RHIZOCTONIA DAMPING OFF OF CARDAMOM (ELETTARIA CARDAMOMUM MATON) AND ITS CONTROL

By

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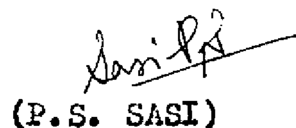

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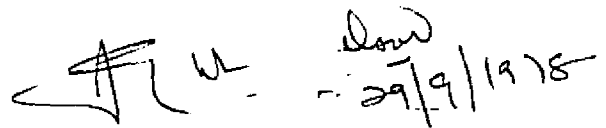

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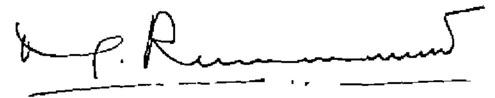

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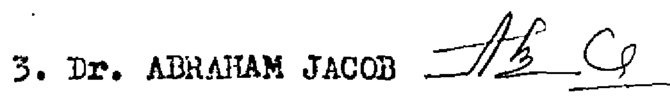
3. Dr. ABRAHAM JACOB 

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INTRODUCTION

INTRODUCTION

Cardamom, popularly known as the " Queen of Spices " is an important spice crop of our country. India accounts for about 70 per cent of the world production of cardamom, with an annual yield ranging from 2400 to 3800 metric tonnes. Of this, Kerala produces nearly 65 per cent of the total cardamom in our country.

Over 60 diseases have been reported on cardamom and its allied genera occurring all over the world. In India, nearly 20 diseases have been reported on this crop. Among the nursery diseases, damping off caused by Pythium spp is commonly noticed in the cardamom growing tracts of our country. A damping off disease of cardamom caused by the fungus Rhizoctonia was noticed at the Cardamom Research Station, Pampadumpara in the Idikki district of Kerala State (Wilson, 1976 unpublished). Eventhough, Rhizoctonia solani has been reported to cause rhizome rot of cardamom in South India (Subba Rao, 1937), there is no authentic report of this fungus causing damage to the seedlings.

Since the fungus Rhizoctonia is known to be ubiquitous in distribution and plurivorus in its host range, it was

felt that the presence of this pathogen in the high range soils will be a potential threat to the successful raising of cardamom nurseries. Investigations were, therefore, undertaken to study the symptomatology of the disease, morphology, pathogenicity, host range and identity of the causal organism, survival of the pathogen in the high range soil and fungicidal control of the disease.

The results obtained are presented in this dissertation.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Diseases caused by species of Rhizoctonia are of world wide distribution. Rhizoctonia diseases of a large number of plants have been reported from our country.

Sundararaman (1927) reported a disease of Cinchona from the Anamalais caused by Rhizoctonia solani. Mitra (1931) recorded a disease of Cicer arietinum caused by R.solani.

Galloway (1935) recorded the fungus on Raphanus sativus. A Rhizoctonia disease of sweet potato was noted by Mundkur (1936) from Karwar, Bombay. Park (1936) reported a collar and rhizome disease of cardamom caused by Rhizoctonia (Corticium) solani from Ceylon. Subba Rao (1937) reported a rhizome rot of Cardamom associated with R.(Corticium) solani and eel worm, from South India. The diseased plants showed a damping off effect with most of the aerial growth collapsing at ground level.

Dey (1946) recorded a wilt and collar rot of Chrysanthemum sp. from New Delhi, caused by Fusarium and R.solani. Jain (1950) recorded a collar and root rot of Coriandrum sativum caused by R.solani from Nagpur. Jain and Mahmud (1950) reported R.solani on Ocimum sanctum and Hydrocotyle asiatica from Nagpur. Sharma and Mahmud (1950) recorded damping off of Antirrhinum majus caused by R.solani. Diseases caused by R.solani have

been reported on Crotalaria juncea, Piper betle, Gossypium sp and Nicotiana sp. (Anon., 1950). Nema and Mahmud (1950) noted a damping off of Solanum melongena seedlings caused by R.solani.

Singh and Gupta (1951) reported a disease of Spinacia oleracea caused by R.solani. Srivastava (1951) recorded Rhizoctonia damping off of Hollyhock. Jain and Mahmud (1952) noted a collar rot of Murraya koenigii caused by R.solani. Singh (1953) reported R.solani on Vigna sinensis and Cyamopsis tetragonoloba. Srivastava and Singh (1954) recorded a seedling disease of Citrus paradesii caused by R.solani. Gupta and Sharma (1955) reported a wilt disease of Kochia indica caused by R.solani. Venkataramani and Venkata Ram (1959) recorded a collar rot of tea caused by R.solani.

Paracer and Singh (1963) noted a sheath blight of rice caused by R.solani. Also, they reported a disease of Cabbage seedlings caused by same fungus. Janardhan and Ganguli (1963) recorded a disease of Digitalis purpurea caused by Rhizoctonia sp. Rathore (1964) recorded a disease of betel caused by R.solani. Sirdhana et al. (1964)

noted a foot rot of Balsam caused by *R.solani*. Srivastava (1968) reported a dry root and bottom rot of mustard caused by *R.solani*. Roy (1968) noted *R.solani* on roots of *Brassica campestris* var. *toria* and *Impatiens balsamina* from Assam. Agarwal and Gupta (1968) recorded *Rhizoctonia* on *Malus sylvestris*. Chandwani *et al.*(1969) reported linseed wilt caused by *Rhizoctonia* sp. Sinha and Jawanda (1969) reported a foot rot of grape vine caused by *R.solani*; *Fusarium* sp and *Alternaria* sp.

Sharma and Kulkarni (1971) reported a leaf blight of *Hibiscus esculentus* caused by *R.solani*. Subramanyam *et al.*(1975) recorded pre-emergence and post-emergence damping off of *Melampodium* and *Cosmos* caused by *R.solani*. Roy (1975) recorded damping off of the seedlings of *Corchorus capsularis* and *Lagenaria leucantha*. He further reported collar rot of *Dianthus barbatus*, *Echium plantagoneum*, *Eschscholzia californica* and *Vinca rosea* and collar rot and root rot of *Phyllanthus urenaria*, caused by same fungus. Also he noted root rot of *Centrella asiatica*, *Linum usitatissimum*, *Mesembryanthomum criniflorum* and *Phalaris arumdanacea* var *picta* and root

canker on Ponzolozia indica caused by R.solani. He recorded a leaf rot of Amarnathus caused by R.solani from Assam.

Morphological characters of R.solani.

Kühn (1858) recorded Rhizoctonia on diseased potato tubers and named the fungus as Rhizoctonia solani. Duggar (1915) reported that the young hyphal branches of R.solani are inclined in the direction of growth and are invariably somewhat constricted at the point of union with the main hyphae. He gave the size of sclerotia as scarcely visible to 1 to 2 cm in diameter.

Palo (1926) measured the hyphae of R.solani on 8 different media and reported that substrate has profound influence on cell dimensions. While working with Rhizoctonia isolates of rice, he noted that in some cases the young branches arise at right angles to the main hyphae, but they later bend towards the direction of the growth of the main filaments.

Wei (1934) gave the range in diameter of hyphae of R.solani as 4-6 μ on PDA and 6-13 μ on Hopkin's synthetic

agar. Frederiksen *et al.* (1938) stated that sclerotia on potato tubers range from about 1 mm diameter to crusts or scales over the entire surface of the tuber.

Townsend and Willets (1954) while describing types of sclerotial development referred *R.solani* as the loose type and stated that in the formation of sclerotial initials there is no definite pattern of organization of the hyphae and the resulting sclerotia are very loosely constructed. Flentje (1956) stated that there were septa in the main hyphae immediately on either side of the branch. Flentje *et al.*(1961) reported that in mature hyphae of *R.solani*, branches arise at right angles or at acute angles, ie., near 45° to the main branch.

Parmeter (Jr.) and Whitney (1970) reported the diagnostic colour of *R.solani* as brown and that of mature sclerotia as numerous shades of brown. They further reported that the sclerotia of *R.solani* ranged from the size of a pin head to 5-6 mm in diameter but through the confluence of several sclerotia a crust of several centimeters might be formed. The following characters have been recognized for *R.solani* by the above investigators :

1. Multinucleate cells in young vegetative hyphae.
2. Prominent septal pore apparatus.
3. Branching near the distal septum of cells in young vegetative hyphae.
4. Constriction of the branch and formation of a septum in the branch near the point of origin.
5. Some shade of brown.

Further they noted that characters like the presence of monilioid cells, sclerotia without differentiated rind and medulla, hyphae greater than 5 μ in diameter, rapid growth rate and pathogenicity are usually associated with *R.solani*, but occasionally one or more of these characters might be lacking in individual isolates.

Growth and survival of *R.solani*.

Elmer (1942) reported that *R.solani* did not survive in the absence of a susceptible host when temperatures during the growing season were too high for mycelial growth and sclerotial production. Sanford (1952) reported that susceptible host plants were more important for survival in soil than were dead or living roots of non-susceptible hosts. He stated that *R.solani* disappeared from heavily

infested soils in less than four months in the absence of susceptible crop, but survival upto eight months was noticed under soil planted to susceptible crop.

Boosalis and Sacharen (1959) by direct microscopic observation of *R.solani* pathogenic to sugar beet seedlings found that it persisted in the form of sclerotia on the surface of plant debris particles and as thick walled hyphae within such particles. McCarter and Halpin (1962) reported that *R.solani* caused moderate to severe damage to clover plants over a temperature range of 50°F to 80°F, but, the damage was generally more at higher temperatures. Van Adrichem and Bosher (1962) reported that straw berry root rot symptoms were predominant at 35-65°F and crown infection at 60-90°F.

Pitt (1964) observed a limited survival in naturally infected cereal straws buried in soil. He reported that saprophytic survival of *R.solani* clones from wheat stem was not a major factor in the persistence and survival of the sharp eye spot disease.

Studies conducted by Kartha and Nema (1969) on the effect of host nutrition on the incidence and severity of

Rhizoctonia disease of Phaseolus aureus indicated that difference in nutrition had a marked effect on the virulence of the pathogen. Tu (1969) reported that most of the saprophytic activity of R.solani occured between the soil surface and 30 cm depth and the hyphae were more pathogenic than sclerotia on Kenaf (Hibiscus spp.) seeds and seedlings.

Hulea et al.(1971) reported that 20-26°C was the favourable temperature for infection of Flax seedlings by Rhizoctonia. Also, he stated that the growth of R.solani was best on Potato glucose agar with malt or Czapek's medium at 18-28°C. Glucose and levulose were found as best carbon sources and arginine as the best nitrogen source.

Mildenhall and Williams (1973) reported that carrot grown in soil at temperatures of 20, 24 and 28°C developed severe crown rot and cavity spot when inoculated with R.solani but little infection occurred at 16°C. Azam and Khan (1973) reported that growth and sclerotial formation of the cauliflower isolate of R.solani after 24 hours were best on Potato dextrose agar followed by Bean pod agar, Leaf extract agar, Czapek's agar, Lima bean agar, Corn meal agar and Malt extract agar in the descending order. After 48 hours,

highest growth was obtained on Czapek's agar, Lima bean agar and Potato dextrose agar and lowest in Prune agar, Corn meal agar and Sabouraud's dextrose agar. After 72 hours, size of the colonies in all except Prune agar was more or less equal. The sclerotial formation was abundant in Potato dextrose agar and high in Czapek's agar. No sclerotial formation was obtained in Corn meal agar even after 6 days of incubation. Mahendra Prabhat et al. (1974) reported that the sclerotia of Corticium sasakii remained viable in soil for 200-220 days while those placed on the surface of the soil lost viability after 160 days.

Inagaki and Makino (1975) noted that R. oryzae grew poorly on media consisting of inorganic compounds and glucose, but grew well with the addition of rice decoction. Studies on the field survival of R. solani conducted by Herr (1976) revealed that in all except one instance low levels of R. solani survived the winter in artificially and naturally infested field soils. Survival in diseased beet placed on soil surface was greater than in those buried in soil. The major reduction in survival in buried beet occured during the 6 week interval from April to June.

Lewis and Papavizas (1977) reported that high temperatures (26-32°C), high moisture holding capacity (70 per cent) and a soil reaction of more than pH 6.6 favoured the disease caused by R.solani on soybeans in green house.

Evaluation of fungicides

Laboratory evaluation

Zentmyer (1955) employed poisoned food technique for the laboratory evaluation of fungicides against Phytophthora cinnamomi and also described a laboratory method for testing soil fungicides as soil drench against this fungus. Laboratory tests conducted by Vaartaja (1960) indicated that PCNB was a relatively weak toxicant to R.solani. Sinclair (1960) reported that isolates of R.solani differed in their sensitivity to PCNB, Captan and Dichlone under laboratory conditions.

In laboratory evaluation of fungicides against Sclerotium rolfsii and R.bataticola by using agar plate method, soil plug method, and soil vial (drench) method, Das and Sen Gupta (1963) noted that in agar plate method,

Mylone was fungicidal to both fungi even at 100 ppm. Vapum was fungicidal to *S. rolfsii* at that dilution but was only fungistatic to *R. bataticola*. Fytolan was not at all effective. In soil plug method, inhibition zones were produced by Vapum, Mylone and Merucline. In soil vial method, Mylone was fungicidal to both fungi at 10 ppm. Vapum killed *S. rolfsii* at the above dilution while *R. bataticola* was killed at 100 ppm. Fytolan was not at all effective.

