EFFECT OF APPLICATION OF PLANT PROTECTION CHEMICALS ON THE SURVIVAL OF *Rhizoctonia solani* Kühn

By

LULU DAS M.Sc.(Ag.)

THESIS

submitted in partial fulfilment of the requirement

for the degree

DOCTOR OF PHILOSOPHY

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF PLANT PATHOLOGY

COLLEGE OF AGRICULTURE

VELLAYANI, TRIVANDRUM

1986

DECLARATION

I hereby declare that this thesis entitled "Effect of application of plant protection chemicals on the survival of *Rhizoctonia solani* Kühn" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to one of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Lulu Das

(LULU DAS)

College of Agriculture,
Vellayani

10th December, 1986.

CERTIFICATE

Certified that this thesis entitled "Effect of application of plant protection chemicals on the survival of Rhizoctonia solani kühn" is a record of research work done independently by Kum. LULU DAS under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Dr. M. CHANDRASEKHARAN NAIR
Chairman
Advisory Committee
Professor of Plant Pathology

College of Agriculture,
Vellayani,
14th December, 1986.

APPROVED BY:

Chairman :

Dr M. CHANDRASEKHARAN NAIR

Members :

1. Dr S. BALAKRISHNAN

2. Dr S. BHAVANI DEVI

3. Dr N. KRISHNAN NAIR 6/3/87

4. Dr A. VISALAKSHY 6/3/87

ACKNOWLEDGEMENT

The author wishes to express her deep sense of gratitude and thanks to Dr M. Chandrasekharan Nair, Professor of Plant Pathology for his constant guidance and help rendered during the course of investigation and in the preparation of the thesis.

I am very happy also to acknowledge with a deep sense of gratitude the various help, support and encouragement received from the members of my Advisory Committee, Dr S.Balakrishnan and Dr S.Bhavani Devi from the Department of Plant Pathology and to Dr N. Krishnan Nair, Professor of Agricultural Botany and Dr A.Visalakshy, Professor of Agricultural Entomology, during the course of investigation and in the preparation of the thesis.

I also thank Dr K.I.Wilson, Professor and Head, Department of Plant Pathology for the facilities provided and valuable suggestions and encouragement.
My thanks are also due to Prof. P.V.Prabhakaran, Head of the Department of Agricultural Statistics, College of Agriculture and to Sri C.E.Ajitkumar, Junior Programmer of the Department of Agricultural Statistics for the help they have rendered to carryout the statistical analysis.

It is my great privilege and pleasure to have the best help and co-operation from all members of the staff of the Department of Plant Pathology especially from Sri B.Balakrishnan for his sincere help rendered in the statistical analysis and interpretation of the data. All such help is gratefully acknowledged.

My greatest debt is due to my parents who sacrificed much to enable me to complete the work.

LULU DAS

C O N T E N T S

LIST OF TABLES

LIST OF PLATES

INTRODUCTION

INTRODUCTION

Many vicissitudes and adversities limit the production of rice, the chief among them being diseases, either pathogenic or non pathogenic causing extensive damage to the grain and straw yields. Sheath blight of rice caused by Rhizoctonia solani Kuhn (Thanatephorus cucumeris (Frank) Donk) though a decade back was considered to be a minor disease has now become one of the most common and destructive diseases of rice in Kerala State. Incidence of this disease has been observed in an epidemic form in high yielding varieties throughout the seasons in almost all the rice tracts of the State. The reduction in grain yield due to severity of this disease has been estimated to vary from 30 to 40 per cent and to total loss in endemic areas. The ability of a fungul pathogen in producing disease depends on its ability to survive under unfavourable conditions, germination of dormant units, profuse sporulation and establishment of a parasitic relationship with its hosts.

The success of control measures depends to a great extent in reducing the potential ability of the pathogen. The main mode of survival of the fungus is by the formation of sclerotia which remain viable in soil for a long period. This perhaps may be the major reason for its endemic nature.

The most practical and easiest means of controlling plant diseases is through application of chemicals. The use of chemicals in plant protection has changed from simple inorganic salts to complex organic systemic fungicides in the recent times. Usually these chemicals are applied against specific targetted organisms. But their effect on untargetted organisms which were often ignored are presently engaging the attention of agricultural scientists.

Another possibility of control of plant pathogens is by biological control. Biological control of plant pathogens has been defined by Garrett (1956) as any condition under which or practice whereby survival or activity of a pathogen is reduced through the agency of any other living organism (except man himself) with the result that there is a reduction in incidence of the disease caused by the pathogen. The reduction in incidence of the disease can be achieved by the application of organisms antagonistic to the pathogen. The application of plant protection chemicals stimulated the presence of certain organisms. Hence a proper understanding of the same is essential to make a judicious selection of the chemicals so as to stimulate those organisms antagonistic to the pathogen in question.

Hence the present study has been undertaken on the following lines:

(1) to study the survival of the organism in different types of soils (2) *In vitro* effect of commonly recommended plant protection chemicals on the radial growth of *R. solani*.

A pot culture experiment was conducted

1. to study the effect of application of plant protection chemicals on the survival of *R.solani* in soil.
2. *In vivo* effect of the plant protection chemicals on sheath blight incidence and intensity.
3. Effect of application of the chemicals on the soil microflora.
4. Microorganisms antagonistic to *R.solani* on the rhizosphere of rice.
5. *In vivo* effect of antagonistic organisms on the intensity of sheath blight disease.
6. Effect of addition of antagonistic organisms and application of selected plant protection chemicals on rhizosphere mycoflora of rice.
7. Studies on the occurrence of mycorrhizae in paddy.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Rhizoctonia solani first recorded from potato tubers by Kuhn in 1858 is currently considered to be an important plant destroyer throughout the world. This anamorph of *Thanatephorus cucumeris* (Frank) Donk, causes a serious disease on rice known by the common name sheath blight and has been recorded from all the rice growing tracts of the world. Miyake (1910) first recorded this disease as a malady of rice from Japan, which he described under the name oriental sheath blight and leaf spot and named the causal organism as *Sclerotium irregulare* nov. sp. Sawada (1912) made a detailed study of the disease and identified the causal organism as *Hypochnus sasakii* shirai. Since then, this disease has been reported from many of the rice growing countries of the world. However, for sometime it was considered to be mainly confined to the Orient since this has been recorded only from countries like Philippines (Reinking, 1918; Palo, 1926); Sri Lanka (Park & Bertus, 1932) and China (Wei, 1934). Matsumoto (1934) described sheath blight disease again from Japan in detail and named the causal organism as *Corticium sasakii* (Shirai) Matsumoto. It has been subsequently recorded from USA also by Ryker and Gooch (1938).

Detailed taxonomic study on the organism causing this disease was made by them and they came to the conclusion that it was a large sclerotial strain of Rhizoctonia solani Kuhn. Following Talbot (1970) the rice sheath blight organism is currently considered as Thanatephorus cucumeris (Frank) Donk and the anamorph as Rhizoctonia solani Kuhn. Subsequently Tu and Kimbrough (1978) have treated the rice fungus as a species separate from T. cucumeris under Comb. nov as T. sasakii (Shirai) Tu and Kimbrough. However, this change has not been widely accepted. Later on, the occurrence of this disease has been reported from Brazil, Surinam, Venezuela and Madagascar, (Ou, 1972).

In the recent past sheath blight of rice is known to occur throughout the temperate and tropical rice growing areas of the world (Hashioka & Makino, 1969). In India, even though it was Butler (1918) who first mentioned about the occurrence of this disease, it was Paracer and Chahal (1963) who first described in detail the sheath blight disease caused by Rhizoctonia solani from Punjab. Subsequently the occurrence of this disease was reported by Kohli (1966) from Punjab and by Singh and Pavgi (1969) from Uttar Pradesh.

In Kerala, the incidence of sheath blight was noticed only in 1969 at the Central Rice Research Station Pattambi and it was Mahendra Prabhath (1971) who first trecorded the disease in the State and attributed the disease to be due to Corticium sasakii (Shirai) Matsumoto. Soon the disease has gained much importance due to severe outbreak in many parts of the State resulting in considerable demage. Hence detailed studies on this disease was carried out during the past few years in the department of Plant Pathology, College of Agriculture, Vellayani.

Various aspects of the disease, viz., symptomatology, host range, varietal reaction, pathophysiology of infected plant, epidemiology and also fungicidal control received much attention in these studies. A number of recommendations to control or combat the disease evolved out of these studies were recommended to the farmers of the state (Anon., 1982; Anon., 1986).

Miyake (1910) first described the symptoms of this disease in detail. According to him initial symptom appeared as discolored ellipsoidal spots on the sheath and leaf which measured up to 10 mm in length and 3 to 4 mm in breadth. These spots gradually enlarged and turned greyish white with a blackish brown margin. Singh and Pavgi (1969) observed

the initial symptoms as oval to irregular straw coloured lesions on the leaf tip and leaf sheath near the leaf base surrounded by a narrow reddish brown band. These lesions increased in size, coalesced and covered the leaf lamina completely. Kozaka (1970) observed the lesions on the leaf sheath at first as greenish grey and ellipsoidal, 2 to 3 cm long or more, gradually becoming white with a blackish brown narrow margin.

Sclerotia constitute the main means of survival of Rhizoctonia solani. Palo (1926) reported that the sclerotia may survive in soil in Philippines for several months. Endo (1931) in Japan reported that the fungus could survive in soil during winter as sclerotia or as mycelium. Naiki and Ui (1969) reported the survival of sclerotia of R. solani in soil for more than 360 days. Yamaguchi et al. (1971) estimated that about 57 sclerotia were produced per plant hill and about 40 per cent of them float in water after field operations. Mahendra Prabhath et al. (1974) conducted studies on the viability of sclerotia of this organism and found that at room temperature (28 to 32°C) the viability of sclerotia was completely lost after 100 days but at lower temperature of 10°C they remained viable for more than 300 days. Roy (1976) observed that the sclerotia of Corticium sasakii on non-sterilized cowdung, rice straw and soil remained viable up to 9 months in Assam with a considerable

decrease after 7 months. Lewis (1979) reported that survival of R. solani in pre colonized table beet seed was greater in a light textured sandy loam than in a heavy textured silty clay loam. Shokes and Mc Carter (1979) found that R. solani in infested cotton stem sections were recoverable in declining numbers up to 96 days and as sclerotia up to 85 days from irrigation ponds. Culture filtrates of Aspergillus niger Van Tiegh A. flavus Link and A. candidus Link inhibited the growth of R. solani isolates from forest soil (Shukla & Dwivedi, 1979). Lee (1980) observed that samples of crop debris of rice sheath blight at 6 cm depth contained 136 to 562 buoyant and 68 to 334 non buoyant sclerotia. Samples from 0.6 to 3.8 cm depth contained 38 to 63 buoyant and 5 to 24 non buoyant sclerotia per litre of soil. Soils 3.8 to 7.6 cm deep contained 27 to 44 buoyant sclerotia per litre and 0 to 14 non buoyant sclerotia per litre. Mew et al. (1980) stated that in unsterilized soil much of the rice straw was well colonized by Trichoderma sp and when sterilized straw was inoculated with the pathogen and Trichoderma sp. many dead sclerotia were recovered with mycelium of Trichoderma coated around them.

Hashiba and Yamada (1981) reported that sclerotia of R. solani formed on rice plants were more resistant to high temperatures and high relative humidity than those

formed on potato sucrose agar. Neem (Azadirachta indica A. Juss) reduced saprophytic activity of rice sheath blight pathogen (Kannaiyan & Prasad, 1981). Dath (1982) reported that sclerotial viability of the rice pathogen was reduced by the green manure crop daincha.

Pot culture experiments conducted by Kannaiyan and Prasad (1983) revealed that survival of rice sheath blight pathogen was reduced by K and PK fertilizers. Kannaiyan and Prasad (1983) reported that the fungicides, Benlate, Brassicol, Brestan, Macuprax, Captan, Wettable Ceresan, EL 273, NF 48, Demosan and Vitavax inhibited the saprophytic survival of the pathogen in soil. The pathogen survived up to 450 days in the untreated control.

Mustafee and Chattopadhyay (1983) observed that survivability of Macrophomina phaseolina (Maubl) Ashby increased with host tissues and the increase was more in the rice tissues. Venkatasubbiah and Safeeulla (1983) noted that the sclerotia of R. solani on the soil surface of coffee nursery beds survived up to 225 days but those buried in the soil survived up to 375 days. Yuen and Raabe (1984) demonstrated that aerobic composting for 21 days eliminated Armillaria mellea (Vahl) Quel, Rhizoctonia solani and Verticillium dahliae from colonized plant residues.

Leu and Yang (1985) reported that germination of sclerotia collected from the rice plants decreased after burial in soil for 4 to 6 months without any correlation to the cover crop.

Laboratory assay of fungicides against Rhizoctonia solani has been attempted by several workers. Sinclair (1960) reported that isolates of R.solani differed in their sensitivity to Captan, PCNB and Dichlone. Sen and Kapoor (1975) found that Captan was effective against R.solani even at a low concentration of 100 ppm. In vitro studies conducted by Muneera (1973) and Mathai (1975) revealed that Captan and Dithane M-45 were ineffective against R. solani. Captafol and Carboxin at 200 ppm each were found to be effective against the sheath blight pathogen in vitro (Dash & Panda, 1984). Among four systemics and sixteen non systemics tested by using poisoned food technique, Sen and Kapoor (1975) reported 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 (1977) too observed the inhibitory effect of Bavistin on the mycelial growth of R. solani in Czapek's agar plates. Delen and Yildiz (1982) demonstrated that out of the four isolates of R. solani only one could grow on agar media containing 1.5 mg/ml Carbendazim. Dash and Panda (1984)

reported complete inhibition of mycelial growth of sheath blight pathogen *in vitro* by Carbendazim, Thiram, Ediphenphos and Kitazin at 100 ppm each. Borum and Sinclair (1968) while conducting studies on the effect of Vitavax against *R. solani* found that Vitavax was fungistatic to *R. solani* at one ppm *in vitro*. The effectiveness of Vitavax on *R. solani* has been attempted by Follen and Diallo (1971) by screening eight fungicides against three fungi and reported that Vitavax, Demosan and Benlate were most effective against *R. solani*. Datta and Sharma (1976) observed that *R. solani* was sensitive to Vitavax and Benomyl which inhibited its growth even at 10 ppm. Jagan Mohan (1977) found that Vitavax and Benlate were effective in inhibiting the growth of the fungus at concentrations of 500 ppm and above in the laboratory. It was found that Hinosan at 100 ppm and above was very effective in inhibiting the growth of *Rhizoctonia solani* (Mahendra Prabhath, 1971; Muneera, 1973; Mathai, 1975). Elsoid and Sinclair (1963) reported that *R. solani* from seedling cotton became tolerant to PCNB, Captan, Dichlone, Maneb and Thiram after 7 serial transfers on potato sucrose agar containing these fungicides. Shatla and Sinclair (1963) found that there was tolerance among naturally occurring isolates of *R. solani* to pentachloro-nitro-benzene.

Martin et al. (1984) while comparing in vitro sensitivity of R.solani and R.solani like fungi to selected fungicides found that R. solani and binucleate Rhizoctonia like fungi were sensitive to Benomyl, whereas isolates of R. zea were tolerant to Benomyl but sensitive to other fungicides.

In vitro effect of insecticides on R. solani has been investigated by several workers (Rao & Harein, 1972; Reddy & Anil Kumar, 1975). In vitro studies conducted with the insecticide Sevin revealed that at 125 ppm it reduced the growth of Rhizoctonia solani (Naguib, 1968). Lakshmanan and Nair (1980) conducted studies on the in vitro toxicity of granular insecticides against Rhizoctonia solani isolated from rice and stated that Sevidol and Thimet were highly inhibitory to the fungal growth and sclerotial formation. Simkover and Shenefelt (1951) in their preliminary laboratory tests indicated that crude BHC dust greatly inhibited mycelial growth of Rhizoctonia solani on agar slants whereas Chlordane dust had no effect. Lindane with a high water solubility was most toxic in super saturation at 25 ppm (Bollen, 1961). Yamaguchi (1974) concluded that Lebaycid (Fenthion) (0 - 0 - diethyl 0.4 methyl sulphinyl phenyl phosphoro thionate) was most effective as dust than as granule formulation against sheath blight of rice

(Corticium sasakii). Rodrigues - Kabana et al. (1976) discovered that Fensulfothion at 10 to 100 ug/ml inhibited the growth of Rhizoctonia solani in PDA. Tisserat et al. (1977) reported that linear growth of R. solani was reduced on PDA amended with Aldicarb (2-methyl - 2 - (methylthio) propionaldehyde, 0 - (methyl - Carbamoyl) oxime) at 4, 8, 16 and 32 ug/ml.

There are several reports on the effect of herbicides on microorganisms, some inhibitory and others stimulatory. R. solani being an organism which survives by means of sclerotia, the effect of various herbicides on this organism is very important. Varma et al. (1978) recorded that Avirosan 50 EC, Saturn 50 EC, Machete 50 EC and Rilof H 500 EC were highly inhibitory to the growth of Corticium sasakii. Lakshmanan and Nair (1980) reported that Saturn was highly inhibitory to the growth of R. solani followed by Sirmate, Tok granules and Machete and the degree of inhibition was related to the concentration of the herbicides. Sirmate was most effective in preventing the formation of sclerotia followed by Tok and Saturn. However, they have observed no inhibitory effect for 2,4D, which in part increased the number and size of sclerotia. Varma et al. (1979) pointed out that the chemical Fluchloralin had no effect on R. bataticola but reduced the radial growth of mycelia of

Fusarium oxysporum f. ciceri (Padwick) Subran and Sclerotium rolfsii Sacc.

Lakshmi (1984) reported that only higher concentrations of Pendimethalin viz., 250 ppm was effective in the inhibition of sclerotia formation in Rhizoctonia solani. Youssef et al. (1985) observed that Pendimethalin, Dinitramine and Butralin at 100 ug/ml reduced mycelial growth of Fusarium oxysporum f sp. vas infectum (Atk) Snyder and Hansen, Rhizoctonia solani and Sclerotium rolfsii. Dath and Swain (1979) studied the in vitro effect of Butachlor, Nitrofen and Propanil at 25, 50, 100, 250 and 500 ppm concentrations on radial growth of R. solani and found that the growth of fungus was completely suppressed at all the concentrations of Propanil followed by Nitrofen. Butachlor was effective only at higher concentrations of 250 and 500 ppm and concluded that Propanil and Nitrofen have potentiality in suppressing the growth of sheath blight pathogen.

Millikan and Fields (1964) reported that 2,4 D at 100 ppm reduced the growth of R. solani by 86 per cent and Simazine reduced the growth of R. solani by 93 per cent. It has been found that 2,4 D, MCPA, Prometryne and Simazine encouraged the development of aerial hyphae of R. solani (Tatsuyama & Jikihara, 1970). R. solani is inhibited in vitro by 2,4 D, Simazine, Atrazine, Diuron, Linuron,

Trifluralin, Nitralin, Isopropalin, Benefin, EPTC, Paraquat, Cycloate and Diphenamid (Katan & Eshel, 1973; Altman & Campbell, (1977). Lakshmanan and Nair (1980) also reported that 2,4 D did not inhibit the growth of R. solani but increased the number and size of sclerotia.

Several chemicals have been found effective in reducing the incidence and intensity of sheath blight disease of rice. A brief review of the literature on the effectiveness of the chemicals used in the present study are presented here. Roy (1981) found that spraying with Captafol and Guazatine was less effective in reducing the incidence of sheath blight than other chemicals. The efficiency of Bavistin in reducing tiller infection of sheath blight has been reported by Bhakthavalsalam et al. (1977). They also found that Benlate was effective but Captan was ineffective. Kannaiyan and Prasad (1979) stated that Bavistin, Kitazin, Hinosan, Benlate, Demosan and Thiabendazole gave significant disease control against sheath blight. Dev (1980) recommended Carbendazim as the best foliage fungicide against R. solani. Roy (1981) stated that sheath blight incidence on rice in pots was reduced by sprays of Carbendazim and Ediphenphos.

Carboxin which has been generally recommended against Basidiomycetes has been tried under Kerala conditions against sheath blight. Mahendra Prabhath (1971) observed good correlation between results obtained *in vitro* and pot culture evaluation of fungicides against *Corticium sasakii* and reported that Vitavax was superior over all other fungicides in controlling the disease and increasing the yields. Jagan Mohan (1977) found that the disease can be controlled by applying higher levels of potash followed by spraying Vitavax. Lakshmanan *et al*. (1980) observed effective control of sheath blight under field conditions with Vitavax. This has been confirmed by further trials conducted subsequently by Gokulapalan (1981). Gokulapalan (1981) also observed that application of Vitavax + Carbofuran significantly reduced the sheath blight intensity and it also reduced the rice root nematode infestation and increased the yield. The superiority of Hinosan over other fungicides in reducing the intensity, per cent hill infection and rate of spread of the disease was confirmed by several workers (Mahendra Prabhath, 1971; Yamaguchi, 1974; Mathai, 1975). From IRRI Philippines, Hinosan, Benlate, BAS 3050 etc., were reported to be effective against sheath blight (Anon., 1973). Umeda (1973) recommended the use of Hinosan (O ethyl s-s diphenyl-dithiophosphate) in controlling the sheath blight disease of rice. According to Radhakrishnan (1975) Hinosan was

was superior to Aureofungin in controlling the sheath blight of rice. Jaganathan and Kannaiyan (1978) found that three sprays at ten days interval with Hinosan, Kitazin, Cuman L or Bavistin provided good protection against sheath blight. Lakshmanan (1979) reported that Hinosan was effective in reducing the disease intensity and per cent hill infection. Gokulapalan (1981) also observed that Hinosan was effective but ranked third in efficiency in controlling the sheath blight pathogen.

Hartzfield (1957) found that Terrachlor dust, WP and E C were effective against sclerotia forming fungi. Sinclair (1957) observed that PCNB plus Captan was promising for the control of Rhizoctonia solani. In glass house tests pentachloronitrobenzene effectively controlled the sheath blight fungus in soil even 35 days after application (Souzafilho, 1979). Dev (1980) recommended Thiram + Ediphenphos followed by PCNB + Ediphenphos as the best control for R. solani. Ohtsuki and Fujinami (1982) reported that Rizolex (tolclofos-methyl) is more effective than PCNB in controlling a number of soil borne diseases including those caused by R.solani.

Hashioka (1952) stated that spraying in the field with Dithane Z-78 (Zinc ethylene bisdithiocarbamate) or Bordeaux mixture or Uspulun (Chlorophenol mercury) at

0.5 per cent did not control Hypochnus (Corticium) sasakii. According to Hashioka and Saito (1953) Zineb + Phygon (2,3 dichloropara - naptho quinone) was intermediate in efficien while Cu dust and Cu SO_4 were almost in effective even at maximum concentrations tested.

There are reports on the efficacy of certain insecticides also on diseases caused by R. solani. Manila and Lapis (1977) reported that there were differences in the responses of the varieties to sheath blight, rice blast and bacterial leaf blight after application of two herbicides and two insecticides one of which is Monocrotophos.

Tisserat et al. (1977) reported that addition of Aldicarb to soil infected with R. solani significantly increased damping off of sugarbeet seedlings in glass house. Ruppel and Hecker (1982) stated that Aldicarb and Phorate applied as side dressing increased severity of Rhizoctonia root rot in sugar beet. Carbofuran too increased root rot caused by R. solani to a certain extent.

Most of the herbicides applied to soil at the recommended doses will disappear in less than 12 months and so no prolonged effect is expected from herbicidal application. However, in the case of organisms which develop special survival structures such as sclerotia or

in controlling the incidence and intensity of sheath blight (Anon., 1986). Inderawati and Heitefuss (1977) tested seven herbicides against Hypochnus (Corticium) sasakii, Pyricularia oryzae Cav. and Xanthommas oryzae (Dowson) Uyeda and Ishiyama, both in vitro and in vivo. Propanil 10 ug/ml was found effective in reducing disease intensity when applied one day before inoculation. The effect of Simetryne and Nitrofen on disease severity was stronger than expected which may be due to their effect on host plant rather than on the pathogen directly. PCB used for weed control in rice fields has been found useful in controlling sheath blight as side effect (Ono & Iwata, 1961; Takatsu & Nishimura, 1962; Inoue and Uchino, 1963; Endo et al., 1965).

Kurodani et al. (1959) found that the pathogenicity of Hypochnus (Corticium) sasakii on rice was increased by spraying with 2,4 D which also increased the size and number of spots formed on plants. Manila and Lapis (1977) from Philippines reported that sheath blight was not affected by the treatments 2,4 D, MCPA and Monocrotophos while it reduced severity of bacterial blight.

Mahendra Prabhath (1971) found good correlation between the results obtained in in vitro studies and pot

culture evaluation of fungicides against Corticium sasakii and reported that Vitavax was superior over all other fungicides in controlling the disease and increasing the yields. Benlate was superior over Hinosan and Captan in reducing the intensity of disease and thereby increasing the yield. (Muneera, 1973). Varma and Menon (1977) reported that though Hinosan was not as effective as Kitazin granules and Aureofungin Sol. in reducing the disease intensity it was significantly superior to all other fungicides tested except Kitazin granules in enhancing the yield. Lakshmanan (1979) found that Hinosan increased the yield even though it was not as effective as Vitavax in controlling the disease. Dev and Satyarajan (1980) reported that Bavistin as foliar spray was the best in reducing the sheath blight disease but increase in yield was not registered. Gokulapalan (1981) found that the yield of rice was increased by the application of Vitavax and Carbofuran. Lee and Coutney (1981) found that among the three fungicides tested against the sheath blight disease, Duter (Fentin hydroxide) performed best in increasing yields. Roy (1981) observed increased grain yield in all cases in which Carbendazim and Ediphenphos and Guazatine and Captafol were sprayed.

Experiments at International Rice Research Institute revealed that Bentazone at 1.5 kg ai/ha gave the highest yield in low land rice (Anon, 1976 b). Sridhar et al. (1976) tried several herbicides in rice in which Benthiocarb treated plots recorded better weed control and least phytotoxicity and maximum yield. Grain yield was less in treatments with Nitrofen 1.75 kg ai/ha and Bentazon 1.5 kg ai/ha than that of the control (Lakshmi, 1984). Stam F.34 1.6 - 4 Kg/ha in direct sown rice gave the highest yield (Singh & Singh, 1970). Kaushik and Mani (1980) reported that Propanil at 2 kg/ha was the most efficient herbicide in increasing grain production of rice.

In modern agriculture, millions of hectares of soils are annually treated with millions of kilograms of pesticides. The activity of these pesticides is not only restricted to the target organisms but extends to the non-target organisms as well. However, different chemicals vary in this aspect.

Agnihotri (1971) stated that the population of Rhizoctonia and Pythium spp. was killed by the application of Captan while the growth of saprophytic species of Penicillium, Trichoderma and Fusarium increased. Bacteria increased by the 7th day and subsequently declined to normal by the 35th. Wainwright and Sowden (1977) found that the

proportion of fungi and bacteria were selectively increased by treatment with Captan, Benomyl and Thiram.

Carbendazim is described as a systemic fungicide controlling a wide range of pathogens (Worthing, 1979).

Pot culture experiments conducted by Kannaiyan and Prasad (1979) revealed that Kitazin, Hinosan, Benlate, Vitavax and Bavistin stimulated growth of bacteria and actinomycetes while they drastically reduced fungal population.

