of late there has been great ecological disturbance by way of deforestation which has become a distinct threat to the cultivation of this shade loving crop. Cardamom cultivation is at present facing a severe crisis as a result of the drought situation in cardamom growing areas of Kerala, Karnataka and Tamil Nadu. The uncertain rains coupled with extensive deforestation in the cardamom hills of Idukki district have been playing havoc with the cultivation of this crop leading to complete destruction of the crop in certain areas since 1981. The extent of damage due to drought in Kerala was estimated to be 60 per cent at large with wide variation. The production for the year 1981-82 was estimated to be 4100 MT while the production during 1982-83 turned out to be 2900 MT registering a sharp decline.

Another important constraint which aggravate crop loss include the damage by pests and diseases. Among the diseases which affect the crop 'Chenthal' is a malady which is reported to cause considerable reduction in yield as well as damage to the plants. Though the disease was reported to be caused by Corynebacterium sp. its etiology is yet to be established conclusively. The occurrence of this disease has been related to a combined effect of nutritional, physiological and environmental factors by a team of scientists who conducted a survey on the incidence of chenthal disease in Idukki district of Kerala (Anon,1979). The incidence of the disease was found to be more severe in areas which do not have proper shade. It was felt that investigations are to be conducted to arrive at better management practices in order to maximise the production of this valuable spice crop.

Thus, the present investigation was taken up to assess the nutritional status of plants and their corresponding soil from the healthy and diseased areas with a view to understand the relationship between the incidence of the disease and the concentration of macro and micronutrient elements in the soil and plant. Another factor included in this investigation was the effect of light intensity on the occurrence and severity of the disease in Kerala.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Cardamom is one of the plantation crops in which only limited efforts have been made to study nutritional and related aspects. Though some attempts have been made in the past to study the nutrient status of some of the cardamom growing soils as well as the nutrient content of different tissues of cardamom in terms of major plant nutrients, literature pertaining to micronutrient status of the soil as well as the plant is scarce. Further, the contribution of soil and plant nutrient status to the yield and yield attributes of cardamom are also lacking. Besides, the critical limits of major and micro nutrients for the development of toxicity and deficiency and their symptoms on the plant, are yet to be understood which may help to differentiate between the symptoms of physiological disorders and plant damage due to pests and diseases.

Cardamom is affected by a number of foliar diseases. "Chenthal" is one among the foliar diseases of cardamom which has become a very serious threat to the cardamom growers in recent years especially in the High Ranges of Kerala, where large cardamom plantations are located. This disease is noticed at all the growth stages of the crop and in all the major cultivars of cardamom, viz., Vazhukka, Malabar and Mysore. It may cause considerable reduction in yield and capsule quality by affecting the plant growth. The extent of

damage as well as the reduction in yield due to the incidence of chenthal disease have not yet been assessed scientifically.

Literature relevant to occurrence of the disease, symptoms, etiology, nutritional aspects of the cardamom plant, in general, and the symptoms exhibited by the cardamom plant due to the deficiency of various nutrient elements etc. are reviewed herein.

2.1 Studies on chenthal disease of cardamom.

2.1.1 Occurrence

The occurrence of a new disease of cardamom from Vandanmettu in the High Ranges of Kerala State was reported by George et al. (1976). It was known locally as "Chenthal" and was reported to be a destructive disease causing severe crop loss. The disease was prevalent in varying intensities in contiguous plantations from Peerumedu to Pampadumpara in Kerala. George (1978) reported that Chenthal disease was found to be severe in thinly shaded areas and suggested not to thin out the shades for cardamom.

2.1.2 Symptoms of chenthal disease.

Mayne (1942) reported a leaf disease of cardamom with the symptoms resembling those of chenthal and stated that young leaves of the plant were comparatively free from the disease symptoms.

George (1978) described the symptoms of chenthal disease of cardamom. Initial symptoms were manifested by the appearance of elongated watersoaked lesions of varying size on the abaxial surface of young leaves. In advanced stages the lesions were brown to dark with a pale yellow halo. These developed near the leaf margins and progressed towards the midrib. As the withering advanced, the pseudostems also started wilting. New shoots emerging from the diseased plants were very much reduced in size. Newly emerged shoots, at about three to four leaf stage, were infected, culminating in total crop loss. Flowers set after the incidence of disease, failed to develop. Starting from the tip downwards, the inflores- cence dried up and the affected gardens presented a burnt appearance.

2.1.3 Etiology and control.

George et al. (1976) considered the chenthal disease to be due to bacterial infection. They conducted studies on the "bacterial blight" disease of cardamom. They examined the infected leaves and observed the presence of a fungus, Curvularia sp. and a gram-positive, rod shaped, bacterium, identified as Corynebacterium sp. Trials conducted using these microorganisms to test their pathogenicity on cardamom plants revealed that only the gram-positive bacterium, Corynebacterium sp. could initiate the symptoms of the disease.

In experimental field trials to control chenthal disease of cardamom, six antibacterial compounds were screened, of which, Penicillin was found to be the most effective. Plants sprayed with 100 mg/ml Penicillin solution for three consecutive days followed by a second spray after a lapse of 30 days showed marked improvement in comparison with the untreated control plants (George and Jayasankar, 1977).

Wilson (1977) observed the association of certain fungi with the incidence of chenthal disease; but it could not be controlled by spraying fungicides or antibiotics like Penicillin or Streptomycin.

2.2 Nutritional aspects of cardamom.

2.2.1 Studies on soil nutrient status.

Mathew and Azizuddin Mir (1968) reported that the soils of Chickmagalur, Hassan and Kodagu districts of Karnataka, where large cardamom plantations are located, were high in organic carbon, low in available phosphorus and medium in available potash.

Kulkarni et al. (1970) found that the cardamom growing soils of Koppa and Mudigere of Chickmagalur district were high in organic carbon and low in available potash. Datta Rao (1971) classified the soils of Koppa and Sringeri taluks of Chickmagalur and soils of Hassan district as medium in organic carbon while Mudigere soils

were high in organic carbon status. Further, these soils were low in available phosphorus as well as potash.

Though the soils were classified as high in organic carbon or nitrogen, most of these soils apparently showed response to added nitrogen. Kulkarni and Agnihothrudu (1972) revised the critical limits for organic carbon to a fairly higher range for classifying the available nitrogen status of plantation soils. The limits were fixed at 1.16 per cent, 1.16 to 2.32 per cent and above 2.32 per cent for low, medium and high organic carbon content respectively.

Srivastava and Bopiah (1973) reported that the available phosphorus, available potash, total calcium and organic carbon content of soils were positively correlated with the yield of green capsules of cardamom per clump. The available phosphorus, potash and soil pH were found to be positively correlated with the number of tillers per clump.

Zachariah (1975) studied the fertility status of various cardamom growing soils and reported that the majority of the soils were high in organic matter and low to medium in available phosphorus.

Nair et al. (1978) studied the distribution of major nutrients in the different layers of cardamom soils and found that the total nitrogen and organic matter decreased with increase in soil depth and the C/N ratio narrowed

towards lower layers. There was not much difference in the content of total potassium between the various layers. The availability of nutrients decreased with soil depth in all the cases. The surface horizon showed a slightly higher pH than lower layers, but, the variation in pH between the various layers was only negligible.

2.2.2 Nutrient uptake by cardamom plant.

The cardamom plant has been reported to contain 5.33 per cent N, 1.33 per cent P_2O_5, 6.69 per cent K_2O, 2.70 per cent CaO and 3.50 per cent MgO on dry weight basis (John, 1967).

Nutrient uptake studies were carried out by Kulkarni et al. (1971) at R.R.S. Mudigere. Analysis of the different plant parts revealed that while nitrogen, phosphorus and calcium content of leaves increased from young to mature stage a general decrease in magnesium and potassium content was seen. However, at the bearing stage, nitrogen, phosphorus and potassium decreased in the leaf tissue while a definite increase was noticed for calcium and magnesium.

It was further reported that in the case of pseudostem, there was a general reduction in nitrogen, phosphorus and potassium content and an increase in the calcium and magnesium concentration with the age of the plants. Regarding the total uptake of nutrients by the

plant at the harvest stage, it was seen that the removal of potasium was maximum (20.01 kg/ha) followed by nitrogen (12.17 kg/ha) and calcium (8.84 kg/ha). However, phosphorus and magnesium were removed in comparatively lesser quantities (1.4 to 2.32 kg/ha). It was also seen that for the production of one kilogram of cardamom capsules, 0.122 kg nitrogen, 0.014 kg phosphorus and 0.200 kg potassium were removed by the plants.

The nutrient uptake studies revealed that nitrogen, phosphorus and potassium were removed continuously by the plant upto the bearing stage and these had to be applied in a soluble or available form till bearing stage. Calcium and magnesium were needed only at later stages of growth of the plant as they were taken up mainly by mature and bearing plants. Out of the different nutrients removed, potassium was found to be the maximum.

2.3 Nutrient deficiency symptoms in cardamom.

Deshpande et al. (1973) described the following diagnostic symptoms for the deficiency of nitrogen, phosphorus potassium, calcium and magnesium in cardamom plants.

2.3.1 Nitrogen.

The deficiency symptoms first appeared on older leaves which were reduced in size. The leaves turned brown at the tip, greenish yellow in the middle and

remained green at the base. There was a largescale reduction in the number of suckers produced but these withered at a later stage. Nitrogen deficiency resulted in considerable elongation of roots which grew more than one and a half times that of the shoots while the shoot growth was meagre.

2.3.2 Phosphorus

Symptoms of phosphorus deficiency appeared in the experimental plants after a period of four and a half months. Phosphorus deficiency resulted in the production of numerous short roots. In the early stages they were brownish, but regained normal colour at a later stage.

2.3.3 Potassium.

Deficiency symptoms first appeared in the older leaves. Root and shoot growth was restricted and the plant showed browning of leaf tips which extended downwards. Later, the whole leaf turned dark brown. No new shoots were produced and ultimately the plant died within two weeks after the expression of symptoms.

2.3.4 Calcium.

The deficiency of calcium resulted in restricted root and shoot growth. The pseudostem showed thickening giving a bulb like appearance. The initial symptom was the discoloration of young leaves,

where the leaf margin turned brown with a golden yellow band beneath. Scattered golden yellow spots appeared on the leaves. The plants finally wilted without making fresh growth.

.3.5 Magnesium.

Magnesium deficiency in cardamom plants resulted in restricted suckering of plants. There was a reduction in internodal length of plants and plants presented a brownish appearance. The top leaves were twisted and showed tip drying. Later, the whole leaf became pale yellow with the mid rib remaining green, while papery spots appeared on the lamina which were the typical symptoms of deficiency of this plant nutrient.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present study was undertaken with a view to investigate the nutritional status of chenthal affected plants and their respective soils. The study comprised of selection of site, scoring of plants affected by the disease, collection of soil and plant samples from the marked plants, chemical analysis of soil and plant samples etc. In addition to these, observations were also taken to study the effect of light intensity on the incidence of the disease.

The details regarding the collection of soil and plant samples, experimental procedures, analytical techniques adopted, and procedures for studying the effect of light intensity on the disease are presented in this chapter.

3.1 Selection of site and observational plants.

3.1.1 Site selection.

Three different cardamom plantations located in Idukki district of Kerala State, each representing a cultivar of cardamom chosen for the present investigation, were selected as the sites for this study. These plantations were:

(a) Illimadam Estate,
Cardamom Research Station, Pampadumpara (Kerala Agricultural University).

(b) Vattâkkânam Estate,
Cardamom Research Station, Pampadumpara (Kerala Agricultural University).

(c) A private estate located at Kattappana.

3.1.2 Selection of observational plants and scoring for disease intensity.

For the present study three common cardamom cultivars, viz., Vazhukka, Malabar and Mysore, were identified and selected from the above mentioned locations based on their prominent plant characters. The details regarding the selection of sites and observational plants are furnished in Table (1)

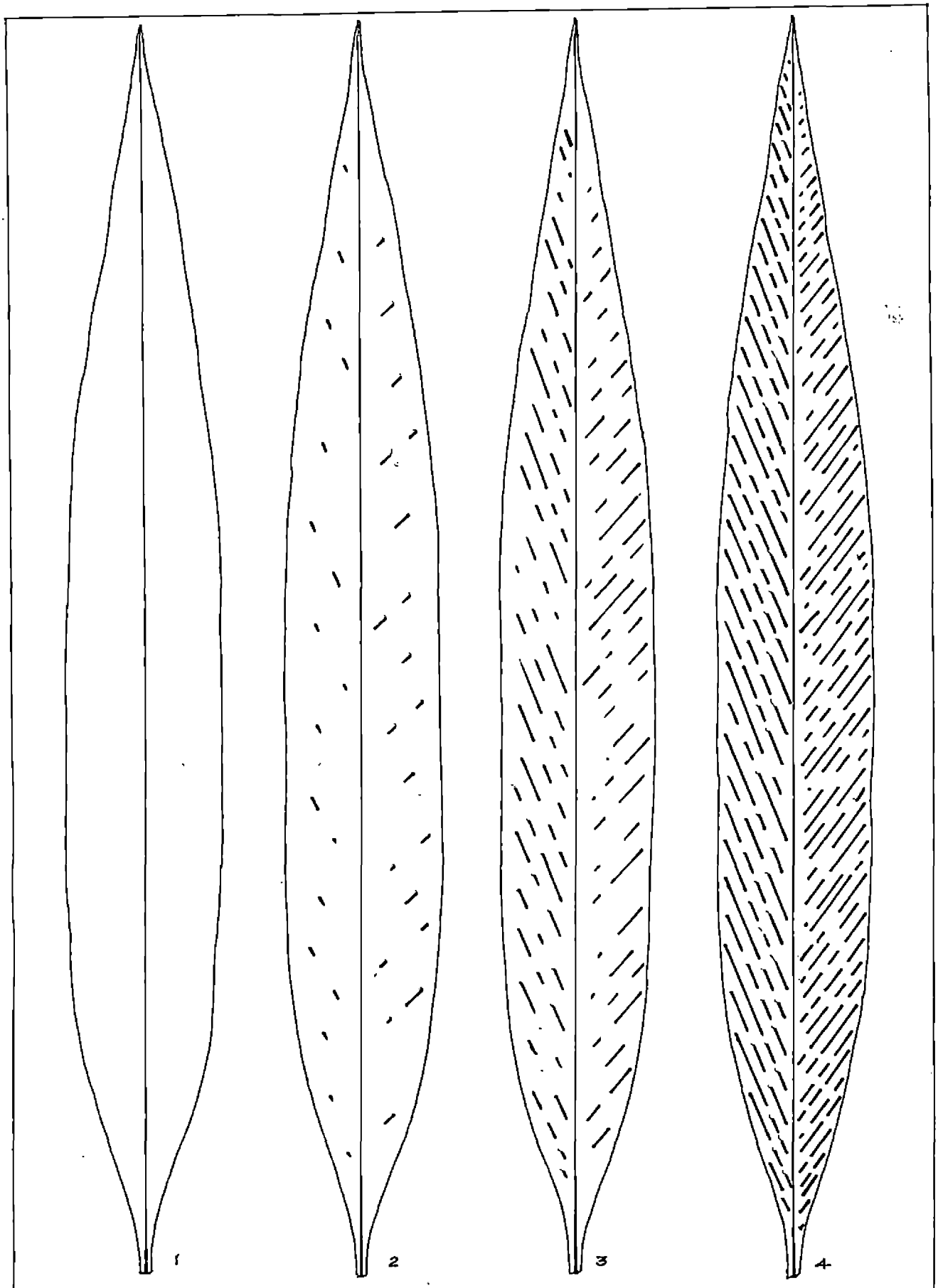
Four different levels of disease intensity were identified by visual observation and a score chart (Fig.1) was prepared. The major criterion for categorising disease intensity into four groups was the percentage of diseased leaves per clump in each category. The different levels of disease intensity according to the above mentioned scoring method are documented below.

