MAJOR PESTS OF GINGER IN KERALA AND THEIR CONTROL

By

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THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENT FOR THE DEGREE
MASTER OF SCIENCE IN AGRICULTURE
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF ENTOMOLOGY
COLLEGE OF AGRICULTURE
VELLAYANI, TRIVANDRUM
1989

Dedicated
To
My Parents

D E C L A R A T I O N

I hereby declare that this thesis entitled 'MAJOR PESTS OF GINGER IN KERALA AND THEIR CONTROL' 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 award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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C E R T I F I C A T E

Certified that this thesis, entitled 'MAJOR PESTS OF GINGER IN KERALA AND THEIR CONTROL' is a record of research work done independently by Sri. RAJAN MATHEW under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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ACKNOWLEDGEMENT

I express my deep sense of gratitude to Dr. George Koshy, Professor of Entomology, who was the Chairman of the Advisory Committee for his valuable guidance throughout the course of the investigations and the help rendered in the preparation of the thesis.

I am very much indebted to Dr. N. Mohan Das, Professor and Head, Department of Entomology and member of Advisory Committee for the critical suggestion given during the course of the investigation and for the very special help given during the different stages in the preparation of thesis.

My sincere thanks are due to Dr.K.I. Wilson, Professor and Head, Department of Plant Pathology and Sri. K.K. Raveendran Nair, Professor of Nematology, Department of Entomology, who are members of the Advisory Committee for giving necessary suggestions during the course of the investigation.

I express my deep gratitude to Sri.P.V. Prabhakaran, Professor and Head, Department of Agricultural Statistics for the suggestions given in designing the survey programme and in the statistical analysis and interpretation of the data.

I acknowledge the services of Sri. C. Ajithkumar, Junior Programmer, Department of Agrl. Statistics in analysing the data.

The valuable help given by Sri. Thomas Biju Mathew, Junior Assistant Professor, Department of Entomology, Sri.C. Gokulapalan and Sri. Babu George, Assistant Professors, Department of Plant Pathology is greatfully acknowledged.

I express my thanks to the Officers of the Department of Agriculture for their help during the survey programme and to Sri.D. Gyanadas, Assistant Director of Agriculture for the help given in taking photographs.

I sincerely thank my colleagues and friends for their goodwill, co-operation and help.

The neat execution of thesis typing by Sri.R. Noel is duly acknowledged.

I am thankful to the Dean, College of Agriculture for providing necessary facilities for the investigations and to the Kerala Agricultural University for providing a fellowship.

The constant encouragement and help received from my parents, brothers and sisters and relatives is remembered.

Finally I am thankful to God.

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INTRODUCTION

INTRODUCTION

Ginger is an important spice crop grown in India, valuable for culinary purpose and export earnings. It is used in food, confectionary and medicines. India is the largest producer of ginger accounting for nearly half of the world production. Kerala ranks first in the production of dried ginger among the different states in India. The production in 1988 was 47,652 metric tonnes of dry ginger from 16,591 ha of land.

Ginger of commerce is the dried rhizome of Zingiber officinale Rosc. The plant grows well upto an altitude of 1500 m. The crop grows well in forest soils and other well drained soils. The main ginger growing districts in the state are Idikki, Wynad, Kottayam, Ernakulam and Calicut.

Eventhough Kerala is the major ginger growing state, the productivity of the crop is discouraging. Among various reasons attributed viz. seed material, climatic fluctuations, improper management and plant protection problems, the role played by insect pests, diseases and nematodes is of importance.

The yield reduction caused to ginger by various pests, diseases and nematodes have been assessed from time to time. Shoot borer (Dichocrocis punctiferalis Guen.) has been

identified as a serious pest destroying the shoots extensively (CPCRI, 1985; Koya et al., 1988). Rhizome maggot (Mimegralla coeruleifrons Macquart) is a pest causing damage to the rhizomes directly and by aggravating some of the serious diseases of the crop (Ghorpade et al., 1988). The leaf roller (Udaspes folus Cram.) is a pest which causes defoliation but of minor importance (Abraham et al., 1975).

Among the diseases, soft rot caused by Pythium sp. has been found as a very damaging one causing yield reduction upto the extent of 80 to 90 per cent in infested fields (Kannan and Nair, 1965; Dake and Edison, 1988). Bacterial wilt disease caused by Pseudomonas solanacearum Smith which was first observed in Wynad District (Das and Kannan, 1986) is now being observed in other areas also (Dake and Edison, 1988). Leaf spot disease caused by Phyllosticta zingiberi Ramkr. is extensively seen in all ginger growing areas (Brahma and Nambiar, 1982). In addition to this a number of nematodes have been reported on the crop, the major ones being Meloidogyne sp and Radopholus sp (Charles and Kurien, 1979).

Though a number of insect pests, diseases and nematodes have been reported on the crop, a systematic survey for the assessment of the extent and intensity of the problems in ginger growing tracts of Kerala has not

been done so far. The avoidable yield loss caused by the pests also have not been estimated. The present investigations were hence taken up with the following objectives: (i) Survey in Idikki and Kottayam Districts of Kerala to assess the extent of damage caused by insect pests, diseases and nematodes, adopting standard statistical procedures. (ii) Assessment of the population build up at different growth stages of the crop. (iii) Assessment of crop loss caused by important pests through a field experiment giving insecticidal protection to the crop. (iv) Detailed studies on the biology of rhizome maggot M. coeruleifrons and the nature of damage caused by the pest. (v) Studies on the cost benefit ratio of the plant protection measures suited for tackling the pest problems in ginger.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The literature available on the incidence of insect pests, diseases and nematodes infesting ginger in the field, the nature and extent of damage caused by pests and diseases, alternate hosts of insect pests, biology and morphology, natural enemies, seasonal occurance, yield loss as well as control are briefly reviewed here.

1.1. Shoot borer, Dichocrocis punctiferalis Guen. (Lepidoptera : Pyralidae)

1.1.1. Host plants

This insect was first reported as a pest of castor (Lefroy, 1906). Subsequently, it was observed on a number of plants. They are karikar (Garuga pinnata L.), mango (Mangifera indica L.), sunflower (Helianthus annus L.), cocoa (Theobroma cacao L.), turmeric (Curcuma domestica Val.), ginger (Zingiber officinale Rosc.), cardamom (Elatteria cardamomi Rosc.) (Fletcher, 1914; Rao, 1940), guava (Psidium guajava L.), sorghum (Sorghum vulgare Pers.), peaches (Prunus persica (L)) (Fletcher, 1914); Caesalpinia crista L. (Fletcher, 1922); pomegranate (Punica granatum L.) (Hussain, 1924); cotton (Gossypium hirsutum L.) (Chopra, 1928); hollyhock (Althaea rosea L.) (Mohan Singh, 1941); jack

(Artocarpus heterophyllus Lamk.), avocado (Persea americana Mill), tamarind (Tamarindus indica L.) (Channabasavanna, 1954); amaranthus (Amaranthus blitum L.), soapnut (Sapindus emerginatus Vahl. (David et al., 1964); Citrus acida (L) (Patel et al., 1964), maize (Zea mays L.) (Twine, 1971), malayinji (Alpinia spp, periyayelam (Aframomum melagueta Rosc.) (Nambiar et al., 1975), Mahonia macrophylla DC. (Gokulpure and Sen, 1977) and Pinus kenia (Singh and Singh, 1978).

1.1.2. Nature of damage

The nature of damage done to different hosts showed variations. It bored into the shoots and capsules of castor (Lefroy, 1906; Fletcher, 1914), heads of sunflower (Lefroy, 1906), heads of sorghum, (Fletcher, 1914), pods of cocoa (Lefroy, 1906; Fletcher, 1914), fruits of karikar (Lefroy, 1906), fruits of guava and peaches, flowers of mango (Fletcher, 1914), psuedostems of turmeric and ginger (Fletcher, 1914; Rao, 1940; Ayyar, 1940; Narayana, 1959) and capsules of cardamom (Fletcher, 1914; Rao, 1940).

The larvae were found boring into the shoot and capsules of castor. If the egg is laid on an axil below the inflorescence, the larva bores inside and consequently the inflorescence dries off. Occasionally, the petiole of leaves are also bored. The pest attacks 4 to 20 per cent of inflorescence and 16 to 82 per cent heads, reducing yield by 9 to 23 per cent (David et al., 1964).

In cardamom, the caterpillars bore into pseudostem of the seedlings in the nursery and young tillers in plantations. The presence of the pest is indicated by entry holes plugged with excreta. The larva feeds on internal contents leading to 'dead heart'. When the panicles and racemes are attacked further production of flowers on them is stopped and the portion above the point of infestation dries up. The larva bores into the capsules and damage the seeds, leaving the capsules empty. Panicles on which capsules are set close are damaged severely than lax panicles (Kumaresan et al., 1978).

Jacob (1981a) had observed that in turmeric, the caterpillars reached the core or heart of the plant through the pseudostem and tunnelled down to the rhizome. The base of the growing bud was gnawed resulting in dead hearts or withered and dried shoots. A few exit holes could be seen on the pseudostem through which frass and excreta came out. When aerial growth was retarded towards harvest time, the caterpillars fed on the rhizomes also.

1.1.3. Biology

The biology of D. punctiferalis was studied on castor (David et al., 1964; Patel and Gangrade, 1971; Bilapate and Talati, 1978), ginger and turmeric (Jacob, 1981) and on cardamom (Varadarasan, 1982).

The adult was a medium sized bright yellow moth, nocturnal, with small black spots on the upper surface of the wings. The wingspan of male and female were 24 mm and 25 mm respectively. Male could be distinguished from the female by the presence of the black tuft of hair at the tip of the abdomen, black costal margins of forewings and by the more slender and longer abdomen. The moth laid eggs singly or in groups of two or three on tender parts of the plant. Freshly laid egg was pale white and flattish oval with a rough surface. After a day, the colour changed to light pink. The incubation period observed on castor was 2 to 6 days (Bilapate and Talati, 1978) and 6 to 7 days on ginger and turmeric (Jacob, 1981a). The fresh larva had a light brown head and light pink thoracic shields. Hairs were sparsely distributed on abdomen. The first instar larva was 1.6 to 1.9 mm long (Bilapate and Talati, 1978). The body was pale greenish with pink warts dorsally. It underwent five instars and the last instar measured 12 mm to 20 mm. The larval period was 10 to 13 days on castor (Bilapate and Talati, 1978) and 15 to 18 days on turmeric (Jacob, 1981a). The pupation was in silken cocoons in the bored pseudostems in turmeric, ginger and cardamom, while in castor, it was in bored capsules. The nascent pupa was cream yellow, but soon got sclerotised and became brown to dark brown. The pupa was 10 to 11 mm long and the pupal period lasted 7 to 9 days. The life

cycle took 23 to 25 days on castor at Coimbatore (David et al., 1964), 19 to 28 days on castor at Gujarat (Bilapate and Talati, 1978) and 31 to 43 days on turmeric at Kasargod (Jacob, 1981a).

1.1.4. Natural enemies

A number of parasites and predators have been recorded on the larval and pupal stages of D. punctiferalis. The parasites reported on the pest from India and outside include an unidentified braconid (Ballard, 1925), Phanerotoma hendecasiella Cam., Xanthopimpla sp and Dolichurus sp (Rodrigo, 1940). Apechthis capulifera Kriechbaumer, Scambus persimilis Ashmead and Brachymeria obscurata Walker [illegible], Angitia (Dioctes) trochanterata (Morley), Apanteles sp and Brachymeria euploeae West, (David et al., 1964), Bracon (Microbracon) hebetor Say. (Patel and Gangrade, 1971), Brachymeria nosatoi Habu and Brachymeria lasus West-wood (Joseph et al., 1973). Brachymeria sp nr. nephantidis Gahan, Nythobia sp and an unidentified eulophid (Bilapate and Talati, 1978); Xanthopimpla australis Kr., Myosoma sp (Jacob, 1981a); Palexorista parachrysops (Kalra, 1984), Friona sp, Agrypon sp, Gotra sp and Temelucha sp (Varadarasan, 1987).

Jacob (1981a) reported Euborellia stali, Philodicus sp, Heligmoneura sp, Araneus sp, Micaria sp and Thyene sp as predators on the pest in turmeric.

1.1.5. Seasonal incidence

D. punctiferalis was observed in Kasargod District from late July to August on turmeric at 4 to 5 leaf stage of the crop (Jacob, 1981a), and in ginger, the pest incidence was highest during September-October months (Jacob, 1981). Koya (1984) recorded that in ginger the percentage of shoots bored by D. punctiferalis was at the minimum of 5 per cent in July and it steadily increased reaching a peak of 14.8 per cent in November.

1.1.6. Yield reduction due to D. punctiferalis infestation

The shoots damaged by D. punctiferalis varied from zero to 100 per cent. More than 50 per cent of the clumps had 20 to 40 per cent incidence and 13 per cent of the clumps had 80 to 100 per cent infestation. It was further observed that even with 50 per cent infestation threre was no reduction in yield compared to control (CPCRI, 1984).

Koya et al. (1986) fixed the critical injury level at the final growth stage (October) as 50 per cent pseudostem damage. The critical injury level in August and September were evaluated as 60 per cent and 45 per cent pseudostem damage respectively. The economic injury level was suggested as two plants above critical injury level per bed of 3 x 1 m or 0.5 plants per row of 3 metre length with critical injury

level. The pest was found to cause a reduction of 38 g green ginger per clump when the pseudostem damage per clump exceeded 50 per cent.

1.1.7. Control

Lefroy (1906), Fletcher (1914) and Rao (1940) suggested removal of affected shoots and capsules as an important method to reduce the damage done by the pest.

In castor, malathion 0.1 per cent or parathion 0.5 per cent spray followed by the application of DDT 10 per cent dust or 0.1 per cent spray as fortnightly intervals (David et al., 1964) and three rounds of parathion 0.05 per cent spray at 21 day intervals from the formation of inflorscence (Sulochana Bai et al., 1968) have been suggested for the control of the pest.

In laboratory experiments, Singhvi et al. (1971) found that larvae of D. punctiferalis collected from field when fed with partly dried castor capsules, dipped for 10 seconds in insecticides at different concentrations, died after 24 hours when DDT 0.05 per cent, parathion 0.05 per cent and dichlorvos 0.05 per cent were used.

For the control of the pest in cardamom, spraying dimethoate or phosphamidon 0.05 per cent emulsion or application of phorate in soil have been suggested.

(Nambiar et al., 1975). In an evaluation trial done at Cardamom Research Station, Pampadumpara, it was found that among the insecticides used against D. punctiferalis on cardamom none was significantly superior. Among the insecticides used, thiodan 0.1 per cent spray was the most effective (KAU, 1981). Endosulphan, fenthion, phosalone, monocrotophos, quinalphos, carbaryl + molasses and dimethoate at 0.1 per cent were found effective against the shoot borer in cardamom (Kumaresan and Joseph, 1982).

Recommendation for control of the pest in ginger included the spraying of endrin 0.05 per cent (Kannan and Nair, 1965), mephospholon 5 per cent granules at nine g a.i. per 3 m^2 bed (1.5 kg a.i./ha) (Pillai and Abraham, 1973), dimethoate 0.05 per cent or quinalphos 0.05 per cent (KAU, 1978), dimethoate 0.05 per cent or phosphamidon 0.05 per cent (CPCRI, 1979a), dimethoate 0.05 to 0.1 per cent or quinalphos 5 per cent granules between leaf sheath and at the base of the plant (Jacob, 1981b) and quinalphos 0.1 per cent or dimethoate 0.1 per cent (Jacob, 1986).

In an insecticidal trial using seven insecticides Koya et al. (1988) found that in ginger, malathion 0.05 per cent was significantly superior for the control of D. punctiferalis and it was followed by monocrotophos

0.05 per cent and quinalphos 0.05 per cent, the percentage of shoots bored at the end of October being 2.8, 3.6 and 4.5 respectively. The sprayings were done 4 times at monthly intervals starting from July.

1.2. Leaf roller (*Udaspes folus* Cram.) (Lepidoptera : Hesperidae)

1.2.1. Host plants

U. folus was considered as a scarce insect by Fletcher (1914a) which could become a serious pest of turmeric and ginger ocassionally. It has a wide range of host plants including ginger (*Zingiber officinale* Rosc.) (Lefroy, 1906; Fletcher, 1914; Abraham *et al.*, 1975), turmeric (*Curcuma domestica* Val.) (Fletcher, 1914; Ayyar, 1940; Abraham *et al.*, 1975), *Alpinia nutans* Rosc. (Fletcher, 1914), Kasthurimanjal (*Curcuma aromatica* Salisb.), (Ayyar, 1940), Cardamom (*Elatteria cardamomi* Rosc.), Periyayelam (*Aframomum melaguets* Rosc.), *Hedychium sp* and Mangainji (*Curcuma amada* Roxb.) (Abraham *et al.*, 1975).

1.2.2. Nature of damage

The caterpillars of *U. folus* make longitudinal folds of the leaf in which they live and feed from within resulting in extensive defoliation (Lefroy, 1906).

1.2.3. Biology

Abraham et al. (1975) studied the biology of U. folus under laboratory conditions on ginger and turmeric. The duration from egg to adult was recorded as 28.6 days on ginger and 25.1 days on turmeric. There were five larval instars. The full grown caterpillar measured 36 mm and the longevity of male and female were 4 and 6.7 days respectively.

1.2.4. Natural enemies

A number of larval and pupal parasites have been recorded on U. folus. Dubey et al. (1975) recorded the larval parasites Ceromya sp, Apanteles sp, Sympiesis sp and a mermithid nematode. The parasitism ranged from 21.8 to 26.42 per cent. The pupal parasite recorded was the chalcid Brachymeria coxodentata Joseph et al. (Dubey et al., 1976).

The bacteria Enterobacter sp and Pseudomonas sp had been isolated from diseased caterpillars of U. folus collected from the field and the former was found to be a potential pathogen (Abraham and Pillai, 1973).

1.2.5. Seasonal incidence

Abraham et al. (1975) observed that the pest was active from August to October in Kasargod District of

Kerala and there was a possibility for pupal hibernation during the off season.

1.3. Rhizome maggot (Mimegralla coeruleifrons Macquart) (Diptera : Micropezidae)

1.3.1. Host plants

M. coeruleifrons had been recorded on a wide range of hosts. The pest had been observed on Curcuma aromatica Salisb., Kaempferia galanga Linn. (Premkumar et al., 1980), ginger and turmeric (CPCRI, 1982; Ghorpade et al., 1983b; Ghorpade et al., 1988), wild ginger, Colacassia sp and wild arrow root (CPCRI, 1986).

1.3.2. Nature of damage

Premkumar, et al. (1980) observed that the maggots of Mimegralla started feeding at the collar region and later migrated into pseudostems and rhizomes, feeding voraceously on the soft tissues. Ghorpade et al. (1988) observed that the maggots migrated from the soil to the plants and entered the rhizome at the collar region, fed inside and destroyed them completely by tunnelling inside. Within eight to ten days, the leaves started yellowing and the leaves as well as shoots dried up due to larval feeding. The rhizomes were also seen completely damaged.

1.3.3. Biology

1.3.3.1. General features of adults

The adults of Mimegralla were found to live for 30 days when fed with 10 per cent honey (CPCRI, 1984a). Ghorpade et al. (1988) recorded the male longevity as 7 to 20 days and that of female 9 to 24 days. The body length varied from 12 to 14 mm for male and 13 to 16 mm for female and the wing span was 13 to 15 mm.

1.3.3.2. Egg laying

The adults of Mimegralla sp failed to lay eggs in captivity (CPCRI, 1981a). However, Ghorpade et al. (1988) reared M. coeruleifrons and obtained eggs which were laid in soil.

The numbers of eggs laid varied from an average of 250 when reared on ginger (CPCRI, 1984a) 76 to 100 when provided with 10 per cent honey for the feeding of egg laying females. The oviposition period was two to three days (Ghorpade et al., 1988).

1.3.3.3. Incubation period and hatching

The incubation period of Mimegralla, eggs was reported as three to five days (CPCRI, 1984a) and two to

three days (Ghorpade et al., 1988). There was 78 to 97 per cent hatching of eggs (Ghorpade et al., 1988).

1.3.3.4. Immature stages

The egg measured 0.81 mm long and 0.22 mm broad. The eggs were white and oblong, tapering at either end (Ghorpade et al., 1988).

Three larval instars had been reported (CPCRI, 1986; Ghorpade et al., 1988). The first instar was 0.63 mm long and 0.15 mm broad, second instar measured 4.5 mm long and 1 mm broad, while the third instar was found to be 9.6 mm long and 1.7 mm broad. The duration of first, second and third instar larvae varied from four to seven days, four to eight days and three to seven days respectively (Ghorpade et al., 1988).

Steyskal (1964) found that the third instar larva of M. coeruleifrons measured 11 to 12 mm long and 1.7 to 1.8 mm broad.

The pupa was reported to measure 7.8 to 8.2 mm long and 1.84 to 1.88 mm broad (Steyskal, 1964) and 8 mm long and 1.7 mm broad (Ghorpade et al, 1988).

