nation was found to be the best treatment in improving growth characteristics of tomato plants.

Sixty days after planting, the root galling and the final nematode population showed significant decrease in treatments with *P. penetrans*, oil cakes and *P. penetrans* + oil cakes, with the combination treatments being the most effective among the three (Table 1). Among the combinations, *P. penetrans* + neem cake was found to be the most effective treatment resulting in 82.2 and 75.1 per cent reduction in galling and final nematode population, respectively. Examination of root powder from plants inoculated with *P. penetrans* and *P. penetrans* + oil cakes showed the presence of the bacterium. The effectiveness of *P. penetrans* as well as oil cakes in suppressing root-knot nematodes has been demonstrated by several workers. The results prove that *P. penetrans* and oil cakes are compatible in soil and the multiple stresses exerted by the two, each having a different mode of action, is more effective in suppressing the nematode.

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Management of sheath Blight Disease of Rice with *Trichoderma viride* and some soil amendments in relation to the Population of Pathogen in soil.

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ABSTRACT

Incidence of sheath blight disease of rice was reduced in plots receiving *Glyricidia* leaves, rice husk or lime (main treatment) as well as *Trichoderma viride* (subtreatment). Interactions between *Glyricidia* leaves and *T. viride*/Carbendazim and rice husk/lime with carbendazim were significant. Maximum stimulation of saprophytes and suppression of pathogen were observed in plots amended with *Glyricidia* leaves or rice husk.

KEY WORDS: Rice Sheath blight control, soil amendments, *Trichoderma viride*, carbendazim.

The sheath blight disease of rice caused by *Rhizoctonia solani* Kuhn is soil-borne in nature. Chemical control of the pathogen is extremely costly and quite laborious. Hence, a field experiment was carried out at the Agricultural Research Station, Mannuthy, during the Kharif season (July-August to October-November) of 1985-'86 to study the effect of the biological control agent *Trichoderma viride*, some soil amendments, and fungicide carbendazim on the populations of *R. solani* and soil saprophytes, intensity and incidence of sheath blight disease and yield of grain and straw.

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MATERIALS AND METHODS

The treatments consisted of five soil amendments (rice husk, punna cake, *Glyricidia*

TABLE 1. Effect of amendments, biocontrol agent and fungicide on the intensity of sheath blight disease at panicle emergence.

Treatments Main/sub	*T. viride*	Carbendazim	Control	Mean
Rice Husk	0.95	2.23	5.11	2.76
Punna Cake	2.95	3.04	3.05	3.02
Glyricidia leaves	0.71	1.15	5.11	3.32
Lime	4.11	2.52	4.21	3.61
Gypsum	2.09	1.17	4.17	2.47
Control	2.36	1.41	5.87	3.38
Mean	2.28	1.92	4.59	

C.D. (P = 0.01) Main treatments N.S. Sub treatments 0.93 Interaction 2.29

leaves, lime and gypsum along with an untreated control) as main treatments and *T. viride* and carbendazim along with an untreated control as sub-treatments. The doses of amendments were fixed depending upon their nitrogen contents. Extra P and K required were supplied through mashoori phosphate and muriate of potash, respectively. In plots amended with lime and gypsum, the required quantities of NPK were supplied through urea, mashoori phosphate and muriate of potash, respectively. Thus, plots of different treatments (except untreated control) received NPK @ 90 : 45 : 45 kg/ha. Then *R. solani* was applied to each plot (3 x 2.5 m) uniformly. Two weeks after amending the plots, 21 day old Jyothi rice seedlings were transplanted with a spacing of 20 x 15 cm. *T. viride* and the fungicide were applied when the initial symptoms of the disease appeared and repeated after two weeks.

Intensity and incidence of the disease was assessed during panicle emergence and just before harvest. Disease intensity was scored on 25 randomly selected hills per plot according to the standard evaluation system. Disease incidence was recorded by observing 40 hills from four rows selected at random in each plot and counting the number of infected tillers.

Soil samples collected 14 weeks after the addition of amendments were dried in shade and *R. solani*, total fungi, bacteria and actinomycetes were assayed using Ko and Hora medium, Martin's rose bengal agar, Allen's soil extract agar and Ken-Knight's agar, respectively.

TABLE 2. Effect of amendments, biocontrol agent and fungicide on the intensity of sheath blight disease before harvest.

Treatments Main/Sub	*T. viride*	Carbendazim	Control	Mean
Rice Husk	1.31	2.85	6.03	3.40
Punna Cake	3.20	3.54	5.31	4.02
Glyricidia leaves	2.50	2.50	5.31	3.44
Lime	4.50	3.20	5.31	4.34
Gypsum	3.33	2.36	4.99	3.56
Control	3.44	3.19	7.31	4.65
Mean	3.05	2.94	5.71	

C.D. (P = 0.01) Main treatment N.S. Sub treatment 0.93 Interaction N.S.