Diease intensity rating.	Disease intensity group	Description.
1	Healthy	disease free plants
2	Low	one to 15 per cent diseased leaves per clump.
3	Medium	16 to 50 per cent diseased leaves per clump.
4	High	more than 50 per cent diseased leaves per clump.

Table. 1. Details of locations and observational plants selected for the study.

Sl. No.	Locations	Cultivars	Disease intensity groups	Number of observational plants.
1.	Vattakkanam Estate, Cardamom Research Station, Pampadumpara (Kerala Agricultural University)	Vazhukka	Healthy	20
			Low	20
			Medium	20
			High	20
			Total	80
2.	Illimadam Estate, Cardamom Research Station, Pampadumpara (Kerala Agricultural University)	Malabar	Healthy	20
			Low	20
			Medium	20
			High	20
			Total	80
3.	A private Estate in Kattappana	Mysore	Healthy	20
			Low	20
			Medium	20
			High	20
			Total	80
			Grand Total	240

FIG.1. SCORE CHART FOR CHENTHAL.



1. HEALTHY - DISEASE FREE.
2. LOW - TRACE TO 25 PERCENT OF LEAF LAMINA INFECTED.
3. MEDIUM - 25 TO 50 PERCENT OF LEAF LAMINA INFECTED.
4. HIGH - ABOVE 50 PERCENT OF LEAF LAMINA INFECTED.

For each cultivar of cardamom, representing a location, a contiguous area was marked out so as to get 50 plants from each disease intensity group. Selection of plants falling into different disease intensity groups was carried out by grouping the plants in the above area as per the score chart. In every clump three shoots were selected at random wherefrom three leaves were further selected randomly from each shoot and were scored according to the score chart. The mean score for each plant was worked out from the scores obtained for all the selected leaves of a clump. Based on this score, plants were categorized into different intensity groups so as to obtain 50 plants in each intensity group of the disease. From these 50 plants, 20 plants were selected at random and were marked as "observational plants". Altogether 240 observational plants were thus selected.

3.2 Biometric observations.

The following biometric observations were made on the observational plants:-

(a) total number of tillers per clump.

(b) number of panicles per clump.

(c) number of capsules per clump.

(d) weight of green capsules per clump.

The observations on the number of tillers and panicles were made during September, 1982 while the number and weight of green capsules per clump were taken at the time of each harvest during December - January, 1982-83.

3.2 Collection and preparation of soil and plant samples.

3.2.1 Collection of soil samples.

Surface soil samples (0-15 cm), at a distance of 50 cm away from the base of the observational plants of all the three cultivars were collected. Sample collection was done twice during the year 1982; first before the onset of South-West monsoon (pre-monsoon period) during the first week of March and the second after the heavy rains (post-monsoon period) during the last week of September. Thus, 80 soil samples each were collected from the three different sites, during the pre-monsoon period. This was repeated during the post-monsoon period also to get a total number of 480 samples.

3.3.2 Preparation of soil samples for analysis.

The samples were serially numbered, brought to the laboratory, air dried, powdered with a wooden mallet and passed through a 2 mm nylon sieve and stored in plastic capped bottles for further analysis.

3.3.3 Collection of plant samples.

Leaf samples were collected from all the observational plants at the time of collection of soil samples during the pre-monsoon and post-monsoon periods.

From each observational plant, the second, fifth and eighth leaves from the top were collected in brown paper envelopes and serially numbered, as in the case of soil samples.

3.3.4 Preparation of plant samples for analysis.

The leaf samples were air dried for two days and then dried to constant weight in an air oven at 70 ± 5°C. Leaf samples were finely chopped, mixed and powdered with hand while hot. They were collected in serially numbered polythene covers, and kept moisture free in a desiccator.

3.4 Analytical Procedures.

3.4.1 Methods used for soil analysis.

3.4.1.1 Electrochemical properties.

3.4.1.1.1. Soil reaction (pH).

The pH of the soil samples was measured in a 1:2.5 soil-water suspension using a Perkin Elmer pH meter with glass and calomel electrodes (Hesse, 1971).

3.4.1.1.2 Electrical Conductivity (E.C.).

The electrical conductivity of the soil was determined in the filtered extract of 1:2.5 soil-water suspension using a Solubridge.

3.4.1.2 Chemical properties.

3.4.1.2.1 Total Nitrogen.

The total nitrogen status of the soil was determined by the micro-kjeldahl digestion-distillation method (Jackson, 1973).

3.4.1.2.2 Available phosphorus.

Available phosphorus of the soil was extracted with Bray No.1 reagent (0.03N NH_4F and 0.025N HCl; Bray and Kurtz, 1945) and colorimetric determination of phosphorus in the extract was done by the chlorostannous reduced molybdophosphoric blue colour method in hydrochloric acid system (Jackson, 1973).

3.4.1.2.3 Exchangeable potassium.

Exchangeable potassium in the soil was determined in the neutral normal ammonium acetate extract after destroying the organic matter by treatment with aqua regia, using an EEL Flamephotometer (Jackson, 1973).

3.4.1.2.4 Exchangeable calcium and magnesium.

From an aliquot of the aqua regia treated ammonium acetate extract calcium and magnesium were

determined by the versenate titration method (Cheng and Bray, 1951).

3.4.1.2.5 Exchangeable iron, manganese and zinc.

The aqua regia treated ammonium acetate extract was used for the determination of exchangeable iron, manganese and zinc in the soil samples and they were measured in an Atomic Absorption Spectrophotometer (Jackson, 1973).

3.4.2 Methods for plant analysis.

3.4.2.1 Total Nitrogen.

Total nitrogen in the plant samples was determined by the micro-kjeldahl digestion-distillation process as described by Jackson, 1973.

Preparation of plant extract.

Triple acid extract was used for the determination of P, K, Ca, Mg, Fe, Mn and Zn in the leaf tissues (Johnson and Ulrich, 1959). For this, one gram of the powdered leaf sample was digested with triple acid mixture until clear. The digest was made upto 100 ml with distilled water, filtered and used for further analysis.

3.4.2.2 Phosphorus.

From an aliquot of the triple acid extract of the plant samples, phosphorus was determined by the

vanadomolybdic yellow colour method in nitric acid system as described by Jackson (1973).

3.4.2.3 Potassium.

The triple acid extract was suitably diluted and the potassium in the extract was estimated using an EEL Flamephotometer.

3.4.2.4 Calcium and magnesium.

Calcium and magnesium were determined in an aliquot of the triple acid extract by the versenate titration method (Cheng and Bray, 1951).

3.4.2.5 Iron, manganese and zinc.

The determination of iron, manganese and zinc were conducted with an Atomic Absorption Spectrophotometer using the triple acid extract of plant sample.

3.5 Observations made to study the effect of light intensity on the incidence of chenthal disease.

3.5.1 Site selection.

Three different sites, representing each cultivar, were selected as described earlier in this chapter (3.1.1.).

3.5.2 Selection of plants.

150 plants were selected, 50 each from a location, from the three different sites mentioned. The plants

were selected from a contiguous area and were scored according to the scoring method detailed below.

3.5.2.1 Scoring for light intensity.

Three levels of light intensity viz., low, medium and high in the experimental area were fixed by visual observations. The plants were rated according to this intensity levels. High rating was given to the plants completely exposed to sunlight while the low rating was given to the plants under complete shade. Plants coming in between and receiving only partial sunlight were rated as medium. The experimental area with the selected plants were scored according to this rating. The light intensity ratings were fixed as one, two and three respectively for low medium and high intensities of light, for the purpose of comparison and computation.

3.5.2.2 Scoring for disease intensity.

The plants within each level of light intensity were further scored for disease intensity as per the score chart described earlier in this chapter(3.1.2). The disease intensity ratings were one, two, three and four respectively for healthy, low, medium and high intensities of the disease.

Thus, a healthy plant receiving low light intensity was given a score of one while the healthy

plants receiving medium light intensity was given a score of two. Similarly, a plant showing low level of disease incidence and receiving low light intensity was given a score of two while those plants with low level of disease intensity and receiving medium light was given a score of four. Such a scoring method was adopted for all the plants at each level of disease and light intensity.

3.6 Statistical Analysis.

The data on yield and yield attributes were subjected to statistical analysis without any seasonal effect as the harvesting was only during one season.

The data obtained was statistically analysed by applying the analysis of variance technique. This analysis was done separately for each cultivar for the different soil and plant nutrient content, and was done to investigate whether there was any difference between the different disease intensity levels or between the two seasons.

Some useful correlation coefficients were also worked out to see the association between crop yield and various soil and plant nutrient factors.

The data on the effect of light intensity on the disease obtained from the three different sites were pooled and analysed by applying the analysis of variance technique.

RESULTS

RESULTS

This chapter includes the results of the study presented after the necessary statistical analyses of data. Samples were taken from different localities with plants as influenced by disease intensity, chemical constitution of soil and plant samples, correlation between yield and chemical constituents of soil and plant and the variation in disease intensity with respect to intensities of shades are presented here.

4.1 Growth characters of cardamom

The data pertaining to the mean values of the various growth characters of the plants at different levels of disease intensity are presented in Table-2; and Appendix-I.

4.1.1 Number of tillers per clump.

The number of tillers produced by the plants at different levels of disease intensity did not vary significantly with the severity of the disease. The mean tillers produced per clump ranged from 22.40 to 23.70, 22.65 to 24.95 and; 25.00 to 28.05 for the cultivars Vazhukka, Malabar and Mysore respectively at different disease intensity levels.

4.1.2 Number of panicles per clump.

There was no significant variation among the number of panicles produced per clump by the plants at

different levels of the disease; although, a difference in the mean values for the number of panicles produced per clump was found among the cultivars. The mean number of panicles produced at different disease intensity levels were in the range 31.25 to 31.75 for Vazhukka, 22.35 to 23.20 for Malabar and; 16.75 to 17.75 for Mysore cultivars.

4.1.3 Number of capsules produced per clump.

The number of capsules produced per clump by the plants at different levels of disease intensity did not show any significant variation. However, in all the cultivars, a non significant reduction in the number of capsules produced per clump was noticed in severely infected plants. The mean number of capsules ranged between 970.50 to 1058.25, 895.50 to 994.25 and 589.40 to 671.70 for the cultivars, Vazhukka, Malabar and Mysore respectively at different levels of disease intensity.

4.1.4 Weight of capsules per clump.

The results showed that the weight of capsules produced per clump was not significantly different for plants at the different disease intensity levels. However, the mean values for all the three cultivars showed a decreasing trend with an increase in the severity of the disease. The values ranged from 637.95 to 687.40 g for Vazhukka, 624.00 to 695.45 g for Malabar and 408.50 to 470.90 g for Mysore cultivars respectively.

Table 2. Growth characters of cardamom at different intensities of the disease.

Cultivar	Disease intensity group	Weight of green capsules/clump(g)	Number of capsules/clump	Number of tillers/clump	Number of panicles/clump.
Vazhukka	Healthy	687.40	1058.25	22.50	31.45
	ow	676.85	1015.70	22.75	31.75
	edium	660.00	988.25	22.40	31.25
	Lgh	637.95	970.50	23.70	31.15
	C.D.	-	-	-	-
Malabar	Healthy	695.45	994.25	24.95	23.20
	Low	678.00	969.55	23.70	22.65
	Medium	662.30	946.40	23.35	22.35
	High	624.00	895.50	22.65	22.60
	C.D.	-	-	-	-
lysore	Healthy	470.90	671.70	28.05	17.75
	Low	454.00	658.55	26.20	16.85
	Medium	448.35	643.50	25.00	17.40
	High	408.50	589.40	26.20	16.75
	C.D.	-	-	-	-

4.2 Soil Analysis

The various tables presented here contain the mean values obtained from chemical analysis of 20 soil samples each around the three cultivars of cardamom at the four disease intensity levels collected during the pre-monsoon and post-monsoon periods.

4.2.1 Electrochemical properties.

4.2.1.1 Soil reaction (pH).

The pH of the soil samples were in the range 4.93 to 5.23 for the three cultivars at different intensities of the disease and the differences were non significant (Table-3; Appendix-II).

4.2.1.2 Electrical conductivity (E.C.).

The electrical conductivity of soil samples was more or less constant showing only non significant differences. The range of values were from 0.11 to 0.14 milli mhos/cm^3 for the three cultivars at different intensities of the disease (Table-4; Appendix-III).

4.2.2 Chemical properties.

4.2.2.1 Total soil nitrogen.

The variation between the total nitrogen status of the soil around the plants at different intensity levels of the disease was not significant (Table-5;

Appendix-IV) and the mean values ranged between 0.193 to 0.210 per cent for Vazhukka cultivar, 0.182 to 0.198 per cent for Malabar and; 0.180 to 0.189 per cent for Mysore. Significant difference in the nitrogen content of soil was observed for all the three cultivars of cardamom. It was found that the nitrogen status of the soils during the pre-monsoon period was significantly higher than that in the post-monsoon period, and their mean values were 0.209, 0.201 and 0.195 per cent for Vazhukka, Malabar and Mysore cultivars respectively.

No significant season - intensity interaction on the soil nitrogen status was noticed for any of the cultivars.

4.2.2.2 Available phosphorus.

The data are furnished in Table 6 and Analysis of Variance in Appendix - V.

The mean values of available phosphorus content showed significant difference neither between the different disease intensity levels nor between the two seasons studied. The range of values were 21 to 23, 20 to 22 and 21 to 22 ppm for the three different soils cultivated to Vazhukka, Malabar and Mysore respectively.

Season-intensity interaction was not significantly different in the soils of any of the cultivars.