The pupal period had been reported as 13 days (CPCRI, 1981a) and 5 to 15 days by Ghorpade et al. (1988).

1.3.3.5. Morphological features of immature stages

Steyskal (1964) described the third instar larva. He observed that the anterior spiracles of the larva had 18 to 20 buds most of which were three times as long as wide. Creeping welts were present on the ventral side. The stigmatophores of posterior spiracles were piceous to black with the three slit fields occupying roughly circular light brown area. Four sets of interspiracular hairs were also observed. Mouth hooks and intermediate piece of cephalopharyngeal skeleton were dark brown while the remaining portion was pale yellow. Dorsal cornu of cephalopharyngeal skeleton was nearly as long as ventral cornu which had a well developed dorso basal lobe.

Ghorpade et al. (1988) gave a brief description of the three instars. He observed that the body segments of the first instar larva were not distinct. The body was found wider at the posterior end and narrowed anteriorily. The second instar larva was white, nearly cylindrical and tapering anteriorily, with 12 segments. A pair of reddish brown spiracle was visible at the blunt end of the last abdominal segment. Two semicircular flaps or oral lobes were present anterior to the mouth orifice on the first body segment. The third instar was creamy white, with much thicker cephalic mouth hooks and posterior spiracles.

1.3.4. Natural enemies

Trichopria sp (Diapriidae), a pupal parasite had been reported on Mimegralla (Jacob, 1980; Ghorpade et al., 1988). A spider predating on immature adults was also observed (CPCRI, 1985).

1.3.5. Seasonal occurrence

Mimegralla adults were observed throughout the year in the field (CPCRI, 1981). The population of adults of M. coeruleifrons was high during August to October (CPCRI, 1986). Ghorpade et al. (1988) observed the activity of the pest from the first week of July in ginger fields and third week of July in turmeric fields. The pest was found to be active from mid-August to mid-October.

1.3.6. Yield loss

Ghorpade et al. (1983a) recorded the rhizome fly M. coeruleifrons as a serious pest of ginger in Maharashtra. Later, the damage in Maharashtra due to the incidence was assessed as 25 per cent in turmeric and 31 per cent in ginger. Ghorpade et al. (1988) found that the per cent damage caused to clumps of ginger in field was 35 while in turmeric, the damage was 37 per cent.

1.3.7. Control

In a field trial conducted in Maharashtra during 1970-71 and 1971-72, Dhoble et al. (1981) found 0.05 to 0.03 per cent sprays of parathion followed by soil application of diazinon, chloradane or aldrin at 0.75 kg per acre to be most effective against the pest.

Carbofuran application was useful against Mimegralla sp, the incidence in treated plots being 15.8 per cent against 66.7 per cent in control. It was also found that phorate and sevimol were least effective against the pest while thiodemeton gave good results (CPCRI, 1982).

1.3.8. Association of M. coeruleifrons with diseases of ginger

Opinions differed as to whether M. coeruleifrons caused primary damage to the ginger rhizome or it caused secondary infestation following incidence of rhizome rot diseases. The pest had been observed in rhizomes which were infected by diseases.

M. coeruleifrons maggots were found in 2.3 per cent of ginger samples infected by bacterial wilt (CPCRI, 1981). Three fungi were isolated from larvae of Mimegralla collected from the field and the same fungi were also

isolated from the rhizomes from which the larvae were collected, indicating the potential of Mimegralla as transmitters of the fungi (CPCRI, 1982).

Mimegralla maggots were found to have the capacity to transmit diseases. It was observed that when maggots collected from field, from soft rot infested rhizomes, were released into potted plants at the rate of 60 per pot, disease was obtained in four out of five pots tested (CPCRI, 1981). Laboratory reared adults feeding on Pythium cultures when released on healthy plants induced rotting (CPCRI, 1982).

Premkumar, et al. (1980) on the other hand reported that the ability of rhizome maggot to carry the disease was poor. Out of 98 maggots collected from infested rhizomes, only one gave positive isolation of Pythium. The infested rhizomes incubated in water showed the presence of Pythium alone in 42 per cent of samples and maggots and Pythium in 58 per cent. Rhizomes infested by maggots alone were not observed. Results showed that Pythium alone could cause damage but the damage would be more when associated with the maggots.

Radke and Borle (1982) while studying the pest status of M. coeruleifrons on ginger cound that disease occurred first and the flies preferred such rhizomes for

egg laying. Koya (1988) reported that the maggots were not observed in samples that have just taken up the disease indicating that disease occur first and maggots infest the rhizomes later. The maggots were observed in soft rot and bacterial wilt affected plants but not in healthy ones. In a survey covering various districts of Kerala, it was found that M. coeruleifrons occurred in 26.4 per cent of the samples of diseased rhizomes collected. The percentages of diseased samples seen associated with M. coeruleifrons were 37.5, 43.5, 53, 66.7 and 14.3 in Malappuram, Cannanore, Palghat, Trivandrum and Kottayam Districts respectively. In Idikki District, the incidence of the disease and maggots was not observed. Ghorpade et al. (1988) reported that in the field, the maggots caused complete damage of rhizomes by direct feeding and also by introducing the micro-organisms Fusarium Pythium and Sclerotium into the rhizomes.

1.4. Other maggots associated with ginger

In addition to M. coeruleifrons, a number of other maggots of minor importance had been recorded on ginger. They include Calobata sp (Lefroy, 1906), Chalcidomya atricornis Mall, Formosina flavipes Mall (Diptera : Chloropidae) (Malloach, 1927; Nair, 1975), Celphus sp (Diptera : Celphidae) and Eumerus sp

(Sharma et al., 1978; Iyer, 1979; CPCRI, 1981; Koya, 1988; Ghorpade et al., 1988b).

1.5. Major diseases of ginger

1.5.1. Soft rot caused by Pythium sp

1.5.1.1. Symptoms

Sarma et al. (1979) observed that the initial symptoms of soft rot disease of ginger appeared with light yellowing of the tips of lower leaves which gradually extended down the leaf blade and leaf sheath along the margin in the early stages. The yellowing later spread from bottom upwards to all the leaves. That was followed by whithering and drying up of the shoots. The collar region showed a translucent brown colour which became water soaked. The infected shoots came off easily at the collar region when pulled. The infection extended to the rhizomes which got discoloured in due course. The roots also got decayed.

1.5.1.2. Extent of damage

Soft rot resulted in yield reduction of 5 to 6 per cent in uplands of Bengal (Mc Rae, 1911). The infestation in wet years was as high as 80 per cent (Butler, 1918) while in Kerala, the yield loss was in

the range of 80 to 90 per cent in some locations (Kannan and Nair, 1965).

1.5.1.3. Seasonal occurrence

In Kerala, the disease occurrence coincided with South-West monsoon when the crop was 50 to 60 days old and maximum disease incidence was noticed from late July to September (Sarma et al., 1979).

1.5.1.4. Susceptibility of ginger types to soft rot disease

Majority of ginger types available in Kerala were found highly susceptible and different fungicides showed different degrees of protection which varied from year to year (Sarma et al., 1979).

1.5.2. Bacterial wilt caused by Pseudomonas solanacearum E.F. Smith

1.5.2.1. Symptoms

Das and Kannan (1986) described the symptoms of bacterial wilt disease. The leaves showed symptoms of wilting and they rolled inwards. The pseudostem remained rather firm, when pulled up, in the initial stages and came off only when the rhizome was completely rotten. Pseudostem when cut at the basal region and kept immersed

in clear water made the water turbid in due course and this was caused by the flow of bacterial ooze from the rhizome.

1.5.2.2. Extent of damage

Raju et al. (1984) found that bacterial wilt incidence varied from 0.5 to 83.3 per cent in Waynad, Cannanore, Pathanamthitta, Ernakulam and Kottayam Districts. Idikki was free from bacterial wilt.

1.5.3. Leaf spot disease caused by Phyllosticta zingiberi Ramkr.

1.5.3.1. Symptoms

The disease was first reported from Godavari District of Andhra Pradesh (Ramakrishnan, 1942). The initial symptoms on the leaves showed presence of small oval to elongated spots measuring 1 to 10 mm to 0.5 mm. A mature spot was papery white at the centre and had a dark brown margin with an yellowish halo surrounding it. The spots were usually isolated by coalesced forming big lesions, causing extensive discolouration.

1.5.3.2. Seasonal incidence

Premanathan et al. (1980) observed the first noticeable symptom 75 days after planting. The disease

was found to occur from the fourth week of June. Plants upto the age of 6 to 7 months were susceptible and two week old leaves were more susceptible than six week old leaves (CPCRI, 1981a). Brahma and Nambiar (1982) observed that the disease was in traces in June, 10.5 per cent in July, 19.1 per cent in August, 22.5 per cent in September and declined to 18.99 per cent October and November.

1.6. Investigations on the nematode incidence in ginger

Nadakal (1963) reported that Meloidogyne sp on ginger causes considerable damage to ginger in Kerala.

Kulkarni and Jain (1965) during an investigation of rhizome rot of ginger found the presence of root galls induced by nematode. Examination of rhizomes revealed the presence of pearly white females of Meloidozyne sp embedded in the tissue, which was observed for the first time. Mammen (1973) also reported that Meloidogyne sp cause considerable damage to ginger. Charles (1978) in a study on the nematode diseases of ginger found that the root knot nematode Meloidogyne sp had a wide distribution in the state and caused upto 46.4 per cent loss in yield. He found in a survey that in Idikki and Kottayam Districts, Meloidogyne sp, Radopholus sp, Pratylenchus sp and Helicotylenchus sp were present in ginger tracts.

Charles and Kurien (1979) found that the incidence of *M. incognita* in soil and in roots of ginger in Kerala was very high and it was followed by *R. similis* and *Pratylenchus sp.* The aerial and underground growth of the plant was considerably reduced by the nematode infestation.

Sundararaju *et al.* (1979) in a sruvey of the plant parasitic nematodes associated with spices in Kerala found that the important plant parasitic nematodes detected from the soil around the root zone of ginger were species of *Meloidogyne*, *Radopholus*, *Helicotylenchus*, *Hemicycliophora*, *Halpiolaimus* and *Rotylenchus*.

MATERIALS AND METHODS

2. MATERIALS AND METHODS

2.1. Assessment of incidence of major insect pests and diseases in Kottayam and Idikki Districts of Kerala

2.1.1. Statistical procedure followed

To study the distribution, nature and extent of damage caused by major insect pests and diseases to ginger in Kerala, two Districts viz. Kottayam and Idikki were selected since the area under ginger in these districts was proportionately high. From Kottayam nine villages and from Idikki fourteen villages were selected based on probability proportional to area under ginger. From each District, data were collected adopting stratified multistage random sampling technique. District represented strata, taluks primary units, villages secondary units, holdings within village third stage units for the drawal of samples. From Kottayam District nine villages were selected from five taluks and from Idikki District, fourteen villages were selected from four taluks. From each of these villages, five holdings were randomly selected for sampling ensuring maximum representation of the areas under the crop.

2.1.2. Observations

The incidence of insect and nematode pests and of the important diseases were recorded as follows.

2.1.2.1. The shoot borer, D. punctiferalis

From each holding in the selected locations, six samples, each consisting of a cluster of five clumps were selected at random. The number of shoots infested by the borer and the total number of shoots in each clump were counted. Shoots having bore holes, dead heart, characterestic scrapings or presence of frass and faecal matter on the terminal leaves were counted as infested. The percentage of infested shoots were calculated from the total number of shoots in the clumps and the number infested (Nybe and Nair, 1977). From the data, the mean per cent incidence of the bored shoots in the locations, village and district were found out. The data were subjected to nested analysis of variance.

2.1.2.2. Leaf roller, U. folus

The clumps selected for assessing shoot borer incidence were observed for leaf roller incidence also. Shoots having leaves rolled or fed by the larvae were counted as infested. The incidence was assessed as the per cent shoots with infestation out of the total number of shoots in the clumps. From this, the mean incidence in the locations, village and district were worked out.

2.1.2.3. Rhizome maggot, M. coeruleifrons

Each selected holding was divided into four approximately equal blocks and from each such block, six clumps were selected at random, treating each block as a replication. The selected clumps were observed for life stages of the insect and the percentage of infested clumps (having maggot/pupa) in each replication was assessed. The data were analysed using nested analysis of variance, after transforming the same as angles.

2.1.2.4. Assessment of nematode population in soil

2.1.2.4.1. Collection of soil and root samples

Soil samples were collected from the base of healthy and diseased ginger clumps at 10 to 15 cm depth. Roots from the rhizomes were also collected. Composite samples of 250 g of soil and 50 g of roots were taken from each holding. A total of 39 samples were thus collected from 13 villages. These were put in seperate polythene bags with proper labels and brought to the laboratory for further studies.

2.1.2.4.2. Extraction of nematodes from soil samples

One hundred g of soil from each sample was processed by Cobb's sieving and shifting technique.

The nematodes in the residue were extracted by wire gauze method. The nematode suspension was drawn out at the end of 24 hours and the nematodes present were identified and counted. This was repeated till no nematodes were seen in the samples drawn. The total number of each species of nematode were assessed and the data were subjected to statistical analysis.

2.1.2.4.3. Extraction of nematodes from root samples

Each root sample was transferred to a plastic basin and adhering soil particles were removed in a stream of water. Ten g each of the root sample was weighed out, cut into small bits and put over tissue paper kept on a flat bottomed circular wiregauze dish with raised border. The wiregauze dish was put over a petridish filled to 3/4th with water in such a way that the wiregauze just touched the water in the petridish. This was left undisturbed for 24 hours and the water in the dish along with the nematodes present was transferred to a beaker and after an hour the water from the top 50 per cent portion was decanted. The concentrated suspension of nematodes in the beaker was transferred to a counting dish and the nematodes present were identified counted and recorded. Again water was poured into the petridish as described earlier and the wiregauze dish with root bits was placed over it.

Removal of this water and counting of nematodes was done at the end of 24 hours. The process was repeated till no more nematodes were obtained in the water drawn.

2.1.2.5. Incidence of soft rot disease

The selected holdings were categorised into four groups viz. A, B, C and D based on the percentage of clumps having the disease out of the total number of clumps in each bed. Beds with no infestation were put under category A, one to 33 per cent clumps affected under category B, 33 to 66 per cent clumps affected under category C and beds with more than 66 per cent clumps infested under category D. These categories (A, B, C and D) were first expressed as the percentage of the total number of beds in the holdings and then graded on a zero to three scale. For category A, a grade of zero, to category B, a grade of one, to category C a grade of two and to category D, a grade of three were given. From this the disease intensity was expressed as the disease index using the formula $\leq wi/\leq w$, where 'w' is the percentage of plots in each category and 'i' their respective grades. The data were subjected to statistical analysis under completely randomised design.

2.1.2.6. Incidence of leaf spot disease

To assess the incidence of leaf spot disease, one shoot from each clump selected as described in

para 2.1.2.1. was observed. Care was taken to see that shoots selected were free from the incidence of insect pests. All the fully opened leaves on the selected shoots were observed for spots. The leaves were then graded on a zero to four scale. Shoots with 0, 1-5, 6-15, 16-40 and 40 or more spots coalased to form patches were grouped in 0, 1st, 2nd, 3rd and 4th grades respectively (Nybe and Nair, 1977). From these gradings, disease indices were worked out using the formula $\leq wi/\leq w$, where 'w' was treated as the percentage of leaves in each category and 'i' their respective grades.

2.2. Assessment of the seasonal incidence of major pests and diseases on ginger

To study the seasonal incidence of shoot borer and leaf spot, observations were made at monthly intervals from June to November at five locations in Thodupuzha taluk where the crop was being cultivated extensively. Five other plots were selected for observing the incidence of soft rot disease and rhizome maggot, in areas where the incidence of the pest and disease was being noted regularly. These plots also were located in Thodupuzha taluk. The incidence of pests and diseases in each observation were assessed following the methods described in para 2.1.2. The data on the damage caused

during each month were calculated by deducting the cumulative percentages/indices of the previous month from the observation recorded during a particular month. The data were subjected to relevant statistical analysis (methods of analysis shown in concerned tables).

2.3. Effect of weather factors on pest and disease incidence

The monthly mean maximum temperature, minimum temperature, relative humidity, total rainfall and number of rainy days during the period of observations were recorded from Oilpalm Research Station, Elamdesom, Thodupuzha and these factors were correlated with incidence of pests and diseases recorded during different months.

2.4. Biology of M. coeruleifrons and nature of damage caused by the pest on ginger

2.4.1. Rearing the insect in the laboratory

Rhizomes of ginger infested by M. coeruleifrons collected from fields in Thodupuzha were used for obtaining laboratory stock of the insect. Six inch diameter pots were filled with soil upto a height of one inch below the top and infested rhizomes were placed flat on the soil surface with 3/4 the portion burried in

the soil. Cylindrical polypropylene cages of diameters adjusted to fit tightly inside the upper end of the pot were made and each cage was fixed to the upper ends of each of the pots ~~(Plate ——)~~. The distal open end of the cage was covered with muslin cloth held in position with a rubber band. The soil was moistened daily to prevent desication. The adults which emerged were provided with 10 per cent honey dipped in a cotton swab.

2.4.2. Mating behaviour and egg laying of the insect

Five pairs of male and female flies, which emerged on the same day were confined in glass troughs at the rate of one pair per trough and the open end of the troughs were closed with pieces of muslin cloth held in position with rubber bands. A petridish (5 cm diameter) with fine moist soil with a ginger rhizome placed in this soil was kept inside each trough for the flies to lay eggs. A cotton swab dipped in 10 per cent honey was stuck to the inner side of the trough which served as food for the flies. Mating behaviour, premating period, pre-oviposition period, oviposition period and longevity of the flies were continuously observed till the flies in the trough died.

2.4.3. Collection of eggs

The petridishes with soil and ginger rhizome, exposed for egg laying (vide para 2.4.2.), were removed daily and fresh dishes with soil and rhizome were placed in the trough for further egg laying. The eggs in the dish removed from the trough at every 24 hours counted. To count the eggs, a small lot of soil in the petridish was put into a 9 cm diameter petridish with water. When this soil was broken up in water, the eggs could be distinguished by its white colour and they were removed with a camel hair brush and counted. Then the soil and water were thrown out. The entire soil in the dish, exposed for egg laying, was thus put in water in small lots and the total number of eggs present were counted and recorded. The effect of feeding the egg laying flies with honey and yeast on the number of eggs produced was also studied following the method described above.

2.4.4. Assessment of the incubation period of the eggs and hatching percentage

Incubation period was studied by keeping 20 eggs each in 10 petridishes over pieces of blotting paper and observing the hatchings twice daily. The paper was moistened daily to prevent desication of eggs.

Freshly laid eggs were used for this purpose. Such eggs were obtained from the soil in petridishes exposed in troughs for egg laying and removed at hourly intervals. The hatchings of the eggs on different substrates viz. moist and dry petridish, ginger leaves, healthy and diseased rhizomes, healthy rhizomes split, shoots of ginger, polythene sheet, blotting paper and dry as well as moist soil were also observed.

2.4.5. Observation on larval duration and mortality

Larval duration and number of instars were observed by keeping freshly hatched larvae on small pieces of ginger rhizomes each taken in a seperate petridish (5 cm diameter). Fifty such dishes were set. They were observed daily and the moulting of the larvae and mortality, if any, were recorded. A parallel set of dishes served for the collection of larvae at each moult for recording larval measurements. These observations were continued till the larvae set passed on to the pupal stage or died.

2.4.6. Observation on pupal duration and pupal mortality

Fresh pupae observed in the dishes set for studies on biology (para 2.4.5.) were sorted out and kept in dishes over moistened filter paper. From the parallel lots kept, pupae were collected and preserved for the morphometric

observations. The duration for the emergence of the adults from the time of pupal formation (pupal period) and the percentage of mortality in the pupal instar also were recorded.

2.4.7. Observations on male-female ratio

Male-female ratio was studied by keeping six sets of 30 pupae each in glass troughs kept closed with muslin cloth. Emerging adults were sorted out into males and females and the numbers were recorded for assessing the sex ratio.

2.4.8. Detailed study on the morphology of immature stages

Immature stages (eggs, larvae and pupae) collected from the experiment described in para 2.4. were preserved in 70% ethyl alcohol and were observed under a microscope for studying the morphological characters. Spirales and mouth hooks were dissected out using micro needles and were kept in 10% KoH for varying durations, depending on the stages and then passed through 70% alcohol for clearing. These were studied under a microscope and sketches were made using a camera lucida and measurements were made with the help of a caliberated occular micrometer.

2.4.9. Identification of insects

Identification service of Commonwealth Institute of Entomology was utilized for identifying the insects collected in the servey.

2.5. Assessment of the damage done by M. coeruleifrons alone and in combination with Pythium

2.5.1. Raising the ginger plants

Ginger plants for the experiment were raised in clay pots (15 x 15 cm). Potting mixture with soil, sand and powdered cowdung mixed in the ratio 2:1:1 was prepared and filled in the pots. Seed rhizomes (10 g weight) were planted in the pots at the rate of one per pot. Watering was done regularly. The sprouting plants were protected using polypropylene cages as described in para 2.4.1. and two month old plants having four shoots each were used for the experiments.