Application of Benomyl in the field had no effect on the gross microbial populations of soil (Peeples, 1974; Midha & Nandwana, 1974). Jain and Sehgal (1980) reported that among the six compounds tested, Benomyl had no effect on the 17 soil fungi assayed. Fusarium and Verticillium components of the soil population were reduced in the presence of Benomyl as reported by Torstensson and Wessen (1984). Farley and Lockwood (1968) reported that Quintozene at 1 ppm reduced actinomycetes by 65 per cent but fungi were un affected. At 25 to 200 ppm bacteria were unaffected while actinomycetes were reduced by 99 per cent.

Some insecticides selectively inhibit the population of sensitive groups of organisms while others rapidly fill up the vacuum caused by them (Agnihotri et al., 1981). In general lower dosages of Carbamate and Organophosphorus insecticides enhance the actinomycete population. Stimulatary effects on actinomycetes have been observed with insecticides like Temik, Phorate, Carbofuran Disulfoton, Malathion, Diazinon etc. (Sethunathan & MacRae, 1969; Swaminathan & Sullia, 1969; Mathur et al., 1976; Kandaswamy et al., 1975). The inhibitory effect of insecticides on soil bacteria is usually temporary because these are able to degrade and/or metabolize them.

Roy et al. (1975) stated that treatments of rice soil microflora with Diazinon, Carbofuran and Endosulfan drastically reduced bacteria and actinomycete population while Carbofuran and Endosulfan treatments alone reduced fungal population drastically. Tu and Miles (1976) reported that growth of species of Bacillus, Pseudomonas and Streptomyces was inhibited by several chlorinated hydrocarbons and organophosphorus insecticides. Studies on the effect of Carbofuran and Dyfonate in soils in which onions and lettuce were grown revealed that the differences in the size of microbial population by Dyfonate was marginal, ambivalent

and transient. Carbofuran applications resulted in about 100 to 300 per cent increases in bacterial and actinomycete population (Mathur et al., 1976)

No deliterious effect was found on the fungal and actinomycete population of rice field by the addition of Carbofuran, Diazinon, Cytrolane, Carbaryl + lindane, Quinalphos and Dursban. But the bacterial population underwent a significant fall due to the insecticide application (Purushothaman et al., 1976). Kandaswamy et al. (1975) stated that Carbofuran at 10 ppm inhibited the bacterial, actinomycete and fungal population. Chelliah (1972) reported that Phorate at 10 kg/ha had no influence on total population of bacteria, fungi or actinomycetes in soil but increased the Azotobacter and Clostridium population. At higher doses of 20 kg /ha it was toxic to fungi with no significant effect on bacteria, actinomycetes or rhizobium population. Satpathy (1974) found that phorate when applied at 2 kg ai/ha displayed moderate antifungal action and it was less toxic to soil bacteria than fungi. Murthy et al. (1976) suggested that Thimet had a depressing effect on the soil and rhizosphere fungal populations of Okra. The Azotobacter population of the soil and rhizosphere were inhibited during the first 3 days of application.

The total number of bacteria decreased on 3rd day of application and remained static. Jain and Sehgal (1980) reported that Thimet reduced the growth of all soil fungi and Carbofuran increased the growth of fungi in the soil. Fusarium and Rhizopus spp. were not affected by any of the soil pesticides used for the study, namely Thimet, Carbofuran, Dasanit, Disystox, Solvirex, Benomyl etc.

Malathion too has an inhibitory effect on soil bacteria (Swaminathan & Sullia, 1969).

Obliswamy et al. (1976) while studying the effect of soil treatment of groundnut with Fensulfothion, Quinalphos and Disulfoton found that these chemicals at 2.0 kg toxicant/ha increased the population of bacteria, actinomycetes and Azotobacter and reduced that of fungi.

Microorganisms like the higher plants respond in very different ways to herbicides. Changes in microflora may be from direct or indirect action of the herbicides, but there is eventually a return to normal. It has been suggested that normal rates of application of most herbicides have no pronounced or adverse effect on at least as far as the total populations are concerned (Bollen, 1961; Audus, 1964). Lakshmi (1984) reported that fungal and bacterial colonies were maximum in Bentazone treated soil

and also there was a high population of actinomycetes. Butachlor, Propanil, Fluchloralin, 2,4D Sodium salt and Benthiocarb did not influence fungal population. But there was an increase in bacterial population due to these herbicides except Fluchloralin and there was not much variation in actinomycetes population due to effects of the above herbicides.

Mosca et al. (1969) reported that most of the soil fungi were inhibited by the action of pre-emerge herbicides, namely Herbitox, Legumin and Leptam. Tang et al. (1970) reported an increase in fungal, bacterial and actinomycetes population in soil by treatment with Trifluralin. In fluchloralin treated plots, soil populations of bacteria and actinomycetes were least. Nitrofen inhibited all the 3 groups of microcoganisms while Pendimethalin inhibited soil fungi but actinomycetes were found to be on the increase (Lakshmi, 1984). Mohammed (1984) observed that spraying the soil with the herbicide Alachlor and Fluchloralin had a stimulatory effect on the fungal populations, especially Aspergillus and Curvularia and a fungistatic effect on Fusaria.

Deshpande et al. (1984) found that treatment with 2,4D resulted in no significant variation in the fungal

population of treated soil but a decrease was seen in the rhizosphere of groundnut plants raised in treated plots.

There are several reports on the presence of microorganisms in soil antagonistic to plant pathogenic fungi. (Weindling, 1932; 1934; Jaarsveld, 1942; Sanford, 1952). It is well known that most plant root parasites will cause greater injury in a soil void of competing organisms than in a normal soil where the parasite much grown in association with numerous saprophytic soil organisms. Soil populations of specific organisms exert a greater antagonistic or competitive action against root parasites than others (Garrett, 1956).

There are numerous reports of fungal antagonism against R. solani. Gupta et al. (1985) demonstrated the antagonistic nature of six isolates of Aspergillus fumigatus Fres. A. luchensis Inui. A. niger etc., to the rice sheath blight pathogen.

Tyeit and Moore (1954) found that Chaetomium globosum Kunzeand Schm C. cochlioides Palliser and an unidentifiable Chaetomium spp. were antagonistic to various fungi including Rhizoctonia sp. The effect was more pronounced at low and moderate than at high temperatures. Sezgin et al. (1982) also reported that a species of Chaetomium was antagonistic to R. solani.

Wood (1951) reported the antagonistic nature of a number of bacteria, actinomycetes and fungi in pure culture against Rhizoctonia. The antagonistic nature of Fusarium moniliforme and F. culmorum Sacc. have been reported by Chand and Logan (1984). Different species of Penicillium exhibited antagonistic activities against Rhizoctonia. Penicillium clavariaforme Bain and P. patulum have been reported by Wood (1951). Chu and Wu (1981) stated that there are five species of Penicillium which could coil around the hyphae of R. solani thereby exhibiting antagonism against the fungus. Penicillium cyclopium Westling and P. nigricans (Bain) Thom. too were antagonistic as reported by Chand and Logan (1984). Gupta et al. (1985) demonstrated that Penicillium oxalicum was antagonistic to the rice sheath blight pathogen. Trichoderma viride Pers. ex. S.F. Gray is a well known antagonistic species known to exert an antagonistic influence on Phytophthora, Pythium, Armillaria, Rhizoctonia and other parasitic forms. (Garrett, 1956; Weindling, 1938). Tisdale (1948) reported that in laboratory tests a number of isolates of Trichoderma from blueberry boxwood and Camellia grew over Rhizoctonia isolated from vegetable seedlings affected by damping off and appeared to be weakly parasitic on them. Dennis and Webster (1971) recorded effective inhibition of mycelial

growth and vacuolation of hyphae of Rhizoctonia solani by isolates of different species of Trichoderma, Ferrera - Cerrato (1976) demonstrated that Trichoderma viride parasitized 14 of 16 strains including Rhizoctonia solani and concluded that glucose and yeast extract at 10 g and 5 g/l strongly stimulated the parasitism. Trichoderma viride prevented the growth of Corticium sasakii on maize meal sand medium and germination of sclerotia was completely inhibited when passed through a culture of T.viride with luxuriant growth (Roy, 1977). In vitro studies conducted that T. pseudokoningii Rifai and T. harzianum could parasitize R. solani. Chu and Wu (1981) stated that the hyphae of 10 isolates of Trichoderma pseudokoningii, three of T. longibrachatum one of T. hamatum (Bonord) Bain two of T. harzianum and one unknown isolate could coil around the hyphae of R. solani. Bell et al. (1982) compared in vitro the interaction between seven isolates of T. harzianum and several pathogenic fungi and noted one between T. harzianum and R. solani to be the most evident. Antagonistic effect of soil microorganisms on rice sheath blight pathogen was studied by Rosales and Mew (1982). The growth of the pathogen ceased after contact with Trichoderma spp. which eventually covered the whole plate. Sychev and Shaposhnik (1982) reported that T. viride inhibited the growth of

Rhizoctonia solani and other fungi. D'Ercole et al. (1983) demonstrated in vitro the antagonism of seven isolates of Trichoderma viride, three of T. harzianum and one of Myrothecium sp. towards R. solani, Fusarium moniliforme, R. fragariae Hussain and Mckeen Pythium ultimum Trow. and Verticillium dahliae Klebahn. Among the bacteria, the most striking antagonistic effects were shown by Bacillus subtilis (Ehrenberg) Cohn. B. brevis, B. dendroides, B. anthracoides, B. megatherium, Pseudomonas fluorescens and P. aeruginosa (Wood, 1951). In an experiment conducted at IRRI, Phillippines, the antagonistic action of many bacterial isolates differing in colony characters obtained from the irrigation water of rice fields and their antagonism on the Sclerotia of R. solani were studied. Many isolates especially those from sclerotia exhibited antagonism to the pathogen (Anon., 1978). Meshram and Jager (1983) reported the antagonism of Azotobacter chroococcum Beijerinck. isolates to Rhizoctonia solani. They found that the degree of antagonism exhibited varied strongly among the isolates and was temperature dependent.

A number of Streptomyces spp. were also reported to be antagonistic to Rhizoctonia solani. Tahvonen (1982) reported that a Streptomyces spp. isolated from peat effectively inhibited the growth of R.solani on PDA.

Rothrock and Gottlieb (1984) found that the population of R. solani was inhibited by Geldanamycin, an antibiotic produced by Streptomyces hygroscopicus on nutrient media.

A number of fungi, bacteria and actinomycetes are highly antagonistic to R. solani and can be used for the control of diseases caused by R. solani (Wood, 1951). Boosalis (1956) reported the parasitization of R. solani in unsterilized pea field by Penicillium vermiculatum Dong.

Shukla and Dwivedi (1979) reported the antagonistic action of Aspergillus spp. against R. solani. Neweigy et al. (1981) stated that two species of Aspergillus and three of Trichoderma were most effective against some pathogens attacking the faba bean cultivars, namely Fusarium solani, Rhizoctonia solani and Sclerotium rolfsii. Venkatasubbaiah and Safeeulla (1984) demonstrated that under glass house and field conditions seed treatment with Aspergillus niger reduced the incidence of collar rot of coffee seedlings.

Endo et al. (1973) reported the reduced incidence of Corticium sasakii, the causal agent of sheath blight of rice plant by Neurospora crassa Shear and Dodge.

Trichoderma viride is highly antagonistic to R.solani and several workers have used the same as a biocontrol agent

against several diseases caused by R. solani. Studies at Queen's University, Belfast revealed that Trichoderma harzianum when grown on a suitable organic substrate could suppress the pathogen, Rhizoctonia solani causing seed decay and damping off of mustard (Akhtar, 1969). Both in vitro and in vivo studies conducted by Sadowski (1976) revealed that Trichoderma viride and Penicillium glaucum inhibited the development of the pathogen R. solani on soils rich in humus. Mall (1975) observed a reduced infection of Phaseolus lunatus when T. viride was either added to soil or inoculated into seedling prior to inoculation with R. solani. The antagonist could not inhibit disease development once infection has taken place. Chet and Baker (1981) suggested parasitism by Trichoderma viride followed by lysis rather than the production of antibiotics during the attack on Rhizoctonia solani. T. hamatum controlled root rot of pea or raddish in soil infested with Pythium sp. or Rhizoctonia solani.

Iqbal et al. (1978) reported that young and mature crop of oat, sorghum, barley, wheat, maize and rice are infected with vesicular arbuscular mycorrhiza, Endogone spp. under field condition in Pakistan. Chaubal et al. (1982) observed vesicular arbuscular mycorrhizal associations in

plants growing on two of the five ponds and in the marsh. All the endophytes isolated could establish mycorrhizal associations in pot cultures. Gangopadhyay and Das (1982) reported infection of rice roots by Endogone spp. which in turn enhanced grain yield. Gangopadhyay and Das (1984) also reported that Glomus mosseae (Endogone) infected rice roots and increased Phosphorus uptake in rice roots than shoots at seedling stage.

MATERIALS AND METHODS

MATERIALS AND METHODS

1. Isolation of the Pathogen.

Rhizoctonia solani (Kuhn) causing sheath blight of rice was isolated from naturally infected rice plants collected from the paddy fields attached to the Instructional Farm, College of Agriculture, Vellayani, Kerala State. For isolation of the pathogen, portions of the sheath showing fresh typical symptoms of sheath blight were cut into small bits, surface sterilized with 0.1 per cent mercuric chloride solution for two minutes and washed in repeated changes of sterile water. These bits were then planted over potato dextrose agar (PDA) poured in sterile petri dishes and incubated under laboratory conditions (28 $\pm$ 2°C). After twenty four hours of incubation the fungal growth was transferred to PDA slants. The isolate was purified by repeated hyphal tip plating and the organism was maintained on PDA by periodical subculturing. The identity of the organism was established by studying their morphological characters.

The pathogenicity of the isolate thus obtained was proved following Koch's postulates. Rice plants of the variety Jyothi were raised in earthen pots and artificially

inoculated by placing two sclerotia in between the sheath of the rice plants and placing a wad of moist cotton wool over it. A high percentage of relative humidity was provided by covering the inoculated plants for 48 hours with wetted polythene bag. The fungus was reisolated from artificially inoculated rice plants as described earlier and maintained on PDA slants after purification by repeated hyphal tip isolation method. This pure culture of the fungus was utilized throughout the study.

2. Survival of Rhizoctonia solani.

The ability of the organism to survive by means of sclerotia as well as on infected plant debris was studied following standard procedure. Three different types of soils, viz., sandy soil, clayey soil and loamy soil were taken separately in pots.

Sclerotia of the organism were produced in maize meal sand medium. Ten sclerotia of uniform size and age were taken in small muslin bags and ten to fifteen such lots were buried in each of the pots containing the different soils. The sclerotia were taken out at intervals of thirty days and tested for their viability after surface sterilization with mercuric chloride solution (0.1%) by placing aseptically on PDA in petri dishes. The viability was tested by counting the number of sclerotia that germinated.

To determine the survival of the organism on infected plant debris, bits of leaf sheath of uniform size were sterilized in conical flasks and inoculated with sclerotia of the fungus. The infected pieces of leaf sheath were then kept in wire meshes and buried in pots containing the different types of soil. The bits were taken out at every thirty day interval and the viability of the sclerotia tested by placing them aseptically on PDA in petri dishes.

3. Effect of common plant protection chemicals on Rhizoctonia solani.

The following commonly recommended plant protection chemicals for rice cultivation in this state were used for the study (Anon., 1982).

A Fungicides

Serial No.	Common name/ Trade name	Chemical name	Dosage
1	Captafol/Foltaf	N-(1,1,2,2 tetra chloroethyl thio) -4 cyclo hexane -1,-2- dicarboximide)	1.5 kg/ha
2	Carbendazim/ Bavistin	Methyl benzimidasol 2 - yl carbamate	250 g/ha

3.	Carboxin/Vitavax	5, 6 dihydro - 2 - methyl - 1, 4 oxathiin - 3 - carboxanilide	500 g/ha
4.	Ediphenphos/Hinosan	O ethyl S, S - diphenyl phos phorodithioate	500 ml/ha
5.	IBP/Kitazin	O O - di isopropyl - S benzyl thiophosphate	500 ml/ha
6.	Mancozeb/Dithane M-45	Zinc ions and manganese ethylene bis dithiocarbamate	2 kg/ha
7.	Quintozene/Brassicol	Pentachloronitro benzene	40 kg/ha
8.	Ziram/Cuman	Zinc dimethyl dithio carbamate	2 kg/ha

B Insecticides

1.	Carbaryl/Sevin	1 - Naphthyl - N methyl carbamate	2.5 kg/ha
2.	Carbaryl - Lindane/ Sevidol	1 - Naphthyl - N - methyl Carbamate + a isomer of HCH	20 kg/ha
3.	Carbofuran/Furadan	2, 3-Di hydro 2,2 di methyl - 7 benzofuranyl methyl carbamate	2.5 kg/ha
4.	Dimethoate/Rogor	O O di methyl S- methyl carbamoyl methyl phosphoro dithioate	2.5 kg/ha

5.	Fenitrothion/Folithion	O, O - di methyl O-nitro m- tolyl phosphorothioate	1000 ml/ha
6.	Fenthion/Lebaycid	O, O-dimethyl O-4-methyl thio -m-tolyl phosphoro thioate	500 ml/ha
7.	Formothion/Anthio	S-(N-formyl - N - methyl Carbamoyl - methyl O, O - alimethyl	1000 ml/ha
8.	Hexachlorocyclo hexane/HCH	1,2,3,4,5,6 hexachloro cyclohexane	2.5 kg/ha
9.	Mercaptothion/Cythion	S-1,2-bis (ethoxy-carbonyl) ethyl O,O-di methyl phos phorodithioate	1000 ml/ha
10.	Methylparathion/ Metacid	O,O - dimethyl O,4 nitro phenyl thiophosphate	500 ml/ha
11.	Monocroto phos/ Nuvacron	Dimethyl (E) - 1- methyl - 2-methyl carbamoyl vinyl phosphate	600 ml/ha
12.	Phorate/thimet	O,)-diethyl S-(ethyl thio methyl)phosphoro dithioate	12.5 kg/ha
	C <u>Herbicidea</u>		
1.	Bentazone/Basagran	3 iso propyl - (1H) - binzo - 2, 1, 3 - thiadazin - 4 one 2, 2-dioxide	1.5 kgai/h

2.	Benthiocarb/Saturn	S-4-chloro benzyl diethyl thiocarbamate	1.75 kgai/h
3.	Butachlor/Delchlor	N-butoxymethyl- a chloro 2'6'-diethyl acetanitide	200 kgai/ha
4.	Fluchloralin/Basalin	N-(2-chloroethyl) trifluoro-2 6-dinitro - N-propyl - p toluidine	700 g ai/ha
5.	Nitrofen/Tok E25	2,4-dichlorophenyl 4-nitrophenyl ether	1.25 kg ai/h
6.	Pendimethalin/Stomp	N-(1-ethyl propyl)-3,4 - dimethyl -2,6-dinitro bezenamine	1.25 kg ai/h
7.	Propanil/Stam F.34	3'-4'- dichloropropionanitide	1.75 kgai/ha
8.	Sodium salt of 2,4D(Fernoxone)	2,4 dichloro phenoxyacetic acid	1.00 kgai/ha

3a. Effect of the plant protection chemicals on the survival of the organism in soil.

A pot culture experiment was laid out with all the twenty eight plant protection chemicals listed above (at field dosage level) and the following ten combinations to evaluate the effect of application of the chemicals on the survival of R. solani in soil and for enumerating the number of viable propagules in soil.

The combinations were

1. Carbaryl + Monocrotophos
2. Carboxin + Carbaryl
3. Carboxin + Monocrotophos
4. Ediphenphos + Carbaryl
5. Ediphenphos + Monocrotophos
6. Ediphenphos + Carboxin
7. 2,4-D Sodium salt + Carbaryl
8. 2,4-D Sodium salt + Carboxin
9. 2,4-D Sodium salt + Ediphenphos
10. 2,4-D Sodium salt + Monocrotophos

Design : C.R.D. (Completely Randomised Des
Variety : Jyothi
Treatments : 40
Replications : 3
Total no. of pots : 120

The pots of size 22 x 26 cm were filled with 10 kg of clayey soil each, collected from the paddy fields of the Instructional Farm of the College of Agriculture, Vellayani. In these pots the fertilizers were added according to the Package of Practices Recommendations for rice (Anon., 1982).

Twenty day old seedlings were transplanted into the pots at the rate of three seedlings per clump after puddling the soil thoroughly. Three weeks later the seedlings were inoculated with three sclerotia each on the leaf sheath and base as described earlier. Inoculated plants were maintained for symptom development. The infection was scored for sheath blight intensity based on the standard evaluation system for rice diseases described elsewhere in this work. A week later the plants were sprayed with the plant protection chemicals except Phorate and Carbofuran which were applied to the soil on the 25th day of transplanting. PCNB too was applied to the soil as well as sprayed on the plant. Soon after the harvest the number of viable propagules in the soil samples were assessed by the following procedure.

One gram of soil from each treatment was taken in 250 ml Erlenmeyer flask containing 100 ml of sterile water. The contents of the flask were shaken well by keeping in a shaker for 20 minutes. One ml of this soil solution was transferred using a sterile pipette into a test tube containing 9 ml sterile water so that the dilution becomes 10^{-3}. This was again shaken well and one ml of this was transferred into another test tube containing 9 ml sterile water so as to bring the dilution to 10^{-4}. From this one ml was pipetted and poured into petri plates and the selective media for R. solani (Ko & Hora, 1971) was added. The poured petri plates were incubated completely under darkness. The number of viable propagules were enumerated by counting the number of white colonies of R. solani which appeared in the dish on the third and fourth day of inoculation.

3b. In vitro effect of plant protection chemicals on Rhizoctonia solani.

The isolate of Rhizoctonia solani causing sheath blight of rice was used for this study. The effect of fungicides, insecticides and herbicides commonly recommended for rice as listed above were used in this study. The poisoned food technique of Zentmyer (1955) was employed for the same.

Five concentrations of each of the plant protection chemicals were used viz., 100, 250, 500, 750 and 1000 ppm. In case of chemicals which showed complete inhibition even at 100 ppm, still lower concentrations viz., 25, 50 and 75 ppm were tried.

Stock solutions of each of these chemicals were first prepared. From these the required quantity was added to 45 ml sterilized molten Potato dextrose agar medium, mixed well and poured into sterile petri plates at the rate of 15 ml per dish. Mycelial discs of 10 mm diameter were cut out from actively growing culture of the fungus, placed in the centre of each petri dish containing the poisoned medium. The petri dishes were incubated at room temperature. The colony diameter was measured on the third day when the growth in the controls covered the petri dish. The percentage inhibition was calculated by the following formula.

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

where C = colony diameter in control
T = colony diameter in treatment

3c. <u>In vivo effect of the plant protection chemicals on sheath blight incidence and intensity</u>.

A pot culture experiment was laid out at the College of Agriculture, Vellayani to study the effect of all the

twenty eight plant protection chemicals listed above and ten combinations of these on the incidence and intensity of sheath blight of rice.

Design	:	C.R.D.(Completely Randomised Design
Variety	:	Jyothi
Treatments	:	40
Replications	:	3
Total no. of pots	:	120

The pots of size 22 x 26 cm were filled with clayey soil of 10 kg each from the paddy fields. Twenty day old seedlings were transplanted into the pots at the rate of three seedlings per clump. Three weeks later the seedlings were inoculated with sclerotia in the leaf sheath. One week later the plants were sprayed with plant protection chemicals except Phorate and Carbofuran which were applied to the soil on the 25th day of transplanting. PCNB was also applied to the soil. On the 60th day the fungicides were sprayed again. Finally the observations on the incidence and intensity were recorded two weeks before the harvest. Disease incidence was estimated by observing all the hills and noting the percentage infection. The intensity of disease was assessed by scoring all the infected hills based on the Standard Evaluation System for Rice Disease (Anon., 1976a).

Description

Grade:

1 Lesions limited to lower 25 per cent of leaf sheath

3 Lesions present on lower 50 per cent of the leaf sheath

5 Lesions present on more than 50 per cent of the leaf sheath

7 Lesions present on more than 75 per cent of leaf sheaths, severe infection on all leaves

9 Lesions reaching top of tillers, severe infection on all leaves

Disease index was calculated based on the following formula.

$$\frac{\text{Total numerical ratings} \times 100}{\text{Total number of hills} \times \text{Maximum score observed}}$$

The average grain yield for each treatment was also worked out and recorded.

3d. Studies on the effect of plant protection chemicals on the soil microflora.

Soil samples were collected at the time of harvest uniformly from each of the treatment pot as detailed under 3a.

The total count of fungi, bacteria and actinomycetes were estimated following the procedure of serial dilution plate technique (Johnson & Curl, 1972).

One gram of soil from each of the treatment was taken in 250 ml Erlenmeyer flask containing 100 ml of sterile water. The contents of the flasks were shaken well in a shaker for 20 minutes. One ml from this was taken using a sterile pipette and transferred into test tubes containing 9 ml of sterile water in each so that the final dilution became 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7} and 10^{-8} respectively. In order to assess the number of soil fungi, one ml from the 10^{-4} dilution was transferred into sterile petri plate and Rose bengal streptomycin agar was added.

For determining the bacterial colonies one ml from the 10^{-6} dilution was pipetted and soil extract agar medium was added. Finally the actinomycetes population was assessed from the 10^{-8} dilution and using Kuster's medium for determining the growth of the actinomycetes.

4. Studies on microorganisms antagonistic to Rhizoctonia solani on the rhizosphere of rice.

4a. Isolation and identification

Representative isolates of fungi, bacteria and actinomycetes obtained from the rhizosphere of rice were purified and maintained on PDA slants. Identity of these isolates were confirmed by referring them to Commonwealth Mycological Institute, Kew, Surrey, England. The colony interactions between R. solani and the non-target microflora were studied in vitro by growing the non-target fungi individually with the pathogenic fungus on PDA in sterile petric dishes. Each pair of fungi was inoculated three cm apart and five replicates were set up per combination. Colony development was observed and assessment made of the interactions between the organisms when the growth pattern became stable. Interaction types were assigned according to the method adopted by Purkayastha and Bhattacharya (1982). The interaction types were grouped into four categories.

A. Homogenous - free inter mingling of hyphae.

B. Over growth - R. solani over grown by test organisms.

C. Cessation of growth at line of contact.

D. Aversion: A clear zone of inhibition seen.

5. In vivo effect of antagonistic organisms on the intensity of sheath blight disease.

A pot culture experiment was laid out at the College

of Agriculture, Vellayani, to assess the effect of antagonistic organisms on the sheath blight disease of rice. The details of the experiment were as follows:

Design	- F.E for factors A & B
Replications	- 3
Total no. of treatments	- 7 x 3 x 3
Factor A	- Antagonistic organisms
Factor B	- Plant protection chemicals

Factor A

A_0 - *Penicillium oxalicum*

A_1 - *Fusarium solani*

A_2 - *Chaetomium globosum*

A_3 - *Aspergillus niger*

A_4 - *Neurospora crassa*

A_5 - *Trichoderma viride*

A_6 - Control

Factor B

B_0 - Carbofuran

B_1 - Carboxin

B_2 - Control

The pots of size 22 x 26 cm were filled with soil collected from the wet land. The population of natural antagonistic organisms already present in the soil was

determined by soil dilution technique. The population of fungi, bacteria and antinomycetes were recorded separately. Fertilizers were added according to Package of Practices recommendations (Anon., 1982). The antagonistic organisms were grown on PDA in petri dishes. These were then multiplied by growing on sand maize meal and incorporated into the soil at the rate of 100 grams.

After a week when these organisms were well established, the seedlings were transplanted into the pots. A week after this the plants were inoculated with R. solani both on the leaf sheath and base. On the twenty fifth day of transplanting, Carbofuran was applied into the soil. The fungicidal spray with Carboxin was given at the time of tillering. The reaction of rice plants to symptom development was noted by recording the intensity of sheath blight disease as described earlier.