From the results of laboratory and green house tests, Zachos *et al.* (1963) reported that Terrachlor 75 W.P. (754 g/ 1000 sq.m soil) gave best control against damping off of cotton when partly applied as seed disinfectant and rest added to the soil. Rhizoctol (12 g/kg seed) was also reported as a promising seed disinfectant.

Sahai (1969) employed a method for laboratory evaluation of fungicides against *Macrophomina phaseoli* by dipping fungal discs in fungicidal solutions for different periods and then transferring to potato dextrose agar medium.

Follin and Diallo (1971) by screening 8 fungicides against *Colletotrichum gossypii*, *R.solani* and *Pythium aphanidermatum* reported that Demosan, Vitavax and Benlate were most effective against *R.solani*. For widening the effects of 3 systemics Agrosan or Difolatan in combined treatments was recommended.

Kataria and Grover (1975) reported that *R.solani* was most sensitive to PCNB followed by Benomyl, Chloroneb, and Thiophanate-methyl *in vitro* and that these fungitoxicants were fungistatic. Formation of infection cushions on cotton threads soaked in four fungitoxicants was inhibited best by Benomyl, while higher concentrations were required for the rest. When the roots of 5 day old *Phaseolus* seedlings were dipped in these fungitoxicants at 250 μ M for 30 minutes and then subjected to invasion to *R.solani*, Benomyl, and Thiophante methyl prevented formation of infection cushions while similar inhibition was obtained with PCNB and Chloroneb at higher concentrations only.

Among 4 systemics and 16 non-systemics tested by using poisoned food technique, Sen and Kapoor (1975) found that Bavistin, Dithane M-45, BAS.3050 F, Benlate, Captan and RH.893 were effective against *R.solani* even at 100 ppm.

Kataria and Grover (1976) reported that the mycelial growth of *R.solani* was strongly inhibited by Benomyl, Chloroneb and Quintozene.

Among 42 fungicides tested in the laboratory, Kataria and Grover (1977) noted that Copper carbonate, Copper sulphate, Mercuric chloride, Agrosan G.N., Quintozene, Kasumin, Carboxin, Pyracarbolid, Bavistin, Chloroneb, S.7258, RH.893 and Terrazole were most inhibitory to the mycelial growth of *R.solani* on Czapek's agar plates. Copper oxychloride, Zineb, Ziram, F.319 and Anilazine were much less toxic.

Among 6 fungicides tested against *R.solani*, *in vitro*, Hiremath *et al*. (1978) recorded that Ceresan wet inhibited the growth of the fungus even at 0.1 per cent concentration whereas, Blitox, Brassicol, and Brestan were ineffective even at 0.3 per cent concentration.

Field evaluation

The results of tests conducted with seventeen compounds against *R.solani* and *Pythium debaryanum* on sugar beets by Foeppel and Gerhold (1954) proved that Manzate was most

effective against these fungi and when used at the rate of 8.0 oz/100 lb seeds its protective effect persisted for a period of one year.

Studies on the effectiveness of seed treatment against damping off of Red pine caused by R.solani and Pythium irregulare, conducted by Cockerill (1955) revealed that with 12 oz of Thiram/100 lb seeds the percentage of mortality was 16.1, with 8 oz 22.6, and with 4 oz 31.3 as compared with 74.4 in the untreated.

Gibson (1956) reported that Granosan indirectly assisted the pine (Pinus patual and P.radiata) seedling damping off pathogens (R.solani and Pythium ultimum) through the soil by its selective action on the antagonistic microflora, competition with which is thereby reduced.

Couch et al.(1962) reported that among the 22 fungicidal formulations tested against R.solani, Terran O.M., Ortho lawn and turf fungicides, California chemical 498, Dyrene, Dithane M-22, Actidione-Thiram and Thimer were good for the control of the fungus. Soil treatments with 100 ppm of Captan and PCNB against six distinct biotypes of R.solani from Pinto bean revealed that three races were

partially resistant to PCNB on cotton and beans (Thomas, 1962). Shatla and Sinclair (1963) reported that strains of R.solani varied from highly tolerant to sensitive to PCNB.

From the results of experiment conducted with five chemicals for controlling damping off of cotton mainly caused by R.solani, Solel and Minz (1964) reported that PCNB and Zineb were good in controlling the disease, PCNB being superior to Zineb.

Studies conducted by Grewal and Singh (1965) on the effectiveness of seed treatment and soil drenching against damping off of cabbage caused by Pythium aphanidermatum, R.solani and R.bataticola revealed that seed treatment with Captan and Arasan were good. Soil drenching with six fungicides viz, Parzate dry, Panogen, Captan, Fytolan, Arasan and Rhizoctol revealed that Parzate dry and Captan (0.2% water suspension) were good.

In a field test conducted by Bird et al. (1966) it was found that seedling stand for four fungicidal treatments viz., Captan + Foelpet, PCNB + 02424 (Ethoxy trichloro methyl thiadiazole), PCNB + Thiram and PCNB + Lanstan

(Chloro-nitropropane) was greater than the control of which PCNB + Lanstan was the best. Dongo and French (1967) reported that six of the 47 chemical mixtures tried gave good control against the Fusarium-Rhizoctonia complex, the best being the mixture Thiram + PCNB.

Sinha et al. (1969) reported that grapevine foot rot caused by R. solani, Fusarium sp. and Alternaria spp. could be controlled by Brassicol (75 W.P). Studies conducted by Agarwal and Singh (1969) on the effectiveness of seed dressing and soil drenching against foot rot of wheat caused by Sclerotium rolfsii, revealed that seed dressing with Arasan was the best in controlling the disease, followed by Captan, Thiram and Bis-dithane. For soil drenching, Rhizoctol was the best followed by Arasan, Captan, and Bis-dithane.

Rizk et al. (1970) reported that four seed dressing chemicals and four soil disinfectants were highly effective against R. solani and Fusarium oxysporum, of which best results were obtained by seed dressing with Rhizoctol.

Jhooty and Grover (1971) reported that *Rhizoctonia* root rot of cucurbits was effectively controlled by seed treatment with Vitavax and Brassicol. Sharma and Kulkarni (1971) stated that leaf blight of bhindi caused by *R.solani* was effectively controlled by PCNB and Coppesan. Based on comparative trials conducted, Davis *et al.*(1971) reported that soil treatment with PCNB and seed dressing with Benomyl controlled the potato stem and stolan infection by *R.solani*.

Ko and Oda (1972) stated that beet seeds did not accumulate sufficient Quintozene (PCNB) from soil in 12 hours to protect them from *R.solani* and the treatment had no effect on the pathogenicity or population of *R.solani* in soil. The control appeared to result from growth suppression rather than destruction of the pathogen. Studies conducted by Schnieder and Potter (1974) on sugar beet indicated that pre-plant applications of PCNB (8 and 16 lb ai/acre) and crown spray applications of chlorothalonil (15 lb), PCNB (2 and 4 lb) and triphenyltin hydroxide (0.3 lb) significantly reduced incidence and severity of root rot caused by *R.solani*.

Shelvin and Katan (1975) reported that Rhizoctonia disease of carrot seedlings could be controlled, with varying degrees of success, by PCNB. The results of the experiments conducted by Mukhopadhyay and Tewari (1975) proved that application of Quintozene (PCNB) at the rate of 12 kg/ha as ridge soil drench 3 months after planting significantly controlled the root rot of sugar beet caused by Sclerotium rolfsii. Dry application of fungicides proved inferior to the ridge soil drenching.

The results of experiment conducted by Roy (1975) revealed that Benomyl and Chloroneb as soil treatment gave good control of R.solani on cowpea upto 30 days and on radish upto 15 days (moderately good upto 30 days). On bhindi, Benomyl was moderately effective upto 15 days and Chloroneb upto 30 days. PCNB was good upto 30 days on bhindi and moderately good upto 15 days on radish. As soil drench, Benomyl and Chloroneb were effective on cowpea and were ineffective on bhindi. PCNB gave moderately good results on bhindi. The residual action of Benomyl and Chloroneb remained in soil for 55 days and possibly longer but that of PCNB for a brief period.

Field studies conducted by Tripathi et al.(1977) revealed that Captafol was the best to control charcoal

rot of sesamum caused by R.bataticola, followed by Carbendazin and Thiram + Captan. Goel and Mehrotra (1977) found that root and collar rot of okra was effectively controlled by Ceresan followed by Thiram and Brassicol.

Among six fungicides tested for their comparative efficacy against R.solani in vivo by seed dressing, soil mix and soil drench methods, Hiremath et al.(1978) noted that Captan was effective in controlling collar rot of fenugreek, both as soil mix and soil drench while Brassicol was superior as seed dresser.

Brown (1947) reported that chlorinated nitrobenzenes are known to affect plant growth. Cetas (1960) recorded phytotoxic effect of PCNB against Spinach seedlings when used at 7.5 lb ai/acre. The experiments on the control of Rhizoctonia infection on potatoes conducted by Livingston et al.(1962) indicated that even though the disease control and yield increase were directly related to increasing doses of PCNB, phytotoxicity also increased at higher doses of PCNB. Schneider and Potter (1974) found that a significant reduction in seedling emergence was associated with 8 and 16 lb PCNB applied in soil as pre plant application against R.solani, causing root rot of sugarbeet.

MATERIALS AND METHODS

MATERIALS AND METHODS

Symptomatology of the disease

Symptomatology of the disease was studied from naturally infected cardamom seedlings at the Cardamom Research Station, Pampadumpara.

Isolation of the causal organism

The causal organism was isolated from infected cardamom seedlings. The diseased plant parts were cut into small bits, surface sterilized with 0.1 per cent mercuric chloride solution and washed three times in sterile water. The bits were then aseptically placed in sterile petridishes previously poured with Czapek's agar medium. After two to three days, the fungal growth was transferred into Czapek's agar slants in test tubes, by means of a sterilized inoculation needle. Pure cultures were maintained on Czapek's agar slants at room temperature (28-30°C).

Morphology of the fungus

The morphology of the fungus was studied by growing cultures on Czapek's agar medium in petridishes.

Growth of the fungus on different culture media

Composition of the media used

1. Czapek's agar

Sucrose	30.00 g
Sodium nitrate	2.00 g
Dipotassium hydrogen phosphate	1.00 g
Magnesium sulphate	0.50 g
Potassium chloride	0.50 g
Ferrous sulphate	0.01 g
Agar agar	20.00 g
Distilled water	1000.00 ml

2. Corn meal agar

Corn meal	20.00 g
Peptone	20.00 g
Dextrose	20.00 g
Agar agar	20.00 g
Distilled water	1000.00 ml

3. Coon's agar

Sucrose	7.20 g
Dextrose	3.60 g
Magnesium sulphate	1.23 g
Potassium acid phosphate	2.72 g
Potassium nitrate	2.02 g
Agar agar	20.00 g
Distilled water	1000.00 ml

4. Oat meal agar

Oat meal	40.00 g
Peptone	10.00 g
Dextrose	10.00 g
Agar agar	20.00 g
Distilled water	1000.00 ml

5. Potato dextrose agar

Potato	200.00 g
Dextrose	20.00 g
Agar agar	20.00 g
Distilled water	1000.00 ml

6. Rawa meal agar

Bombay rawa	40.00 g
Dextrose	10.00 g
Peptone	10.00 g
Agar agar	20.00 g
Distilled water	1000.00 ml

7. Richard's agar

Sucrose	50.00 g
Potassium nitrate	10.00 g
Potassium dihydrogen phosphate	5.00 g
Magnesium sulphate	2.50 g
Ferric chloride	0.02 g
Agar agar	20.00 g
Distilled water	1000.00 ml.

8. Soil extract agar

Soil extract	1000.00 ml
Dextrose	10.00 g
Peptone	10.00 g
Agar agar	20.00 g

9. Sabouraud's agar

Glucose	40.00 g
Peptone	10.00 g
Agar agar	20.00 g
Distilled water	1000.00 ml

Five mm diameter discs were cut out from a petridish culture of the fungus grown on Czapek's agar medium and transferred to the centre of petridishes containing the different media. Three petridishes were used for each medium. Growth was recorded when the mycelium in any one of the medium completely covered the petridish. The sclerotial formation was recorded 15 days after inoculation on the media.

Pathogenicity of the organism

The pathogenicity was tested by inoculating cardamom seedlings with the fungus grown on Rawa meal sand medium. The soil in earthen pots was mixed with the culture of the fungus at the rate of 2.5 per cent by weight (approximately) before sowing the seeds. Larger seedlings were inoculated by placing the culture at the collar region and covering with moist cotton. The pathogen was reisolated from artificially infected seedlings.

Host range of the fungus

The following species of plants were used for host range studies. Inoculations were done as mentioned above.

1. Azolla — *Azolla pinnata* Lam.
2. Bengal gram — *Cicer arietinum* Linn.

3. Balsam	*Impatiens balsamina* L.
4. Bitter gourd	*Momordica charantia* L.
5. Betelvine	*Piper betle* Linn.
6. Brinjal	*Solanum melongena* L.
7. Bhindi	*Abelmoschus esculentus* Moench.
8. Cow pea	*Vigna sinensis* (L.) Savi.
9. Cucumber	*Cucumis sativus* L.
10. Cluster beans	*Cyamopsis tetragonoloba* (L.) Taub.
11. Commelina	*Commelina benghalensis* L.
12. Green gram	*Phaseolus aureus* Roxb.
13. Kataladi	*Achyranthus aspera* L.
14. Kizhanelli	*Phyllanthus niruri* L.
15. Mustard	*Brassica juncea* Coss.
16. Nut grass (Muthanga)	*Cyperus rotundus* L.
17. Nithya vazhuthana	*Calonyction muricatum* Don.
18. Onion	*Allium cepa* Linn.
19. Oorppum	*Abutilon indicum* L.
20. Potato	*Solanum tuberosum* Linn.
21. Napier grass	*Pennisetum purpureum* Schum.
22. Pepper	*Piper nigrum* L.
23. Peringalam	*Clerodendron infortunatum* L.
24. Snake gourd	*Trichosanthes anguina* L.
25. Sword bean	*Canavalia gladiata* DC.