2.5.2. Isolation of Pythium for inoculation

The isolate of Pythium used in the study was obtained from diseased ginger rhizomes collected from the fields at Thodupuzha. The infected portion of rhizomes were cut into small bits, surface sterilized with 0.1% mercuric chloride and were repeatedly washed

in three changes of sterile water. The pieces were then planted over potato dextrose agar (PDA) taken in sterile petridishes and incubated under sterile conditions. The isolate was purified by repeated hyphal tip planting and the organism was maintained on PDA by subculturing periodically.

2.5.3. Rearing of rhizome fly for the experiment

The rearing of rhizome fly was done as described in para 2.4.1. They were then transferred to glass troughs. Males and females were included in equal proportion. They were fed with honey and yeast regularly and left for mating. The mated female flies were used for assessing the extent of damage caused by the flies.

2.5.4. Inoculation of fungus

Mycelial bits of the fungus were removed from culture tube with the help of an inoculation needle and was placed at the collar region of single shoots after cleaning the portion off soil and dirt. After this, a wet cotton swab was placed over the inoculum to provide ideal conditions for mycelial growth. The plants were then kept covered with suitable polypropylene cages.

2.5.5. Treatments

There were six treatments in the experiment (vide Table 14), each replicated thrice. The experiment was in completely randomised design. The treatments consisted of the plants exposed to the flies alone, to the fungus alone, to the fungus followed by the fly, to the fungus and fly simultaneously and plants maintained as control unexposed to the insect or pathogen (~~Plate~~).

2.5.6. Releasing the insects on the experimental plants

The flies required for the experiment were collected from the culture maintained in the laboratory as described in para 2.5.3. They were released on the experimental plants confined with in polypropylene cages, at the rate of four female flies per plant.

2.5.7. Observations recorded

The disease incidence was graded on a zero to seven scale at intervals of four days. Zero score represented plants with no damage, score one represented marginal yellowing of one or two leaves, score three represented yelowing on all leaves except the youngest ones, score five represented complete yellowing and

drooping of all leaves on a shoot, score seven represented completely decayed and toppled down shoot. The data obtained were subjected to statistical analysis.

2.6. Control of major insect pests of ginger in the field

A field experiment was laid out in farmer's field near State Seed Farm, Karimannoor in Thodupuzha taluk to find out a suitable control measure against the major pests in the field.

2.6.1. Selection of site

The field was selected in an area having extensive cultivation of ginger and in a field where regular infestation of pests was being noticed.

2.6.2. Design and layout of the experiment

The experiment was laid out in randomised block design. The plots consisted of 3 x 1 m beds, 15 cm high. A gap of 30 cm was provided around each bed. Seed ginger (15 g in weight) were planted in the beds at a spacing of 20 x 20 cm so as to have 60 plants in each bed. Dried and powdered cowdung was applied to cover the planted rhizomes. As basal dose, phosphorus and potash at the rate of 200 kg and 40 kg per ha respectively were applied. Afterwards, the beds were

thickly mulched with green leaves. Nitrogen was applied in two splits of 82.5 kg/ha each, at 60 and 120 days after planting and the second dose of potash, at the rate of 40 kg/ha was applied at 120 days after planting. Mulching was done after each fertilizer application and weeding was done as and when required.

2.6.3. Treatments

There were eight treatments in the experiment, consisting of the applications of phorate or carbofuran granules at planting, combinations of the above treatments, with need based sprayings of quinalphos or dimethoate and the need based application of quinalphos/dimethoate alone. One treatment was maintained with bi-weekly sprays of dimethoate and quinalphos alternately to give maximum protection in the experiment. A plot sprayed with water alone served as control (vide Table 11).

2.6.4. Observations recorded

One inner three metre row of each plot which had 15 clumps, was observed for assessing the incidence of shoot borer. The same row was observed throughout the experiment. The number of shoots on each clump as well as the numbers of shoots infested were recorded. The infestation was assessed in terms of the percentage

of infested shoots out of the total number of shoots. Observations were made at monthly intervals till 180th day after planting. The yield of ginger in each plot was recorded at the end of the experiment. The data were subjected to suitable statistical analysis. The population of other pests of ginger were too low during the period of the experiment and hence it was not recorded.

RESULTS

3. RESULTS

3.1. Pests of ginger observed in the survey conducted in Kottayam and Idukki Districts of Kerala

Around 30 species of insect pests had been recorded from India and among these, D. punctiferalis, M. coeruleifrons and U. folus were observed as major ones in the present survey.

3.1.1. The shoot borer D. punctiferalis

This was the most predominent pest observed in all the ginger growing areas in the state. The nature of damage caused by the pest was observed in detail.

The eggs were laid on the tender leaves, petiole or leaf spindle. The emerging larva scraped the green matter of the leaf blade, at the midrib or petioles of still older leaves for some time. Then they moved down to the base of the third or fourth leaf and bore into the spindle leaf portion. They tunneled upwards and caused the dead heart formation (Plate I). After the second moult, the larva again came out through the entry hole, moved down the pseudostem and made a fresh entry hole at the base of the stem. Then the larva bored upwards through the central portion of the pseudostem

Plate I

A. Dead heart caused by *D. punctiferalis* on ginger observed in field.

B. Pseudostem infested by *D. punctiferalis* showing the drying symptoms beyond the point of fourth leaf from above.

A

B

Plate II

A. Pseudostem of ginger tunnelled by the larvae of D. punctiferalis upwards/downwards from the entry hole.

B. Ginger plant infested by U. folus

(a) leaf lamina cut and rolled by the larva
(b) complete leaf folded by the larva
(c) leaf stump left after the feeding of larva


A
B

(Plate IIA). It did not cause the death of the lower part of the stem portion. When the inner portion was completely eaten up, the larvae some time bored into the rhizome and fed on the tissue there and they very often migrated out of the pseudostem and attacked the adjacent pseudostem. Life cycle was completed within the pseudostem and the adult emerged through the entry hole of the larva itself.

3.1.2. Leaf roller (U. folus)

Leaf roller caused minor damage to the crop by defoliation. The eggs were laid on the tender leaves and the larva by making a parallel cut across the margin of the leaf and rolling up the cut bit, bound the edge with silken threads. It thrust the head out of the roll and bit the adjacent areas of the leaf lamina (Plate IIB). After each moult, the larva made bigger folds and in later instars the whole leaf was folded longitudinally and they remained inside. The leaf lamina including the midrib was eaten away leaving the petioles alone. The leaves appeared to have been cut with a blade in some cases, all the leaves of a shoot might be damaged. Pupation took place inside a folded leaf.

3.1.3. Rhizome maggot (M. coeruleifrons)

The larvae were the destructive stage of the pest. The eggs were laid in the soil and the larvae on hatching

Plate III

A. Ginger rhizome invaded by the maggots of *M. coeruleifrons* (cross section)

(1) Control

(2) to (5) damage caused by the maggots - advancing stages of the symptom

B. Ginger rhizome invaded by the maggots of *M. coeruleifrons* (longitudinal section)

A

B

PLATE III

entered either at the collar region of shoot or at the growing point of rhizomes either through wounds if any or through the tissues rendered soft by the infection of micro organisms. The healthy rhizomes were not seen infested by the maggots. Through the entry point, they moved towards the inner core of the rhizome. The second and third instar maggots were voraceous feeders and they fed the inner core of the rhizomes causing extensive tunnelling inside (Plate III), within 10 to 13 days. The periphery of the rhizome remained firm, while the inner tissues got rotten. Fifty to sixty maggots could be seen with in a single rhizome. Rhizomes when split open showed extensive tunnels and immature stages of the fly inside.

3.2. Distribution of major insect pests and diseases of ginger in different locations of selected villages in Kottayam District, Kerala

The results of the survey conducted to assess the distribution of major pests and diseases of ginger in Kottayam District are presented in Table 1 along with the results of statistical analysis of the data, and in Fig.1.

3.2.1. Shoot borer (*D. punctiferalis*)

No significant difference was observed in the incidence of shoot borer among different villages. The

T nl 1 D tribution of major in ect je s and i eases of ginger in ifferent locations of selected villages in otta am District erala

Village	Locat ons	Pe t incidence			Di e incidence		Type of oil	Pr vious crop	In ecti cide treat ment	Fungi cide treat ment	Ag of crop (y)
		D [unctiferalis p r cent hoots bored[1]	coeruleifrons [er cent clumps infested[2]	U folus er cent oots with leaf i fe ted[3]	L af ot Disease indices[4]	oft rot Disease indices[4]					
Anicad	nicad e t	1(00 (24 34)	17 86 (4 34)	0 00	1 224	0 303	L	F	Y	Y	12
	Anic d a t	36 62 (37 23)	3 01 (2 21)	2 60	1 020	0 152	L	T		Y	120
	lampally	12 08 (20 33)	10 13 (3 44)	3 50	0 880	0 495	C	V	Y	Y	1 5
	Puthupallybhagam	1 7 (26 40)	0 00 (1 00)	0 00	0 080	0 000	L	T		Y	115
	ooro ada	2 1 (36 02)	0 00 (1 00)	0 00	1 576	0 000	C	V		N	125
an		2 73 (28 07)	6 38 (2 38)	1 1	1 136	0 190					
D		5 45									
Akalakunnam	all khathodu	26 5 (31 03)	13 06 (3 74)	0 00	2 632	0 327	C	B			115
	Akalakunnam	23 35 (28 88)	8 09 (3 02)	0 00	0 808	0 059	Lo	B			120
	allakkara	6 71 (15 01)	0 00 (1 00)	2 35	1 504	0 104	L	B			140
	damula	20 49 (26 0)	15 57 (4 07)	0 00	0 056	0 184	L	G		Y	125
	Vadakkumbhagom	17 86 (24 9)	0 00 (1 00)	0 00	1 80	1 232	L	R			115
ean		1 00 (25 36)	7 34 (2 61)	0 47	1 379	0 381					
C D		5 45	N								
Vellavoor	adayani ad	10 53 (18 3)	0 00 (1 00	0 00	2 024	0 000	L	B		N	125
	Vadalanam	16 36 (23 85)	15 60 (4 07)	0 00	0 344	0 316	L	T		Y	1 0
	ellavoor	3 9 [3 21)	5 75 (2 59	0 00	1 02	0 091	L	T		Y	135
	Frayar	26 33 (30 81)	0 00 (1 00)	0 00	0 160	0 000	L	B		Y	120
	unnumbhagom	18 06 (25 14)	22 55 (4 85)	1 25	1 296	0 836	L	G			115
Mean		22 54 (27 59)	8 77 (2 70)	0 25	1 163	0 24					
C D		5 45	1 07								
animala	animala ast	28 25 32 0)	0 00 (1 00)	0 00	1 064	0 000	L	B			130
	ar kattoor	37 6 (37 86)	8 07 (3 01)	0 00	1 056	0 049	L	G			140
	Pulikkallu	18 07 (25 15)	28 2 (5 41)	1 43	1 440	0 427	Lo	Y	N	Y	125
	Alapra	16 1 (23 72)	0 00 (1 00)	0 00	0 032	0 000	C	Fa			130
	nimala est	22 32 (28 18)	0 00 (1 00)	2 07	0 616	0 000	L				120
ean		2 50 (2 80)	7 24 (2 2)	70	0 842	0 05					
D			1 07								
aduthuruthy	aduthuruthy	8 7 (17 24)	13 57 (3 81)	00	256	0 201	C			Y	115
	ravimangalam	2 31 (2 18)	3 0 (21)	0 00	0 152	0 044	Lo	Y	Y	N	135
	alak ara	13 5 (21 5)	0 00 (1 00)	0 00	2 02	0 000	L	T			120
	mku y	13 28 (21 36)	3 64 (2 19)	0 00	1 232	0 83	L	C		Y	120
	Valla seri	27 1 (31 6)	10 75 (3 42)	8 35	0 744	0 00	C	B			125
n		17 11 (24 01)	6 25 (2 1)	1 67	0 55	0 445					
D			1 07								
V llila ally	ondad	41 47 (40 07)	16 87 (4 23)	0 00	1 808	0 173	C	T			135
	Ve lila ly	21 52 (2 62)	8 27 (3 04)	0 00	0 952	0 103	L	T	I	Y	115
	Aimcompu	33 35 (35 26)	0 00 (1 00)	0 00	0 584	0 000	L	B	N		140
	arangad	23 61 (2 06)	0 00 (1 0)	0 00	0 408	0 000	L	Fa		Y	120
	hacherry	24 02 (3 66)	1 68 (4 54)	0 00	1 510	0 479					1 5
ean		2 1 (32 53)	8 97 (2 76)	0 00	1 053	0 151					
D			1 07								
ur vil ng d	o ha	23 12 (2 73)	3 0 (2 21)	0 00	0 768	0 114	C	V	Y		140
	urav langad	22 86 (29 36)	0 00 (1 00)	0 00	480	0 000	L	G			2
	enpally	18 45 (25 72)	16 89 (4 23)	0 00	1 352	0 492	L				135
	kulathoor	13 6 (21 3)	2 25 (1 0)	0 00	0 016	0 235	L	G	N	Y	125
	alikavu	22 53 (28 33)	13 80 (85)	0 00	2 208	0 047		B		Y	125
an		20 13 (2 61)	7 37 (2 62)	00	0 65	0 178					
C D			S								
Ayarkunnam	unna hara	21 07 (27 31)	3 0 (2 21)	0 00	1 760	0 024	L	T			135
	Aramannoor	24 0 (2 92)	2 24 (1 79)	0 00	0 152	0 466	C	G			125
	A a annoor	16 3 (24 29)	0 00 (1 00	0 00	1 448	0 000	Lo	F	Y		130
	Ayar unnam	42 36 (40 59)	32 58 (5 7)	1 47	1 800	0 38	C	G			125
	Farambukara	28 73 (32 3)	2 25 (1 80)	1 8	0 480	0 104	C	B			125
ean		2 7 (30 90)	8 1 (2 52)	0 00	1 128	0 195					
C D		5 45	1 07								
urichithanam	uriyanad	41 9 (40 38)	23 63 (4 96)	0 00	0 016	0 482	L	C			120
	urichithanam	21 52 (27 62)	13 57 (3 81)	0 00	1 472	0 103	L				13
	alak attumala	33 35 (35 26)	0 00 (1 00)	0 00	0 928	0 000	L	Y			120
	arangattupally	23 61 (2 06)	17 40 (4 25)	0 00	0 880	0 470	L	T			135
	Andoor	26 02 (30 66)	0 00 (1 00)	0 00	0 528	0 000	C				120
an		29 2 (32 59)	10 87 (3 01)	0 00	0 765	0 213					
D		S	1 07								
Di trict m n		23 5	7 3	0 48	1 043	0 233					
CD for compar ng villages			S			S					

1 Fig r n p e th se are tran formed values (angles)
2 i ure in p nth t form d valu s ($\sqrt{x+1}$)
3 D t no ati ticall an l/ d
r lat ng to vil age alone w r statistically analy d
nc r lic t on value were not available for locations

L Laterite soil
C l cy oil
Lo Lo y oil

B
Fa
G
T

B nana
Fallow
G ng r
T
c
m
V egetabl

a m
T at d

Fig 1

KOTTAYAM DISTRICT

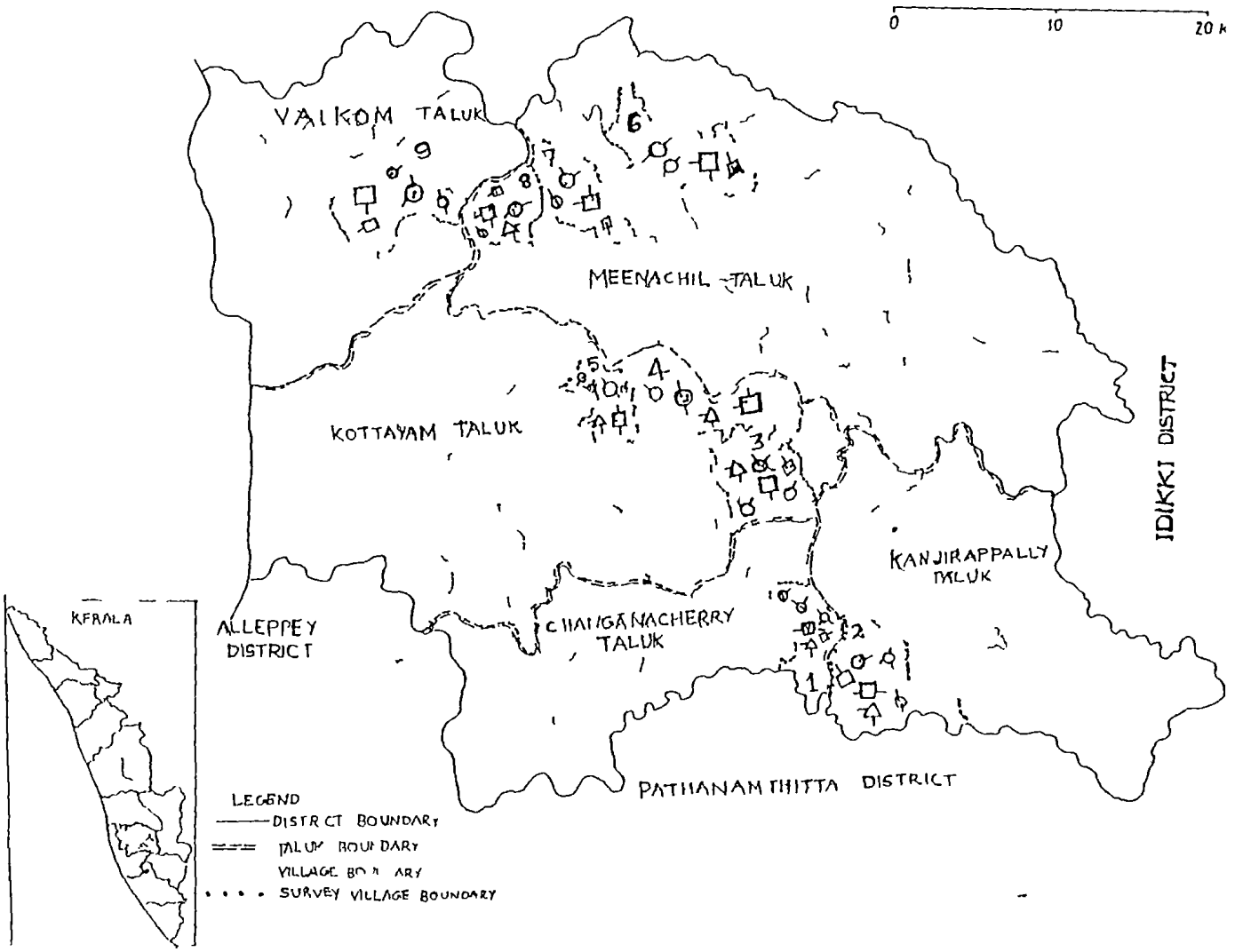
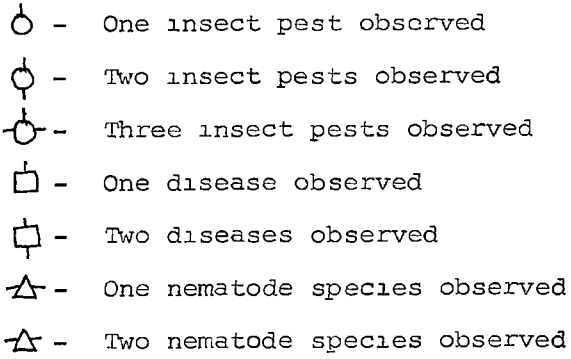


Fig. 1. Map of Kottayam District showing the distribution of pests/diseases/nematodes in different villages.

1. Vellavoor
2. Manimala
3. Anicad
4. Akalakunnam
5. Ayarkunnam
6. Vellilappally
7. Kurichithanam
8. Kuravilangad
9. Kaduthuruthy



The dots inside the marks indicate the number of locations having pests/diseases/nematodes

In Vellavoor, the least incidence was observed at Kadayanikkad (10.53 per cent) which was on par with the incidence at Vadakkanam. The incidence at Vadakkanam, Prayar and Kunnumohagom were on par among themselves but significantly less than that observed at Vellavoor, which was the highest in the village (39.99 per cent).

The incidence at different locations in Ayarkunnam village also varied significantly. It was least at Amayannoor (16.93 per cent) which was statistically on par with that observed at Punnathara (21.07). The incidence at Punnathara, Aramannoor and Paramoukara did not vary among themselves out were significantly less than that observed at Ayarkunnam which was the highest (42.36 per cent).

3.2.2. Rhizome maggot (M. coeruleifrons)

Significant difference was not observed in the incidence of the maggot among villages.

However significant difference was observed in the incidence of the maggot among different locations in six villages viz. Vellavoor, Manimala, Kaduthuruthy, Vellilappally, Ayarkunnam and Kurichithanam.

In Vellavoor village, no infestation was observed in two out of the five locations viz. Kadayanikad and Prayar.