5a. Effect of addition of antagonistic organisms and application of selected plant protection chemicals on rhizosphere mycroflora of rice.

A pot culture trial was conducted to study the effect of addition of antagonistic organisms and application of few of the selected biocides on the non-target mycoflora of rice.

Design - Completely Randomised

Replications - 3

Variety - Thriveni

Treatments:

Fungicides:

1. Mancozeb - 0.2 % spray
2. Ediphenphos - 0.1 % spray
3. Carboxin - 0.2 % spray

Insecticides:

1. Carbaryl - 0.2 % spray
2. Carbofuran - 0.6 kg/ha soil application

Herbicides:

1. Bentazone - 4 l/ha soil application
2. Benthiocarb - 4 l/ha soil application
3. Propanil - 5.7 l/ha soil application
4. Nitrofen - 6 l/ha soil application
5. 2,4D sodium salt - 1.25 kg/ha soil application

Control - No biocides

Replications - 3

The experimental pots were filled with wet land soil. The soil mycoflora of these were determined prior to treatments by the soil dilution plate technique. Twenty one day old rice seedlings were transplanted at the rate of three

seedlings per clump. Two weeks after this, the plants were inoculated with uniform sized sclerotia by keeping them between the folds of the outer most sheath and covering with moist cotton. A week after this a uniform spray of the selected antagonistic organisms was given. On the 25th day of transplanting the herbicides and Carbofuran were applied to the soil. At the active tillering stage the remaining fungicides and Carbaryl were sprayed into the plants. Two weeks before harvest the plants were uprooted and the rhizosphere mycoflora determined by the soil dilution plate technique.

6. Studies on the occurrence of mycorrhiza in paddy.

A pot culture experiment was laid out to study the influence of plant protection chemicals on the mycorrhizal associations on rice. The following soil treatments were used for the study. The details of the experiment were as follows:

Treatments:

T_0 - Carbofuran

T_1 - Phorate

T_2 - Carboxin

T_3 - Quintozene

T_4 - Carbendazim

T_5 - Control

W_0 - No inoculation with sclerotia

W_1 - Inoculation with sclerotia of R.solani

f_0 - Without fertilizer

f_1 - With fertilizer

Treatments

T_0 W0 f^0	T_3 W0 f^0
T_0 W0 f^1	T_3 W0 f^1
T_0 W1 f^0	T_3 W1 f^0
T_0 W1 f^1	T_3 W1 f^0
T_1 W0 f^0	T_4 W0 f^0
T_1 W0 f^1	T_4 W0 f^1
T_1 W1 f^0	T_4 W1 f^0
T_1 W1 f^1	T_4 W1 f^1
T_2 W0 f^0	T_5 W0 f^0
T_2 W0 f^1	T_5 W0 f^1
T_2 W1 f^0	T_5 W1 f^0
T_2 W1 f^1	T_5 W1 f^1

Design : C.R.D.

Variety : Jyothi

Treatments : 24

Replications : 3

Total no. of pots : 72

The pots were filled with wet land soil. In one set the recommended dose of fertilizers was added according to the Package of Practices Recommendations (Anon., 1982). Another set was maintained without the addition of any fertilizer. The seedlings were inoculated with sclerotia uniformly while the uninoculated plants served as control. The chemicals Phorate and Carbofuran were applied into the soil on the twenty fifth day of transplanting. Carboxin and Carbendazim were sprayed into the plants during the tillering stage while Quintozine was applied to the soil alone. The plants were observed periodically for mycorrhizal association following the method of Philips and Hayman (1970). Eight to ten freshly formed roots were taken from each pot. The roots were cut into small bits of 1 to 2 cm in length. These bits were then transferred into test tubes and boiled for 1 to 2 hours after adding 10 per cent KOH. The root samples were carefully taken out, rinsed thoroughly with repeated changes of distilled water. These treated bits were then immersed in 2 per cent dilute hydrochloric acid solution for 5 minutes. The acid solution was poured off and typan blue was added. Finally the tubes were decanted, lactophenol added, kept over night and root bits examined under the microscope.

Note:

i. The composition of all the media, stains, reagents etc., mentioned above are given in appendix.

ii. Unless otherwise stated routine laboratory procedures were followed for regular plant pathological work.

RESULTS

RESULT

1. Isolation of the pathogen

Rhizoctonia solani kuhn was isolated and purified from naturally infected rice plants collected from the paddy fields attached to the Instructional Farm, of the College of Agriculture. The identity of the organism was confirmed by studying their morphological characters and their pathogenicity established following Koch's postulates.

2. Survival of Rhizoctonia solani

Survival of the organism as sclerotia in soil and in the infected plant debris in three different types of soils, namely sandy, loamy and clayey were studied. The periodical observations on the germination of sclerotia buried in different types of soil for varying intervals are presented in Table 1. It can be seen from these data that the sclerotia remained viable upto 210 days in all the three types of soils. On the 240th day none of the sclerotia from the clayey soil germinated. However, germination was completely lost on the 270th day. The sclerotia retained its viability much better than the organism in the straw bits.

Table 1. Viability of sclerotia of *R. solani* buried in different types of soils.

Serial No.	Interval of observation in days	Type of soil		
		Sandy	Loamy	Clayey
1	30	+	+	+
2	60	+	+	+
3	90	+	+	+
4	120	+	+	+
5	150	+	+	+
6	180	+	+	+
7	210	+	+	+
8	240	+	+	-
9	270	-	-	-

+ Viable - Not viable

Tests on the viability of the organism on straw bits gave positive results only upto 180th day and thereafter it declined (Table 2).

Table 2. Survival of the organism R. solani on infected sheath bits buried in different types of soils.

Serial No.	Interval of observation in days	Type of soil		
		Sandy	Loamy	Clayey
1	30	+	+	+
2	60	+	+	+
3	90	+	+	+
4	120	+	+	+
5	150	+	+	+
6	180	+	+	+
7	210	-	-	-

3. Effect of common plant protection chemicals on R. solani

A total number of twenty eight commonly recommended plant protection chemicals in rice culture as listed under Materials and Methods used for this study. This included 8 fungicides, 12 insecticides and 8 herbicides. The effect of these biocides on the survival or R. solani in soil and also their in vitro and in vivo effect of this organism were studied and presented here.

3a. Effect on the survival of the organism in soil

The effect of various fungicides applied to rice

for the control of sheath blight on the survival of *R. solani* are tabulated in Table 3.

The minimum recovery of viable *R. solani* propagules was from soils treated with Mancozeb; Quintozene and Carboxin which were on par. Carbendazim and Kitazin were least effective in reducing soil propagules but they were significantly different from the control. Ediphenphos, Ziram and Captafol were equally effective ranking next to Manfozeb (Table 3).

Table 3. Effect of fungicides applied on rice on the survival of *R. solani* in soil.

Serial No.	Fungicides	Viable propagules of *R. solani* after x+1 transformation
1	Captafol	2.44
2	Carbendazim	3.14
3	Carboxin	1.41
4	Ediphenphos	1.98
5	Kitazin	2.76
6	Mancozeb	1.24
7	Quintozene	1.28
8	Ziram	2.06
9	Control	3.60
	CD = 0.5628	

The study on the effect of insecticides on soil propagules showed that Carbaryl + Lindane ranked first followed by Methyl parathion, Carbofuran, Phorate, Monocrotophos and Fenitrothion which were on par Carbaryl, Malathion, Dimethoate, Formothion, Hexachlorocyclohexane and Fenthion were equally effective and next to Carbaryl + Lindane and were significantly different from the control. The least effective insecticide in reducing the number of propagules was Fenthion (Table 4).

Table 4. Effect of insecticides applied on rice on the survival of *R. solani* in soil.

Serial No.	Insecticides	Viable propagules of *R. solani* after x + 1 transformation
1	Carbaryl	2.64
2	Carbaryl + Lindane	1.61
3	Carbofuran	1.63
4	Dimethoate	2.92
5	Fenitrothion	2.16
6	Fenthion	3.29
7	Formothion	3.11
8	Hexachlorocyclohexane	3.11
9	Malathion	2.76
10	Methylparathion	1.63
11	Monocrotophos	1.96
12	Phorate	1.73
13	Control	3.60

CD = 0.5986

Among the herbicides tested Nitrofen was the most superior one with respect to maximum inhibition of soil propagules, followed by Propanil which were on par (Table 5). 2,4D Sodium salt, Bentazone and Fluchloralin were found equally effective next to Nitrofen and Propanil and they were on par. Butachlor was found to be on par with Fluchloralin but was significantly inferior to 2,4D Sodium salt. It was also noticed that Benthiocarb and Pendimethalin were equally effective as Butachlor but significantly different from control. Pendimethalin has shown the minimum effect.

Table 5. Effect of herbicides applied on rice on the survival of R. solani in soil.

Serial No.	Herbicides	Viable propagules of R. solani after x + 1 transformation
1	Bentazone	2.44
2	Benthiocarb	3.15
3	Butachlor	2.74
4	Fluchloralin	2.54
5	Nitrofen	1.28
6	Pendimethalin	3.16
7	Propanil	1.38
8	Sodium salt of 2,4D	2.44
9	Control	3.60

CD = 0.4804

3b. In vitro effect of plant protection chemicals on Rhizectonia solani

All the eight fungicides tested were found effective in reducing the radial growth of R. solani. Among the various levels of the chemicals tried, namely 100 ppm to 1000 ppm for all fungicides except Ediphenphos for which lower levels were tried, it was noticed that Ediphenphos at 100 and 250 ppm, Carbendazim at 750 and 1000 ppm, Carboxin at 750 and 1000 ppm, Kitazin at 500, 750 and 1000 ppm and also PCNB at the same levels were equally effective in checking the radial growth of the organism. Ziram, Captafol and Mancozeb were effective at 1000 ppm and above only. These treatments were found statistically on par (Table 6, Plates 1-8). Ediphenphos and Kitazin were effective even at lower concentrations, namely 75 ppm for Ediphenphos and 100 ppm for Kitazin and these were equally effective as Carboxin at 500 ppm, Quintozene 250 ppm, Ziram 750 ppm and Captafol 1000 ppm. These treatments were statistically different from the control.

Mancozeb and Carbendazim at 100 ppm were found to be the least effective treatments to inhibit the mycelial growth of the organism. But these were also significantly different from that of the control. Quintozene, Ziram and Captafol each at 100 ppm concentration were equally effective as Carbendazim 500 ppm which were on par (Table 6).

Table 6. *In vitro* effect of fungicides on the radial growth of *R. solani*.

Serial No.	Fungicides	Concentration in ppm	Mean colony diameter (mm)	Per cent inhibition over control
1	Captafol	100	38.16	52.30
		250	26.83	66.46
		500	24.33	69.59
		750	20.33	74.59
		1000	10.33	87.09
		1250	0	100
2	Carbendazim	100	61.33	23.34
		250	54.17	32.29
		500	36.33	54.59
		750	0	100
		1000	0	100
3	Carboxin	100	18.00	77.50
		250	15.00	81.25
		500	12.00	85.00
		750	0	100
		1000	0	100
4	Ediphenphos	25	28.00	65.00
		50	18.00	77.50
		75	12.33	84.59
		100	0	100
		250	0	100
5	Kitazin	100	11.83	85.21
		250	11.17	86.03
		500	0	100
		750	0	100
		1000	0	100
6	Mancozeb	100	61.50	23.13
		250	40.00	50.00
		500	28.00	65.00
		750	15.00	81.25
		1000	0	100
7	Quintozene	100	28.17	64.79
		250	12.33	84.59
		500	0	100
		750	0	100
		1000	0	100
8	Ziram	100	38.00	52.50
		250	24.00	70.00
		500	11.83	85.21
		750	10.83	86.46
		1000	0	100
	Control	-	80.00	-

CD for comparison of treatments = 1.6448

PLATE 1

Effect of Captafol on the radial growth of Rhizoctonia solani.

PLATE 2.

Effect of Carbendazim on the radial growth of Rhizoctonia solani.

Plate

Carbox .

100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

Plate

Ediphenphos:

1 - 25 ppm, 2 - 50 ppm, 3 - [illegible] ppm,
4 - 100 ppm, 5 - 250 ppm, 0 - Control.

PLATE 3
Effect of Carboxin on the radial growth of Rhizoctonia solani

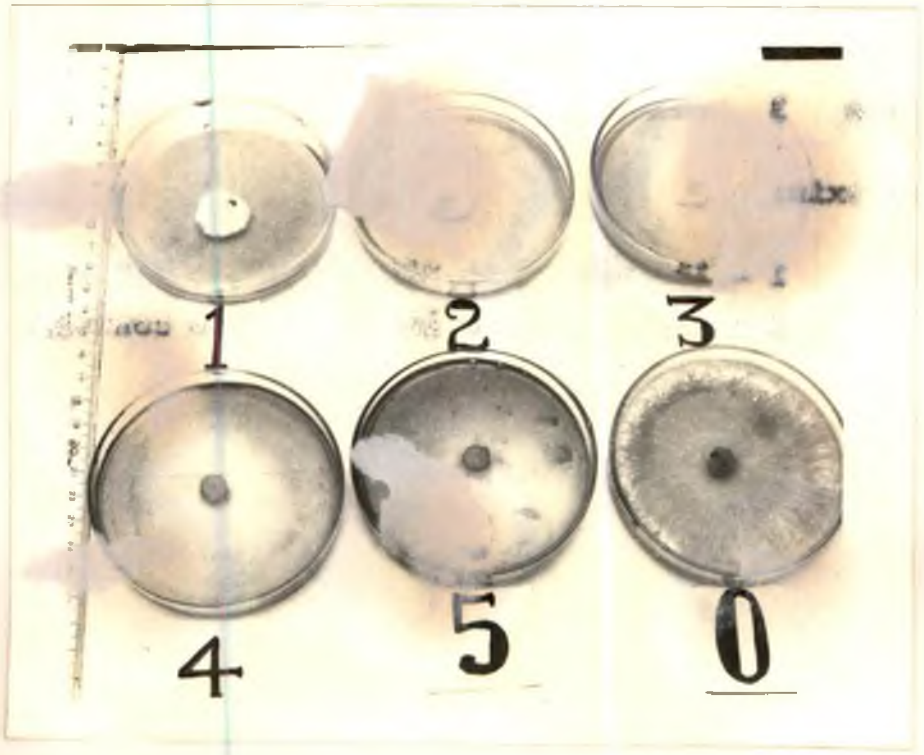


PLATE 4
Effect of Ediphenphos on the radial growth of R. solani

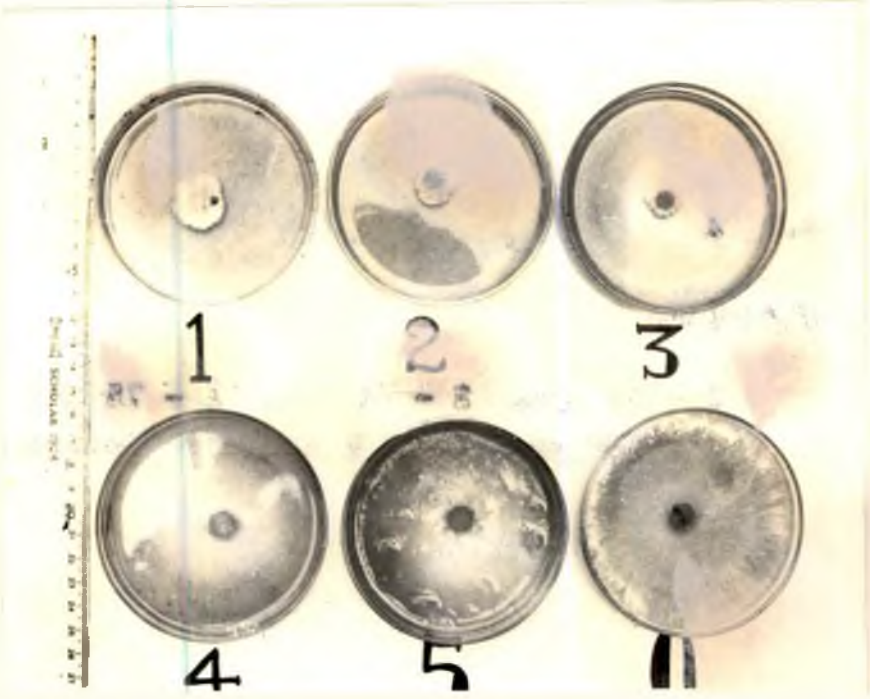


Plate 5

Kitazin:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

Plate 6

Mancozab:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

PLATE 5

Effect of Kitazin on the radial growth of *R. solani*

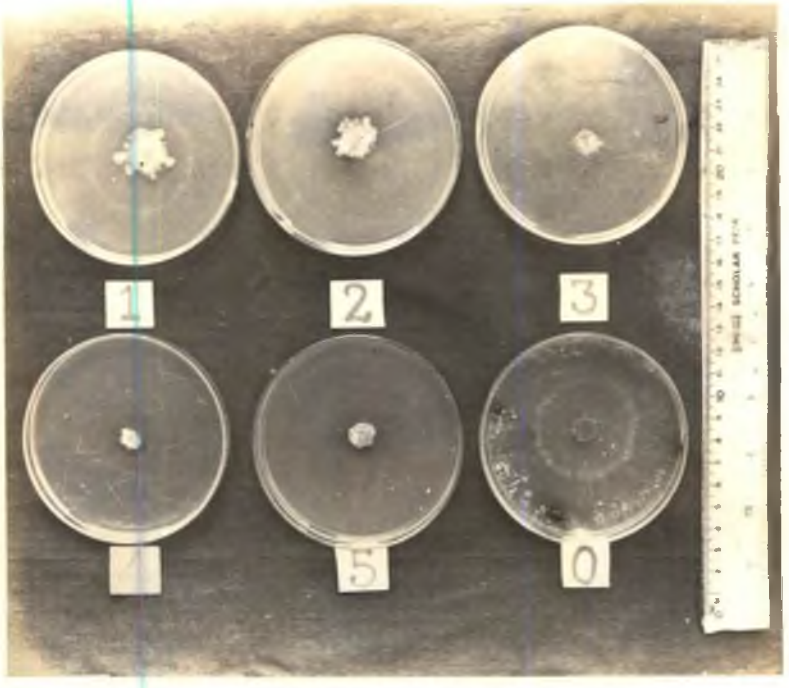


PLATE 6

Effect of Mancozeb on the radial growth of *R. solani*

Plate 7

Quintozene:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

Plate 8

Ziram:

1 - 1000 ppm, 2 - ppm, 3 - 500 ppm
4 - 750 ppm, 5 - ppm, 0 - Control

PLATE 7

Effect of Quintozene on the radial growth of *R. solani*

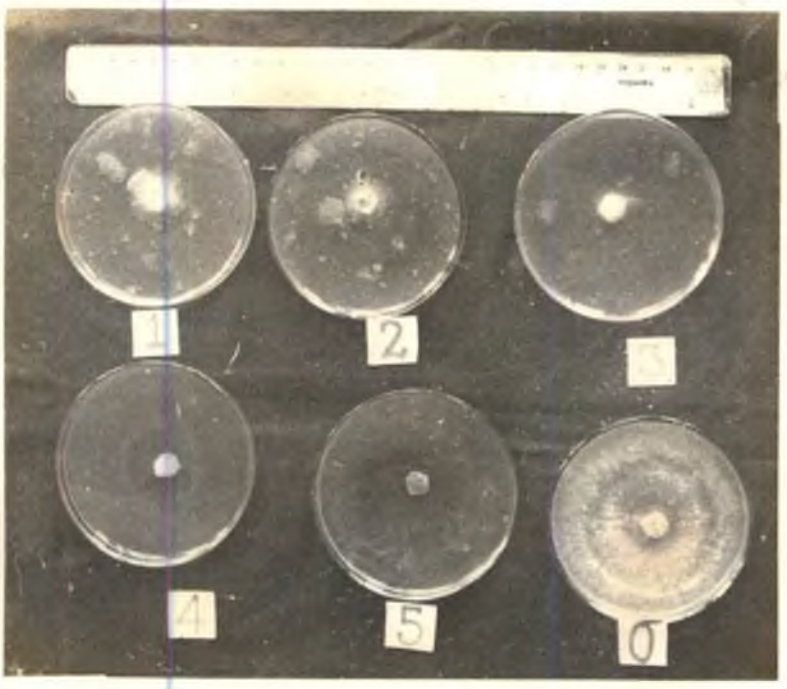
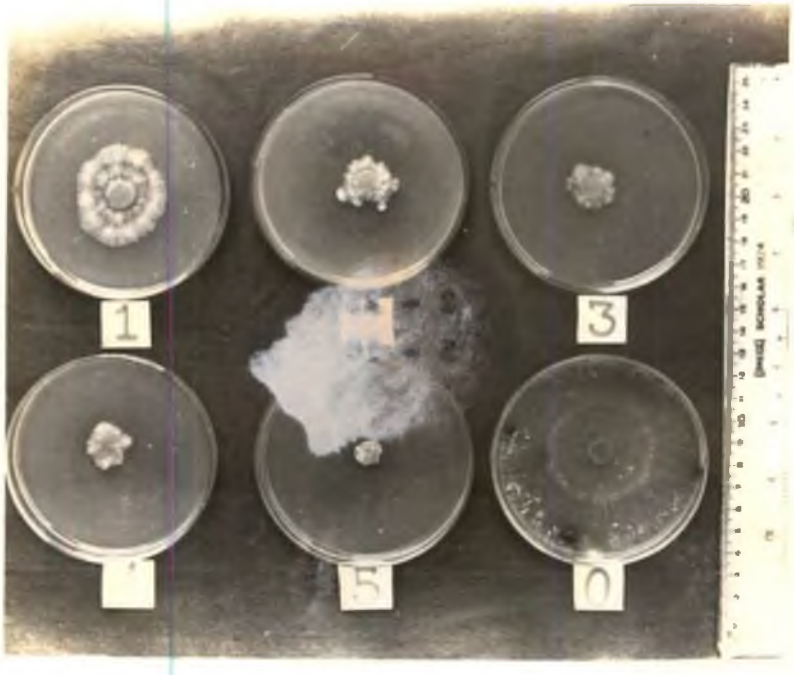


PLATE 8

Effect of Ziram on the radial growth of *R. solani*



Results on the trials with insecticides revealed that most of the insecticides tried, could inhibit the radial growth of the fungus. Carbaryl at 1000 ppm was found the most effective insecticide followed by Carbaryl + Lindane, Carbofuran, Dimethoate, Hexachlorocyclohexane, Fenitrothion, Formothion, Fenthion, Methyl-parathion, Monocrotophos and Phorate at 1000 ppm each which were on par. Methyl parathion and Monocrotophos were found equally effective even at lower concentrations, namely 750 and 500 ppm. Carbaryl, Carbaryl + Lindane, Phorate, Fenitro-thion, Formothion, Hexachlorocyclohexane and Malathion each at 750 ppm concentrations were equally effective as Dimethoate at 750 ppm and these were also on par with Monocrotophos, Methyl parathion, Carbaryl and Fenitrothion at 500 ppm. All the other doses of the chemicals tested were found less effective against the fungus. Malathion at 100 ppm and Carbofuran too at 100 ppm were the most inferior chemicals in inhibiting the mycelial growth of the fungus (Table 7, Plates 9-20).

Table 7. *In vitro* effect of insecticides on the radial growth of *R. solani*.

Serial No.	Insecticides	Concentration in ppm	Mean colony diameter (mm)	Per cent inhibition over control
1	2	3	4	5
1	Carbaryl	100	38.66	51.68
		250	25.33	68.34
		500	15.00	81.25
		750	10.66	86.68
		1000	0	100
2	Carbaryl + Lindane	100	50.67	36.66
		250	46.33	42.09
		500	20.00	75.00
		750	10.66	86.68
		1000	0	100

Table 7. Contd.

1	2	3	4	5
3	Carbofuran	100	66.33	17.09
		250	50.00	37.50
		500	41.00	48.75
		750	28.00	65.00
		1000	0	100
4	Dimethoate	100	21.66	79.93
		250	20.33	74.59
		500	15.00	81.25
		750	5.00	93.75
		1000	0	100
5	Fenitrothion	100	27.50	65.33
		250	21.00	78.75
		500	17.83	77.73
		750	15.00	81.25
		1000	0	100
6	Fenthion	100	38.33	52.08
		250	30.00	62.50
		500	28.00	65.00
		750	25.00	68.75
		1000	0	100
7	Formothion	100	27.83	65.21
		250	20.00	75.00
		500	18.00	77.50
		750	15.33	80.84
		1000	0	100
8	Hexachlorocyclohexane	100	45.50	43.13
		250	30.00	60.24
		500	28.00	65.00
		750	15.33	80.84
		1000	0	100
9	Malathion	100	79.83	0.21
		250	52.33	34.59
		500	38.33	52.08
		750	20.00	75.00
		1000	5.00	93.75
10	Methyl parathion	100	21.00	73.75
		250	10.66	86.68
		500	0	100
		750	0	100
		1000	0	100
11	Monocrotophos	100	10.00	87.50
		250	5.00	93.75
		500	0	100
		750	0	100
		1000	0	100
12	Phorate	100	51.00	34.12
		250	45.00	43.75
		500	19.83	75.23
		750	11.00	86.25
		1000	0	100
13	Control	-	80.00	-

CD for comparison of treatments = 1.2608

Plate 9

Carbaryl:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

Plate 10.