26. Tomato — <u>Lycopersicon</u> <u>esculentum</u> Mill.

27. Venappacha — <u>Heliotropium</u> <u>indicum</u> L.

<u>Composition of Rawa meal sand medium</u>

Bombay rawa	40.00 g
Dry sand	1000.00 g
Water	100.00 ml

<u>Evaluation of fungicides for the control of the fungus</u>

The following fungicides were used for laboratory and field experiments:

<u>Fungicide</u>	<u>Active ingredient</u>
1. Bavistin	2 (methoxy - carbamoyl) benzimidazole.
2. Daconil	Tetra chloro isophthalonitrile.
3. Difolatan	Cis N- [(1,2, 2-tetrachloro ethyl) thio] 4-cyclohexene-1, 2-dicarboxymide.
4. Dithane M-45	Zinc ion and Manganese ethelene bis dithiocarbamate.
5. Fytolan	Copper oxychloride
6. Mildothane	Thiophanate-methyl (1,2-bis 3 methoxy carbonyl-2- thioureide) benzene.
7. PCNB (Brassicol)	Pentachloro nitrobenzene.
8. Thiride	Tetra methyl thiuram disulphide.

Laboratory evaluation of fungicides

a. Poisoned Food Technique

The effect of different fungicides on the growth of the fungus was studied by the poisoned food technique (Zentmyer, 1955). Three concentrations were used for each fungicide. The required quantity of fungicide was added to 50 ml sterilized molten Czapek's agar medium, mixed well and poured into sterilized petridishes at the rate of 15 ml in each. One 5 mm mycelial disc cut out from an actively growing petridish culture of the fungus was placed in the centre of each petridish containing the poisoned medium. The petridishes were then incubated at laboratory temperature. Observations on the radial growth were taken on the third day after incubation. The per cent inhibition of growth was calculated by the following formula:

$$\text{Per cent inhibition of growth} = \frac{C-T}{C} \times 100$$

where C = radial growth in control

T = radial growth in treatment

b. Immersing mycelial discs in fungicidal solution

The method followed by Sahai (1969) was adopted for this experiment. The highest concentration of the fungicides

used in the above experiment was employed in this study. The fungicidal solutions were prepared in 50 ml sterile, distilled water. Discs of 5 mm diameter were cut out from actively growing culture of the fungus grown on Czapek's agar medium and then immersed in the fungicidal solutions. After intervals of 10 minutes, 30 minutes, 1 hour, 3 hours and 24 hours, the discs were removed from the fungicidal solutions, rinsed in sterile water and placed on Czapek's agar medium in petridishes. These were then incubated at room temperature. Three replications were maintained for each treatment. Growth of the fungus was recorded at 24, 48 and 72 hours after incubation.

c. Soil drenching of fungicides in glass tubes

i. Using culture discs of the fungus

This was studied according to the method described by Zentmyer (1955). The soil was air dried, sieved through 20 mesh sieve and autoclaved for 45 minutes each at 15 lb pressure on two days. The sterilized soil was taken in 2.5 cm diameter sterile glass specimen tubes upto a height of 2.5 cm. The fungal growth from 3 days old culture was cut out into 5 mm diameter discs and one disc was placed over the soil in each tube. Another 2.5 cm column of sterilized soil was then

placed over the inoculum. Five ml of the fungicidal solution was poured gently over the soil surface, the tube plugged with sterilized cotton wool and incubated at room temperature. After 24 hours, the tubes were emptied, the culture disc separated, washed thoroughly in sterile water and was asceptically placed on Czapek's agar in petridishes. The plates were then incubated at room temperature and observed for growth of the fungus upto 72 hours. For the control tubes, five ml of sterile distilled water was poured instead of the fungicidal solutions. Three replications were maintained for each treatment.

2. Using Rawa meal sand culture of the fungus

Four hundred and fifty grams of dry, sieved (through 20 mesh sieve) soil was taken in 1000 ml flask, plugged and autoclaved at 15 lb pressure for one hour. After cooling, 50 g of a ten day old culture of the fungus grown on Rawa meal sand medium was added into the flask and mixed well with the soil. This soil - fungus mixture was then dispensed into sterile 18 mm diameter test tubes upto a height of 9 cm in each and 7 ml of each of the fungicidal solutions prepared in sterile water was carefully added

into each test tube. For the control tubes, only seven ml of sterile water was added. After 24 hours, the tubes were emptied and 1 g sample of the soil was placed (uniformly spread) on selective medium (given below) in petridishes. Three replications were maintained for each fungicide. Observations were taken 72 hours after incubation.

In another set, unsterilized soil was used for the experiment.

<u>Composition of selective medium</u> (Ko and Frances, 1971)

$K_2H\ PO_4$	2.00 g
$Mg\ SO_4\ 7H_2O$	0.50g
KCl	0.50 g
$Fe\ SO_4 7H_2O$	0.01 g
$Na\ NO_2$	0.20 g
Gallic acid	0.40 g
Dexon (Sodium p di-methyl amino) benzene diazo sulph-onate.	0.09 g
Chloramphenicol	0.05 g
Streptomycin	0.05 g
Agar agar	20.00 g
Water	1000.00 ml

(All mineral salts were added before autoclaving and gallic acid, dexon, chloramphenicol and streptomycin were added just before pouring).

Pot culture studies

a. Effect of fungicides at different depths of soil

Rawa meal sand culture of the fungus was mixed with unsterilized soil to give 2.5 per cent inoculum level and the mixture was filled in 30 cm diameter earthen pots and were kept in an open place. After three days, the required concentration of the fungicidal solution was poured at the rate of 2 litres per pot. At intervals of 1, 5, 15 and 30 days after treatment with the fungicides, soil samples were collected from depths between 2.0 cm to 2.5 cm, 7.0 cm to 7.5 cm and 14.5 cm to 15.0 cm by means of a 2.5 cm diameter iron pipe and one gram samples of the same were then placed on selective medium as mentioned earlier. For the control pots, 2 litres of water was poured. Three replications were maintained for each treatment.

b. Residual toxicity of fungicides in soil

Thirty cm diameter earthen pots were filled with soil and the required concentration of fungicidal solution

was poured at the rate of 2 litres per pot. At intervals of 1, 5, 15 and 30 days after treatment with the fungicides, the soil in the pots upto a depth of 2.5 cm was mixed with 25 g of Rawa meal sand culture of the fungus and 500 ml of water was then poured into each pot. Twenty four hours after mixing the fungus, soil samples were taken from the pots and placed on the selective medium as mentioned earlier. Three replications were maintained for each treatment.

Field evaluation of fungicides

The comparative efficacy of fungicides for the control of *Rhizoctonia* damping off of cardamom seedlings was tested by drenching the fungicides in primary nursery beds, at the Cardamom Research Station, Pampadumpara.

The concentration of fungicides used for the experiment is as follows: Bavistin (0.1%), Daconil (0.3%), Difolatan (0.3%), Dithane M-45 (0.3%), Fytolan (0.3%), Mildothane (0.2%), PCNB (Brassicol)(0.3%) and Thiride (0.3%).

The fungicides were applied at two time intervals.

Set I:- Two days before sowing seeds (4-11-1977)
Set II: One month after sowing (5-12-1977).

Primary nursery beds of 2 M x 1 M x 0.03 M size were prepared and the top soil was made into a fine tilth by removing pebbles and other materials. Five hundred grams of the Rawa meal sand culture of the fungus was first mixed with 1.5 kg of sand and was evenly distributed on each bed and mixed well with the soil upto a depth of approximately 7.5 cm. After levelling, a thin layer of sand was evenly spread over the beds. After two days, beds in Set I were drenched with the different fungicides at the rate of 3 litres per bed. Two days after application of fungicides, seeds were sown in all the beds including that of Set II, at the rate of 1000 seeds per bed. The beds were then covered with a layer of potha grass (Granotia striota). One month after sowing the seeds, the beds in Set II were drenched with the fungicides as mentioned above, after removing the grass mulch. The mulch was replaced after drenching with the fungicides. Suitable controls of seed beds with and without the addition of the fungus were also maintained. Three replications were maintained for each treatment. The beds were watered daily from the time of sowing.

Potha grass mulch was removed when the seeds started germinating. Observations on the number of healthy seedlings were taken during the fifth and eighth month (April and July, 1978) after sowing.

Survival of the fungus in soil

The period upto which the fungus will be able to survive in the soil was studied at the Cardamom Research Station, Pampadumpara. The soil of nursery beds was mixed with the fungus and seeds sown as described for the field evaluation of fungicides. Samples of the top 7.5 cm layer of soil were collected during the 5th and 8th month after sowing, from four different places of each bed. These were mixed and the presence of viable propagules of the fungus was tested by placing on selective medium as described in the pot culture experiment.

RESULTS

RESULTS

Symptomatology

Symptoms of the disease appeared after the emergence of seedlings. The collar region of infected seedlings exhibited light brown discolouration in the early stages. As the infection advanced, the colour at the collar region became dark brown and the seedlings collapsed and decayed. In the case of older seedlings, as the collar region became brown, the lower leaves appeared water-soaked and later on became dirty white to yellowish brown in colour and parchment-like. Infected seedlings eventually collapsed at the collar region, shrivelled and died in patches. When the infected seedlings were uprooted, the basal regions including the young developing rhizomes were seen dirty brown coloured and decayed. Discolouration and decaying of the roots were also noticed. Seedlings in the primary nursery were found susceptible to infection by the fungus upto about six months.

Isolation and Pathogenicity of the fungus

The fungus was isolated, brought into pure culture and maintained on Czapek's agar medium in test tubes. Artificial inoculations proved the fungus to be highly pathogenic

to young cardamom seedlings upto about six months. Symptoms identical to those occurring in nature were produced on the artificially inoculated seedlings. When the rhizomes of older plants were inoculated with the fungus, those became soft and brown in colour. When such rhizomes were split open, rotting of internal tissues was noticed. Young shoots arising from infected rhizomes wilted and dried.

Morphology of the fungus

The young hyphae appeared hyaline and spreading. These later became brown in colour. The hyphal branches usually developed at right angles. But branching at 45 degrees was also noticed often. The branches were invariably seen some what constricted near the point of origin and a septum could be noticed in the branch near the constriction. Young hyphae ranged from 3.2 μ to 6.4 μ in diameter. The length of individual cells ranged from 128 μ to 252 μ. In older cultures, the hyphal cells became shorter and more or less barrel shaped. These measured 28.8 μ to 38.4 μ in length and 6.4 μ to 9.6 μ in diameter. Monilioid cells measuring 19.2 μ to 28.8 μ in length and 11.2 μ to 12.8 μ in diameter were also noticed in old cultures.

Sclerotial initials were white and loose textured. Mature sclerotia appeared brown in colour. The size of sclerotia ranged from 86.4 μ to 374.4 μ. Confluence of a number of sclerotia forming crust like patches on the sides of petridishes was noticed in culture.

Growth on different media

The fungus grew on all the media tested. On the third day after inoculation, very good mycelial growth was obtained on Coon's agar, Oat meal agar, Potato dextrose agar, Czapek's agar and Richard's agar. Corn meal agar was found to be a poor medium for the growth of the fungus (Table 1). Statistical analysis revealed that Coon's agar, Oat meal agar, Potato dextrose agar, Czapek's agar and Richard's agar were superior to the other media tested. The differences among the above five media were not significant.

Sclerotial formation started on the fifth day of inoculation and was found to be abundant on Czapek's agar, Richard's agar, Potato dextrose agar and Sabouraud's agar. No sclerotial formation was noticed on Rawa meal agar, Soil extract agar and Corn meal agar, even upto 15 days.

Table 1

Growth of *Rhizoctonia solani* on different (solid) culture media

No.	Medium	Mean colony diameter in cm.	Colony characters
1.	Coon's agar	9.00	Brown mycelium, Sclerotial formation moderate.
2.	Corn meal agar	5.33	Light, yellowish brown aerial mycelium, Sclerotial formation nil.
3.	Czapek's agar	9.00	Mycelium brown in colour, sclerotial formation abundant.
4.	Oat meal agar	9.00	Mycelium brown in colour, sclerotial formation moderate.
5.	Potato dextrose agar	9.00	Mycelium brown in colour, sclerotial formation good.
6.	Rawa meal agar	6.70	Light yellowish brown woolly aerial mycelium, sclerotial formation nil.
7.	Richard's agar	9.00	Mycelium brown in colour, sclerotial formation good.
8.	Sabouraud's agar	7.25	Brown mycelium,sclerotial formation abundant.
9.	Soil extract agar	5.67	Light yellowish brown woolly aerial mycelium, sclerotial formation nil.

C.D. for comparing treatment combination at 5 per cent level 0.0384

Host range of the fungus

The fungus was found to infect the following plants on artificial inoculation:

1. Azolla

A light brown patch was noticed initially. As the infection advanced, the entire culture of the fern became dark brown, decayed and settled at the bottom of the trough.