Table 3. pH of the soils for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean pH values for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
	Pre-monsoon	5.03	5.12	4.99	5.09	5.06
	Post-monsoon	5.11	5.08	5.05	5.03	5.07
Vazhukka	Intensity means	5.07	5.10	5.02	5.06	
	SE ±m/plot	0.0399				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	5.16	5.21	5.19	5.21	5.19
	Post-monsoon	5.20	5.19	5.15	5.25	5.20
Malabar	Intensity means	5.18	5.20	5.17	5.23	
	SE ±m/plot	0.0276				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	4.91	5.00	5.05	4.93	4.97
	Post-monsoon	4.95	4.98	5.15	4.97	5.01
Mysore	Intensity means	4.93	4.99	5.10	4.95	
	SE ±m/plot	0.0861				
	C.D. I	-				
	C.D. II	-				

C.D.I - C.D. for comparing intensity means.

C.D.II- C.D. for comparing season-intensity interaction means.

Table 4. Electrical conductivity of the soils for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean electrical conductivity (milli mhos/cm^3) for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
Vazhukka	Pre-monsoon	0.15	0.14	0.15	0.13	0.14
	Post-monsoon	0.13	0.14	0.11	0.15	0.13
	Intensity means	0.14	0.14	0.13	0.14	
	SE ±m/plot	0.0155				
	C.D. I	-				
	C.D. II	-				
Malabar	Pre-monsoon	0.13	0.13	0.12	0.14	0.13
	Post-monsoon	0.15	0.11	0.12	0.12	0.14
	Intensity means	0.14	0.12	0.12	0.13	
	SE ± m/plot	0.0213				
	C.D. I	-				
	C.D. II	-				
Mysore	Pre-monsoon	0.11	0.12	0.11	0.13	0.12
	Post-monsoon	0.13	0.14	0.11	0.11	0.12
	Intensity means	0.12	0.13	0.11	0.12	
	SE ±m/plot	0.0224				
	C.D. I	-				
	C.D. II	-				

C.D.I - C.D. for comparing intensity means.

C.D.II - C.D. for comparing season-intensity interaction means.

Table 5. Total soil nitrogen status for the three cultivars at different intensities of disease during the two seasons.

Cultivar	Season	Mean total soil nitrogen (%) for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
Vazhukka	Pre-monsoon	0.219	0.208	0.201	0.212	0.209
	Post-monsoon	0.194	0.190	0.190	0.204	0.191
	Itensity means	0.201	0.193	0.196	0.210	
	SE +m/plot	0.0097				
	C.D. I	-				
	C.D. II	-				
Malabar	Pre-monsoon	0.193	0.208	0.201	0.201	0.201
	Post-monsoon	0.171	0.189	0.184	0.192	0.184
	Intensity means	0.182	0.198	0.192	0.197	
	SE ±m/plot	0.0107				
	C.D. I	-				
	C.D. II	-				
Mysore	Pre-monsoon	0.190	0.197	0.197	0.196	0.195
	Post-monsoon	0.170	0.172	0.179	0.183	0.176
	Intensity means	0.180	0.184	0.188	0.189	
	SE ±m/plot	0.0114				
	C.D. I	-				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D.II - C.D. for comparing season-intensity interaction means.

Table 6. Available phosphorus content of soils for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean available phosphorus (ppm) of soil for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
	Pre-monsoon	23.4	21.8	22.6	22.7	22.7
	Post-monsoon	23.0	20.4	21.4	20.6	21.4
Vazhukka	Intensity means	23.2	21.1	22.0	21.8	
	SE ±m/plot	1.383				
	C.D. I	-				
	C.D. II	-				
	Pre-monsson	20.4	21.9	21.9	20.4	21.6
	Post-monsoon	19.7	21.4	20.9	19.8	20.4
Malabar	Intensity means	20.0	21.7	21.4	20.1	
	SE ±m/plot	1.393				
	C.D. I	-				
	C.D.II	-				
	Pre-monsoon	20.8	21.9	22.0	22.1	21.7
	Post-monsoon	20.5	21.4	21.5	21.7	21.3
	Intensity means	20.6	21.6	21.8	21.9	
	SE ±m/plot	1.166				
	C.D. I	-				
	C.D. II					

C.D. I - C.D. for comparing intensity means.

C.D.II - C.D. for comparing season-intensity interaction means.

4.2.2.3 Exchangeable potassium.

The data are given in Table-7 and Appendix-VI. The results revealed that there was no significant interaction between the season and intensity and that the difference between the exchangeable potassium content of the soils around the plants at different levels of disease intensity was not significant. However, in all the three cultivars, there was a significant reduction in the exchangeable potassium content from the pre-monsoon to the post-monsoon period with a mean difference of 14 ppm for the soils of Vazhukka, 9 ppm for the soils of Malabar and; 13 ppm for the soils of Mysore cultivar.

4.2.2.4 Exchangeable calcium and magnesium.

The mean values for exchangeable calcium and magnesium are furnished in Tables 8 and 9 and Analysis of variance in Appendices VII and VIII respectively.

The data indicated that there was neither a significant difference in the exchangeable calcium content between the soils at different intensities of the disease nor a significant interaction between the season and intensity in any of the three cultivars studied. The seasonal variation in the content of exchangeable calcium was not significant. The range of mean exchangeable calcium content of soils at

Table 7. Exchangeable potassium content of soils for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean exchangeable potassium (ppm) for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
	Pre-monsoon	109.3	93.3	90.0	88.6	95.3
	Post-monsoon	88.5	84.3	74.1	77.7	81.1
Vazhukka	Intensity means	98.9	88.8	82.0	83.1	
	SE ±m/plot	7.679				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	85.5	79.8	76.5	77.7	79.9
	Post-monsoon	76.0	71.7	68.6	67.9	
Malabar	Intensity means	80.8	75.8	72.5	72.7	
	SE ±m/plot	5.531				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	99.9	90.7	89.7	83.7	91.0
	Post-monsoon	83.9	76.5	76.5	74.3	77.8
	Intensity means	91.9	83.6	83.0	77.0	
	SE ±m/plot	9.135				
	C.D. I	-				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D.II - C.D. for comparing season-intensity interaction means.

Table 8. Exchangeable calcium content of soils for the three cultivars at different intensities of the disease during the two season.

Cultivar	Season	Mean exchangeable calcium (ppm) for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
	Pre-monsoon	260	258	247	264	257
	Post-monsoon	256	255	243	261	254
Vazhukka	Intensity means	258	256	245	263	
	SE ±m/plot	10.85				
	C.D. I	-				
	C.D.II	-				
	Pre-monsoon	254	259	248	256	
	Post-monsoon	252	256	244	252	
Malabar	Intensity means	253	258	246	254	
	SE ±m/plot	4.77				
	C.D. I					
	C.D.II					
	Pre-monsoon	240	235	234	238	237
	Post-monsoon	236	229	230	233	232
	Intensity means	238	232	232	235	
	SE ±m/plot	5.95				
	C.D. I	-				
	C.D.II	-				

C.D. I - C.D. for comparing intensity means.

C.D. II - C.D. for comparing season-intensity interaction means.

different disease intensity levels were 245 to 262, 246 to 258 and 231 to 238 ppm respectively for the cultivars Vazhukka, Malabar and Mysore.

The exchangeable magnesium content of the soils were significantly different between the plants at different intensity levels of the disease for all the cultivars of cardamom. There was a decreasing tendency in the exchangeable magnesium content of all the soils as the level of disease increased from healthy to high intensity. In Vazhukka, the maximum content of soil exchangeable magnesium was observed for healthy plants (218 ppm) and the minimum for severely diseased plants (192 ppm). However, it was seen that the exchangeable magnesium content of soils of healthy plants was on par with that of the low and medium level of disease infection while, the magnesium content of soils around severely infected plants was found to be significantly lower than the healthy group of plants.

Significant difference in the content of exchangeable magnesium was noted in the soils around the plants of the cultivar Malabar which were at different levels of disease intensity. The maximum content was recorded by the healthy plants (225 ppm) and the minimum by the highly infected plants (207 ppm)

Table 9. Exchangeable magnesium content of soils for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean exchangeable magnesium for the disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
	Pre-monsoon	226	211	208	197	211
	Post-monsoon	210	202	198	188	198
Vazhukka	Intensity Means	218	207	203	192	
	SE ±m/plot	6.913				
	C.D. I	19.261				
	C.D. II	13.620				
	Pre-monsoon	231	223	218	211	221
	Post-monsoon	220	220	215	203	214
Malabar	Intensity means	225	221	217	207	
	SE ±m/plot	4.382				
	C.D. I	8.633				
	C.D. II	-				
	Pre-monsoon	216	211	206	196	207
	Post-monsoon	206	200	195	185	197
	Intensity means	211	205	200	190	
	SE ±m/plot	6.237				
	C.D. I	12.287				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D. II - C.D. for comparing season-intensity interaction means

The exchangeable magnesium status of soils where Mysore cultivar was taken for observations, also showed significantly different mean exchangeable magnesium content between the different disease intensity levels with a maximum of 211 ppm by the healthy plants and a minimum of 190 ppm by the highly infected plants. The exchangeable magnesium content of the soil for healthy plants was found to be on par with that of the low and medium levels of disease intensity. However, the medium and low levels were significantly different from the severely infected plants for their soil content of exchangeable magnesium.

All the three cultivars of cardamom showed significant reduction in their soil content of exchangeable magnesium from the pre-monsoon to post-monsoon period. The mean reduction for the soils of the three cultivars were 11 ppm for Vazhukka, 6 ppm for Malabar and 6 ppm for Mysore.

Season-intensity interaction was noticed for the cultivar Vazhukka while, the Malabar and Mysore cultivars did not show any significant season-intensity interaction for the exchangeable magnesium content of the soils.

4.2.2.5 Exchangeable iron, manganese and zinc.

The data on the mean values for exchangeable iron, manganese and zinc content of soil around plants

at different levels of disease intensity are presented in Table 10, 11 and 12 and Analysis of Variance in Appendices IX, X and XI, respectively.

Results revealed that there was no significant variation between the exchangeable iron content of soils around plants at various levels of disease intensities or between the two seasons studied. The range of exchangeable iron content for the soils representing the different cultivars were 41 to 43 ppm for Vazhukka, 39 to 40 ppm for Malabar and; 39 to 46 ppm for Mysore cultivars. Similar results were observed for exchangeable manganese also. However, there was an increasing trend in the exchangeable iron and manganese content of the soil after the monsoon. The exchangeable manganese content were found to range from 117 to 125, 131 to 141 and 124 to 136 ppm for the different soils cultivated to Vazhukka, Malabar and Mysore cultivars respectively. Exchangeable zinc content of different soils under present investigation did not show any significant variation between the different levels of disease intensity or between the two seasons for any of the cultivars. The exchangeable zinc content of the soils representing the three different cultivars were in the range 41 to 44, 64 to 71 and 50 to 58 ppm respectively for Vazhukka, Malabar and Mysore cultivars.

Table 10. Exchangeable iron content of soils for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean exchangeable iron (ppm) for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
	Pre-monsoon	42.7	40.0	42.9	40.7	41.6
	Post-monsoon	43.1	41.5	43.8	40.9	42.4
Vazhukka	Intensity means	42.9	40.8	43.4	40.8	
	SE ±m/plot	3.038				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	39.6	39.8	38.2	38.6	39.3
	Post-monsoon	40.9	40.8	39.5	39.9	40.3
Malabar	Intensity means	40.3	40.3	38.8	39.3	
	SE ±m/plot	3.678				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	41.2	44.2	41.9	37.1	41.1
	Post-monsoon	44.3	47.1	44.1	40.6	44.0
Mysore	Intensity means	42.7	45.6	43.0	38.8	
	SE ±m/plot	3.691				
	C.D I	-				
	C.D II	-				

C.D. I - C.D. for comparing intensity means.

C.D. II - C.D. for comparing season-intensity interaction means.

Table 11. Exchangeable manganese content of soils for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean exchangeable manganese (ppm) for disease intensity groups				Seasional means
		Healthy	Low	Medium	High	
Vazhukka	Pre-monsoon	118	120	125	117	120
	Post-monsoon	120	123	126	117	121
	Intensity means	119	122	125	117	
	SE ±m/plot	3.849				
	C.D I	-				
	C.D. II	-				
Malabar	Pre-monsoon	140	129	138	140	137
	Post-monsoon	142	132	143	142	140
	Intensity means	141	131	141	141	
	SE ±m/plot	5.492				
	C.D I	-				
	C.D. II	-				
Mysore	Pre-monsoon	122	129	133	123	131
	Post-monsoon	125	135	138	127	127
	Intensity means	124	132	136	125	
	SE ±m/plot	5.555				
	C.D. I	-				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D. II - C.D. for comparing season-intensity interaction means.

Table 12. Exchangeable zinc content of soils for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean exchangeable zinc (ppm) for disease intensity groups				Seasional means
		Healthy	Low	Medium	High	
	Pre-monsoon	43.6	44.7	40.7	42.0	42.7
	Post-monsoon	41.5	43.5	39.8	41.3	41.5
Vazhukka	Intensity means	42.2	44.1	40.1	40.8	
	SE ±m/plot	3.486				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	67.9	64.4	76.8	70.8	70.0
	Post-monsoon	65.9	63.5	71.5	68.0	67.2
Malabar	Intensity means	66.9	64.0	74.1	69.4	
	SE ±m/plot	11.602				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	59.6	57.6	51.3	51.6	55.0
	Post-monsoon	56.4	54.1	49.2	48.2	51.9
Mysore	Intensity means	58.0	55.8	50.2	49.9	
	SE ±m/plot	3.838				
	C.D. I	-				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D.II - C.D. for comparing season-intensity interaction means.

None of the three cultivars showed any significant season-intensity interaction for the content of soil exchangeable iron, manganese or zinc.

4.3 Plant Analysis.

The various tables presented here contain mean values obtained from the chemical analysis of 20 plant samples each from the three different cultivars of cardamom at the four disease intensity levels during the pre-monsoon and post-monsoon periods.

4.3.1 Total nitrogen.

The data on the total nitrogen content of plants are furnished in Table-13 and Appendix-XII.

There was no significant variation between the nitrogen content of Vazhukka plants between the different levels of disease intensity or between the two seasons studied. However, the nitrogen content of plants showed a decreasing trend after the monsoon. The other two cultivars also gave similar results while, none of the cultivars showed season-intensity interaction.

The mean nitrogen content of the plants ranged from 2.080 to 2.199 per cent between the different levels of the disease intensity for the cultivars Vazhukka, 2.086 to 2.155 per cent for Malabar and 2.090 to 2.117 per cent for Mysore cultivars. The maximum mean nitrogen content was recorded by the healthy plants of the cultivar,

Table 13. Plant nitrogen content for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean nitrogen content (%) for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
	Pre-monsoon	2.213	2.186	2.110	2.103	2.153
	Post-monsoon	2.186	2.110	2.076	2.068	2.110
Vazhukka	Intensity means	2.199	2.148	2.098	2.081	
	SE ±m/plot	0.084				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	2.151	2.172	2.124	2.103	2.138
	Post-monsoon	2.110	2.138	2.096	2.069	2.107
Malabar	Intensity means	2.131	2.155	2.110	2.086	
	SE ±m/plot	0.077				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	2.124	2.144	2.110	2.103	2.120
	Post-monsoon	2.089	2.089	2.075	2.076	2.086
Mysore	Intensity means	2.107	2.117	2.093	2.090	
	SE ±m/plot	0.077				
	C.D. I	-				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D. II - C.D. for comparing season-intensity interaction means.