Carba Lindane

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

PLATE 9

Effect of Carbaryl on the radial growth of *R. solani*

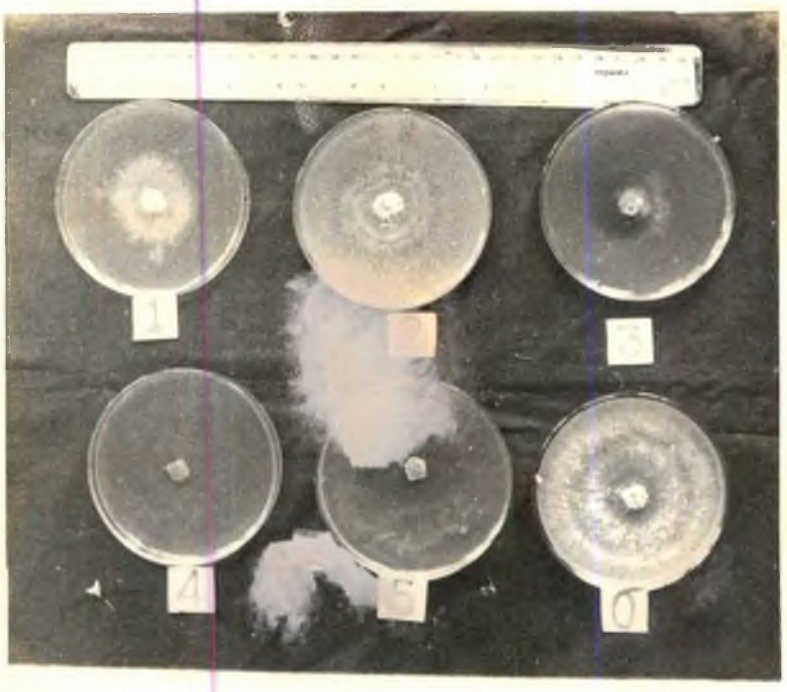


PLATE 10

Effect of Carbaryl + Lindane on the radial growth of *R. solani*

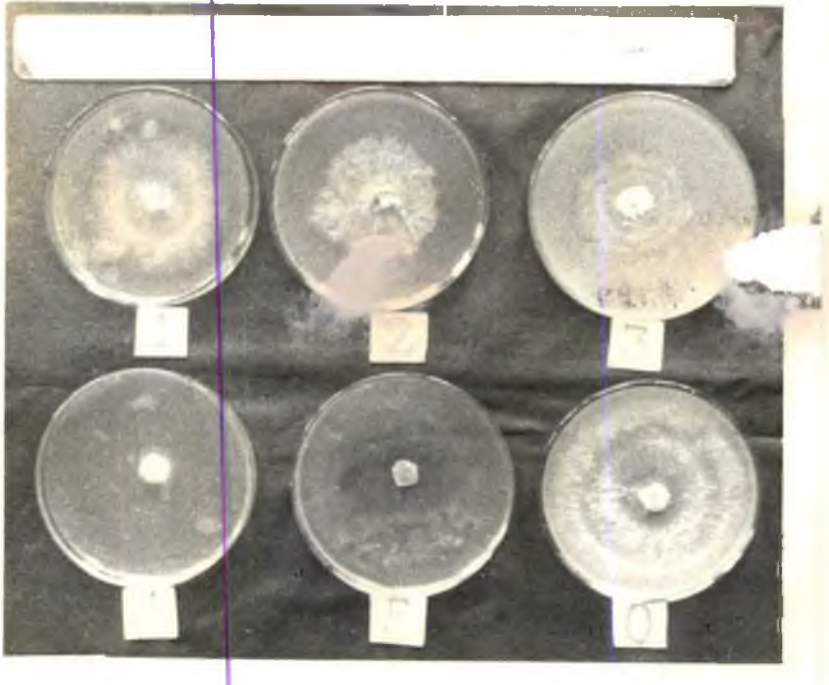


Plate 11

Carbofuran:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

Plate 12

Dimethoate:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

Plate 11

Carbofuran:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

Plate 12

Dimethoate:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

PLATE 11
Effect of Carbofuran on the radial growth of R. solani

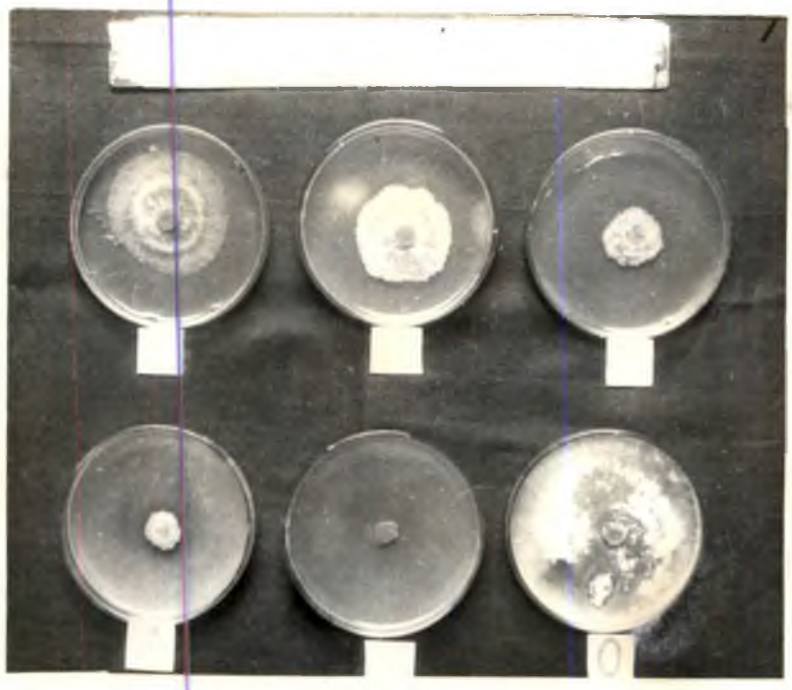


PLATE 12
Effect of Dimethoate on the radial growth of R. solani

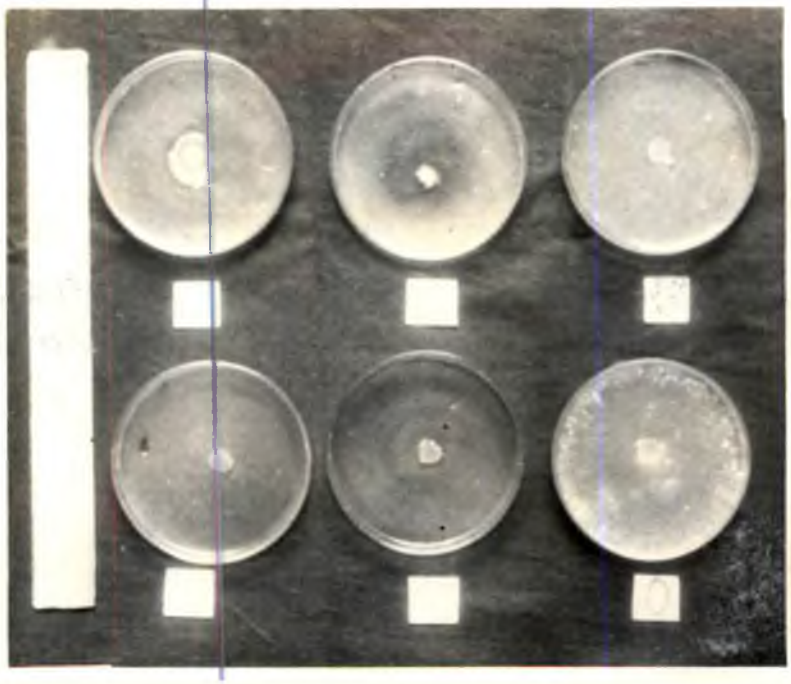


Plate 13

Fenitrothion:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

Plate 14

Fenthion:

1 - 1000 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

PLATE 13
Effect of Fenitrothion on the radial growth of *R. solani*

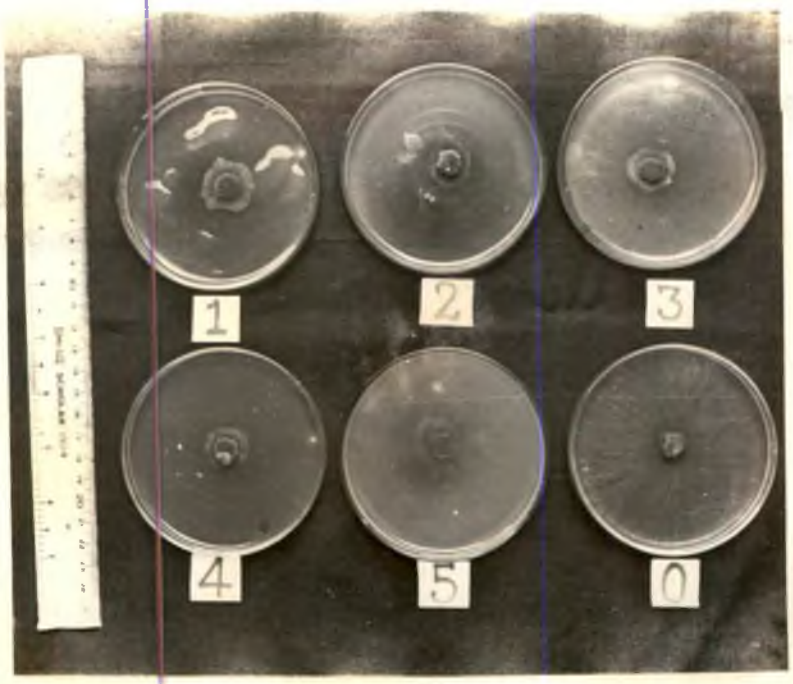


PLATE 14
Effect of Fenthion on the radial growth of *R. solani*

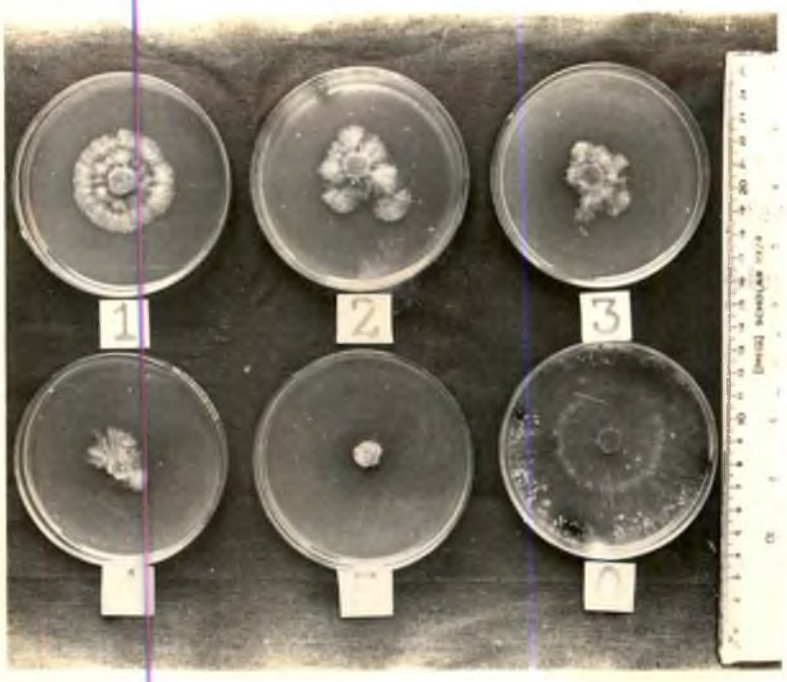


Plate 15

Formothion:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

Plate 15

Hexachlorocyclohexane:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

PLATE 15
Effect of Formothion on the radial growth of *R. solani*

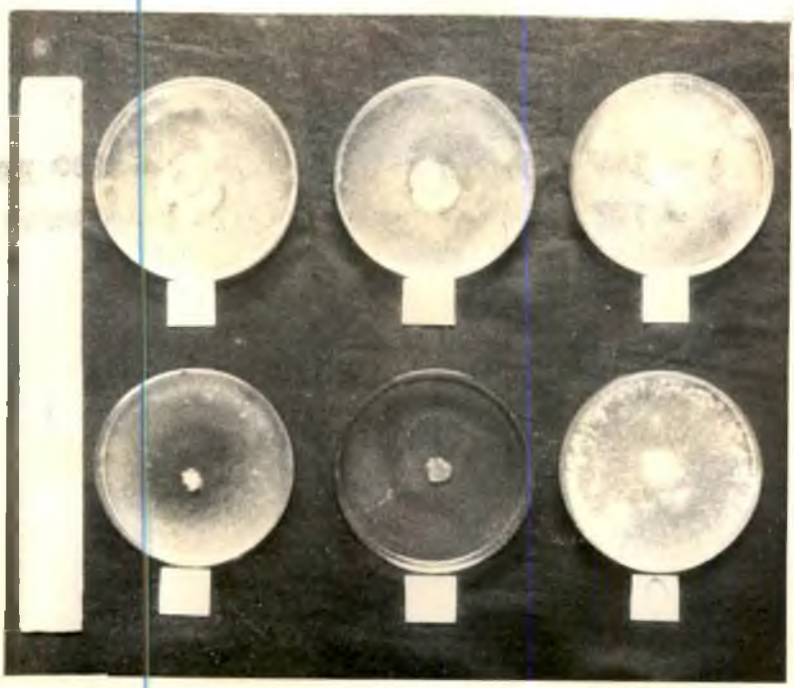


PLATE 16
Effect of Hexachlorocyclohexane on the radial growth of *R. solani*

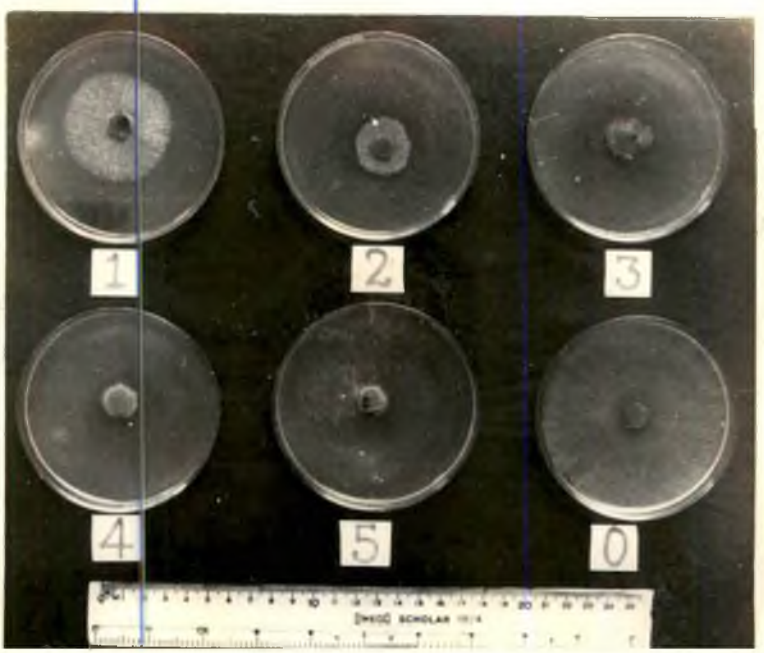


Plate 17

Malathion:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

Plate 18

Methylparathion:

- 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

PLATE 17
Effect of Malathion on the radial growth of R. solani

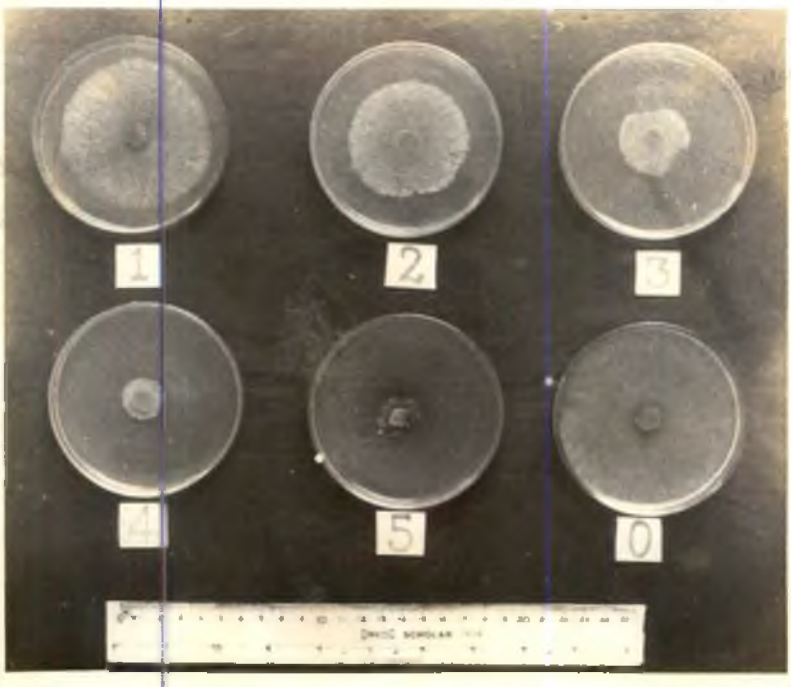
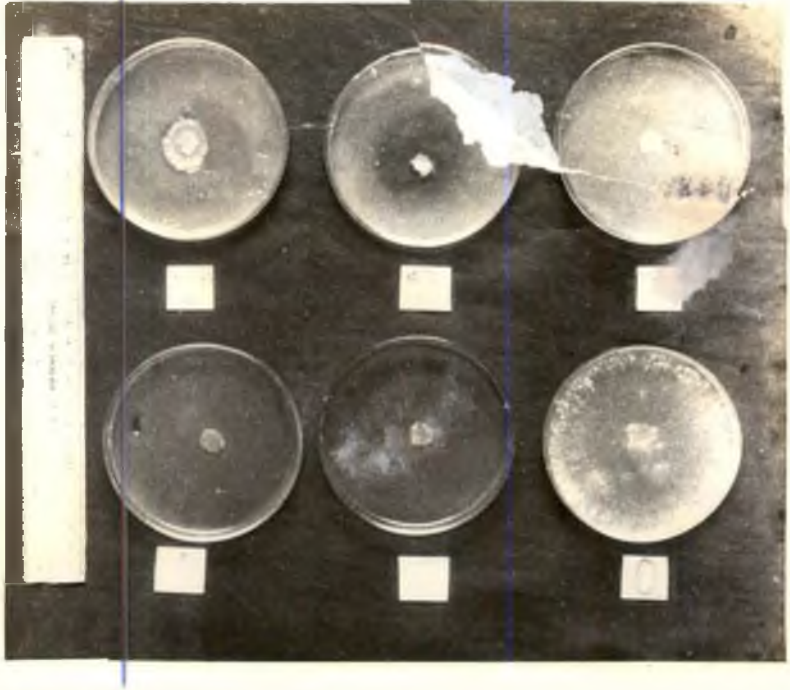


PLATE 18
Effect of Methyl parathion on the radial growth of R. solani



19

Plate

Monocrotophos:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

Plate 20

Phorate:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

PLATE 20
Effect of Phorate on the radial growth of *R. solani*

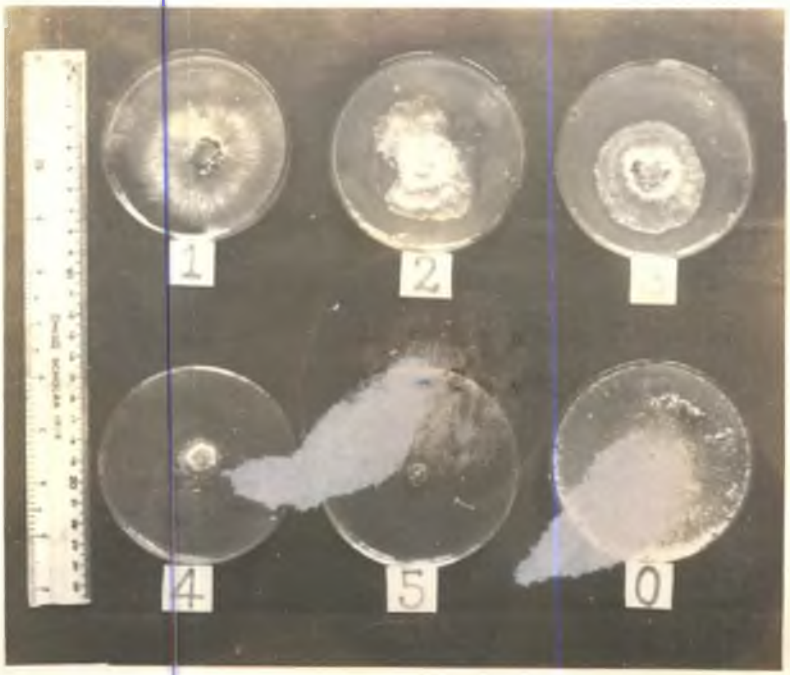
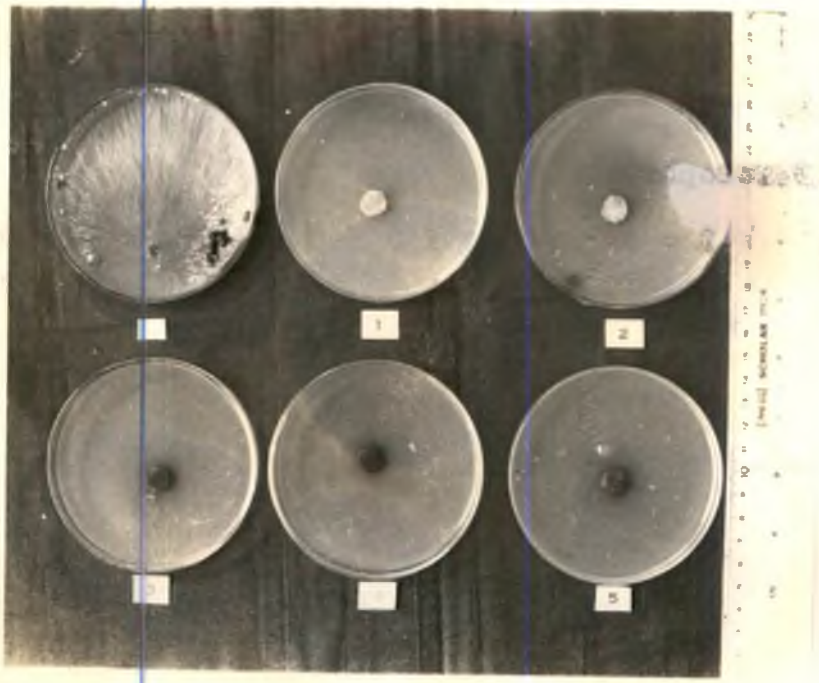


PLATE 19

Effect of Monocrotophos on the radial growth of *R. solani*



Among the herbicides tried, Bentazone at 1000 ppm was the most effective one followed by Benthiocarb, Butachlor, Fluchloralin, Nitrofen and 2,4D Sodium salt each at a concentration of 1000 ppm. The above treatments were on par with lower levels viz., 750 and 1000 ppm of Pendimethalin and still lower levels viz., 500, 750, and 1000 ppm of Propanil (Table 8).

Bentazone at 750 ppm was the next effective treatment which was followed by Pendimethalin 500 ppm and Propanil 250 ppm and these were on par. The next effective treatments include Propanil at 100 ppm, 2,4D Sodium salt at 750 ppm, Pendimethalin at 250 ppm, Bentazone at 500 ppm, Pendimethalin at 100 ppm, Nitrofen at 750 ppm, Benthiocarb at 750 ppm and Butachlor at 750 ppm. All the remaining treatments were found less effective but most of them was significantly different from each other. Fluchloralin at 1000 ppm, Nitrofen at 250 ppm and Nitrofen at 100 ppm were found the most inferior herbicides with respect to inhibition of mycelial growth (Table 8, Plates 21 - 28).

Table 8. *In vitro* effect of herbicides on the radial growth of *R. solani*.

Serial No.	Herbicides	Concentration in ppm	Mean colony diameter (mm)	Per cent inhibition over control
1	Bentazone	100	48.67	39.16
		250	27.33	65.84
		500	18.33	77.09
		750	5.00	93.75
		1000	0	100
2	Benthiocarb	100	59.67	25.41
		250	40.00	50.00
		500	33.67	57.91
		750	26.00	67.50
		1000	0	100
3	Butachlor	100	66.33	17.09
		250	44.00	45.00
		500	31.67	60.41
		750	27.00	66.25
		1000	0	100
4	Fluchloralin	100	78.00	2.50
		250	65.00	18.75
		500	65.00	18.75
		750	54.00	32.50
		1000	44.33	44.59
		1250	0	0
5	Nitrofen	100	80.00	Nil
		250	78.00	2.50
		500	59.67	25.41
		750	20.00	75.00
		1000	0	100
6	Pendimethalin	100	20.00	75.00
		250	16.33	79.57
		500	10.00	87.50
		750	0	100
		1000	0	100
7	Propanil	100	11.00	86.25
		250	10.00	87.50
		500	0	100
		750	0	100
		1000	0	100
8	Sodium salt of 2,4D	100	60.33	24.59
		250	54.66	31.68
		500	40.00	50.00
		750	0	100
		1000	0	100
9	Control		80.00	Nil

CD for comparison between treatments = 1.5334

Plate 21

Bentazone:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

Plate 22

Benthiocarb:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

PLATE 21
Effed of Bentazone on the radial growth of R. solani

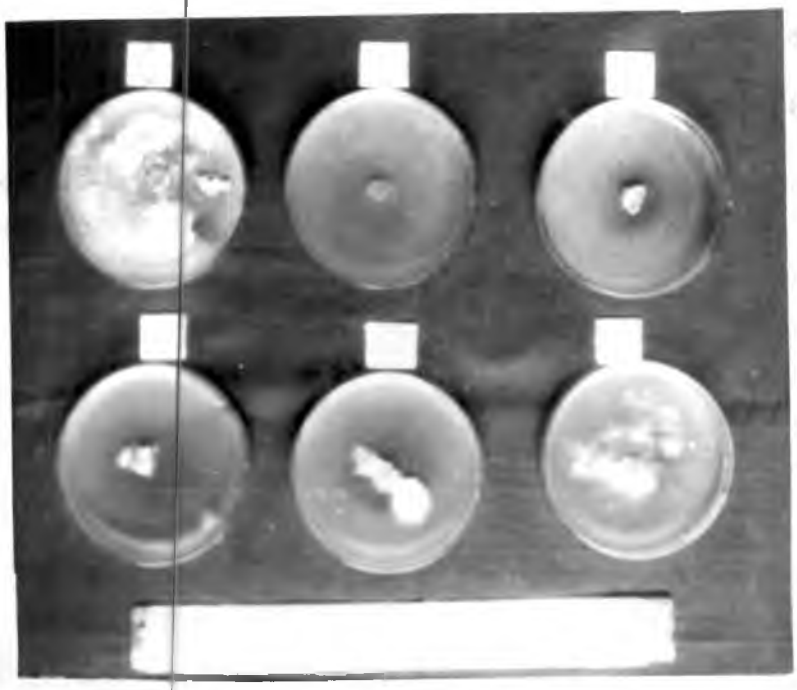


PLATE 22
Effect of Benthiocarb on the radial growth of R. solani

Plate 23

Butachlor:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

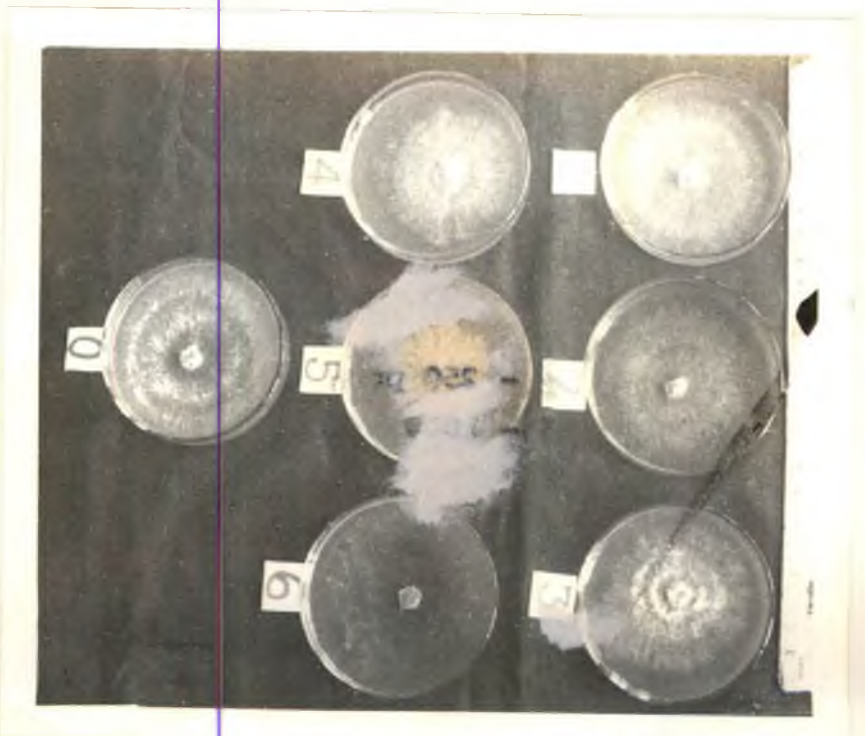
Plate 24

Fluchloralin:

1 - 100 ppm, 2 - 250 500 ppm,
4 - 750 ppm, 5 -

PLATE 23
Effect of Butachlor on the radial growth of *R. solani*

PLATE 24
Effed of Fluchloralin on the radial growth of *R. solani*



2

Plate 25

Nitrofen:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

Plate 26

Pendimethalin:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

2

Plate 25

Nitrofen:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

Plate 26

Pendimethalin:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

PLATE 25
Effect of Nitrofen on the radial growth of *R. Solani*

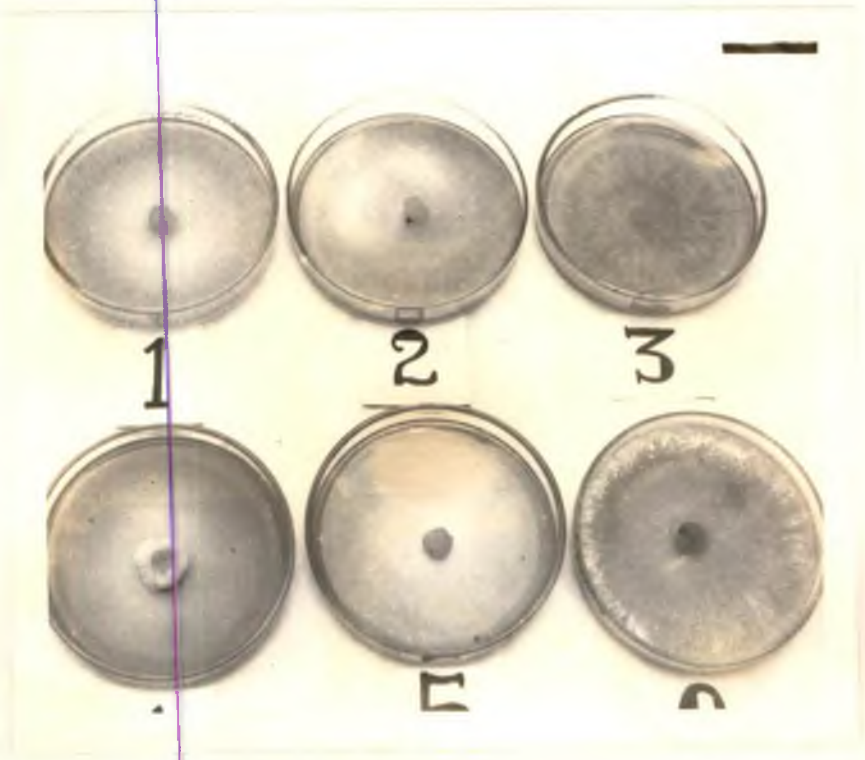


PLATE 26
Effect of Pendimethalin on the radial growth of *R. Solani*

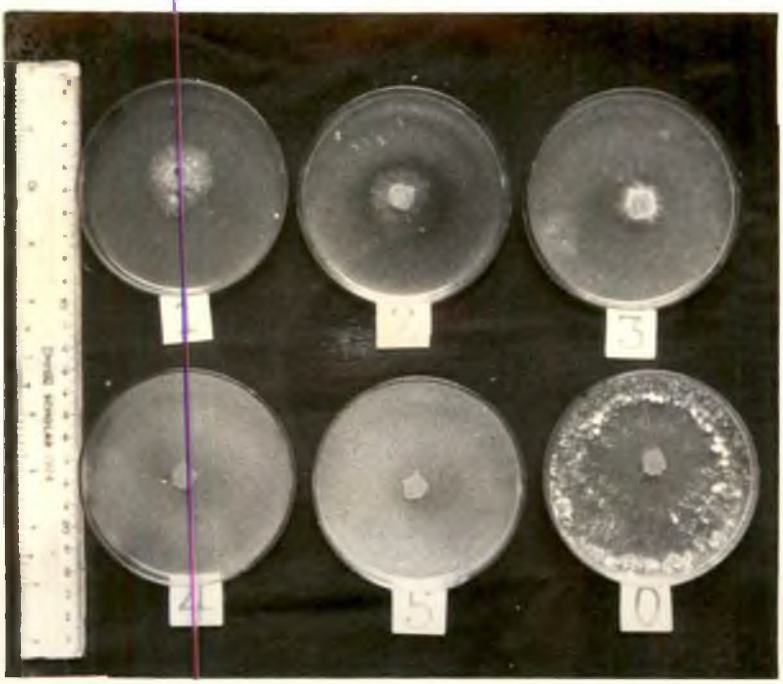


Plate 27

Propanil:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

Plate 28

2, 4D Sodium salt:

1 - 100 ppm, 2 - 250 ppm, 3 - 500 ppm,
4 - 750 ppm, 5 - 1000 ppm, 0 - Control.