The incidence at Vellavoor (5.57 per cent) was significantly lower than those of Vadakanam and Kunnumbhagom which were on par among themselves. The incidence at Kunnumbhagom was the highest (22.55 per cent).

There was no incidence of the pest in three out of the five locations in Manimala village (Manimala East, Alapra and Manimala West). The incidence in Karikattoor and Pulikallu were 8.07 and 28.29 respectively which showed statistically significant difference.

Among the five locations surveyed in Kaduthuruthy village, there was no incidence at Palakara. Among the remaining locations, incidence at Ayamkudi (3.64 per cent) was the least, and at Eravimangalam was on par but significantly less compared to the incidence at Vallesseri and Kaduthuruthy (10.75 and 13.57) which did not show statistically significant difference in population. The incidence at Kaduthuruthy was the highest in the village.

There was no incidence in two locations viz. Aimcompu and Marangad in Vellilappally village. The incidence at Vellilappally location (8.27 per cent) was significantly low when compared with the incidence at Kodanad and Ezhacherry which were on par among themselves. The incidence of 19.68 per cent at Ezhacherry was the maximum at Vellilappally village.

The incidence of the pest in Ayarkunnam village was zero at Amayannoor, while the pest intensity at Aramannoor, Parambukara and Punnathara were on par. The incidence was least at Aramannoor (2.24 per cent). The highest incidence of 32.58 per cent was observed at Ayarkunnam, which was significantly higher compared to the incidence in all other locations.

In Kurichithanam village, pest incidence was observed at Kuriyanad, Kurichithanam and Marangattupally and the per cent incidence at Kurichithanam (13.57) and Marangattupally (17.4) were statistically on par but the incidence at Kurichithanam was significantly lower compared to the incidence at Kuriyanad where maximum incidence of 23.63 per cent was recorded.

3.2.3. Leaf spot disease

No significant difference was observed in disease intensity among the nine villages surveyed. The mean disease index in villages varied from 0.765 in Kurichithanam (lowest) to 1.379 in Akalakunnam (highest). Among the various locations in the different villages, the minimum and maximum disease intensities of 0.016 and 2.632 were recorded from Kalathur and Pallikkathodu locations in Kuravilangad and Akalakunnam villages respectively. All the surveyed holdings had disease incidence.

3.2.4. Soft rot disease

There was no significant difference among different villages in the incidence of the disease. The incidence was lowest in Manimala, the disease index being 0.095 and highest at Kaduthuruthy (0.445). The disease was not observed in 14 out of 45 holdings surveyed. The maximum among the different locations in villages was observed at Vadakumbhagom (1.232) in Akalakunnam village. The mean disease index in the village was 0.233.

3.2.5. Leaf roller *U. folus*

The pest incidence was observed in six out of the nine villages surveyed. The maximum incidence (1.67 per cent) was observed at Kaduthuruthy and among the different locations, maximum incidence (8.35 per cent) was observed at Kaduthuruthy proper. The mean per cent incidence in the District was 0.55 per cent.

The soil of the locations covered in the survey included laterite, clay and loam types. The crop was rotated with ginger, tapioca, yam, vegetables and banana and in five locations the land was left fallowed between two successive crops. Only in five locations insecticide application was done during the period of the observation while in 75 per cent of the locations fungicidal applications were received. The growth stages of the crop when surveyed ranged from 115 to 140 days from sowing.

3.3. Distribution of major insect pests and diseases of ginger in different locations of selected villages in Idikki District, Kerala

The data relating to the survey and results of statistical analysis of the same are presented in Table 2 and in Fig. 2.

3.3.1. Shoot borer *D. punctiferalis*

There was no significant difference in the mean shoot borer incidence among the villages surveyed. The intensity of shoot borer incidence varied from 18.95 in Chinnakkanal to 33.09 per cent in Rajakumary village.

Significant differences were observed in the incidence of shoot borer among different locations in five villages viz. Thodupuzha, Udumpannoor, Arakulam, Manacad and Pallivasal.

In Thodupuzha village, the incidence was least (16.86 per cent) at Olamattom and it was on par with the incidence at Thodupuzha and Kanjiramattom. The highest incidence of 52.75 per cent was observed at Mudalakodam area which was significantly higher compared to the incidence at other locations.

Among the different locations at Udumpannoor village, the incidence was least at Cheenikuzhy

Table 2 Distribution of major insect pests and diseases of ginger in different locations of selected villages in Idikki District Kerala

Village	Locations	Pest incidence: D punctiferalis per cent shoots bored[1]	Pest incidence: M coeruleifrons per cent clumps infested[2]	Pest incidence: U folus per cent shoots with leaf infested[3]	Disease incidence: Leaf spot Disease indices[4]	Disease incidence: Soft rot Disease indices[4]	Type of soil	Previous crop	Insecticide treatment	Fungicide treatment	Age of crop (Days)
Thodupuzha	Kunnam	25 59 (30 98)	13 06 (3 75)	0 00	1 720	0 300	L	G	N	N	105
	Thodupuzha	17 03 (24 37)	30 97 (5 65)	0 00	0 552	0 758	C	G	N	N	125
	Mudalakkodam	52 75 (46 50)	0 00 (1 00)	0 00	1 392	0 000	C	G	N	N	120
	Panjiramattom	22 26 (28 41)	4° 62 (7 11)	0 00	0 240	1 042	L	T	N	Y	135
	Olamattom	16 86 (24 23)	31 01 (5 66)	0 00	0 352	0 380	L	T	N	Y	125
M n		? 07 (30 89)	24 92 (4 64)	0 00	0 851	0 496					
C D		12	0 73								
Udumpannoor	Panchikkal damaruku	55 83 (48 33)	8 09 (3 02)	0 00	2 230	0 218	L	Fa			125
		21 49 (27 61)	0 00 (1 00)	0 00	0 728	0 000	Lo	G	N	Y	130
	Cheenikuzhy	6 93 (15 25)	10 75 (3 42)	0 00	1 328	0 421	C	G	N	N	120
	Pallickal	29 83 (33 09)	0 00 (1 00)	0 00	0 125	0 000	L	F	N	N	120
	Udumpannoor	18 81 (25 69)	39 81 (6 39)	0 00	1 200	0 898	C	R	N	Y	135
ean		26 57 (2° 98)	11 75 (2 97)	0 00	1 130	0 307					
C D		6 12	0 73								
Karimannoor	Chilavu urampalamattom	20 61 (26 99)	2 25 (1 80)	0 00	1 704	0 097	Lo	T	N	N	125
		24 62 (2° 74)	32 97 (5 83)	3 17	1 784	1 557	C	B	N	Y	135
	Pannoor	25 19 (30 12)	0 00 (1 00)	3 23	0 240	0 000	C	G	Y	Y	120
	Karimannoor	21 09 (27 32)	34 35 (5 95)	0 00	1 936	1 125	L	Y	N	Y	120
	Neyyasseri	34 31 (35 84)	0 00 (1 00)	0 00	0 248	0 000	L	R	N	Y	135
Mean		25 16 (30 00	13 91 (3 12)	1 28	1 180	0 856					
C D		NS	0 73								
Arakulam	Arakulam North	9 21 (17 67)	0 00 (1 00)	0 00	0 664	0 000	Lo	Tu	N	N	125
	Poolamattom	24 15 (29 42)	5 78 (2 60)	0 00	1 472	1 120	L	T	N	Y	120
	Karippalangad	25 61 (30 39)	3 90 (2 21)	0 00	1 462	0 113	C	G	N	Y	120
	Arakulam south	26 22 (30 79)	8 09 (3 02)	0 00	0 280	0 139	C	V	N	Y	120
	Elappally	12 10 (20 35)	0 00 (1 00)	6 57	1 944	0 000	C	B	Y	Y	135
Mean		19 44 (25 72)	3 55 (1 97)	1 31	1 170	0 074					
C D		6 12	NS								
Karimkunnam	Mrala	25 52 (30 33)	5 78 (2 60)	0 00	0 288	0 072	C	T	N	Y	120
	Polani	16 48 (23 94)	0 00 (1 00)	0 00	2 320	0 000	C	T	N	N	120
	Karimkunnam	29 67 (32 99)	3 90 (2 21)	0 00	0 040	0 022	Lo	G	N	N	125
	Ottalloor	27 19 (31 42)	1° 71 (4 55)	0 00	1 704	0 387	L	Y	N	N	110
	Thattarathatta	20 86 (27 16)	13 58 (3 82)	0 00	0 720	0 181	C	Fa	N	N	125
Mean		23 94 (2° 17)	8 54 (2 89)	0 00	1 010	0 132					
C D		NS	NS								
Manacad	Nediyasala	36 75 (37 30)	25 46 (5 14)	0 00	1 900	0 113	L	G	N	N	120
	Arikuzha	44 13 (41 61)	8 09 (3 02)	0 00	2 850	0 163	Lo	T	N	Y	125
	Vengalloor	18 36 (25 36)	5 78 (2 60)	0 00	3 000	0 373	C	D	N	Y	125
	Manacad	16 86 (24 23)	0 00 (1 00)	0 00	2 620	0 000	L	G	Y	Y	110
	Puthupariyaram	23 92 (2° 27)	0 00 (1 00)	0 00	2 940	0 000	L	G	N	N	125
Mean		24 60 (32 55)	7 87 (2 55)	0 00	2 870	0 129					
C D		6 12	0 73								
Purapuzha	Vengalloor	29 88 (33 13)	3 90 (2 21)	8 02	2 100	0 043	L	G	N	N	125
	Chilavoor	29 83 (33 09)	17 86 (4 34)	0 00	1 270	0 553	C	B	N	Y	125
	ura u ha	17 49 (24 71)	0 00 (1 00)	0 00	2 650	0 000	L	Y	N	N	120
	hooralloor	22 94 (28 60)	5 78 (2 60)	3 23	1 660	0 247	L	B	N	N	120
	uniji	1° 04 (28 85)	0 00 (1 00)	0 00	1 350	0 000	L	T	Y	Y	140
Mean		23 84 (2° 07)	5 51 (2 23)	2 25	1 810	0 169					
C D		NS	NS								
Pannamkandom	Chattupara	20 31 (26 77)	30 96 (5 65)	0 00	1 300	0 758	C	B	Y	Y	120
	Deviyar	24 07 (2° 37)	8 09 (3 02)	0 00	2 160	0 300	C	B	N	N	120
	Koompanpara	25 12 (30 07)	10 13 (3 34)	0 00	1 200	0 421	L	G	N	N	135
	Pachiplavu	20 43 (26 86)	0 00 (1 00)	0 00	1 400	0 000	L	G	N	N	125
	Valara	23 40 (28 92)	36 82 (6 15)	0 00	2 200	0 898	C	B	N	Y	120
Mean		22 67 (28 39)	17 20 (3 83)	0 00	1 660	0 476					
C D		NS	0 73								
Konnathady	Konnathady	18 06 (25 14)	0 00 (1 00)	0 00	1 870	0 000	L	G	N	N	120
	Attupara	24 23 (29 47)	13 96 (3 85)	0 00	0 830	1 560	C	B	N	Y	110
	Pamblikandom	22 06 (27 99)	26 41 (5 24)	0 00	1 450	1 120	F	G	Y	Y	125
	Panickarkudy	13 55 (21 58)	0 00 (1 00)	0 00	2 390	0 000	C	G	N	Y	105
	Puthunkal	37 18 (37 56)	0 00 (1 00)	0 00	2 950	0 000	L	G	N	N	130
Mean		23 12 (28 35)	8 07 (2 42)	0 00	1 900	0 536					
C D		NS	0 73								
Pallivasal	Anaviratty	41 31 (3° 98)	16 13 (4 13)	0 00	1 790	0 387	C	G	N	Y	105
	Thokkupara	39 73 (39 06)	0 00 (1 00)	0 00	1 780	0 000	F	G	N	Y	125
	Paradippara	22 °3 (28 60)	0 00 (1 00)	6 80	2 780	0 000	F	T	N	N	135
	Kallar	35 30 (36 44)	0 00 (1 00)	0 00	3 530	0 000	F	D	Y	N	120
	Iruttukanam	15 31 (23 02)	0 00 (1 00)	2 35	1 910	0 000	F	G	N	N	105
ean		30 92 (33 42)	3 23 (1 63)	1 83	2 360	0 077					
C D		6 12	NS								
Rajakumary	Kulapparachal	35 86 (36 77)	0 00 (1 00)	0 00	1 630	0 000	F	G	N	Y	125
	Padukkacity	28 97 (32 55)	13 58 (3 82)	0 00	1 400	0 421	C	B	N	Y	105
	Kuruvilacity	44 96 (42 09)	8 09 (3 02)	0 00	0 670	0 181	F	T	Y	Y	120
	Rajakumary	30 84 (33 72)	0 00 (1 00)	0 00	2 670	0 000	F	T	N	N	115
	Muttukadu South	24 84 (29 88)	0 00 (1 00)	0 00	2 330	0 000	F	G	N		125
ean		33 09 (35 00)	4 33 (1 97)	0 00	1 730	0 120					
C D		NS	No								
Raja ad	Nullakkanam	22 92 (28 59)	0 00 (1 00)	0 00	2 410	0 000	F	T	N	N	120
	Rajakad	23 82 (29 19)	8 09 (3 02)	0 00	2 750	0 247	C	T	N	N	105
	R city	21 43 (27 57)	0 00 (1 00)	0 00	1 490	0 000	F	T	N	Y	120
	Thekkumkanam	18 76 (25 66)	0 00 (1 00)	0 00	2 550	0 000	F	Fa	N	N	105
	Pottankad	27 67 (31 72)	0 00 (1 00)	0 00	1 °00	0 154	L	T	N	Y	105
Mean		22 92 (28 54)	1 62 (1 40)	0 00	2 220	0 080					
C D		NS	NS								
Santhanpara	Estate Poopara	23 89 (29 25)	8 10 (3 02)	6 06	1 870	0 222	F	G	N	Y	105
	Santhanpara	40 24 (1° 36)	3 90 (2 21)	0 00	0 830	0 253	F	G	N	Y	105
	Murikkinthotty	18 79 (25 68)	0 00 (1 00)	0 00	2 310	0 000	F	G	N	Y	115
	Pethotty	20 59 (26 98)	0 00 (1 00)	0 00	2 230	0 000	F	T	N	N	120
	Puthady	30 01 (33 20)	0 00 (1 00)	0 00	1 300	0 000	F	G	N	Y	120
ean		26 70 (30 89)	2 40 (1 64)	1 06	1 710	0 095					
C D		NS	NS								
h nna kanal	Chinnakkanal	20 15 (26 66)	0 00 (1 00)	0 00	0 850	0 000	F	Fa	N		105
	Chempakathozhu	24 54 (29 68)	0 00 (1 00)	0 00	1 580	0 000	F	R	Y	Y	105
	Bealram	1° 20 (25 98)	2 25 (1 80)	0 00	1 490	0 110	F	G	N	Y	120
	Singhkandom	1° 48 (26 18)	0 00 (1 00)	0 00	0 840	0 000	F	G	N	N	105
	Muttukadu North	11 39 (19 71)	0 00 (1 00)	0 00	1 130	0 000	F	G	N	Y	120
ean		18 95 (25 64)	0 45 (1 16)	0 00	1 180	0 022					
		NS	NS								
District mean		24 92	8 09	0 55	1 627	0 234					
CD for comparing villages		NS	1 22		0 877	0 455					

1 Figures in parentheses are transformed values (angles)
2 Figure in parenthe es are transformed values ($\sqrt{x+1}$)
3 Data not statistically analysed
4 Data relating to villages alone were statistically analysed since replication values were not available for locations

L Laterite soil
C Claye soil
Lo Loamy soil
F Forest soil

B Banana
Fa Fallow
G Ginger
R - Ragi
T Tapioca
Tu Turmeric
Y Yams

N No treatment
Y Treated

(6.93 per cent) and it was significantly lower that the incidence in other locations. The incidence at Udumpannoor and Edamaruku were on par but significantly lower than that of Manchikkal North which had the highest incidence of 55.83 per cent.

The incidence of the pest in Arakkulam village showed that the incidence at Arakkulam North (9.21 per cent) and Elappally (12.1 per cent) were on par and these were significantly lower than the incidence at the other three locations viz. Moolamattom, Karippalangad and Arakkulam South which were on par among themselves. The highest incidence (26.22 per cent) was recorded from Arakulam South.

Significant differences in the incidence was observed in Manacad village. The least incidence (16.86 per cent) was oobserved at Manacad proper which was on par with the incidence at Vengalloor and Puthupariyaram. These three locations had significantly lower incidence compared with Nediyasala and Arikuzha which were on par. The incidence was highest at Arikuzha (44.13 per cent).

The incidence of the borer in Pallivasal village showed that two locations viz. Irittukanam and Karadippara had significantly lower incidence compared to other three locations, the above locations being on par. The least

incidence (15.31 per cent) was recorded at Irittukanam. The incidence in the other three locations were on par among themselves with Anaviratty showing the maximum incidence of 41.31 per cent.

3.3.2. Rhizome maggot M. coeruleifrons

Significant difference was observed among the different villages in the incidence of the pest.

The incidence of M. coeruleifrons in Thodupuzha village was significantly higher (24.92 per cent) compared to all other villages except Mannamkandom (17.20). The incidence of the maggot in Konnathady, Karimkunnam, Udumpannoor, Karimannoor and Mannamkandom were on par (8.07 to 17.20 per cent) and significantly high compared to the incidence in Chinnakkanal (0.45 per cent). The pest incidence in Rajakumary, Arakulam, Purapuzha, Manacad, Konnathady, Karimkunnam and Udumpannoor did not vary among themselves. Similarly, the incidence in Chinnakkanal, Rajakad, Pallivasal, Santhanpara, Rajakumary, Arakulam and Purapuzha were on par (0.45 to 5.51) but significantly low, compared to Mannankandom and Thodupuzha. The minimum and maximum infestations were recorded in villages Chinnakkanal and Thodupuzha with mean per cent infestations of 0.45 and 24.92 respectively.

Significant difference in pest incidence in different locations was observed in six of the 14 villages surveyed viz. Thodupuzha, Udumpannoor, Karimannoor, Manacad, Mannamkandom and Konnathady.

In Thodupuzha village, the incidence at Kanjiramattom (49.62 per cent) was significantly higher than other locations. The incidence at Olamattom and Thodupuzha were on par but significantly high compared with the incidence at Kunnam (13.06 per cent). No incidence was observed at Mudalakkodam.

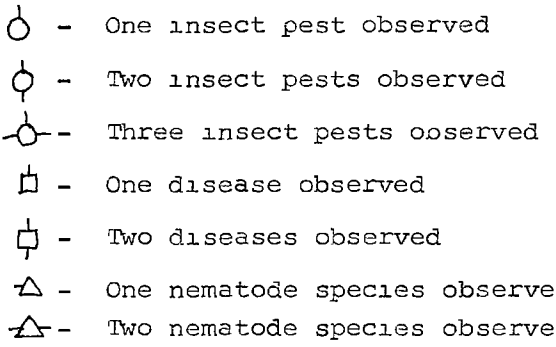
The incidence at Udumpannoor (39.81 per cent) in Udumpannoor village was significantly high compared with Manchikkal and Cheenikuzhy which were on par (8.09 and 10.75 per cent).

In Karimannoor village, Purampalamattom and Karimannoor recorded high incidence of 32.97 and 34.35 respectively which were on par and significantly higher than the incidence at Chilavu (2.25 per cent). The pest incidence at locations Arikuzha and Vengalloor in Manacad (8.09 and 5.78 per cent) was on par but significantly less compared to the incidence at Nediyasala (25.46 per cent).

In Mannamkandom village, the highest incidence was recorded from Valara (36.82 per cent) and Chattupara (30.96 per cent) also came on par. These were significantly

Fig. 2. Map of Idukki District showing the distribution of pests/diseases/nematodes in different villages.