2. Bengal gram

Light brown discolouration was first noticed at the collar region of the seedlings. This later turned dark brown and the seedlings collapsed within three days.

3. Balsam

The infected seedlings developed a brown discolouration at the collar region and collapsed within two to three days.

4. Bitter gourd

A light brown discolouration developed at the collar region of the seedlings. Such seedlings fell off as the infection advanced.

5. Betelvine

Foot and collar rot symptoms were noticed in the inoculated rooted cuttings. The collar region developed light brown discolouration which soon turned into dark brown. The underground parts of such rooted cuttings decayed, causing death of the plant within 20 days.

6. Brinjal

Light brown discolouration could be noticed at the collar region. Later, this turned into dark brown and eventually the seedlings toppled down.

7. Bhindi

Collar rot symptoms developed on the inoculated seedlings. This later caused damping off of the seedlings.

8. Cow pea

The collar region of infected seedlings developed brown discolouration and the seedlings toppled down and decayed. Some of the older infected seedlings appeared apparently healthy, but showed dark brown lesion at the collar region and stunted growth.

9. Cucumber

Damping off symptoms were noticed. At the collar region, brownish, water-soaked lesion developed and the seedlings collapsed.

10. Cluster beans

The fungus caused damping off of the seedlings. The collar region become infected, causing death of seedlings.

11. Commelina

At the collar region, water-soaked lesions were formed initially. These soon enlarged and ultimately caused death of the plant. Plants of all ages were found susceptible to infection.

12. Green gram

The infected seedlings developed a light brown discolouration at the collar region. Later, this was turned into dark brown and within three days the seedlings toppled down and decayed.

13. Kataladi

The fungus caused damping off of seedlings. At the initial stages of infection, a light brown discolouration

could be noticed at the collar region. As the infection advanced, the colour turned into dark brown and the seedlings toppled down.

14. Kizhanelli

Seedlings exhibited damping off symptoms. A brown discolouration was noticed at the collar region of the infected seedling, which soon collapsed and died.

15. Mustard

The fungus caused damping off of seedlings. A light brown discolouration was developed at the collar region and this later turned into dark brown. Within three days the seedlings toppled down.

16. Nut grass

Collar and root rot symptoms were noticed. A brown discolouration developed at the collar region and this soon extended to the leaves causing death of theleaves. Infected plants when uprooted showed brown coloured rotted roots.

17. Nithyavazhuthana

Seedlings exhibited damping off symptoms. Collar region of the seedlings developed light brown discolouration.

This soon became dark coloured and within two days the seedlings collapsed.

18. <u>Onion</u>

Collar rot symptoms were noticed. At the initial stages, the collar region developed a light brown discolouration. As the disease advanced, the colour turned into dark brown and the collar region got shrivelled. Within three days the aerial parts collapsed.

19. <u>Coropum</u>

Infected seedlings exhibited collar rot symptoms. At the initial stages, the collar region became brown. Later the colour darkened and the seedlings collapsed.

20. <u>Potato</u>

A light brown discolouration was formed at the collar region of the young shoots. As the disease advanced, the colour turned into dark brown and the collar region got shrivelled. Within two to three days the infected shoots toppled down.

21 <u>Napier grass</u>

The fungus produced damping off of seedlings. A light brown discolouration was developed at the collar region

and this soon turned into dark brown. Within three days the seedlings fell down.

22. Pepper

The rooted cuttings developed collar rot symptoms. The collar region became brown initially and this discolouration extended downwards. Eventually, all the underground parts including roots rotted, causing death of the plants.

23. Peringalam

The seedlings exhibited collar rot symptoms. A light brown discolouration was seen at the collar region and the seedlings collapsed as the infection advanced.

24. Snake gourd

The fungus caused damping off of seedlings. A water-soaked lesion was formed at the collar region. Later this became dark brown in colour and such seedlings toppled down.

25. Sword bean

Seedlings exhibited collar rot. Around the collar region, dark brown discolouration was formed. As the disease advanced, constriction at the collar region occurred due

to decaying of the tissues. Infected seedlings when uprooted showed brownish, rotted roots.

26. Tomato

The fungus caused damping off of seedlings. At the initial stages, brown discolouration developed at the collar region. This later turned into dark brown and the infected seedlings collapsed within two days.

27. Venappacha

A light brown discolouration was formed at the collar region of seedlings during the initial stages. The lesion enalrged rapidly and became dark brown, causing damping off of seedlings.

Laboratory evaluation of fungicides

a. Poisoned food technique

Complete inhibition of growth of the fungus was obtained with 250 ppm of Bavistin, 500 ppm of Mildothane, 1000 ppm of PCNB (Brassicol) and 1000 ppm of Thiride in the medium. Fytolan was found to be the least effective among the fungicides tested. Even at 3000 ppm, this fungicide could effect only 87.44 per cent inhibition of the growth of the

fungus. Dithane M-45 caused 92 per cent inhibition at 3000 ppm concentration while, Daconil and Difolatan caused 89.78 and 85.52 per cent inhibition at the same concentration (Table 2). Statistical analysis of the data revealed that Bavistin, Mildothane, PCNB and Thiride were superior to the other fungicides tested, while there was no significant difference between them.

b. Immersing culture discs in fungicidal solution

The results indicated that Bavistin and Thiride could cause complete inhibition of the growth of the fungus when culture discs were immersed for 10 minutes, and observations taken upto 72 hours after incubation. Difolatan effected complete inhibition of growth when culture discs were immersed for 30 minutes. Daconil effected complete inhibition of growth when culture discs were immersed for 3 hours except when observation was taken 72 hours after incubation. Dithane M-45 caused complete inhibition of growth when culture discs were immersed for a period of 24 hours. Eventhough Fytolan also caused complete inhibition when discs were immersed for 24 hours, this inhibitory effect was noticed only when observations were taken 24

Table 2

Effect of different fungicides on the growth of *Rhizoctonia solani* in Czapek's agar medium

(Poisoned Food Technique)

Fungicide	Concentration in ppm.	Mean colony diameter in cm.	Per cent inhibition over control
Bavistin	250	0.00	100.00
	500	0.00	100.00
	1000	0.00	100.00
Daconil	1000	2.02	73.33
	2000	1.80	80.00
	3000	0.92	89.78
Difolatan	1000	2.40	73.33
	2000	2.15	76.11
	3000	1.33	85.52
Dithane M-45	1000	1.10	85.78
	2000	0.80	91.11
	3000	0.72	92.00
Fytolan	1000	6.28	30.22
	2000	6.10	32.22
	3000	1.13	87.44
Mildothane	500	0.00	100.00
	1000	0.00	100.00
	2000	0.00	100.00
PCNB (Brassicol)	1000	0.00	100.00
	2000	0.00	100.00
	3000	0.00	100.00
Thiride	1000	0.00	100.00
	2000	0.00	100.00
	3000	0.00	100.00
Control	..	9.00	..

C.D. for comparing treatment combinations. 0.0921

C.D. for comparing concentrations 0.0532

EFFECT OF DIFFERENT FUNGICIDES ON THE GROWTH OF RHIZOCTONIA SOLANI IN CZAPEK'S MEDIUM

[POISONED FOOD TECHNIQUE]

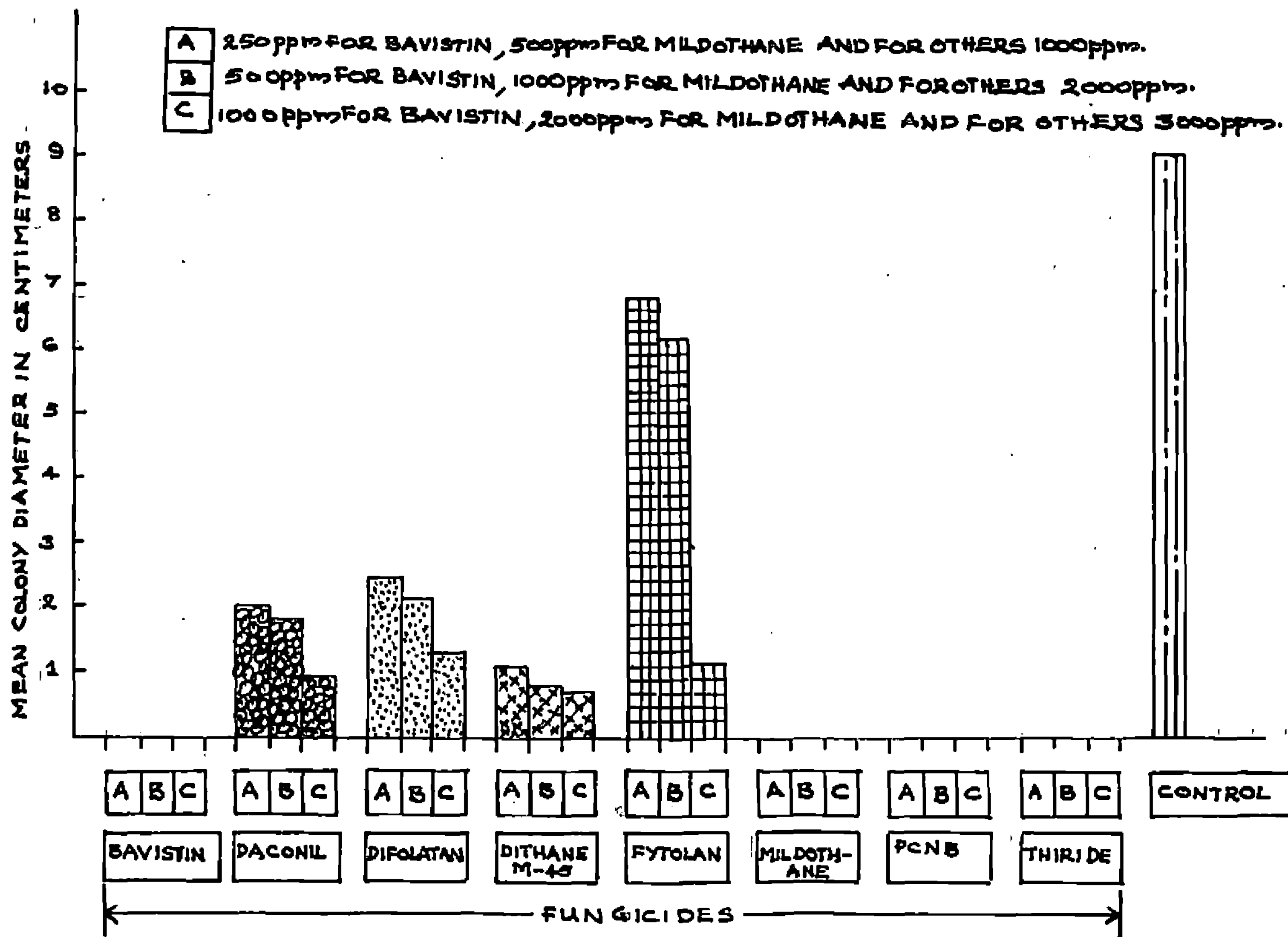


Fig. 1

hours after incubation. A similar trend was noticed in the case of PCNB also. Mildothane could not effect inhibition of growth even after 24 hours immersion (Tables 3, 4, 5).

c. Soil drenching of fungicides in glass tubes

1. Using culture discs of the fungus

When the culture discs were transferred to Czapek's agar medium, 24 hours after treatment with fungicides, it was noticed that in all treatments the fungus could grow into the medium. This indicated that none of the fungicides could kill the fungus when tested by this method.

2. Using Rawa meal sand culture

When the effect of fungicides as soil drench in glass tubes was tested using culture of the fungus grown on Rawa meal sand medium, it was noticed that Bavistin, Daconil, Difolatan, Dithane M-45 and Thiride were able to kill the fungus both in sterilized and unsterilized soil, when exposed for 24 hours. In the case of Fytolan, Mildothane, and PCNB, the fungus was able to grow when incubated on the selective medium. PCNB was found to be the least effective when tested by this method (Tables 6, 7). Statistical analysis also confirmed the above findings.

Table 3

Effect of immersing culture discs in fungicidal solutions on the viability of *Rhizoctonia solani*

A. twenty four hours incubation in Czapek's agar medium after treatment with fungicides.

Fungicide	Period of immersion in the fungicidal solution				
	10 minutes	30 minutes	1 hour	3 hours	24 hours
Bavistin 1000 ppm	0	0	0	0	0
Daconil 3000 ppm	++	++	++	0	0
Difolatan 3000 ppm	+	0	0	0	0
Dithane M-45 3000 ppm	+++	++	++	+	0
Fytolan 3000 ppm	+++	+++	+++	+++	0
Mildothane 2000 ppm	+++	+++	+++	+++	++
PCNB (Brassicol) 3000 ppm	++	++	++	++	0
Thiride 3000 ppm	0	0	0	0	0

0 - No growth
\+ - 2-3 hyphae protruding out upto 1 cm diameter
++ - Hyphal growth upto 1-2 cm diameter
+++ - Hyphal growth between 2-4 cm diameter.