PLATE 27
Effect of Propanil on the radial growth of *R. solani*

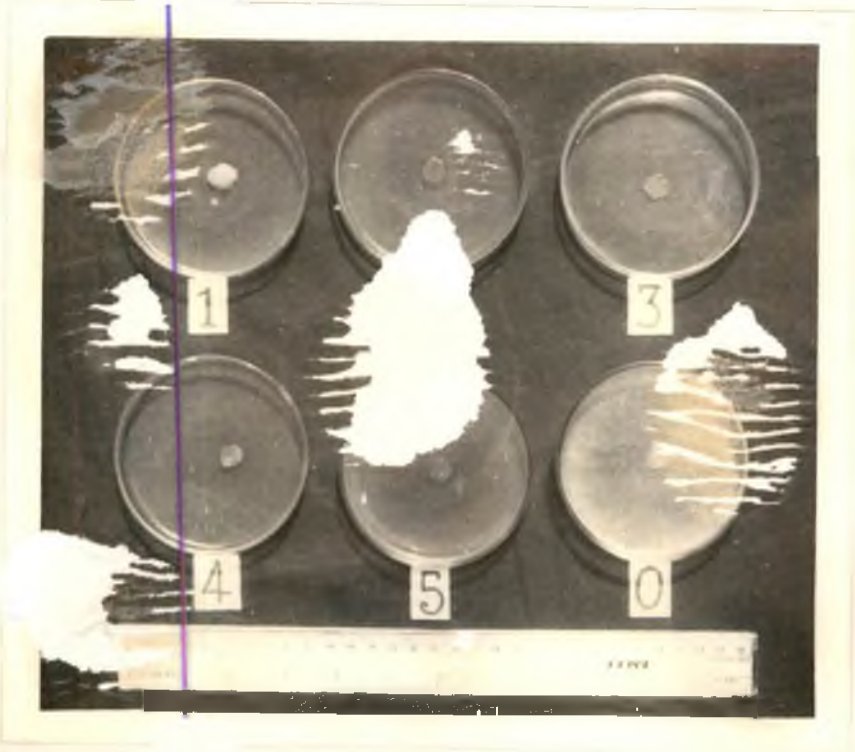
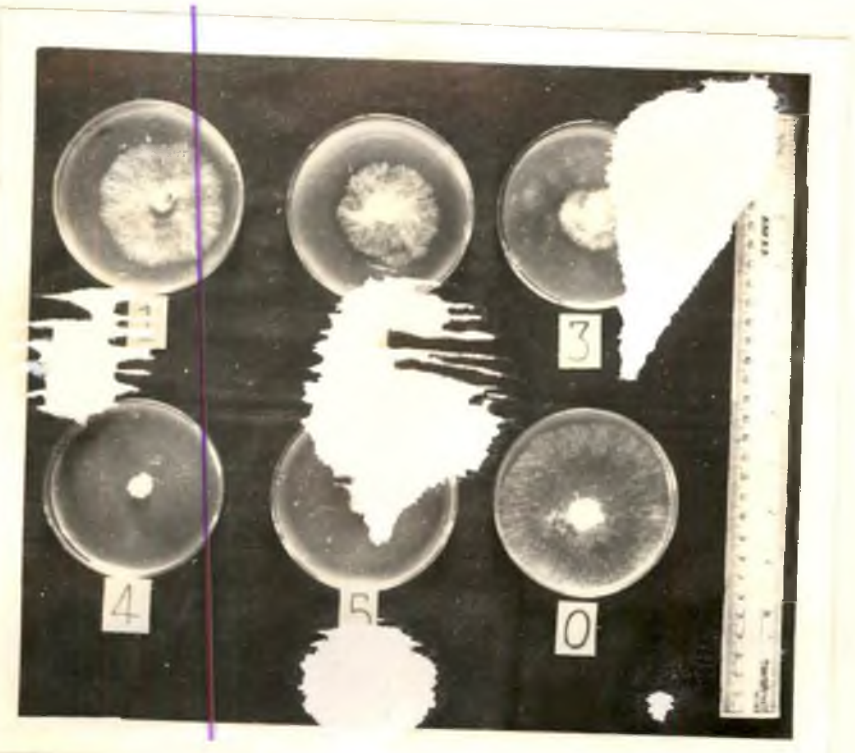


PLATE 28
Effect of Sodium Salt of 2,4-D on the radial growth of *R. solani*



3c. In vivo effect of plant protection chemicals on sheath blight incidence and intensity

The results of the pot culture experiment conducted revealed that among the fungicides tested, Ediphenphos was the most effective chemical in minimising the incidence of sheath blight followed by Carboxin and Kitazin which were on par with Ediphenphos. Treatment of Quintozene in soil was found equally effective as Kitazin, Carbendazim and Ziram. The chemical Captafol was found to be on par with Ziram but significantly inferior to Carbendazim and Quintozene. Mancozeb was the least effective one with respect to control of disease (Table 9). Regarding the intensity of disease, Carbendazim was the most superior one in minimising the disease followed by Captafol and Carboxin which were on par. These were significantly different from other treatments.

Table 9. Effect of application of fungicides on the incidence and intensity of sheath blight disease.

Serial No.	Fungicides	Mean per cent hill infection	Rank	Mean disease intensity	Rank
1	Captafol	41.527	VII	9.87	VII
2	Carbendazim	34.566	V	4.075	I
3	Carboxin	27.353	II	10.97	III
4	Ediphenphos	24.564	I	22.22	V
5	Kitazin	28.696	III	24.69	VI
6	Mancozeb	53.666	IX	35.79	II
7	Quintozene	33.742	IV	19.75	IV
8	Ziram	38.619	VI	40.74	VIII
9	Control	53.004	VIII	77.77	IX

CD for comparison of disease incidence = 5.8517
CD for comparison of disease intensity = 14.4724

Among the remaining fungicides, Quintazene followed by Kitazin' and Ediphenphos were found equally effective which were on par. Mancozeb and Ziram were found to be the most inferior one with respect to reduction in disease intensity but these were also significantly different from the control.

Application of insecticides though not so effective as fungicides in reducing disease intensity also resulted in a reduction in the incidence and intensity of sheath blight in rice. Among the insecticides tested, Carbaryl was the most effective one in reducing the incidence. The chemical was found to be on par with Carbofuran, Fenthion and Carbaryl + Lindane. Methyl parathion was found equally effective as Fenthion and they were on par with Carbaryl + Lindane and Monocrotophos but these were found significantly inferior to Carbaryl and Carbofuran. Formothion was equally effective as Methyl parathion, Monocrotophos, Dimethoate and Phorate but these treatments were significantly inferior to Carbaryl. Hexachlorocyclohexane, Malathion and Fenitrothion were the least effective chemicals which were on par with control. When the intensity was considered, Monocrotophos minimised the disease intensity to the lowest level, followed by Methyl parathion, Carbaryl, Fenthion, Carbaryl + Lindane and Hexachlorocyclohexane and these treatments were on par. Formothion Dimethoate, Fenitrothion, Carbofuran and Phorate

were significantly different from Monocrotophos and were equally effective. Malathion recorded the maximum disease intensity which was on par with the control (Table 10).

Table 10. Effect of insecticides on the incidence and intensity of sheath blight.

Serial No.	Insecticides	Mean per cent hill infection	Rank	Mean disease intensity	Rank
1	Carbaryl	26.62	I	18.51	III
2	Carbaryl + Lindane	33.40	V	20.99	V
3	Carbofuran	27.35	II	30.86	XI
4	Dimethoate	41.05	VIII	25.92	VIII
5	Fenitrothion	48.84	X	19.75	IV
6	Fenthion	29.57	III	28.39	IX
7	Formothion	40.74	VII	24.69	VII
8	Hexachlorocyclohexane	55.55	XIII	23.65	VI
9	Malathion	49.81	XI	54.31	XII
10	Methylparathion	38.02	VI	17.28	II
11	Monocrotophos	36.97	V	12.34	I
12	Phorate	41.95	IX	30.86	X
13	Control	51.73	XII	54.31	XIII

CD for comparison of disease incidence = 9.7802

CD for comparison of disease intensity = 11.8652

Application of herbicides also minimised the disease incidence as well as intensity. Propanil was the most effective herbicide followed by Benthiocarb, Pendimethalin and Bentazone which were on par. Butachlor and Nitrofen were equally effective as Benthiocarb but significantly inferior to Propanil. Fluchloralin and 2,4D Sodium salt were the least effective chemicals which were on par with the control (Table 11).

Table 11. Effect of application of herbicides on the incidence and intensity of sheath blight.

Serial No.	Treatments	Mean per cent hill infection	Rank	Mean disease intensity	Rank
1	Bentazone	34.83	IV	21.01	II
2	Benthiocarb	33.99	II	22.22	III
3	Butachlor	41.48	V	11.97	VIII
4	Fluchloralin	48.17	VIII	33.33	VII
5	Nitrofen	42.98	VI	28.39	V
6	Pendimethalin	34.19	III	30.86	VI
7	Propanil	27.69	I	13.57	I
8	Sodium salt of 2,4D	46.74	VII	25.92	IV
9	Control	53.00	IX	54.31	IX

CD for comparison of disease incidence = 10.6217
CD for comparison of disease intensity = 18.1101

Table 12. Effect of combined application of chemicals on the incidence and intensity of sheath blight.

Serial No.	Treatment combinations	Mean per cent hill infection	Rank	Mean disease intensity	Rank
1	Carbaryl + Monocrotophos	41.89	VIII	38.23	X
2	Carboxin + Carbaryl	29.27	III	13.59	V
3	Carboxin + Monocrotophos	40.93	IX	13.59	V
4	Ediphenphos + Carbaryl	26.48	II	8.64	II
5	Ediphenphos+Monocrotophos	31.06	IV	13.59	V
6	Ediphenphos + Carboxin	24.56	I	8.64	II
7	2,4D Sodium salt+Carbaryl	36.52	VII	10.70	III
8	2,4D Sodium salt+Carboxin	45.78	X	6.99	I
9	2,4D Sodium salt + Carboxin	36.22	V	6.99	I
10	2,4D Sodium salt + Monocrotophos	36.39	VI	11.52	IV
11	Control	54.21	XI	54.31	VI

CD for comparison of disease incidence = 7.3585
CD for comparison of disease intensity = 13.8372

When the combination of chemicals was tried, it was evident that Ediphenphos + Carboxin was the most effective treatment in minimising the incidence of sheath blight followed by Ediphenphos + Carbaryl, Carboxin + Carbaryl and Ediphenphos + Monocrotophos which were on par. 2,4D Sodium salt + Ediphenphos was equally effective as Ediphenphos + Monocrotophos which were on par with 2,4D Sodium salt + Carbaryl and 2,4D Sodium salt + Monocrotophos but was significantly inferior to Ediphenphos + Carboxin (Table 12).

Carboxin + Monocrotophos and Carbaryl + Monocrotophos were found equally effective as 2,4D Sodium salt + Ediphenphos and were on par with 2,4D Sodium salt + Monocrotophos and 2,4D Sodium salt + Carbaryl. 2,4D Sodium salt + Carboxin was the least effective treatment which was on par with control.

In reducing the intensity of disease, the treatment combination, 2,4D Sodium salt + Vitavax ranked first followed by 2,4D Sodium salt + Ediphenphos, Ediphenphos + Carboxin, Ediphenphos + Carbaryl, 2,4D Sodium salt + Carbaryl, 2,4D Sodium salt + Monocrotophos, Ediphenphos + Monocrotophos, Carboxin + Carbaryl and Carboxin + Monocrotophos which were on par. Carbaryl + Monocrotophos was the most inferior combination with respect to the reduction of sheath blight intensity which was on par with the control.

Yield

No significant differences in yield were obtained by application of plant protection chemicals. Among the fungicides, Ediphenphos recorded the maximum yield but the treatments were statistically insignificant (Table 13).

Table 13. Effect of application of fungicides on the yield of rice plants.

Serial No.	Fungicides	Yield of rice per pot (g)
1	Captafol	46.67
2	Carbendazim	40.33
3	Carboxin	45.33
4	Ediphenphos	51.33
5	Kitazin	43.00
6	Mancozeb	45.33
7	Quintozene	39.67
8	Ziram	38.00
9	Control	38.00

CD = 19.19640

Regarding insecticides too, no significant differences was noticed between treatments. However, Dimethoate recorded the maximum yield of 49 grams and Carbaryl + Lindane the lowest of 38 grams (Table 14).

Table 14. Effect of application of insecticides on the yield of rice plants.

Serial No.	Insecticides	Yield of rice per pot (g)
1	Carbaryl	44.00
2	Carbaryl + Lindane	38.00
3	Carbofuran	40.00
4	Dimethoate	49.00
5	Fenitrothion	47.33
6	Fenthion	41.33
7	Formothion	44.00
8	Hexachlorocyclohexane	44.00
9	Malathion	41.00
10	Methyl parathion	40.00
11	Monocrotophos	40.33
12	Phorate	43.00
13	Control	41.00

CD = 18.3574

Application of herbicides too had no pronounced effect on the yield. All the treatments were statistically insignificant. However, Benthiocarb and Nitrofen recorded the maximum and minimum grain yield (Table 15).

Table 15. Effect of application of herbicides on the yield.

Serial No.	Herbicides	Yield per pot(g)
1	Bentazone	44.67
2	Benthiocarb	40.33
3	Butachlor	42.00
4	Fluchloralin	47.00
5	Nitrofen	38.33
6	Pendimethalin	42.00
7	Propanil	42.00
8	Sodium salt of 2,4D	46.00
9	Control	40.00

CD = 20.57228

Table 16. Effect of combined application of plant protection chemicals on the yield.

Serial No.	Treatments	Yield per pot (g)
1	Carbaryl + Monocrotophos	38.00
2	Carboxin + Carbaryl	40.00
3	Carboxin + Monocrotophos	42.00
4	Ediphenphos + Carbaryl	47.67
5	Ediphenphos + Monocrotophos	39.00
6	Ediphenphos + Carboxin	43.67
7	2,4D Sodium salt + Carbaryl	42.00
8	2,4D Sodium salt + Carboxin	43.67
9	2,4D Sodium salt + Ediphenphos	41.67
10	2,4D Sodium salt + Monocrotophos	38.33
11	Control	39.33

CD = 7.358584

None of the above treatments were significant with regard to the yield. However, Ediphenphos + Carbaryl recorded the maximum yield and Carbaryl + Monocrotophos the lowest yield (Table 16).

3d. Effect of application of plant protection chemicals on the soil microflora.

The effect of application of fungicides, insecticides and herbicides on soil microflora was studied by serial dilution technique as described under Materials and Methods. It was found that Captafol, Ediphenphos and Carboxin enhanced the soil fungal population (Table 17). Ziram followed by Mancozeb, Carbendazim, Quintozene and Kitazin decreased the fungal population. However, these treatments were statistically on par with control.

Table 17. Effect of application of fungicides on soil microflora.

Serial No.	Fungicides	Mean counts of fungi after x transformation	Mean counts of bacteria after x transformation	Mean counts of actinomycetes after x + 1 transformation
1	Captafol	8.77	3.26	2.21
2	Carbendazim	5.75	2.29	2.04
3	Carboxin	7.60	2.06	1.82
4	Ediphenphos	7.96	3.60	1.47
5	Kitazin	6.19	2.69	1.28
6	Mancozeb	5.49	2.75	1.24
7	Quintozene	5.79	2.55	1.14
8	Ziram	5.28	2.43	1.24
9	Control	5.76	2.82	2.28

CD for comparison of a = 1.0086
CD for comparison of b = 0.6045
CD for comparison of c = 0.8466

The population of bacteria was also affected by the addition of chemicals. Carboxin ranked first in reducing the bacterial population followed by Carbendazim, Ziram and Quintozene. These treatments were on par. Ediphenphos was found to enhance the bacterial population to maximum level, followed by Captafol, Mancozeb and Kitazin which were on par with control.

With regard to actinomycetes population, Quintozene was the most superior one in reducing the population followed by Ziram, Mancozeb, Kitazin, Ediphenphos and Carboxin which were on par. Carbendazim and Captafol were significantly inferior to Quintozene which were on par with control.

Insecticides too affect the soil microflora in quite a diversified manner. Carbofuran, Carbaryl + Lindane, Carbaryl and Fenthion were found to enhance the fungal population significantly. Treatments Phorate and Fenitrothion tend to reduce the fungal population to the maximum and they were on par (Table 18).

Table 18. Effect of application of insecticides on soil microflora.

Serial No.	Insecticides	Mean counts of fungi after x transformation	Mean counts of bacteria after x transformation	Mean counts of actinomycetes after x+1 transformation
1	Carbaryl	7.34	3.08	1.82
2	Carbaryl + Lindane	7.20	3.32	1.79
3	Carbofuran	7.17	3.88	1.82
4	Dimethoate	6.14	3.72	1.49
5	Fenitrothion	4.43	3.03	1.38
6	Fenthion	7.68	3.57	1.55
7	Formothion	5.48	3.30	1.99
8	Hexachlorocyclohexane	5.28	3.54	2.14
9	Malathion	6.61	3.34	1.79
10	Methylparathion	5.57	3.09	1.49
11	Monocrotophos	6.95	3.89	1.14
12	Phorate	3.57	3.23	2.29
13	Control	5.71	2.94	2.43

CD for comparison of a = 1.7976
CD for comparison of b = 1.1307
CD for comparison of c = 0.9470

Formothion, Hexachlorocyclohexane, Methyl parathion, Dimethoate, Malathion and Monocrotophos too reduced the fungal population but less effective than Phorate and Fenitrothion and were on par with the control. All the insecticides tried were found to increase the bacterial population while all of them decreased the actinomycetes population.

Herbicides in general tend to decrease the soil microflora. Studies on the effect of herbicides on soil

microflora revealed that excepting Nitrofen all other chemicals decreased the fungal population (Table 19). 2,4D Sodium salt was the most superior one. Bentazone, Fluchloralin, Butachlor and Propanil were equally effective as 2,4D Sodium salt in reducing the fungal population. Benthiocarb and Pendimethalin were significantly inferior to 2,4D Sodium salt and were on par (Table 19).

Table 19. Effect of application of herbicides on the soil microflora.

Serial No.	Herbicides	Mean counts of fungi after x transformation	Mean counts of bacteria after x transformation	Mean counts of actinomycetes after x+1 transformation
1	Bentazone	3.55	2.20	2.08
2	Benthiocarb	4.66	2.58	1.14
3	Butachlor	3.93	4.89	2.03
4	Fluchloralin	3.78	2.45	1.52
5	Nitrofen	6.83	3.01	2.19
6	Pendimethalin	5.70	3.40	1.14
7	Propanil	4.51	3.27	2.16
8	Sodium salt of 2,4D	3.50	2.24	1.38
9	Control	5.71	3.19	1.97

CD for comparison of a = 1.0356
CD for comparison of b = 0.9838
CD for comparison of c = 0.6410

In the case of bacterial population excepting Butachlor, Pendimethalin and Propanil all other treatments decreased the bacterial population. The maximum reduction in bacterial population was noted in the case of Bentazone, followed by 2,4D Sodium salt, Fluchloralin, Benthiocarb and Nitrofen which were on par. Propanil and Pendimethalin were inferior to Bentazone and these were on par with the control.

Regarding actinomycetes population too, Nitrofen Propanil, Butachlor and Bentazone increased the population while all other treatments decreased the same. Benthiocarb was the most effective herbicide in reducing the population which was on par with Pendimethalin, 2,4D Sodium salt and Fluchloralin. Propanil, Bentazone, Butachlor and Fluchloralin were on par with control and significantly inferior to Benthiocarb (Table 19).

4. Studies on microorganisms antagonistic to Rhizoctonia solani on the rhizosphere of rice

4a. Isolation and identification

Representative isolates of fungi, bacteria and actinomycetes obtained from the rhizosphere were subcultured and maintained on PDA slants. The identification of all these fungi were confirmed by Commonwealth Mycological Institute, Surrey, England.

The colony interactions between R. solani and the non target mycoflora isolated were studied in vitro by growing the non target fungi individually with the pathogenic fungus on PDA in sterile petri dishes. Each pair of fungi was inoculated in petri dishes three centimetres apart and three replicates were set up per combination. Monoculture of the fungi in petri dishes inoculated under identical conditions served as control. The results are presented in Table 20 (Plates 29-34).

Table 20. Antagonistic activity of common microflora obtained from rhizosphere of rice on Rhizoctonia solani.

Serial No.	Fungi	Reactions		
1	Aspergillus flavus	-	-	-
2	Aspergillus niger	+	+	+
3	Aspergillus sparsus Raper & Thom	-	-	-
4	Aspergillus sydowii Bainier & Sartory	-	-	-
5	Aspergillus terreus Thom	-	-	-
6	Botryodiplodia theobromae Pat	-	-	-
7	Chaetomium globosum Kunzeex F.	+	+	+
8	Curvularia lunata Wakker	-	-	-
9	Cylindrocladium camelliae Venkataramani & Venkataram	-	-	-
10	Fusarium solani (Mart) Sacc.	+	+	+
11	Neurospora crassa	+	+	+
12	Penicillium citrinum Thoma	-	-	-
13	Penicillium javanicum (V.Beyma.)Stolk & Scott	-	-	-
14	Penicillium oxalicum Currie & Thom	+	+	+
15	Thermoascus aurantiacus Miche	-	-	-
16	Trichoderma viride	+	+	+
17	Bacillus sp.	+	+	+
18	Streptomyces sp.	+	+	+

'+' = indicates positive antagonistic activity
'-' = indicates negative antagonistic activity

Plate 29

0 - *Rhizoctonia solani*

1 - *Aspergillus niger* x *R. solani*

2 - *Aspergillus niger*

Plate 30

0 - *Chaetomium globosum*

1 - *Chaetomium globosum* x *R. solani*

2 - *R. solani*

PLATE 29
Antagonism of *Aspergillus niger* and *R. solani*

PLATE 30
Antagonism of *Chaetomium globosum* and *R. solani*

Plate 31

0 - *Fusarium solani*
1 - *Fusarium solani* x *R. solani*
2 - *R. solani*

Plate 32

0 - *Neurospora crassa*
1 - *Neurospora crassa* x *R. solani*
2 - *R. solani*

PLATE 31
Antagonism of *Fusarium solani* and *R. solani*

PLATE 32
Antagonism of *Neurospora crassa* and *R. solani*

Plate 33

0 - *Penicillium oxalicum*

1 - *Penicillium oxalicum* x *R. solani*

2 - *R. solani*

Plate 34

0 - *Trichoderma viride*

1 - *Trichoderma viride* x *R. solani*

2 - *R. solani*

PLATE 33
Antagonism of *Penicillium oxalicum* and *R. solani*

PLATE 34
Antagonism of *Trichoderma viride* and *R. solani*

Colony development was observed and assessment made of the interactions between the organisms when the growth pattern became stable. The interaction types were assigned accordingly as shown in Table 21.

Table 21. Pairing of antagonistic cultures obtained from soil with Rhizoctonia solani.

Serial No.	Antagonistic organism	Type of interaction
1	Aspergillus niger	B
2	Chaetomium globosum	C
3	Fusarium solani	A
4	Neurospora crassa	B
5	Penicillium oxalicum	C
6	Trichoderma viride	B
7	Bacillus sp.	D
8	Streptomyces sp.	C

A. Homogenous - free inter mingling of hyphae.
B. Over growth - R. solani over grown by test organisms.
C. Cessation of growth at the line of contact.
D. Aversion: A clear zone of inhibition seen.

5. In vivo effect of antagonistic organisms on the intensity of sheath blight disease

Studies on the effect of antagonistic organisms on the incidence of sheath blight revealed that among the organisms tried for the control of sheath blight, Trichoderma viride (Plate 35) was the superior one which recorded the maximum reduction of disease followed by Neurospora crassa,

Aspergillus niger and Chaetomium globosum. Fusarium solani and Penicillium oxalicum (Plate 37) were found inferior in controlling the disease when compared to other treatments (Table 22).