Vazhukka, while, the Malabar and Mysore cultivars registered higher mean nitrogen content for plants showing the low level of disease infection. However, these differences were not statistically significant.

4.3.2 Phosphorus.

The data on the plant content of phosphorus for the three different cultivars at the different disease intensity levels are presented in Table 14 and Analysis of Variance in Appendix-XIII.

The results obtained revealed that the plants at different degrees of disease infection did not vary significantly in the phosphorus content, in any of the three cultivars selected for the present investigation. However, the mean phosphorus content for the cultivars Malabar and Mysore showed a decreasing tendency with the increase in the degree of the disease as well as with the change in the season from pre-monsoon to post-monsoon period.

The mean values for the phosphorus content registered by the three cultivars at the different levels of the disease were in the range 0.170 to 0.185, 0.157 to 0.173 and 0.156 to 0.172 per cent respectively for Vazhukka, Malabar and Mysore cultivars. However, none of these cultivars showed marked season-intensity interaction.

Table 14. Plant phosphorus content for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean phosphorus content (%) for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
	Pre-monsoon	0.186	0.181	0.170	0.178	0.179
	Post-monsoon	0.184	0.179	0.169	0.176	0.177
Vazhukka	Intensity means	0.185	0.180	0.170	0.177	
	SE ±m/plot	0.008				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	0.173	0.164	0.163	0.158	0.165
	Post-monsoon	0.172	0.163	0.162	0.156	0.163
Malabar	Intensity means	0.173	0.164	0.163	0.157	
	SE ±m/plot	0.007				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	0.173	0.172	0.158	0.157	0.165
	Post-monsoon	0.171	0.170	0.156	0.155	0.163
	Intensity means	0.172	0.171	0.157	0.156	
	C.D. I	-				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D. II - C.D. for comparing season-intensity interaction means.

4.3.3 Potassium.

The details are furnished in Table-15 and Appendix-XIV.

All the three cultivars of cardamom selected for the present investigation, showed significant difference in the potassium content of leaves of plants at different levels of disease intensity. In all the cases, a gradual reduction in the potassium content of leaves was noticed as the severity of the disease increased.

In the cultivar Vazhukka, the maximum mean potassium content was recorded by the healthy plants (2.66 per cent) followed by the plants showing low (2. per cent) and medium (2.16 per cent) levels of diseas infection, while, the highly infected plants recorded the minimum content (2.14 per cent).

The cultivar Malabar, also recorded the highest potassium content for the healthy plants (2.48 per cent) and the lowest by the highly infected plants (2.04 per cent).

The healthy plants registered a maximum mean potassium content of 2.61 per cent in the cultivar Mysore which was found to be on par with that of the low intensity plants having 2.58 per cent potassium. However, these two disease intensity groups showed a significant difference in potassium content with the plants showing medium

(2.04 per cent) and high (1.86 per cent) degree of disease infection.

All the three cultivars showed a significant reduction in the potassium content with a change in the season from pre-monsoon to post-monsoon period (Fig. 3b). Their mean values for the two seasons were 2.53, 2.40 and 2.46 per cent for the cultivars Vazhukka, Malabar and Mysore respectively

None of the cultivars showed any significant interaction between the season and intensity of the disease.

4.3.4 Calcium and magnesium.

The details regarding the calcium and magnesi... content of plants at the different levels of disease intensity are furnished in Tables 16 and 17 and Appendices XV and XVI.

The results indicated that the calcium content of plants at the various disease intensity levels did not vary significantly in any of the three cultivars selected for the present study. Besides, none of the cultivars showed any significant variation between the pre-monsoon and post-monsoon period or interaction between the season and intensity of the disease for their calcium status. However, there was a non-significant reduction

in the calcium content between the two seasons studied in all the three cultivars.

The mean calcium status of plants at the different disease intensity levels were found to range from 0.777 to 0.854, 0.745 to 0.774 and 0.826 to 0.851 per cent respectively for the cultivars Vazhukka, Malabar and Mysore.

The results on the magnesium content of plants at different disease intensity levels revealed that all the three cultivars varied significantly in their magnesium content with a change in the degree of the disease. Highly significant results at one per cent level, was observed for the cultivar Mysore while Vazhukka and Malabar showed significant results only at five per cent level, for the magnesium content of leaves.

All the cultivars recorded lower mean magnesium values with severely infected plants and the reduction in the magnesium content was gradual from healthy to highly infected plants (Fig. 4b).

In Vazhukka the healthy plants registered a maximum magnesium content of 0.304 per cent which was found to be on par with the plants showing low and medium level of disease intensity. However, the severely infected plants showed significantly lower mean magnesium values (0.233 per cent) than all other plants.

In the cultivar Malabar, the maximum magnesium content was recorded by the healthy plants (0.356 per cent) followed by the plants showing low level of disease intensity (0.326 per cent). The healthy plants were found to be on par with those showing low and medium level of disease but were significantly different from the severely infected plants with a mean magnesium content of 0.263 per cent.

The cultivar Mysore also showed similar trends as that of Malabar, wherein the healthy plants recorded the maximum mean magnesium content of 0.348 per cent. The plants at low level of the disease gave a mean value of 0.320 per cent for magnesium and was found to be on par with the healthy and medium disease intensity plants. The minimum mean magnesium content (0.257 per cent) was recorded by the severely infected plants, which was significantly lower than the plants showing low and medium level of disease intensity.

The seasonal variation in the magnesium content of plants was not significant in any of the three cultivars. However, the plants showed a decreasing trend in the magnesium content with a change from pre-monsoon to post-monsoon period. None of the cultivars showed any season-intensity interaction.

Table 15. Plant potassium content for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean potassium content (%) for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
Vazhukka	Pre-monsoon	2.865	2.575	2.340	2.335	2.529
	Post-monsoon	2.466	2.200	1.975	1.945	2.145
	Intensity means	2.663	2.338	2.158	2.140	
	SE ±m/plot	0.111				
	C.D. I	0.2187				
	C.D. II	-				
Malabar	Pre-monsoon	2.695	2.360	2.325	2.225	2.401
	Post-monsoon	2.270	1.950	1.925	1.850	1.998
	Intensity means	2.483	2.155	2.125	2.038	
	SE ±m/plot	0.090				
	C.D. I	0.1782				
	C.D. II	-				
Mysore	Pre-monsoon	2.855	2.765	2.190	2.020	2.458
	Post-monsoon	2.370	2.385	1.880	1.710	2.086
	Intensity means	2.613	2.575	2.035	1.863	
	SE ±m/plot	0.090				
	C.D. I	0.1775				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D. II- C.D. for comparing season-intensity interaction means.

Table 16. Plant calcium content for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean plant calcium content (%) for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
	Pre-monsoon	0.850	0.776	0.776	0.819	0.805
	Post-monsoon	0.857	0.778	0.742	0.809	0.797
Vazhukka	Intensity means	0.854	0.777	0.759	0.814	
	SE ±m/plot	0.040				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	0.779	0.770	0.747	0.750	0.762
	Post-monsoon	0.769	0.754	0.742	0.744	0.752
Malabar	Intensity means	0.774	0.762	0.745	0.747	
	SE ±m/plot	0.032				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	0.863	0.833	0.855	0.848	0.849
	Post-monsoon	0.838	0.819	0.842	0.842	0.835
Mysore	Intensity means	0.851	0.826	0.848	0.845	
	SE ±m/plot	0.014				
	C.D. I	-				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D. II - C.D. for comparing season-intensity interaction means.

Table 17. Plant magnesium content for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean plant magnesium content (%) for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
Vazhukka	Pre-monsoon	0.311	0.291	0.286	0.235	0.281
	Post-monsoon	0.297	0.281	0.274	0.230	0.271
	Intensity means	0.304	0.286	0.280	0.233	
	SE ±m/plot	0.019				
	C.D. I	0.0379				
	C.D. II	-				
Malabar	Pre-monsoon	0.359	0.333	0.310	0.268	0.318
	Post-monsoon	0.352	0.319	0.291	0.258	0.305
	Intensity means	0.356	0.326	0.301	0.263	
	SE ±m/plot	0.026				
	C.D. I	0.0513				
	C.D. II	-				
Mysore	Pre-monsoon	0.359	0.330	0.295	0.261	0.311
	Post-monsoon	0.336	0.310	0.281	0.253	0.295
	Intensity means	0.348	0.320	0.288	0.257	
	SE ±m/plot	0.025				
	C.D. I	0.0496				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D. II- C.D. for comparing season-intensity interaction means.

4.3.5 Iron, manganese and zinc.

The details regarding the iron, manganese and zinc content of plants at the different levels of the disease intensity are presented in Tables 18, 19 and 20 and in Appendices XVII, XVIII and XIX respectively.

The plants at different levels of the disease did not very significantly for their content of iron in leaf lamina. Further, there was no interaction between season and intensity of the disease. The seasonal effect on the iron content of plants was also insignificant.

The mean iron content of plants for the three cultivars were in the range 217 to 228 ppm for Vazhukka, 217 to 220 ppm for Malabar and; 227 to 236 ppm for Mysore.

The results indicated that the manganese status of the plants was not significantly different between the different levels of the disease or between the two seasons studied. The season.intensity interaction was also not significant.

The range of manganese content in the plants were found to be 73 to 79, 73 to 80 and 76 to 90 ppm for the cultivars Vazhukka, Malabar and Mysore respectively.

There was no season-intensity interaction for the zinc status of plants. The plants at different intensities

Table 18. Plant iron content for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean plant iron content (ppm) for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
Vazhukka	Pre-monsoon	227	217	229	223	224
	Post-monsoon	227	216	226	220	223
	Intensity means	227	217	228	221	
	SE ±m/plot	6.435				
	C.D. I	-				
	C.D. II	-				
Malabar	Pre-monsoon	222	220	218	219	220
	Post-monsoon	219	215	216	214	216
	Intensity means	220	217	217	217	
	SE ±m/plot	7.134				
	C.D. I	-				
	C.D. II	-				
Mysore	Pre-monsoon	229	238	236	236	234
	Post-monsoon	225	234	233	232	231
	Intensity means	227	236	235	234	
	SE ±m/plot	6.017				
	C.D. I	-				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D. II - C.D. for comparing season-intensity interaction means.

Table 19. Plant manganese content for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean plant manganese content (ppm) for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
Vazhukka	Pre-monsoon	78.2	80.3	77.6	74.1	77.5
	Post-monsoon	76.0	77.8	75.5	72.2	75.3
	Intensity means	77.1	79.0	76.5	73.1	
	SE ±m/plot	8.880				
	C.D. I	-				
	C.D. II	-				
Malabar	Pre-monsoon	78.7	77.7	80.5	75.7	78.1
	Post-monsoon	76.1	72.3	78.7	71.1	74.5
	Intensity means	77.4	75.0	79.5	73.4	
	SE ±m/plot	8.059				
	C.D. I	-				
	C.D. II	-				
Mysore	Pre-monsoon	81.8	77.2	88.8	91.8	84.9
	Post-monsoon	80.0	75.0	86.5	87.7	82.3
	Intensity means	80.9	76.1	87.6	89.7	
	SE ±m/plot	8.247				
	C.D. I	-				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D. II - C.D. for comparing season-intensity interaction means.

Table 20. Plant zinc content for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean plant zinc content (ppm) for the disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
	Pre-monsoon	65.9	71.1	64.1	63.7	66.3
	Post-monsoon	64.0	69.1	62.2	61.2	64.1
Vazhukka	Intensity means	64.9	70.1	63.2	62.4	
	SE ±m/plot	10.107				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	63.7	60.8	63.7	62.9	62.8
	Post-monsoon	61.0	59.1	58.5	59.9	59.6
Malabar	Intensity means	62.3	59.9	61.1	61.4	
	SE ±m/plot	4.899				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	64.9	68.3	71.3	72.4	69.2
	Post-monsoon	62.1	65.3	67.2	66.0	65.1
Mysore	Intensity means	63.4	66.8	69.2	69.2	
	SE ±m/plot	9.341				
	C.D. I	-				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D. II - C.D. for comparing season-intensity interaction means.

of the disease did not express any significant variation between their zinc concentration. The variation in the zinc content of plants at the two seasons studied was also not significant.

The range of mean values for the zinc content of plants at different levels of disease intensity were 62 to 70, 60 to 62 and 63 to 69 ppm respectively for the Vazhukka, Malabar and Mysore cultivars.

4.4 Cation Ratios

4.4.1 Soil factors.

4.4.1.1 Potassium/(Calcium+Magnesium) Ratio.

The details of soil K/(Ca+Mg) ratios for the three different cultivars are presented in Table 21(a) and Appendix-XX.

The results revealed that there was no significant variation in the K/(Ca+Mg) ratio of soils in any of the cultivars at the different disease intensity levels. However, in all the cultivars, the ratio narrowed from the pre-monsoon to post-monsoon period. The mean values at different disease intensity levels were in the range 0.0701 to 0.0811, 0.0619 to 0.0648 and 0.0681 to 0.0750 for the cultivars Vazhukka, Malabar and Mysore respectively (Fig. 5a).

Table 21 (a). K/(Ca+Mg) ratio in the soil for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean K/(Ca+Mg) ratio in the soil for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
Vazhukka	Pre-monsoon	0.0835	0.0727	0.0790	0.0786	0.0785
	Post-monsoon	0.0787	0.0676	0.0670	0.0705	0,0719
	Intensity means	0.0811	0.0701	0.0730	0.0746	
	SE ±m/plot	0.0063				
	C.D. I	-				
	C.D. II	-				
Malabar	Pre-monsoon	0.0668	0.0641	0,0644	0.0660	0,0653
	Post-monsoon	0.0629	0.0599	0.0594	0.0593	0.0604
	Intensity means	0.0648	0.0620	0.0619	0.0627	
	SE ±m/plot	0.0047				
	C.D. I	-				
	C.D. II	-				
Mysore	Pre-monsoon	0.0787	0.0765	0.0671	0.0779	0.0751
	Post-monsoon	0.0712	0.0669	0.0690	0.0667	0.0689
	Intensity means	0.0750	0.0717	0.0681	0.0733	
	SE ±m/plot	0.0067				
	C.D. I	-				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D. II - C.D. for comparing season-intensity interaction means.

4.4.1.2 Potassium/Magnesium ratio.

The details are furnished in Table 21(b) and Appendix-XXI.

None of the cultivars showed any significant variation in the K/Mg ratio in the soils around plants at different degrees of disease intensity. In all the cultivars the ratio narrowed after the monsoon. However, this was significant only with the cultivar Mysore while others showed only a non significant tendency for decrease (Fig. 5b).

