MANAGEMENT OF SHEATH BLIGHT DISEASE OF RICE IN RELATION TO THE POPULATION OF THE PATHOGEN IN SOIL

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Management of sheath blight disease of rice in relation to the population of the pathogen in soil" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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SHAJI ALEXANDER

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INTRODUCTION

INTRODUCTION

Rice is the staple food of more than 60 per cent of the world's population. It is grown in an area of about 145 million hectares in the world with a total production of over 320 million tonnes of rice. In India, rice is the most important and extensively grown food crop, occupying about 40 million hectares, which is about 40 per cent of the total area under cereals in the country. Eventhough, India occupies the first position in its area under rice, in the per hectare yield, it is perhaps, the lowest in the whole world.

The low yield in India is attributed to several reasons, chief among them being socio economic conditions, poor water management, deficiency of inputs and occurrence of pests and diseases. In an attempt to boost up rice production, many new hybrid varieties have been evolved. In fact, this has been mainly responsible for change in disease situation in that, diseases which were unknown or minor in the past have become extremely damaging. The sheath blight disease caused by Rhizoctonia solani Kuhn (Thanatephorus

oryzae (Frank) Donk) was first reported from Japan during the beginning of the twentieth century. In India, this disease appeared during the early sixties. However, this disease has taken an aggressive form during late sixties after the introduction of high yielding semi dwarf rice varieties.

In Kerala, the damage due to the disease is found to be very serious during the kharif season. Among different States in India, Kerala suffers maximum extent as the climate is quite congenial for the multiplication of the pathogen. Losses due to sheath blight of rice is generally 30 - 40 per cent and it may be even 100 per cent in endemic areas.

As the disease is soil-borne in nature, chemical control of the pathogen is extremely costly and quite laborious. Hence, drenching of chemical cannot generally be recommended as a practical measure of management. A search made by the scientists all over the world for a gene resisting sheath blight pathogen has so far been unsuccesful. Under the above circumstances, modification of soil environment - physical, chemical and biological - by appropriate

methods has been suggested to be helpful to decrease the population of the pathogen in soil, and thereby useful in the reduction of the disease intensity and incidence.

The present study has been undertaken with the objective of exploring the possibility of success in the management of sheath blight disease of rice by appropriate modification of the soil environment, under the following lines of investigation.

(i) In vitro studies on the influence of tillage and fallowing on viability of sclerotia of the pathogen.

(ii) Pot studies on the effect of soil amendments, pesticides and crop rotation on populations of pathogen and soil saprophytes and intensity and incidence of sheath blight disease.

(iii) A field experiment on the influence of amendments, biocontrol agent Trichoderma viride and fungicide carbendazim on the populations of the pathogen and soil saprophytes, intensity and incidence of sheath blight disease and yields of grain and straw.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Sheath blight disease of rice was first described by Miyake (1910) from Japan under the name oriental sheath blight and leaf spot. He named the organism as Sclerotium irregulare. Thereafter the disease was reported in the Philippines in 1918. From 1930 to 1940, it was reported from Sri Lanka and China and a similar disease was reported in the U.S.A. Now, it occurs in most rice growing countries (Ou, 1973).

The first Indian report on the incidence of the disease was from Punjab in 1963 (Paracer and Chahal, 1963) Subsequently the disease spread to other parts of Punjab (Kohli, 1966) and to the neighbouring State, Utter Pradesh (Singh and Pavgi, 1969). In Kerala, the disease occured in a severe form after the introduction of high yielding varieties (Prabhat, 1971). A survey of rice diseases in farmers' fields of major rice growing areas of Kerala viz., Palghat, Kole areas of Trichur and Kuttanad regions of Alleppey at monthly intervals for six continuous cropping seasons from 1977 onwards has shown that sheath blight was quite severe on all high yielding varieties. Eventhough the local varieties succumbed to

infection, the pathogen does not travel to the inner whorls and hence plants are not killed outright (Rajan, 1983).

The causal organism is a fungus. Several names such as Hypochnus sasakii Shirai (from Japan), Rhizoctonia solani kuhn (from China, Sri Lanka and Philippines), Corticium vagum. Bert and Cart(from India and West Germany), Corticium solani (Prill and Delacy), Bourd and Galz, Pellicularia filamentosa (Pat) Rogers f. sp sasakii and P.sasakii (shirai) S.Ito. According to recent studies, the imperfect stage of the fungus is known as Rhizoctonia solani and the perfect stage is called Thanatephorus cucumeris (Frank) Donk (Ou, 1973; Gangopadhyay, 1983).

The fungus produces two types of mycelia, the straight running type and the lobated type. When a fungus is not actively colonizing a substrate, it may survive in the form of mycelial aggregate giving rise to a sclerotium. There are three types of sclerotia, host sclerotia of smallest size, soil sclerotia of medium size and laboratory sclerotia of largest size (Gangopadhyay, 1983).

Nisikado and Hirata (1937) have concluded that elimination of the fungus from rice fields is difficult. They observed that the viability of sclerotia at 20, 25 and 30°C were three years, sixteen months and six months under dry conditions and was three years, six months and three months under wet conditions, respectively.

Kannaiyan and Prasad (1978) studied the viability of the fungus under dry and wet conditions. They have observed that at five cm depth, sclerotia remained viable for more than one year, while at soil surface, the viability was lost after seven months under dry conditions. When the condition was created in which the sclerotia were floating, they were viable for about an year. These workers have suggested that factors favouring long survival in soil and water play a significant role in the spread of the disease in fields especially under water logged conditions.

DISEASE MANAGEMENT

Physical Methods

Prabhat (1971) studying the viability of the fungal sclerotia in different soil depths suggested

that the viability was not influenced by the depth under dry conditions. However, he observed that viability was lost at deeper layers of more than 10.0 cm depth by providing a submerged condition for more than 2 months. Tu and his associates (1979) noticed that when sclerotia in the surface of the field survived for more than sixteen months, those buried at depths of two cm survived only for a period of less than eight months.

Hashiba and Mogi (1973) observed that in uncultivated fields, there were marked reduction in the number of sclerotia and their loss in germination as time passed, indicating the importance of fallowing in sheath blight management.

Prabhat and his associates (1974) suggested that by flooding the rice field for a period of two to three months after harvest, the sclerotia loose their viability, indicating the importance of flood fallowing in disease management.

Rovira (1986) after a three year field study found that in case of bare patch of wheat (Rhizoctonia solani), the area of the affected crop was consistently

larger when wheat followed wheat, indicating the importance of crop rotation in the management of R.solani.

BIOLOGICAL METHODS

The history of biological control dates back to 1908 when Potter showed that plant pathogens could be inhibited by their own metabolic products. Garett (1956) defined biological control of plant diseases 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 by himself with the result that there is a reduction in the incidence of the disease caused by the pathogen. Thus, biological control is mainly based on the assumption that suitable management of soil conditions like amending the soil with organic material can stimulate the activity of soil micro organisms which, in turn, can be antagonistic to a given pathogen.

It is more relevent in soil-borne diseases as inoculum potential plays a much more dominant role in soil-borne diseases than air-borne diseases due to

obvious reasons. Hence, the aim is to bring down the population of the pathogen to a level lower than the minimum inoculum potential required for infection by adopting biological measures.

As early as 1935, Hino noticed Rhizoctonia solani, causal agent of sheath blight of rice incorporated into a loamy soil was destroyed in five days by Bacillus lactis and Trichoderma lignorum which were native flora of that particular soil.

Endo (1973) suggested the possible use of Neurospora crassa to control sheath blight of rice as the disease incidence was markedly reduced by Neurospora crassa in soil while seedling growth was not affected. Roy (1977) observed the efficiency of Trichoderma viride as a bio control organism. When R.solani was grown in combination with T.viride, the growth and sclerotial germination of the former became detrimental. However, when spores of T.viride were sprayed on aereal parts of rice plant before inoculation with R.solani, the disease could not be checked.

Mew and his associates (1980) noticed that Trichoderma sp. coil around the sclerotia and make them

inactive. Mew and Rosales (1984) observed that T.harzianum reduced survival of R.solani. In vitro studies of Gokulapalan and Nair (1984) indicated that Aspergillus niger and T.viride inhibited linear growth of R.solani while certain bacterial isolates reduced the germination of sclerotia. Enhanced plant growth resulting from amendments of soil with T.harzianum and T.koningii has been noticed by Windham et al. (1986).

Another bio control agent identified for the management of R.solani is Laetisaria arvalis (Burdsall et al, 1980). Larsen and co-workers (1985) observed temporary depressions in the field population of R.solani after amending the soil with L.arvalis during winter and early spring in sugar beet fields. Tschen and Kuo (1985) noticed that application of antibiotic from Bacillus subtilis culture filtrate to rice leaves inhibited growth of R.solani and prevented the development of the disease.

The role of organic soil amendments in the suppression of soil-borne plant pathogens has been emphasized by Stover (1962); Huber and Watson (1970), Linderman (1970) and Papavizas and Davey (1960).

Incorporation of organic materials to soil has shown to be effective in reducing the intensity of the diseases such as take all of wheat (Ophibolus graminis) (Fellows, 1929), Phymatotrichum root rot of cotton (King et al., 1934), Potato scab (Streptomyces scabies) (Millard, 1923) and Phytophthora root rot of avacado (Zentmyer and Paulus, 1957). Although much work has been undertaken on the control of various plant diseases with organic materials like decomposing plant materials, green manure, crop residues, food bases and agricultural and industrial waste materials, not much work has been carried out with regard to the control of sheath blight disease of rice caused by Rhizoctonia solani.

As early as 1962, Papavizas and his associates have noticed that the saprophytic activity of R.solani was as effectively reduced by cellulose powder, Oat straw and sugarbeet hay enriched with ammonium nitrate as quitosene. In 1963, Loo suggested that tea seed cake at the rate of 1500 kg/ha reduced the disease intensity due to R.solani. Rajan and Menon (1975) observed that growth of rice plants was considerably

increased with a corresponding decrease in the intensity of sheath blight (R.solani) by the addition of various oil cakes and organic materials like saw dust, cashew shell powder and coconut husk to soil. Rajan (1980) has opinioned that non edible oil cakes, saw dust and rice husk are equally effective in suppressing sheath blight of rice. Nath (1979) noticed that survival period and viability of sclerotia were reduced by incorporation of green manure like Sesbania aculata. Kannaiyan and Prasad (1981 a) suggested that seedling infection of Rhizoctonia solani was reduced by amendments such as rice chaff, neem cake, saw dust and manure. George et al. (1984) obtained good field control of sheath blight of rice with amendments such as paddy husk or neem cake. On evaluating the population of soil saprophytes, these workers have suggested that in plots amended with rice husk or neem cake, there was tremendous increase of saprophytes and there was significant negative correlation between populations of saprophytes and population of the pathogen R.solani.

CHEMICAL METHODS

In 1953, Hashioka and Saito succeeded in controlling the disease by applying Arasan (thiram 75 per cent ai). Yoshimura (1954) obtained reduced disease intensity by application of Bordeaux mixture. Kozaka and his associates (1957) reported that organic arsenic compound 'Urbazid' was highly effective against sheath blight. Abeygunawardena and De silva (1964) observed that natural infection by Corticium sasakii can be reduced by organo arsenic sprays. Thirumalachar et al. (1969) noticed the efficiency of Aureofungin inhibiting the growth of Corticium sasakii under field conditions.

Bhaktavatsalam et al. (1977) in field and other tests against the disease found that Bavistin was the most effective fungicide. This was followed by MBC and Benlate. Other workers also have reported the efficacy of Bavistin in controlling the disease (Jaganathan and Kannaiyan, 1978; Dev, 1980; Reddy et al., 1981). Kannaiyan and Prasad (1977 a) reported that fungicide Benlate, Demosan, Hinosan, Kitazin and Daconil are highly effective against the disease. Efficacy of

Hinosan and Kitazin have been reported by Jayanathan and Kannaiyan (1978); Rajan et al (1979); Kannaiyan and Prasad (1979 b) and Dev (1980). Kannaiyan and Prasad (1977 b) observed that the antifungal antibiotic aureofungin was highly effective against the disease. Roy and Saikia (1976) in green house and field tests found that the best control of Corticium sasakii on rice was given by MBC (carbendazim 0.05 per cent) followed by benomyl and mancozeb. Jaganathan and Kanniyan (1978) was of opinion that cuman was effective against the disease. Rao et al. (1978) tested the fungitoxicity of copper, nickel and iron chelates against the disease and all of them were found to be more toxic than mancozeb, even at 50 and 100 ppm. They suggested that the fungistatic activity was in the order Cu > Ni > Fe > Zn > Mn > Co.

Kannaiyan and Prasad (1979 c) found that Vitavax (carboxin) completely inhibited the sclerotial germination. Kannaiyan and Prasad (1979 b) in pot trials found that N.F.48 and Daconil (chlorathalonil) were also effective against the disease. Kannaiyan and Prasad (1979 d) have reported that application of trace elements like borax, zinc sulphate, copper sulphate and ferrous sulphate at 0.05 per cent as two foliar sprays

at ten days interval reduced the disease and increased the grain yield.

Leu and Yang (1979) sprayed rice plants grown in pots before and after inoculation with Thanatephorus cucumeris. The best control was with 0.4 per cent Neo Asozine (ammonium salts of ferric methyl arsenic acids), eight per cent Monsan (calcium methyl arsenic acid) and 0.5 per cent Neo Asozin E.C.

Rajan et al. (1979) reported good control of the disease by spraying Dithane Z-78 or Dithane M-45. Dev and Sathyarajan (1980) observed that a soil drench of thiram followed by a spray of Hinosan reduced tiller infection by about 40 per cent, while drenching with brassicol followed by Hinosan spray reduced 20 per cent tiller infection in comparison to untreated control.

Kannaiyan and Prasad (1980 a) studied the effect of various phenolic compounds on the disease and found that catechol, ferulic acid and hydroxycinnamic acid completely inhibited sclerotial production at 100 and 200 ppm. Kannaiyan and Prasad (1980 b) found that seed treatment with thiram, oxycarboxin, chlorathalonil, benomyl and captan at 0.2 per cent increased the root growth of rice seedlings. Seeds treated with oxycarboxin and MBMC maintained more than 90 per cent

viability after 8 months storage. Kannaiyan and Prasad (1981 b) reported that seed treatment with antibiotics like Agrimycin-500 and Aureofungin and storing for eight months increased the seed germination and seedling growth.

Reddy et al. (1981) observed that fungicides MBC, Derosal and Bavistin checked the development of Rhizoctonia solani and increased the yield. Recently it is reported that a new systemic fungicide Moncut in the benzanilide group effectively controlled rice sheath blight (Kurono, 1985).

Several herbicides have proved their potential in suppressing the populations of the pathogen. But a few of these increased the population of the pathogen. Kurosani 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 the number of spots found on the plant. However, the beneficial effects of the herbicides are more. Bain (1961) tested several herbicides against Rhizoctonia sp. and found the inhibition of growth. Pentachlorophenol and 2 chlor-N, N-dialkyl acetamide were the most active.

The weedicide, 2,4-D at 100 ppm reduced the growth of Rhizoctonia by 86 per cent in Fries nutrient solution while simazine reduced the growth by 93 per cent (Millikan, 1964). Rodriguez-Kabana et al. (1966) reported that the total mycelial dry weight of R.solani was considerably less for each concentration of atrazine than for the check throughout the 22 day incubation period and the degree of growth inhibition was directly related to increased herbicide concentration from 10 to 70 ppm, out of the four herbicides tested against Rhizoctonia solani viz., atrazine, diuron, EPTC and Paraquat.

When high levels of trifluralin or prometryne were used in the growth chamber, an interaction injurious to cotton occured with R.solani. Both compounds were found antagonistic to the pathogen (Chandler and Santelmann, 1968). Cole and Batson (1975) reported that growth of R.solani was reduced in the medium containing the herbicide diphenamid.

Inderawati and Heitefuss (1977) tested seven herbicides against R.solani in culture and for subsequent influence on disease intensity. The growth of the

pathogen in agar media containing 10 /ug/ml commercial formulation was reduced to C 50 per cent of the control. The effect of simetryn and nitrofen on disease severity was stronger than expected from small direct action on the pathogen in cultures.

In field tests with two herbicides on 12 rice varieties, Manila and Lapis (1977) found that sheath blight was not influenced by treatment with 2,4-D and MCPA. Laboratory tests were carried out to study the effect of herbicides on the growth of R.solani by Varma et al. (1978). Out of the 10 herbicides tested Avirosan 500 EC was found most effective. Saturn 50 EC, Pilot H 500 EC and Mashetti 50 EC were also found effective in checking the growth of this fungus. Dath and Swain (1979) reported that weedicides like propanyl and Nitrofen have potentiality in suppressing the growth of the sheath blight pathogen.

In field tests in Kerala conducted by Vasavan et al. (1980), it was found that saturn (benthiocarb) at 2 kg ai/ha controlled the sheath blight of rice. Lekshmy (1984) reported that out of the eight herbicides tested against R.solani, propanyl was the most toxic one, which completely

inhibited the radial growth of the test organism even at 125 ppm. The herbicides prevented the sclerotial germination at higher concentrations of 2000 and 3000 ppm and also at lower concentration when treated for prolonged periods. Benthiocarb, Nitrofen and Butachlor were also found highly toxic to the test fungus which decreased the radial mycelial growth with increasing concentration of the chemical. 2,4-D enhanced the growth and survival of R.solani in culture.

The interaction of insecticides with the sheath blight pathogen R.solani has also been reported by some workers. Seed treatment of cotton with phorate increased the stand of the seedlings in soil infested with R.solani (Erwin and Reynolds, 1958).

Chlorinated hydrocarbon insecticides are fungitoxic in proportion to their water solubility and vapour pressure (Bollen, 1961). Tested by plate culture technique against R.solani, lindane which has a high water solubility (7.3 ppm at 25°C) was most toxic in supersaturation at 25 ppm.

Hacskaylo and Stewart (1962) reported that phorate treatment of cotton seeds controlled Rhizoctonia within a temperature range of 82 - 92°F. Manila and Lapis (1977) observed that monocrotophos did not alter the intensity of sheath blight (R.solani).

Dath and Swain (1979) reported that nematicides like Furaban, Phorate and DBCP have potentiality in suppressing the growth of the sheath blight pathogen. Sankaralingam (1980) observed that the insecticides carbofuran and phorate inhibited the growth of pathogen in solid media. They delayed the sclerotial production besides reducing the sclerotial size, but did not alter the germination of sclerotia.

MATERIALS AND METHODS

MATERIALS AND METHODS

Isolation and pure culture of the organism

The organism causing sheath blight disease of rice *Rhizoctonia solani* was brought into pure culture from the naturally infected rice specimen collected from Agricultural Research Station, Mannuthy, Trichur, Kerala. Basal portions of the sheath showing early symptom of the disease, as evidenced by light ellipsoidal spots, were cut into small pieces, were washed in running tap water to remove the soil particles and were allowed to dry up by placing them on laboratory bench. Later on, they were surface sterilized by dipping them in 0.1 per cent mercuric chloride solution for two minutes. This was followed by washing the bit in three changes of sterile water to remove the traces of mercuric chloride adhered to the bit. Each bit was carefully picked up and was placed aseptically in a sterilized petridish containing melted cooled potato dextrose agar. The plates were incubated under laboratory conditions. After 24 hours, fungal growth in the infected bit was placed in a sterile petridish containing melted cooled plain agar medium. After 24 hours of incubation in the plain

agar medium, the plates were directly placed under the microscope and hyphal tips were marked in the dish. These hyphal tips were aseptically carried to Potato Dextrose Agar in petriplates. The growth of the organism from one hyphal tip was multiplied in petriplates and in slants and was utilised for laboratory, pot and field studies.

The pathogenicity of the fungus was tested by inoculating it on rice seedlings followed by its reisolation from inoculated seedlings and comparison of the two isolates.

The causal fungus Rhizoctonia solani was mass cultured on sterilized sand-maize meal medium in 1000 ml Erlen Meyer flasks. Maize meal was thoroughly mixed with washed white sand in the ratio of 1 : 19 and this mixture was taken in flasks moistened with water and was sterilized by autoclaving under a pressure of 15 lbs for one hour. Three day old culture discs of Rhizoctonia solani were aseptically introduced into the flask containing sterilized sand-maize meal medium and were incubated for twenty days.

LABORATORY EXPERIMENTS

The above consisted of two sets of experiments to study the effect of tillage, fallowing and flooding on the viability of sclerotia of the fungus. Plastic pots of 20 cm height were used for the above. Pots were filled to a depth of 15 cm with soil collected from paddy field. Ten sclerotia, each of uniform size obtained from mass production technique were buried in pots at five depths viz., 0, 2.5, 5, 7.5 and 10.0 cm from the soil surface and were kept under laboratory conditions.