Table 22. Effect of application of antagonistic organisms and chemicals on the intensity of sheath blight.

Serial No.	Treatments	Intensity of sheath blight
1	Penicillium oxalicum + Carbofuran	4.33
2	Penicillium oxalicum + Carboxin	3.66
3	Penicillium oxalicum + Control	5.22
4	Fusarium solani + Carbofuran	4.55
5	Fusarium solani + Carboxin	5.22
6	Fusarium solani + Control	4.55
7	Chaetomium globosum + Carbofuran	3.44
8	Chaetomium globosum + Carboxin	2.33
9	Chaetomium globosum + Control	3.22
10	Aspergillus niger + Carbofuran	3.22
11	Aspergillus niger + Carboxin	2.77
12	Aspergillus niger + Control	2.55
13	Neurospora crassa + Carbofuran	2.55
14	Neurospora crassa + Carboxin	2.55
15	Neurospora crassa + Control	2.55
16	Trichoderma viride + Carbofuran	1.66
17	Trichoderma viride + Carboxin	1.44
18	Trichoderma viride + Control	1.44
19	Control + Carbofuran	6.33
20	Control + Carboxin	1.87
21	Control	2.11

CD for comparison of factor a = 0.8282
CD for comparison of factor b = 0.5422
CD for comparison of factor c = 1.4345

Plate 35

0 - Healthy plant

4 - Rice plant sprayed with Trichoderma viride

Plate 36

0 - Healthy plant

2 - Rice plant sprayed with Trichoderma viride x Carboxin

PLATE 35
Effect of application of *Trichoderma viride* on the intensity of sheath blight

PLATE 36
Effect of application of *Trichoderma viride* + Carboxin on the intensity of sheath blight.

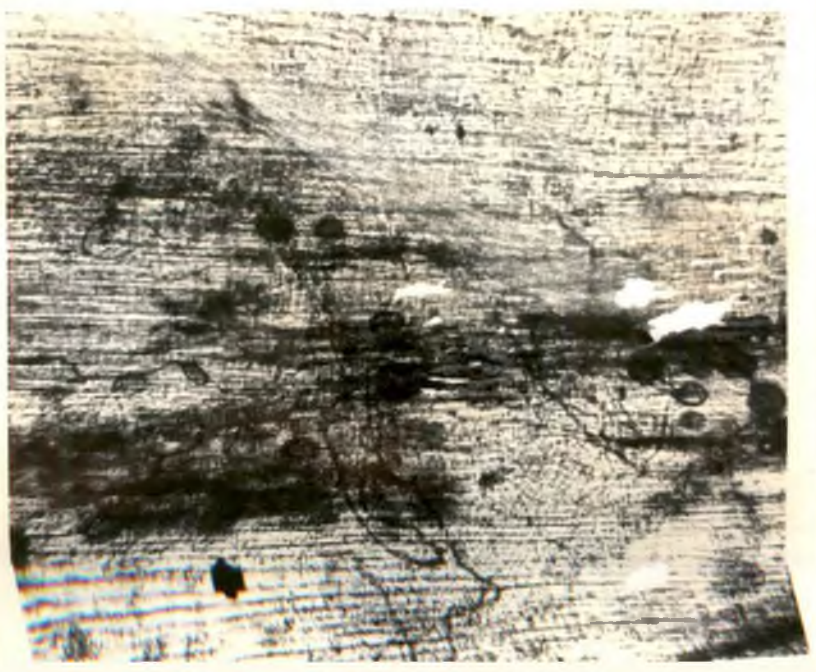
Plate 37

0 - Healthy plant

1 - Rice plant sprayed with *Penicillium oxalicum*

PLATE 37
Effect of application of Penicillium oxalicum on the intensity of sheath blight

PLATE 38
Occurrence of mycorrhizae in plants treated with Quintozene



Among the chemicals tried, Carbofuran was the most effective chemical followed by Carboxin and they were on par. When a combination of the antagonistic organisms together with pesticides was tried, it was found that Trichoderma viride + Carbofuran and Trichoderma viride + Carboxin (Plate 36) were the most effective treatment combinations since these treatment combinations recorded a lesser incidence of the disease (Table 22). These treatments were followed by Trichoderma viride + water spray, Control + Carbofuran, Control + Carboxin, Neurospora crassa + Carboxin, Neurospora crassa + Carbofuran, Neurospora crassa + water spray, Fusarium solani + Carbofuran, Chaetomium globosum + Carbodin and these treatments were on par.

Among the remaining combinations Aspergillus niger + water spray, Chaetomium globosum + Carboxin , Chaetomium globosum + water spray, Control + water spray, Fusarium solani + water spray Fusarium solani + Carbofuran and Fusarium solani + Carboxin were on par and significantly different from the control. The combination Penicillium oxalicum + Carbofuran alone was found inferior in controlling the disease which was on par with the control (Table 22).

5a. Effect of addition of antagonistic organisms and application of selected plant protection chemicals on rhizosphere mycoflora of rice.

The rhizosphere mycoflora of rice was found to be differing greatly in their response to the application of plant protection chemicals (Table 23). The soil population of Trichoderma viride was found to be enhanced by the application of plant protection chemicals. Another case of enhancement of rhizosphere population occurred for Aspergillus niger by the application of Carbaryl, Mancozeb, Ediphemphos, and Carboxin. The application of Carbaryl, Mancozeb and Carbofuran had a depressing influence on the soil population of Fusarium solani. The population of Penicillium oxalicum was increased by the application of Carbaryl and Carboxin while Mancozeb, Carbofuran and Ediphenphos had a depressing influence.

Herbicides generally caused a fall in the soil mycofloral count (Table 23). The population of Aspergillus niger was found to be enhanced by the application of Bentazone, Propanil and Nitrofen while that of Fusarium solani was increased by the application of Bentazone and Propanil. In all the other treatments the antagonistic organisms were tremendously decreased.

6. Studies on the occurrence of mycorrhizae in paddy

Maximum occurrence of mycorrhizal association could be seen in rice plants treated with Quintozene (90%) (Plate 38) and those in which fertilizers were added along with Quintozene spraying. This was on par with the control plants (Plate 40). The percentage occurrence of mycorrhizae in plants inoculated with *R. solani* and in which fertilizers have been added together with spraying of Quintozene was also high and amounted to 81 per cent. The presence of mycorrhizae was also conspicuous in certain rice plants treated with Carbofuran (Plate 39). No mycorrhizal association could be seen in rice plants treated with Phorate, Carbendazim and Carboxin (Table 24).

Table 24. Occurrence of mycorrhizae in paddy after treatment with plant protection chemicals.

Serial No.	Treatments Chemical/Inoculation with *R. solani*/Fertilizer	Mean percentage occurence of mycorrhiza after angular transformation
1	Carbofuran + no inoculation + no fertilizer	70.195
2	Carbofuran + no inoculation + fertilizer	0
3	Carbofuran + inoculation + no fertilizer	0
4	Carbofuran + inoculation + fertilizer	62.154
5	Phorate + no inoculation + no fertilizer	0
6	Phorate + no inoculation + fertilizer	0
7	Phorate + inoculation + no fertilizer	0
8	Phorate + inoculation + fertilizer	0
9	Carboxin + no inoculation + no fertilizer	0
10	Carboxin + no inoculation + fertilizer	0
11	Carboxin + inoculation + no fertilizer	0
12	Carboxin + inoculation + fertilizer	0
13	Quintozene + no inoculation + no fertilizer	90.0
14	Quintozene + inoculation + fertilizer	81.951
15	Quintozene + inoculation + no fertilizer	73.902
16	Quintozene + inoculation + fertilizer	90.00
17	Carbendazim + no inoculation + no fertilizer	0
18	Carbendazim + no inoculation + fertilizer	0
19	Carbendazim + inoculation + no fertilizer	0
20	Carbendazim + inoculation + fertilizer	0
21	Control + no inoculation + no fertilizer	90.00
22	Control + no inoculation + fertilizer	65.944
23	Control + inoculation + no fertilizer	90.00
24	Control + inoculation + fertilizer	44.980

PLATE 39
Occurrence of mycorrhizae in rice seedlings treated with Carbofuran

PLATE 40
Occurrence of mycorrhizae in the untreated rice seedlings.

DISCUSSION

DISCUSSION

The incidence of sheath blight of rice has been observed in endemic form in most of the important rice growing tracts of Kerala. A number of biocides are now recommended in rice cultivation in the State for the control of pests, diseases and weeds. The present investigations were undertaken to make a critical assessment of the efficacy of the various plant protection chemicals, viz., fungicides, insecticides and herbicides on the incidence and intensity of sheath blight of rice and on the survival of the pathogen. Aspects like *in vitro* effects of the chemicals on the mycelial growth of *R. solani*, antagonistic effects of various micro-organisms obtained from rhizosphere to the sheath blight pathogen and effect of combined application of chemicals and antagonistic organisms on the incidence of sheath blight etc., were also included in the present study.

R. solani being an ubiquitous fungus, an attempt has been made in the present investigation to prove its pathogenicity in rice. An isolate was obtained

from the naturally infected rice fields. To prove the pathogenicity this isolate was artificially inoculated on to the rice variety Jyothi. The symptoms produced were similar to those observed under natural conditions. The pathogen was reisolated and the culture maintained throughout the study. Studies on the viability of sclerotia remained viable upto 210 days in all the three different types of soils used namely, sandy, clayey and loamy soils. The organism could survive on straw bits only upto 180th day. Roy (1976) reported that the sclerotia of Corticium sasakii remained viable upto nine months and he could not detect any difference between sterilized and unsterilized soil in supporting the survival of the sclerotia. He also reported that the rice sheath blight pathogen survived upto eight months and could over winter in soil and that the viability declined drastically during the ninth month under field conditions. In the present study it was detected that when tested on the 240th day, none of the sclerotia from the clayey soil germinated, whereas ninety per cent of the sclerotia kept in the sandy and loamy soils germinated. This sudden loss in viability may be due to absorption of moisture from the surface of sclerotia by the clay particles. According to Papavizas and Davey (1961) high soil moisture content will stimulate bacterial activity which in turn will affect the viability of R. solani.

The longer viability of sclerotia under dry conditions may be due to the formation of thick and hard wall which resist the adverse effect of environment as pointed out by Butler (1966). The lesser viability of the organism on plant debris in the different types of soils is mainly due to the disintegration of the debris as pointed out by Onesirosan and Sagay (1975) who remarked that infectivity of R. solani was lost when infected leaves were buried in soil with the disintegration of leaves. It may be likely that one or more of the above possibilities discussed were in operation in the present situation also. Whatever be the actual mechanism, it is evident that this organism had an efficient mechanism of survival as sclerotia of better than in the infected plant debris.

Kannaiyan and Prasad (1983) reported that the fungicides Benlate, Brassicol, Brestan, Macuprax, Captan, Wettable Cerasan, EL 273, NF 48, Demosan and Vitavax inhibited the saprophytic survival of the pathogen in soil. The pathogen survived upto 450 days in the untreated control. In the study on the effect of plant protection chemicals on the survival of R. solani, the minimum recovery of viable R. solani propagules was from soils treated with Mancozeb, Quintozene and Carboxin which were on par.

Results of the study on the *in vitro* effect of fungicides on *R. solani* revealed that Ediphenphos at 100 and 250 ppm, Carbendazim at 750 and 1000 ppm, Carboxin at 750 and 1000 ppm, Kitazin at 500, 750 and 1000 ppm and also Quintozene at the same levels were effective in checking the radial growth of the fungus. Ziram, Captafol and Mancozeb were effective only at 1000 ppm and above. The *in vitro* effect of fungicides on *R. solani* has been reviewed and attempted by several workers from time to time (Follen & Diallo, 1971; Mahendra Prabhath, 1971; Muneera, 1973; Mathai, 1975; Sen & Kapoor, 1975; Kataria & Grover, 1977). Regarding the effect of PCNB, there was difference of opinion among earlier workers. Vaartaja (1960) reported that PCNB was the least toxicant to *R. solani* whereas Nakanisha and Oku (1970) demonstrated that PCNB was strongly fungitoxic to *R. solani* in culture. Similarly Sinclair (1960) reported that *R. solani* isolates differed in their sensitivity to PCNB. Kesavan (1984) reported that mycelial growth of R. solani was effectively controlled by Captafol and PCNB at 10 ppm. The present results showed that Ziram, Captafol and Mancozeb were able to inhibit growth only at higher concentrations namely 1000 ppm and above. Muneera (1973) and Mathai (1975) have reported that Captan and Dithane M.45 were least effective at lower concentrations in inhibiting the growth of *R. solani* in culture.

Studies on the effect of insecticides on the *in vitro* growth of the fungus revealed that Carbaryl at 1000 ppm was able to give maximum inhibition of mycelial growth. Carbaryl + Lindane (Sevidol), Carbofuran, Dimethoate, Hexachlorocyclo hexane, Fenitrothion, Formothion, Fenthion, Methyl parathion, Monocrotophos and Phorate at the same concentrations as Carbaryl were equally effective in inhibiting the growth of the fungus. The effect of various insecticides on the *in vitro* growth has already been discussed by earlier workers.

Simkover and Shenefelt (1951) observed in their laboratory tests that crude BHC dusts would effectively inhibit the mycelial growth of *R. solani* on agar slants. The effect of Phorate against *R. solani* has been reviewed by Macskaylo and Steward (1962). They showed that the rate of inhibition of mycelial growth decreased as the concentration of Phorate increased in the medium. Naguib (1968) observed that Sevin (Carbaryl) even at lower concentrations could effectively reduce the growth of *R.solani*.

Lakshmanan and Nair (1980) from a detailed *in vitro* study with granular insecticides concluded that Sevidol and Thimet were highly inhibitory to the growth of *R.solani* and its sclerotial formation and they have also suggested that the toxicity of Sevidol may be due to the presence of BHC moiety in it as its component. The present

observations also indicated that Carbaryl and the granular insecticides, namely, Phorate and Sevidol were inhibitory to R. solani.

The results of the in vitro effect of herbicides revealed that Bentazone at 1000 ppm was the most effective one followed by Benthiocarb, Butachlor, Fluchloralin, Nitrofen and 2,4D Sodium salt each at 1000 ppm concentration. Propanil at lower levels of 500, 750 and 1000 ppm and also 750 and 1000 ppm of Pendimethalin were also equally effective as the above treatment. The effectiveness of Benthiocarb, Butachlor, Fluchloralin, Nitrofen and 2,4D have been reviewed and attempted by various workers (Varma et al., 1978; Lakshmanan and Nair, 1980; Millikan and Fields, 1964).

Propanil was effective even at lower concentrations of 500 ppm. Inderawati and Heitefuss (1977) reported fifty per cent reduction of radial growth of Corticium sasakii with 10 ug/ml commercial formulation of Propanil. Dath and Swain (1979) also found complete inhibition of radial growth of Corticium sasakii in the presence of 25 to 500 ppm of Propanil. Out of the ten herbicides tested, Propanil was the most effective one to inhibit the growth of Corticium sasakii. The results of the present study also are in conformity with these findings and Propanil can be

considered as a herbicide with high potentiality in suppressing the growth of sheath blight organism. Fluchloralin used for the *in vitro* tests was effective only at higher concentration of 1250 ppm. Verma *et al.* (1979) pointed out that the chemical Fluchloralin has no effect on *R. bataticola* but reduced the radial growth of mycelia of other fungi, namely, *Fusarium oxysporum* f. *ciceri* and *Sclerotium rolfsii*. Vyas and Khare (1983) also reported the high toxicity of the chemical on *S. rolfsii* than on *R. bataticola* and *F. oxysporum* 2,4d Sodium salt was effective only at high concentrations of 1000 ppm. At lower concentrations of 100, 250 and 500 ppm there was complete growth of the test fungus. According to Millikan and Fields (1964) there was only 86 per cent inhibition of growth in 100 ppm of the chemical. In the present study too, only 56 per cent inhibition of growth was obtained in 100 ppm of the chemical. However, there was no stimulation of growth as detected by Kurodani *et al.* (1959) and Tatsuyama and Jikihara (1970). Studies conducted by Lakshmanan and Nair (1980) revealed that a number of the common herbicides recommended for rice fields except that of 2,4D did not inhibit the growth of *R.solani*. From the results of the present study, it can be concluded

that Propanil at 500 and 750 ppm is the most effective herbicide in checking the growth of R. solani. The effects of Bentazone, Benthiocarb and Butachlor are on par with that of Propanil.

Results of the pot culture study undertaken to evaluate the influence of various plant protection chemicals on the incidence and intensity of sheath blight disease on rice crop revealed that fungicides ranked first in reducing the disease intensity. Among the fungicides Ediphenphos was able to give maximum reduction of the incidence of the disease. This was followed by Carboxin and Kitazin which were on par. Application of Quintozene in soil was found equally effective as Kitazin Carbendazim and Ziram. The fungicides Captafol and Ziram were equally effective in minimising the disease but inferior to Carbendazim. Considering the intensity of the disease, the fungicides Carbendazim recorded the maximum reduction followed by Captafol and Carboxin. Kitazin, Ediphenphos and Quintozene were found equally effective in minimising the intensity but these were significantly inferior to Carbendazim. The in vivo effect of different fungicides have been reviewed by various workers from time to time from various parts of the world. Eventhough a wide range of

fungicides have been detected to be effective against this disease, the use of Ediphenphos, Carboxin and Carbendazim is more commonly recommended. (Umeda, 1973; Kannaiyan & Prasad, 1976; Mukherjee, 1978; Nair & Rajan, 1978; Jaganathan & Kannaiyan, 1978; Kannaiyan & Prasad, 1979; Dev & Satyarajan, 1980; Roy, 1981; Anon., 1986).

The effect of PCNB in checking the disease has also been reviewed by Kannaiyan and Prasad (1976). PCNB is reported to be effective in controlling a number of soil borne diseases caused by Rhizoctonia solani. Another study by Suhag and Rana (1984) showed that soil drenching with Quintozene could protect onion seedlings from R.solani infection in glass house.

Among the fungicides tested Mancozeb and Ziram appeared the most inferior treatments. The inefficacy of Ziram in controlling the sheath blight pathogen was discussed by Hashioka (1952).

In the case of insecticides, Carbaryl was the most effective one in reducing the incidence of disease. Regarding herbicides, Propanil was the most effective herbicide followed by Benthiocarb, Pendimethalin and Bentazone.

Fluchloralin and 2,4D Sodium salt were the least effective in reducing the incidence.When the intensity of disease was considered, Propanil was the most superior treatment and Butachlor the most inferior. The efficacy of Propanil in reducing the disease intensity has been confirmed by Inderawati and Heitefuss (1977) who found that Propanil 10 ug/ml was effective in reducing the intensity. Lakshmi (1984) while conducting pot culture studies on the effect of herbicides on the intensity of sheath blight reported that Propanil was the most effective herbicide in reducing the intensity of sheath blight disease in rice.

Fluchloralin and 2,4D Sodium salt were the least effective in reducing the incidence. Fluchloralin r applied to soil reduced damping off of seedling by Pythium butleri at 20-25°C and enhanced damping off at 30°C. In vitro assay also revealed that Fluchloralin was effective only at a concentration above 1000 ppm.

There are several reports on the effect of 2,4D on the sheath blight pathogen. Kurodani et al. (1959) reported that sheath blight was increased by spraying with 2,4D.

Though in the present experiment there was no increase in the incidence of disease it tends to be unaffected by spraying 2,4D. According to Manila and Lapis (1977) the disease was not affected by 2,4D.

Populations of fungi, bacterial and actinomycetes were less in the rhizosphere of infected plants than in healthy plants. The activity of the pesticides applied to the crop is not only restricted to the target organism but extends to the non-target organisms as well. In the pot culture studies conducted it was found that Captafol, Ediphenphos and Carboxin enhanced the soil microbial population. Wainwright and Sowden (1977) have reviewed that Benomyl, Captan and Thiram increased the proportion of fungi and bacteria in soil. The fungal population was reduced by Ziram, Carbendazim, Quintozene and Kitazin. Kannaiyan and Prasad (1979) conducted pot culture experiments using several fungicides and have found that Kitazin, Hinosan, Benlate, Vitavax and Bavistin inhibited fungal population.

Regarding bacterial and actinomycetes population, it was found that Ediphenphos enhanced the bacterial population while Carboxin, Carbendazim, Ziram and Quintozene decreased the population of bacteria. All the fungicides

tested, reduced the actinomycetes population of the soil. The role of Ediphenphos in enhancing the bacterial population was already been established by Kannaiyan and Prasad (1979). Farley and Lockwood (1968) reported that Quintozene at 1 ppm reduced actinomycetes by 65% and at 25 - 200 ppm actinomycetes were reduced by 99%. This finding is in confirmity with the result obtained in the present study, in which Quintozene was reported to reduce the actinomycete population drastically.

Insecticides affect the soil microflora in quite a diversified manner. Carbofuran, Carbaryl + Lindane, Carbaryl and Fenthion enhanced the fungal population significantly. Treatment with Phorate and Fenitrothion tend to reduce the fungal population to the maximum. Visalakshy et al. (1980) reported that Carbofuran when used at recommended dosages did not affect the microbial activity. The toxicity of Phorate at higher dose of 20 kg/ha was already established by Chelliah (1972) and Satpathy (1974). All insecticides tested in the present study enhanced the bacterial population while the actinomycetes population was decreased. There are reports on 100 to 300 per cent increase in bacterial population by the application of Carbofuran (Mathur et al., 1976). Obliswamy et al. (1977)

reported that Fensulfothion, Quinalphos and Disulfoton increased the population of bacteria and actinomycets. In the present study too, the bacterial population was enhanced while the actinomycetes population was significantly reduced by the application of insecticides. This is supported by the work of Roy et al. (1975) who reviewed that Diazinon, Carbofuran and Endosulfan reduced the actinomycete population.

Regarding the herbicides excepting Nitrofen all other chemicals decreased the fungal population as well as actinomycetes population. In the case of bacterial population excepting Butachlor all other treatments decreased the bacterial population. Venkataraman and Rajyalakshmi (1971) have reported that the bacterial and actinomycete population were suppressed by Ceresan M, Dithane, 2,4D, Dalapan, Propazine, Coloran, Linuron and Diuron. Another conclusive proof to the inhibition of soil fungi by herbicides was the work of Mosca et al. (1969). They found that most of the soil fungi were inhibited by the action of pre-emerge herbicides namely Herbitox Legumin and Leptam.

Soil organisms which are antagonistic to the rice sheath blight pathogen are very common under natural conditions in soil. The results of the study on the

antagonistic nature of mycoflora obtained from soil revealed that certain microorganisms exhibited a greater degree of antagonism towards the pathogen compared to others. Among the fungi, Trichoderma viride was the most virulent. Others exhibiting antagonism were Aspergillus niger, Neurospora crassa, Penicillium oxalium, Chaetomium globosum and Fusarium solani. The antagonistic activity of T. viride towards R. solani has been well established by many workers (Orgura & Akai, 1965; Naim & El Gsawy, 1965; Naiki & Ui, 1972; Roy, 1977). Gokulapalan (1981) recorded antagonistic activity of Aspergillus flavus and A. niger on R. solani. In the present study, A. niger was found to be highly antagonistic though no antagonism was noted for A. flavus. The antagonistic nature of Neurospora crassa to Pellicularia sasakii has already been noted by Endo et al. (1973). The possible use of the above organism to control sheath blight has been discussed. Penicillium oxalicum too has antagonistic action against Rhizoctonia solani. The antagonistic nature of Penicilium spp has been proved by Chu and Wu (1980). Tweit and Moore (1954) reported that Chaetomium globosum was antagonistic to Rhizoctonia sp. In the present study, Chaetomium globosum was found to be antagonistic to R. solani.

One bacterial isolate (Bacillus sp.) and one actinomycete isolate (Streptomyces sp.) both unidentified have also been found to be antagonistic to R. solani. There are several reports on the antagonistic activity of Bacillus subtilis on R. solani (Wood, 1951; Olsen, 1965; Chu, 1982). Antagonism of actinomycetes strains to R. solani has also been reported by Cooper and Chillon, 1949; Wood 1951; Chand & Logan, 1984).

The results of the potculture experiment laid out to study the effect of application of antagonistic organisms and plant protection chemicals on the incidence of sheath blight revealed that among the organisms used, Trichoderma viride was the most superior one resulting in maximum reduction of disease followed by Neurospora crassa, Aspergillus niger and Chaetomium globosum. There are several reports on the efficacy of Trichoderma viride in inhibiting the development of R. solani and several workers have used the same as a biocontrol agent against several diseases caused by R. solani. Both in vitro and in vivo experiments conducted by Sadowski (1976) it was evident that T. viride and T. glaucum inhibited the development of the pathogen R. solani in soils rich in humus. Other species of Trichoderma namely T. harzianum could suppress the pathogen R. solani causing seed decay and damping off of mustard.

(Akhtar, 1969). T. hamatum controlled root rot of pea or raddish in soil infested with R. solani or Pythium sp. (Chet et al., 1981) Neurospora crassa was the second most effective organism in controlling the incidence of sheath blight. Endo et al. (1973) has reported the reduced incidence of Corticium sasakii the causal agent of sheath blight of rice plant by Neurospora crassa. The effectiveness of Aspergillus niger has been reviewed by several workers (Shukla & Dwivedi, 1979; Neweigy et al., 1981). Venkata-subbaiah and Safeeulla (1984) demonstrated that under glass house conditions seed treatment with A. niger reduced the incidence of collar rot of coffee seedlings.

Studies on the occurrence of mycorrhizae revealed that mycorrhizae were present in rice plants and it has been enhanced in the pots treated with Quintozene. Fertilizer addition too did not inhibit the presence of mycorhizae. The occurrence of mycorrhizae has already been reviewed by several workers (Iqbal et al., 1978; Gangopadhyay & Das, 1982; Gangapadhyay & Das, 1984). Increased endomycorrhizae cottan roots, after application of nemalicides has been observed by Bird et al. (1974) while deleterious effects of certain fungi toxicants on formation of mycorrhizae in corn root has been noted by Nesheim and Zinn (1969).

SUMMARY

SUMMARY

Rhizoctonia solani is an ubiquitous fungus affecting a wide range of crop plants. In rice, the sheath blight disease caused by R. solani is devastating resulting in great economic loss. The present investigation was undertaken to make a critical assessment of the efficacy of various plant protection chemicals, viz., fungicides, insecticides and herbicides on the incidence and intensity of sheath blight of rice and on the survival of the pathogen.

The organism was isolated from naturally infected rice fields and its pathogenicity proved. The pathogen was reisolated and the culture maintained throughout the study. Studies on the viability of sclerotia revealed that sclerotia remained viable upto 210 days in all the different types of soils used, namely sandy, clayey and loamy. The organism could survive in straw bits only upto 180th day.

Results of the in vitro evaluation of fungicides on R. solani revealed that Ediphenphos at 100 and 250 ppm, Carbendazim at 750 and 1000 ppm, Carboxin at 750 and 1000 ppm, Kitazin at 500, 750 and 1000 ppm and also

Quintozene at the same levels were effective in checking the radial growth of the fungus. Studies on the effect of insecticides on the *in vitro* growth of the fungus revealed that Carbaryl at 1000 ppm was able to give maximum inhibition of mycelial growth. Carbaryl + Lindane (sevidol) Carbofuran, Dimethoate, Hexachlorocyclohexane, Fenitrothion, Formothion, Fenthion, Methyl parathion, Monocrotophos and Phorate at the same concentrations as Carbaryl were equally effective in inhibiting the growth of the fungus. Regarding herbicides, Bentazone at 1000 ppm was the most effective one followed by Benthiocarb, Butachlor, Fluchloralin, Nitrofen and 2,4D sodium salt each at 1000 ppm concentration. Propanil at lower levels of 500, 750 and 1000 ppm and also 750 and 1000 ppm of Pendimethalin were also equally effective as the above treatment. A pot culture experiment revealed that Ediphenphos was the most effective fungicide against the disease. This was followed by Carboxin and Kitazin which were on par. The fungicides Captafol and Ziram were equally effective in minimising the disease but inferior to Carbendazim.