The ranges of K/Mg ratios at different levels of disease intensity were 1.351 to 1.503, 1.100 to 1.186 and 1.270 to 1.333 respectively for the cultivars Vazhukka, Malabar and Mysore.

4.4.2 Plant factors.

The details of K/(Ca+Mg) and K/Mg ratios in the plant are furnished in Tables 21(c) and 21(d) and Appendices XXII and XXIII respectively.

4.4.2.1 Potassium/(Calcium + Magnesium) Ratio.

All the cultivars indicated a highly significant variation in the K/(Ca+Mg) ratio at different levels of disease intensity. In all the three cultivars the ratio at first showed a decline but then increased with the severity of the disease (Fig.5c). In the cultivar

Table 21(b). K/Mg Ratio in the soil for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean K/Mg ratio in the soil for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
	Pre-monsoon	1.595	1.474	1.436	1.465	1.492
	Post-monsoon	1.412	1.381	1.267	1.349	1.352
Vazhukka	Intensity means	1.503	1,428	1.351	1.407	
	SE ±m/plot	0.1341				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	1.253	1.156	1140	1.209	1.189
	Post-monsoon	1.119	1.102	1.061	1.107	1.097
Malabar	Intensity means	1.186	1.129	1.100	1.158	
	SE ±m/plot	0.0797				
	C.D. I	-				
	C.D.II	-				
	Pre-monsoon	1.448	1.347	1.382	1.367	1.386
	Post-monsoon	1.217	1.192	1.238	1.280	1.232
	Intensity means	1.333	1.270	1.310	1.324	
	SE ±m/plot	0.1157				
	C.D. I	-				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D. II - C.D. for comparing season-intensity interaction means.

Table 21(c). Plant K/(Ca+Mg) ratio for the cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean Plant K/(Ca+Mg) ratio for disease intensity groups.				Seasonal means
		Healthy	Low	Medium	High	
	Pre-monsoon	1.008	0.926	0.864	1.012	0.952
	Post-monsoon	0.963	0.841	0.818	0.912	0.884
Vazhukka	Intensity means	0.985	0.884	0.841	0.962	
	SE ±m/plot	0.0286				
	C.D. I	0.0564				
	C.D. II	-				
	Pre-monsson	1.014	0.932	0.859	0.967	0.943
	Post-monsoon	0.983	0.797	0.833	0.810	0.856
Malabar	Intensity means	0.998	0.865	0.846	0.888	
	SE ±m/plot	0.0296				
	C.D. I	0.0583				
	C.D. II	-				
	Pre-monsoon	1.035	0.785	0.841	1.034	0.924
	Post-monsoon	0.930	0.691	0.746	0.877	0.811
Mysore	Intensity means	0.983	0.738	0.794	0.956	
	S.E. ±m/plot	0.0264				
	C.D. I	0.0519				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D.II - C.D. for comparing season-intensity interaction means.

Vazhukka, the highest mean ratio was given by healthy plants (0.985) which was found to be on par with the severely infected plants (0.962). However, plants showing low and medium level of disease incidence were found to be on par for their mean K/(Ca+Mg) ratio (0.884 and 0.841 respectively. However, the K/(Ca + Mg) ratio of the diseased plants were significantly different from those of healthy plants.

In the cultivar Malabar the highest mean ratio for K/(Ca+Mg) was given by the healthy plants (0.998) followed by the plants showing high (0.888), low (0.865) and medium (0.846) level of disease incidence. However, the plants at high, medium, and low levels of the disease were found to be on par for their K/Ca+Mg) ratio.

In the cultivar Mysore, the highest mean ratio was given by the healthy plants (0.983). However, these plants were significantly different from the plants showing medium level of incidence (0.794). The lowest value was recorded by the plants at low level of disease incidence (0.738) which was significantly different from all other plants.

4.4.2.2 Potassium/Magnesium Ratio.

The results revealed that there was no significant variation in the K/Mg ratio in plants at different intensity levels of the disease. However, the ratio narrowed after the monsoon period (Fig.5d).

Table 21(d). Plant K/Mg ratio for the three cultivars at different intensities of the disease during the two seasons.

Cultivar	Season	Mean Plant K/Mg ratio for disease intensity groups				Seasonal means
		Healthy	Low	Medium	High	
	Pre-monsoon	3.006	2.826	2.700	3.062	2.898
	Post-monsoon	2.777	2.499	2.437	2.679	2.598
Vazhukka	Intensity means	2.892	2.662	2.568	2.870	
	SE ±m/plot	0.1756				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	2,737	2.375	2,463	2.311	2.529
	Post-monsoon	2.311	2.052	2.155	2.737	2.169
Malabar	Intensity means	2.524	2.215	2.309	2.346	
	SE ±m/plot	0.1348				
	C.D. I	-				
	C.D. II	-				
	Pre-monsoon	2.786	2.499	2.480	2.632	2.599
	Post-monsoon	2.362	2.157	2.429	2.462	2.352
	Intensity means	2.574	2.328	2.455	2.547	
	SE ±m/plot	0.1352				
	C.D. I	-				
	C.D. II	-				

C.D. I - C.D. for comparing intensity means.

C.D. II - C.D. for comparing season-intensity interaction means.

The range of mean K/Mg ratios for the different cultivars at the different disease intensity levels, were 2.568 to 2.892, 2.215 to 2.524 and 2.328 to 2.574 for Vazhukka, Malabar and Mysore cultivars respectively.

4.5 Correlation studied between Crop yield and Nutrient Factors

Correlation between all the plant and soil nutrient factors with the yield of cardamom was worked out, ignoring the disease factor. The results obtained are presented herein.

4.5.1 Nutrient content of soils.

The different soil nutrient factors were found to influence the yield in all the three cultivars of cardamom studied. The correlation coefficients of soil nutrient factors with yield are presented in Table 22(a).

4.5.1 It may be observed from the Table 22(a) that, among the different nutrients, the available phophorus content of soil showed maximum correlation with yield in all the three cultivars of cardamom ($r = 0.666$, 0.555, 0.626, respectively for Vazhukka, Malabar and Mysore. All the other nutrients showed varying degrees of correlation with yield in the three cultivars.

In Vazhukka, the next highest correlation was obtained for exchangeable potassium ($r = 0.528$)

Table 22. Simple correlation coefficients

(a) Field versus soil nutrient factors

Cultivar	Soil nutrient factors							
	Total nitrogen	Available Phosphorus	Exchangeable potassium	Exchangeable calcium	Exchangeable magnesium	Exchangeable iron	Exchangeable manganese	Exchangeable zinc
Vazhukka	0.105 NS	0.666**	0.528**	0.196*	0.403**	0.423**	0.138 NS	0.278**
Malabar	0.504**	0.743**	0.1224 NS	0.255**	0.166*	0.525**	0.493**	0.266**
Mysore	0.205*	0.626**	0.481**	0.052NS	0.164*	0.630**	0.582**	0.102 NS

(b) Yield versus plant nutrient factors

Cultivar	Plant nutrient factors							
	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Iron	Manganese	Zinc
Vazhukka	0.302**	0.988**	0.208**	0.373**	0.784**	0.399**	0.075 NS	0.164*
Malabar	0.518**	0.847**	0.743**	0.187**	0.336**	0.463**	0.358**	0.283**
Mysore	0.797**	0.869**	0.448**	0.514**	0.457**	0.388**		

* Significant at 5% level.
** Significant at 1% level
NS Non-significant.

followed by exchangeable iron and magnesium (r=0.423 and 0.403 respectively). Total soil nitrogen and exchangeable manganese showed only poor correlation with yield.

In Malabar, the correlation with yield was noted next to phosphorus for iron (r = 0.505) manganese (r = 0.493) and nitrogen (r = 0.540) while a a non-significant correlation was observed for potassium (r = 0.122). The correlation between yield and soil content of exchangeable calcium, magnesium and zinc was poor.

For the cultivar Mysore also, the yield was correlated with exchangeable iron (r = 0.630) and manganese (r = 0.582) next to available phosphorus. However, the exchangeable zinc and calcium were found to be uncorrelated with the yield of capsules per clump (r = 0.102 and 0.052).

4.5.2 Nutrient content of plants.

The results indicated that the yield of capsules per clump was positively correlated with the nutrient content of plants.

Maximum association was noted for phosphorus in all the three cultivars and their respective correlation coefficients (r) were 0.988, 0.847 and 0.869 for the cultivars Vazhukka, Malabar and Mysore.

Table 23. Effect of light intensity on chenthal disease (mean interaction scores between light and disease intensity).

		Intensities of light			Means
		Low	Medium	high	
	Healthy	3.67	8.00	5.00	5.56
Intensities	Low	12.00	21.33	14.00	15.78
of the	Medium	14.00	36.00	33.00	27.67
disease	High	10.67	37.33	64.00	37.33
	Meang	10.08	25.67	29.00	

In Vazhukka, phosphorus was followed by magnesium (r=0.784) while in Malabar, it was potassium (r = 0.743) that followed phosphorus. In the cultivar Mysore a highest correlation coefficient of 0.797 for plant nitrogen content could be obtained which ranked second after phosphorus in its association with the yield of capsules.

The cultivar Malabar showed significant correlation between manganese content and capsule yield while the cultivars Vazhukka and Mysore expressed only a non-significant correlation. All the cultivars recorded positive correlation for iron and zinc with yield of capsules per clump.

4.6 Observations made to study the effect of Light intensity on the incidence of Chenthal disease

The results are furnished in Table 23 and Appendix-XXIV.

The results revealed that there was significant interaction between different levels of light intensity and disease intensity. The highest mean interaction score was recorded by the severely infected plants receiving high light intensity (64.00) while the healthy plants receiving low level of light intensity recorded only a mean interaction score of 3.67.

DISCUSSION

DISCUSSION

The results of the study to elucidate the role of different nutrient elements on the development of chenthal disease in cardamom and the effect of shade on the intensity of the disease are discussed in this chapter.

5.1 Growth characters of cardamom

5.1.1 Number of tillers per clump.

The number of tillers produced per clump in the three cultivars of cardamom viz., Vazhukka, Malabar and Mysore at different levels of disease intensity did not show any significant variation indicating that the incidence of the disease did not affect the production of tillers or the general growth characters of the plant. Cardamom is a perennial crop in which the tillers are produced from the early vegetative phase onwards and continues even after the maturity of the plant. Sufficient number of tillers will be established before the plant starts bearing and hence a sudden attack of chenthal disease on the leaves of the plant may not probably have any significant effect on the total number of tillers in a clump. At advanced stage of infection, however, some of the tillers may get damaged as observed and reported by George (1978).

5.1.2 Number of panicles per clump.

The number of panicles produced per clump was not

significantly different at different levels of disease intensity showing that the disease had not seriously affected the production of panicles.

5.1.3 Number of capsules produced per clump.

The results presented in Table-2 indicated that all the cultivars showed a decreasing tendency with regard to the number of capsules produced per clump with an increase in the severity of the disease. Although this reduction was not statistically significant, the percentage reduction was found to be 8.29, 8.88 and 12.25 respectively for the cultivars Vazhukka, Malabar and Mysore (Fig.2). Considerable drying up of flowers on the panicles was noticed in the case of severely infected plants. The reduction in the number of capsules per clump could thus be attributed to the drying up of blossoms due to the disease. A similar observation was made by George (1978) in his studies on the effect of disease infestation in cardamom plantations.

5.1.4 Weight of green capsules per clump.

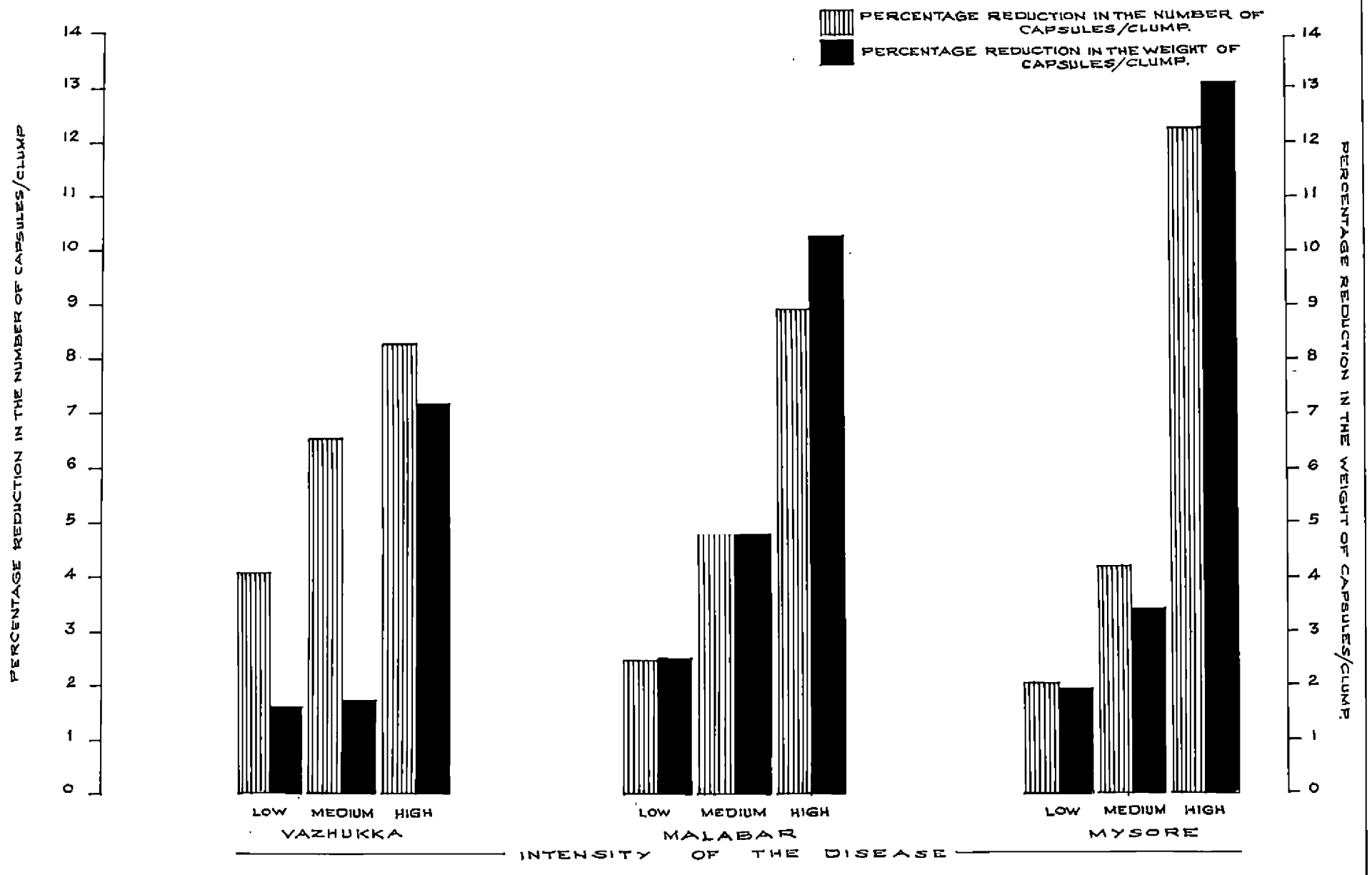
A reduction in the weight of capsules produced per clump of the order of 29.45 g for Vazhukka, 71.45 g for Malabar and 22.55 g for Mysore was noticed between their respective healthy and severely infected plants. (Table-2). Although this reduction in the weight of

capsules per clumps at different levels of disease intensity was not statistically significant, there was a decreasing trend in the weight of capsules per clump with an increase in the severity of the disease (Fig.2). The percentage reduction in the weight of capsules per clump for the three cultivars worked out to be 7.19, 10.27 and 13.09 respectively for Vazhukka, Malabar and Mysore. The decrease in the weight of capsules could be the direct result of a diminution in the number of capsules produced by these plants. George(1978) reported a similar yield reduction in cardamom due to the incidence of chenthal disease.