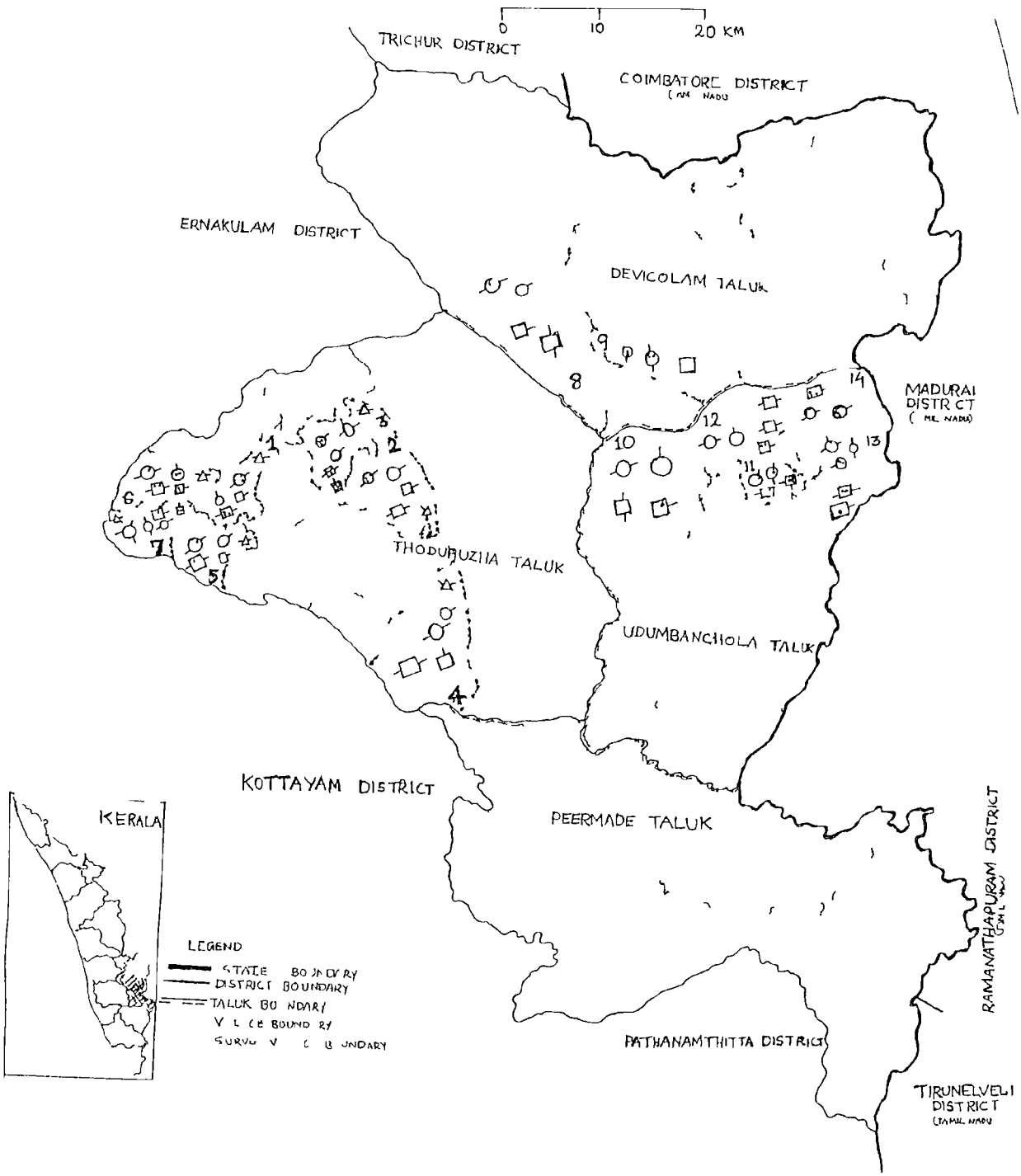
1. Thodupuzha
2. Udumpannoor
3. Karimannoor
4. Arakulam
5. Karimkunnam
6. Manacad
7. Purapuzha
8. Mannamkandom
9. Pallivasal
10. Konnathady
11. Rajakumary
12. Rajakad
13. Santhanpara
14. Chinnakkanal



The dots inside the marks indicate the number of locations having pests/diseases/nematodes

Fig 2

IDIKKI DISTRICT



higher than the incidence at Koompanpara and Deviyar, which were on par (10.13 and 8.09 per cent). The incidence at Attupara and Kambilikandom in Konnathady village showed significant variations, the per cent incidence being 13.96 and 26.41 respectively. The other three locations were free from pest incidence.

3.3.3. Leaf roller U. folus

The incidence of leaf roller U. folus was observed only in five villages out of the 14 surveyed. The maximum infestation of 2.25 per cent was observed in Purapuzha village. The highest incidence among the different locations was also observed from the above village (8.02 per cent). The mean per cent incidence in the district was 0.55 per cent.

3.3.4. Leaf spot disease

The leaf spot incidence varied significantly among different villages in Idikki District.

The disease incidence was very high in Manacad, Pallivasal and Rajakad villages, the disease indices being in the range of 2.87 to 2.22 which were on par and significantly high compared with other villages. Among these three, the incidence in the villages Pallivasal and

Rajakad were on par with that of Konnathady, Purapuzha, Rajakumary, Santhanpara and Mannamkandom (Disease indices 1.900 to 1.660), which were on par among themselves. Karimannoor, Chinnakkanal, Arakulam, Udumpannoor and Karimkunnam had disease indices ranging from 1.180 to 1.010 and they were on par. The lowest disease index of 0.85 was recorded from Thodupuzha, which was on par with all the other villages except Manacad, Pallivasal, Rajakad, Konnathady and Purapuzha which had significantly higher level of incidence.

3.3.5. Soft rot disease

Significant difference was observed in the incidence of soft rot disease among the different villages surveyed. The disease incidence in Karimannoor village (0.856) was significantly higher compared with those of Santhanpara, Rajakkad, Pallivasal and Chinnakkanal (disease indices 0.095 to 0.022). The incidence in Konnathady (0.536) was significantly hign compared with the incidence in Pallivasal and Chinnakkanal (0.077 and 0.022) but was on par with the rest of the villages. The disease indices in all the villages except Santhanpara, Rajakad, Pallivasal and Chinnakkanal were on par. Similarly, the incidence in all the villages except Karimannoor, Konnathady and Thodupuzha

were on par. The disease indices in Karimannoor, Konnathady, Thodupuzha, Munnamkandom and Udumpannoor villages were in the high range of 0.856 to 0.307, while Purapuzha, Karimkunnam, Manacad and Rajakumary were having disease indices in the medium range of 0.169 to 0.120. Villages Santhanpara, Rajakad, Pallivasal, and Chinnakkanal had lower range of disease indices (0.095 to 0.022). The mean disease incidence in the District was 0.234.

The soils of the locations covered in the survey included laterite, clay, loam and forest types. The crop was rotated with ginger, tapioca, banana, yams, vegetable, ragi and turmeric. In some locations the crop was raised on land left fallow. While fungicidal application was done in more than 60 per cent of the locations, insecticidal application was given in only a few locations. The growth stages of the crop when surveyed ranged from 105 to 140 days.

3.4. Influence of different soil types in Kottayam District, Kerala on the incidence of different pests and diseases in ginger observed in September-October, 1986

The data on the above and the results of the statistical analysis are given in Table 3 .

Table 3. Influence of different soil types in Kottayam District, Kerala on the incidence of different pests and diseases in ginger observed in September/October 1986

Soil type	Mean per cent of shoots bored by *D. punctiferalis*[1]	Mean per cent of clumps infested by *M. coeruleifrons*[2]	Mean indices of leaf spot disease	Mean indices of soft rot disease
With fungicide treatment				
Laterite soil	22.21 (28.02)	7.49 (2.91)	0.884	0.209
Loamy soil	19.93 (26.63)	7.25 (2.87)	0.768	0.236
Clayey soil	24.03 (29.71)	6.45 (2.73)	0.829	0.412
Not treated				
Laterite soil	26.02 (30.66)	2.57 (1.89)	1.298	0.147
Loamy soil	22.31 (28.18)	3.90 (2.21)	0.952	0.049
Clayey soil	28.19 (32.06)	9.56 (3.25)	1.882	0.476
CD (0.05 level)	NS	NS	NS	NS

1 Figures in parentheses are transformed values (angular)

2 Figures in parentheses are transformed values ($\sqrt{x+1}$)

The results showed that the incidence of D. punctiferalis was not significantly influenced by the different types of soil in which plants were grown though the percentage of infested shoots ranged from 19.93 to 28.19. The mean percentage of clumps infested by M. coerleifrons ranged from 2.57 to 9.56 in different soils observed. These data also did not show significant variations. The mean indices of leaf spot disease also was not seen significantly associated with the different types of soil although the index varied from 0.952 to 1.882. The mean indices of soft rot disease also was not significantly associated with the type of soil even though it was as high as 0.476 in clayey soil.

3.5. Influence of different soil types in Idukki District, Kerala on the incidence of different pests and diseases in ginger observed in September-October 1986

The data on the above and the results of the statistical analysis are given in Table 4.

The results showed that the incidence of D. punctiferalis was not significantly influenced by the different types of soil in which the plants were grown though the percentage of infested shoots ranged from 22.98 to 29.67. The mean percentage of clumps infested by M. coerulefrons ranged from 1.25 to 12.39 in different

Table 4. Influence of different soil types in Idikki District, Kerala on the incidence of different pests and diseases in ginger observed in September/October 1986

Soil type	Mean per cent of shoots bored by *D. punctiferalis*[1]	Mean per cent of clumps infested by *M. coeruleifrons*[2]	Mean indices of leaf spot disease	Mean indices of soft rot disease
With fungicide treatment				
Laterite soil	26.21 (30.78)	7.12 (2.85)	1.252	0.313
Loamy soil	24.05 (29.37)	3.04 (2.01)	1.289	0.065
Clayey soil	22.98 (28.68)	12.25 (3.64)	1.300	0.497
Forest soil	25.14 (30.09)	2.69 (1.92)	1.460	0.022
Without fungicide treatment				
Laterite soil	25.59 (30.58)	5.50 (2.55)	1.940	0.369
Loamy soil	29.67 (32.99)	1.25 (1.50)	1.204	0.121
Clayey soil	24.07 (29.38)	12.39 (3.66)	1.583	0.572
Forest soil	23.82 (29.19)	1.63 (1.28)	2.200	0.008

1. Figures in parentheses are transformed values (angular)
2. Figures in parentheses are transformed values ($\sqrt{x+1}$)

CD for comparing soft rot disease indices in clayey and forest soils 0.41

Remaining data did not show statistically significant variations

soils observed. These data also did not show significant variations. The mean indices of leaf spot disease also was not seen significantly associated with the different types of soil though the index in forest soil was as high as 2.2 while it ranged from 1.204 to 1.94 in the remaining soils. The mean indices of soft rot disease was seen significantly associated with the type of soil and the disease was significantly lower in forest soils.

3.6. Correlation coefficients between incidence of rhizome maggot and soft rot disease on ginger

The correlation coefficients between the incidence of rhizome maggot and soft rot disease in Kottayam and Idikki Districts were worked out.

Significant correlations were obtained between the incidence of the pest and that of the disease in Kottayam District (r = 0.4155 (sig at 0.05 level) and in Idikki District (r = 0.4654 (sig at 0.01 level).

3.7. Correlation between age of crop and incidence of pests and diseases of ginger

The correlation coefficients between age of crop and the incidence of pests and diseases in both the districts were worked out.

The incidence of soft rot in Idikki District alone was negetively and significantly correlated with age of crop while rhizome maggot and soft rot diseases were negetively correlated but these correlations were not statistically significant.

3.8. Plant parasitic nematodes associated with ginger in Kottayam District, Kerala

The data on the above are given in Taole 5.

Meloidogyne sp and Radopholus sp were observed both in the soil around ginger plants as well as in root samples. Helicotylenchus sp was obtained from the soil from all the villages and in the case of roots, it was absent in two villages viz. Anicad and Manimala. Tylenchorhynchus sp, Criconema sp were obtained from soil only from three and two villages respectively. The populations of Meloidogyne sp and Radopholus sp in soil as well as in roots were high. No significant difference was observed in the population of any of the above nematode species in soil among the different villages. The population of Meloidogyne sp, Radopholus sp and Helicotylenchus sp in soil varied from 8.59 to 22.98, 20.89 to 47.23 and 1.59 to 5.41 respectively. The mean populations of Tylenchorhynchus sp and Criconema sp which were observed only in soil ranged between 2.83 and 0.92 only.

Table 5. Plant parasitic nematodes associated with ginger in Kottayam District, Kerala

Village	Mean number of nematodes observed in soil (100 g) and root (10 g) samples									
	Meloidogyne sp.		*Radopholus* sp.		*Helicotylenchus* sp.		*Tylenchorhynchus* sp.		*Criconema* sp	
	Soil	Root	Soil	Root	Soil	Root	Soil	Root	Soil	Root
Anicad	22.98 (4.89)	31.97 (5.74)	40.97 (6.48)	34.12 (5.93)	2.65 (1.91)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)
Akalakunnam	11.79 (3.58)	13.52 (3.81)	38.14 (6.26)	53.11 (7.36)	5.41 (2.53)	5.19 (2.48)	0 (1)	0 (1)	0 (1)	0 (1)
Vellavoor	14.28 (3.91)	45.70 (6.83)	39.28 (6.35)	25.77 (5.17)	1.59 (1.61)	4.44 (2.33)	4.91 (2.43)	0 (1)	3.17 (2.04)	0 (1)
Ayarkunnam	8.59 (3.09)	18.44 (4.41)	20.95 (4.68)	12.85 (3.72)	4.15 (2.27)	2.21 (1.79)	5.43 (2.54)	0 (1)	0 (1)	0 (1)
Kuravilangad	21.12 (4.70)	52.79 (7.33)	20.89 (4.67)	64.49 (8.09)	3.65 (2.16)	4.91 (2.43)	0 (1)	0 (1)	0 (1)	0 (1)
Manimala	19.89 (4.57)	53.60 (7.39)	47.23 (6.94)	67.87 (8.29)	3.17 (2.04)	0 (1)	6.63 (2.76)	0 (1)	2.32 (1.82)	0 (1)
Mean	16.44	36.00	34.58	43.03	3.44	2.79	2.83	0	0.92	0
CD (0.05 per cent level)	NS	1.91	NS	1.65	NS	NS	NS	NS	NS	NS

Figures in parentheses are transformed values ($\sqrt{x+1}$)

Significant difference in the population of Meloidogyne sp and Radopholus sp in root was observed. The population of Meloidogyne sp in the root observed at Ayarkunnam and Akalakunnam villages (18.44 and 13.52) were low and did not vary significantly between themselves, but these were significantly lower than the populations at Vellavoor, Kuravilangad and Manimala, which were on par among themselves(45.7, 52.79 and 53.6).

Radopholus population was least in Ayarkunnam (12.85) which was significantly lower compared with other villages except Vellavoor (25.77). The population in Manimala (67.87) which was the highest was on par with the population at Kuravilangad (64.49) and Akalakunnam (53.11), all these three being significantly higher than the population observed at Ayarkunnam and Vellavoor.

3.9. Plant parasitic nematodes associated with ginger in Idikki District of Kerala

The data relating to the above are given in Table 6.

Meloidogyne sp, Radopholus sp and Helicotylenchus sp were observed in soil as well as in roots while Tylenchorhynchus sp, Criconema, Xiphenema sp and Monochus sp were observed in soil only.

Table 6. Plant parasitic nematodes associated with ginger in Idikki District, Kerala

Village	Mean number of nematodes observed in soil (100 g) and root (10 g) samples													
	Meloidogyne sp.		*Radopholus* sp.		*Helicotylenchus* sp.		*Tylenchorhynchus* sp.		*Criconema* sp.		*Xiphinema* sp.		*Monochus* sp.	
	Soil	Root	Soil	Root	Soil	Root	Soil	Root	Soil	Root	Soil	Root	Soil	Root
Arakulam	12.83 (3.72)	13.17 (3.76)	15.36 (4.04)	27.45 (5.33)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	1.40 (1.55)	0 (1)
Thodupuzha	5.59 (2.57)	8.85 (3.14)	5.34 (2.62)	21.91 (4.79)	4.55 (2.35)	7.07 (2.84)	0 (1)	0 (1)	2.49 (1.80)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)
Manacad	12.42 (3.66)	22.80 (4.88)	29.13 (5.49)	47.59 (6.97)	2.55 (1.88)	8.64 (3.11)	0 (1)	0 (1)	3.33 (2.08)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)
Purapuzha	7.29 (3.21)	8.85 (3.14)	34.01 (5.92)	35.51 (6.04)	4.18 (2.28)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	6.11 (2.67)	0 (1)	0 (1)	0 (1)
Karimannoor	7.88 (2.98)	38.37 (6.27)	33.76 (5.89)	55.25 (7.49)	3.55 (2.13)	14.61 (3.95)	0 (1)	0 (1)	1.96 (1.72)	0 (1)	1.96 (1.72)	0 (1)	0 (1)	0 (1)
Udumpannoor	8.62 (3.10)	16.71 (4.29)	23.40 (4.94)	62.60 (7.98)	9.26 (3.20)	17.39 (4.29)	13.89 (3.86)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)
Karimkunnam	22.46 (4.84)	45.34 (6.81)	21.16 (4.71)	70.55 (8.46)	1.17 (1.47)	7.73 (2.95)	10.72 (3.42)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)
Mean	11.01	22.01	23.17	45.84	3.61	7.92	3.52	0	1.11	0	1.15	0	0.2	0
CD (0.05 per cent level)	1.30	1.92	1.15	2.06	0.97	NS	NS	NS	NS	NS	NS	NS	NS	NS

Figures in parantheses are $\sqrt{x+1}$ transformations.

Significant differences were observed in the population of Meloidogyne sp and Radopholus sp in soil as well as in root. The population of Meloidogyne sp varied from 5.59 to 22.46. The population in all the villages except Karimkunnam (22.46) were on par. The population in Karimkunnam was on par with that of Manacad and Arakulam. The population of Meloidogyne sp in roots varied from 8.85 at Purapuzha to 45.34 at Karimkunnam. The population at Karimkunnam and Karimannoor were significantly high compared with the populations in other villages.

The population of Radopholus sp in soil varied from 5.34 at Thodupuzha to 34.01 at Purapuzha. The population in Manacad, Purapuzha, Karimannoor and Udumpanoor were on par and significantly higher than the population at Thodupuzha (5.34), which had the lowest population.

Radopholus population in root varied from 21.91 at Thodupuzha to 70.55 at Karimkunnam. The population at Karimkunnam, which was the highest was on par with that of Udumpannoor, Karimannoor and Manacad and significantly higher than the rest of the villages.

Population of Helicotylenchus sp varied from zero at Arakulam to 9.26 at Udumpannoor. The population

at Udumpannoor was on par with that of Purapuzha and Thodupuzha and significantly higher than the population in the rest of the villages.

The populations of Helicotylenchus sp in root did not vary significantly among different villages. Similarly the variations in population of Tylenchorhynchus sp, Criconema sp, Xiphinema sp and Monochus sp in soil among different villages were also non significant.

3.10. Population build up of shoot borer D. punctiferalis

The data relating to the population build up of shoot borer at five locations in Thodupuzha Taluk observed at monthly intervals, observations starting from the end of June are presented in Table 7.

The population build up of the borer during the months of July, August and September showed a steady increase compared to the population in the previous months. The mean incidence of bored shoots reached the peak of 20.50 per cent in the month of September. The incidence in October was slightly less (17.08 per cent) but on par with that of September. The percentage of shoots bored by the pest reached the minimum of 8.56 per cent by the end of November and it was significantly lower than that of October.

Table 7. Population build up of shoot borer, *D. punctiferalis*, on ginger observed in Thodupuzha Taluk of Idikki District, Kerala

Location	Mean percentage of shoot bored during the month of						Mean
	June (30 DAP)	July (60 DAP)	August (90 DAP)	September (120 DAP)	October (150 DAP)	November (180 DAP)	
Karimannoor	0.00 (0.00)	8.17 (16.60)	8.17 (17.15)	30.85 (33.73)	15.15 (22.90)	10.08 (18.50)	12.16 (18.14)
Udumpannoor	1.66 (7.39)	2.95 (9.89)	13.99 (21.96)	13.11 (21.22)	22.17 (28.08)	11.76 (20.04)	10.94 (18.09)
Karimkunnam	1.28 (6.49)	3.71 (11.10)	17.93 (25.04)	20.59 (26.98)	24.01 (29.33)	10.91 (19.28)	13.07 (19.71)
Mudalakodam	0.42 (3.69)	3.65 (11.02)	6.14 (14.32)	5.77 (13.89)	6.05 (14.24)	2.66 (9.38)	4.12 (11.08)
Cheenikuzhy	0.00 (0.00)	6.74 (15.04)	14.45 (22.23)	32.17 (34.54)	18.03 (25.12)	9.61 (18.05)	13.52 (19.18)
Mean	0.67 (3.52)	5.04 (12.73)	12.24 (20.17)	20.50 (26.07)	17.08 (23.93)	8.56 (17.05)	

CD (0.01 per cent level) for comparing the incidence at different locations: 3.41
CD (0.01 per cent level) for comparing the incidence during different periods: 3.73
Figures in parenthesis are angular transformations.

Comparing the mean incidence of the borer at different locations during the entire period, in four out of the five locations, the mean incidence of the borer were on par. The borer incidence in the other location (Mudalakkodam) was significantly lower (4.12 per cent). Comparing the different locations, no infestation occurred in two locations during June viz. Karimannoor and Cheenikuzhy, the peak infestation being in September. In Udumpannoor the peak infestation was in October. The pest population at Mudalakodam and Karimkunnam during August, September and October were on par.

3.11. Population build up of rhizome maggot *M. coeruleifrons* on ginger

The data relating to the survey and results of statistical analysis of the same are presented in Table 8.

There was no significant difference in the mean populations of the pest observed in various locations, (3.65 to 11.63 per cent of clumps).