Table 4

Effect of immersing culture discs in fungicidal solutions on the viability of <u>Rhizoctonia solani</u>

B. Fourty eight hours incubation on Czapek's agar medium after treatment with fungicides.

Fungicide	Period of immersion in the fungicidal solution				
	10 minutes	30 minutes	1 hour	3 hours	24 hours
Bavistin 1000 ppm	0	0	0	0	0
Daconil 3000 ppm	+++	+++	+++	0	0
Difolatan 3000 ppm	+++	0	0	0	0
Dithane M-45 3000 ppm	++++	++++	++++	++	0
Fytolan 3000 ppm	+++++	+++++	+++++	+++++	+++
Mildothane 2000 ppm	++++	++++	++++	++++	++++
PCNB (Brassicol) 3000 ppm	++++	++++	++++	++++	++
Thiride 3000 ppm	0	0	0	0	0

0 - No growth
\+ - 2-3 phyphae protruding out upto 1 cm diameter.
++ - Hyphal growth upto 1-2 cm diameter.
+++ - Hyphal growth between 2-4 cm diameter.
++++ - Growth between 4-6 cm
+++++ - Growth between 6-8 cm

Table 5

Effect of immersing culture discs in fungicidal solutions on the viability of <u>Rhizoctonia solani</u>.

C. Seventy two hours incubation on Czapek's agar medium after treatment with fungicides.

Fungicide	Period of immersion in the fungicidal solution				
	10 minutes	30 minutes	1 hour	3 hours	24 hours
Bavistin 1000 ppm	0	0	0	0	0
Daconil 3000 ppm	+++++	+++++	+++++	++	0
Difolatan 3000 ppm	++++++	0	0	0	0
Dithane M-45 3000 ppm	++++++	++++++	++++++	+++	0
Fytolan 3000 ppm	++++++	++++++	++++++	++++++	+++++
Mildothane 2000 ppm	++++++	++++++	++++++	++++++	++++++
PCNB (Brassicol) 3000 ppm	++++++	++++++	++++++	++++++	+++
Thiride 3000 ppm	0	0	0	0	0

0 - No growth
+ - 2-3 hyphae protruding out upto 1 cm diameter
++ - Hyphal growth upto 1-2 cm diameter
+++ - Hyphal growth between 2-4 cm diameter
++++ - Growth between 4-6 cm
+++++ - Growth between 6-8 cm
++++++ - Full growth (9 cm)

Table 6

Effect of soil drenching fungicides on the viability of *Rhizoctonia solani*

A. Sterilized soil in test tubes

Fungicide	Average No.of colonies from 1 gm of soil*	Per cent inhibition over control.
Bavistin 1000 ppm	0	100.00
Daconil 3000 ppm	0	100.00
Difolatan 3000 ppm	0	100.00
Dithane M-45 3000 ppm	0	100.00
Fytolan 3000 ppm	6	90.00
Mildothane 2000 ppm	3	95.00
PCNB (Brassicol) 3000 ppm	9	85.00
Thiride 3000 ppm	0	100.00
Control	60	..

* Rounded to the nearest whole number.

C.D. for comparing treatment combinations - 0.2402.

Table 7

Effect of drenching fungicides on the viability of *Rhizoctonia solani*

B. Unsterilized soil in test tubes

Fungicide	Average No. of colonies from 1 gm of soil.*	Per cent inhibition over control
Bavistin 1000 ppm	0	100.00
Daconil 3000 ppm	0	100.00
Difolatan 3000 ppm	0	100.00
Dithane M-45 3000ppm	0	100.00
Fytolan 3000 ppm	5	92.08
Mildothane 2000 ppm	1	98.41
PCNB (Brassicol) 3000 ppm	15	76.19
Thiride 3000 ppm	0	100.00
Control	63	..

* Rounded to the nearest whole number.

C.D. for comparing treatment combinations - 0.7608.

Pot culture studies

1. Effect of fungicides at different depths of soil

When soil samples at a depth of 2.0 to 2.5 cm were tested for the viability of the fungus on selective medium, after drenching with the different fungicides, it was noticed that Dithane M-45 and Thiride caused complete inhibition of fungal growth at all the periods tried. In the case of soil treated with Bavistin, no colony of the fungus developed on the medium when tested upto five days after treatment with the fungicide. In soil drenched with Difolatan, no colony developed one day after the treatment, whereas a few colonies were noticed during the later observations. Only one colony of the fungus developed in the case of soil drenched with Daconil upto five days, but on the fifteenth and thirtieth day, a number of colonies developed in this treatment. Mildothane also showed a more or less similar trend. Fytolan and PCNB showed very little detrimental effect on the viability of the fungus (Table 8).

At a depth of 7.0 cm to 7.5 cm also, no colony of the fungus developed on the selective medium upto 30 days

Table 8

Effect of drenching fungicides on the viability of
<u>Rhizoctonia solani</u>

A. 2.0 to 2.5 cm depth.

Fungicide	Average number of colonies from one gram of soil after *			
	1 day	5 days	15 days	30 days
Bavistin 1000 ppm	0	0	23	38
Daconil 3000 ppm	1	1	8	14
Difolatan 3000 ppm	0	1	2	3
Dithane M-45 3000 ppm	0	0	0	0
Fytolan 3000 ppm	7	2	40	50
Mildothane 2000 ppm	2	1	5	35
PCNB (Brassicol) 3000 ppm	17	16	38	59
Thiride 3000 ppm	0	0	0	0
Control	56	56	55	90

* Rounded to the nearest whole number

C.D. for treatment combinations 0.4984
C.D. for periods 0.1439
C.D. for depths 0.1661

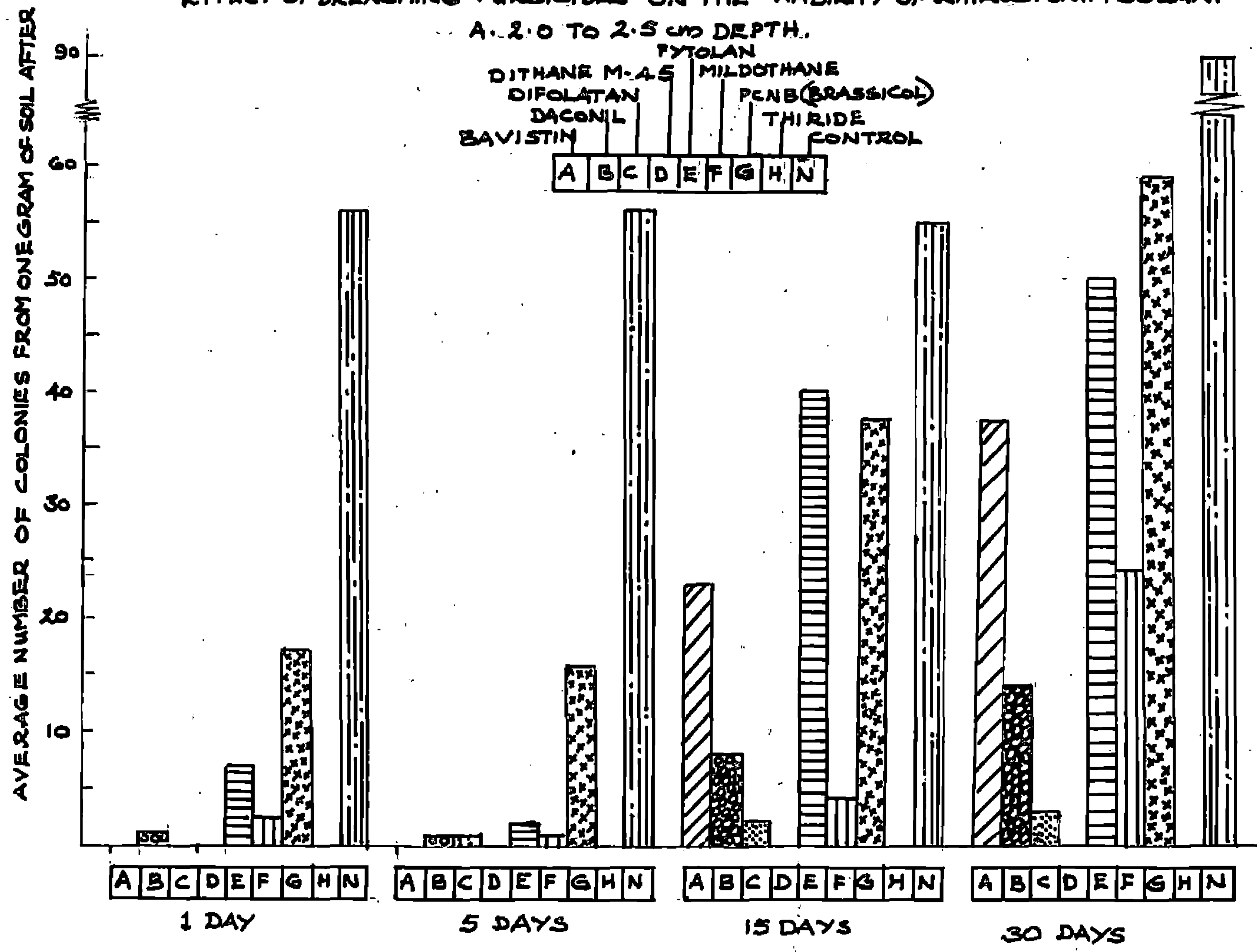


Fig-2

after treatment with Dithane M-45 and Thiride. With regard to the other fungicides, the effect was found to be almost similar to that obtained at 2.0 cm to 2.5 cm depth (Table 9).

When the viability of the fungus was tested at 14.5 cm to 15.0 cm depth, it was noticed that, on the thirtieth day, one colony developed from the soil treated with Dithane M-45 and 5 colonies developed from Thiride treated soil. No colony was developed from the soil treated with these two fungicides when tested on the first, fifth, and fifteenth day after treatment. In the case of soil treated with Bavistin, eventhough no colony developed on the first and fifth day after treatment, considerable number of colonies were noticed when tested on the fifteenth and thirtieth day after treatment. Daconil, Difolatan and Mildothane did not exhibit any appreciable variation from that of the other two depths observed. Fytolan and PCNB were not found effective, as observed for the other two depths (Table 10).

Statistical analysis of the combined data revealed that Dithane M-45 and Thiride were superior to the other six fungicides tested. There was no significant difference

Table 9

Effect of drenching fungicides on the viability of *Rhizoctonia solani* in soil

B. 7.0 to 7.5 cm depth.

Fungicide	Average number of colonies from one gram of soil after *			
	1 day	5 days	15 days	30 days
Bavistin 1000 ppm	0	0	20	47
Daconil 3000 ppm	1	1	10	10
Difolatan 3000 ppm	1	3	5	7
Dithane M-45 3000 ppm	0	0	0	0
Fytolan 3000 ppm	20	5	39	48
Mildothane 2000 ppm	5	6	13	18
PCNB (Brassicol) 3000 ppm	19	17	47	52
Thiride 3000 ppm	0	0	0	0
Control	63	61	59	78

* Rounded to the nearest whole number.

C.D. for treatment combinations 0.4984
C.D. for periods 0.1439
C.D. for depths 0.1661

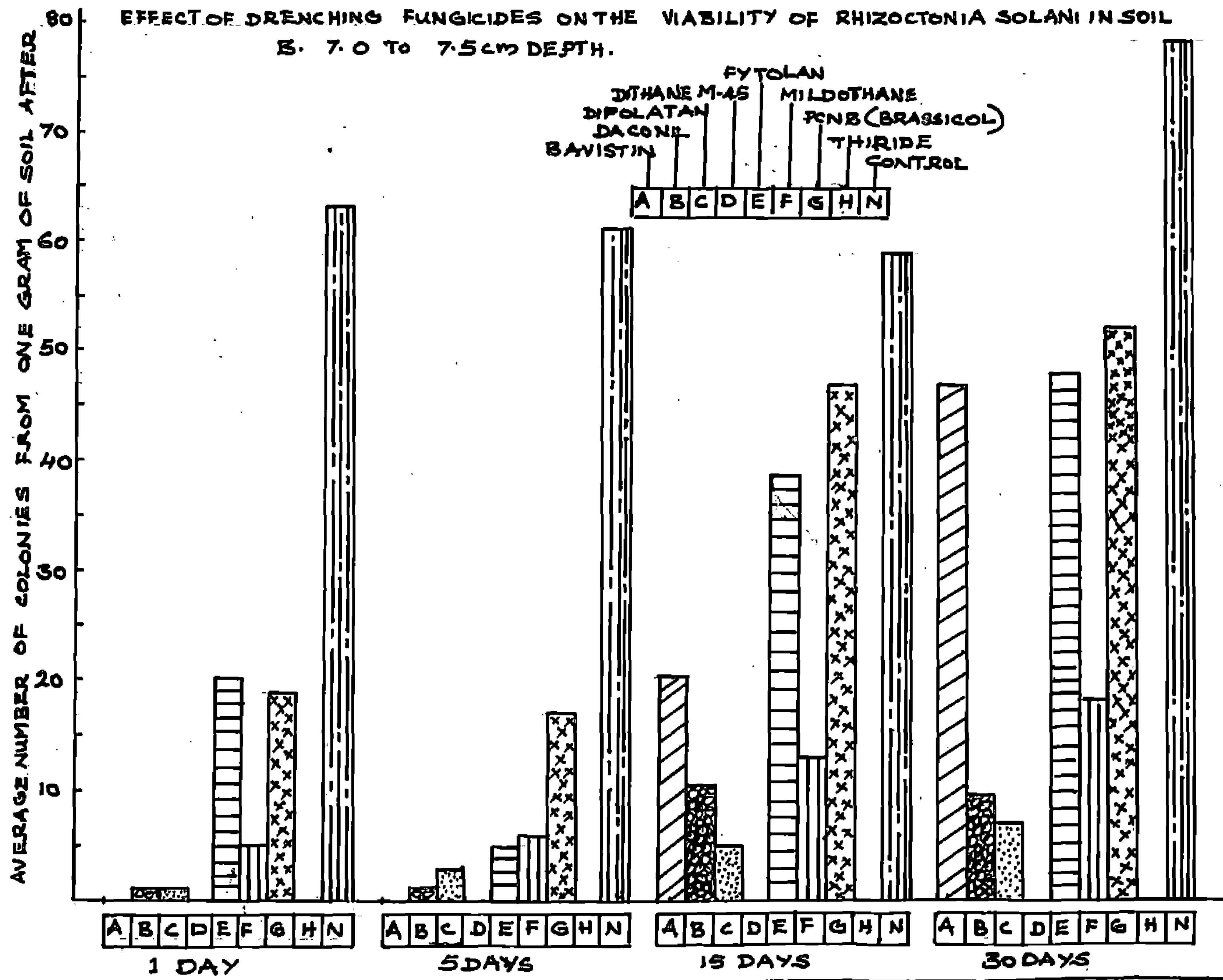


Fig - 3

Table 10

Effect of drenching fungicides on the viability of *Rhizoctonia solani* in soil

C. 14.5 to 15.0 cm depth.

Fungicide	Average number of colonies from one gram of soil after *			
	1 day	5 days	15 days	30 days
Bavistin 1000 ppm	0	0	29	48
Daconil 3000 ppm	1	1	14	17
Difolatan 3000 ppm	1	3	11	7
Dithane M-45 3000 ppm	0	0	0	1
Fytolan 3000 ppm	21	3	35	58
Mildothane 2000 ppm	2	6	10	24
PCNB (Brassicol) 3000 ppm	44	16	38	59
Thiride 3000 ppm	0	0	0	5
Control	58	56	56	93