Regarding intensity of the disease, Carbendazim recorded the maximum reduction followed by Captafol and Carboxin. Kitazin, Ediphenphos and Quintozene were found equally effective in minimising the intensity but these were significantly inferior to Carbendazim.

Among the insecticides, Carbaryl was the most effective one in reducing the incidence of disease. Regarding herbicides, Propanil was the most effective herbicide followed by Benthiocarb, Pendimethalin and Bentazone. Fluchloralin and 2,4D Sodium salt were the least effective in reducing the incidence.

Studies conducted on the effect of pesticides on the rhizosphere population revealed that Captafol, Ediphenphos and Carboxin enhanced the soil microbial population while Ziram, Carbendazin, Quintozene and Kitazin reduced the population. Regarding bacterial and actinomycetes population it was found that Ediphenphos enhanced the bacterial population while carboxin, Carbendazim, Ziram and Quintozene decreased the population of bacteria. All the fungicides tested, reduced the actinomycetes population of the soil. Insecticides affect the soil microflora in quite a diversified manner. Carbofuran, Carbaryl + Lindane, Carbaryl and Fenthion enhanced the fungal population significantly. Treatment with Phorate and Fenitrothion tend to reduce the fungal population to the maximum. All insecticides tested in the study enhanced the bacterial population while the actinomycetes population was decreased.

A pot culture experiment revealed that Ediphenphos was the most effective fungicide against the disease followed by Carboxin and Kitazin which were on par. Among the insecticides, Carbaryl was the most effective one in reducing the incidence of disease and Propanil the best herbicide fluchloralin and 2,4D Sodium salt were the least effective herbicides.

Among the antagonistic flora obtained from soil Trichoderma viride was the most virulent. Others exhibiting antagonism were Aspergillus niger, Neurospora crassa, Penicillium oxalicum, Chaetomium globosum and Fusarium solani.

The results of the pot culture experiment laid out to study the effect of application of antagonistic organism and plant protection chemicals on the incidence of sheath blight revealed that among the organisms used, Trichoderma viride was superior since it resulted in the maximum reduction of disease followed by Neurospora crassa, Aspergillus niger and Chaetomium globosum. Studies on the occurrence of mycorrhizae revealed that mycorrhizae were present in rice plants and it has been enhanced in the pots treated with Quintozene.

REFERENCES

REFERENCES

Agnihotri, V.P. (1971). Persistence of Captan and its effect on microflora, respiration and nutrification of a forest nursery soil. Can. J. Microbiol 17: 377-383.

Agnihotri, V.P., Sinha, A.P., Kishan Singh (1981). Influence of insecticides on soil micro organisms and their bio chemical activity. Pesticides 15(8): 16-24.

Akhtar, C.M. (1969). Biological control of Rhizoctonia solani causing seed decay and damping off of mustard. W. Pakist. Jnl. agric. Res. 7: 29-52.

Altman, J. and Campbell, C.L. (1977). Effects of herbicides on plant diseases Ann. Rev. Phytopathol. 15: 361-385.

Anonymous (1973). Plant Pathology. The International Rice Research Institute Annual report, IRRI, Philippines. pp.123-126.

Anonymous (1976 a). Standard evaluation system for rice, IRRI, Laguna, Philippines. 64 pp.

Anonymous (1976 b). Zero tillage in rice. Annual report, IRRI, Philippines. 230-231.

Anonymous (1978). Plant Pathology. The International Rice Research Institute, Annual Report. IRRI. Philippines. 178-180.

Anonymous (1982). Package of Practices Recommendations Kerala Agricultural University, Mannuthy, 199 pp.

Anonymous (1986). Package of practices Recommendations. Kerala Agricultural University, Mannuthy, 239 pp.

Audus, L.J. (1964). Herbicides behaviour in soil II. Interaction with soil micro organisms. In L.J. Audus (Ed). The physiology and Biochemistry of herbicides, Academic Press New York, 196 pp.

Bell, D.K., Wells, H.D. and Marrwam, C.K. (1982). In vitro antagonism of Trichoderma species against 6 fungul plant pathogens. Phytopathology 72:379-382.

Bhakthavalsalam, G., Reddy, A.P.K. and John, J.T. (1977). Chemical control of sheath blight of rice Pesticides 11(12): 13-16.

Bird, G.W., Rich, J.R. and Glover, S.U. (1974). Increased endomycorrhizae of cotton roots in soil treated with nematicides. Phytopathology 64: 48-51.

Bollen, W.B. (1961). Interaction between pesticides and soil microorganisms. Ann. Rev. Microbiol, 15:69-92.

Boosalis, M.G. (1956). Effect of soil temperature and green manure amendment of unsterilised soil on parasitism on Rhizoctonia solani by Penicillium vermiculatum and Trichoderma sp. Phytopathology 46: 473-478.

Borum, E.D. and Sinclair, J.B. (1968). Evidence of systemic protection against R. solani with Vitavax in cotton seedlings. Phytopathology 58:976-980.

Butler, E.J. (1918). Fungi and diseases in plants Thacker Spink and Co., Calcutta, pp.547.

Butler E.J. (1966). Vegetative structure. In G.C. Ainsworth and S. Sussman (Ed). The Fungi II The fungal organism pp. 83-112. Academic Press New York and London.pp.

Chand, T. and Logan, C. (1984). Antagonists and parasites of Rhizoctonia solani and their efficacy in reducing stem canker of potato under controlled conditions. Trans. Brit. mycol. Soc. 83;107-112.

Chaubal, R., Sharma, G.D. and Mishra, R.R. (1982). Visicular arbuscular mycorrhyza in sub tropical aquatic and marshy plant communities. Proc. Indian Acad Sci. Plant Sciences 91: 69-77.

Chelliah, S. (1972). Effect of pesticides on soil micro organisms, biological activities in soil and their influence on growth, nodulation and yield of Co-1 Black gram (Phaseolus mungo) M.Sc. Thesis Tamil Nadu Agricultural University, Coimbatore.

Chet, I. and Baker, R. (1981). Isolation and biocontrol potential of Trichoderma hamatum from soil naturally suppressive to Rhizoctonia solani. Phytopathology 71: 286-290.

Chu, F.F. and Wu, W.S. (1980). Antagonistic action of Trichoderma and Penicillium spp. on R. solani. Memoirs of the College of Agriculture, National Taiwan University. 21(2): 4-18.

Chu, F.F. and Wu, W.S. (1981). Biological and chemical control of Rhizoctonia solani by pea seed treatment. Memors of the College of Agriculture, National Taiwan University, 21(2): 12-28.

Cooper, W.E. and Chilton, S.J.P. (1949). Studies on antibiotic soil organisms I. Actinomyces antibiotic to Pythium arrhenomanes in sugarcane soils of Loisiana. Phytopathology 40: 544-552.

Dash, S.C. and Panda, S. (1984). Chemical control of rice sheath blight disease. Indian Phytopath. 37: 79-82.

Dath, A.P. (1982). Effect of soil amendments with some green manures on the survival of sclerotia of Corticium Sasakii Indian Phytopath. 35:523-525.

Dath, A.P. and Swain, A. (1979). In vitro effects of certain nematicides and weedicides on Corticium sasakii. Indian J. Mycol. Pl: Pathol.9: 95-96

Datta, T.P. and Sharma, B.D. (1976). A preliminary study on the control of soreshing disease of cotton in West Bengal. Pesticides 10(8): 28-29.

D'Ercole, N., Sportelli, M. and Nipoti, P. (1983). Different types of antagonism of Trichoderma sp towards plant pathogenic soil fungi. Informatore Fitopatologico 34(11): 43-47.

Delen, N. and Yildiz, M. (1982). Fungicide resistance of some fungal pathogens isolated from green houses in Turkey. Journal of Turkish Phytopathology 11(½): 33-40.

Dennis, C. and Webster, J. (1971). Antagonistic properties of species groups of Trichoderma III Hyphal interaction. Trans. Br. mycol. Soc. 57:363-369.

Deshpande, J., Gangawane, L.V. and Awasarmol, B.V. (1984). Effect of 2, 4D on non target mycoflora in the rhizosphere of groundnut Indian Botanical Reports 3: 104-105.

Dev, V.P.S. (1980). Sheath blight control with soil fungicides., IRRN 5(3): 14-15.

Dev, V.P.S. and Sathyarajan, P.K. (1980). Efficiency of certain fungicides on the control of sheath blight disease of rice. Agric. Res. Kerala 18: 113-115.

Elsaid, H.M. and Sinclair, J.B. (1963). A new green house technique for evaluating fungicides for the control of cotton score - Shin. Plant. Dis. Reptr. 46: 852-856.

Endo, S. (1931). Studies on the sclerotium diseases of the rice plant. Ability of overwintering of certain important fungi causing sclerotium disease of the rice plant and their resistance to dry conditions Forsch. Geb. Pflanzenkrankh (Tokyo) 1: 149-167.

Endo, S., Shinohara, M., Kikuchi, J. and Wiraboyashi, Y. (1973). Studies on the soil borne pathogens parasitic on the same host. The antagonistic activity of Rhizoctonia solani to Fusarium oxysporum f. cucumerinum and its effect on the occurrence of fusarium wilt of cucumber plant. Bull. Coll. Agric. Vet. Med. Nihon Univ. 30: 85-95.

Endo, S. Shinohara, S. and Wara, S. (1965). Effect of PCP. Na herbicide on sheath blight of rice plant I. The inhibitive mechanism of PCP Na herbicide to the occurrence of the disease. II Residual effectiveness of PCP Na herbicide on Pellicularia sasakii (Shirai) S. Ito in irrigation. Bull. Coll. Agric. Vet. Med. Nihori Univ. 20: 1-9, 11-17.

Forley, J.D. and Lockwood, J.L. (1968). The suppression of actinomycetes by PCNB in culture media used for enumerating soil bacteria. Phytopathology 58: 714-715.

Ferrera - Cerratø, R. (1976). Hyperparasitism of Trichoderma viride (Hyphomycetes) on pathogenic and saprophytic fungi Revista Latinoamericana de Microbiologia 18: 77-81.

Follen, J.C. and Diallo, D. (1971). Damping off of cotton seedlings in Ivory coast I Study of fungicides in the laboratory. Cotton fibr trob 26: 303-306.

Gangopadhyay, S. and Das, K.M. (1982). Occurrence of vesicular arbuscular mycorrhizae in rice in India. Indian Phytopath 35: 83-85.

Gangopadhyay, S. and Das, K.M. (1984). Interaction between vesicular arbuscular mycorrhiza and rice roots. Indian Phytopath. 37: 34-38.

Gerret, S.D. (1956). Biology of Root Infecting Fungi. Cambridge University Press, London. 293 pp.

Gokulapalan, C. (1981). Role of rice root nematode (Hirschmanniella oryzae) in the incidence of sheath blight disease of rice in Kerala. M.Sc.(Ag) Thesis. Kerala Agricultural University. 89 pp.

Gupta, A.K., Aggarwal, A. and Mehrotra, R.S. (1985). In vitro studies on antagonistic microorganisms against Sclerotium oryzae. Catt Geobios 12(1): 3-5.

Hartzfield, F.G. (1957). 'Terrachlor' a new fungicide Agric. Chemic. 21: 31-33.

Hashiba, T. and Yamada, M. (1981). Viability of sclerotia famed on rice plants and on culture media by Rhizoctonia solani. Ann. phytopath. Soc. Japan. 47: 464-471.

Hashioka, Y. (1952). Application of new fungicides to rice cultivation. Agric. & Hort. Tokyo 27: 485-492.

Hashioka, Y. and Makino, M. (1969). Rhizoctonia group causing the rice sheath spot in the temperate and tropical regions with special reference to Pellicularia sasakii and Rhizoctonia oryzae Res. Bull. Fac. Agric. Gifu Univ. 28:51-63.

Hashioka, Y. and Saito, Y. (1953). Phytopharmacology of the rice diseases. I. In vitro tests on application of the dust fungicides to the important pathogenic fungi. Res. Bull. Coll. Agric. Gifu Univ. 2: 12-18.

Hackskaylo, J. and Steward, R.B. (1962). Efficacy of phorate as a fungicide. Phytopathology 52: 341.

Inderawati, E. and Heitefuss, R. (1977). Effect of herbicides on diseases of rice (Oryzae sativa). Weed Sci. 25: 445-447.

Inove, Y. and Uchino, K. (1963). Studies on sheath blight of rice plant caused by Pellicularia sasakii (Shirai) S. Ito. I.Ecology of damage and chemical control. Minist. Agric. For fish Res. Coun. Japan, Expt. No.4 at Yamaguchi Agric. Expt. Stn. pp.136.

Iqbal, S.H., Tangeer, S., Azis, A.I., Ahmad, J.S. and Iqbal, H.M. (1978). A field survey of vesicular arbuscular mycorrhizal association in cereals. Biologia Pakistan 24: 97-113.

Jaarsveld, A. (1942). The influence of various soil fungi on the virulence of Rhizoctonia solani Kuhn Phytopath. Z. 14: 175.

Jagan Mohan, K.P. (1977). Studies on the control of sheath blight of rice caused by Corticium sasakii (Sherai) Matsumoto. M.Sc.(Ag) Thesis. Kerala Agricultural University. 55 pp.

Jaganathan, R. and Kannaiyan, S. (1978). Studies on the chemical control of sheath blight disease or rice. Indian J. Plant Protecn 6(1):30-32.

Jain, R.K. and Sehgal, S.P. (1978). Effect of certain pesticides on soil microflora. Indian J. Mycol Pl. Pathol. 10(1): 88-89.

Johnson, L.F. and CURL, E.A. (1972). Isolation of groups of microorganisms from soil. In Methods for Research in the Ecology of soil borne plant pathogens. Burgess Publ. Co. 1-33.

Kandaswamy, D., Bhaskaran, R., Obliswami, G. and Subramaniam T.R. (1975). Changes in the rhizosphere microflora of bhendi as influenced by the application of disyston. Madras Agric. Journal 61(10): 1017-1019.

Kannaiyan, S. and Prasad, N.N. (1979). Effect of foliar spray of certain fungicides in the control of sheath blight disease of rice. Res. Bull. Macco. Agric. Digest. 4: 3-6.

Kannaiyan, S. and Prasad, N.N. (1981). Effect of mechanical composition of soil on the survival of Rhizoctonia solani kuhn Science and culture 47:103.

Kannaiyan, S. and Prasad, N.N. (1983). Effect of Nitrogen, Phosphorus and Potassium on the survival and saprophytic activity of Rhizoctonia solani. Madras Agric. Journal 70:506-510.

Katan, J. and Eshel, Y. (1973). Interaction between herbicides and plant pathogens. Residue Reviews 45: 145-147.

Kataria, H.R. and Grover, R.K. (1977). Comparison of fungicides for the control of Rhizoctonia solani causing damping of mung bean. (Phaseolus aureus) (Abstr) Indian Phytopath 30:151.

Kaushik, S.K. and Mani, V.S. (1980). Weed control in direct seeded and transplanted rice. Indian J. Weed Sci. 10: 73-78.

Kesavan, R. (1984). In vitro efficacy of certain fungicides against Rhizoctonia solani and sclerotium rolfsii Fitopatologia Brasiloira 9:627-630.

Ko, W.H. and Hora, F.K. (1971). A selective medium for the quantitative determination of Rhizoctonia solani in soil Phytopathology 61: 707-710.

Kohli, C.K. (1966). Pathogenicity and host range studies in the paddy sheath blight pathogen (Rhizoctonia solani) Kuhn. J. Res. Ludhiana 3: 37-40.

Kozaka, T. (1970). Pellicularia sheath blight of rice plants and its control. Jap. Agric. Res. Q. 5:12-16.

Kuhn, J.G. (1958). Die Krankheiten der Kulturegi wachse thre Ussachen and ihre Verhutung. Gustav Bosselmann Berlin pp.312.

Kurodani, K., Yokogi, K. and Yamamoto, M. (1959). On the effect of 2.4 dichlorophenoxy acetic acid to mycelial growth of Hypochnus sasakii Shirai, Forsch Geb pflahzenkrankh. Kyoto, 6: 132-135.

Lakshmanan, P. (1979). Studies on sheath blight of rice with special reference to the survival of the causal organism and control of the disease. M.Sc.(Ag) Thesis. Kerala Agricultural University. 98 pp.

Lakshmanan, P. and Nair, M.C. (1980 a). In vitro toxicity of granular insecticides against Rhizoctonia solani Madras. Agric. J. 67: 59-60.

Lakshmanan, P. and Nair, M.C. (1980 b). In vitro effects of certain herbicides on Rhizoctonia solani kuhn Pesticides 14(11): 30-41.

Lakshmanan, P., Nair, M.C. and Menon, M.R. (1980). Comparative efficacy of certain fungicides on the control of sheath blight of rice. Pesticides 14(2):30-31.

Lakshmi, T.R. (1984). Evaluation of various herbicides on the control of sheath blight disease (Rhizoctonia solani kuhn) on rice. M.Sc.(Ag) Thesis. Kerala Agricultural University, 108 pp.

Lee, F.N. (1980). Number, viebility and buoyancy of R. solani sclerotia in Arkanas rice fields: Pl.Dis. 64:298-300.

Lee, F.N. and Coutney, M.L. (1981). Foliar fungicide testing for rice sheath blight control. Arkanas Farm Research 30(3): 11.

Leu, L.S. and Yang, M.C. (1985). Distribution and survival of sclerotia of rice sheath blight fungus Thanatephnus cucumeris in Taiwan Ann. Phytopath. Soc. Japan, 51: 1-7.

Lewis, (1979). Influence of soil texture on survival and saprophytic activity of R. solani in soil Can. J. Microbiol. 25: 1310-1314.

Mahendra Prabhath, C.A. (1971). Studies on sheath blight of rice caused by Corticium sasakii (Shirai) Matsumoto M.Sc.(Ag) Thesis, University of Kerala. 80 pp.

Mahendra Prabath, C.A., Menon, M.R., Devi, L.R. and Ramakrishnan, C.K. (1974). Studies on the viability of sclerotia of Corticium sasakii (Shirai) Matsumoto Agric. Res. J. Kerala, 12: 96-98.

Mall, S. (1975). Rhizoctonia diseases of legume crops as affected by Trichoderma viride. Proc. Indian Natal. Sci. Acad. 41: 559-563.

Manila, C.E. and Lapis, D.B. (1977). Severity of rice blast, bacterial blight and sheath blight in rice after application with herbicide and insecticides. Philippine agriculturist 61:1-11.

Martin, S.B., Lucas, L.T. and Campbell, C.C. (1984). Comparative sensitivity of Rhizoctonia solani and Rhizoctonia like fungi to selected fungicides. in vitro. Phytopathology 74: 778-781.

Mathai, G. (1975). Studies on the effect of fungicides and silica in the control of sheath blight of rice caused by Corticium sasakii (Shirai) Matsumoto. M.Sc.(Ag) Thesis, Kerala Agricultural University. pp.58.

Mathur, S.P., Hamilton, H.A., Greenhalgh, R., MacMillan, K.A. and Khan, S.U. (1976). Effect of micro organisms and persistence of field applied Carbofuran and Dyfonate in a humic mesosol. Can J. Soil Sci. 56: 89.

Matsumoto, T. (1934). Some remarks on the taxonomy of the fungus Hypochnus sasakii Shirai. Trans. Sapporo. Nat. Hist. Soc. 13: 115-120.

Meshram, S.U. and Jager, G. (1983). Antagonismof Azotobacter chroococcum isolates to Rhizoctonia solani. Netherlands J. of Plant Pathology 89(5):191-197.

Mew, T.W., Rosales, A.M., Elazegui, F.A. (1980). Ecology of the rice sheath blight pathogen. Saprophytic survival, I.R.R.N. 5: 15.

Millikan, D.F. and Fields, M.L. (1964). Influence of some representative herbicidal chemicals upon the growth of some soil fungi Phytopathology 54:901.

Midha, S.K. and Nandwana, R.P. (1974). Effect of certain nematicides on the population of soil microorganisms, I. Quantitative and qualitative changes in the fungal flora. Indian Phytopath 27(3): 312-315.

Miyake, I. (1910). Studies uber die pitze der Reispflange in Japan. J. Coll. Agric. Tokyo 2: 237-276.

Mohammed, G. (1984). Influence of alachlor and fluchloralin on the rhizosphere and rhizoplane fungi of soybean crop. J. of Maharashtra Agrl. Universities 9:303-305.

Mosca, Anna, M.L. and Mortarino, Carla, F. (1969). Action in vitro of some herbicides on soil fungi. Allionia, 15: 85-98.

Mukherjee, N. (1978). Sheath blight of rice (Thanatephorus cucumeris) and its conidial possibilities. Pesticides 12: 39-40.

Muneera, V.K. (1973). Studies on the control of sheath blight of rice. M.Sc.(Ag) Thesis, Kerala Agricultural University, 60 pp.

Murthy, V.K., Edward, J.C. and Singh, K.P., (1976). Effect of Thimet on the soil and rhizosphere microflora of okra Assoc. microbiol India. 17th Ann. Conf. ab. pp.4.

Mustafee, T.P. and Chattopathyay, S. (1983). Survivability of soil borne pathogens with and without host tissues. Indian Phytopath 36: 58-61.

Naguib, M.I. (1968). Effect of sevin on the metabolism of Rhizoctonia solani. J. Bot. UAR., 11:7-18.

Nakanishi, T. and Oku, H. (1970). Metabolism and accumulation of Pentachloronitrobenzene by phytopathogenic fungi in relation to selective toxicity. Phytopathology 59: 1761-1762.

Naiki, T. and Ui, T. (1969). On the survival of the sclerotia of Rhizoctonia solani kuhn in soil. Mem. Fac. Agric. Hokkaido. Univ. 6: 430-436.

Naiki, T. and Ui, T. (1972). Themicroorganism associated with the sclerotia of Rhizoctonia solani kuhn in soil and their effects on the viability of pathogen. Mem. Fac. Agric. Hokkaido Univ. 8: 252-256.

Naim, M.S. and El-Esawy, A.A.F. (1965). Growth responses of Rhizoctonia solani kuhn to its metabolites and to those of antagonistic rhizospheric bacteria and fungi of cotton. Phytopath. Mediterranean. 4: 1-5.

Nair, P.V., Rajan, K.M. (1978). Operational research on sheath blight control. I.R.R.N. 3: 14.

Nesheim, O.N. and Linn, M.B. (1969). Deleterious effects of certain fungitoxicants on the formation of mycorrhiza on corn by Endogone fasiculata and on corn root development Phytopathology 59: 297-300.

Neweigy, N.A., Elsa, N.A. EL-shewy, L.A. (1981). Antagonistic microbial isolates from the rhizosphere of broad bean plants against the pathogens to R. solani and S. rolfsii II Bacteria and actinomycetes. Res. Bull. Faculty of Agriculture, Aimshaws Univ. No.1891 pp.16.

Obliswamy, G. Balaraman, K., Natarajan, T. and Kulandanelu, R. (1976). Effect of organophosphorus insecticides on soil microflora, nodulation and yield of groundnut Symposium on plant protection Research and Development pp.6.

Ohtsuki, S. and Fuginami, A. (1982). Rizolex (tolclofosmethyl). Japan Pesticide Information 41: 21-25.

Olsen, C.M. (1965). Antagonistic effects of microorganisms on Rhizoctonia in soil. Dis. Abstr. 25:3783-3784.

Onesirosan, P.T. and Sagay, S.O.(1975). Survival of two pathogens of Cowpea over the dry season. Pl. Dis. Rept. 59: 1018-1020.

One, K. and Iwatu, K. (1961). Control of sheath blight disease of rice plant by P.C.P. Nogyo Oyobi. Engei 36: 71-74.

Orgura, M. and Akai, S. (1965). Studies on Rhizoctonia solani (Pellicularia filamentosa (Pat) Rogers IV. The activity of antagonists to R. solani kuhn Ann. phytopath Soc. Japan. 30: 219-224.

Ou, S.H. (1972). Rice Diseases. Commonwealth Mycological Institute, Kew, Survey - England 368 pp.

Palo, M.A. (1926). Rhizoctonia diseases of rice I.A study of the disease and of the influence of certain conditions upon the viability of sclerotial bodies of the causal fungus. Philipp Agric. 15: 361-375.

Papavizas, G.C. and Davey, C.B. (1961). Saprophytic behavior of Rhizoctonia in soil. Phytopathology 51: 693-699.

Paracer, C.S. and Chahal, Das. (1963). Sheath blight of rice caused by Rhizoctonia solani kuhn a new record in India. Curr. Sci. 32: 328-329.

Park, M. and Bertus, L.S. (1932). Sclerotial diseases of rice in Ceylon I. Rhizoctonia solani kuhn Ceylon J. Sci. Sect. II: 319-331.

Peeples, J.L. (1974). Microbial activity in Benomyl treated soils. Phytopathology 64: 857-860.

Philips J.M. and D.S. Hayman (1970) Improved procedures for clearing roots and staining parasitic and vesicular arbuscular mycorrhizal fungi for rapid assessment of infection Trans. Brit. mycol. Soc. 55: 158-161.

Purkayastha, R.P. and Bhattecharya, B. (1982). Antagonism of microorganism from jute towards Colletotrichum corchori Trans. Brit. mycol. soc. 78: 509-513.

Purushothaman, D., Venkataraman, C.V., Janaki, I.P. and Velusamy, R. (1976). Effect of Cytrolane on soil microflora and certain soil enzymes in rice fields. Curr. Res. 5: 43-44.

Radhakrishnan, T.C. (1975). Studies on the control of sheath blight of rice caused by Corticium sasakii (Shirai) Matsumoto. M.Sc.(Ag). Thesis, Kerala Agricultural University 96 pp.

Rao, H.R.G. and Harein, P.K. (1972). Dichlorvos as an inhibitor of aflatoxin production on wheat, corn, rice and peanuts. J. Econ. Entomol 65: 988.

Reddy, H.R. and Anilkumar, T.B. (1975). Toxicity of insecticides to Sclerotium rolfsii. Pesticides. 9: 48.

Reinking, O.A. (1918). Philippine economic plant diseases. Philippine Sci. A. 13: 165-274.

Rodriguez - Kabana, R., Curl, E.A. and Funder burk, H.H.J. (1966). Effect of herbicides on growth of Rhizoctonia solani. Phytopathology 56: 1332-1333.

Rosales, A.M. and Mew, T.W. (1982). Antagonistic effect of soil microorganisms on rice sheath blight pathogen., I.R.R.N. 7: 12-13.

Rothrock, C.S. and Gottlieb, D. (1984). Role of antibiosis on antagonism of Streptomyces hygroscopicus var geldanus to Rhizoctonia solani in soil. Microbiol 3: 1440-1447.

Roy, A.K. (1976). Studies on the survival of sclerotia of Corticium sasakii Phytopath. Z. 86: 270-275.

Roy, A.K. (1977). Parasitic activity of Trichoderma viride on the sheath blight fungus of rice (Corticium sasakii) Z. Pflkrankh. Pflschutz, 84: 675-683.

Roy, A.K. (1981) Efficacy of a few fungicides on the control of sheath blight of rice. J. Res. Assam Agrl. University. 2: 177-181.