Significant differences in the intensity of the pest, incidence was observed during the different months. The infestation was zero in the month of June. The incidence during July (3.18 per cent) was on par with that of August (6.63 per cent). The incidence in September (11.02 per cent) was on par with that of

Table 8. Population build up of rhizome maggot M. coeruleifrons on ginger, observed in Thodupuzha Taluk of Idikki District, Kerala

Location	Mean percentage of clumps infested - observed at the end of						Mean
	June (30 DAP)	July (60 DAP)	August (90 DAP)	September (120 DAP)	October (150 DAP)	November (180 DAP)	
Karimannoor	0.00 (1.00)	0.00 (1.00)	5.78 (2.60)	10.75 (3.43)	19.79 (4.56)	10.59 (3.41)	7.82 (2.67)
Udumpannoor	0.00 (1.00)	0.00 (1.00)	5.78 (2.60)	8.09 (3.01)	13.58 (3.81)	5.79 (2.60)	5.54 (2.33)
Karimkunnam	0.00 (1.00)	10.14 (3.34)	13.58 (3.82)	16.89 (4.23)	23.41 (4.94)	5.78 (2.60)	11.63 (3.32)
Mudalakodam	0.00 (1.00)	0.00 (1.00)	2.25 (1.80)	5.78 (2.60)	8.09 (3.02)	5.78 (2.60)	3.65 (2.00)
Cheenikuzhy	0.00 (1.00)	5.78 (2.60)	5.78 (2.60)	13.58 (3.82)	16.89 (4.23)	5.78 (2.60)	7.97 (2.81)
Mean	0.00 (1.00)	3.18 (1.78)	6.63 (2.76)	11.02 (3.42)	16.35 (4.11)	6.74 (2.78)	

Data relating to the different locations did not show statistically significant variations

CD for comparing periods : 0.96

Figures in parentheses are transferred values ($\sqrt{x+1}$)

August and November (6.74), but significantly higher than the incidence in July. The incidence in October was the highest (16.35 per cent) and was significantly higher than the incidence in all previous months except September (11.02) with which it was on par.

3.12. Seasonal incidence of leaf spot and soft rot diseases of ginger observed at different locations in Thodupuzha Taluk

The data relating to the observations and the results of statistical analysis of the same are presented in Table 9.

Leaf spot incidence in various months during the crop period showed significant variation. The disease was not observed during June. The disease incidence in July was significantly lower than those of the succeeding months. August and November recorded mean indices of 0.217, 0.211 respectively which were on par. The disease intensity was maximum at 0.525 in September and was significantly higher than the disease index of 0.392 in October. The highest index of 0.596 observed among the different locations was also recorded in September.

Soft rot incidence also showed significant variations during the different months of the crop duration. The incidence was zero in June. The mean

Table 9. Seasonal incidence of leaf spot and soft rot diseases of ginger observed at five different locations (vide Table 7) in Thodupuzha Taluk

Month	Leaf spot (indices)		Soft rot (indices)	
	Mean	Range	Mean	Range
June	0.000	(0.000 - 0.000)	0.000	(0.000 - 0.000)
July	0.018	(0.000 - 0.056)	0.110	(0.000 - 0.230)
August	0.217	(0.168 - 0.271)	0.252	(0.080 - 0.520)
September	0.525	(0.442 - 0.596)	0.360	(0.120 - 0.610)
October	0.392	(0.260 - 0.482)	0.292	(0.090 - 0.440)
November	0.211	(0.144 - 0.291)	0.136	(0.080 - 0.410)
CD (5% level)	0.072		0.163	

disease indices observed in July, August and November were on par but significantly lower than that observed in September. The disease indices in August, September and October were statistically on par. The mean maximum disease index of 0.360 was recorded in September. The highest disease index of 0.610 recorded among the different locations also was observed during September.

3.13. Correlation of weather parameters with the incidence of pests and diseases of ginger

The correlation coefficients of weather parameters with pests namely *D. punctiferalis* and *M. coeruleifrons*, and diseases namely leaf spot and soft rot are given in Table 10.

Maximum temperature was found to be correlated negatively with the incidence of *D. punctiferalis*, *M. coeruleifrons* and soft rot disease and positively with the incidence of leaf spot disease, though not significant. With minimum temperature, the correlation was positive except with the incidence of *M. coeruleifrons*. These correlations were also not significant.

Relative humidity was found to have a high positive correlation with the incidence of both pests and diseases. The correlation was significant in the case of soft rot

Table 10. Correlation coefficients of weather parameters with the incidence of pests and diseases of ginger

Pest/Disease	Correlation coefficients with				Number of rainy days
	Maximum temperature	Minimum temperature	Relative humidity	Total rainfall (mm)	
D. punctiferalis	-0.1814	0.1302	0.7324	-0.3116	-0.4676
M. coeruleifrons	-0.5321	-0.1942	0.7151	-0.5627	-0.5211
Leaf spot	0.0143	0.1326	0.5863	-0.1972	-0.5374
Soft rot	-0.4672	0.0282	0.8537*	-0.1767	-0.4924

disease and non significant in the case of D. punctiferalis, M. coeruleifrons and leaf spot diseases.

Total rainfall had a negative correlation with the incidence of pests and diseases but these correlations were not statistically significant. The number of rainy days also was negatively correlated with the incidence of both pests and diseases under study. Though the correlation coefficients were high, they were not statistically significant.

3.14. Biology and morphology of rhizome maggot M. coerulefrons

3.14.1. General habits of adults

Adults of M. coeruleifrons were medium sized flies with long legs, with which they moved about constantly. The first pair of legs which were shorter are used for cleaning body parts and were generally held in front of the head while resting. They were not brisk fliers. They were found in the field in the morning and evening hours and prefer shade when the sun was hot. The flies had the habit of congregating around decayed and diseased clumps and they fed on decayed tissues.

Adult male was 1.02 cm long (range 0.9 to 1.1 cm) and had a wingspan of 1.6 cm (range 1.5 to 1.7), while

the female adult was 1.49 cm long (range 1.4 to 1.6 cm) and had a wingspan of 1.58 cm (range 1.4 to 1.6 cm) respectively. The abdomen of male and female differed as shown in Fig. 3. In female, the fore, mid and hind legs measured 0.94, 1.5 and 1.89 cm in length with ranges of 0.9 to 1, 1.4 to 1.6 and 1.8 to 2.0 cm respectively, while in female, they were 1.05, 1.56 and 1.95 cm long with ranges of 1 to 1.1, 1.5 to 1.6 and 1.9 to 2.0 cm respectively. Both in male and female, the tarsal segments of the forelegs except the first segment were white in colour. The second and third pair of legs had yellowish femur with intermittant dark coloured tibia and tarsal segments. The wings were transparent, pubescent with the top and middle portion having brownish shade. The body was dark in colour.

3.14.2. Mating and oviposition

Mating was observed during day time in the field. In the laboratory, it was observed during day and night. A single male mated with more than one female and also more than once with a particular female. The mating lasted for 2 to 5 minutes. The mating took place after a mean pre-mating period of 12.6 days with a range of 10 to 15 days.

3.14.3. Oviposition

Oviposition started after the mean oviposition period of 1.83 days with a range of one to three days and the oviposition period lasted for 20 to 27 days with a mean of 23.67 days. But more than 90 per cent of the eggs were laid in the first 15 days of the oviposition period.

The eggs were generally laid singly, but they were found in small clusters too. Majority of eggs were laid in the soil around collar region. However, some eggs could also be observed in small numbers on leaves, leaf axils and shoots. The eggs were thrust by the female into the soil up to a depth of 50 to 100 mm.

The adult female laid on an average 234.2 eggs when fed with 10 per cent honey and 398 eggs when fed with 10 per cent honey mixed with a few grains of yeast. The ranges in the number of eggs laid were 173 to 294 and 357 to 426 respectively. The adult male lived for an average of 40 days while the female lived for 49.33 days with in a range of 32 to 49 days and 34 to 54 days respectively. The females were more in number with 1.318 females per male (range 1.14 to 1.5).

3.14.4. Egg stage

The egg was elongate oval, with the posterior extremity broadly rounded while the anterior portion

Fig. 3. Life stages of the rhizome maggot *M. coeruleifrons* on ginger.

A. Egg

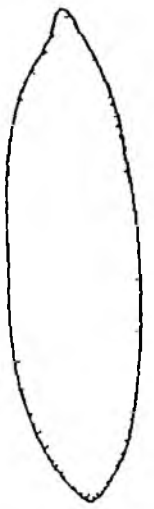
B. First instar larva

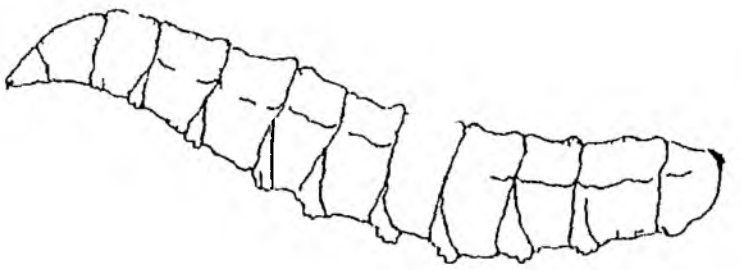
C. Second instar larva

D. Pupa

E. Adult male

F. Adult female





0 mm

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A

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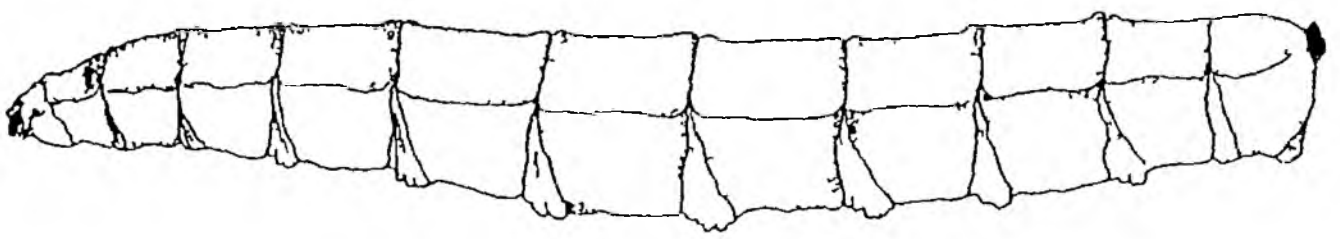

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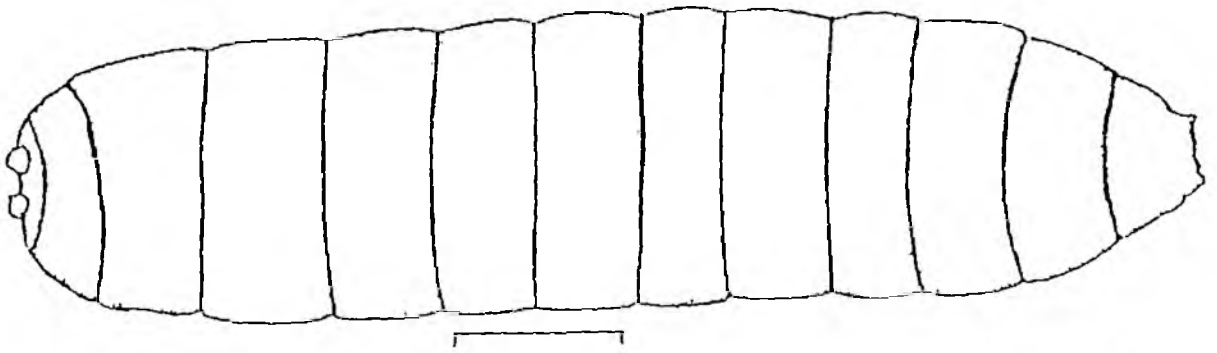

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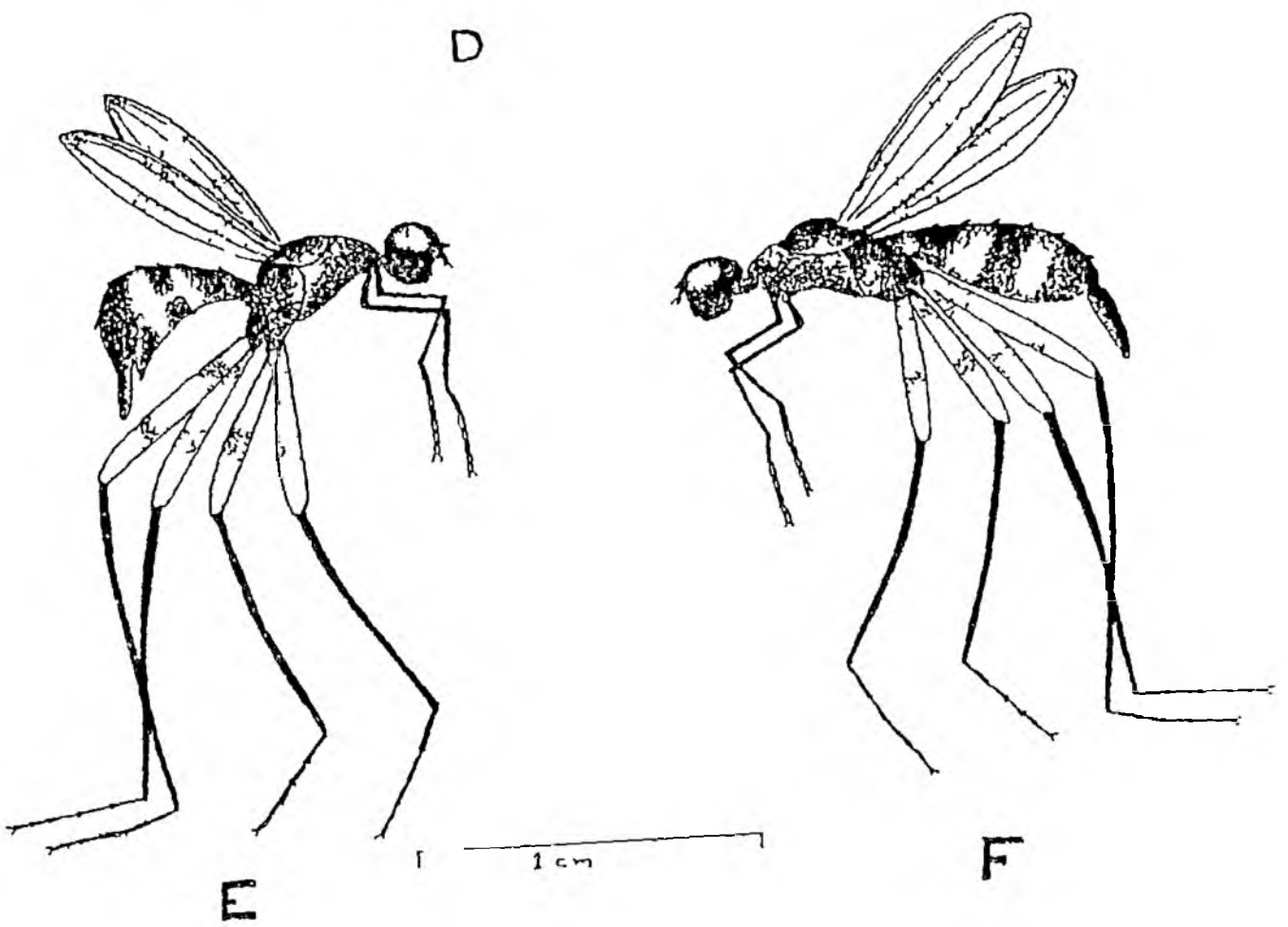


1 cm

E

F

terminated in a small finger shaped projection (Fig. 3A). The colour was pearly white, which faded slightly as it approached hatching. The chorion of the egg was sculptured with numerous longitudinal ridges and grooves.

The egg stage extended upto four days during which period, upto 85 per cent of eggs hatched out (vide Table 11) The egg was 0.07 cm long and 0.012 cm broad at the middle. The time taken for 50 per cent of eggs to hatch was 2.83 days (range 2 to 3 days) and the peak period of hatch was at 2.66 (range 2 to 3 days). The mean per cent hatch was 91.67.

3.14.5. Larval instars

Three larval instars were identified by observing the moulting. Variations in the size and structure of mouth hooks, anterior and posterior spiracles were also taken into account in deciding the larval instars.

3.14.6. First instar larva

The larva emerged through a longitudinal slit near the anterior end of the egg. The larva was slender, white and translucent, cylindrical but for the anterior end which was tapering (Fig. 3B). The body consisted of 12 segments. The head represented by the first segment was vestegial. The mouth was slit like and situated in

the middle of the lower surface of the head, in between two oral lobes, which had two antennal buds at the apex. Anterior spiracles present on second and third instar absent. Spinular areas were present on the ventral side of almost every segment with two rows of hooklets. Posterior spiracles were situated close together as shown in Fig.4B. Inter spiracular hairs were visible. Mouth hooks light yellowish brown in colour were also seen.

The duration of first instar larva extended from 3 to 5 days and during this period, the length increased from 0.077 cm at hatching to 0.325 cm at moult (Table 11) 4 to 12 per cent of the first instar larvae died (mean 8) before reaching the second instar. The larva preferred to reamin concealed.

3.14.7. Second Instal larva

The second instar larva was slightly yellowish and more opaque (Fig. 3C). The posterior spiracles were visible as two reddish brown projections. A pair of anterior spiracles situated dorsolaterally on either side of the prothoraic segment was also seen prominently. The anterior spiracle was funnel shaped with several digitate structures and resembled that of third instar (Fig. 4A). There were 12 segments with two rows of spinules aiding locomotion on the ventral side as in the

first instar. The body surface was smooth except the mouth region and spinular areas. The mouth hooks were darker and larger than in the first instar larva and its ventral and dorsal process were equal in length and resembled that of third instar (Fig. 4C). The posterior spiracles were not situated close together as in the first instar. Two spiracular openings were present. Four sets of interspiracular hairs which were transparent and branched, were present.

The length of the larva increased from 0.400 cm at moulting to 0.650 cm at the next moult and the width increased from 0.065 to 0.085 cm during the period. The second instar lasted for 4 to 6 days and 4 to 16 per cent of the larvae of this instar (mean 8 per cent) failed to reach the third instar. The larva fed voraceously, preferring concealed conditions.

3.14.8. Third instar larva

The third instar larva was circular in cross section, longer, stouter, opaque and cream coloured and was similar to the second instar except in size and the number of spiracular openings. There were 12 segments in the body. The anterior and posterior spiracles and mouth hooks became larger and more sclerotized. The spinular areas on the under surface of the segments also

Fig. 4. The anterior and posterior spiracles and the cephalopharyngeal skeleton of the third instar larva of M. coeruleifrons.