* Rounded to the nearest whole number

C.D. for treatment combinations - 0.4984
C.D. for periods - 0.1439
C.D. for depths - 0.1661

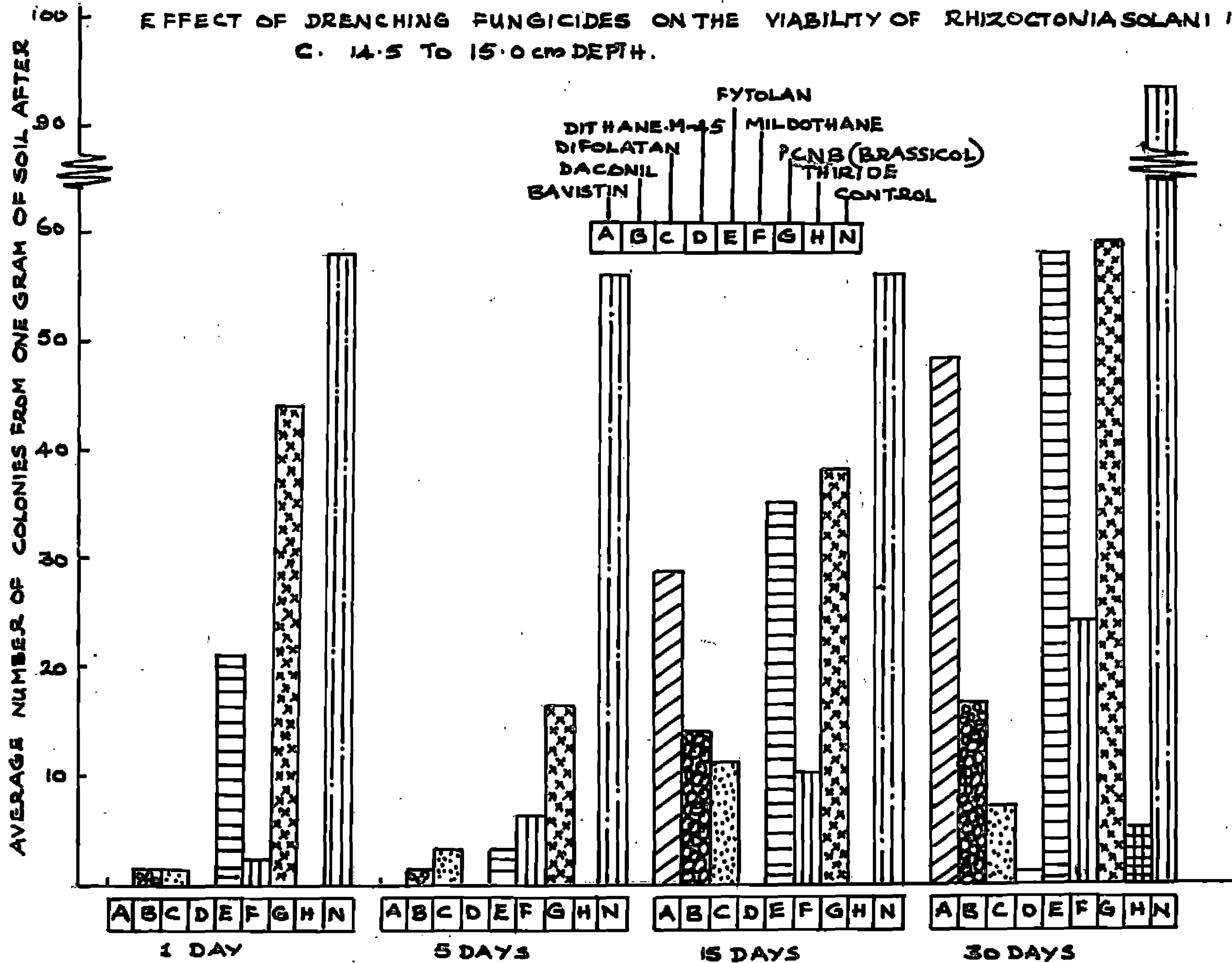


Fig - 4

between Dithane M-45 and Thiride. Difolatan was superior to Bavistin, Daconil, Fytolan, Mildothane and PCNB. In the case of time intervals, fifth day was found superior to the rest of the periods tested. With regard to depth of soil, the fungicidal effect was found to be maximum at 2.0 cm to 2.5 cm depth followed by 7.0 to 7.5 cm and 14.5 cm to 15.0 cm respectively and the differences among them were statistically significant.

2. Residual toxicity of fungicides in soil

Results of this experiment indicated that Dithane M-45 and Thiride had the maximum residual toxicity against the fungus. No colony of the fungus developed in the selective medium upto 15 days. When observations were taken 30 days after treatment, two colonies developed from the soil treated with Dithane M-45 and six colonies from Thiride treated soil. In the case of soil treated with Bavistin, no colony developed on the medium upto five days after treatment, while a number of colonies developed after 15 and 30 days of treatment. In the case of Difolatan, no colony developed after one day, one colony after 5 days, 6 colonies after 15 days and seven colonies after 30 days.

Daconil, Fytolan, Mildothane and PCNB were not effective at all the periods tested (Table 11). Statistical analysis revealed that Dithane M-45 and Thiride were significantly superior to the other fungicides tested. The difference between these two fungicides was not significant. In the case of time intervals after application of fungicides, maximum toxicity was exhibited five days after treatment and this period was statistically significant over the other periods tried.

Field evaluation of fungicides

When observations were taken during the fifth month after sowing, it was noticed that in Set I, the beds treated (before sowing) with Dithane M-45 had the maximum number of seedlings. This was followed by Bavistin and Difolatan. In set II (fungicide applied one month after sowing) also Dithane M-45 was found to be the best, based on the number of seedlings on the beds treated with this fungicide. Thiride was found to be second and Difolatan was third in rank.

In the observations taken during the eighth month after sowing, the seedling stand was found to be best in the beds treated with Dithane M-45 before sowing (Set I),

Table 11

Residual toxicity of fungicides against
Rhizoctonia solani in soil

Fungicide	Average number of colonies from one gram of soil after *			
	1 day	5 days	15 days	30 days
Bavistin 1000 ppm	0	0	22	60
Daconil 3000 ppm	9	2	9	18
Difolatan 3000 ppm	0	1	6	7
Dithane M-45 3000 ppm	0	0	0	2
Fytolan 3000 ppm	29	31	36	44
Mildothane 2000 ppm	12	6	12	46
PCNB (Brassicol) 3000 ppm	39	39	42	71
Thiride 3000 ppm	0	0	0	6
Control	46	48	50	80

* Rounded to the nearest whole number.
C.D. for treatment combinations - 0.8159
C.D. for fungicides - 0.4079
C.D. for periods - 0.2720

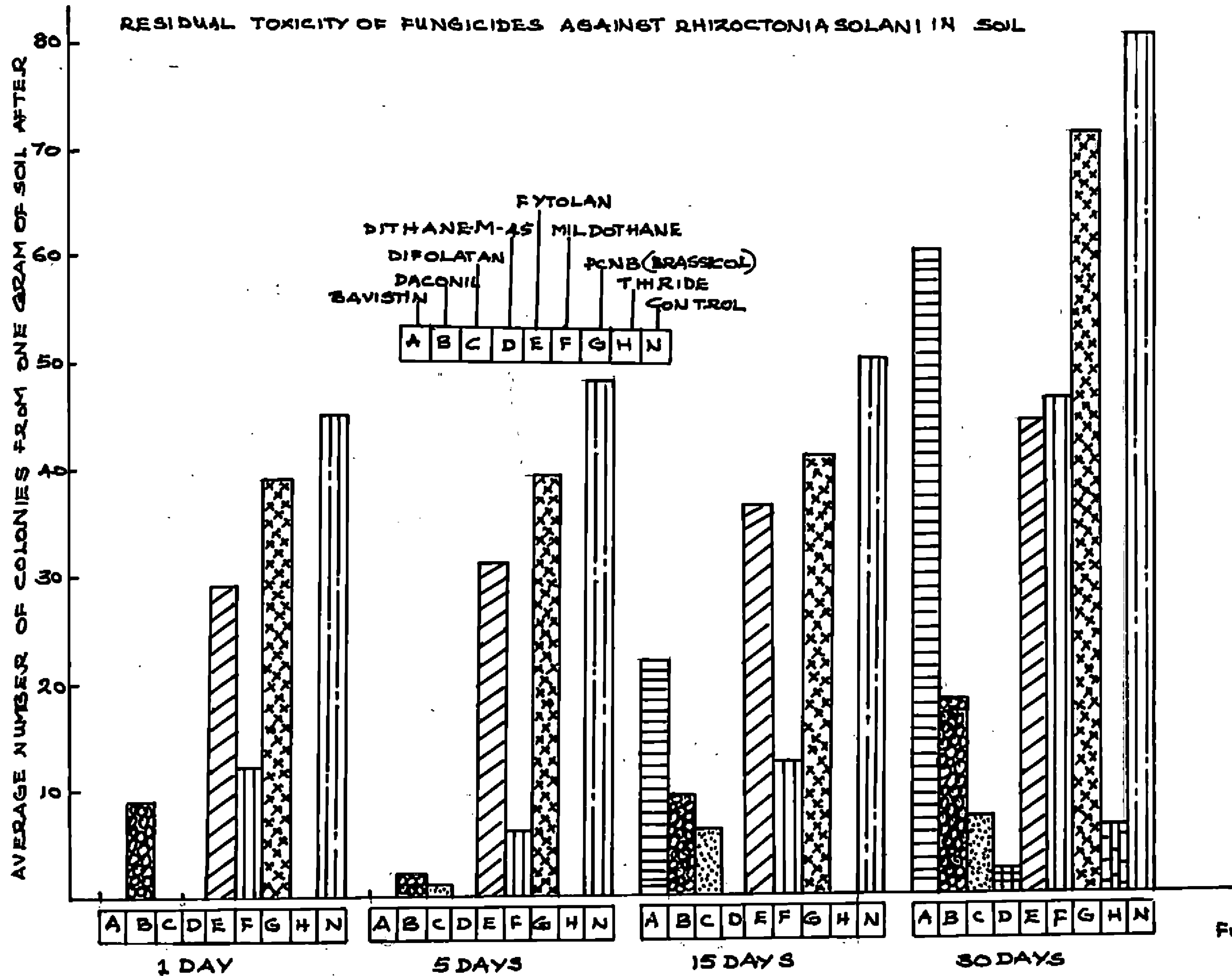


Fig - 5

followed by that in Bavistin and Difolatan. In set II however, Thiride proved to be the best, closely followed by Difolatan and Dithane M-45. Seedling stand in control I and II was poor. It was noticed that, there were only very few seedlings in the beds treated with PCNB during the first observation and there was no seedling in these beds when observations were taken eight months after sowing. This indicated that treatment with this fungicide had some deleterious effect on the seeds for seedlings of cardamom (Table 12).