The difference between two sets of experiments was that in the former, there was no standing water in the pots, while in the latter, water was retained to five cm height above the soil surface in all the treatments during the entire period of investigation.

After two, four, six and eight weeks of burial, sclerotia at different depths were recovered, surface sterilized with 0.1 per cent mercuric chloride, washed in three changes of sterile water and were placed in PDA for viability test.

POT CULTURE EXPERIMENTS

Pot experiments were carried out to study the effect of amendments (other than oil cakes), effect of oil cakes, effect of pesticides and effect of crop rotation on the intensity and incidence of sheath blight disease and population of the pathogen *Rhizoctonia solani* and associated saprophytic microflora viz., total fungi, bacteria and actinomycetes.

(a) Experiment with amendments (other than oil cakes)

The experiment consisted of nine treatments (rice straw, rice husk (*Oryza sativa*), glyricidia leaves (*Glyricidia maculata*), press mud (*Saccaharum officinarum*), saw dust, lime, gypsum, coconut pith (*Cocos nucifera*) with an untreated control and three replications. The soil was artificially inoculated with 100 g of one week old vigourously growing culture of *Rhizoctonia solani* grown on sand-maize meal medium. The amendments were incorporated to soil one week after inoculation. The quantities of various amendments were fixed according to their nitrogen content. Analytical data of the amendments are presented in table 1. Other major nutrients phosphorus

Table - 1

Organic and inorganic amendments and their major nutrient contents

Name of amendment	Nutrient content (per cent)		
	N	P_2O_5	K_2O
Rice straw	0.56	0.52	0.53
Rice husk	0.64	0.27	0.72
Glyricidia leaves	0.84	0.10	0.72
Press mud	0.50	0.50	0.06
Saw dust	0.14	Traces	0.16
Lime	-	-	-
Gypsum	-	-	-
Coconut pith	2.24	Traces	0.07

and potash received through each amendment were calculated and the balance were supplied through mashoori phosphate and muriate of potash, respectively. Thus, all the different treatments had uniform dose of NPK viz., 90:45:45 kg/ha (Anonymous, Package of Practices recommendations, Kerala Agricultural University, 1986). Lime and gypsum were added at the rate of 200 kg/ha. In pots receiving inorganic amendments viz., lime and gypsum, urea, mashoori phosphate and muriate of potash were used to give NPK at the rate of 90:45:45 kg/ha (Anonymous, Package of Practices recommendations, Kerala Agricultural University, 1986).

Twenty one day old rice seedlings of variety Jyothi were transplanted into pots at the rate of three hills per pot, two weeks after amendment.

(c) Experiment with oil cakes

The experiment was carried out with five treatments (different non-edible oil cakes viz., Mahua cake (Madhuca indica), Marotti cake (Hydnocarpus kurzii), Neem cake (Azadirachta indica), Punna cake (Calophyllum ionophyllum) with an untreated control

and four replications. Quantities of various oilcakes were fixed as in the previous experiment and were added to soil one week after inoculation (Table 2). Twentyone day old rice seedlings of variety Jyothi were transplanted into pots at the rate of three hills per pot two weeks after amendment.

(c) Experiment with pesticides

The commonly used pesticides viz., fungicides such as Bavistin (carbendazim), Foltaf (captafol), Hinosan (ediphenphos) (0.1 per cent each) and Dithane M-45 (mancozeb) (0.2 per cent); insecticides such as Nuvacron (monocrotophos), Ekalux (quinalphos) (0.2 per cent each) and Sevin (carbaryl, 2.5 kg 50 WP per hectare) and weedicides such as Weedon (2,4-D sodium salt, 1.0 kg ai per hectare) and Saturn (benthiocarb, 1.5 kg ai per hectare) were used. Soil was inoculated as in previous experiments. The fungicides Bavistin, Foltaf, Hinosan and Dithane M-45 were applied on fortyfifth day, among insecticides, Sevin was applied fifteen days after transplanting, while Nuvacron and Ekalux were applied on twentieth day. Among weedicides, Weedon was applied on twentyfifth day, while Saturn was applied on sixth day. Twenty one

Table - 2

Nonedible oil cakes and their major nutrient contents

Name of oilcake	Nutrient content (per cent)		
	N	P_2O_5	K_2O
Mahua cake (*Madhuca indica*)	2.80	0.01	1.90
Marotti cake (*Hydnocarpus kurzii*)	2.53	0.01	1.81
Neem cake (*Azadirachta indica*)	3.18	0.11	2.91
Punna cake (*Calophyllum inophyllum*)	3.85	0.25	2.80

day old rice seedlings of variety Jyothi were transplanted to pots at the rate of three hills per pot, three weeks after inoculation of soil.

(a) Experiment with crop rotation

Four kg soil each were filled in pots obtained from different crop rotations viz., rice-vegetables, rice-banana, rice-cowpea, rice-groundnut, rice-tapioca and rice-rice during the first crop (kharif) and second crop (rabi) seasons, respectively. Twentyone day old rice seedlings of variety Jyothi were transplanted into pots at the rate of three hills per pot. Soil was dug up to a depth of about 30 cm at four different locations under each rotation, they were pooled and from this lot, a representative sample of four kg was drawn to fill the pots.

Microbial assay

Soil samples collected during different periods viz., before amendment, two weeks, six weeks and ten weeks after amendment were subjected to microbial assay in experiment with amendments (other than oil cakes) and experiment with oil cakes.

Pathogen (Rhizoctonia solani)

The number of propagules of the pathogen (R. solani) in soil incorporated with different amendments were analysed using Ko and Hora medium (Ko and Hora, 1971).

Ko and Hora medium

Dipotassium hydrogen phosphate	1.0 g
Magnesium sulphate	1.0 g
Potassium chloride	0.5 g
Ferrous sulphate	10.0 mg
Sodium nitrite	0.2 g
Gallic acid	0.4 g
Dexon	90.0 mg
Chloramphenicol	50.0 mg
Streptomycin	50.0 mg
Agar	20.0 g
Distilled water	1000.0 ml
pH	7.0

Gallic acid, dexon, chloramphenicol and streptomycin were added after sterilization. The procedure employed for the assay is as follows.

Ten g of soil was moistened with sterile distilled water, compacted with a spatula and evenly distributed in petriplates containing the selective medium.

Total fungi

Assay of total fungalflora in soil was done employing the selective medium peptone dextrose agar with rose bengal and streptomycin (Martin, 1950).

One g soil was placed in conical flasks containing 99 ml sterile distilled water and flasks were shaken in a mechanical shaker for 20 minutes. One ml of the suspension was pipetted from the flask while swirling and transferred to 99 ml sterile water contained in flask thus making the dilution one in 10,000. One ml of each of 10^{-4} dilution was pipetted to sterile petridishes, 15 ml of each Martin's medium was poured to the above plates and were utilized for estimating the population of fungi. Fungal colonies were counted from fourth day onwards.

Bacteria and Actinomycetes

The population of bacteria and actinomycetes were estimated in a similar manner except in that the ultimate dilution used was 10^{-6}. Media used were soil extract agar (Allen, 1957) and Kenknights agar (Anonymous, 1966) for bacteria and actinomycetes, respectively. The colonies were counted from seventh day.

Growth characters of rice plants such as height of the plants and the number of tillers were recorded in each of the experiment during active tillering phase.

Intensity and incidence of the disease were assessed in the panicle emergence stage. Intensity of the disease was scored in each tiller as per standard evaluation system (Figure 1). Details are as follows.

Grade	Description
1	Lesions limited to lower ¼ of leaf sheath.
3	Lesions present in lower ½ of leaf sheath.
5	Lesions in more than ½ of the leaf sheath, slight infection on lower leaves (third or fourth leaves).
7	Lesions present in more than ¾ of leaf sheath, severe infection on lower leaves and slight infection on upper leaves (flag leaf and second leaf).
9	Lesions reached the top tillers, severe infection on all leaves.

Incidence of the disease was assessed as the percentage of number of infected tillers.

FIELD EXPERIMENT

The field experiment was laid out at the Agricultural Research Station, Mannuthy during kharif season (July-August to October-November) of 1985-86 in a Factorial Randomised block design with 18 treatment combinations and three replications. The treatments consisted of soil amendments (rice husk, punna cake, glyricidia leaves, lime, gypsum along with control) as main treatments and biocontrol agent Trichoderma viride and fungicide carbendazim along with an untreated control as sub treatments. Quantities of each amendment were fixed depending upon their nitrogen contents. As in pot experiment, NPK were equated by extra supply of mashooriphosphate and muriate of potash. Thus, each plot received NPK at the rate of 90:45:45 kg/ha (Anonymous, Package of Practices recommendations, Kerala Agricultural University, 1996). In plots amended with inorganic materials (lime and gypsum), required quantities of NPK were supplied through Urea, mashooriphosphate and muriate of potash, respectively.

FIG : 1. SHEATH BLIGHT INFECTION GRADES

FIELD EXPERIMENT

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The experimental field was ploughed twice and soil was brought to a fine tilth and plots of size 3 x 2.5 m were prepared (Figure 2). On completion of field preparation and levelling a vigorous culture of Rhizoctonia solani (obtained by mass production technique) was applied to each plot uniformly at the rate of one kg of culture per plot.

Two weeks after amending plots with different materials, 21 day old Jyothi seedlings were transplanted to plots at a spacing of 20 cm x 15 cm. Controlled irrigation was given uniformly throughout the cropping season. Plots were weeded at 20 day intervals. Three weeks after transplanting, one insecticidal spray (0.2 per cent Ekalux) was given against rice hispa in all plots.

Before amending, soil samples were collected from different plots, dried in shade and were utilized for the assay of total fungi, bacteria, actinomycetes and the pathogen R.solani. Media used and procedure were the same as described earlier.

Application of biocontrol agent Trichoderma viride as well as spraying carbendasim in respective plots were done when the initial symptoms of the disease

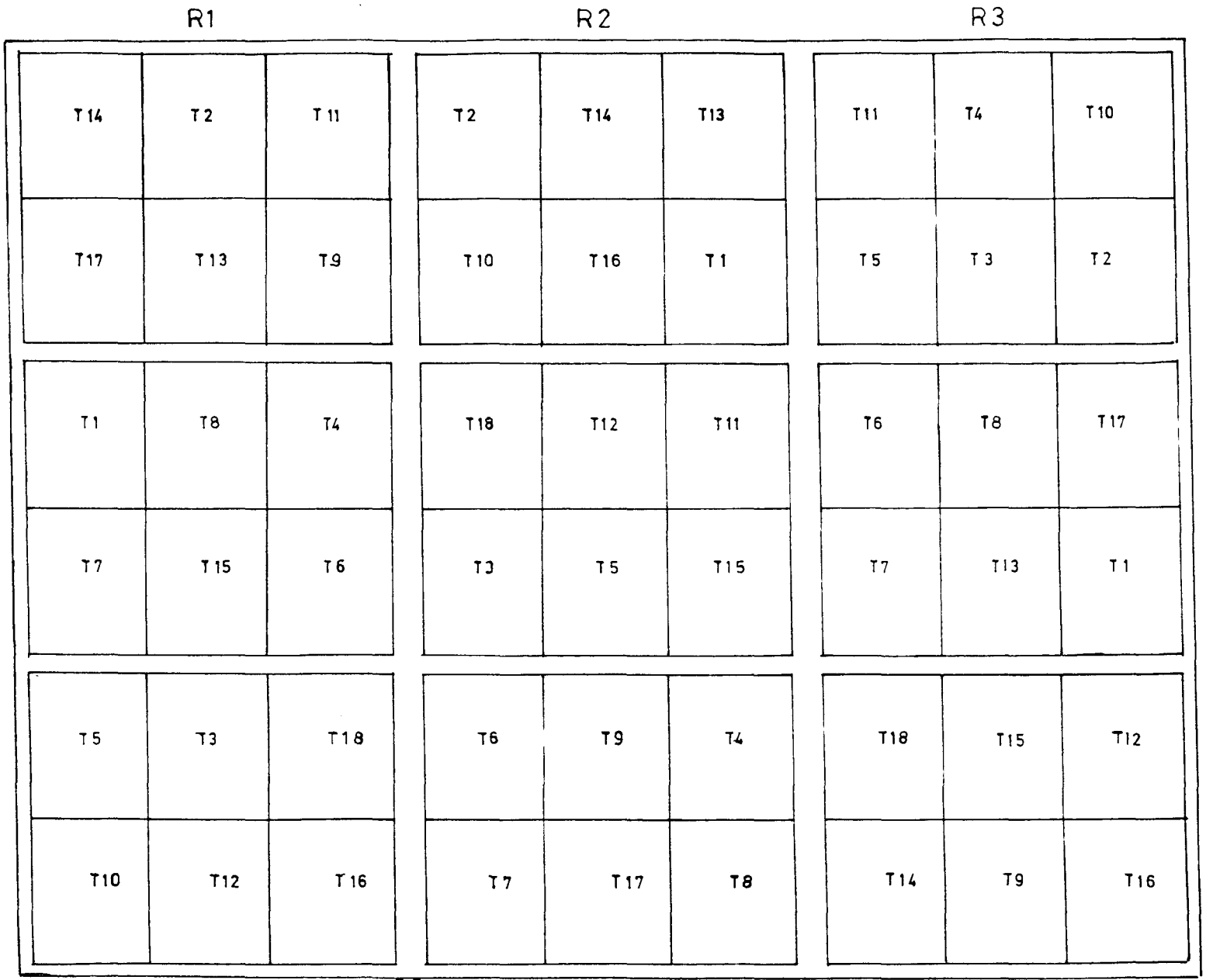


FIGURE • 2

LAY OUT PLAN – FACTORIAL RANDOMISED BLOCK DESIGN

N

TREATMENTS

T1 - Rice husk + Trichoderma viride
T2 - Rice husk + Carbendazim
T3 - Rice husk alone
T4 - Punna cake + T. viride
T5 - Punna cake + Carbendazim
T6 - Punna cake alone
T7 - Glyricidia leaves + T. viride
T8 - Glyricidia leaves + Carbendazim
T9 - Glyricidia leaves alone
T10 - Lime + T. viride
T11 - Lime + Carbendazim
T12 - Lime alone
T13 - Gypsum + T. viride
T14 - Gypsum + Carbendazim
T15 - Gypsum alone
T16 - T. viride alone
T17 - Carbendazim alone
T18 - Control

appeared in the field. A second application of the fungicide and biocontrol agent was done fourteen days after the first application.

Observations were taken on total and productive tillers and height of the plants during active tillering phase and just before harvest. Intensity and incidence of sheath blight disease were assessed at three stages (Maximum tillering, panicle emergence and just before harvest) and yields of grain and straw after harvest. Disease intensity was scored on 25 randomly selected hills per plot according to Standard Evaluation System of IRRI (Fig.1). Disease incidence was recorded by observing 40 hills from randomly selected four rows in each plot and counting the number of infected tillers.

Microbial antagonism

Soil samples were collected from plots receiving different treatments and isolation of total fungi was done from the collected samples employing serial dilution technique. Morphologically different fungal colonies were purified by hyptal tip method. Each colony was tested for the antagonism towards the sheath blight pathogen R.solani by placing the discs of the pathogen

as well as of the isolated fungal colony side by side in a single petridish containing melted and cooled potato dextrose agar and observing for the antagonism.

Chemical analysis of soil

The major nutrient content and pH of the soil before and after the addition of different amendments were analysed.

Statystical analysis

The populations of microorganisms viz., total fungi, bacteria and actinomycetes were analysed after logarithmic transformation. Disease incidence was subjected to angular transformation. Population of *R.solani*, disease intensity, yields of grain and straw, and the agronomical observations were analysed directly.

RESULTS

RESULTS

Laboratory Trials

The laboratory trial conducted to study the effect of tillage on sclerotial viability of *Rhizoctonia solani* has shown that under dry conditions, sclerotia remained viable even after eight weeks in soil at different depths viz., zero to ten cm of soil surface. However, when pots were flooded to a height of five cm above soil surface, germination was delayed at deeper layers of 7.5 cm and ten cm depths. It was observed that at soil surface as well as at shallow depths of 2.5 cm and five cm, the germination of sclerotia was almost similar to that of sclerotia collected from dry soil. But, in deeper layers, there was appreciable delay of about 24 hours for germination and the germ tube development was weak and improper after four weeks of flooding.

Pot culture experiments

(a) Experiment with amendments (other than oil cakes)

In general, amendments increased plant height, eventhough there was no significant improvement in

tiller production (Table 3). Plants amended with glyricidia leaves and saw dust (with nutrients) were significantly taller than plants of other treatments.

The intensity as well as incidence of sheath blight disease were less in all treatments when compared to untreated control (Figure 3). A comparison of different treatments has indicated that least disease intensity and incidence were noticed in pots of glyricidia leaves, rice husk, gypsum or saw dust (with nutrients). In coconut pith amendment, the intensity of the disease was as low as the above mentioned treatment, eventhough the disease incidence was of a higher magnitude.

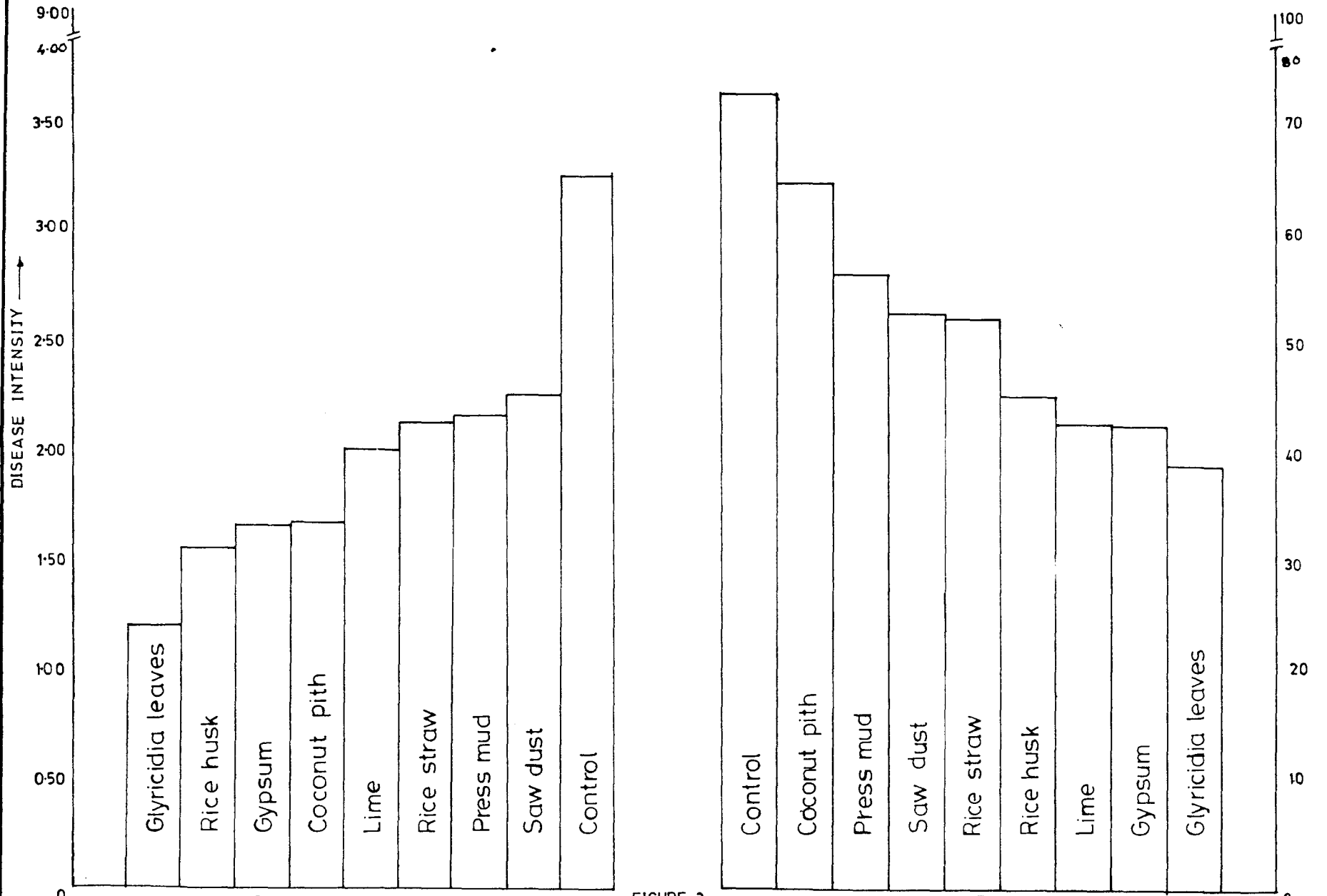
Microbial population

Populations of Rhizoctonia solani, total fungi, bacteria and actinomycetes in soil collected from different amendments at different periods viz., before amendment, two weeks, six weeks and ten weeks after amendment, as well as the percentage deviation of the above microbial populations with the original populations before amendment are presented (Table 4 and 5).