A. Anterior spiracle

(a) Papplae
(b) Stalk

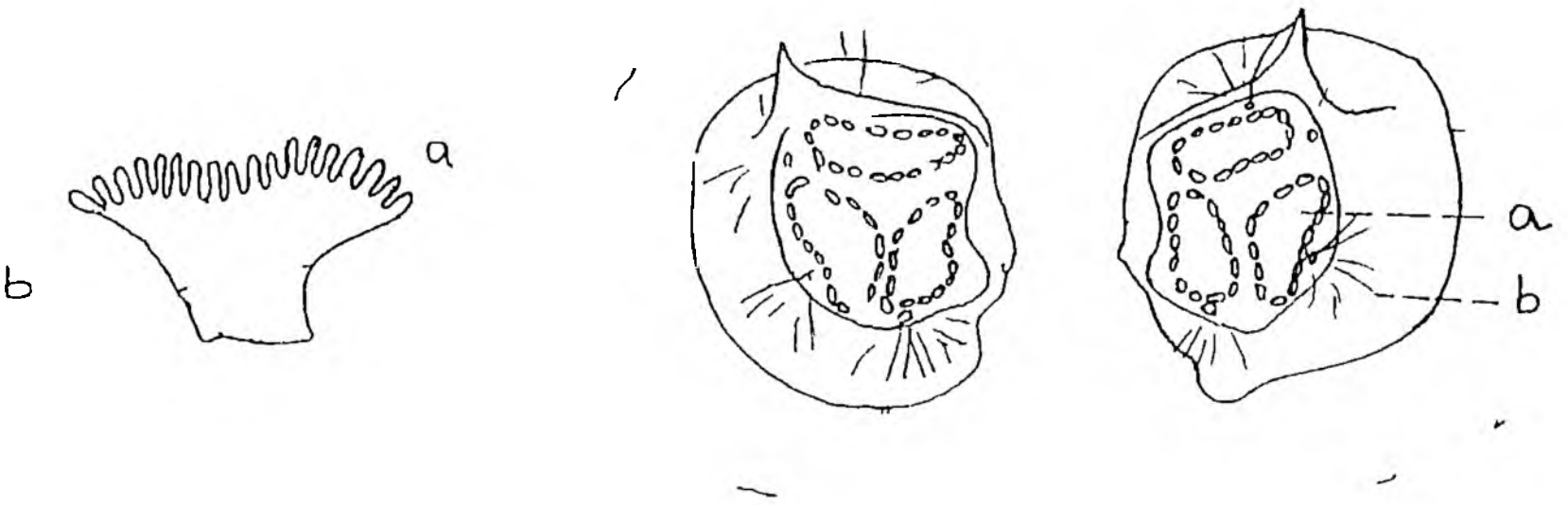
B. Posterior spiracles

(a) Spiracular slit
(b) Interspiracular hairs
(c) Peritreme

C. Cephalopharyngeal skeleton

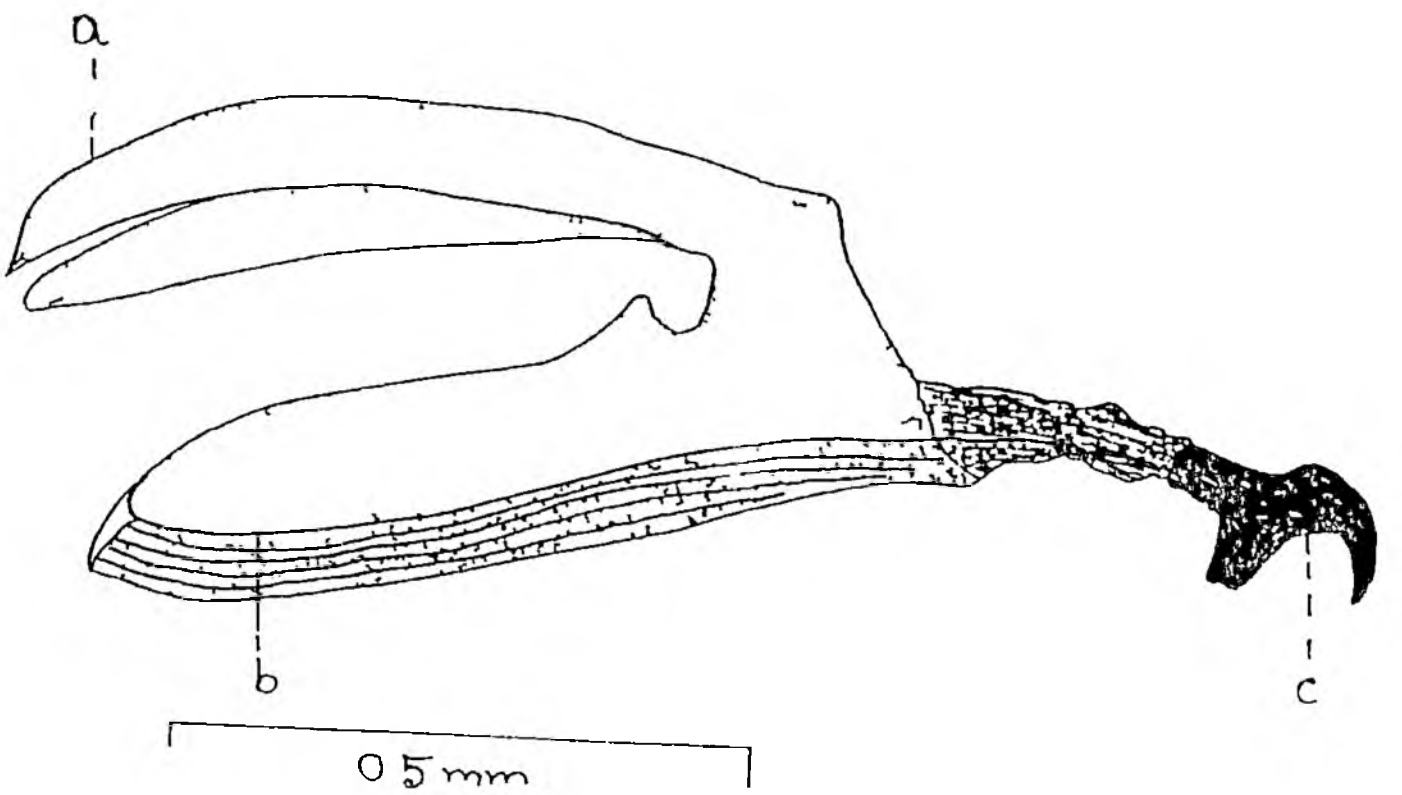
(a) Dorsal processes
(b) Ventral processes
(c) Mouth hooks

Fig 4.



A

B



C

became bigger with larger spines. A prominent anal protruberance was observed on the ventral side of the last abdominal segment. The larvae of this instar were voraceous feeders.

3.14.8.1. Head region

Bilobed, with the mouth hooks projecting backwards. Cephalopharyngeal skeleton as in Fig. 4C . Mouth hooks and intermediate piece were darker than the remaining portion which was pale yellow in colour. The dorsal and ventral processes of the mouth hook were almost equal in length.

3.14.8.2. Anterior spiracle

Anterior spiracle as shown in Fig. 4A . It was light yellowish, funnel shaped with 18 to 20 finger shaped structures at the free end which were longer than broad.

3.14.8.3. Posterior spiracle

Posterior spiracle was reddish brown in colour. It had an outer strongly sclerotized areaor peritreme, (Fig. 4B) encircling the spiracle. The spiracular slits were three in number as against two in second instar. Four sets of inter spiracular hairs, transparent and most of them branched were visible.

Table 11. Biology of *M. coeruleifrons* reared on ginger under laboratory conditions

Stage	Duration (days)		Mortality (%)		Length (cm)		Width (cm)	
	Mean	Range	Mean	Renge	Mean	Range	Mean	Range
Egg	2.80	1 - 4	8.33	0 - 15	0.07	0.068 - 0.073	0.012	0.009 - 0.014
First Instar	4.30	3 - 5	8.00	4 - 12	0.195	0.077 - 0.325	0.033	0.013 - 0.052
Second Instar	5.20	4 - 6	7.20	4 - 16	0.535	0.400 - 0.650	0.077	0.065 - 0.085
Third Instar	5.30	4 - 7	8.80	4 - 16	0.845	0.700 - 1.000	0.136	0.100 - 0.160
Pupa	9.80	7 - 14	4.80	4 - 8	0.795	0.750 - 0.850	0.174	0.140 - 0.185

The third instar larva measured a minimum of 0.7 cm at moult and extended to a maximum length of 1 cm before entering pupation (Table 11). The width increased from 0.1 to 0.16 cm. The third instar lasted for 4 to 7 days and the maximum mortality during this period was 16 per cent. The total larval mortality was 37.13 per cent with a range of 12 to 44 per cent. The mean total duration of the three larval instars was 14.8 days with a range of 11 to 18 days.

3.14.9. Pupal stage

The pupa was enclosed in a puparium, immobile, barrel shaped and slightly flattened dorsoventrally (Fig. 3D). The colour was light yellow at formation and became brown and dark as it matured. The rudiments of posterior and anterior spiracles were visible. The pupal duration varied from 7 to 14 days during which period, a maximum mortality of 8 per cent was observed. The length and breadth varied from 0.75 to 0.85 and 0.14 to 0.185 cm respectively.

The adult emerged from the puparium by breaking open the tip of the puparium in a circular fashion with the help of the ptilinum which was clearly visible in a just emerged adult. The wings and legs were under-developed and after a few hours it attained normal adult

shape. The adult was pale in colour initially but attained the characteristic shade within hours. The total period from egg to adult ranged from 18 to 32 days with a mean of 24.6 days.

3.14.10. Influence of moisture on the hatching of eggs

Moisture was found to be critical for egg hatching. In the absence of moisture, the egg got shrunk and failed to hatch when the eggs were placed on different surfaces for hatching (see para 2.4.4.), it was found that on surfaces where moisture was absent, the hatching percentage was only 0 to 15 while on moist substrate, the hatching ranged from 85 to 95 per cent.

3.14.11. Parasites on M. coeruleifrons

A parasite, parasitising the pupae of M. coeruleifrons was collected in the survey and was identified as Trichopria sp. (Diapriidae : Hymenoptera), six to twelve adult parasites emerged out of a pupa.

3.14.12. Alternate hosts

Turmeric (Curcuma domestica Val.) and Kacholam (Kaempferia galanga Linn.) were observed as alternate hosts to M. coeruleifrons in the field.

3.15.1. Control of ginger shoot borer D. punctiferalis using insecticides

The data relating to the experiment and results of statistical analysis of the same are presented in Table 12.

There was no pest incidence at 30 DAP in all the treatments including control.

At 60 DAP the incidence of borer in all the treatments including maximum protected plot failed to show any significant difference among themselves as well as with that of control. The mean per cent of shoots bored in plots given basal treatment with carbofuran was 6.04 while that of phorate treated plots was 7.00. The mean incidence in plots that did not receive any treatment ranged from 8.30 to 8.58 per cent. The incidence of borer in maximum protected plot was 4.52.

Observations at 90 DAP showed that the treatments of carbofuran and phorate did not bring about any significant control in borer incidence compared with the incidence in plots that did not receive any treatment. The mean per cent incidence in carbofuran treated, phorate treated and plots which did not receive any treatment at the time were 11.05, 11.96 and 11.09 per cent

Table 12. Control of ginger shoot borer D. punctiferalis, using insecticides

Treatments*	Mean percentage shoots infested/3m^2						Mean yield (kg/3m^2 bed)
	June (30 DAP)	July (60 DAP)	August (90 DAP)	September (120 DAP)	October (150 DAP)	November (180 DAP)	
Carbofuran 1 kg a.i./ha	0.00 (0.00)	5.07 (13.00)	12.31 (20.53)	31.84 (34.34)	23.47 (28.96)	14.36 (22.26)	4.79
Phorate 1.5 kg a.i./ha	0.00 (0.00)	8.71 (17.16)	10.47 (18.87)	30.55 (33.54)	22.53 (28.32)	14.08 (22.03)	5.02
Carbofuran 1 kg a.i./ha + quinalphos 0.05 per cent	0.00 (0.00)	6.67 (14.96)	10.19 (18.60)	10.59 (18.99)	4.65 (13.45)	4.23 (11.86)	6.37
Phorate 1.5 kg a.i./ha + quinalphos 0.05 per cent	0.00 (0.00)	7.82 (16.23)	12.97 (21.10)	9.17 (17.62)	4.50 (12.25)	2.73 (9.51)	6.25
Carbofuran 1 kg a.i./ha + dimethoate 0.05 per cent	0.00 (0.00)	6.39 (14.64)	10.64 (19.03)	13.35 (21.13)	5.52 (13.58)	3.89 (11.37)	6.16
Phorate 1.5 kg a.i./ha + dimethoate 0.05 per cent	0.00 (0.00)	4.48 (12.23)	12.43 (20.64)	8.93 (17.38)	5.96 (14.13)	2.63 (9.33)	6.05
Quinalphos 0.05 per cent	0.00 (0.00)	8.58 (17.03)	10.84 (19.21)	10.31 (18.72)	6.06 (14.25)	2.98 (9.94)	6.20
Dimethoate 0.05 per cent	0.00 (0.00)	7.69 (16.09)	8.72 (17.17)	12.55 (20.73)	5.09 (13.04)	3.35 (10.55)	5.95
Control	0.00 (0.00)	8.30 (16.74)	13.71 (21.73)	32.64 (34.83)	22.82 (28.53)	16.02 (23.59)	4.73
Maximum protection	0.00 (0.00)	4.52 (12.27)	2.51 (9.10)	1.85 (7.81)	2.12 (8.36)	1.33 (6.63)	6.83
CD		NS	6.13	3.86	7.51	2.79	0.67

*Granular insecticides were applied at planting and the sprayings were done on need basis.

For maximum protection dimethoate and quinalphos were alternately sprayed at bi-weekly intervals.

Figures in parentheses are angular transformations.

respectively. The incidence in maximum protected plots was however significantly less (2.51 per cent).

The first need based sprays of quinalphos and dimethoate, each at 0.05 per cent were given immediately after the above observation.

Observations taken 30 days after the need based spray (120 DAP) showed that the sprays of quinalphos and dimethoate brought about significant reduction in borer infestation. The incidence was least (8.93) in plots that received combination of phorate and dimethoate followed by combination of phorate and quinalphos (9.17). However, in the incidence in plots which received carbofuran or phorate alone were significantly high and on par among themselves (31.84 and 30.55 per cent) as well as with that of control (32.64 per cent). The incidence in maximum protected plot was only 1.85 per cent which was significantly lower compared to all other treatments.

At 150 DAP, the per cent infestation observed in treated plots was much less compared to control. Sprays of dimethoate or quinalphos were able to effect significant reduction in borer incidence infestation compared to control as well as plots which received only carbofuran or phorate. The incidence in plots that received carbofuran and phorate treatments only and control

(23.47, 22.53 and 22.82 per cent) were less compared to previous month's counts but was significantly higher compared to plots which received insecticide sprays. Among the plots which received need based sprays, least incidence was observed in plots which received quinalphos in combination with phorate (4.50 per cent) followed by quinalphos in combination with carbofuran. The incidence in all the plots that received need based sprays were statistically on par with that of maximum protected plots which recorded an incidence of 2.12 per cent was given on the borer incidence.

Observations recorded at 180 DAP showed that, borer incidence in plots which received need based sprays remained significantly lower compared to plots which received carbofuran and phorate only. The mean incidence in plots that received treatment of carbofuran and phorate alone were 14.36 and 14.08 respectively, which were on par among themselves as well as with that of control. The maximum protected plot showed the incidence of 1.33 per cent which was significantly lower compared to all other treatments except combination of phorate and dimethoate.

The yields recorded at 210 DAP were significantly higher in all plots that received spraying of quinalphos or dimethoate compared to plots which received carbofuran

or phorate treatment alone. The mean yield in plots that received treatments of carbofuran alone, phorate alone and control plots were 4.79, 5.02 and 4.73 kg respectively which were on par. Among the plots that received need based sprays, the yield was highest in combination of carbofuran + quinalphos (6.37 kg) followed by phorate + quinalphos (6.25 kg). The yield in plots which received need based sprays, with or without granules except (phorate + dimethoate) and (dimethoate) were on par with the yield in plots that received maximum protection which recorded an yield of 6.83 kg. Quinalphos used alone and in combination with granules came on par with maximum protection.

The extent of cumulative damage in plots treated with the granules alone ranged from 50.38 to 53.15 per cent. In the maximum protected plot, the mean incidence was 14.6 per cent only and in the remaining treatments, the incidence ranged from 25.86 to 27.88 while in control the incidence was 53.41 per cent. The yield in the above three lots of treatment were 101.27 to 106.13, 127.91 to 134.67 and 144.39 per cent over control respectively. Thus the results showed that granular application done at the time of planting alone could not control the pest effectively. But the need based application of dimethoate or quinalphos done along with the granular treatments or done alone are

Table 13. Economics of different insecticidal treatments tried for the control of shoot borer, D. punctiferalis on ginger (vide Table 12)

Treatments	Cost of insecticides Rs. Ps.	Cost of labour Rs. Ps.	Mean yield per plot from the experiment (kg)	Increase in yield over control (kg)	Additional income over control Rs. Ps.	Cost benefit ratio
Carbofuran 1 kg a.i./ha	1175.00	120.00	4.79	162	324.00	1:0.25
Phorate 1.5 kg a.i./ha	500.00	120.00	5.02	783	1566.00	1:2.53
Carbofuran 1 kg a.i./ha + quinalphos 0.05% need based	1375.00	240.00	6.37	4428	8856.00	1:6.84
Phorate 1.5 kg a.i./ha + quinalphos 0.05% need based	700.00	240.00	6.25	4104	8208.00	1:8.73
Carbofuran 1 kg a.i./ha + dimethoate 0.05% need based	1125.00	240.00	6.16	3861	7722.00	1:5.66
Phorate 1.5 kg a.i./ha + dimethoate 0.05% need based	650.00	240.00	6.05	3645	7290.00	1:8.19
Quinalphos 0.05%	200.00	120.00	6.20	3969	7938.00	1:24.81
Dimethoate 0.05%	150.00	120.00	5.95	3294	6588.00	1:24.40
Control	-	-	4.73	-	-	-
Maximum protection	1950.00	1320.00	6.83	5670	11340.00	1:3.47

The yield per ha was based on the yield from $3m^2$ area in the experiment, giving allowance for the space left between beds

Wages for insecticidal application was calculated at Rs.30/- per labourer

The market value of ginger was calculated at the rate of Rs.2/- per kg

almost equally effective in controlling the pest. Between dimethoate and quinalphos the latter was slightly superior. Comparison of the data in control and maximum protected plot revealed that the avoidable loss caused by the pest was around 45 per cent of the yield obtained in control.

3.15.2. Economics of different insecticidal treatments tried for the control of shoot borer D. punctiferalis on ginger (vide Table 12)

The data relating to the above is given in Table 13

On cost benefit basis, the most beneficial treatment was found to be the need based application of quinalphos 0.05 per cent and it was followed by dimethoate (0.05 per cent) need based spraying. The above treatments given in combinations with basal application of carbofuran and phorate also were advantageous, the benefit being 5.02 to 7.6 times the investment cost, and the application of carbofuran and phorate alone were not found advantageous.

3.16. Damage done by M. coeruleifrons alone and in combination with Pythium

The data relating to the experiment and the results of statistical analysis are presented in Table 14.

Table 14. The damage done by *M. coeruleifrons* alone and in combination with *Pythium* to ginger in pot culture

Treatments	Mean disease score observed at different intervals after treatment			
	4 days	8 days	12 days	16 days
Plants exposed to flies alone	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
Plants exposed to fungus alone	0.33 (1.15)	2.33 (1.82)	5.17 (2.48)	6.83 (2.79)
Fly followed by fungus	0.27 (1.13)	2.22 (1.79)	5.42 (2.53)	6.91 (2.81)
Fungus followed by fly	0.25 (1.11)	2.17 (1.78)	5.00 (2.44)	7.00 (2.83)
Fungus and fly simultaneously	0.17 (1.08)	2.25 (1.80)	5.67 (2.58)	7.00 (2.83)
Plant alone	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
CD (0.05 level)	0.305	0.244	0.191	0.238

Figures in parentheses are transformed values ($\sqrt{x+1}$)

At the end of four days, the treatments in which Pythium was inoculated alone showed symptoms of the disease and the score in all the treatments involving the fungus were on par.

At the eighth day after treatment the disease symptoms got intensified and the mean disease indices ranged from 2.17 to 2.33 in treatments innoculated with the fungus in various sequences. There was no disease in plants exposed to insect alone.

At 12th and 16th days after treatment, the disease indices ranged from 5.00 to 5.67 and 6.83 to 7.00 respectively while in control and in plants exposed to insect alone, there was no disease symptoms observed. The treatments consisting of different combination of the fungus and insect came on par with the treatment with fungus alone and not with the insect alone.

DISCUSSION

DISCUSSION

The distribution of the pests infesting ginger and the extent of damage caused by them, in the major ginger growing tracts of Kerala, were studied through a detailed survey for the first time. Among the large number of insects recorded as pests of ginger (Lefroy, 1906; Fletcher, 1914; Ayyar, 1940; Nair, 1975 and Dubey et al.,1975). D. punctiferalis, M. coeruleifrons and U. folus alone were observed at pest status in Kottayam and Idikki Districts of Kerala in the present survey (vide para 3.1). The nature of damage observed in detail also revealed some interesting aspects.

4.1. The shoot borer, D. punctiferalis

Koya,(1985) observed that the first instar larva of D. punctiferalis when placed in half opened leaves of ginger tunnelled down into the pseudostem. But as described in para 3.1.1. it was observed that the first instar larvae make their entry through the midrib and petiole into the pseudostem at the fourth or fifth leaf axil from above and tunnels upwards causing the 'dead heart', which affects the pseudostem only partially (vide Plate I). The larva on re-emergence move down through the outer surface of the pseudostem and then

enter in through a fresh hole near the base. The tunnelling of the pseudostem does not cause the death of the same, but it might affect the downward flow of the food materials synthesised by the leaves and consequently reduce the yield of the crop. In turmeric Jacob,(1981a), observed that pseudostem generally harbours more than one larva. In ginger, such co-habitation of larvae was not observed. When the larva finishes the internal content of a pseudostem by feeding, it migrates and enters the adjacent pseudostem. This behaviour increases the damage potential of the pest. When the pseudostem withers and fresh pseudostems are not available, the larvae bore into the rhizome and causes significant damage, thereby reducing the yield of the crop.

The distribution of the pest in the different villages of Kottayam and Idikki Districts (para 3.2.1. and 3.3.1.) did not show significant variations. The mean incidence in Idikki and Kottayam Districts were 24.92 and 23.59 per cent respectively. However, in some locations within the villages, the incidence of the pest was comparitively low. In Kottayam District, Elapally, Mallakkara, Akalakunnam, Kadayanikad, Amayannoor and Ayarkunnam and in Idikki District, Olamattom, Thodupuzha, Cheenikuzhy, Arakulam North, Manacad, Irittukanam and Karadippara, the incidence was significantly low.

In Kottayam District, locations with less incidence of D. punctiferalis were distributed in four out of the nine villages covered in the survey and in Idikki District the locations were distributed in five out of the fourteen villages surveyed. These villages were not in contigous belts and as such no particular location in the two districts could be identified as less affected by the pest.

However, the limited variability found in the extent of damage caused by the pests was correlated with the different types of soil in which the crop was cultivated and the age of crop at the time of observation (Table 1 & 2). No significant association was observed between these factors vide para 3.4. and 3.6.