TABLE 3. Effect of amendments, biocontrol agent and fungicide on the incidence of sheath blight disease at panicle emergence.

Treatments Main/Sub	*T. viride*	Carbendazim	Control	Mean
Rice Husk	21.75	15.64	20.62	19.34
Punna Cake	21.20	20.72	25.65	22.52
Glyricidia leaves	15.86	12.19	19.73	15.93
Lime	17.77	16.47	22.89	19.05
Gypsum	26.89	16.62	32.57	25.36
Control	39.16	21.05	47.36	35.86
Mean	23.77	17.12	28.14	

C.D. (P = 0.01) Main treatments 4.54 Sub treatments 3.21 Interaction 7.86

RESULTS AND DISCUSSION

At panicle initiation stage, the disease intensity in plots treated with different amendments did not vary significantly. However, carbendazim or *T. viride* treatments recorded significantly lesser disease intensity. Addition of amendments had a significant interaction with *T. viride*. The plots treated with *Glyricidia* leaves or rice husk with *T. viride* treatment recorded the least intensity of disease (Table 1). The disease intensity at preharvest stage due to main plot treatments and the interaction effect were found to be not significant. The effect of *T. viride* and carbendazim showed the same trend as that in the panicle initiation stage (Table 2).

Glyricidia leaves or lime-amended plots recorded significantly lesser disease incidence in both panicle emergence and pre harvest stages (Table 3 and 4). Carbendazim treatment recorded significantly a lesser disease incidence of 17.12 and 21.24 per cent followed by *T. viride* which recorded 23.77 and 26.90% at both stages of the crop respectively. *Glyricidia* leaves in combination with carbendazim or *T. viride* had recorded significantly the least incidence of sheath blight in all the stages followed by lime or rice husk with carbendazim or *T. viride*. In general, carbendazim treatment recorded lesser incidence in all the treatments when compared to *T. viride* but both the treatments with amendments were found to be on par (Table 3 and 4).

Least population of *R. solani* was noticed in plots applied with *Glyricidia* leaves. Amendments combined with *T. viride* were more

TABLE 4. Effect of amendments, biocontrol agent and fungicide on the incidence of sheath blight disease before harvest.

Treatments Main/Sub	*T. viride*	Carbendazim	Control	Mean
Rice husk	23.81	18.55	26.78	23.05
Punna cake	25.84	23.71	31.74	27.10
Glyricidia leaves	21.12	17.20	21.13	19.82
Lime	19.46	18.66	25.81	21.31
Gypsum	28.74	22.35	35.63	28.91
Control	42.41	26·94	48.32	39.22
Mean	26.90	21.24	31.57	

C.D. (P = 0.01) Main treatments 4.25 Sub treatments 3.01 Interaction 7.37

TABLE 5. Number of propagales of *Rhizoctonia solani*/10g soil collected from different amendments, biocontrol agent and fungicides after 14 weeks

Treatments Mean/sub	*T. viride*	Carbendazim	Control	Mean
Rice Husk	9.30	8.27	9.97	9.18
Punna cake	8.00	10.53	9.00	9.18
Glyricidia leaves	3.80	5.03	6.00	4.94
Lime	8.17	8.00	9.53	8.57
Gypsum	10.00	10.50	6.40	8.97
Control	15.73	18.33	16.80	17.56
Mean	9.17	10.11	9.62	

C.D. (P=0.01) Main treatments 2.86 Sub treatments N.S. Interaction 3.10

effective in reducing the number of propagules of *R. solani* than carbendazim (Table 5). Higher fungal populations were observed in plots amended with punna cake or lime. The interaction of amendments and carbendazim was found to be significant. Punna cake with carbendazim recorded the highest fungal population (Table 6). Least bacterial population was recorded in lime-amended plots whereas, *Glyricidia* leaves-amended plots recorded the highest bacterial population. Bacterial population was not influenced by either carbendazim or *T. viride* (Table 7). The plots amended with rice husk or punna cake had the highest actinomycetes population. Whereas, carbendazim or *T. viride* had no effect on the actinomycetes population. Rice husk applied with carbendazim had the highest actinomycete population (Table 8).

Rice husk contains momilactone A, B, C, P — coumaric acid and S (+) dehydrovomefolil which inhibits spore germination of the pathogen (Gangopadhyay, 1983). Rajan (1980) showed that non-edible cakes, saw dust and rice husk suppressed sheath blight disease. Dath (1979) suggested that survival period and viability of sclerotia were reduced by incorporation of green manures like *Sesbania aculata*. Kannaiyan and Prasad (1981) observed reduction in infection when rice chaff, neem cake, saw dust and manure were added. George *et al.* (1984) obtained excellent field control of sheath blight with amendments such as rice husk or neem cake.