Table - 3

Effect of amendments (other than oil cakes) on height and number of tillers of rice crop and intensity and incidence of sheath blight disease of rice.

Treatment	Height (cm)	Number of tillers	Sheath blight intensity (0 - 9 scale)	Sheath blight incidence (percentage of number of tillers infected)
Rice straw	45.78	4.44	2.129	51.937
Rice husk	41.89	4.33	1.540	44.810
Glyricidia leaves	48.89	7.67	1.206	38.973
Press mud	45.22	4.33	2.162	56.273
Saw dust	46.78	4.55	2.280	52.140
Lime	47.22	5.56	2.018	42.370
Gypsum	48.56	6.67	1.650	42.357
Coconut pith	47.44	6.00	1.658	64.603
Control	44.67	5.78	3.254	72.540
C D (0.01)	4.05	N S	0.876	7.600



FIGURE·3

EFFECT OF AMENDMENTS(OTHER THAN OILCAKES) ON INTENSITY AND INCIDENCE OF SHEATH BLIGHT DISEASE OF RICE

Table - 4

Number of propogules of *Rhizoctonia solani* (10 g), population of total fungi, bacteria and actinomycetes per g dry soil treated with different amendments (other than oil cakes)*

Treatments	Rhizoctonia solani						
	Before addition	Period after addition (weeks)			Percentage deviation after (weeks)		
		2	6	10	2	6	10
Rice straw	12.000	12.000	19.600	9.300	0	+63	-24
Rice husk	12.000	13.200	15.600	6.300	+10	+30	-48
Glyricidia leaves	12.600	12.800	22.400	10.200	+ 2	+78	-19
Press mud	10.600	9.000	18.000	16.067	-15	+70	+32
Saw dust	11.400	11.600	10.800	7.200	+ 2	- 5	-33
Lime	14.600	16.200	16.600	9.200	+11	+14	-37
Gypsum	14.000	16.000	14.400	8.200	+14	+ 3	-41
Coconut pith	12.600	12.000	15.000	11.000	- 5	+19	-13
Control	12.000	15.000	16.700	17.933	+25	+39	+48
C D (0.01)	N S	2.433	2.810	2.238			

* Values of population of total fungi, bacteria and actinomycetes presented are transformed using logarithmic transformation. Their original values are presented in Table 5.

(contd.....)

(Table 4 contd.)

Treatments	Total fungi						
	Before addition	Period after addition (weeks)			Percentage deviation after (weeks)		
		2	6	10	2	6	10
Rice straw	4.885	5.055	5.313	5.322	+4	+ 9	+ 8
Rice husk	4.899	5.342	5.459	5.317	+9	+11	+ 8
Glyricidia leaves	4.885	5.114	5.512	5.664	+5	+13	+16
Press mud	4.835	5.102	5.398	5.547	+7	+12	+15
Saw dust	4.772	5.135	5.180	5.510	+8	+ 9	+15
Lime	4.802	4.976	5.201	5.156	+4	+ 8	+ 8
Gypsum	4.726	4.985	5.224	5.546	+5	+10	+17
Coconut pith	4.864	5.261	5.250	5.511	+8	+ 8	+12
Control	4.818	4.913	5.023	5.171	+2	+ 4	+ 7
C D (0.01)	N S	0.200	0.220	0.220			

(contd.... .)

(Table 4 contd.)

Treatments	Bacteria						
	Before addition	Period after addition (weeks)			Percentage deviation after (weeks)		
		2	6	10	2	6	10
Rice straw	6.664	7.068	7.267	7.005	+6	+9	+ 5
Rice husk	6.918	7.157	7.154	7.021	+6	+3	+ 1
Glyricidia leaves	6.853	7.184	7.494	7.425	+5	+9	+10
Press mud	6.783	7.260	7.426	7.158	+7	+D	+ 6
Saw dust	6.723	6.770	6.630	7.216	+1	-1	+ 7
Lime	6.852	6.928	7.341	7.185	+1	+7	+ 4
Gypsum	6.836	6.881	6.641	7.080	+2	-3	+ 4
Coconut pith	6.867	6.968	7.123	7.346	+1	+4	+ 6
Control	6.822	6.558	6.715	7.019	-1	+2	+ 6
C D (0.01)	N S	0.476	0.450	N S			

(contd.....)

(Table 4 contd.)

Treatments	Actinomycetes						
	Before addition	Period after addition (weeks)			Percentage deviation after (weeks)		
		2	6	10	2	6	10
Rice straw	6.638	7.082	7.550	7.614	+7	+14	+15
Rice husk	6.874	7.120	7.557	7.625	+4	+10	+10
Glyricidia leaves	6.865	7.160	7.546	7.764	+4	+10	+13
Press mud	6.863	7.257	7.604	7.716	+6	+11	+12
Saw dust	6.957	6.666	7.120	7.401	-4	+ 2	+ 6
Lime	6.852	6.929	7.423	7.678	+1	+ 8	+12
Gypsum	6.861	6.896	6.790	7.259	+1	- 1	+ 6
Coconut pith	7.050	7.020	7.484	7.690	-0.4	+ 6	+ 7
Control	6.898	6.592	6.926	7.302	-5	+0.4	+ 7
C D (0.01)	N S	0.461	0.465	0.493			

Table - 5

Populations of total fungi ($\times 10^4$) bacteria ($\times 10^6$) and actinomycetes ($\times 10^6$) per g dry soil treated with different amendments (other than oil cakes)

Treatments	Total fungi				Bacteria				Actinomycetes			
	Before addition	Period after addition (weeks)			Before addition	Period after addition (weeks)			Before addition	Period after addition (weeks)		
		2	6	10		2	6	10		2	6	10
Rice straw	7.33	11.5	20.6	21.0	4.73	11.7	18.5	10.2	4.40	12.1	35.5	65.2
Rice husk	7.97	22.1	28.8	20.8	8.31	14.4	14.3	10.5	7.60	13.2	36.1	42.2
Glyricidia leaves	7.73	13.2	32.5	46.2	7.34	15.3	31.2	26.6	7.34	14.5	35.2	58.1
Press mud	6.91	15.2	25.2	35.3	6.14	18.2	26.7	14.4	7.29	18.1	40.2	52.1
Saw dust	6.06	13.7	15.2	26.0	5.31	5.9	4.3	16.6	9.09	4.8	13.2	25.2
Lime	6.38	9.5	16.0	14.4	7.13	8.5	22.0	15.5	7.13	8.5	26.7	30.1
Gypsum	5.36	9.8	26.8	35.2	6.90	7.6	4.4	12.1	7.28	7.9	6.2	18.2
Coconut pith	7.36	18.3	17.8	32.5	7.36	9.3	13.3	22.1	11.24	10.5	30.5	49.3
Control	6.60	8.2	10.6	15.0	4.26	3.8	5.2	10.6	8.14	4.0	8.5	20.2

R.solani

A general decline in the population of R.solani was observed during tenth week of addition in all treatments except in press mud. Among different treatments, rice husk, lime and gypsum treated pots had significantly lower population than others. During sixth week, only saw dust treated pots had lower population, while in pots of rice straw or glyricidia leaves, populations were significantly increased. During second week, pots amended with press mud had significantly lower population than other treatments, eventhough those of saw dust, rice straw or coconut pith had populations lower than other treatments and untreated control.

During second week, the fluctuation in population of R.solani in different treatments were quite limited as the range varied from +14 per cent in gypsum to -15 per cent in press mud. In untreated control, the population increased by 25 per cent. After six weeks, considerable increase (about 60 - 80 per cent) was noticed in treatments viz. glyricidia leaves, press mud and rice straw. In other treatments, the increase was of lower magnitude than untreated control (+39 per cent). The increase was quite nominal in gypsum, while in saw

dust population was slightly lower (-5 per cent), than original. After ten weeks, about 50 per cent reduction in the population of R.solani was observed in pots of rice husk, while 40 per cent reduction was noticed in gypsum and lime. In saw dust (with nutrients), the reduction was about 30 per cent while in rice straw and glyricidia leaves, the same was about 20 per cent each. In coconut pith the reduction was 10 per cent. However, an increase in population of about 30 per cent was noticed in pots of press mud.

Total fungi

In general, population of total fungi increased in different amendments after two, six and ten weeks. Glyricidia leaves and press mud had significantly higher population than control during all the observations. During the early period (after two weeks), rice husk, saw dust (with nutrients) and coconut pith also had higher fungal population than control. Among the treatments, rice husk, coconut pith and press mud had higher population than other treatments. During sixth week glyricidia leaves, rice husk, press mud and rice straw had significantly more

fungal population than other treatments and control. Among others, coconut pith had more population than the rest and control. During tenth week, pots of glyricidia leaves, press mud, gypsum and coconut pith had more population than other treatments and control.

The percentage stimulation of total fungi in different treatments was slight. During second week, the range was +2 per cent in control and +9 per cent in rice husk. During sixth week, the range was +4 per cent in control and +13 per cent in glyricidia leaves. During tenth week, the range varied from +7 per cent in control to +17 per cent in gypsum. The stimulation during last phase (after ten weeks) in glyricidia leaves was 16 per cent and 15 per cent each in press mud and saw dust (with nutrients).

Bacteria

During second week, a higher bacterial population was observed in pots amended with press mud, glyricidia leaves, rice husk or rice straw, while during fourth week, higher population was observed in pots amended with glyricidia leaves, press mud, lime or rice straw.

However, during the end of tenth week, the population in pots of different amendments were more or less same and was equal to that of untreated control.

Fluctuation in bacterial population was, in general, slight during different periods of observation. During second week, the stimulation was 7 per cent in press mud, 6 per cent in rice straw and rice husk and 5 per cent in glyricidia leaves. During sixth week, 10 per cent increase in press mud, 9 per cent each in rice straw and glyricidia leaves and 7 per cent in lime were observed. During tenth week, 10 per cent increase in glyricidia leaves, 7 per cent in saw dust (with nutrients), 6 per cent in press mud and 5 per cent in rice straw were observed.

Actinomycetes

Rice straw is the only amendment, which gave a significantly higher actinomycete population during all the periods of observation. During second and sixth week, along with rice straw, press mud, glyricidia leaves and rice husk also had significantly more population of actinomycetes. However, during

sixth week, in addition to the above treatments, coconut pith and lime also showed higher population of actinomycetes than remaining treatments and untreated control.

About 7 per cent increase in population was observed in rice straw amended pots during second week which became 14 per cent and 18 per cent during sixth and tenth week respectively. In glyricidia leaves, 13 per cent stimulation during tenth week and 10 per cent in sixth week were observed, though the original stimulation was as low as 4 per cent in second week. In press mud, the stimulation was 6 per cent, 11 per cent and 12 per cent at second, sixth and tenth week respectively. In lime, 12 per cent stimulation was observed during tenth week, eventhough the increase was slight in early periods (1 per cent in second and 8 per cent in sixth week). In rice husk, stimulation was 4 per cent in second week, and 10 per cent in sixth and tenth week.

(b) Experiment with oil cakes

The different non-edible oil cakes did not influence plant height or production of tillers.

However, significant differences were noticed among different treatments with respect to disease intensity as well as disease incidence (Figure 4, Table 6). Except mahua cake, all others viz., neem cake, punna cake and marotti cake had disease intensity lower than untreated control while, disease incidence was significantly less in pots amended with anyone of the above cakes (including mahua) when compared to untreated control. Among them, punna cake and neem cake were found to be better than mahua or marotti cake in reducing the disease incidence.

Microbial population

R.solani

During second week, fluctuation in the pathogen (R.solani) population was slight in all the treatments except in neem cake in which the increase was 12 per cent and in marotti cake in which the decrease was 6 per cent. During sixth week, maximum population increase was in neem cake, in which the increase was about 90 per cent. Among other treatments, 30 and 24 per cent increase occured in punna cake and marotti cake respectively. In control pot, the increase was

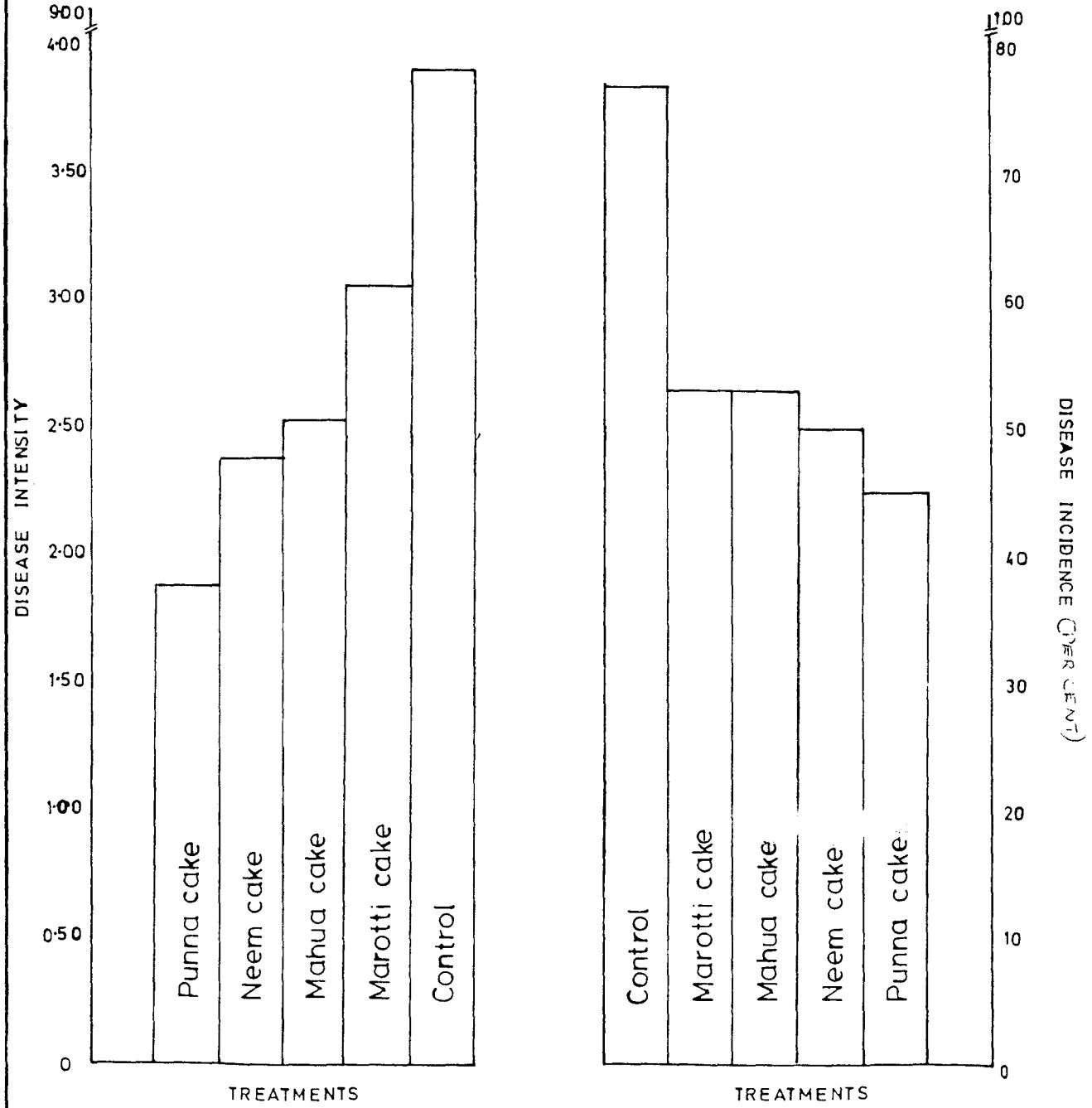


FIGURE-4

EFFECT OF OIL CAKES ON INTENSITY AND INCIDENCE OF SHEATH BLIGHT DISEASE OF RICE

Table - 6

Effect of oil cakes on height and number of tillers of rice crop and intensity and incidence of sheath blight of rice.

Treatments	Height (cm)	Number of tillers	Intensity (0 - 9 scale)	Incidence (percentage of number of infected tillers)
Mahua cake	47.583	5.332	2.523	53.838
Marotti cake	48.418	5.083	3.070	53.865
Neem cake	47.333	5.083	2.348	50.125
Punna cake	45.915	5.335	1.874	45.108
Control	46.335	5.418	3.903	77.192
C D (0.01)	N S	N S	0.979	8.300

Table - 7

Number of propagules of *Rhizoctonia solani* (10 g), population of total fungi, bacteria and actinomycetes per g dry soil treated with different oil cakes*

Treatments	*Rhizoctonia solani*					
	Before addition	Period after addition (weeks)			Percentage deviation after (weeks)	
		2	6	10	2	6	10
Mahua cake	15.400	15.600	21.200	16.300	+ 1	+ 6	+ 6
Marotti cake	16.000	14.800	19.800	14.300	- 8	+24	-11
Neem cake	13.400	15.000	25.200	20.200	+12	+88	+51
Punna cake	14.000	13.400	18.200	10.000	- 4	+30	-28
Control	14.600	15.000	22.100	25.400	+ 3	+51	+74
C D (0.01)		N S	N S	2.313	2.100		

*The values of population of total fungi, bacteria and actinomycetes presented are transformed using logarithmic transformation. Their original values are presented in Table 8.

(contd.....)

(Table 7 contd.)

Treatments	Total fungi						
	Before addition	Period after addition (weeks)			Percentage deviation after (weeks)		
		2	6	10	2	6	10
Mahua cake	4.609	5.006	5.259	5.186	+ 9	+14	+13
Marotti cake	4.732	4.989	5.292	5.274	+ 6	+12	+13
Neem cake	4.727	5.022	5.418	5.607	+ 6	+15	+19
Punna cake	4.701	5.182	5.508	5.610	+10	+17	+19
Control	4.784	4.854	5.006	5.156	+ 2	+ 5	+ 6
C D (0.01)	N S	0.216	0.280	0.249			

(contd.....)

(Table 7 contd.)

Treatments	Bacteria						
	Before addition	Period after addition (weeks)			Percentage deviation after (weeks)		
		2	6	10	2	6	10
Mahua cake	6.890	7.024	7.328	7.217	+ 2	+ 6	+ 5
Marotti cake	6.757	7.049	7.098	7.076	+ 4	+ 5	+ 5
Neem cake	6.659	7.019	7.261	7.005	+ 5	+ 8	+ 5
Punna cake	6.763	7.134	7.413	7.180	+ 6	+10	+ 6
Control	6.641	6.578	6.736	6.880	- 1	+ 2	+ 4
C D (0.01)	N S	0.304	0.300	0.290			

(contd.....)

(Table 7 contd.)

Treatments	Actinomycetes						
	Before addition	Period after addition (weeks)			Percentage deviation after (weeks)		
		2	6	10	2	6	10
Mahua cake	6.908	6.980	7.177	7.659	+ 1	+ 4	+11
Marotti cake	6.783	6.780	7.013	7.486	-0.4	+ 3	+10
Neem cake	7.004	7.048	7.040	7.346	+ 1	+ 1	+ 5
Punna cake	6.760	6.874	6.996	7.280	+ 2	+ 4	+ 8
Control	6.780	6.874	6.844	7.001	+ 3	+ 2	+ 5
C D (0.01)	N S	N S	0.310	0.325			

Table - 8

Population of total fungi (x 10^4), bacteria (x 10^6) and actinomycetes (x 10^6) per g dry soil treated with different oil cakes.

Treatments	Total fungi				Bacteria				Actinomycetes			
	Before addition	Period after addition (weeks)			Before addition	Period after addition (weeks)			Before addition	Period after addition (weeks)		
		2	6	10		2	6	10		2	6	10
Mahua cake	4.07	10.2	18.4	15.4	7.78	10.6	21.3	16.5	8.14	9.6	15.2	45.7
Marotti cake	5.35	9.8	19.6	19.0	5.78	11.2	12.5	12.0	5.36	6.3	10.3	30.8
Neem cake	5.38	10.6	26.2	40.5	4.95	10.5	18.3	10.2	9.99	11.2	11.0	22.2
Punna cake	5.12	15.2	32.2	40.8	5.81	13.6	26.2	15.2	5.84	7.5	9.9	19.2
Control	5.51	7.2	10.2	14.4	4.41	3.8	5.5	7.7	7.35	7.5	7.0	10.1

about 50 per cent. During tenth week, stimulation occured only in untreated control (74 per cent and pots of neem cake (51 per cent) while in punna cake and marotti cake, population declined at 25 per cent and 11 per cent respectively.