Another probable reason contributing to the reduction in the yield of disease affected plants could be a decrease in the quantity of photosynthates available for the filling up of capsules on account of the damage caused to the net photosynthetic area of the leaf lamina. It could be noted that in plants most severely affected by the disease, as high as 50 per cent of the leaf area was covered with watersoaked lesions which could suppress both photosynthetic assimilation as well as translocation of the assimilates needed for the filling up of the capsules.

The study of the growth characters of the plants affected by the disease did not reveal any remarkable

FIG. 2. PERCENTAGE REDUCTION IN THE YIELD OF CARDAMOM AT DIFFERENT INTENSITIES OF THE DISEASE.



reduction in the number of tillers as well as panicles present in a clump. The effect of the disease, though not statistically significant, was evident only on the number and weight of capsules produced per clump. As the photosynthetic efficiency of the plants diminishes with the severity of the disease, it may be reflected on the emergence of lesser number of tillers in the succeeding years.

5.2 Soil chemical properties and plant nutrient content

5.2.1 Electrochemical properties of the soil.

Since the electrochemical properties of the soil such as pH and electrical conductivity were more or less similar for all the cultivars in the three locations at different levels of disease intensity, it may be concluded that these factors were not having any particulars effect on the development of the disease.

5.2.2 Soil and plant nutrient factors.

5.2.2.1 Nitrogen.

The total nitrogen content of the soils as well as the plants did not show any significant difference at different levels of disease intensity in any of the three cultivars studied (Tables 5 and 13), both during the pre-monsoon and post-monsoon periods. This revealed that nitrogen may have only a minor role in the syndrome

development of the disease. It may be noted from Table-5 that the nitrogen content of the soil samples in the present study were in the"high"rating range for nitrogen and that there cannot be a possibility of nitrogen deficiency being a predisposing condition for the development of the disease. Kulkarni (1970), Dattu Rao (1971) and Zachariah (1975) also reported very high values for the easily oxidisable organic matter content of the cardamom soils which indirectly indicate the high nitrogen status of these soils.

The mean soil nitrogen content around the plants at different levels of disease intensity showed a significant decrease after the monsoon in all the cultivars studied. The mean reduction was 0.018 per cent for the cultivar Vazhukka, 0.017 per cent for Malabar and 0.019 per cent for Mysore. It could be noted from the results of plant analysis (Table-13) that this reduction in the soil nitrogen content after the monsoon was not associated with a corresponding increase in the content of plant nitrogen.

The reduction in the soil nitrogen content could be accounted by the increased crop demand during the monsoon period for the production of more of vegetative matter by way of new shoots and tillers. Additional nitrogen is also necessary for the development of the

capsules which emerge during this period. Kulkarni (1971) reported a higher demand of the cardamom plant for nitrogen and potassium for the development of capsules. The reduction in the soil nitrogen content observed after the monsoon could thus be the result of an increased rate of absorption by the plants for the development of green matter as well as for capsules which are formed during the monsoon period.

The mean nitrogen content of the plant samples, though not significant, also showed a reduction after the monsoon (Table-13). This could partly be a result of the translocation of nitrogen from the leaves to the developing capsules which are formed during this period. Kulkarni (1971) had reported that about 0.122 kg of nitrogen was removed for each kilogram of dry capsules produced.

The lowering of plant nitrogen content can possibly be also due to a dilution effect in the plant consequent to the emergence of fresh tillers and other vegetative parts during the monsoon period.

5.2.2.2 Phosphorus.

It was seen that the available phosphorus content of soils was not significantly different around the plants at different intensities of the disease (Table-6). It could be considered that, like nitrogen, the available

phosphorus content of the soil may play only a minor role in the development of disease symptoms. The content of phosphorus was also not significantly different among plants at the different intensities of the disease.

Compared to the healthy plants, a gradual reduction in the content of phosphorus was noticed in the leaves of plants affected by the disease (Table-14). Although this reduction was not statistically significant, it may point either to a lesser absorption rate or a poor utilisation capacity of the plants associated with an increase in the severity of the disease. This condition can also be a result of an increased utilisation of high energy phosphates of ATP molecules to overcome the stress condition in the plant.

The effect of season in enhancing the available phosphorus content of the soil was found to be insignificant (Table-6). Even though there was a possibility of more of phosphorus coming into the available pool, due to the seasonal effects leading to an enhanced rate of mineralization of organic phosphorus and dissolution of insoluble inorganic phosphorus compounds to available forms, no increase in the available phosphorus content of the soil was noticed after the rains. The additional phosphorus requirement

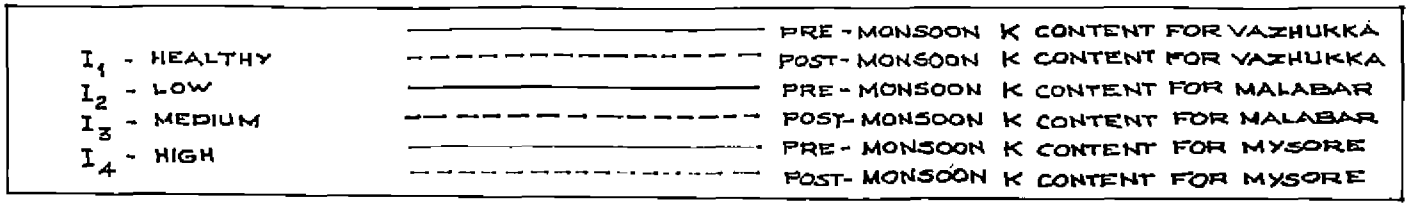
for the vegetative flush formed during this period would have come mainly from this source and hence no increase in the available phosphorus content of soils could be noticed. Kulkarni (1971) reported that the phosphorus requirement of cardamom was only very little compared to the requirememts of other major nutrient elements like nitrogen and potassium.

The absence of a significant difference in the content of phosphorus in the soil as well as in plant which are severely infected by the disease, eliminates the probability of this element acting as a decisive factor in the incidence of chenthal disease.

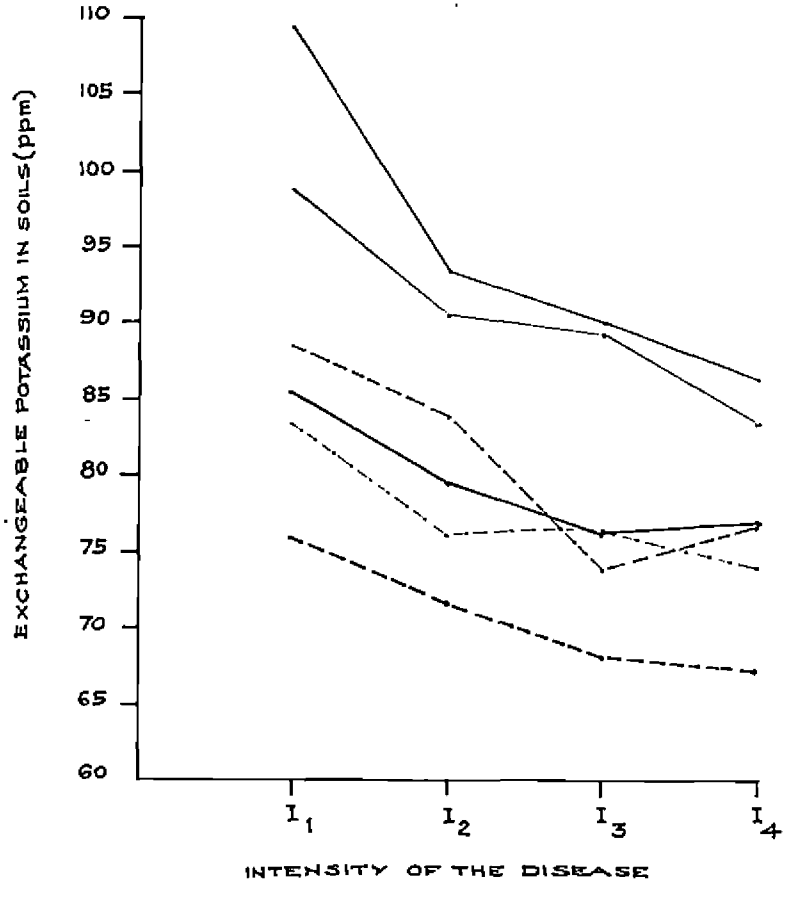
5.2.2.3 Potassium.

The content of exchangeable potassium of the soils did not vary much at different levels of disease intensity in any of the three sites selected for the study (Table-7). However, the plant potassium content at different stages of disease intensity expressed a statistically significant variation. In the healthy plants the potassium content was 2.66, 2.48 and 2.61 per cent while in the corresponding severely infected plants it was 2.14, 2.04 and 1.86 per cent respectively for the cultivars Vazhukka, Malabar and Mysore (Table-15). The decrease in the potassium content was more prominent in the cultivar Mysore compared to the other two. The decrease

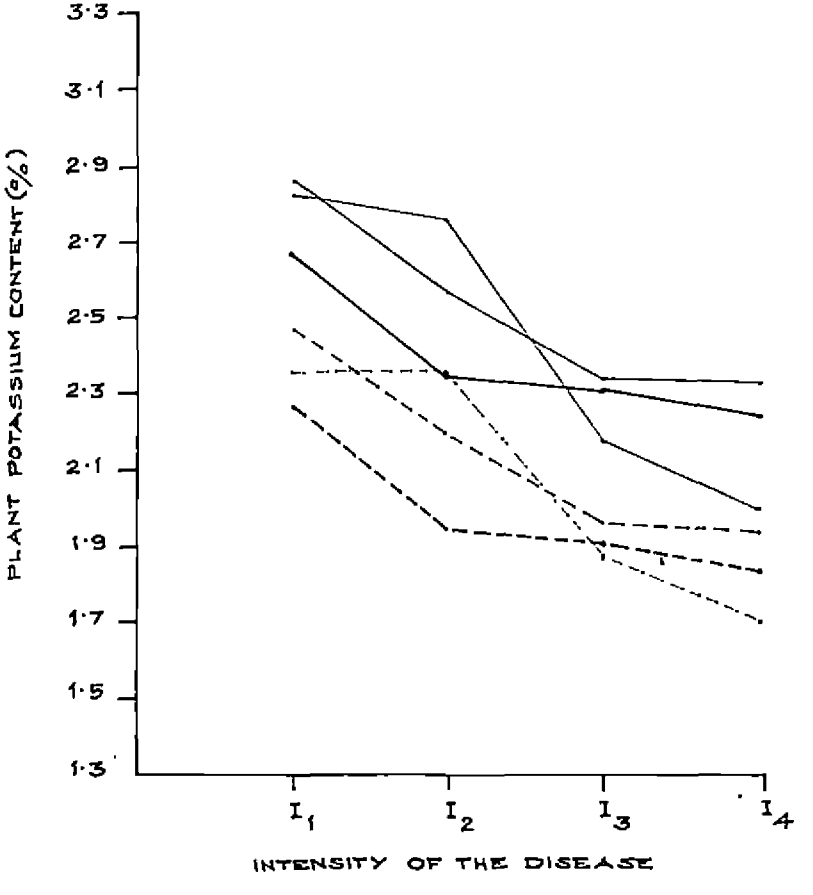
FIG. 3. POTASSIUM CONTENT OF SOILS AND PLANTS FOR THE TWO SEASONS AT DIFFERENT DISEASE INTENSITY LEVELS.



a) EXCHANGEABLE K CONTENT OF SOILS.



b) K CONTENT OF PLANTS.



in the potassium content observed in the diseased plants (Fig.3b) definitely indicate a lesser rate of absorption or assimilation of this nutrient in such plants. Potassium is known to be associated with imparting disease resistance to most crops (Agarwala and Sharma, 1976). The low content of potassium noticed in the diseased plants could be presumed to have acted as a predisposing factor, making the plants more susceptible for the incidence of the disease. Alternatively, the physiological condition associated with the disease might have affected the uptake as well as translocation of potassium by the plants resulting in a low status of plant potassium, as evidenced from the inverse relationship of the potassium content in plants with the severity of the disease.

A reduction in the exchangeable potassium content of the soils was noticed after the monspon period(Fig.3a). This may be attributed to the higher uptake of potassium for the production of new tillers as well as development of capsules on the panicles. Nutrient uptake studies on cardamom conducted by Kulkarni (1971) showed that the crop required higher quantities of potassium at the time of panicle and capsule formation. Further, one hectare of cardamom removed 52.11 kg of potassium from the soil while the corresponding figures for nitrogen and phosphorus were only 25.97 and 4.35 kg respectively. The panicle.

husk and seed contained 3.45, 4.28 and 3.72 per cent potassium respectively.

A comparatively higher requirement of potassium by the cardamom plant is indicative of the decisive role of potassium in the nutrition of the plant. As a significant correlation between the intensity of the disease and potassium content was obtained, the importance of potassium in the development of the disease cannot be ignored.

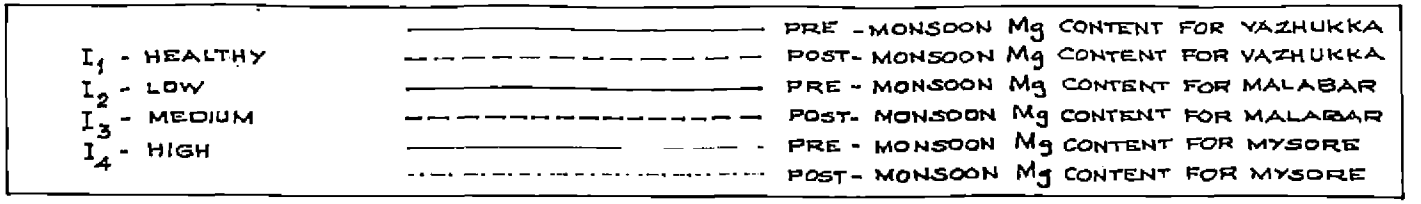
None of the cultivars showed any season-intensity interaction indicating that the disease incidence is not a direct result of the joint action of season and intensity.