Roy, P., Sinha, P.K. and Mukherjee, N., (1975). Effect of granular insecticides on rice soil microflora. Ind. J. Entomol. 37: 93-95.

Ruppel, D. and Hecker, B.S. (1982). Increased severity of Rhizoctonia root rot in sugarbeet treated with systemic insecticides. Crop Protecn. 1: 75-81.

Ryker, T.C. and Gooch, F.S. (1938). Rhizoctonia sheath rot of rice. Phytopathology 28: 233-246.

Sadowski, S. (1970). Properties and ecological requirements of some Mazurian isolates of R. solani kuhn. Zaaz. nauk. wyzsz, Szk. roin Olsztyn ser Azo. (Suppl. 2), 3-71.

Sanford, G.B. (1952) Persistence of Rhizoctonia solani kuhn in soil. Can. J. Bot. 30: 652-664.

Satpathy, J.M. (1974). Effect of soil treatment with granular insecticides on soil microorganisms. Ind J. Entomol. 36: 139-141.

Sawada, K. (1912). 'Shirakinibuyo' of Camphor. Spec. Bull. Formosa Agric. Expt. Stn. 4: 805.

Sen, B. and Kapoor, I.J. (1975). Control of Rhizoctonia collar rot of cauliflower. Pesticides 9: 36.

Sethumathan, N. and MacRac, I.C. (1969). Persistence and biodegradation of diazinon in submerged soils J. Agric. Fd. Chemistry: 17: 221-225.

Sezgin, E., Kareililioghu, A. and Yomiscioghi, V. (1982). Investigations on the effects of some cultural applications and antagonistic fungi on Rhizoctonia solani kuhn and Verticullium dahliae Kleb in Algean region. Effects of herbicides on antagonistic fungi. J. Turkish phytopathol 11: 79-91.

Shatla, M.N. and Sinclair, J.B. (1963). Tolerance to PCNB and Pathogenicity correlated in natural occurring isolates of Rhizoctonia solani. Phytopathology 53: 1407-1411.

Shokes, J.M. and McCarter, S.M. (1979). Occurrence, dissemination and survival of plant pathogens in surface irrigation ponds in Southern Georgia. Phytopathology 69: 510-516.

Shukla, A.N. and Dwivedi, R.S. (1979). Survival of Rhizoctonia solani kuhn under the influence of staling growth products of some Aspergilli and its growth response to some phenolic substances. Proc. Ind. Nat. Sci. Acad. 45:

Simkover, H.G. and Shenefelt, R.D. (1951). Effect of benzene hexachloride and chlordane on certain soil organisms. J. Econ. Entomol. 44: 426-427.

Sinclair, J.B. (1957). Laboratory and green house screening of certain fungicides for control of Rhizoctonia damping off of cotton seedlings Pl. Dis. Reptr. 41: 1045-1050.

Sinclair, J.B. (1958). Reaction of four Rhizoctonia isolates to certain chemicals. Phytopathology 48: 398.

Sinclair, J.B. (1960). Reaction of Rhizoctonia solani isolates to certain chemicals. Pl. Dis. Reptr. 44: 474-477.

Singh, R.A. and Pavgi, M.S. (1969). Oriental sheath and leafspot of rice. Pl. Dis. Reptr. 53: 444-445.

Singh, R.P. and Singh, M. (1970). Effect of herbicides on weed, control and yield of direct seeded rice under puddled conditions. J. Scient. Res. Banaras Hindu University. 27: 51-54.

Souzafilho, B.F. De (1979). Effect of fungicides, inoculum density and inoculum depth on isolation of Rhizoctonia solani kuhn from soil. Fitopatol Bras. 4: 417-421.

Sridhar, T.S., Yogeswar Rao, Y. and Sankar Reddy, G.W. (1976). Effect of granular herbicides on the control of weeds in rice directly seeded in puddled soil. Madras Agric. J. 61: 431-433.

Suhag, L.S. and Rana, R.S. (1984). Rhizoctonia leaf blight of ginger in Haryana. Indian. J. Mycol. Path. 14: 195-196.

Swaminathan, R. and Sullia, R.B. (1969). Influence of the pesticide Malathion on groundnut (Arachis hypogaea L.) microflora. Curr. Sci. 38: 282-284.

Sychev, P.A. and Shaposnik, Y.A. (1982). Antagonistic effects of Trichoderma viride fr. in relation to some pathogens of Cucumis sativum L. Mikologiya fitopatologiya. 16: 154-159.

Tahvonen, R. (1982). Preliminary experiments into the use of Streptomyces spp. isolated from peat in the biological control of soil and seed borne disease in peat culture. J. Scient. Agric. Soc. Finland. 54: 357-369.

Takatasu, S. and Nishimura, J.C. (1962). Studies on the control of sheath blight of rice plant. IV. Effect of sodium salt pentachlorophenon. Bull. Fyogo pref. agric Exp. Stn. 10: 27-30.

Talbot, P.H.B. (1970). Taxonomy and nomenclature of the perfect state. In J.R. Parmeter (Jr) (ed) pp 20-21 Rhizoctonia solani, Biology and Pathology, University of California Press, Berkeley, 255

Tang, A., Curl, E.A. and Rodriguez, Kabana, R. (1970). Effect of Trifluralin on inoculum density and spore germination of Fusarium oxysporum f. sp. vas infectum in soil. Phytopathology 60: 1082.

Tatsuyama, K.S. and Jikihara, K. (1970). Influence of herbicide treatments on the occurrence of soil borne plant disease. Ann. phytopath. Soc. Japan. 30: 290-294.

Tisdale, W.B. (1948). Annual report of the Agricultural Experiment Station. Florida (Abstr) RAM 28:326.

Tisserat, N., Altman, J. and Campell, C.L. (1977). Pesticide plant diseases interactions, the influence of aldicarb on growth of Rhizoctonia solani and damping off of sugarbeet seedlings. Phytopathology 67: 791-793.

Torstensson, L. and Wessen, B. (1984). Interactions between the fungicide benomyl and soil micro organisms. Soil Biol. Biochem. 16: 445-452.

Tu, C.M. and Kimbrough, J.W. (1978). Systematics and phylogeny of fungi in the Rhizoctonia complex Bot. Gazette 139: 454-466.

Tu, C.M. and Miles, J.R.W. (1976). Interaction between insecticides and soil microbes. Res. Reviews. 64: 17-65.

Tveit, M. and Moore, M.B. (1954). Isolates of Chaetomium Sp that protect oats from Helminthosporium victoriae. Phytopathology 44: 686-689.

Umeda, V. (1973). Hinosan, a fungicide for control of rice blast. Japan Pesticide Information 17: 25-28.

Vaartaja, O. (1960). Selectivity of fungicidal materials in agar cultures. Phytopathology 50: 870-873.

Varma, A. S. and Menon, M.R. (1977). Fungicidal trial on the control of sheath blight of rice. Madras Agri. J. 64: 415-417.

Varma, A.S., Peethambaran, C.K., Balakrishnan, S. and Menon, M.R. (1978). In vitro effects of certain herbicidal formulations on Corticium sasakii Shirai) Matsumoto. A Agric. Res. J. Kerala. 16: 114-116.

Varma, R.K., Vyas, S.S., Shastry, P.I. and Jain, A.C. (1979). Laboratory screening of some herbicides against three soil borne fungi. Indian Phytopath. 32 394-396.

Vasavan, M.G., Rajan, K.M. and Thomas, M.J. (1980). Herbicides in plant disease control. I.R.R.N. 5: 18.

Venkataraman, G.S. and Rajyalakshmi, B. (1971). Interaction between pesticides and soil micro organisms. Indian J. Exp. Biol. 9: 521-522.

Venkatasubbiah, P. and Safeeulla, K.M. (1983). Studies on the viability of sclerotia of Rhizoctonia solani in the soil. J. Coffee Res. 13: 30-32.

Venkatasubbaiah, P. and Safeeulla, K.M. (1984). Aspergillus niger for biological control of Rhizoctonia solani on coffee seedlings. Trop. Pest Management 30-401-406.

Visalakshy, A., Ali, A.B.M., Devi, L.R. and Das, N.M.(1980) The effect of carbofuran on the rhizosphere microflora of rice. Indian J. Ent. 20(2):147-148.

Vyas, S.C. and Khare, M.N. (1983). Seminar on pesticides on environment Aug 4-5 1983. Abstract of paper dept of Entomology, TNAU, Coimbatore.

Wainwright, M. and Sowden, F.J. (1977). Influence of fungicide treatment on $CaCl_2$ extractable phosphorus and phosphate solubilizing micro organisms in soil. Pl. Soil. 48: 335-345.

Wei, C.T. (1934). Rhizoctonia sheath blight of rice Bull. Univ. Nanking. Coll. Agric. For. 15: 21.

Weindling, R. (1932). Trichoderma lignorum as a parasite of other soil fungi. Phytopathology 22: 837-845.

Weindling, R. (1934). Various fungi recently found to be parasitic on Rhizoctonia solani. Phytopathology 24: 1141.

Weindling, R. (1938). Association effects of fungi Bot. Rev. 14: 475-496.

Wood, R.K.S. (1951). The control of diseases of lettuce by the use of antagonistic organisms. 1. The control of Botrytis cinerea Pers. The control of Rhizoctonia solani kuhn. Ann. appl. Biol. 38: 203-230.

Worthing, C.R. (1979). The pesticide manual. A world compendium. U.K. Crop protect. Coun. Croydin. 655 pp

Yamaguchi, T. (1974). Control. of rice diseases by fine granular formulations, Japan Pesticide information 19: 9-13.

Yamaguchi, T., K. Iwata and T. Kuramoto (1971). Studies on forcasting the sheath blight of rice plants caused by Rhizoctonia sasakii (Shirai) S. Ito I Relation between hibernated sclerotium and disease outbreak. Bull. Hokuriku. Nati. Agric. Exp. Stn. 13: 15-34.

Youssef, B.A., AMR, A.M., Heitefuss, R. (1985). Interactions between herbicides and soil borne pathogens of cotton under green house conditions. Z. Pflkrankh. Pflsch ut2. 92:55-62.

Yuen, G.Y. and Raabe, R.D. (1984). Effects of small scale aerobic composting on survival of some fungal plant pathogens. Pl. Dis. 68: 134-136.

Zentmyer, C.A. (1955). A laboratory method for soil testing fungicides with Phytopathora cinnamomi as test organism. Phytopathology. 45: 398-404.

APPENDICES

APPENDIX I

Composition of Potato dextrose agar

Potato	- 200 g
Dextrose	- 20 g
Agar	- 20 g
Distilled water	- 1 L

APPENDIX II

Rose bengal Streptomycin agar

Dextrose	- 10 g
Peptone	- 5 g
Potassium dihydrogen phosphate	- 1 g
$MgSO_4$	- 0.5 g
Rose bengal (1 part in 30,000 parts)	
Agar	- 20 g
Distilled water	- 1 L

APPENDIX III

Soil extract agar

Soil extract	- 1000 ml
Dextrose	- 10 g
Peptone	- 10 g
Agar	- 20 g

APPENDIX IV

Kuster's medium

Glycerol	- 10 g
Casein	- 0.3 g
$Mg\ SO_4$	- 0.5 g
$FeSO_4$	- 0.1 g
$K\ No_3$	- 2. g
Nacl	- 2 g
K_2HPO_4	- 0.5 g
$CaCO_3$	- 0.2 g
Distilled water	- 1 L
PH	- 6.8 - 7

APPENDIX V

Selective medium for *R. solani* (Ko and Hora 1971)

K_2HPo_4	- 1 g
$Mg\ So_4$	- 0.5 g
Kcl	- 0.5
$FeSO_4$	- 10 mg
$Na\ No_2$	- 0.2 g
Dexon	- 90 mg
Chloram phenicol	- 50 mg
Streptomycin sulfate	- 50 mg
Gallic acid	- 0.4 g
Agar	- 20 g
Distilled water	- 1 L.

APPENDIX VI

Analysis of variance table

Effect of fungicides on the survival of R. solani in soil

Source	D.F.	Sum of squares	Mean sum of squares	F calculated
Treatments	8	17.03011	2.128763	
Error	18	2.528427	1404682	15.15477*
Total	26	19.55853		

* Significant at .05 level

Ranking : T_6 T_7 T_3 T_4 T_8 T_1 T_5 T_2 T_9

CD = 0.562819

APPENDIX VII

Analysis of variance table

Effect of insecticides on the survival of R. solani in soil

Source	D.F	Sum of squares	Mean sum of squares	F calculated
Treatments	12	18.4664	1.538862	
Error	26	3.052094	1173882	13.10917 *
Total	38	21.51843		

* Significant at .05 level

CD = .598647

Ranking T_2T_{10} T_3 T_{12} T_{11} T_5 T_1 T_9 T_4 T_7 T_8 T_6 T_{13}

APPENDIX VIII

Analysis of variance table

Effect of herbicides on the survival of *R. solani*

Source	D.F.	Sum of squares	Mean sum of squares	F calculated
Treatments	8	14.66249	1.832811	
Error	18	1.842468	1023594	17.905666*
Total	26	16.50496		

* significant .05 level

CD = .480444

C.D. T_5 T_7 T_8 T_1 T_4 T_3 T_2 T_6 T_9

APPENDIX IX

Analysis of variance table

In vitro effect of fungicides on the radial growth of *R.solani*

Source	D.F	Sum of squares	Mean sum of squares	F calculated
Treatments	40	600.4606	15.01152	14.31803*
TRTD Vs Control	1	87.75354	87.75354	83.69961*
Error	84	88.06848	1.048434	
Total	125	688.5291		

* Significant at 0.05 level

CD = 1.644829

APPENDIX X

In vitro effect of insecticides on the radial growth of R.solani

Source	D.F	Sum of squares	Mean sum of squares	F calculated
Treatments	59	882.8996	14.9644	25.43708
TRTD Vs Control	1	71.11133	71.11133	120.8778*
Error	122	71.77149	.5882909	
Total	182	954.6711		

* significant at 0.05 level

CD = 1.260824

APPENDIX XI

In vitro effect of herbicides on the radial growth of R.solani

Source	D.F.	Sum of squares	Mean sum of squares	F calculated
Treatments	40	955.9734	23.89934	36.53454*
TRTD Vs control	1	52.92261	52.92261	80.90196*
Error	84	2.02661	.024125	
Total	125	1010.923		

* Significant at 0.05 level

CD = 1.5334

APPENDIX XII

Analysis of variance table

Effect of application of fungicides on the incidence of sheath blight

Source	D.F.	Sum of squares	Mean sum of squares	F Calculated
Treatments	8	2658.27	332.2759	
Error	18	273.332	15.18511	21.88169*
Total	26	2931.539		

* Significant at 0.05 level

CD = 5.8518

Ranking = $T_4T_3T_5T_7$ $T_2T_8T_1T_4T_6$

APPENDIX XIII

Analysis of variance table

Effect of application of fungicides on the intensity of sheath blight

Source	D.F	Sum of squares	Mean sum of squares	F Calculated
Treatments	8	11998.32	1499.791	
Error	18	1281.131	71.17394	18.73083*
Total	26	13279.46		

* Significant at 0.05 level

CD = 14.472412

Ranking $\overline{T_2T_1T_3}$ $\overline{T_7T_4}$ $\overline{T_5T_6T_8T_9}$

APPENDIX XIV

Effect of insecticides on the incidence of sheath blight

Source	D.F	Sum of squares	Mean sum of squares	F calculated
Treatments	12	3191.844	265.987	
Error	26	814.6172	31.3314	8.489462*
Total	38	4006.461		

* Significant at 0.05 level
CD = 9.78022
Ranking $T_1T_3T_6T_2$ $T_{11}T_{10}T_7T_4T_{12}$ $T_5T_9T_{13}T_8$

APPENDIX XV

Analysis of variance table

Effect of application of insecticides on the intensity of sheath blight

Source	D.F	Sum of squares	Mean sum of squares	F Calculated
Treatments	12	6006.627	500.5523	
Error	26	1298.887	49.95718	9.24885*
Total	38	7305.514		

* Significant at 0.05 level
CD = 11.8652
Ranking $T_{11}T_{10}T_1T_5T_2T_8$ $T_7T_4T_6T_3T_{12}$ T_9T_{13}

APPENDIX XVI

Analysis of variance table

Effect of application of herbicides on the incidence of sheath blight

Source	D.F	Sum of squares	Mean sum of squares	F Calculated
Treatments	8	1617.539	202.1924	
Error	18	900.5469	50.03038	4.041392
Total	26	2518.086		

* Significant at 0.05 level
CD = 10.62176
Ranking $T_7T_2T_6T_1$ T_3T_5 $T_8T_4T_9$

APPENDIX XVII

Analysis of variance table

Effect of application of herbicides on the intensity of sheath blight

Source	D.F	Sum of squares	Mean sum of squares	F Calculated
Treatments	8	3528.834	441.1043	
Error	18	2006.115	111.4509	3.51807*
Total	26	5534.949		

* Significant at 0.05 level
CD = 18.110157
Ranking $T_7T_1T_2T_8T_5T_6T_4$ T_3T_9

APPENDIX XVIII

Analysis of variance table

Effect of combined application of chemicals on the incidence of sheath blight

Source	D.F	Sum of squares	Mean sum of squares	F Calculated
Treatments	10	2319.91	231.991	
Error	22	377.6524	17.16602	13.51455*
Total	32	2697.563		

* Significant at 0.05 level

CD = 7.358584

Ranking $T_6T_4T_2T_5$ $T_9T_{10}T_7T_1T_3T_8T_{11}$

APPENDIX XIX

Analysis of variance table

Effect of combined application of chemicals on the intensity of sheath blight

Source	D.F	Sum of squares	Mean sum of squares	F Calculated
Treatments	10	2269.966	252.2185	4.36207*
Error	22	1156.415	57.8207	4.36207*
Total	32	3426.381		

* Significant at 0.05 level

CD = 13.8372

Ranking $T_9T_8T_6T_4T_7T_0T_5T_2T_3$ $T_{10}T_{11}$

APPENDIX XX

Analysis of variance table

Effect of application of fungicides on the yield of rice plants

Source	D.F	Sum of squares	Mean sum of squares	F Calculated
Treatments	8	485.8516	60.73145	
Error	18	2254	125.222	.484989
ETotal	26	2739.852		

Insignificant at 0.05 level

CD = 18.35747

APPENDIX XXI

Analysis of variance table

Effect of application of insecticides on the yield of rice plants.

Source	D.F	Sum of squares	Mean sum of squares	F Calculated
Treatments	12	347.6953	28.9746	
Error	26	2870	110.3846	.2624878
Total	38	3217.695		

Insignificant at 0.05 level

CD = 18.35747

APPENDIX XXII

Analysis of variance table

Effect of application of herbicides on the yield of rice plants.

Source	D.F	Sum of squares	Mean sum of squares	F Calculated
Treatments	8	194.0742	24.25928	
Error	18	2588.668	143.8149	.168684
Total	26	2782.742		

Insignificant at 0.05 level

CD = 20.57228

APPENDIX XXIII

Analysis of variance table

Effect of combined application of plant protection chemicals on the yield of rice plants

Source	D.F	Sum of squares	Mean sum of squares	F Calculated
Treatments	10	249.8789	24.98798	
Error	22	1032	46.9090	.53263
Total	32	1281.879		

Insignificant at 0.05 level

CD = 12.16433

APPENDIX XXIV

Analysis of variance table

Effect of application of fungicides on soil fungi

Source	D.F	Sum of squares	Mean sum of squares	F Calculated
Treatments	8	38.11853	4.7648	
Error	18	5.531128	.3072849	15.50619*
Total	26	43.64966		

Significant at 0.05 level
CD = 1.008619
Ranking: $T_8T_6T_2T_9T_7T_5T_3\ T_4T_1$

APPENDIX XXV

Analysis of variance table

Effect of application of fungicides on soil bacteria

Source	D.F	Sum of squares	Mean sum of squares	F Calculated
Treatments	8	5.062052	.6827565	
Error	18	1.986984	.110388	6.18506*
Total	26	7.449036		

Significant at 0.05 level
CD = .6045298
Ranking $T_3T_2T_8T_7\ T_5T_6T_9T_1T_4$

APPENDIX XXVI

Effect of application of fungicides on soil actino mycelis

Source	D.F	Sum of squares	Mean sum of s squares	F Calculated
Treatments	8	4.921677	.6152096	
Error	18	3.897492	.2165273	2.84125*
Total	26	8.819168		

* Significant at 0.05 level

CD = .84666

Ranking : $T_7T_8T_6T_5T_4T_3$ $T_2T_1T_9$

APPENDIX XXVII

Effect of application of insecticides on soil fungi

Source	D.F	Sum of squares	Mean sum of s squares	F Calculated
Treatments	12	57.29993	4.774994	
Error	26	27.5221	1.058542	4.510915*
Total	38	84.82202		

* Significant at 0.05 level

CD = 1.797681

Ranking: $T_{12}T_5$ $T_8T_7T_{10}T_{13}T_4T_9T_{11}$ $T_3T_2T_1T_6$

APPENDIX XXVIII

Effect of application of insecticides on soil bacteria

Source	D.F	Sum of squares	Mean sum of squares	F Calculated
Treatments	12	3.61535	.3012797	
Error	26	10.8884	.4187845	.719416
Total	38	14.50375		

*Significant at .05 level

CD = 1.13071

Ranking : $7_{11}T_3T_4T_6T_8T_9T_2T_7T_{12}T_{10}T_1T_5T_{13}$

APPENDIX XXIX

Effect of application of insecticides on soil actino mycetes

Source	D.F	Sum of squares	Mean sum of squares	F Calculated
Treatments	12	4.965828	.413819	
Error	26	7.638902	.2938074	1.40847*
Total	38	12.60482		

* Significant at .05 level

CD = .947087

Ranking: $T_{11}T_5T_{10}T_4T_6T_2T_9T_3T_1T_7T_8T_{12}T_{13}$

APPENDIX XXX

Analysis of variabe table

Effect of application of herbicides on soil fungi

Source	D.F	Sum of squares	Mean sum of squares	F calculated
Treatments	8	32.37616	4.04702	
Error	18	5.831482	.3239712	1.249191 *
Total	26	38.20764		

* Significant at 0.05 level

CD = 1.035643

Ranking: $T_8T_1T_4T_3T_7$ $T_2T_6T_9T_5$

APPENDIX XXXI

Analysis of variance table

Effect of application of herbicides on soil bacteria

Source	D.F.	Sum of squares	Mean sum of squares	F Calculated
Treatments	8	16.57695	2.072119	
Error	18	5.26297	.2923872	7.086899*
Total	26	21.83992		

* Significant at .05 level

CD = .9838659

Ranking: $T_1T_8T_4T_2T_5$ $T_7T_6T_9T_3$

APPENDIX XXX II

Analysis of variance table

Effect of application of herbicides on the soil actino mycetes

Source	D.F	Sum of squares	Mean sum of squares	F Calculated
Treatments	8	4.586273	.5732841	
Error	18	2.234039	.1241133	4.619031*
Total	26	6.820313		

* Significant at .05 level

CD = .6410115

Ranking: $T_2T_6T_8T_4T_9T_3\ T_1T_7T_5$

APPENDIX XXXIII

Analysis of variance table

Effect of application of antagonistic organisms and chemicals on the intensity of sheath blight

Source	D.F	Sum of squares	Mean sum of squares	F Calculated
Treatments	20	112.9638	5.64818	7.10261*
A	6	67.65601	11.278	14.88858*
B	2	8.99938	4.49969	5.94129*
A x B	12	36.30835	3.025696	3.995061*
Error	42	31.80908	.7573951	
Total	62	144.7728		

CD for comparison of treatments A = .8282462

CD for comparison of treatments B = .5422144

CD for comparison of treatment combination A+B = 1.4345646

EFFECT OF APPLICATION OF PLANT PROTECTION CHEMICALS ON THE SURVIVAL OF *Rhizoctonia solani* Kühn

By

LULU DAS M.Sc.(Ag.)

ABSTRACT OF A THESIS

submitted in partial fulfilment of the requirement

for the degree

DOCTOR OF PHILOSOPHY

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF PLANT PATHOLOGY

COLLEGE OF AGRICULTURE

VELLAYANI, TRIVANDRUM

1986

EFFECT OF APPLICATION OF PLANT PROTECTION CHEMICALS ON THE SURVIVAL OF *Rhizoctonia solani* Kühn

By
LULU DAS M.Sc.(Ag.)

ABSTRACT OF A THESIS
submitted in partial fulfilment of the requirement
for the degree
DOCTOR OF PHILOSOPHY
Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF PLANT PATHOLOGY
COLLEGE OF AGRICULTURE
VELLAYANI, TRIVANDRUM

1986

ABSTRACT

In Kerala, the incidence of sheath blight of rice is endemic causing great economic loss. The present investigation was undertaken to make a critical assessment of the efficacy of various plant protection chemicals, viz., fungicides, insecticides and herbicides on the incidence and intensity of sheath blight of rice and on the survival of the pathogen. The organism was isolated from naturally infected rice fields and its pathogenicity proved.

Studies on the viability of sclerotia revealed that they sclerotia remained viable upto 210 days in all the different types of soils namely sandy, clayey and loamy. The organism could survive on straw bits upto 180th day only.

In vitro evaluation of plant protection chemicals on R. solani revealed that Ediphenphos at 100 ppm was the most effective fungicide in checking the radial growth of the fungus. A Carbaryl, among the insecticides at 100 ppm was able to give maximum inhibition of mycelial growth. Regarding herbicides, Bentazone at 1000 ppm was the most effective one.

A pot culture experiment revealed that Ediphenphos was the most effective fungicide against the disease followed by Carboxin and ketazin which were on par. Among the insecticides, Carbaryl was the most effective in reducing the incedence of disease and propanil the best herbicide fluchloralin and 2,4D Sodium salt were the least effective herbicides.

Among the antagonistic flora obtained from soil, Trichoderma viride was the most virulent, others exhibiting antagonism were Aspergillus niger, Neurospora crassa, Penicillium oxalicum, Chaetomium globosum and Fusarium solani.

The results of the pot culture experiment laid out to study the effect of application of antagonistic organism and plant protection chemicals on the incidence of sheath blight revealed that among the organisms used, Trichoderma viride was the superior one in the maximum reduction of disease followed by Neurospora crassa, Aspergillus niger and chaetomium globosum. Studies on the occurrence of mycorrhizae revealed that mycorrhizae were present in rice plants and it has been enhanced in the pots treated with Quintozene.

chlamydospores, the effect may last over 12 months and if it is favourable for its survival this period of survival may increase for 5 to 10 years or if it is toxic to potential pathogen their capacity to induce disease may be reduced as pointed by Altman and Campbell (1977). Since R. solani is an organism which survives by formation of sclerotia it is true that some of the herbicides have got beneficial effects while some others are detrimental to them.

Lakshmi (1984) found that sheath blight incidence was least in Bentazone treated pots and in the case of minimising intensity Bentazone was second to Propanil.

In a field test in Kerala, post emergence application of Saturn at 2 kg ai/ha controlled sheath blight and sheath rot of rice (Corticium sasakii and Sarocladium oryzae) respectively. (Vasavan et al., 1980). Varma et al. (1978) in Kerala recorded that Avirosan 50 EC, Saturn 50 EC, Machete 50 EC and Rilof H50 EC were highly inhibitory to the growth of Corticium sasakii.

A multilocational trial conducted by Kerala Agricultural University at Adoor and Moncompu during 1981-82 on the effect of various herbicides on the control of sheath blight disease revealed that Nitrofen 1.25 kg/ha and 1.75 kg/ha, Basagran (Bentazone) 1.75 kg/ha are effective