Among different oil cakes, punna cake had least population after ten weeks during which period, other treatments had less population than untreated control. During sixth week, punna cake treated pots had significantly lower population while neem cake amended pots had significantly more R.solani. During second week, treatment effect was not significant.

Total fungi

Population of the total fungal flora showed an increase in all the different treatments with time. Population was significantly higher in punna cake during all the different periods of assessment. After six weeks, all treatments except mahua cake showed significantly higher population, eventhough in second week, only punna cake brought about significant improvement in the population. Population

of total fungi was significantly higher in neem cake and punna cake over control as well as other treatments after a period of ten weeks.

During second week, stimulation of the fungal population ranged between 2 per cent in control to 13 per cent in punna cake. It was about 6 per cent each in marotti cake and neem cake while in mahua cake, it was about 9 per cent. During sixth week, stimulation ranged between 5 per cent in control to 17 per cent in punna cake. It was about 15 per cent each in mahua cake and neem cake, while in marotti cake, it was about 12 per cent. After ten weeks, the increase in population was about 19 per cent each in neem cake and punna cake while it was 13 per cent each in manua cake and marotti cake. In untreated control, only about 6 per cent increase was noticed.

Bacteria

Population of bacteria also increased with time up to six weeks and thereafter, a general decline was noticed. Mahua cake and punna cake had significantly higher population than control during all the different periods of estimation. During second week, all the oil

cakes tested showed significant improvement in the population over control. During sixth week, mahua cake, neem cake and punna cake recorded a population significantly higher than other treatments and control. Population in marotti cake was significantly higher than control. However, during tenth week, only mahua cake and punna cake treated pots showed significantly higher populations of bacteria.

The increase in bacterial population was slight in second week ranging between 2 per cent in mahua cake and 6 per cent in punna cake, eventhough in control, a slight decline of about 1 per cent was noticed. Neem cake and marotti cake showed a stimulation of about 5 per cent. During sixth week, about 10 per cent and 8 per cent increase was observed in soil treated with neem cake and punna cake, respectively. In mahua cake and marotti cake, it was about 5 per cent each, while in control, the increase was only about 2 per cent. During tenth week, the increase was about 5 per cent in all the oil cakes tested, while in control, it was only 4 per cent.

Actinomycetes

Population of actinomycetes did not significantly differ in oil cake treated soil during second week. But during sixth week, mahua cake showed significant increase in population. After ten weeks, all the oil cakes, except punna cake showed significant increase over untreated control.

During second week, the stimulation of actinomycetes in the amended pots was slight and was of lower than in untreated control. However, during sixth week, the stimulation was slightly more in pots of punna cake, mahua cake and marotti cake, than in untreated control. After tenth week, the magnitude of stimulation was raised to 10 per cent in mahua and marotti cakes. The same was 8 per cent in pots of punna cake. In untreated control, stimulation was only 5 per cent.

(c) Experiment with pesticides

The different pesticides had no influence on plant height or on tiller production. However, intensity and incidence of sheath blight disease were reduced by all the pesticides used, except quinalphos

and 2,4-D sodium salt. Carbendazim and ediphenphos were quite effective as evidenced by lower disease score. In weedicide benthiocarb, disease incidence was as low as in fungicides viz. carbendazim, ediphenphos and mancozeb (Table 9, Figure 5).

(d) Experiment with crop rotation

Soils under rice during first crop season followed by different crops in second crop season viz., brinjal, banana, cowpea, groundnut and rice when used for raising rice in pots did not show difference in height of the rice crop or tiller production. Intensity of sheath blight disease was low in rice following tapioca and rice following banana. Disease incidence was low in rice following banana or brinjal (Table 10, Figure 6).

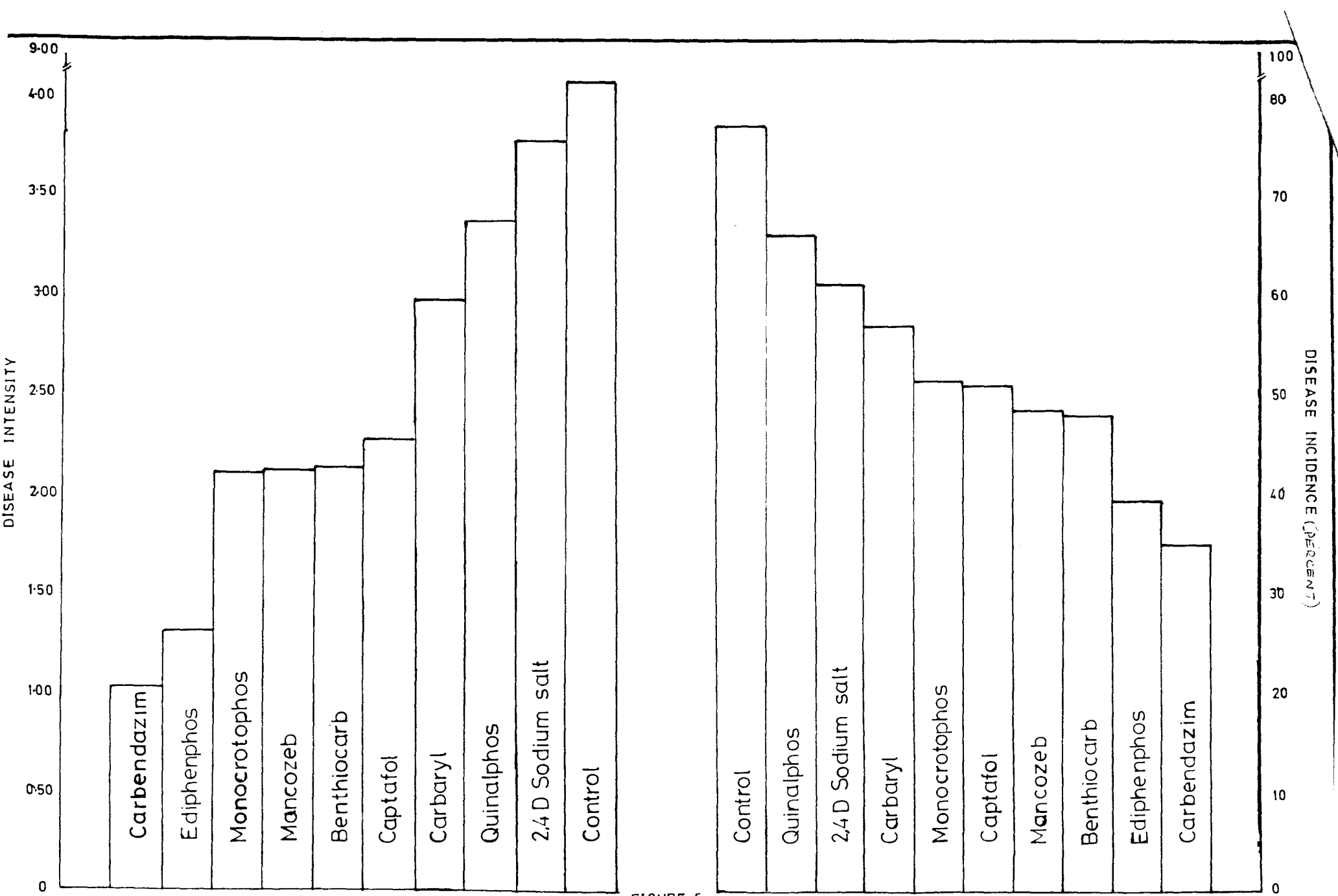
Microbial population

Soil samples were subjected to a microbial analysis before transplanting the seedlings. Populations of the pathogen and bacteria exhibited only a slight difference among treatments. But the population of total fungi and actinomycetes were high in rotations involving banana and tapioca (Table 11).

Table - 9

Effect of pesticides on height and number of tillers of rice crop and intensity and incidence of sheath blight disease of rice.

Treatments	Height (cm)	Number of tillers	Intensity (0 - 9 scale)	Incidence (percentage of number of tillers infected)
Carbendazim	45.890	4.780	1.027	34.990
Mancozeb	43.000	4.110	2.097	48.553
Captafol	48.000	6.110	2.283	51.003
Edifenphos	48.777	5.223	1.290	38.873
Monocrotophos	44.110	4.553	2.092	51.323
Quinalphos	47.333	5.557	3.382	66.187
Carbaryl	48.447	5.890	2.975	57.113
2,4-D sodium salt	44.553	3.000	3.773	61.493
Benthiocarb	41.333	3.223	2.120	48.023
Control	48.000	6.447	4.097	77.983
C D (0.01)	N S	N S	0.882	13.722



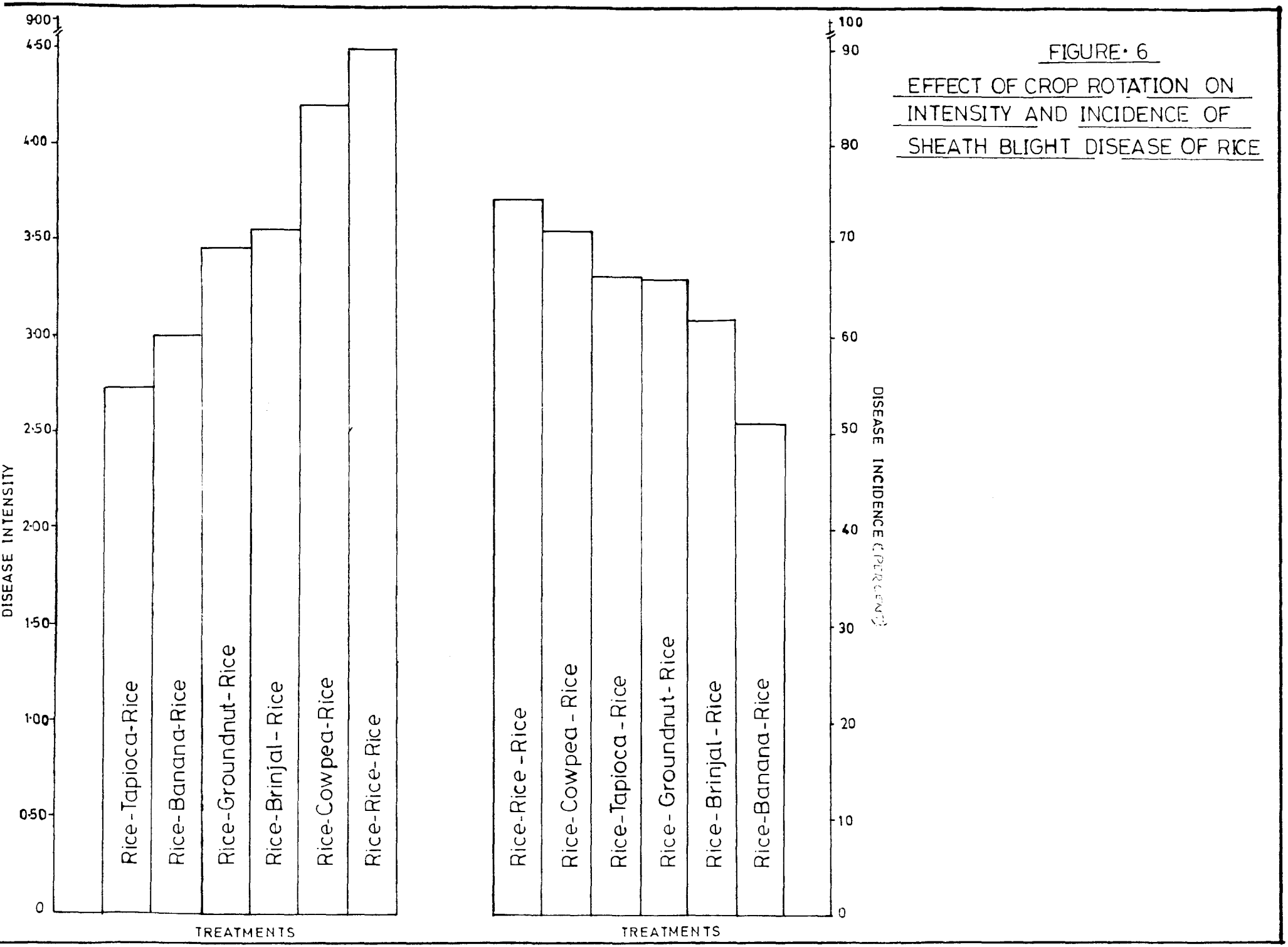
FIGURE·5

EFFECT OF PESTICIDES ON INTENSITY AND INCIDENCE OF SHEATH BLIGHT DISEASE OF RICE

Table - 10

Effect of crop rotation on height and number of tillers of rice crop and intensity and incidence of sheath blight disease of rice.

Treatments	Height (cm)	Number of tillers	Intensity (0 - 9 scale)	Incidence (percentage of number of tillers infected)
Rice-brinjal-rice	47.557	4.777	3.577	61.937
Rice-banana-rice	46.557	4.557	3.012	51.360
Rice-cowpea-rice	45.223	4.000	4.190	71.090
Rice-groundnut-rice	47.557	4.780	3.460	66.560
Rice-tapioca-rice	44.777	5.000	2.725	66.613
Rice-rice-rice	49.443	4.663	4.585	74.733
C D (0.01)	N S	N S	1.281	10.241



FIGURE· 6

EFFECT OF CROP ROTATION ON INTENSITY AND INCIDENCE OF SHEATH BLIGHT DISEASE OF RICE

Table - 11

Effect of crop rotation on microbial population in soil

Treatments	Number of propagules of *R.solani* (per 10 g dry soil)	Population of saprophytes per g dry soil		
		Total fungi ($\times 10^4$)	Bacteria ($\times 10^6$)	Actinomycetes ($\times 10^6$)
Rice-brinjal-rice	12.0	9.2	7.3	7.7
Rice-banana-rice	12.3	19.2	7.1	23.2
Rice-cowpea-rice	13.3	10.9	10.2	20.5
Rice-groundnut-rice	13.0	10.3	10.3	10.8
Rice-tapioca-rice	13.0	16.2	10.0	20.1
Rice-rice-rice	12.3	6.3	8.5	8.5

FIELD EXPERIMENT

The field experiment was laid out with organic and inorganic materials as main treatments and the bio control agent Trichoderma viride and fungicide carbendazim as sub treatments.

The agronomical observations viz., tiller count, height of the plants, yields of grain and straw, length of the panicle, number of grains per panicle, 1000 grain weight and chaff per centage as well as intensity and incidence of the disease recorded in the field trial are presented (Table 12 and 13).

The different treatments had no influence on height of the plants or on tiller production during vegetative phase. The number of productive tillers also was not influenced by the treatments. However, it was observed that at maturity, plants in T.viride treated plots were taller than fungicide treated as well as untreated plots.

Yields of grain and straw did not significantly differ among treatments. The length of the panicle was more in plots treated with rice husk - T.viride combination. The same combination recorded maximum

Table - 12

ject of amendments, biocontrol agent and fungicide on growth and yield of rice crop and intensity and incidence of sheath blight disease of rice*

reatment	Tiller count		Height of Plants (cm)		Yield per hectare (kg)		Length of panicle (cm)	Number of grains per panicle	1000 grain weight (g)	Percentage of chaff	Intensity of sheath blight (0 - 9 scale)			Incidence of sheath blight (percentage of number of infected tillers		
	Vegetative phase	Before harvest	Vegetative phase	Before harvest	Grain yield	Straw yield					Maximum tillering	Panicle emergence	Before harvest	Maximum tillering	Panicle emergence	Before harvest
treatments																
husk	15.01	11.80	54.01	71.20	1813.13	2783.85	17.92	77.81	26.56	22.94	0.36	2.76	3.40	15.04	19.34	23.05
a cake	13.52	12.58	52.83	72.84	1656.81	2519.77	17.63	67.12	25.76	24.88	0.74	3.02	4.02	18.11	22.52	27.10
icidia leaves	14.51	11.89	55.74	72.67	1642.53	2562.37	17.79	72.44	27.32	23.00	0.25	2.32	3.44	8.92	15.93	19.82
	13.87	11.96	54.73	73.27	1560.74	2855.39	16.79	62.93	27.05	22.31	0.53	3.61	4.34	14.01	19.05	21.31
um	14.81	11.73	53.26	73.27	1739.56	2642.44	16.54	62.56	26.73	23.14	0.51	2.47	3.56	14.87	25.36	28.91
rol	14.01	11.27	54.79	73.38	1740.00	2541.92	17.14	65.87	27.07	22.65	0.92	3.38	4.65	25.47	35.86	39.22
treatments																
hoderma viride	14.19	11.81	54.97	74.47	1714.42	2737.84	17.95	71.26	26.94	21.61	0.38	2.28	3.05	13.88	23.77	26.90
endazim	14.32	12.32	54.21	72.20	1715.47	2829.00	17.04	69.69	26.88	24.75	0.57	1.92	2.94	16.04	17.12	21.24
rol	14.35	11.48	53.51	71.64	1646.48	2386.03	16.92	63.42	26.41	23.10	0.71	4.59	5.71	18.29	28.14	31.57
.D. for comparison (0.05)																
ain treatments	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	0.497	N.S.	N.S.	4.43	4.54	4.25
ub treatments	N.S.	N.S.	N.S.	2.22	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	0.262	0.93	0.93	3.13	3.21	3.01

e values presented in the table represents the treatment means.

e interactions are presented in Table 13.

Table - 13

Effect of amendments, biocontrol agent and fungicide on growth and yield of rice and intensity and incidence of sheath blight

Main treatment	Sub treatment	Tiller count		Height of plants (cm)		Yield per hectare (kg)		Length of panicle (cm)	No.of grains per panicle	1000 grain weight (g)	Percentage of chaff	Intensity of sheath blight (0 - 9 scale)			Incidence of sheath blight (percent of number of infected tillers)		
		Vegetative phase	Before harvest	Vegetative phase	Before harvest	Grain yield	Straw yield					Maximum tillering	Panicle emergence	Before harvest	Maximum tillering	Panicle emergence	Before harvest
Rice husk	Trichoderma viride	16.60	12.60	55.27	75.47	2019.26	2903.11	19.67	95.00	26.47	14.4	0.21	0.95	1.31	14.81	21.75	23.81
Rice husk	Carbendazim	14.10	10.93	54.30	69.87	1828.93	2974.66	17.67	80.70	26.86	20.2	0.37	2.23	2.85	11.38	15.64	18.55
Rice husk	control	14.33	11.87	52.73	68.27	1591.19	2473.78	16.43	57.73	26.35	12.2	0.50	5.11	6.03	18.94	20.62	26.78
Punna cake	T. viride	13.97	13.07	53.33	74.40	1815.56	2949.10	17.03	56.03	26.29	14.4	0.57	2.95	3.20	13.17	21.20	25.84
Punna cake	carbendazim	13.23	13.00	53.97	73.60	1468.88	2647.55	18.00	82.70	25.31	25.7	1.00	3.04	3.54	22.23	20.72	23.71
Punna cake	control	14.37	11.67	51.23	70.53	1685.98	1962.66	17.87	62.63	25.69	14.3	0.67	3.05	5.31	18.93	25.65	31.74
Glyricidia leaves	T. viride	14.50	10.37	54.77	73.93	1471.17	2514.66	19.57	86.20	27.95	9.8	0.12	0.71	2.50	8.97	15.86	21.12
Glyricidia leaves	carbendazim	13.40	13.27	56.53	73.20	1928.09	2637.33	18.03	76.47	27.46	18.6	0.39	1.15	2.50	8.51	12.19	17.20
Glyricidia leaves	control	15.63	11.53	55.93	70.87	1527.74	2535.11	15.77	54.67	26.56	18.8	0.24	5.11	5.31	9.27	19.73	21.13
Lime	T. viride	12.60	11.87	54.53	74.93	1449.77	2739.52	18.33	71.03	26.96	19.2	0.50	4.11	4.50	12.37	17.77	19.46
Lime	carbendazim	14.77	12.33	54.40	69.60	1668.02	3332.44	14.70	52.57	27.11	13.5	0.63	2.52	3.20	14.43	16.47	18.66
Lime	control	14.23	11.67	55.27	75.27	1564.43	2494.22	17.33	65.20	27.07	12.2	0.46	4.21	5.31	15.22	22.89	25.81
Gypsum	T. viride	16.17	11.73	55.50	74.13	1826.07	2806.00	16.00	56.20	26.88	9.2	0.13	2.09	3.33	12.36	26.89	28.74
Gypsum	carbendazim	15.00	11.33	51.17	71.80	1676.43	2703.77	15.07	56.77	27.04	19.0	0.14	1.17	2.36	13.95	16.62	22.35
Gypsum	control	13.27	12.13	53.10	73.87	1716.17	2417.55	17.97	74.70	26.26	19.5	1.26	4.17	4.99	18.32	32.57	35.63
Control	T. viride	12.33	10.73	56.40	73.93	1704.71	2514.66	17.10	63.10	27.10	17.6	0.74	2.86	3.44	21.60	39.17	42.41
Control	carbendazim	15.43	13.07	55.17	75.13	1721.91	2678.22	18.17	68.93	27.53	11.4	0.86	1.41	3.19	25.75	21.05	26.94
Control	control	14.27	10.00	52.80	71.07	1793.88	2432.89	16.17	65.57	26.56	16.7	1.16	5.87	7.31	29.06	47.36	48.32
C.D. (0.01)		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	2.96	25.34	N.S.	N.S.	N.S.	2.29	N.S.	N.S.	7.86	7.37

number of grains per panicle also. The weight of the grains as well as percentage of chaff were not influenced by the treatments.