5.2.2.4 Calcium and magnesium.

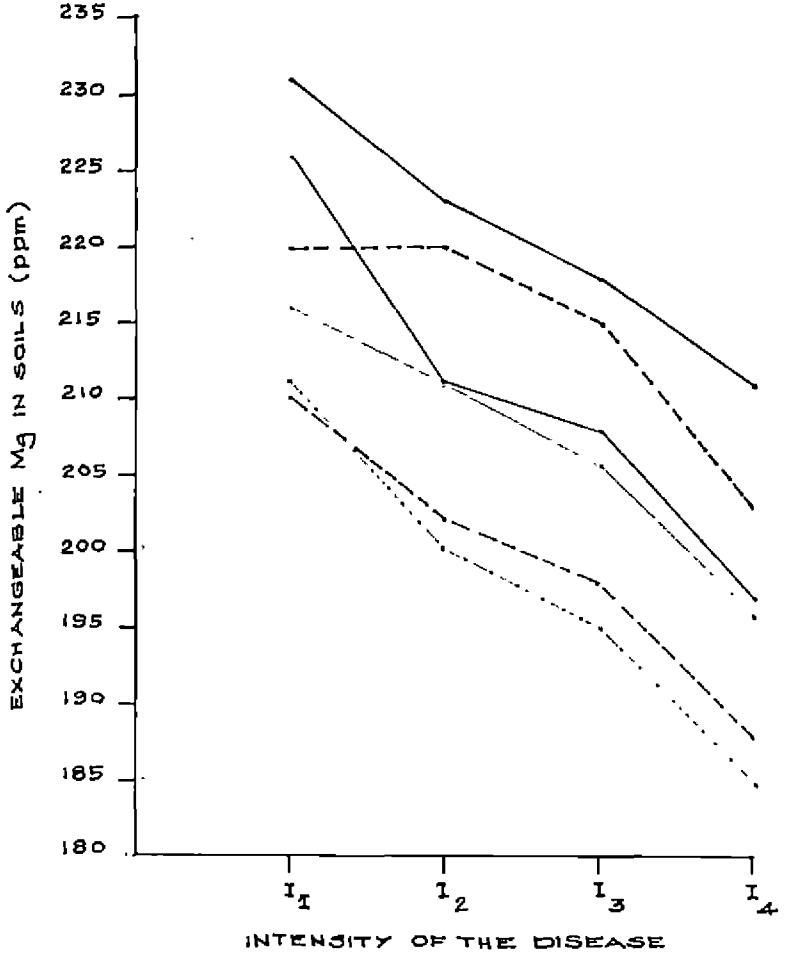
Exchangeable calcium content of the soils around the plants were not found to differ significantly between the different intensities of the disease or between the two seasons studied (Table-8). This may indicate a poor rate of removal of calcium from the soil for the newly formed tillers and capsules.

The calcium content of the plants did not differ significantly at different levels of disease intensity. The seasonal variation in plant calcium content was also negligible, though all the plants suffered a slight decrease after the monsoon (Table-16).

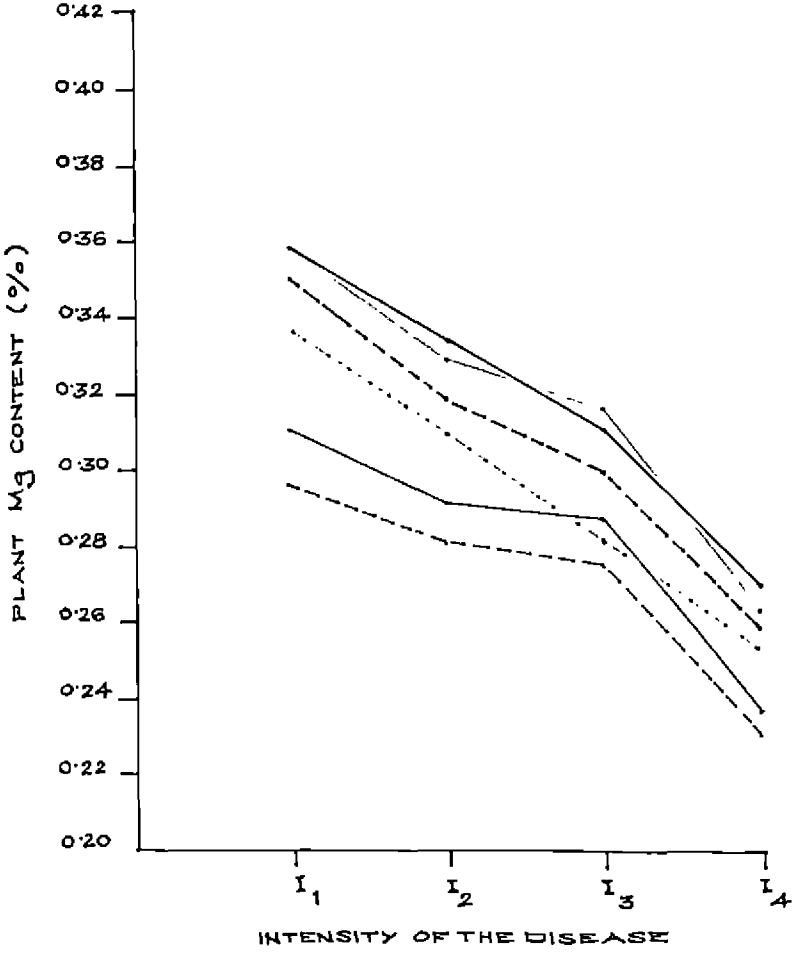
FIG.4. MAGNESIUM CONTENT OF SOILS AND PLANTS FOR THE TWO SEASONS AT DIFFERENT DISEASE INTENSITY LEVELS.



a) EXCHANGEABLE Mg CONTENT OF SOILS.



b) Mg CONTENT OF PLANTS.



The magnesium content of soil and plant showed significant differences with respect to the different levels of disease intensity in all the three cultivars of cardamom; a low magnesium status being associated with disease affected plants and their corresponding soils (Fig.4). The difference in the magnesium content of soils around healthy and diseased plants were 26 ppm for the cultivar Vazhukka, 18 ppm for Malabar and 21 ppm for Mysore (Table-9), while the respective variation in the plant magnesium content was 0.071 per cent for the cultivar Mysore (Table-17).

The diminution in the chlorophyll content of plants heavily affected by the disease could be attributed to the lack of supply of magnesium to the leaves, or to a degeneration of chlorophyllous tissues. The decreased rate of photosynthesis found in magnesium deficient plants could perhaps be largely account for in terms of the known role of magnesium as a constituent of chlorophyll and inactivation of several enzymes participating in the dark reactions in photosynthesis (Agarwala and Sharma, 1976). However, the typical magnesium deficiency symptoms as described by Deshpande (1973) were not evident in any of the plants, except the typical brownish watersoaked lesions of chemthal disease on the leaves of infected plants. The low

content of magnesium in the diseased plants together with a low content of exchangeable magnesium in the soils of the affected plants were suggestive of a lower level of magnesium uptake by the infected plants compared to healthy ones. The low magnesium content of plants, presumably may act as a predisposing factor for the development of the disease. However, this has to be verified by supplying magnesium salts to the plant either through the soil or as a foliar spray and noting its effect on the incidence of the disease, by conducting suitable experiments.

A significant reduction in the echangeable magnesium content of the soils was noticed in all the three locations after the rains, although a corresponding increase in the plant magnesium content was not evidenced (Table 9 and 17). The reduction in the exchangeable magnesium content of the soil could be largely attributed to the very high leaching losses from the soils during monsoon period as crop removal was found to be only negligible. This is in accordance with the findings of Kulkarni (1971) that the requirement of magnesium for cardamom was only meagre, compared to other nutrients

5.2.2.5 Iron, manganese and zinc.

The exchangeable iron, manganese and zinc content of the soils around plants at different levels of disease

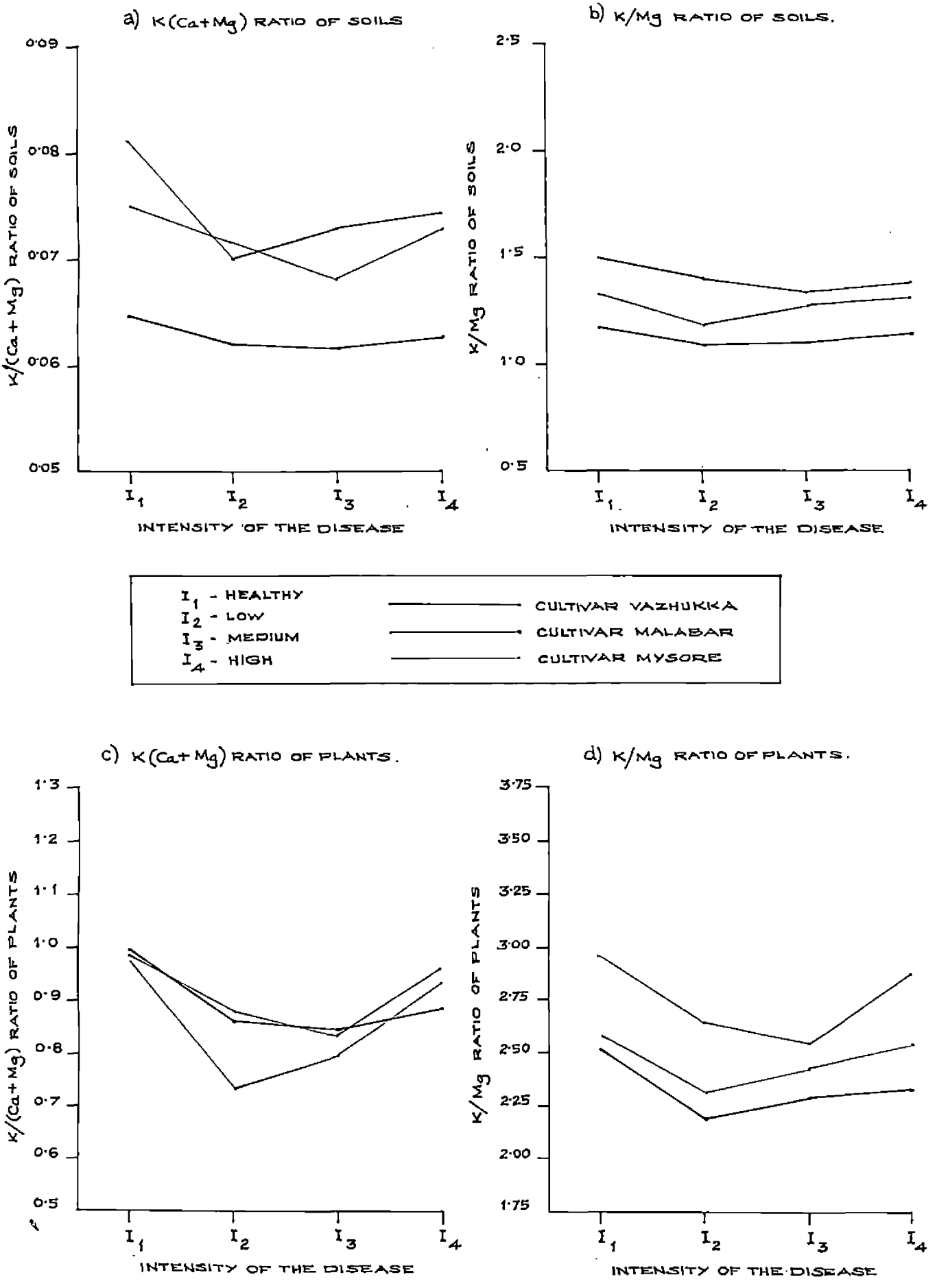
intensity did not differ significantly in any of the three cultivars studied. However, there was an increasing trend in the exchangeable iron and manganese content after the monsoon which could be attributed to the relative accumulation of these elements as a result of heavy leaching of other bases, a typical characteristic of humid tropical soils (Tables 10 and 11). The plant content of iron, manganese and zinc also showed no significant variation with the season or intensity of the disease indicating that these plant nutrient elements were not directly involved in the development of the disease.

5.3 Cation Ratios

The K/(Ca + Mg) and K/Mg ratios of the soil at the three different sites indicate a decreasing trend with the severity of the disease incidence (Fig.5). However, the decrease was statistically not significant for any of the locations. The decreasing trend could be attributed to an imbalance in the ratio either due to an increased utilization of one element over the others or due to a shift in the concentration of one of the elements from the exchangeable pool to unavailable pool.

A similar trend was shown by the different cultivars also for the K/(Ca+Mg) and K/Mg ratio in the plants (Fig.5). Thus it would be concluded that a shift in

FIG.5. CATION RATIOS OF SOILS AND PLANTS AT DIFFERENT DISEASE INTENSITY LEVELS.



the cationic ratio might have helped in the development of the disease or the development of the disease itself might have altered the cationic balance in the plants resulting in a shift in the ratio. In either case, the disease was found to be associated with an imbalance in the ratio of potassium and magnesium in the soil as well as plant.

5.4 Correlation studies between crop yield and nutrient factors

The different soil and plant nutrient factors were found to be directly correlated with the yield of cardamom in all the three cultivars (Table-22).

The best correlation with the yield was obtained for phosphorus both in the soil ($r = 0.666$, 0.743 and 0.626 respectively for Vazhukka, Malabar and Mysore cultivars) and in the plant ($r = 0.988$, 0.847 and 0.869 for Vazhukka, Malabar and Mysore cultivars respectively) indicating that in spite of the low requirement of this element, cardamom yields were highly influenced by the content of phosphorus in the soil as well as in the plant.

The exchangeable iron gave fairly good correlation for the cultivars Malabar and Mysore ($r = 0.525$ and 0.630 respectively) while the cultivar Vazhukka showed good correlation with potassium ($r = 0.528$) next to phosphorus. However, in all the cases exchangeable calcium and zinc

were found to be not correlated with the yield of cardamom indicating the poor role of these nutrients in deciding the yield of the crop.

The different cultivars indicated differential association between their yield and plant content of nitrogen, potassium and magnesium. All the cultivars showed direct correlation between the yield of capsules and the plant content of iron and zinc indicating that these nutrients also may have an influence on the production of capsules.

5.5 Effect of Light intensity on the incidence of Chenthal disease

The results (Table 23) indicated that as the intensity of light falling on the plant increased, there was a significant increase in the incidence of the disease. This result is in accordance with the report of George (1978) that the chenthal disease was found to be more severe in thinly shaded areas.

It is wellknown that cardamom is a shade loving plant which prefers diffused sunlight. Hence higher light intensities might have produced some physiological derangement in the plant leading to the development of the symptoms of chenthal disease.

SUMMARY

SUMMARY AND CONCLUSIONS

An investigation was carried out to study the nutritional status of the soil and plant in relation to the incidence of chenthal disease in three cultivars of cardamom viz., Vazhukka, Malabar and Mysore, at the College of Agriculture, Vellayani. Soil and plant samples for the study were collected from the cardamom plantations in the High Ranges of Idukki district of Kerala State during the periods March,1982 (pre-monsoon period) and September, 1982 (post-monsoon period).