The incidence of the pest commences one month after the planting and the population showed a steady and increasing trend through July, August and September. During October, the incidence showed a declining trend. In November the percentage of fresh shoots bored by the borer reached the minimum level but this decline in the extent of damage caused by the pest was consequent to the reduction in the number of fresh shoots emerging from the rhizomes. Peak damage was noted with slight variations at different locations and it occurred in September or October. Jacob (1981a) also observed that the highest

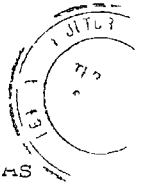
population of the pest in ginger occurrs in September-October. Koya (1986) observed that the emergence of new shoots from the rhizome and the incidence of the shoot damaged by the pests did not show any increase from the month of October. The data obtained from the present investigation were thus in agreement with this finding.

The results presented in para 3.13 showed that the incidence of D. punctiferalis was negatively correlated with maximum temperature and total rainfall and positively correlated with the remaining climatic factors though the correlation were not statistically significant.

The yield loss caused by the pests could not be assessed directly from the data collected from the survey. However, a pot culture study in wnich the yield losses were assessed in relation with varying levels of shoot damage showed that for the average incidence of 30 per cent damage, 24 per cent reduction in yield was possible, (CPCRI, 1985). On the basis of this finding, the two districts covered in the survey were likely to suffer a mean loss of 20 to 25 per cent of the yield since the mean incidence of bored shoot in the two districts were around 25 per cent. But the possible yield loss in some locations could be considerably higher than this since the extent from damage had gone upto 42.36 per cent in

Kottayam District, and 55.83 per cent in Idikki District.

The results of the field experiment described in para 3.15.1. revealed that a need based application of dimethoate 0.05 per cent or quinalphos 0.05 per cent would effectively control the incidence of D. punctiferalis Application of phorate or carbofuran at the time of planting gave some initial reduction in pest population but the effect did not persist till the end of the crop and it did not enhance the advantage derived from the need based sprayings of quinalphos or dimethoate.



By the different treatments 28 to 35 per cent increase in yield over control could be obtained. As shown in para 3.15.2., the maximum benefit could be derived from the adoption of need based treatments with quinalphos.

The efficiency of quinalphos and dimethoate in D. punctiferalis had been reported by earlier workers also (KAU, 1978; CPCRI, 1979; Jacob, 1981b; Jacob, 1986). But earlier recommendations were the repeated application of the pesticides in schedule, commencing from the planting time. But in the present experiment, the need based application of quinalphos and dimethoate were given only once 91 DAP when the mean incidences of bored shoots in the plots ranged from 8.73-12.97. The results thus showed the feasibility of restricting the treatments to

one or two rounds if the damage levels were taken as the criteria for deciding the need for spraying. The economic injury levels had been reported as to two plants having more than 50 per cent tillers bored per bed of 3 x 1 m area (Koya, 1986). Since the damage occurs in the field without much variation in intensity it may not be desirable to withold spraying till 50 per cent shoot damage level was reached in some clumps. Obviously an ETL for this may have to be fixed through precise control trials. The field experiment indicated that the level may be around 25 per cent.

The data also showed that there was an increase of 44.39 per cent of the yield over control in plots which were given maximum protection. This indicated that the available loss caused by the pest was nearly 50 per cent. In maximum protection plots 14.60 per cent of the shoots were soon damaged.

4.2. Rhizome maggot M. coeruleifrons

The nature of damage done by this insect to ginger and its association with rhizome rot disease were assessed in detail in the present studies. The nature of damage described in para 3.1.3. was in broad agreement with the earlier observations made by Premkumar, (1980) and Ghorpade *et al* (1988). The insect had been recorded as a primary pest of rhizome. In the present investigation it was

observed that the existence of some injury or the softening of the tissue by the incidence of disease patnogens was a pre-requisite for the entry of the first instar rhizome maggot emerging from eggs laid in soil. The results of the pot culture studies presented in para 3.16. also showed conclusively that the larvae did not enter the healthy rhizomes. Results of the experiments also showed that the disease symptoms present on the aerial parts of the plants as revealed from the disease indices given in table 14 was not altered by the association of the fly maggots with the disease. This aspect has been controversial for a long time. Earlier reports indicated that the rotting of the rhizome was associated with the attack of the fly (CPCRI, 1982). But later the rotting was attributed to the pathogen alone and the fly maggot was suspected as carrier of the disease (CPCRI, 1981). The recent reports indicated that the fly was only a secondary invador of the rotting tissues developed by the incidence of disease causing pathogens (fungus/bacteria). It was further observed in the investigation that the outer portion of the rhizomes infested by the maggots remained hard.

The fly was found to be widely distributed in the two districts covered in the survey. Unlike D. punctiferalis the distribution was not uniform among the different villages (vide para 3.2.2.). Some of the locations observed

in each village were totally free from the pest. In Idikki district, the villages covered in the high ranges namely Chinnakkanal, Rajakad, Pallivasal, Santhanpara and Rajakumary showed only a low incidence of the pest. Out of 25 locations surveyed in these villages only 7 locations showed the occurrence of the infested rhizomes. The incidence was high in low ranges of Idikki District, especially in Thodupuzha and Devikulam Taluks (Fig. 2).

The highly positive significant correlation between the incidence of rhizome maggot and rhizome rot disease established the high association between the two. Koya (1988) observed in a survey conducted in different districts of Kerala in 1984, that Idikki District was free from the incidence of rhizome maggot while from Kottayam District he could collect the insect in association with rhizome rot disease. This observation might be due to the limited number of samples taken or the limited number of locations covered in the survey.

The association of the disease with the pest was also observed as a prominent feature in the survey. In Idikki District the pest was observed in 34 out of the 70 locations covered in the survey. The survey showed the presence of the disease in all these locations, where the pest was observed. Only one location showed

the presence of disease without the fly. But there was no instance of the fly damaging the rhizomes without the presence of the disease. In Kottayam District, out of 31 locations where the disease was identified 24 samples contained the life stages of the insect and there was no sample containing the insect alone. These observations indicated that the occurrence of the disease was a pre-requisite for the entry of the maggots. In an earlier survey Koya (1988) found that 14.3 per cent of the diseased samples collected from Kottayam District in a random survey was associated with the fly.

The possible reasons for the wide variation in the distribution of the pest in different location were studied by working out the correlation coefficients between the population levels of the pest and various environmental factors, soil types and age of crop. No significant correlation was obtained with the above factors in both the districts.

The biology of the pest was studied briefly by Ghorpade et al. (1988). But detailed investigations were carried out in the present studies. The congregation of flies around decayed rhizome and their feeding on the decayed matter, their shade loving nature and the usual locomotion on legs were observed for the first time in the present investigation. The premating period

observed was very long lasting for 10 to 15 days and the longivity ranged from 39 to 54. But Ghorpade et al.(1988) had recorded the longivity of the fly to be 7 to 24 days. The oviposition period reported was only 2 to 3 days, but in the present observations it was found to last for 20 to 27 days. The pre-oviposition period was 1.83 days and it was observed for the first time. The feeding of the fly with honey and yeast was found to enhance the fecundity significantly. Since the insect is having a long pre-oviposition period the adult nutrition is likely to exert significant influence on the number of eggs produced in the ovary . Similar observations have been made in the case of seed corn maggot(Hylemia cilicrura Roud.) (Mc Leod, 1964). Differing from the observations of Ghorpade et al. (1988) the egg was found to have a typical finger like projection at the anterior end. The observations on the egg, duration and percentage of hatch broadly agreed with the earlier reports (CPCRI, 1984a; Ghorpade et al., 1988). The body segments of first instar larva were reported to be indistinct (Ghorpade et al.(1988) but as shown in Fig.3B the body of the first instar was distinctly seen divided into 12 segments. The other morphological features of the first instar were in general agreement with the observations made earlier.

Detailed description of second instar larva was made for the first time. The development of the anterior spiracle and the more prominent development of the posterior spiracles with two spiracular openings were the typical characters for distinguishing the second instar from the first instar.

The posterior spiracles in the third instar larva developed an additional slit thus resulting three spiracular slits. The remaining morphological features observed, described in para 3.14.8 were in broad agreement with the description furnished by Steyskal (1964) and Ghorpade (1988). The pupal instar also did not show significant variations from the available information, the vital role of moisture in deciding the percentage of egg hatch (para 3.14.10) was observed for the first time.

The occurrence of Trichopria sp as a pupal parasite recorded in the present investigation (para 3.14.11) was reported earlier (CPCRI, 1984)., Ghorpade et al. (1988) its prevalence in the field population was observed observed in the present study.

The incidence of rhizome maggot reported to be high in the months of September-October (CPCRI, 1981) and August to October (CPCRI, 1986; Ghorpade, et al., 1988). In Kottayam and Idikki Districts the incidence of the fly

was high in September/October. The delayed occurrence of the insect observed in the present investigation might be due to the delayed incidence of the soft rot disease in the field (vide para 3.11).

Since the pest was invariably found associated with the rhizome rot disease of ginger, the most effective method for minimising the possible damage from the insect, could be through the adoption of effective steps for controlling the disease. The avoidance of mechanical injury at the collar region of stem during cultural operations may also help to reduce the pest incidence.

4.3. Leaf roller U. folus

Fletcher (1914) observed that the leaf roller U. folus was a minor pest which could become serious causing extensive defoliation of ginger. Abraham et al. (1975) observed that the occurrence of this pest was high in Kassargod District. But in the present investigation U. folus was observed as a very minor pest on ginger in Kottayam (para 3.2.5) and Idikki (para 3.3.3) Districts. The nature of damage caused by pests was observed in detail in the present study.

4.4. Leaf spot disease

Leaf spot disease was prevelent in all the locations covered in the survey. Significant differences were lacking

among the villages of Kottayam District. But in Idikki District Manacad, Pallivasal, Rajakad villages had significantly higher level of disease incidence. (vide para 3.3.4). The mean indices of the disease were 1.043 and 1.627 in Kottayam and Idikki Districts respectively.

The incidence of the disease was not significantly correlated with the weather factors, soil type and age of the crop during the period of observation. As observed by Premanathan et al. (1980) and Bramha and Nambiar (1982), the commencement of the disease symptom was observed in July and reached the peak in September and continued upto November.

4.5. Soft rot disease

The distribution of the disease showed significant variation among the villages of Idikki District. The disease was significantly lower in Rajakad, Pallivasal, Santhanpara, and Chinnakkanal villages (para 3.3.5.) at the higher elevation of the District. Significant variations were not observed among the villages of Kottayam District with reference to incidence of rhizome rot disease. However, there were disease free locations in all the villages except Akalakunnam. Thus a discontinuous distribution of the disease was evident in both the districts. These

observations did not agree with the report of Koya (1988) that Idikki District was free from the disease. The disease was reported to cause severe damage resulting in 80 to 90 per cent loss in some locations (Kannan and Nair, 1965). Joshi and Sharma (1982) observed that the loss caused by the occurrence of ginger rhizome rot normally exceeded 50 per cent. As reported by Sarma et al. (1979), the disease was found to commence by July. The disease continued upto November though it was on a declining trend. The mean indices of disease recorded in Idikki and Kottayam Districts were 0.234 and 0.233 respectively.

From the data obtained from Idikki District, the incidence of the disease was seen significantly correlated with the soil type and it was lower in forest soils and this explains the reason for the lower incidence of the disease in the high ranges of Idikki District. The humidity levels had positive correlation with the incidence of the disease. The age of the crop had a significant negative correlation with the prevalence of the disease.

Since basic information on the reduction in yield in relation to the levels of leaf spot and soft rot disease are not available in literature, the possible extent of yield reduction for the disease indices recorded in the survey could not be estimated. However, from the high indices observed in many locations, these diseases have

got to be identified as serious limiting factors in the productivity of ginger in the two Districts of Kerala.

4.6. Plant parasitic nematodes

The results presented in para 3.8. and 3.9. showed that the population of Meloidogyne sp. and Radopholus sp alone were high in soil and root samples collected from Idikki and Kottayam Districts of Kerala. These nematodes were present in all the locations covered in the survey. The mean soil population of Meloidogyne sp in Kottayam and Idikki Districts were 16.44 and 11.11 per 100 g soil and the root population was 36 and 32 per 10 g roots respectively. These populations are not likely to cause economic loss to the crops. However, the root population was very low in Thodupuzha and Purapuzha Villages.

Radopholous population in root ranged from the mean levels of 34.17 to 23.17 and 43.05 to 45.84 in Kottayam and Idikki Districts respectively. The soil populations did not vary significantly among the villages in Kottayam District, but in Idikki District the population was low in Thodupuzha. In Ayarkunnam in Kottayam and Manacad and Thodupuzha of Idikki District, the root populations were found to be less. In other villages the population levels did not show statistical differences.

Charles and Kurian (1978) conducted a survey and identified these two as the major pests of ginger in the area. They recorded Pratylenchus sp and Helicotylenchus sp also in soil and ginger root in the area. But Pratylenchus sp was not observed in the present survey and the population of Helicotylenchus in both the Districts were very low and were below the E.T. levels. The lower populations of Tylenchorhynchus and Criconema observed in some villages of Kottayam and Idikki Districts and of Aphinema and Monochus found in some villages of Idikki District were the first record of these nematodes in ginger from Kerala. But these nematodes were present in the soil around the roots of the crop and not within the roots. Further, the population levels were very low. In general, the plant parasitic nematodes did not appear to have reached the status of serious pest of ginger in Idikki and Kottayam Districts so as to cause significant yield reduction in the crop.

SUMMARY

SUMMARY

The distribution and extent of damage caused by the insect pests infesting ginger in the two major ginger growing districts of Kerala (Kottayam and Idikki) were studied through a detailed survey adopting stratified multistage random sampling technique. The survey and some related pot culture studies and field experiments led to the following findings:

(1) D. punctiferalis was the major pest infesting the crop in both the districts.

(2) The first instar larvae bored into the pseudostem at the fourth or fifth leaf axil and caused the drying up of the upper portion of the stem. It came out after the second instar and bored into the stem again near the base and bored in and tunnelled upwards and downwards. The lower part of the pseudostem remained green. The tunnelling probably affected the food flow and caused reduction in the development of rhizome.

(3) The pest was more or less uniformly distributed in all the locations in the villages covered in the survey and statistically significant variations were not observed in the extent of damage observed in different villages of the two Districts.

(4) The mean incidence of bored shoots were 23.59 per cent in Kottayam District and 24.92 in Idikki District. In out of 115 locations covered in the survey the occurrence

of damage was significantly lower. But these locations were not contiguously placed and hence no portions of the Districts could be identified as less infested by the pest.

(5) The variability in the incidence of the pest was correlated with the soil type in which the crop was grown and the age of the crop at the time of observation. No significant associations could be identified.

(6) The observations on the occurrence of the pest at different growth stages of the crop revealed that the pest population was high in August, September and October and the population declined in November.

(7) Based on the earlier estimations made by CPCRI (1981a) the possible yield loss for the levels of damage observed in the survey was estimated as around 25 per cent in the two Districts.

(8) A field experiment conducted to asses the avoidable yield loss caused by the pest, by the adoption of chemical control methods and for evolving a suitable strategy for controlling the pest revealed that:

(a) The avoidable yield loss caused by D. punctiferalis was around 40 per cent.

(b) The application of granules at the time of planting gave some initial reduction in the damage caused

by D. punctiferalis. But the effect did not persist long enough to reduce the yield loss caused by the pest.

(c) The need based spraying of quinalphos 0.05 per cent or dimethoate 0.05 per cent controlled the pest effectively.

(d) The maximum economic gain was obtained from the plots treated with quinalphos 0.05 per cent and hence the need based spraying of the insecticide may be recommended as a suitable technology for preventing the yield loss.

(9) The second important pest found infesting ginger in Kottayam and Idikki Districts was M. coeruleifrons.

(10) The observations on the nature of damage caused by M. coeruleifrons indicated that the fly entered the rhizome only through mechanical injury at the collar region or rhizomes or through the tissue at the point softened by the earlier infection of pathogens (fungus/bacteria).

(11) A pot culture study in which the inoculation of the fungus and infestation of the insects were taken independently or in combination as treatments showed that the fly infested the rhizome along with the fungus only. The presence of the maggots did not aggravate the disease symptoms. Thus the observations proved categorically that the insect is a secondary pest invading the rhizomes infected by pathogens.

(12) M. Coeruleifrons had a dis-continuous distribution in the two districts. Some locations were completely free from the pest. The high ranges of Idikki District had a very low incidence of the pest.

(13) The incidence of the fly was highly positively correlated with the occurrence of rhizome rot disease.

(14) In the survey the pest was recorded only from those locations where the rhizome rot disease was observed. In some location, the disease occurrence without the association of the insect was observed but not vice versa. The results thus endorsed the earlier finding that the pest is a secondary invader in rhizomes infected by pathogens.

(15) The biology of the pest was studied in detail for the first time and morphological characters of different life stages were studied in detail and the variations observed from earlier reports were highlighted.

(16) The leaf roller U. folus was observed as a minor pest distributed in some locations covered in the survey in both Kottayam and Idikki Districts.

(17) The leaf spot disease was prevelent in all the locations of Kottayam and Idikki Districts. The mean

indices of the disease were 1.043 in Kottayam and 1.627 in Idikki District. The disease commenced in July and reached the peak in September and continued upto November.

(18) The occurrence of soft rot disease was observed in Kottayam and Idikki Districts, but it had a discontinuous distribution and many of the locations were free from the disease. The higher elevations of Idikki District had limited incidence of the disease whereas it was severe in low ranges of Idikki District, especially in Thodupuzha Taluk. The disease was at its peak during the month of September. The incidence of the disease was significantly low in forest soils. The humidity levels had a positive correlation with the occurrence of the disease and age of the crop had a significant negative correlation.

(19) Fairly high levels of Meloidogyne sp and Radopholus sp were observed in the two districts covered in the survey. But the populations observed were not sufficient to cause serious problems to ginger cultivation. Very low populations of Helicotylenchus sp in the root and soil and Tylenchorhynchus sp, Criconema sp, Xiphinema sp and Monochus sp in soil were also recorded.

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MAJOR PESTS OF GINGER IN KERALA AND THEIR CONTROL

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ABSTRACT OF A THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENT FOR THE DEGREE
MASTER OF SCIENCE IN AGRICULTURE
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF ENTOMOLOGY
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VELLAYANI, TRIVANDRUM

1989

ABSTRACT

A survey conducted in Kottayam and Idukki Districts (ginger tracts) of Kerala, adopting multistage random sampling technique, revealed that D. punctiferalis is the major pest infesting the crop in both the Districts. The first instar larvae bored in at the fourth or fifth leaf axil of the psuedostem and caused the drying up of the distal part. Then the larvae emerged out and tunnelled in at the base of the psuedostem. The lower part of the stem did not dry up. The pest had a uniform distribution in the two Districts. The extent of shoot damage ranged between 23.59 and 24.92 per cent. The incidence of the pest was not significantly associated with the soil type in which the crop was grown or with the age of the crop. The damage observed was higher during August, September and October and started declining from November. The possible yield loss for the mean damage of 23 to 24 per cent of the psuedostem could be estimated as 25 per cent based on the observations of CPCRI (1981a).

A field experiment conducted in the two Districts showed that the avoidable yield loss caused by D. punctiferalis was around 40 per cent. Application of granules (carbofuran and phorate) caused initial reduction in the damage done by D. punctiferalis but it did not persist to reduce the final yield loss caused by the pest.

Need based spraying of dimethoate or quinalphos 0.05 per cent emulsion controlled the pest effectively. Spraying of quinalphos was more economical.

Studies on the nature of damage done by the rhizome maggot M. coeruleifrons revealed that the entry of the maggot into the rhizome occurred only when there were mechanical injury at the collar region or the tissues at the point was softened by prior infection of bacteria or fungi. A pot culture study showed that the fly maggots invaded the rhizome infected by fungus and not vice versa. The fly was seen distributed in both the Districts, but the distribution was discontinuous. The incidence in the high ranges was very low. The incidence of the pest was positively correlated with the rhizome rot disease incidence. The biology of the pest was studied in detail and the life stages of the pest have been described in detail.

The leaf roller U. folus was observed as a minor pest of ginger and it was distributed in a few locations covered in the survey.

The leaf spot disease was prevalent in Idikki and Kottayam Districts the mean indices of the disease being 1.627 and 1.043 respectively. The disease commenced in July, reached the peak in September and continued upto November.

Soft rot disease was prevalent in Idikki and Kottayam Districts; but the distribution was discontinuous. It was less in higher elevations of Idikki District. The peak incidence of the disease was in September. It was less common in forest lands. The relative humidity was positively correlated with disease incidence while the age of the crop had a negative influence.

Meloidogyne sp and Radopholus sp were obtained from the root and soil samples collected from the different locations covered in the survey. But population was too low to cause significant crop loss. Low population of Helicotylenchus sp. in root and soil samples and Criconema sp, Xiphinema sp and Mononchus sp in soil samples were also recorded.