Intensity of the disease

During maximum tillering stage, least disease intensity was noticed in glyricidia leaves or rice husk among main treatments and in biocontrol agent T.viride among sub treatments. During panicle emergence stage, there was no difference among main treatments in disease intensity. However, both sub treatments (fungicide carbendazim as well as biocontrol agent T.viride) had significantly lower disease intensity than untreated control. During the last phase (at crop maturity) fungicide as well as T.viride treated plots had lower disease than control (Figures 7, 8 and 9).

Incidence of the disease

Incidence of sheath blight disease recorded during maximum tillering stage, panicle emergence and at maturity stage are presented (Figures 10, 11 and 12 respectively).

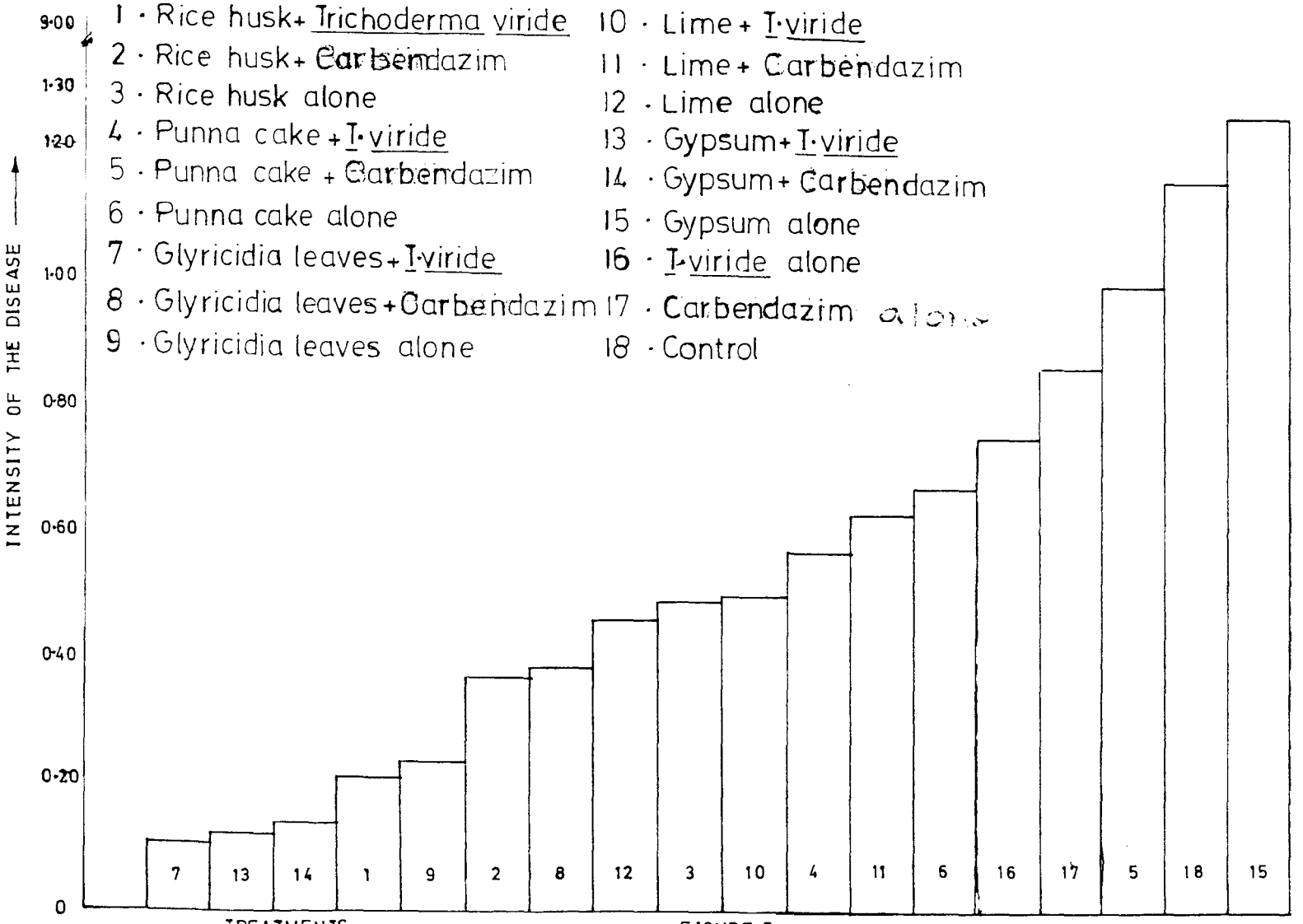


FIGURE 7

EFFECT OF AMENDMENTS, BIOCONTROL AGENT AND FUNGICIDE ON INTENSITY OF THE DISEASE AT MAXIMUM TILLERING STAGE

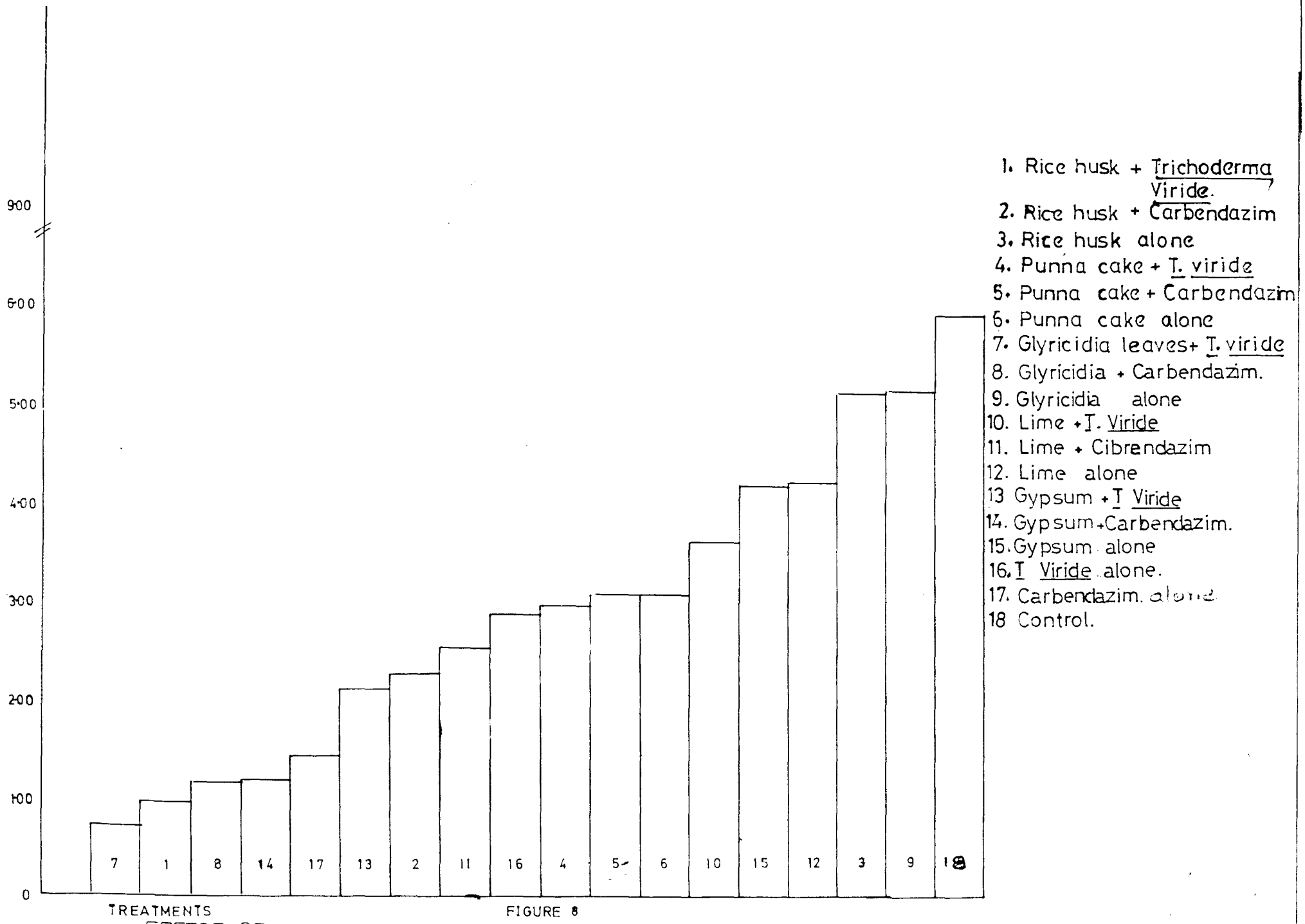
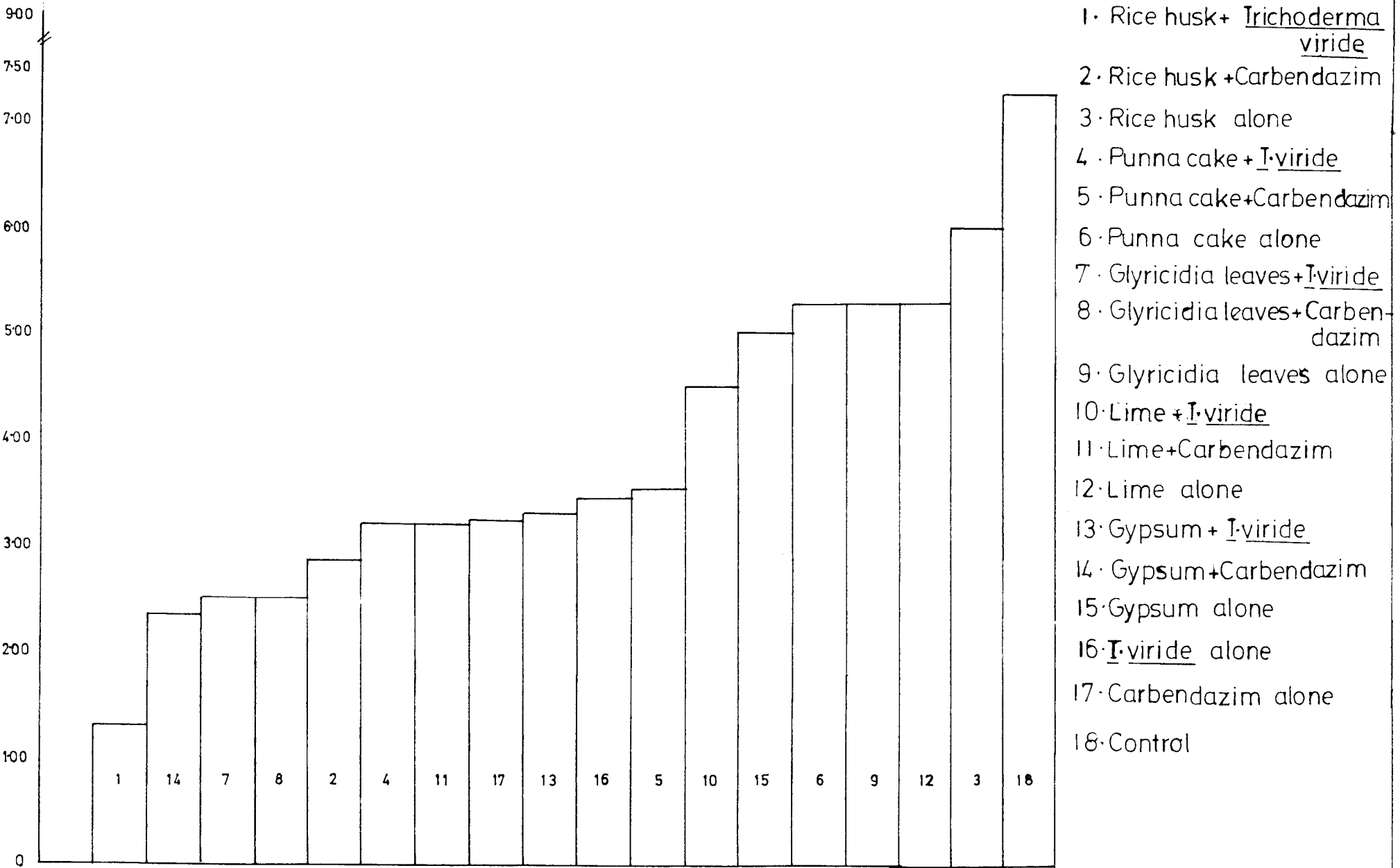