Balasubramanian and Shanmugam (1986) established an inverse relationship between tissue calcium content of blackgram and leaf

TABLE 6. Population of total fungi/g soil ($x10^4$) collected from different amendments, biocontrol agent and fungicide after 14 weeks

Treatments Main/sub	*T. viride*	Carbendazim	Control	Mean
Rice Husk	5.22	5.31	5.27	5.30
Punna cake	5.45	5.50	5.37	5.44
Glyricidia leaves	5.27	5.30	5.26	5.28
Lime	5.45	5.30	5.30	5.35
Gypsum	5.21	5.26	5.33	5.27
Control	5.21	5.01	4.92	5.05
Mean	5.32	5.28	5.24	

C.D. (P=0.01) Main treatments 0.25 Sub treatments N.S. Interaction 0.25

TABLE 7. Population of bacteria (x10⁶)/g soil collected from different amendments, biocontrol agent and fungicide after 14 weeks

Treatments Main/sub	*T. viride*	Carbendazim	Control	Mean
Rice Husk	7.22	7.31	7.21	7.25
Punna Cake	7.25	7.30	7.31	7.29
Glyricidia leaves	7.38	7.26	7.46	7.36
Lime	7.19	7.01	6.99	7.06
Gypsum	7.22	7.23	7.31	7.25
Control	7.31	7.28	6.21	7.27
Mean	7.26	7.23	7.25	

C.D. (P=0.01) Main treatments 0.18 Sub treatments N.S. Interaction N.S.

blight intensity indicating the basis for reduced disease incidence following the application of lime and gypsum. The reduced sheath blight incidence following application of lime can be attributed to the formation of calcium pectate, which induces resistance to the invasion by the pathogen.

Least population of pathogen was noticed in plots amended with *Glyricidia* leaves. Plots treated with rice husk, lime, gypsum or punna cake also reduced the population of *R. solani*. Papavizas *et al.* (1962) noticed that saprophytic activity of *R. solani* was reduced by amendments like oat straw. Padmakumari and Balakrishnan (1987) observed reduced saprophytic activity of *R. solani* when punna cake, neem cake, rice husk, saw dust, fish waste and groundnut shell were applied to soil.

The interaction between amendment and fungicide/*T. viride* was significant for disease incidence during panicle emergence and pre-harvest stages. In the former, *Glyricidia* leaves had interacted with both carbendazim and *T. viride*, while rice husk, lime and gypsum interacted with carbendazim alone. In the latter, *Glyricidia* leaves, rice husk, lime and gypsum interacted with both carbendazim and *T. viride*, while punna cake interacted with carbendazim alone.

Populations of total fungi, bacteria and actinomycetes tremendously increased in various treatments. A critical analysis indicates that fluctuations of populations of fungi, bacteria and actinomycetes in relation to the pathogen have a major role in disease management. Rajan and Singh (1972) working on soft rot

TABLE 8. Population of actinomycetes (x10⁶)/g soil collected from different amendments, biocontrol agent and fungicides after 14 weeks

Treatments Main/Sub	*T. viride*	Carbendazim	Control	Mean
Rice Husk	7.45	7.48	7.45	7.46
Punna cake	7.42	7.41	7.48	7.44
Glyricidia leaves	7.48	7.31	7.43	7.41
Lime	7.30	7.22	7.26	7.26
Gypsum	7.22	7.39	7.23	7.28
Control	7.30	7.00	6.93	7.08
Mean	7.36	7.30	7.30	

C.D. (P=0.01) Main treatments 0.33 Sub treatments N.S. Interaction 0.41

disease of ginger caused by *Pythium aphanidermatum* found negative correlations between the pathogen and total fungi during early decomposition period and between the pathogen and bacterial population during later period. Several organic materials have been shown to reduce the severity of soil-borne diseases. The benefit gained may only be due to competition and 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 the capacity of the environment to produce the disease (capacity factor).

The present investigations revealed the efficacy of carbendazim in the management of the disease, confirming the finding of Bhaktavatsalam *et al.* (1977). *T. viride* has been found to be quite effective in the management of sheath blight disease. Padmakumari and Balakrishnan (1986) have reported *T. viride* to be antagonistic to *R. solani*. Alagarsamy *et al.* (1987) observed that pre and post emergent mortality of cotton seedlings were reduced by amending the soil with *T. viride*.

The results of the present investigations provide ample proof of satisfactory management of sheath blight disease by amending soil with *Glyricidia* leaves/rice husk and by application of bio-control agent *T. viride*. Application of lime has been effective only in reducing the disease incidence but not intensity. Normally the cost of fungicidal application is about Rs. 750/- per hectare per season. Hence, organic amendment followed by the application of *T. viride* reduces the cultivation cost substantially.

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