The plants were categorized into four disease intensity groups viz., healthy, low, medium and high based on the score chart prepared (Fig.1). Twenty plant samples from each category of the disease intensity and their corresponding soils were collected for the three cultivars during the pre-monsoon and post-monsoon periods. These samples were analysed by suitable analytical techniques to assess their content of N, P, K, Ca, Mg, Fe, Mn and Zn. The data was subjected to statistical analysis to bring out the association between these nutrients and disease intensity during the two seasons. Correlation between these nutrients and yield of cardamom were also worked out.

The important results and conclusions drawn from the study are summerised hereunder.

1. The growth characters such as number of tillers and

number of panicles per clump did not express any variation with the intensity of the disease indicating that the disease could not produce any marked reduction in the number of tillers or panicles. However, the yield of cardamom (both number and weight of green capsules per clump) showed a decrease with the severity of the disease. The reduction in the number and weight of capsules per clump of severely affected plants over the healthy plants were 8.29 and 7.19 per cent for the cultivar Vazhukka 8.88 and 10.27 per cent for Malabar and 12.25 and 13.09 per cent for Mysore cultivars ~~respectively~~. However, this reduction in yield was not statistically significant.

2. Total nitrogen, available phosphorus, exchangeable potassium, calcium, iron, manganese and zinc of the soils were not found to influence the development of the disease in any of the cultivars studied. The content of nitrogen phosphorus, calcium, iron, manganese and zinc also were more or less similar in all the plants at different levels of the disease indicating their minor role in the development of the disease symptoms.

3. Although the exchangeable potassium content of the soil was not significantly different, the plant content of the element recorded a decrease with an increase in the disease intensity. Hence it may be presumed that potassium could be associated with the disease.

4. Exchangeable magnesium content of the soils showed a decrease with the severity of the disease in all the cultivars. Similarly, the plant magnesium content also showed decreasing trends with the increase in the intensity of the disease indicating that magnesium may probably be associated with the incidence of the disease.

5. The monovalent to divalent ratio (K/Ca+Mg) ratio of both the soil and plant narrowed with the severity of the disease. A slight increase in the ratio was noticed in the severely affected plants. K/Mg ratio of the soil and plant also showed similar trends. Hence it may be inferred that the disease was probably associated with an imbalance in the monovalent to divalent cationic ratio. However, whether the development of the disease was a result of an imbalance in the ratio or an imbalance in the ratio resulted in the disease development could not be revealed from the results.

6. Correlation studies between the yield and nutrient status of soil and plant revealed that among the different nutrient, phosphorus was well correlated with the yield of cardamom in all the cultivars. The different cultivars expressed differential response to other nutrients with their yield. The correlation between the various nutrients in the soil and plant with their yields for the three cultivars can be ranked as follows:

Soil nutrient factors.

Cultivar Vazhukka - P > K > Fe > Mg > Zn > Ca > Mn > N

Cultivar Malabar - P > Fe > N > Mn > Zn > Ca > Mg > K

Cultivar Mysore - P > Fe > Mn > K > N > Mg > Zn > Ca

Plant nutrient factors.

Cultivar Vazhukka - P > Mg > Fe > Ca > N > K > Zn > Mn

Cultivar Malabar - P > K > N > Fe > Mn > Mg > Zn > Ca

Cultivar Mysore - P > N > Ca > Mg > K > Fe > Zn > Mn

7. The observations made to study the effect of light on the intensity of the disease revealed that, the disease was most severe with the plants receiving maximum sunlight while the plants growing under shaded conditions, were comparatively free from the disease. This shows that light plays an important role in aggravating the disease and stresses the importance of shade in cardamom plantations.

In general from the results of the present study nonutrient factors could be ascribed as a predisposing factor for the incidence of the disease. The development of the disease could only be correlated with an imbalance in the K and Mg content in the plant. A shift in the ratio of K and Mg might have affected the metabolic activities of the plant resulting in the development of the disease or the disease might have affected the utilisation pattern of the plant leading to a shift in their ratio.

Based on the findings of the present study, the following lines of work can be taken up.

1. Studies on the effect of potassium and magnesium in different ratios on the diseased plants by supplying them either as a foliar spray or as a soil treatment.

2. Light management studies in the affected plantations to reduce the intensity of the disease during summer.

3. Studies on the effect of phosphorus in increasing the yield of cardamom.

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* Original not seen

APPENDICES

APPENDIX - I

Analysis of Variance Table - Growth characters of cardamom.

Growth characters	Source	df	Mean Squares for cultivars		
			Vazhukka	Malabar	Mysore
Number of tillers/ clump	Disease intensity	3	7.0	18.5	95.1
	Error	76	18.1	11.6	1589.4
Number of panicles/ clump	Disease intensity	3	1.4	2.6	4.4
	Error	76	51.4	23.6	13.9
Number of capsules/ clump	Disease intensity	3	29203.6	28157.4	26127.5
	Error	76	41716.5	29385.9	31576.2
Weight of capsules/ clump	Disease intensity	3	9056.8	18563.2	15127.0
	Error	76	19888.7	1226389.3	16136.7

APPENDIX - II

Analysis of Variance Table - Soil pH

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	0.0437	0.0230	0.0160
Season	1	0.0040	0.0040	0.0640
Season x intensity	3	0.0603	0.0160	0.0240
Error	152	0.0319	0.0152	0.1481

APPENDIX - III

Analysis of Variance Table - Electrical conductivity of soil

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	0.0010	0.0037	0.0027
Season	1	0.0040	0.0040	0.0010
Season x intensity	3	0.0067	0.0027	0.0037
Error	152	0.0048	0.0091	0.0100

APPENDIX-IV

Analysis of Variance Table - Percentage nitrogen in the soil

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	0.00140	0.00120	0.00069
Season	1	0.01030*	0.01120*	0.01440*
Season x Intensity	3	0.00060	0.00030	0.00002
Error	152	0.00190	0.00230	0.00260

APPENDIX - V

Analysis of Variance Table - Available phosphorus in the soil (ppm)

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	31.0383	29.6185	12.8510
Season	1	67.2209	20.4776	8.5748
Season x Intensity	3	5.5309	0.5267	0.0577
Error	152	38.2647	38.8133	54.9103

* Significant at 5% level.

APPENDIX - VI

Analysis of Variance Table - Exchangeable potassium in the soil.

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	2382.7560	594.3896	1169.2250
Season	1	8023.0560*	3159.5062*	6943.2250*
Season x Intensity	3	282.4730	99.6567	77.6250
Error	152	1179.2330	611.8490	1668.9066

APPENDIX - VII

Analysis of Variance Table - Exchangeable calcium in the soil (ppm)

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	2338.5230	977.2067	399.7733
Season	1	465.8060	369.0562	955.5062
Season x Intensity	3	6.9410	11.1079	6.1226
Error	152	2354.9290	455.2878	708.1296

* Significant at 5% level.

APPENDIX - VIII

Analysis of Variance Table - Exchangeable magnesium in the soil (ppm)

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	4525.4750**	2362.5900*	3016.1583*
Season	1	4622.5000**	3657.6562**	4473.2250**
Season x Intensity	3	6160.6920*	38.3560	2.0250
Error	152	955.9210	384.0500	778.0070

APPENDIX - IX

Analysis of Variance Table - Exchangeable iron in the soil (ppm)

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	75.1420	13.6729	313.6062
Season	1	22.5000	41.0062	345.1562
Season x Intensity	3	3.3170	17.3062	3.1062
Error	152	184.6150	270.5832	272.5168

* significant at 5 % level

** significant at 1 % level

APPENDIX - X

Analysis of Variance Table - Exchangeable manganese in the soil (ppm).

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	480.1080	1050.2733	1300.0067
Season	1	108.9000	357.0062	701.4062
Season x Intensity	3	13.3840	792.3534	4.8393
Error	152	296.2990	603.1845	617.2615

APPENDIX - XI

Analysis of Variance Table - Exchangeable zinc in the soil (ppm)

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease Intensity	3	107.2060	742.3729	656.6750
Season	1	61.2560	299.7562	372.1000
Season x Intensity	3	37.1070	34.1230	3.7167
Error	152	243.0260	2692.0080	294.6760

APPENDIX - XII

Analysis of Variance Table - Percentage nitrogen in the plant

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	0.11350	0.03450	0.00620
Season	1	0.07400	0.04690	0.05780
Season x Intensity	3	0.00470	0.00030	0.00140
Error	152	0.14210	0.118490	0.11760

APPENDIX - XIII

Analysis of Variance Table - Percentage phosphorus in the plant.

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	0.001600	0.001650	0.003013
Season	1	0.000160	0.000060	0.000159
Season x Intensity	3	0.000100	0.000003	0.000007
Error	152	0.001220	0.000968	0.001216

APPENDIX - XIV

Analysis of Variance Table - Percentage potassium in the plant

Source	df	Mean Squares for Cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	2.3937**	1.5181**	5.7276**
Season	1	5.8906**	6.4802**	5.5131**
Season x Intensity	3	0.0030	0.0044	0.0684
Error	152	0.2464	0.1636	0.1624

APPENDIX - XV

Analysis of Variance Table - Percentage calcium in the plant

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	0.07020	0.00760	0.00500
Season	1	0.00300	0.00340	0.00860
Season x Intensity	3	0.00430	0.00023	0.00060
Error	152	0.03230	0.02060	0.00378

** Significant at 1% level.

APPENDIX - XVI

Analysis of Variance Table - Percentage magnesium in the plant

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	0.0225*	0.0616*	0.0623**
Season	1	0.0041	0.0062	0.0108
Season x Intensity	3	0.0002	0.0003	0.0006
Error	152	0.0074	0.0136	0.0127

APPENDIX - XVII

Analysis of Variance Table - Iron content in the plant (ppm)

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	1058.8417	108.0000	650.8250
Season	1	93.0250	547.6000	562.5000
Season x Intensity	3	20.7417	16.5667	1.3333
Error	152	828.2842	1017.8530	724.1303

* Significant at 5% level.

** Significant at 1% level

APPENDIX - XVIII

Analysis of Variance Table - Manganese content in the plant (ppm)

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	242.8833	290.8562	1563.4080
Season	1	189.2250	522.0062	275.6250
Season x Intensity	3	0.7750	27.9563	10.8750
Error	152	1577.2428	1298.9707	1360.2260

APPENDIX - XIX

Analysis of Variance Table - Zinc content in the plant (ppm)

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	465.4167	38.4417	299.2229
Season	1	193.6000	403.2250	668.3062
Season x Intensity	3	0.7833	21.2417	28.3396
Error	152	2043.1375	480.0332	1745.2550

APPENDIX XX

Analysis of Variance Table - Soil K/(Ca+Mg) ratio

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	0.00090	0.00008	0.00030
Season	1	0.00220	0.00100	0.00150
Season x Intensity	3	0.00170	0.00002	0.00030
Error	152	0.00080	0.00044	0.00090

APPENDIX - XXI

Analysis of Variance Table - Soil K/Mg ratio

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	0.1576	0.0542	0.0310
Season	1	0.7854	0.3394	0.9533
Season x Intensity	3	0.0181	0.0119	0.0350
Error	152	0.3599	0.1271	0.2676

APPENDIX - XXII

Analysis of Variance Table - K/(Ca + Mg) ratio in the plant

Source	df	Mean Squares for cultivars		
		azhukka	Malabar	Mysore
Disease intensity	3	0.1802**	0.1865**	0.5778**
Season	1	0.1893**	0.3065**	0.5073**
Season x Intensity	3	0.0008	0.0463	0.0100
Error	152	0.0164	0.0175	0.0139

* Significant at 5% level

* Significant at 1% level

APPENDIX XXIII

Analysis of Variance Table - K/Mg ratio in the plant

Source	df	Mean Squares for cultivars		
		Vazhukka	Malabar	Mysore
Disease intensity	3	1.0047	0.6694	0.4933
Season	1	3.6117*	5.1922**	2.4431
Season x Intensity	3	0.0466	0.0279	0.2820
Error	152	0.6168	0.3633	0.3657

* Significant at 5% level

** Significant at 1% level.

APPENDIX - XXIV

Analysis of variance Table - Effect of light intensity on the disease.

Source	df	Mean Squares
Disease intensity	3	1726.991**
Light intensity	2	1223.583**
Disease x light intensity	6	474.657*
Error	24	66.0279

* Significant at 5% level

** Significant at 1% level

NUTRITIONAL STATUS OF SOIL AND PLANT IN RELATION TO THE INCIDENCE OF CHENTHAL DISEASE OF CARDAMOM

By

K. N. DILEEP KUMAR B.Sc. (Ag.)

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirement for the degree

MASTER OF SCIENCE IN AGRICULTURE

FACULTY OF AGRICULTURE

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ABSTRACT

An investigation was carried out at the College of Agriculture, Vellayani, to study the nutritional status of soil and plant in relation to the incidence of chenthal disease in three major cultivars of cardamom viz., Vazhukka, Malabar and Mysore. Soil and plant samples for the study were collected from the cardamom plantations in the High Ranges of Idukki district of Kerala State during March, 1982 (Pre-monsoon period) and September, 1982 (Post-monsoon period)

The plants were categorized into four disease intensity groups based on a score chart. Twenty plants were identified as observational plants for a cultivar from each category of the disease intensity and their growth and yield characters were studied. Plant and soil samples collected from all the observational plants during the pre and post-monsoon periods were analysed for their content of N, P, K, Ca, Mg, Fe, Mn and Zn.

The results of the study revealed that all the cultivars of cardamom showed a decreasing trend in their yield with the severity of the disease, without showing any serious difference in the number of tillers or number of panicles per clump.

Exchangeable magnesium content of the soils as well as potassium and magnesium content of plants recorded a decrease with the severity of the disease indicating a

deficiency of these elements being possibly associated with the incidence of the disease. However, soil and plant content of other nutrient elements such as N, P, Ca, Fe, Mn and Zn were not found to influence the development of the disease.

The K/(Ca+Mg) and K/Mg ratios in the soil and plant at first narrowed with the severity of the disease but, showed a slightly increasing tendency with the highly infected plants indicating an imbalance in the ratio of monovalent and divalent cations in the diseased plants.

Correlation studies between the yield of cardamom and soil and plant nutrient status indicated that among the various nutrients yield was well correlated with phosphorus content in the soil and plant. All the three cultivars showed a differential response of yield to other nutrients.

The observations made from the study on the effect of light intensity on the development of the disease showed that the disease was most severe in the plants exposed to sunlight while, the plants growing under shaded conditions were comparatively free from the disease emphasising the importance of shade for cardamom.

The findings from the present work suggest the need for further studies on the effect of phosphorus in increasing the yield of cardamom, the effect of K and Mg in various ratios on the control of the disease as well as shade management for protection of the crop from chenthal disease.