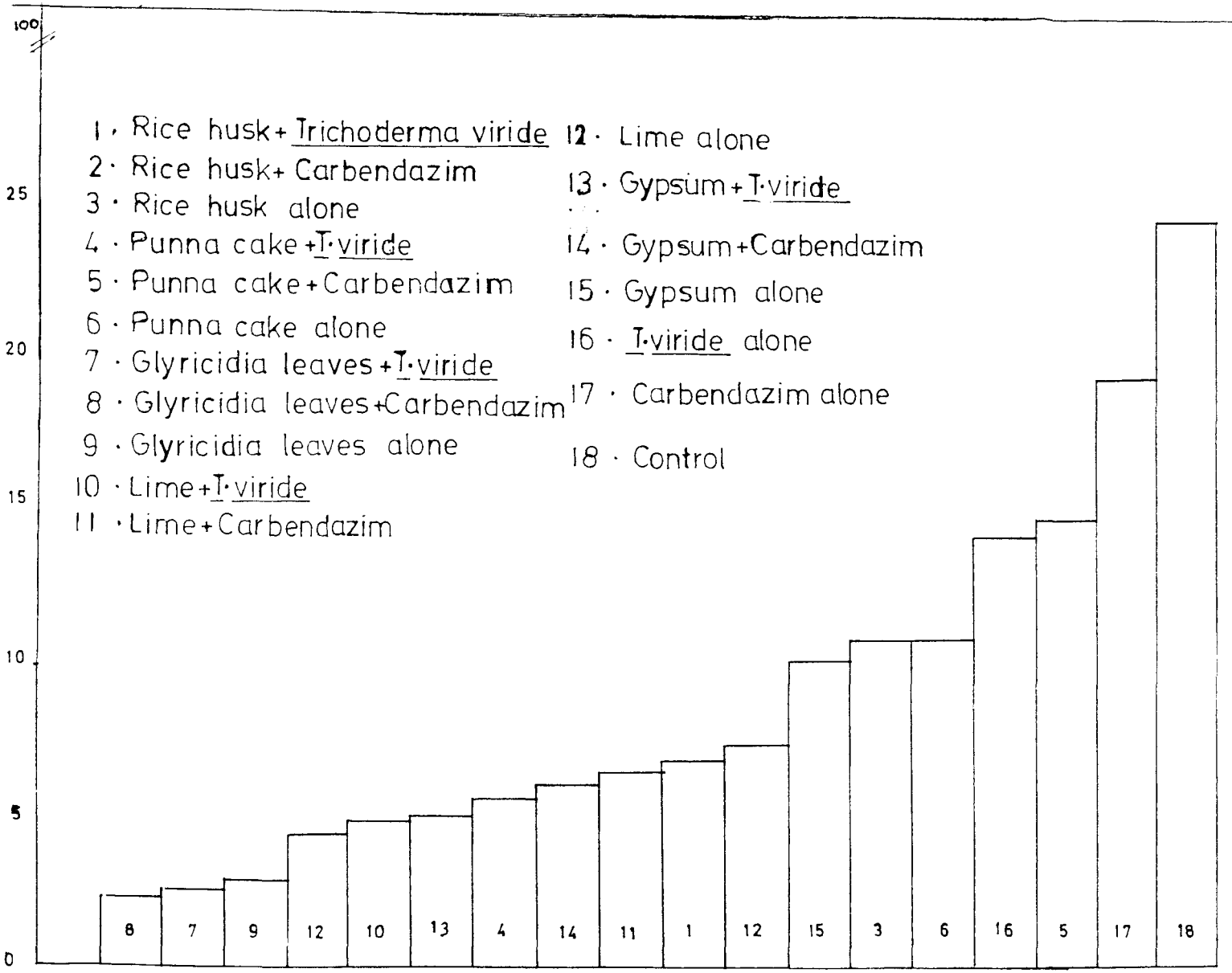
FIGURE 8

EFFECT OF AMENDMENTS, BIOCONTROL AGENT AND FUNGICIDE ON INTENSITY OF THE DISEASE AT PANICLE EMERGENCE STAGE



FIGURE· 9

EFFECT OF AMENDMENTS, BIOCONTROL AGENT AND FUNGICIDE ON INTENSITY OF THE DISEASE JUST BEFORE HARVEST



FIGURE·10

DISEASE INCIDENCE AS INFLUENCED BY AMENDMENTS, BIOCONTROL AGENT AND FUNGICIDE AT MAXIMUM TILLERING STAGE

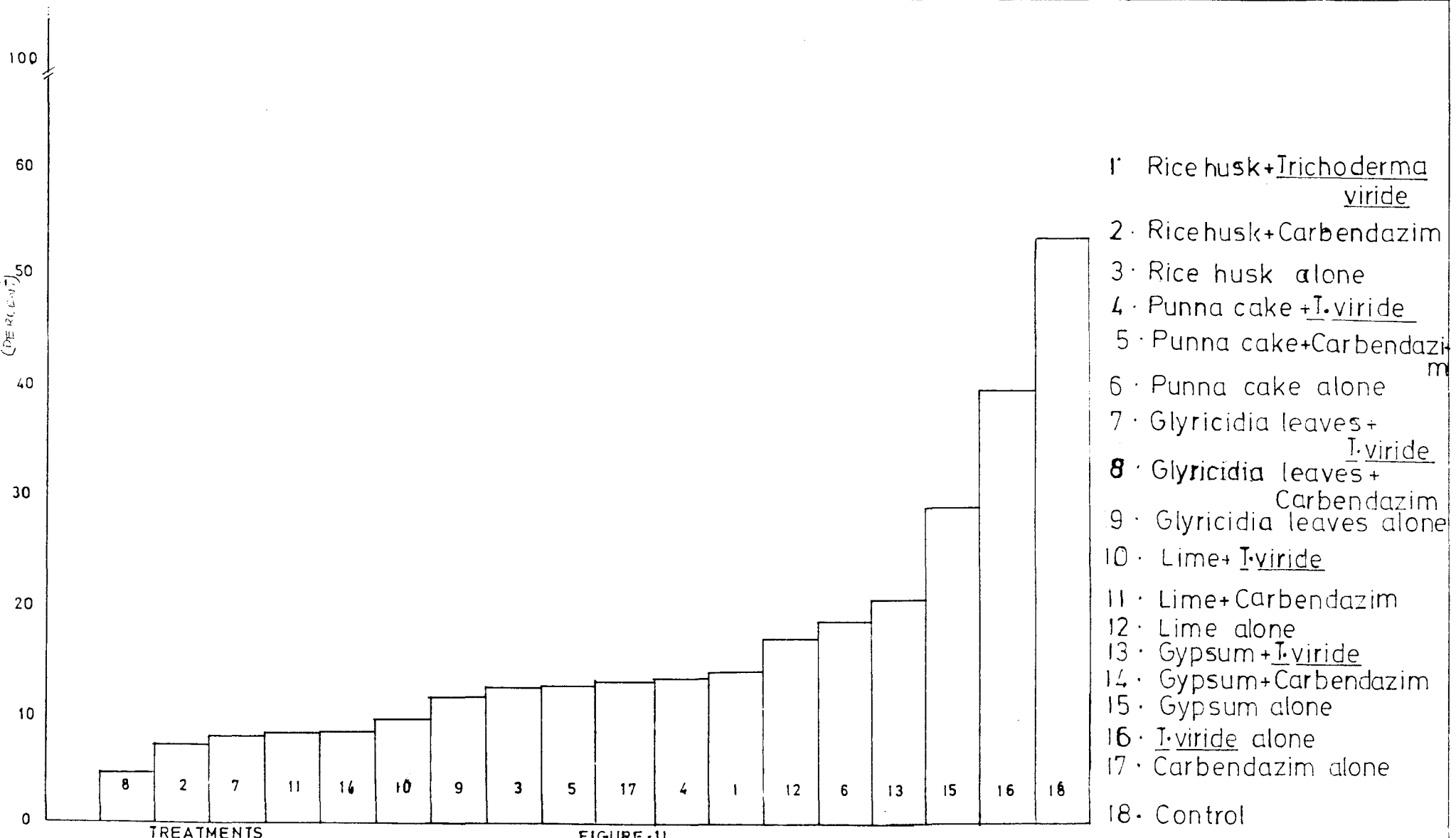


FIGURE-11

EFFECT OF AMENDMENTS, BIOCONTROL AGENT AND FUNGICIDE ON INCIDENCE OF THE DISEASE AT PANICLE EMERGENCE STAGE

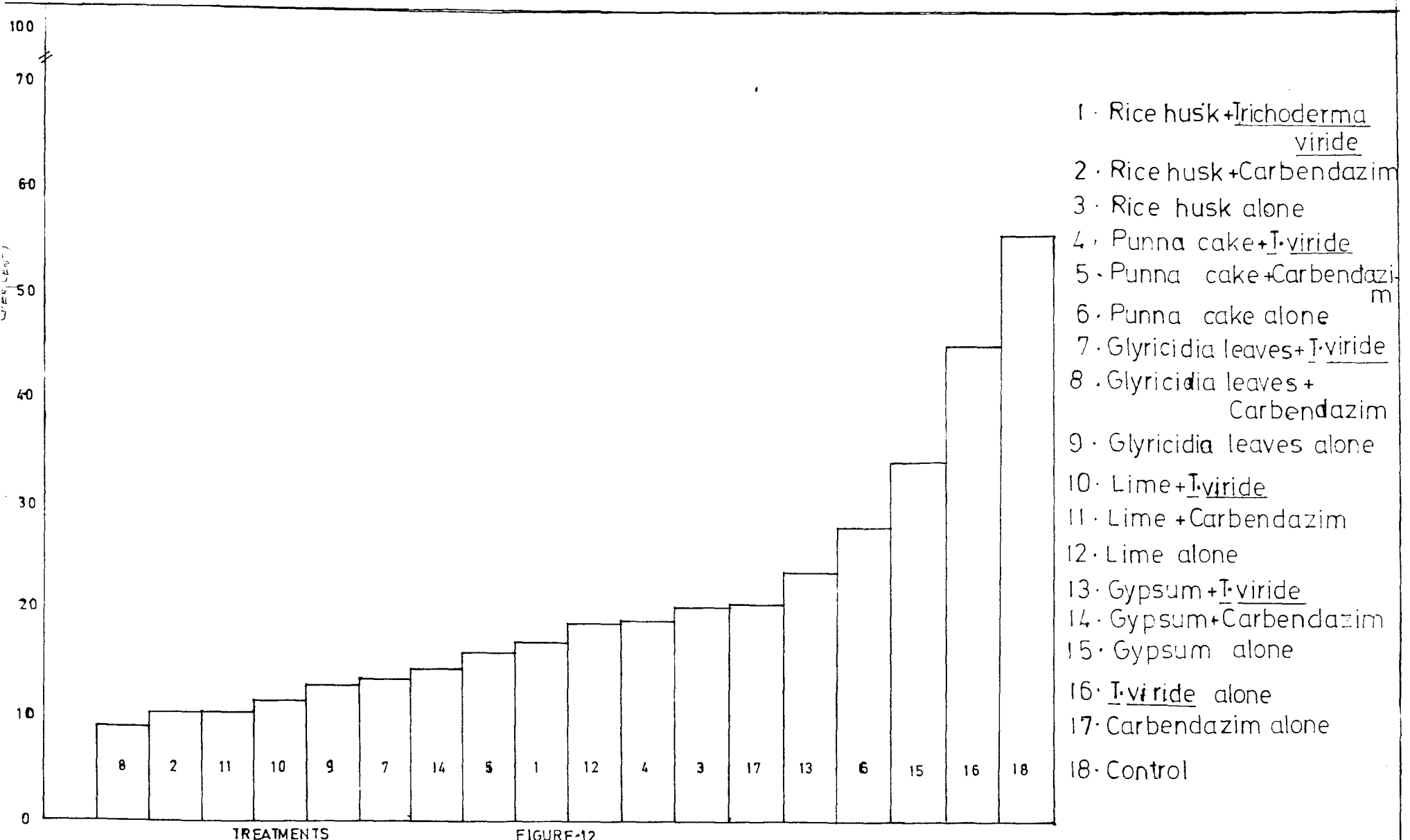


FIGURE-12

EFFECT OF AMENDMENTS, BIOCONTROL AGENT AND FUNGICIDE ON INCIDENCE OF THE DISEASE JUST BEFORE HARVEST

During maximum tillering stage, plots amended with glyricidia leaves showed a disease incidence significantly lower than that of other treatments and unamended plots. In T.viride treated plots, lower disease incidence than untreated control was noticed. At panicle emergence stage, plots amended with glyricidia leaves, rice husk or lime had significantly lower disease incidence than other treatments, eventhough other treatments had lower disease than untreated control. Among sub treatments, fungicide carbendazim treated plots had lower disease than biocontrol agent as well as untreated control. Combination of glyricidia leaves with carbendazim was also found significant. During the last phase of observation at maturity, it was found that glyricidia leaves, rice husk or lime had significantly lower disease incidence than other treatments - gypsum or punna cake. However, all amendments had disease lower than control. As in the previous stage, during this phase also, among sub treatments, carbendazim and among combinations, glyricidia leaves - carbendazim were found to be significant.

Microbial population

Population of the pathogen, as well as total fungi, bacteria and actinomycetes under different treatments at different periods with their deviation from original populations are presented in table 14, 15 and 16.

Rhizoctonia solani

Population of the pathogen showed no significant difference among main treatments during second and sixth week after amendment. Plots amended with glyricidia leaves recorded significantly lower population than control as well as other treatments during tenth and fourteenth week. During both these periods, all the amendments had lower population than control. However, sub treatments had no influence on the population of the pathogen during any of the assessment. Combination of main treatments (amendments) with sub treatments had no influence on the pathogen population during second and sixth week eventhough the combinations involving amendments showed significantly low populations during tenth and fourteenth week.

Table - 14

Number of propagules of *Rhizoctonia solani* (10 g), population of total fungi, bacteria and actinomycetes per g dry soil treated with different amendments biocontrol agent and fungicide*

Treatments	*Rhizoctonia solani*** Period after addition (weeks)				*Rhizoctonia solani*** Percentage deviation after (weeks)			
	2	6	10	14	2	6	10	14
Main Treatments								
Rice husk	12.43	12.67	9.24	9.18	+13	+15	-16	-17
Punna cake	11.60	11.67	9.33	9.18	+ 5	+ 6	-15	-17
Glyricidia leaves	10.16	11.00	5.46	4.94	- 8	0	-50	-55
Lime	11.93	11.67	8.53	8.57	+ 8	+ 6	-22	-22
Gypsum	12.07	12.00	11.20	8.97	+10	9	+ 2	-18
Control	10.47	11.33	15.97	17.56	- 5	+ 3	+45	+60
Sub Treatments								
Trichoderma viride	11.47	11.50	9.63	9.17	+ 4	+ 5	-12	-14
Carbendazim	11.61	12.33	10.06	10.11	+ 6	+12	- 9	- 8
Control	11.25	11.33	10.17	9.62	+ 2	+ 3	-8	-12
C.D.Values (0.01)								
Main treatments	N S	N S	2.81	2.86				
Sub treatments	N S	N S	N S	N S				

*The values presented in the table represents the treatment means. The interactions are presented in Table 15.

**The initial population of the pathogen before amendment addition was 11.0 propagules/10 g soil.

(contd.....)

(Table 14 contd.)

Treatments	Total fungi								
	Before addition	Period after addition (weeks)				Percentage deviation after (weeks)			
		2	6	10	14	2	6	10	14
Main Treatments									
Rice husk	4.80	4.88	5.33	5.23	5.30	+ 2	+11	+ 9	+10
Punna cake	4.87	5.13	5.41	5.43	5.44	+ 5	+11	+11	+12
Glyricidia leaves	4.86	4.86	5.21	5.22	5.28	0	+ 7	+ 7	+ 9
Lime	4.90	5.03	5.34	5.32	5.35	+ 3	+ 9	+ 9	+ 9
Gypsum	4.79	4.93	5.26	5.25	5.27	+ 3	+10	+10	+10
Control	4.78	4.84	4.87	4.97	5.05	+ 1	+ 2	+ 4	+ 6
Sub treatments									
Trichoderma viride	4.83	4.96	5.24	5.32	5.32	+ 3	+ 4	+10	+10
Carbendazim	4.84	4.91	5.25	5.20	5.28	+ 2	+ 9	+ 8	+ 9
Control	4.83	4.97	5.21	5.20	5.24	+ 3	+ 7	+ 8	+ 9
C.D. values (0.01)									
Main treatments	N S	0.20	0.21	0.25	0.25				
Sub treatments	N S	N S	N S	0.10	N S				

(contd.....)

(Table 14 contd.)

Treatments	Bacteria								
	Before addition	Period after addition (weeks)				Percentage deviation after (weeks)			
		2	6	10	14	2	6	10	14
Main Treatments									
Rice husk	6.48	6.64	7.23	7.32	7.25	+ 2	+12	+13	+12
Punna cake	6.73	6.74	7.24	7.35	7.29	+0.2	+ 8	+ 9	+ 8
Glyricidia leaves	6.59	6.68	7.26	7.39	7.36	+ 1	+10	+12	+12
Lime	6.66	6.84	7.12	7.20	7.06	+ 3	+ 7	+ 8	+ 6
Gypsum	6.54	6.65	7.23	7.33	7.25	+ 2	+11	+13	+12
Control	6.71	6.79	7.10	7.22	7.27	+ 1	+ 6	+ 7	+ 8
Sub Treatments									
Trichoderma viride	6.52	6.69	7.16	7.31	7.26	+ 3	+10	+12	+11
Carbendazim	6.67	6.72	7.23	7.31	7.23	+ 1	+ 6	+10	+ 8
Control	6.61	6.76	7.20	7.32	7.25	+ 2	+ 9	+11	+10
C.D.Values (0.01)									
Main treatments	N S	N S	N S	0.15	0.18				
Sub treatments	N S	N S	N S	N S	N S				

(contd.....)

(Table 14 contd.)

Treatments	Actinomycetes								
	Before addition	Period after addition (weeks)				Percentage deviation after (weeks)			
		2	6	10	14	2	6	10	14
Main Treatments									
Rice husk	6.66	6.72	7.24	7.31	7.46	+ 1	+ 9	+10	+12
Punna cake	6.56	6.67	7.10	7.33	7.44	+ 2	+ 8	+12	+13
Glyricidia leaves	6.71	6.85	7.10	7.22	7.41	+ 2	+ 6	+ 8	+10
Lime	6.51	6.58	7.10	7.21	7.26	+ 1	+ 9	+11	+12
Gypsum	6.72	6.80	7.11	7.10	7.28	+ 1	+ 6	+ 6	+ 8
Control	6.36	6.55	6.89	7.06	7.08	+ 3	+ 8	+11	+11
Sub treatments									
Trichoderma viride	6.60	6.69	7.06	7.24	7.36	+ 1	+ 7	+10	+12
Carbendazim	6.58	6.70	7.13	7.16	7.30	+ 2	+ 9	+ 9	+11
Control	6.58	6.69	7.09	7.21	7.30	+ 2	+ 8	+ 9	+11
C.D.Values (0.01)									
Main treatments	N S	0.24	0.31	N S	0.33				
Sub treatments	N S	N S	N S	N S	N S				

Table - 13

Number of propagules of *Rhizoctonia solani* (10 g), populations of total fungi (x 10^4), bacteria (x 10^5) and actinomycetes (x 10^6) per g dry soil treated with different amendments, biocontrol agent and fungicide*

Main treatment	Sub treatment	*Rhizoctonia solani*** Period after addition (weeks)				Percentage deviation after (weeks)			
		2	6	10	14	2	6	10	14
Rice husk	*Trichoderma viride*	12.00	13.00	9.50	9.30	+ 9	+18	-14	-15
Rice husk	carbendazim	12.30	12.00	8.40	8.27	+12	+ 9	-24	-25
Rice husk	control	13.00	13.00	9.83	9.97	+18	+18	-11	- 9
Punna cake	*T.viride*	12.00	13.00	7.50	8.00	+ 9	+18	-32	-27
Punna cake	carbendazim	12.80	12.00	12.00	10.53	+16	+ 9	+ 9	- 4
Punna cake	control	10.00	10.00	8.50	9.00	- 9	- 9	-23	-18
Glyricidia leaves	*T.viride*	10.00	8.90	5.40	3.80	- 9	-18	-51	-65
Glyricidia leaves	carbendazim	9.97	13.00	4.87	5.03	- 9	+ 9	-56	-54
Glyricidia leaves	control	10.50	11.00	6.10	6.00	- 5	0	-45	-45
Lime	*T.viride*	10.80	11.00	7.50	8.17	- 2	0	-32	-26
Lime	carbendazim	12.50	13.00	8.60	8.00	+14	+ 9	-22	-27
Lime	control	12.50	11.00	9.50	9.53	+14	0	-14	-13
Gypsum	*T.viride*	13.00	12.00	12.30	10.00	+18	+ 9	+12	- 9
Gypsum	carbendazim	12.00	12.00	10.40	10.50	+ 9	+ 9	- 5	- 5
Gypsum	control	11.20	12.00	10.90	6.40	+ 2	+ 9	- 1	-42
Control	*T.viride*	11.00	11.00	15.60	15.73	0	0	+42	+60
Control	carbendazim	10.10	12.00	16.10	18.33	- 8	+ 9	+46	+67
Control	control	10.30	11.00	16.20	16.80	- 6	0	+47	+53
C.D. (0.01)		N S	N S	2.995	3.100				

* The value of population of total fungi, bacteria and actinomycetes presented are transformed using logarithmic transformation. The original values are presented in Table 16.

** The original population of *R.solani* before addition of amendment was 11.0 propagules per 10 g soil.

(contd.....)

(Table 15 contd.)

Main treatment	Sub treatment	Total fungi								
		Before addition	Period after addition (weeks)				Percentage deviation after (weeks)			
			2	6	10	14	2	6	10	14
Rice husk	Trichoderma viride	4.76	4.88	5.32	5.23	5.32	+ 3	+12	+10	+12
Rice husk	carbendazim	4.76	4.86	5.34	5.23	5.31	+ 2	+12	+10	+12
Rice husk	control	4.87	4.91	5.34	5.23	5.27	+ 1	+10	+ 7	+ 8
Punna cake	T.viride	4.83	5.17	5.38	5.48	5.45	+ 7	+11	+14	+13
Punna cake	carbendazim	4.82	5.10	5.45	5.44	5.50	+ 6	+13	+13	+14
Punna cake	control	4.95	5.12	5.40	5.37	5.37	+ 3	+ 9	+ 9	+ 9
Glyricidia leaves	T.viride	4.95	4.85	5.19	5.26	5.27	- 2	+ 5	+ 6	+ 7
Glyricidia leaves	carbendazim	4.94	4.85	5.21	5.20	5.30	- 2	+ 6	+ 5	+ 7
Glyricidia leaves	control	4.69	4.89	5.22	5.20	5.26	+ 4	+11	+11	+12
Lime	T.viride	4.90	5.08	5.34	5.39	5.45	+ 4	+ 9	+10	+11
Lime	carbendazim	4.94	4.94	5.31	5.28	5.30	0	+ 8	+ 7	+ 7
Lime	control	4.85	5.08	5.36	5.30	5.30	+ 5	+11	+ 9	+ 9
Gypsum	T.viride	4.76	4.90	5.24	5.32	5.21	+ 3	+10	+12	+10
Gypsum	carbendazim	4.78	4.89	5.26	5.15	5.26	+ 2	+10	+ 8	+10
Gypsum	control	4.83	5.00	5.27	5.29	5.33	+ 4	+ 9	+10	+10
Control	T.viride	4.78	4.85	4.96	5.19	5.21	+ 2	+ 4	+ 9	+ 9
Control	carbendazim	4.77	4.85	4.95	4.90	5.01	+ 2	+ 4	+ 3	+ 5
Control	control	4.78	4.84	4.69	4.81	4.92	+ 1	- 2	+ 1	+ 3
C.D. (0.01)		N S	.200	.209	.205	.250				

(contd.....)

(Table 15 contd.)

Main treatment	Sub treatment	Bacteria								
		Before addition	Period after addition (weeks)				Percentage deviation after (weeks)			
			2	6	10	14	2	6	10	14
Rice husk	Trichoderma viride	6.37	6.54	7.21	7.31	7.22	+ 3	+13	+15	+13
Rice husk	carbendazim	6.58	6.68	7.22	7.42	7.31	+ 2	+10	+13	+11
Rice husk	control	6.50	6.70	7.25	7.23	7.21	+ 3	+12	+11	+11
Punna cake	T.viride	6.60	6.79	7.21	7.29	7.25	+ 3	+ 9	+11	+10
Punna cake	carbendazim	6.88	6.71	7.24	7.35	7.30	+ 3	+ 5	+ 7	+ 6
Punna cake	control	6.71	6.72	7.26	7.41	7.31	+0.1	+ 8	+10	+ 9
Glyricidia leaves	T.viride	6.47	6.72	7.21	7.31	7.38	+ 4	+11	+13	+14
Glyricidia leaves	carbendazim	6.57	6.58	7.32	7.36	7.26	+0.2	+11	+12	+11
Glyricidia leaves	control	6.72	6.73	7.25	7.50	7.46	+0.2	+ 8	+12	+11
Lime	T.viride	6.60	6.68	7.00	7.29	7.19	+ 1	+ 6	+11	+ 7
Lime	carbendazim	6.68	6.90	7.19	7.20	7.01	+ 3	+ 8	+ 8	+ 5
Lime	control	6.70	6.95	7.18	7.12	6.99	+ 4	+ 7	+ 6	+ 4
Gypsum	T.viride	6.40	6.54	7.24	7.31	7.22	+ 2	+13	+14	+13
Gypsum	carbendazim	6.54	6.70	7.24	7.24	7.23	+ 2	+11	+11	+11
Gypsum	control	6.34	6.71	7.20	7.44	7.31	+ 6	+14	+17	+15
Control	T.viride	6.69	6.80	7.09	7.33	7.31	+ 3	+ 6	+10	+ 9
Control	carbendazim	6.77	6.77	7.13	7.26	7.28	0	+ 5	+ 7	+ 8
Control	control	6.68	6.73	7.06	7.11	6.21	+ 1	+ 6	+ 8	+ 8
C D (0.01)			N S	N S	.259	.275	N S			

(contd.....)

(Table 15 contd.)

Main treatment	Sub treatment	Actinomycetes							
		Before addition	Period after addition (weeks)				Percentage deviation after (weeks)			
			2	6	10	14	2	6	10	14
Rice husk	Trichoderma viride	6.70	6.77	7.25	7.30	7.45	+ 1	+ 8	+ 9	+11
Rice husk	carbendazim	6.60	6.88	7.24	7.31	7.48	+ 4	+10	+ 9	+13
Rice husk	control	6.68	6.69	7.24	7.31	7.45	+0.1	+ 8	+ 9	+12
Punna cake	T.viride	6.50	6.72	6.91	7.39	7.42	+ 3	+ 6	+14	+14
Punna cake	carbendazim	6.48	6.58	7.18	7.26	7.41	+ 2	+11	+12	+14
Punna cake	control	6.71	6.70	7.19	7.34	7.48	-0.1	+ 7	+ 9	+12
Glyricidia leaves	T.viride	6.76	6.86	7.09	7.19	7.48	+ 1	+ 5	+ 6	+11
Glyricidia leaves	carbendazim	6.09	6.85	7.14	7.13	7.31	+ 2	+ 7	+ 7	+ 9
Glyricidia leaves	control	6.67	6.83	7.06	7.34	7.43	+ 2	+ 6	+10	+11
Lime	T.viride	6.48	6.57	7.09	7.27	7.30	+ 1	+ 9	+12	+13
Lime	carbendazim	6.57	6.59	7.18	7.24	7.22	+0.3	+ 9	+10	+10
Lime	control	6.48	6.57	7.03	7.12	7.26	+ 1	+ 9	+10	+12
Gypsum	T.viride	6.60	6.65	6.99	7.00	7.22	+ 1	+ 6	+ 6	+ 9
Gypsum	carbendazim	6.85	6.90	7.20	7.16	7.39	+ 1	+ 5	+ 5	+ 8
Gypsum	control	6.71	6.85	7.15	7.14	7.23	+ 2	+ 7	+ 6	+ 8
Control	T.viride	6.58	6.59	7.00	7.31	7.30	+0.2	+ 6	+11	+11
Control	carbendazim	6.31	6.59	6.81	6.89	7.00	+ 4	+ 8	+ 9	+11
Control	control	6.51	6.48	6.86	6.97	6.93	+ 4	+11	+ 2	+12
C D (0.01)		N S	.311	.362	.395	.410				

Table - 16

Populations of total fungi (x 10^4), bacteria (x 10^6) and actinomycetes (x 10^6) per g dry soil collected from different amendments, biocontrol agent and fungicide.