Statistical analysis of the results (Set I and II together) of the observations taken during the 5th month after sowing revealed that Dithane M-45 was significantly superior to the other fungicides as well as controls. This was followed by Bavistin, Difolatan, Thiride and Mildothane in the descending order. The differences among these fungicides were not significant. Analysis of the data (Sets I and II together) of the observations taken during the eighth month after sowing indicated that, drenching Dithane M-45 was the most effective, followed by Difolatan, Bavistin and Thiride. The difference

Table 12 Effect of drenching fungicides on the damping off of Cardamom seedlings in primary nursery beds

	Fungicide	Seedling stand during	
		Fifth month after sowing	Eight month after sowing
S_I FUNGICIDE APPLICATION BEFORE SOWING	Bavistin	188	205
	Daconil	96	111
	Difolatan	174	176
	Dithane M-45	207	228
	Fytolan	86	66
	Mildothane	82	90
	PCNB (Brassicol)	1	0
	Thiride	90	110
	Control-I	73	71
	Control-II	114	94
S_{II} FUNGICIDE APPLICATION ONE MONTH AFTER SOWING	Bavistin	101	120
	Daconil	7	5
	Difolatan	143	169
	Dithane M-45	211	162
	Fytolan	83	99
	Mildothane	106	118
	PCNB (Brassicol)	0	0
	Thiride	158	176
	Control-I	88	78
	Control-II	63	66

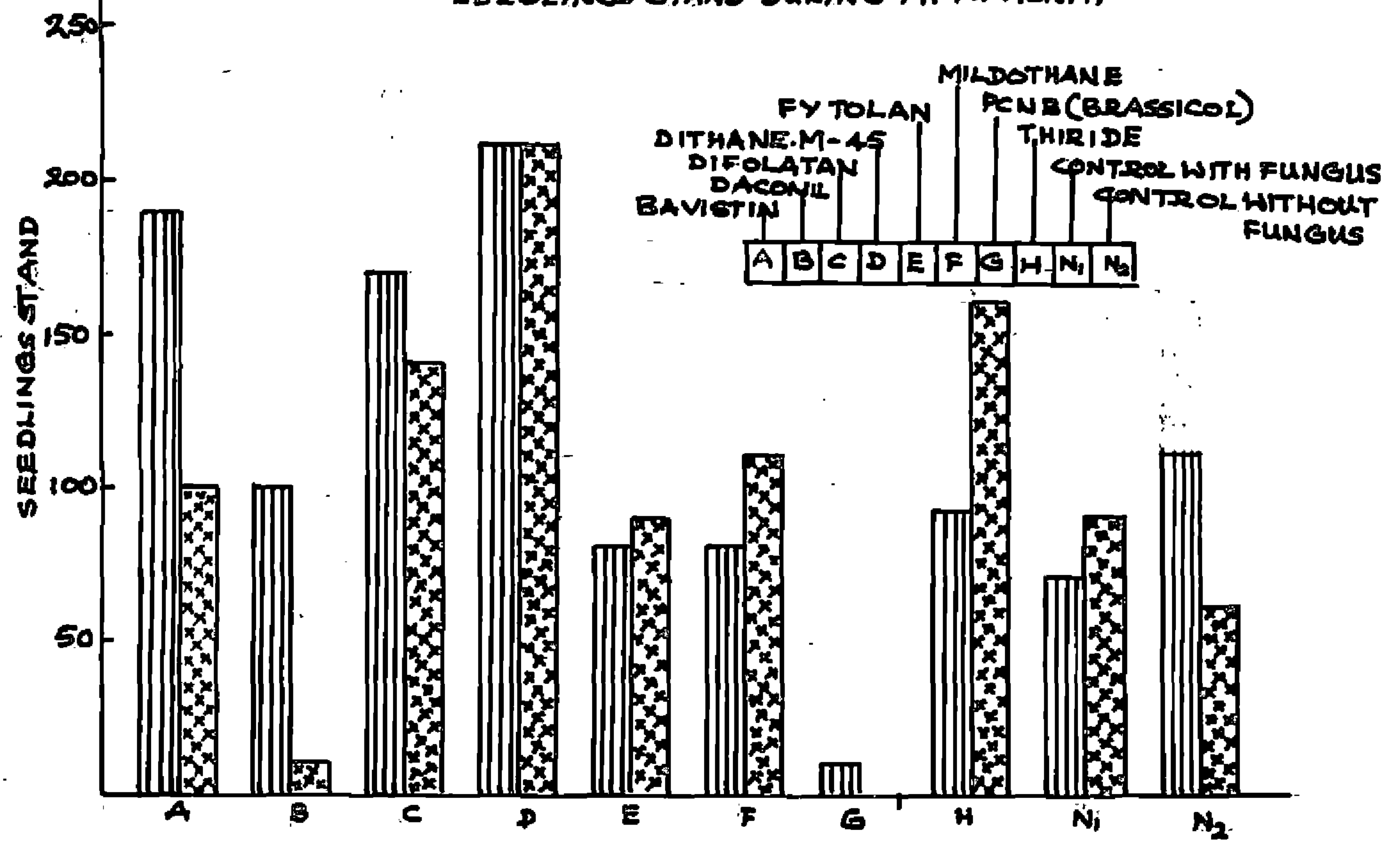
Seedling stand during 5th month after sowing

C.D. for combinations 4.52
C.D. for treatment 3.20

Seedling stand during 8th month after sowing

C.D. for combinations 2.45
C.D. for treatment 0.86

EFFECT OF FUNGICIDES ON THE DAMPING OFF OF CARDAMOM SEEDLINGS IN PRIMARY NURSERY BEDS



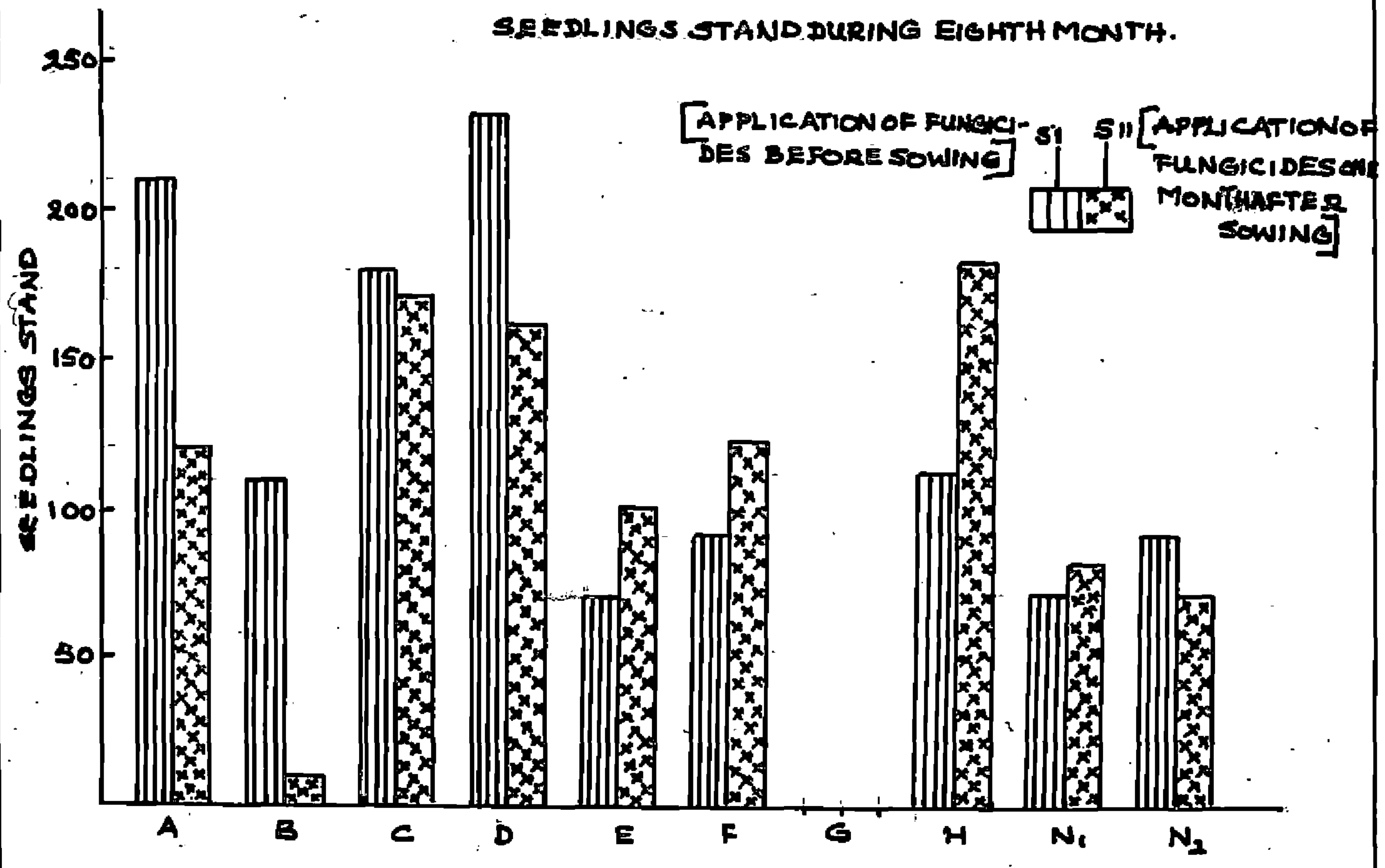


Fig-6

between Dithane M-45 and Difolatan was not found to be significant. Dithane M-45 was significantly superior to Bavistin and Thiride, while the differences among Difolatan, Bavistin and Thiride were not significant. With regard to time of application, it was noticed that there was no significant difference between the treatments, drenching fungicides before sowing and fungicidal application one month after sowing.

Survival of the fungus in soil

It was noticed that the fungus was able to survive for over eight months (November to July) in the primary nursery beds under the conditions prevalent at Pampadumpara. The temperature and rainfall recorded during this period ~~is~~ are given below:-

Month	Temperature	Rainfall
November (4-11-1977 to 30-11-1977)	14°C to 29°C	121.5 mm
December, 1977	13°C to 28°C	Nil
January, 1978	13°C to 26°C	5 mm
February, 1978	15°C to 29°C	6.3 mm
March, 1978	15°C to 31°C	26.8 mm
April, 1978	16°C to 32°C	76.8 mm
May, 1978	17°C to 31°C	130.5 mm
June, 1978	16°C to 26°C	374.8 mm
July, 1978 (1-7-1978 to 4-7-1978)	16°C to 24°C	40.5 mm

The above data revealed that the fungus could survive in high range soils, under varying conditions of temperature and rainfall. However, it may be pointed out that the observations in this regard were limited only to the period of raising primary nurseries.

DISCUSSION

DISCUSSION

The role of Rhizoctonia in causing damping off of Cardamom in the primary nursery was established during the present investigation. Rhizoctonia solani has been reported to cause rhizome rot of Cardamom in South India (Subba Rao, 1937; Subramoniam, 1969). Sahadevan (1965) made a mention of Rhizoctonia sp as one of the fungi causing damping off of Cardamom seedlings; but without authority. Wilson (1976 unpublished) recorded Rhizoctonia damping off of Cardamom at Pampadumpara in the Idikki district of Kerala State.

Brown discolouration and rotting at the collar region, yellowing of leaves and death of seedlings were found to be the important field symptoms of the disease. The seedlings were found susceptible to infection by the fungus upto about six months. Artificial inoculations proved that the fungus could cause rotting of well developed rhizomes, in addition to inciting damping off of seedlings.

Morphological characters of the pathogen include, branching mostly at right angle or at 45° angle, constriction of the branch near the point of origin, septum near the constriction and presence of short barrel

shaped cells, as well as monilioid cells in older cultures. These characters agree with those described for Rhizoctonia solani (Duggar, 1915; Peltier, 1916; Flentje et al. 1963; Townsend and Willetts, 1955; Parmeter (Jr.) and Whitney, 1970).

The fungus was found to grow well on Coon's agar Czapek's agar, Potato dextrose agar and Richard's agar media. Sclerotial formation was abundant on Czapek's agar, Potato dextrose agar, Richard's agar and Sabouraud's agar. These observations are in agreement with those of Hulea et al (1971) and Azam and Khan (1973).

In host range studies, it was noticed that the fungus was able to infect 27 plant species including Achyranthes aspera, Commelina benghalensis, Phyllanthus - niruri, Calonyction muricatum, Cyperus rotundus, Abutilon indicum, Heliotropium indicum and the fern Azolla pinnata. These plants have been found to be new host records for Rhizoctonia spp in our country. The above plants, except Calonyction muricatum and Azolla pinnata are common weeds in Cardamom plantations. It is possible that these plants might act as collateral hosts of the pathogen in nature.

Based on its morphology, pathogenicity and host range, the fungus causing damping off of Cardamom in the high ranges of Kerala was identified as Rhizoctonia solani Kuhn. Dr. J.E.M. Mordue of the Commonwealth Mycological Institute, London has confirmed the identity of the fungus. The culture has been deposited in the above institute (IMI No. 227934).

Laboratory evaluation of fungicides using poisoned food technique (Zentmyer, 1955) revealed that Bavistin at 250 ppm, Mildothane 500 ppm and PCNB and Thiride at 1000 ppm completely inhibited the growth of the fungus in Czapek's agar medium. The other fungicides could not cause complete inhibition of growth at the concentrations tested. Fytolan was found to be the least effective among the fungicides tested. Bavistin, Dithane M-45 and PCNB have been reported to be effective in checking the growth of the fungus in nutrient media (Zachos et al 1963; Sen and Kapoor, 1975; Kataria and Grover, 1977) while, copper oxychlorides have been found to be ineffective (Das and Sen Gupta, 1963; Kataria and Grover, 1977; Hiremath et al 1978).

When the efficacy of fungicides was tested by immersing culture discs in fungicidal solutions, as described by

Sahai (1969), it was noticed that the fungus was killed when the discs were immersed for 10 minutes in 1000 ppm Bavistin, and 3000 ppm Thiride. Difolatan (3000 ppm) was able to kill the fungus when discs were immersed for 30 minutes, while Daconil (3000 ppm) and Dithane M-45 (3000 ppm) required 24 hours for killing the fungus. Fytolan, Mildothane and PCNB were not found to be effective. The above method has not been employed earlier for testing the effect of fungicides against Rhizoctonia spp.

The variations noticed in the effects of fungicides when tested by the poisoned food technique (Zentmyer, 1955) and " culture disc immersion" method (Sahai, 1969) are believed to be due to the presence of nutrients in the poisoned medium and the differences in the ability of fungicides to permeate into the culture discs, in the immersion method.

Results of the experiment on drenching fungicides in specimen tubes, as per the method described by Zentmyer (1955) indicated that this method is not suitable for evaluating fungicides against Rhizoctonia.

Results of soil drenching of fungicides in test tubes, using Rawa meal sand culture of the fungus revealed that,

Bavistin, Daconil, Difolatan, Dithane M-45 and Thiride could kill the fungus, both in sterilized and unsterilized soil, when exposed for 24 hours. These results are in agreement with those obtained in the culture disc immersion method. Testing the efficacy of fungicides by this method has not been described earlier. It is felt that, the above method might prove useful for evaluating fungicides against other soil fungi also.

When the efficacy of fungicides was tested in pots by drenching the soil, it was noticed that Dithane M-45 and Thiride were the most effective ones, at all the depths and periods tried. This was followed by Difolatan, Daconil, Mildothane, Bavistin, Fytolan and PCNB in the descending order. The fungicidal effect was found to be maximum at 2.0 to 2.5 cm depth and at 5 days after treatment. Studies on the effect of fungicides on R.solani at different depths of soil have not been made by earlier investigators.

In the experiment to study the residual toxicity of fungicides in soil, it was observed that Dithane M-45 and Thiride possessed the maximum residual action against the fungus. Roy (1975) reported that Benomyl and Chloroneb

exhibited residual effect upto 55 days while, PCNB retained its residual action for a short period only.

When the efficacy of fungicides for controlling damping off of Cardamom seedlings was tested in the field, Dithane M-45 yielded the best results, as evidenced by the number of healthy seedlings obtained on the primary nursery beds drenched with this fungicide. In regard to the time of application of fungicides, no significant difference was noticed between drenching before sowing and drenching one month after sowing.

The results of pot culture as well as those of field trials indicated that, Dithane M-45 was the most effective fungicide against the pathogen causing damping off of Cardamom. Eventhough, Thiride appeared to be very effective in pot culture stüdies, this fungicide did not prove to be efficient in checking the disease in the primary nursery beds. It is possible that, Thiride was not able to check the infectivity of the pathogen in the nursery beds, as much as it was able to check the viability of the organism in the potted soil.

Eventhough, PCNB has been reported to be effective against R.solani by number of investigators (Solel and

Mins, 1964; Sinha *et al* 1969; Jhooty and Grover, 1971; Sharma and Kulkarni, 1971; Davis *et al* 1971; Hiremath *et al*, 1978) certain strains of the fungus have been found to be tolerant or partially resistant to this fungicide (Thomas, 1962; Shatla and Sinclair, 1963; Ko and Oda, 1972).

PCNB, which is known to be a good soil fungicide was not found effective against the isolate of *R.solani* from Cardamom. More over, this fungicide exhibited phytotoxic effect on the seeds/seedlings of Cardamom. Phytotoxicity of PCNB to certain plant species has been reported by Brown (1947), Livingston *et al* (1962) and Schneider and Potter (1974). The fungus was found to survive in high range soil for over eight months, in the presence of host material. Survival of fungi like *R.solani* and *Corticium sasakii*, for long periods in soil, has been reported by Park and Bertus (1932), Sanford (1952) and Mahendra Prabhat *et al* (1974).

The selective medium described by Ko and Frances (1971) was found convenient for estimating the viable propogules of *R.solani* in soils treated with different fungicides.

Rawa meal sand medium employed during the present investigation, was found to be a suitable substrate for the large scale culturing of R.solani. The fungus produced profuse mycelial growth, with abundant number of sclerotia, when cultured on this medium. Rawa (locally known as Bombay rawa) is readily available all over the country and is very much cheaper than processed oats, which is generally used for the preparation of culture media. Maize (corn), another material used for the preparation of culture media, is not very easily available in this region.

Based on the results obtained during the present investigation, application of 0.3 per cent Dithane M-45 can be recommended for the control of damping off of Cardamom, caused by Rhizoctonia solani. The nursery beds can be drenched with the fungicide either before sowing or one month after sowing the seeds.

SUMMARY

SUMMARY

The role of Rhizoctonia in causing damping off of Cardamom in the primary nursery was established and the symptoms of the disease have been described. The fungus infected Cardamom seedlings upto about six months.

Good growth of the fungus was obtained on Coon's agar, Czapek's agar, Potato dextrose agar and Richard's agar media. Sclerotial formation was abundant on Czapek's agar. Potato dextrose agar, Richard's agar and Sabouraud's agar.

The morphological characters of the pathogen have been described.

The fungus was able to infect 27 plant species including *Achyranthes aspera*, *Commelina benghalensis*, *Phyllanthus niruri*, *Calonyction muricatum*, *Cyperus rotundus*, *Abutilon indicum*, *Heliotropium indicum* and *Azolla pinnata*, which are new host records in our country. The possibility of some of these plants acting as collateral hosts of the pathogen is indicated.

Based on its morphology, pathogenicity and host range, the fungus causing damping off of Cardamom in the high

ranges of Kerala was identified as Rhizoctonia solani Kuhn. There is no authentic report of this fungus causing damping off of Cardamom in our country.

Laboratory evaluation of fungicides, using poisoned food technique, revealed that Bavistin at 250 ppm, Mildothane 500 ppm and PCNB and Thiride at 1000 ppm completely inhibited the growth of the fungus in Czapek's agar. When the efficacy of fungicides was tested by the " culture disc immersion" method, it was noticed that the fungus could be killed by immersion for 10 minutes in 1000 ppm Bavistin and 3000 ppm Thiride, 30 minutes in 3000 ppm, Difolatan and 24 hours in 3000 ppm Daconil and 3000 ppm Dithane M-45. Results of drenching fungicides in soil in test tubes, with Rawa meal sand culture of the fungus, revealed that Bavistin, Daconil, Difolatan, Dithane M-45 and Thiride could kill the fungus, both in sterilized and unsterilized soil, when exposed for 24 hours. This method of testing fungicides has not been described earlier. Rawa meal sand medium employed during this study was found to be a suitable substrate for the large scale culturing of R.solani.

When the efficacy of fungicides was tested in potted soil, Dithane M-45 and Thiride proved to be the most effective ones, at all the depths and periods tried. These two fungicides were found to possess the maximum residual toxicity against R.solani in soil.

Results of the experiment to study the efficacy of fungicides for controlling damping off of Cardamom in the primary nursery beds revealed that Dithane M-45 was superior to all the other fungicides tested. There was no difference between drenching fungicides before sowing and one month after sowing.

The pathogen was found to survive in high range soil for over 8 months, in the presence of host material.

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* Original not seen.

APPENDICES

Appendix I

Summary of the analysis of variance table for the growth of the fungus on different media, Effect of soil drenching fungicides in test tubes. (Sterilized and non-sterilized)

Source	df	Mean squares		
		Growth of fungus on different media.	Effect of soil drenching fungicides in test tubes (sterilized)	Effect of soil drenching fungicides in test tubes (non-sterilized)
Treatment	8	0.2145**	14.8848**	16.6430**
Error	18	0.0005	0.0196	0.1967

* Significant at 1% level.

Appendix II

Summary of the analysis of variance table for the laboratory evaluation of fungicides (solid media)

Source	df	Mean squares
Treatment	26	1.61**
Fungicides	8	3.14**
Concentration	2	1.30**
Fungicide x concentration	16	0.89**
Error	54	0.01

** Significant at 1% level.

Appendix III

Summary of the analysis of variance table for the effect of drenching fungicides on the viability of *Rhizoctonia solani* on different days at different depths.

Source	df	Mean squares
Treatment	107	21.9752**
Fungicides	8	134.8300**
Periods	3	9.0919**
Fungicides x periods	24	9.0180**
Depth	2	5.6074**
Fungicides x depth	16	0.4288
Periods x depth	6	0.5173
Fungicides x periods x depth	48	6.1213**
Error	216	0.0970

** Significant at 1% level.

Appendix IV

Summary of the analysis of variance table for the effect of residual toxicity of fungicides in soil against *Rhizoctonia solani*.

Source	df	Mean square
Treatment	35	20.7898**
Fungicides	8	66.7654**
Periods	3	44.4087**
Fungicides x periods	24	3.0711*
Error	72	0.2344

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

Appendix VI

Summary of the analysis of variance table for the effect of fungicides on the damping off of Cardamom seedlings

Source	df	Mean squares	
		Seedlings stand of Cardamom during	
		Fifth month after sowing	Eighth month after sowing
Block	2	3.5153	1.3348
Treatment	19	154.2485**	191.5108**
Fungicide	7	358.6675**	437.8803**
Period	1	16.1936	5.3235
Fungicide x period	7	54.0233**	68.0734**
Control I vs Treatment	2	2.4930	10.5045
Control IIvs Treatment	2	0.1670	5.5440
Error	38	7.7124	2.2577

** Significant at 1% level

PLATES

Fig.1. Cardamom seedlings showing damping off caused by *Rhizoctonia solani*

Left - Healthy seedlings
Right - Diseased seedlings.

Fig. 2. Symptoms of damping off of Cardamom seedlings.

Fig.3. Cardamom seedlings showing decaying of rhizome and roots.

Left - Diseased seedling
Right - Healthy seedling

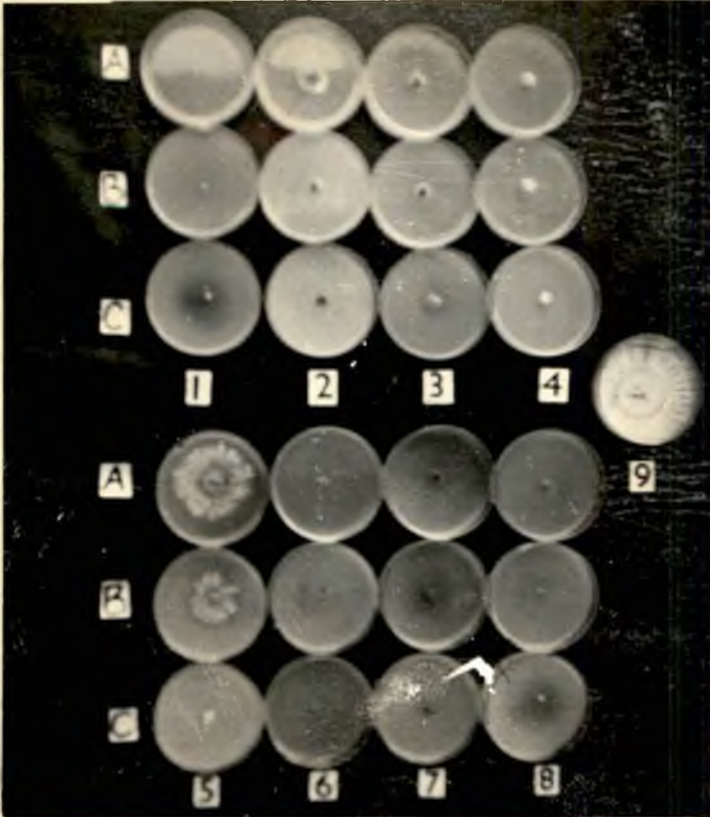
Fig. 4. Effect of fungicides in Czapek's agar medium on the growth of <u>Rhizoctonia</u> <u>solani</u>.

1. Bavistin
2. Daconil
3. Difolatan
4. Dithane M-45
5. Fytolan
6. Mildothane
7. PCNB (Brassicol)
8. Thiride
9. Control

A - Bavistin 250 ppm, Mildothane 500 ppm and other fungicides 1000 ppm.

B - Bavistin 500 ppm, Mildothane 1000 ppm and other fungicides 2000 ppm

B - Bavistin 1000 ppm, Mildothane 2000 ppm and other fungicides 3000 ppm.



A
B
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1
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RHIZOCTONIA DAMPING OFF OF CARDAMOM (ELETTARIA CARDAMOMUM MATON) AND ITS CONTROL

By

P. S. SASI

ABSTRACT OF A THESIS

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ABSTRACT

The role of Rhizoctonia in causing damping off of Cardamom in the primary nursery was established and the symptoms of the disease have been described. The fungus grew well on a number of solid media. The morphological characters of the fungus were studied. It was able to infect 27 plant species including Achyranthes aspera, Commelina benghalensis, Phyllanthus niruri, Calonyction - muricatum, Cyperus rotundus, Abutilon indicum, Heliotropium - indicum and Azolla pinnata on artificial inoculation. These plants have been found to be new hosts of the fungus in our country. The pathogen was identified as Rhizoctonia solani Kuhn.

Among the 8 fungicides tested, Bavistin, Daconil, Difolatan, Dithane M-45 and Thiride were found effective against the fungus in laboratory evaluation.

In potted soil, Dithane M-45 and Thiride proved to be the most effective fungicides, at all depths and periods tried. These two fungicides possessed maximum residual toxicity against the fungus.

Rawa meal sand medium employed during this study was found to be a suitable substrate for the large scale culturing of R.solani.

Drenching the primary nursery beds with 0.3 per cent Dithane M-45 was found to be the most effective treatment for controlling damping off of Cardamom.

R.solani was found to survive in high range soil for over 8 months, in the presence of host material.