Main treatment	Sub treatment	Total fungi					Bacteria					Actinomycetes				
		Before addition	Period after addition (weeks) 2	6	10	14	Before addition	Period after addition (weeks) 2	6	10	14	Before addition	Period after addition (weeks) 2	6	10	14
Rice husk	Trichoderma viride	5.8	7.7	21.0	17.00	20.8	2.5	3.5	16.2	20.2	16.4	5.0	5.9	18.0	20.0	28.3
Rice husk	carbendazim	5.9	7.2	22.1	16.8	20.6	3.8	4.9	16.5	26.3	20.3	4.0	4.8	17.4	20.5	30.3
Rice husk	control	7.5	8.1	22.1	17.1	18.5	3.2	5.0	18.0	17.0	16.4	4.8	5.0	17.2	20.5	28.3
Punna cake	T. viride	6.8	14.7	24.0	30.4	29.6	4.0	6.2	16.1	19.5	17.7	3.2	5.3	17.6	24.3	26.5
Punna cake	carbendazim	6.7	12.4	28.0	27.9	32.1	8.2	5.1	17.6	22.3	20.2	3.0	3.8	15.3	18.1	25.8
Punna cake	control	9.0	13.0	25.1	23.7	23.2	5.2	5.3	18.0	26.0	20.3	5.1	5.0	15.6	21.8	30.5
Glyricidia leaves	T. viride	9.1	7.2	15.6	18.2	18.8	3.0	5.3	16.2	20.5	24.0	5.8	7.2	12.3	15.7	30.2
Glyricidia leaves	carbendazim	8.7	7.0	16.2	16.1	20.2	3.8	3.8	20.8	23.1	18.1	4.9	7.1	13.7	13.5	20.2
Glyricidia leaves	control	5.0	7.8	16.6	16.0	18.1	4.0	5.3	17.6	31.5	28.5	4.7	6.8	11.6	22.1	27.3
Lime	T. viride	8.0	12.0	22.0	24.6	28.2	4.0	4.8	10.0	19.6	15.3	3.0	3.8	12.4	18.6	20.2
Lime	carbendazim	8.8	10.8	20.7	19.3	20.1	4.8	8.0	15.6	16.1	10.2	3.8	3.9	15.3	16.8	16.4
Lime	control	7.0	12.1	22.8	19.8	20.1	5.0	8.9	15.3	13.0	9.8	3.0	3.8	10.8	13.3	18.3
Gypsum	T. viride	5.9	7.0	18.0	20.7	16.4	2.5	3.5	17.2	20.4	16.5	4.0	4.5	9.8	9.9	16.7
Gypsum	carbendazim	6.0	7.8	18.5	13.7	18.2	3.5	5.0	17.5	17.5	17.2	7.2	7.9	15.8	14.5	24.5
Gypsum	control	6.8	10.1	17.6	19.5	21.3	2.2	5.1	16.0	28.0	20.5	5.2	7.2	14.0	14.0	17.2
Control	T. viride	6.0	7.0	9.8	15.6	16.2	5.0	7.2	12.3	21.6	20.5	3.8	3.9	10.0	20.5	20.3
Control	carbendazim	5.9	7.0	9.0	7.9	10.3	5.9	5.9	13.6	18.3	19.2	2.0	3.9	6.4	7.7	10.2
Control	control	6.1	6.9	5.0	6.4	8.4	4.8	5.5	11.6	16.5	16.5	3.1	3.0	7.2	9.5	8.5

During second week, plots amended with glyricidia leaves showed about 8 per cent decline in the population where as it was 5 per cent in control. For other treatments, the population showed an increase which was about 13 per cent for rice husk and 10 per cent for gypsum. For lime, the increase was 8 per cent while it was 5 per cent for punna cake. During sixth week, increase was 15 per cent in rice husk, 9 per cent in gypsum and 6 per cent each in punna cake and lime. From tenth week onwards, population showed a decline. The decline was about 50 per cent in glyricidia leaves, 22 per cent in lime and about 15 per cent each in rice husk and punna cake. In control, the population increased by 45 per cent. After fourteen weeks, the decline was about 55 per cent in glyricidia leaves, 22 per cent in lime and about 17 per cent each in rice husk, punna cake and gypsum. In control, population increased by 60 per cent.

Among sub treatments, the deviation was +4, +5, -12 and -14 percentages during second, sixth, tenth and fourteenth week respectively for Trichoderma viride, where as the same was +6, +12, -9 and -8 percentages

for carbendazim. For control, it was +2, +3, -8 and -12 percentages respectively.

Among combinations, deviation during second week was between -9 per cent each in punna cake alone and combinations of glyricidia leaves with T.viride and carbendazim to +18 per cent in rice husk alone and gypsum - T.viride combination. During sixth week, the same varied between -18 per cent in glyricidia leaves - T.viride combination to +18 per cent in rice husk alone and combinations of T.viride with rice husk and punna cake. During tenth week, the range was -56 per cent in glyricidia leaves - carbendazim combination to +47 per cent in control. After 14 weeks, the range was -65 per cent in glyricidia leaves - T.viride combination to +67 per cent in carbendazim alone.

Total fungi

Among main treatments, punna cake showed significantly higher population of total fungi during second week. Punna cake and lime had significantly higher population during sixth, tenth and fourteenth week than control. In addition, rice husk, glyricidia leaves and gypsum had significantly higher population

during sixth week and gypsum had higher population during tenth week. Among sub treatments, there was no significant difference during all the periods of assessment, except that, during tenth week, plots treated with T.viride had higher fungal population. During all the periods of estimation, combinations involving punna cake or lime showed significantly higher population than other treatments and control.

The increase in population during second week was slight. It was about 5 per cent in punna cake and 3 per cent each in lime and gypsum. During sixth week, the stimulation was about 11 per cent each in rice husk and punna cake and about 10 per cent each in lime and gypsum. For glyricidia leaves, it was 7 per cent while in control, only 2 per cent increase was observed. During tenth week, about 11 per cent increase was noticed in punna cake while it was 10 per cent in gypsum and 9 per cent each in rice husk and lime. For glyricidia leaves, it was 7 per cent, while in control, stimulation was only 4 per cent. During fourteenth week, stimulation was 12 per cent in punna cake, 10 per cent each in rice husk and gypsum and 9 per cent each in glyricidia leaves and lime.

Among sub treatments, the increase was 3 per cent and 4 per cent during second and sixth weeks respectively and 10 per cent each in tenth and fourteenth weeks in T.viride treated plots. It was 2, 9, 8 and 9 percentages respectively during the same periods for carbendazim treated plots while in control, the increase was 3, 7, 8 and 9 per cent respectively.

Among combinations, during second week, plots receiving glyricidia leaves with T.viride or carbendazim showed a decline in the population (-2 per cent each). During sixth week, the range of deviation varied from -2 per cent in control to +13 per cent in punna cake + carbendazim combination. During tenth week, the range was between +1 per cent in control to +14 per cent in punna cake + T.viride combination and during fourteenth week, the range was between +3 per cent in control to +14 per cent in punna cake + carbendazim combination.

Bacteria

Bacterial population was not influenced by the amendments during second and sixth weeks. During tenth week glyricidia leaves amended plots exhibited significantly higher population of bacteria. During

fourteenth week, population in lime treated plots was significantly lower than other treatments and control. The sub treatments did not influence the population of bacteria at any stage of crop growth.

During second and fourteenth weeks, differences were not statistically significant among combinations. During tenth week, only four treatments gave high bacterial population viz., rice husk - carbendazim combination, punna cake alone, glyricidia leaves alone and gypsum alone; where as after six weeks, only glyricidia leaves - carbendazim combination produced significantly higher population.

The stimulation of the population was slight during second week among main treatments. During sixth week, increase was 12 per cent in rice husk, 10 per cent each in glyricidia leaves and gypsum. Stimulation was 8, 7 and 6 percentages in punna cake, lime and control, respectively. During tenth week, stimulation was 13 per cent each in rice husk and gypsum, 12 per cent in glyricidia leaves, 9 per cent in punna cake and 8 per cent in lime. In control,

stimulation was only 7 per cent. During fourteenth week, increase was 12 per cent each in rice husk, glyricidia leaves and gypsum, 8 per cent each in punna cake and control, while in lime, it was only 6 per cent.

Among sub treatments, plots treated with T.viride recorded about 3, 10, 12 and 12 percentages increase during second, sixth, tenth and fourteenth weeks respectively. For carbendazim sprayed plots, the same was 1, 9, 10 and 8 percentages respectively and in control, it was 2, 9, 11 and 10 percentages respectively.

Among combinations, during second week, the increase was generally slight and less than 5 per cent, except gypsum alone (6 per cent increase). Punna cake-carbendazim combination recorded a 3 per cent decline in population. During sixth week, the stimulation ranged between +5 per cent in carbendazim alone to +14 per cent in gypsum alone. During tenth week, the range was +6 per cent in lime alone and 17 per cent in gypsum alone and during fourteenth week, stimulation ranged between 4 per cent in lime alone and 15 per cent in gypsum alone.

Actinomycetes

Population of actinomycetes was significantly high in plots amended with glyricidia leaves and gypsum during second week, while during sixth week, population was high in rice husk treated plots. During fourteenth week, population was significantly higher in plots amended with rice husk and punna cake eventhough treatments did not differ significantly during tenth week. The sub treatments had no influence on the population during any of the assessments.

Among combinations, during second week, plots receiving glyricidia leaves, gypsum and rice husk - carbendazim combination showed higher populations. During sixth week, rice husk - T.viride combination and during tenth week, punna cake - T.viride combination recorded significantly higher population of actinomycetes. During fourteenth week, plots receiving combinations of rice husk, punna cake and glyricidia leaves as well as gypsum - carbendazim combination showed significantly higher population.

Stimulation of actinomycetes by main treatments during second week was slight and less than 5 per cent.

During sixth week, the stimulation was 9 per cent each in rice husk and lime, 8 per cent each in punna cake and control and 6 per cent each in glyricidia leaves and gypsum. During tenth week, the same was 12 per cent in punna cake, and about 10 per cent each in rice husk, lime and control. Stimulation was about 8 per cent in glyricidia leaves and 6 per cent in gypsum. During fourteenth week, the increase was 13 per cent in punna cake, 12 per cent each in rice husk and lime, about 10 per cent in glyricidia leaves and control, while in gypsum, it was only 8 per cent.

Among sub treatments, the stimulation was 1, 7, 10 and 12 percentages during second, sixth, tenth and fourteenth weeks respectively for T.viride treated plots while the same was 2, 9, 9 and 11 per cent respectively for carbendazim sprayed plots. In control, the stimulation was 2, 8, 9 and 11 per cent respectively during the same periods.

During second week, among combinations, the range was -0.1 per cent in punna cake alone and +4 per cent in rice husk - carbendazim combination, carbendazim alone and control. During sixth week, the

stimulation ranged between +3 per cent in gypsum - carbendazim combination and glyricidia leaves - T.viride combination to 11 per cent in punna cake-carbendazim combination and untreated control. After 10 weeks, the stimulation ranged between 2 per cent in untreated control and 14 per cent in punna cake - T.viride combination. During fourteenth week, the stimulation was almost uniform, ranging between 8 per cent in gypsum alone and gypsum - carbendazim combination to 14 per cent in combinations of punna cake with T.viride and carbendazim.

Studies on antagonism

The fungal flora obtained in petriplates by serial dilution under different amendments were purified by hyphal tip method. The fungal colonies obtained from soil treated with rice husk and glyricidia leaves included species of Trichoderma, Aspergillus, Fusarium, Rhizopus and Mucor. Soil treated with punna cake showed the predominance of species of Trichoderma and Pythium while species of Mucor, Aspergillus and Penicillium were abundant

under lime. In gypsum treated plots, species of Trichoderma and Aspergillus were more where as in untreated plots, the major genera present were Pythium and Penicillium

The antagonistic studies have revealed that species of Trichoderma, Aspergillus and Mucor suppressed the colonies of Rhizoctonia solani in the order of preference.

Chemical analysis of soil

Results of the chemical analysis of soil before and after the experiment are presented (Table 17).

pH of the soil showed an increase during the experiment in plots treated with lime. Treatment with punna cake also increased the pH of the soil. In all other treatments, soil acidity was enhanced.

Nitrogen content of the soil showed a general increase after the experiment where as potash content was decreased. Plots treated with punna cake, lime and gypsum showed an increase in phosphorus content whereas the same showed a decline during the course of the experiment in soil amended with rice husk or glyricidia leaves and in unamended soil.

Table - 17

pH and major nutrient content of soil as influenced by different amendments.

	Nutrient percentages			
	pH	N	P_2O_5	K_2O
Before experiment	6.2	0.046	0.017	0.004
After experiment				
1. Rice husk	5.7	0.108	0.015	0.0025
2. Punna cake	6.7	0.077	0.018	0.0038
3. Glyricidia leaves	5.8	0.085	0.015	0.0025
4. Lime	7.1	0.069	0.023	0.0025
5. Gypsum	5.2	0.108	0.019	0.0038
6. Control	5.9	0.100	0.015	0.0025

DISCUSSION

DISCUSSION

Management of soil-borne diseases seems to be much more complex than that of air-borne diseases, as in the former, application of chemicals is difficult and extremely costly. Hence, successful management of soil-borne diseases can be achieved only through an integration of various methods viz., physical, chemical and biological. The pathogen causing sheath blight disease of rice Rhizoctonia solani remains in soil even in the absence of the crop and hence a knowledge of the survival ability of the pathogen is important in successful handling of the disease.

In the present investigation, laboratory trials have shown that under dry conditions, sclerotia were alive upto 10 cm depth of soil during the entire period of observation viz., eight weeks. However, when pots were flooded to a depth of 5 cm, the viability of sclerotia was affected at deeper layers of 7.5 and 10 cm depths. But sclerotia kept on the surface or up to a depth of 5 cm or below were viable. In a separate pot trial, field soil under different

rotations when used for growing rice, it was seen that the least disease incidence and intensity occured in rice-tapioca-rice, rice-brinjal-rice, or rice-banana-rice.

The above studies indicate the importance of deeper ploughing followed by submergence and an effective crop rotation schedule in disease management. Prabhat and his co-workers (1974) noticed that the sclerotial viability under submerged conditions was lost after two to three months. They suggested that by flooding field for three months after harvest, sclerotia loose their viability. Hashiba and Mogi (1973) have stressed the need for fallowing rice fields to manage sheath blight disease as the number and germination of sclerotia were drastically reduced as time progressed. Tu and his associates (1979) noticed that when sclerotia on the surface survived for more than sixteen months, those buried to a depth of 2 cm did not survive even for eight months. Kannaiyan and Prasad (1978) observed that at 5 cm depth, sclerotia remained viable for more than one year, while on the surface viability was lost within seven months, under dry condition.

In a separate study Kannaiyan (1977) observed that seedling infection of rice due to R.solani reduced with an increasing moisture level from 97 per cent at 30 per cent moisture to 10 per cent at water logged condition. He concluded that high moisture content was detrimental to the pathogen due to poor soil aeration and increased Co_2 concentration. Another reason for reduced infection might be the lysis of R.solani mycelia at higher moisture level due to increased bacterial activity.

A recent study conducted by Lakshmanan and Mohan (1986) in blight (R.solani) of siratro, a fodder crop has revealed that sclerotia mixed with soil and farm yard manure lost viability in seven months under dry conditions, while under flooded situations, the viability was lost in fifty days. The trend of the present studies endorses the view experienced by Kannaiyan (1977) and Kannaiyan and Prasad (1978) on the importance of physical factors in successful management of the pathogen. The fact that both viability and number of sclerotia have been substantially reduced in deeper layers of 7.5 and

10 cm depths and submergence to a level of 5 cm with water suggests that deep ploughing followed by flood fallowing for two months is quite useful to combat this pathogen. However, this information is too fragmentary as the same has been obtained from laboratory and pot studies. Hence, replicated randomised multilocational field trials are to be carried out in different regions of the State before landing on any broad conclusion regarding the effective management of the pathogen.

Monoculture has several disadvantages, the chief among them being the unlimited spread of insect pests and diseases. This unlimited build up of pathogenic organisms can be successfully prevented by growing a non host crop in between two successive rice crops. Among the various crops tested, tapioca, banana and brinjal have reduced the intensity and incidence of sheath blight disease (Table 10). It is presumable that roots of these crops may liberate certain chemicals which may selectively reduce the pathogen population in soil through one or other of the antagonistic principles viz., antibiosis, competition and/or exploitation.

Kohli (1966) and Roy (1973) have indicated that host range of sheath blight pathogen is restricted to plants belonging to Graminae, Cyperaceae and Commelinaceae. Prabhat (1971) has shown that plants belonging to Pontederiaceae, zingiberaceae and Papilionaceae are also susceptible. Kannaiyan and Prasad (1979 a) while testing ten rice cultivars, 46 other crop plants and 84 weed hosts under artificial conditions have observed that sheath blight pathogen possesses a very wide host range. However, graminaceous hosts viz., Sorghum vulgare and S.sudanese were least affected. It is well known that different species of sorghum possess certain cyanogenic glycosides as in the case of tapioca.

Davis and Mc Dole (1979) observed that soil from a cereal potatoe rotation had half the number of propagules of R.solani per kg of soil as that from soil planted continuously with potatoes, indicating that rotation affects pathogen levels and disease control by rotation may be possible. Alice and Padmakumari (1986) noticed that R.solani isolated from rice can infect cowpea causing collar rot and

web blight. They have suggested rotation of rice with non host crops in order to prevent the build up of the population of R.solani. Chakroborty and Misra (1956) found that collar rot and root rot of Jute (caused by Macrophomina phaseolina) can be successfully managed by crop rotation. The present observation that when rice is grown in rotation with tapioca, banana or brinjal, the incidence and intensity of sheath blight were low, is in conformity with the results of the above workers.

Among different soil amendments tried in pots, glyricidia leaves, rice husk, gypsum, saw dust and oil cakes like punna, neem and marotti were efficient in reducing the intensity and incidence of sheath blight disease of rice (Table 3). However, under field conditions only a few of them viz., glyricidia leaves, rice husk and lime alone were effective. During maximum tillering stage, panicle emergence and maturity stages, both glyricidia leaves and rice husk were useful, while lime was efficiant during panicle emergence and at maturity stages only.

Rajan and Menon (1975) tried various industrial and agricultural waste materials against sheath blight disease. They have suggested that coconut pith (with NPK), eluppa cake, rubber seed cake and punna cake have been successful in reducing the intensity of sheath blight disease. Rajan (1980) has found that non edible cakes, saw dust and rice husk are equally effective in suppressing sheath blight disease. Dath (1979) suggested that survival period and viability of sclerotia were reduced by incorporation of green manure like Sesbania aculata. Kannaiyan and Prasad (1981 a) observed reduction in seedling infection of R.solani by amendment such as rice chaff, neem cake, saw dust and manure. George et al. (1984) obtained excellent field control of sheath blight with amendments such as rice husk or neem cake.

The observation in the present investigation that glyricidia leaves or rice husk reduced the disease during maximum tillering stage, panicle emergence stage and maturity stage and lime during latter phase alone are important points in disease management. Glyricidia leaves and rice husk are

effective in reducing the disease score as well as infestation of different tillers while lime application did not reduce the score (Table 12). The present investigation reveals the superiority of glyricidia leaves and rice husk over other materials. Rice husk contain momilactone A, B, C, p coumaric acid and 5 (+) dehydrovomifoliol which inhibit spore germination of the pathogen (Gangopadhyay, 1983). The efficiency of oil cakes in management of R.solani has been revealed by recent studies also. Alagarsamy et al. (1987 b) suggested that neem cake at the rate of 2.5 t/ha reduced the root rot of cotton due to R.solani. Padmakumari and Balakrishnan (1987) found that cakes of punna and neem reduced the saprophytic survival of R.solani.

Oil cakes have been widely used in the past for the management of various soil-borne diseases viz., soft rot of ginger caused by Pythium aphanidermatum (Rajan 1971, Rajan and Singh, 1972; Rajan and Singh, 1974; Balagopal et al. 1973; Rajan and Singh, 1975), stem rot of groundnut caused by Sclerotium rolfsii (Maiti et al., 1987). Root rot of soybean

(Macrophomina phaseolina) and bacterial wilt of tomato caused by Pseudomonas solanacearum (Jayaprakash, 1977; Rajan and Jayaprakash, 1984).

Balasubramanian and Shanmugham (1986) established the inverse relation between tissue calcium content of blackgram prior to inoculation and leaf blight intensity indicating the basis for reduced disease incidence after application of lime and gypsum as observed in the present study. The reduced disease incidence following application of lime and gypsum can be attributed to the formation of calcium pectate, a structure resistant to the invasion by the pathogen. Earlier workers in this field have also reported the control of plant diseases by application of calcium. Corden (1965) suggested the control of vascular wilt of tomato (Fusarium oxysporum) by calcium nutrition. Bateman and Miller (1966) observed the resistance of beans against R.solani following application of calcium.

Least population of the pathogen under field condition was noticed in plots amended with glyricidia leaves after tenth and fourteenth weeks. However, plots

treated with rice husk, lime, gypsum and punna cake also had low population of R.solani. As early as 1962, Papavizas and his associates have noticed that saprophytic activity of R.solani was reduced by amendments like Oat straw. Dwivedy and Singh (1986) observed the population of Macrophomina phaseolina causing root rot of cotton to be reduced under different oil cakes. Among various cakes, neem and cotton were found to be the best in which recovery was reduced to 50 per cent in four weeks time.

Padmakumari and Balakrishnan (1987) observed reduced saprophytic activity of R.solani under amendments like punna cake, neem cake, rice husk, saw dust, fish waste and groundnut shell. Maiti et al. (1987) observed that oil cakes of groundnut, black till, mustard, neem and Kharanja reduced the sclerotial population of Sclerotium rolfsii in soil causing stem rot of groundnut. Among the above, groundnut cake was the best, followed by neem cake.

Both pot trial as well as field experiment have shown that saprophytic flora in soil viz., total fungi, bacteria and actinomycetes have tremendously

increased in various treatments. Among organic materials (other than oil cakes), glyricidia leaves and press mud had highest fungal population throughout the period of investigation ie. from second till tenth week. Others like rice husk, saw dust and coconut pith also had higher fungal population during later stages. Among oil cakes, punna cake had high fungal population during all the different periods of assessment. During second week, only punna cake had higher fungal population eventhough during later stages, all the oil cakes tested stimulated the fungal population. Increased population of total fungi following soil amendment has been widely accepted (Smith and Ashworth, 1965; George, 1981).

Among the treatments which have encouraged the total fungal flora, glyricidia leaves and rice husk had very good influence on the intensity and incidence of the disease. In amendments such as press mud, saw dust and coconut pith, the intensity and incidence of the disease were more than that of rice husk and glyricidia leaves inspite of increased total fungal

population. This necessitates a closer probe into the subject matter as in the same quantitative picture, there is possibility of variation in the qualitative picture. It is presumable that in pots amended with glyricidia leaves or rice husk, specific flora antagonistic to R.solani were predominant and they in turn might have been responsible for reduced intensity and incidence of the disease following lower pathogen counts.

The disease management by soil amendments and subsequent build up of fungal antagonists has been reported by other workers. Padmakumari and Balakrishnan (1987) reported that amendment of soil with punna cake and neem cake reduced the saprophytic survival of R.solani and increased the fungal population. They observed increased populations of antagonists like Trichoderma viride, T.harzianum, Aspergillus flavus, A.niger and Chaetomium globosum after the amendment and concluded that the mechanism of biological control may be antibiosis and/or competition.

Efficiency of Trichoderma spp. to manage plant diseases has been observed by several workers. Mukhopadhyay and Indulika Chandra (1986) observed that T.harzianum controls sugarbeet and tobacco damping off (Pythium aphanidermatum). Padmanabhan and Alexander (1986) indicated the ability of T.viride in managing root rot of sugarcane (Pythium graminicolum). Fusarium wilt of tomato was effectively controlled by T.viride (Veerasamy et al., 1986).

Among the different amendments tested, populations of bacteria and actinomycetes were more in glyricidia leaves, press mud and rice straw during second and sixth weeks. However, population increase during tenth week was not significant. Among the different oil cakes tested, mahua cake and punna cake had higher population of bacteria during all the different periods of assessment. During second week, all the oil cakes tested showed higher bacterial population, whereas during sixth week, treatments which recorded higher population were mahua cake, neem cake and punna cake. During tenth week only mahua cake and punna cake treated soil showed significantly

higher population. However, in the field trial population of bacteria was high in glyricidia leaves amended soil during tenth week, and lime amended plots during fourteenth week. During early periods of second and sixth week amendments had no significant influence on bacterial population.

Rice straw is the only amendment which gave significantly higher actinomycetes population during all periods of observation. Press mud, glyricidia leaves and rice husk also had higher population during second and sixth week. Population of actinomycetes did not differ among oil cakes in second week. But during sixth week, mahua cake showed higher population and during tenth week, all cakes except punna cake recorded higher population. Padmakumari and Balakrishnan (1987) have reported that punna cake, neem cake, rice husk and saw dust increased the populations of bacteria and actinomycetes in soil. Among them, species of Bacillus and Streptomyces were predominant. The present investigation also revealed that populations of bacteria and actinomycetes were more in soil amended with different organic materials.

Krishnamohan and Kandasamy (1986) observed higher populations of bacteria and actinomycetes in soil amended with rice straw, saw dust, coconut fibre and neem cake. Khare and Jharia (1987) found that organic materials like straw, oil cakes, saw dust, wood shavings and farm yard manure modify the physical, chemical and biological environment of the soil and help to control the disease by better conditions for growth, increased antagonists, stimulation of spore germination following lysis, inactivation of the pathogen by direct action of certain chemicals produced during decomposition, immobilisation of nitrogen and by release of nutrients favouring competition among soil microorganisms.

In the present investigation, it was observed that plants treated with those amendments which stimulated bacterial and actinomycetes flora like press mud, rice straw, rice husk, glyricidia leaves and various non edible oil cakes had low intensity and incidence of the disease. It is presumable that the antagonistic activity of the stimulated bacteria

and actinomycetes have contributed to the disease management through one or other of the antagonistic principles.

A critical analysis of the whole situation will therefore indicate that fluctuation of population of saprophytic flora - fungi, bacteria and actinomycetes - in relation to pathogen has got a major role in disease management. Earlier workers on biological control of soil-borne diseases have shown that fungi are important in early decomposition stage. This is followed by bacteria and finally by actinomycetes. This difference is possibly due to difference in their enzyme system capable of digesting organic substrates of varying complexity. Simple sugars are easily digested by certain soil fungi referred as sugar fungi. It is oovious that in the early period of decomposition the population of sugar fungi increases. This increased population of sugar fungi declines once the simple sugars are exhausted. This possibly creates an atmosphere for increased population of bacteria. However, once decomposition is fast, the temperature goes up and only highly resistant organic

fraction remain undecomposed. At this stage, only actinomycetes will be able to act and hence the population of actinomycetes increases at the last phase.

Since food substates in soil are generally short, addition of organic materials having a complex of substances ranging in their degree and ease of decomposition lead to intense microbial activity. Thus, the greater efficiency of fungi over bacteria in colonising substrates which are easily decomposible make the former dominate over the latter during early period of decomposition. Garett (1956) suggested greater efficiency of fungi over bacteria in decomposing simple organic substrates.

Rajan and Singh (1972) working with soft rot of ginger caused by Pythium aphanidermatum have shown that negative correlation between the pathogen and total fungi were significant during early decomposition period, but during later period, negative correlation between pathogen and bacterial population was significant. Gilbert et al. (1968) reported that during early stages of decomposition of organic

amendments, the breakdown of fungistasis results in increase in the number of propagules of the pathogen in soil together with increase in the saprophytic flora. However, soon the activity of enhanced microflora reduces the population of pathogen through various antagonistic and competitive effects.

Organic materials have shown to be effective in reducing the severity of several soil-borne diseases. The benefit gained by the practice may not only be due to the starvation of the pathogen (competition) but also due to the stimulation of antagonistic properties of soil microflora (antibiosis). The reduction in disease incidence is therefore, linked with the concept of inoculum potential, a product of the quantity of inoculum present (intensity factor) and capacity of the environment to produce the disease (capacity factor).

Hence, in any circumstance wherein the inoculum potential happens to be extremely high, the fall in inoculum potential has to be undertaken by an appropriate chemical and thereafter further rise in the inoculum may be prevented biologically. In the

present investigation, it may be seen that the inoculum potential of the pathogen was medium and this might have been the reason that simply by amending soil with certain organic materials like glyricidia leaves and rice husk, the management of disease was fair.

The present investigation revealed the efficacy of fungicides like carbendazim and edifenphos in the management of sheath blight disease. Field experiments conducted by Bhaktavatsalam et al. (1977) have also revealed that Bavistin was the most effective chemical against the disease. They observed that disease severity in Bavistin sprayed plots was 5.5 per cent compared to 75 per cent in the unsprayed control. They recommended that spraying rice crop twice with Bavistin (at 80 and 95 days after planting) would be effective.

Jayanathan and Kannaiyan (1978) opined that three sprays at ten day interval during maximum tillering stage with Bavistin provided good protection against sheath blight. Kannaiyan and Prasad (1977 a) observed that spray of Hinosan twice during maximum

tillering stage effectively checked the disease. The present study also demonstrated the superiority of carbendazim (Bavistin) and ediphenphos (Hinosan) over other fungicides in the management of sheath blight disease of rice. Several other workers have also reported the efficacy of these chemicals in the management of the disease (Dev, 1980; Rajan et al., 1979; Reddy et al., 1981).

The present study indicated that weedicide benthiocarb was effective in managing the disease incidence. This finding is in accordance with the finding of Vasavan et al. (1980) and Rajan and Ittyavirah (1981) and Anonymous (1984). Sankaralingam (1980) observed that linear growth of R.solani and Sclerotium rolfsii was inhibited by herbicides nitrofen and fluchoralin. In culture media, these herbicides inhibited the sclerotial production. Sankaralingam and Jeyarajan (1986) suggested that the herbicides nitrofen and fluchoralin inactivate the endopolygalacturonase, exopolygalacturonase and polygalacturonase transeliminase produced by R.solani.

These herbicides inhibited the sclerotial production and were found to be more toxic than insecticides tested viz., phorate and carbofuran.

In the present study undertaken, it was seen that insecticides like quinalphos and carbaryl are not as effective as fungicides or herbicides tested in reducing the disease. Ramadoss and Sivaprakasam (1986) observed that insecticides are less effective than fungicides in inhibiting the linear growth of Macrophomina phaseolina. However, Sankaralingam (1980) observed that insecticides delayed the sclerotial production, eventhough they failed to inhibit its formation.

In the field trial, different treatments had no influence on height of the plants or on tiller production during vegetative phase. The number of productive tillers also were not influenced. However, it was observed that, at maturity plants in T.viride treated plots were taller than fungicide treated plots. The increased vegetative growth after treatment with T.viride could be attributed to the production of growth promoting substances by T.viride. Windham et al.

(1986) observed enhanced plant growth resulted from amendment of the soil with T.harzianum and T.koningii and suggested that Trichoderma spp. produced growth regulating factors which increased the rate of seed germination and dry weight of shoots and stems. Similar results have been reported by Chang et al. (1986) who found that T.harzianum induced increased height in various floricultural and horticultural crops, when fungus was applied in conidial suspensions or in a peat bran mixture.

Neither grain yield nor straw yield was found to differ in any of the treatments in the field trial. However, non significant increase in grain yield was observed in plots receiving rice husk along with T.viride or glyricidia leaves with carbendazim. Yield of straw was more in plots receiving lime with carbendazim, eventhough the difference was not significant. No difference among treatments was observed in grain weight and percentage of chaff also. The non significant difference in grain and straw yields among different fungicides compared to untreated control has been reported in earlier studies conducted at Rice Research Station, Moncompu and Regional

Agricultural Research Station, Pattambi, Kerala (Anonymous, Research Report, Kerala Agricultural University, 1984).

The trial employing the biocontrol agent T.viride resulted in a reduced disease intensity and incidence indicating the efficiency of the biocontrol agent T.viride in managing sheath blight of rice. The antagonism is resultant of any one of the mechanisms viz., antibiosis, competition, exploitation or in combination. Khare and Jharia (1987) found that organic materials like straw, oil cakes and saw dust increase the population of antagonists of soil bringing about a reduced disease incidence after amendment of the soil with these materials. Nagarajan and Reddy (1986) found that T.viride controls tobacco damping off caused by Pythium aphanidermatum. Padmakumari and Balakrishnan (1986) have reported T.viride as being antagonistic to R.solani as in a combination, the recovery was reduced. Alagarsamy et al. (1987 b) observed that pre and post emergence mortality of seedlings were reduced by amending with T.viride. Several other workers have also reported about the

efficiency of T.viride in controlling R.solani (Hino and Endo, 1940; Roy, 1977; Gokulapalan and Nair, 1984).

Certain other species of Trichoderma are also reported effective in competing with and suppressing R.solani. Treatment of seeds of Radish and Pea with conidia of T.hamatum in a methocel slurry protected seeds and seedlings from R.solani and Pythium spp. nearly as effectively as fungicide seed treatment (Harman et al., 1980). They found that in soils containing T.hamatum, there were lower densities of R.solani. T.lignorum also has found highly destructive to corticium sasakii (Hino, 1935). Laetisaria arvalis as a possible agent for bio control of R.solani in sugarbeet field has been described by Larsen et al. (1985). Efficiency of T.harzianum as an antagonist against plant pathogens has been reported by Padmakumari and Balakrishnan (1986); Bhaskaran and Seetharaman (1986) and Nagarajan and Reddy (1986). Alagarsamy et al. (1987 a) suggested seed coating of T.harzianum to reduce the pre and post emergence mortality of seedlings. Manian and Paulsamy (1987)

found that T.aureoviride and its filtrate were antagonistic to mycelial growth and sclerotial initiation of R.solani.

Chemical analysis of soil revealed that pH of the soil was increased in plots amended with punna cake and lime, while in rice husk, glyricidia leaves and gypsum, the acidity was enhanced. The altered pH after amendment might have contributed to the disease management by an indirect effect of selectively stimulating some of the specific antagonists. Analysis also showed that there was a general increase in soil nitrogen content and a decline in potash content indicating that the rice plants have taken up less of nitrogen and more of potash during its growth, both of which have contributed to the resistance of the plants towards sheath blight.

SUMMARY

SUMMARY

1. Laboratory and pot experiments were conducted in the department of plant pathology, College of Horticulture, Vellanikkara, Trichur during 1984-86 to study the role of various physical, chemical and biological factors on management of sheath blight disease of rice caused by Rhizoctonia solani, a soil-borne pathogen.

2. Results of the laboratory trials indicated that sclerotia of R.solani will remain alive in soil irrespective of the depth for more than two months under dry conditions. But under flooded situations, germination of sclerotia at depths of 7.5 cm or more from soil surface was weak and delayed after four weeks.

3. It was observed that among amendments (other than oil cakes) tried in pots, glyricidia leaves and saw dust increased the plant height, but none of the treatments influenced the production of tillers. Intensity and incidence of the disease were least in pots amended with glyricidia leaves, rice husk, gypsum

or saw dust. In coconut pith amendment, the intensity was less eventhough incidence was of a higher magnitude.

4. Assessment of the populations of the pathogen and saprophytes in soil during different stages of crop growth revealed that there was a general increase in the population of the soil saprophytic flora following amendment with a resultant reduction in the population of the pathogen. However, the degree of stimulation varied with the kind of amendment and time lapse.

5. Different non edible oil cakes did not influence plant height or production of tillers. Except mahua cake, all others viz. neem cake, punna cake and marotti cake lowered the disease intensity. However, disease incidence was less in pots amended with anyone of the oil cakes, among which neem cake and punna cake were found to be the best. Fluctuation of the microbial population was almost in a similar pattern as observed in the above mentioned experiment.

6. Different pesticides had no influence on plant height or tiller production. However, intensity and

incidence of the disease were reduced by all the pesticides tested except quinalphos and 2,4-D sodium salt. Carbendazim and ediphenphos were best among the pesticides tested with respect to disease intensity. However, in weedicide benthiocarb and a fungicide mancozeb, the disease incidence was as low as that of the above fungicides.

7. Different rotations had no influence on plant height or production of tillers. Intensity of sheath blight disease was low in rice following tapioca and rice following banana. Incidence of the disease was low in rice following banana or brinjal.

8. A field experiment was laid out in the Agricultural Research Station, Mannuthy during the kharif season of 1986 to study the effect of organic and inorganic amendments, fungicide (carbendazim) and bio control agent (Trichoderma viride) on management of sheath blight disease of rice.

9. Results of the investigation revealed that treatments had no influence on height of the plants during vegetative phase or on tiller production. However, at maturity, plants in T.viride treated plots

had more height than fungicide treated plots as well as untreated plots. Yields of grain and straw were not influenced by the treatments. However, plots receiving both rice husk and T.viride recorded more panicle length and number of grains per panicle. Treatments did not influence the weight of the grains or percentage of chaff.

10. Disease intensity was least in plots amended with rice husk or glyricidia leaves and plots treated with T.viride at maximum tillering stage. At panicle emergence stage and at crop maturity, the bio control agent T.viride and the fungicide carbendazim reduced the intensity of the disease.

11. Disease incidence was least during maximum tillering stage in plots amended with glyricidia leaves and those treated with T.viride. During panicle emergence stage and at crop maturity, plots treated with glyricidia leaves, rice husk, lime and carbendazim had lower disease incidence.

12. Population of saprophytes was stimulated and that of pathogen was reduced by all the amendments

tried in the field experiment. However, maximum stimulation of saprophytes and suppression of the pathogen was observed in plots amended with glyricidia leaves or rice husk.

13. The predominant fungal flora under each treatment in the field experiment were isolated, purified and studied. Antagonistic studies revealed that species of Trichoderma, Aspergillus and Mucor were antagonistic to colonies of R.solani.

14. Chemical analysis of the soil before and after the field experiment revealed that pH of the soil was increased in plots amended with lime or punna cake where as for other treatments viz., rice husk, glyricidia leaves and gypsum, soil acidity was enhanced. Nitrogen content of the soil was increased and potash content being decreased in all the amendments after the experiment. Phosphorus content was enhanced in amendments viz., punna cake, lime and gypsum.

The above studies indicate the importance of some organic amendments viz., glyricidia leaves, rice husk and inorganic amendments like lime on the

population of the pathogen *R.solani* in soil in relation to saprophytic microflora of total fungi, bacteria and actinomycetes. It may be seen that the above are useful in the management of sheath blight disease under field conditions.

The trial with the biocontrol agent *T.viride* is quite promising as when the above was used in place of the most potent systemic fungicide carbendazim, the results were almost similar. However, further elaborate multilocational field trials are required to precisely judge the efficiency of glyricidia leaves, rice husk and lime and the feasibility of substituting the biocontrol agent *T.viride* for a fungicidal spray for the management of sheath blight disease.

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* Originals not seen.

MANAGEMENT OF SHEATH BLIGHT DISEASE OF RICE IN RELATION TO THE POPULATION OF THE PATHOGEN IN SOIL

BY

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ABSTRACT

Laboratory, pot and field experiments were carried out to study the role of various physical, chemical and biological factors on the management of sheath blight disease of rice caused by Rhizoctonia solani Kuhn. (Thanatephorus cucumeris (Frank) Donk). Populations of total fungi, bacteria and actinomycetes in soil were enumerated at different stages of growth of the crop in order to assess their role in reducing the intensity and incidence of sheath blight disease. Results of the investigation revealed that the pathogen can be managed by deeper ploughing followed by submergence of the soil for a minimum period of two months. Amendments like glyricidia leaves, rice husk, lime and non edible oil cakes of marotti, neem and punna were useful in reducing the severity and spread of the disease. Fungicides like carbendazim and ediphenphos and the herbicide benthiocarb were also efficient in managing the disease. Rotation of rice with crops like tapioca, banana and brinjal was also useful. It was seen that amendments stimulated the population of saprophytes like Trichoderma viride

in soil which are antagonistic to *R.solani* resulting in a subsequent reduction in population of the pathogen. In spite of the reduction in severity and spread of the disease, grain and straw yields were not enhanced by the treatments. More elaborate field trials are to be undertaken before landing on any ultimate conclusion regarding the use of these practices as tools for disease management.