STUDIES ON THE EFFECT OF FUNGICIDES AND SILICA IN THE CONTROL OF SHEATH BLIGHT OF RICE CAUSED BY *Corticium Sasakii* (Shirai) Matsumoto

BY

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THESIS

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Certified that this thesis is a record of research work done independently by Shri. G. Mathai under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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C O N T E N T S

INTRODUCTION

INTRODUCTION

Several diseases, pathogenic and non-pathogenic have been found to occur on the rice crop causing extensive damage to the grain and straw yields. Among the pathogens, fungi alone account for nearly thirty diseases in the country. Of the fungal diseases blast and blight are considered to be the most important. Sheath blight of rice caused by *Corticium sasakii* (Shirai) Matsumoto, though considered to be a minor disease, has become one of the most common and destructive diseases next to rice blast in Kerala State.

Extensive studies on sheath blight control have been done in Japan, particularly in recent years, emphasis being mainly on chemical control. Eventhough some attempts have been made in India to study the sheath blight disease, not much work has been done on the control of this disease. From the earlier studies conducted in this laboratory it was gathered that reduced level of nitrogen and higher level of potash combined with fungicidal treatment can considerably minimise the severity of the disease. The perfect stage of the sheath blight fungus was rarely reported to occur on rice in the field. But the discovery of the basidial stage of the organism from India and I.R.R.I. Farm, Philippines suggested another possible means of dissemination of the disease besides sclerotial bodies. Keeping in view the importance of the disease to the rice growers, an attempt was made to formulate more effective and suitable control measures for this disease and to study the occurrence of perfect stage of the causal organism. The present study was aimed to determine the effect of fungicides under three levels of silica and to assess the role of silica in imparting resistance to infection and reducing the intensity of the sheath blight disease of rice. The results of the investigations, which will help to a large extent in the control of the disease, are presented in this thesis.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The first occurrence of sheath blight disease of rice was reported from Japan by Miyake (1910). Later the incidence of the disease was reported by Reinking (1918) and Palo (1926) from Philippines, Park and Bertus (1932) from Ceylon and Wei (1934) from China. In Japan, the spread of the disease turned to be severe and has become one of the most common diseases and destructive next to rice blast (Kozaka, 1970). The disease is widely distributed in the oriental countries, but few in the United States. For this reason the disease was also called by the name "Oriental sheath and leaf spot". Recently it has also been reported from Brazil, Surinam, Venezuela and Madagascar (Ou, 1972).

Eventhough Butler (1918) described the organism from India, the first report of the incidence of sheath blight was made by Paracer and Chahal (1963) from Gurdaspur, India. Subsequently, the disease was observed in other rice growing areas of the Punjab State (Kohli, 1967). The occurrence of the disease was noted in Kerala only in 1969 (Mahendra Prabhat, 1971). An exhaustive study of the symptoms of the disease, causal organism, reactions of different varieties of rice to infection, host range of the pathogen and the mode of spread and survival of the causative organism has been made by Mahendra Prabhat (1971). Muneera (1973) studied the effect of fungicides on the incidence and intensity of the disease at two levels of nitrogen. The effect of different levels of potash on the intensity of the disease was also studied by her.

The mode of infection and spread of the disease was investigated extensively by Kozaka et al. (1957 a), Kawai et al. (1958), Kitani et al. (1958) and Ikata and Hitomi (1930). According to them primary infection is caused by sclerotia produced on the diseased rice plants and on several wild grasses. The sclerotia over-winter in paddy fields and infect the succeeding crop. In the field the disease spreads within hills as well as among hills (Anon., 1973). Thus sclerotia has been conventionally considered to be the sole source of primary inoculum. Kozaka (1970) reported that secondary infection is mostly from mycelium and rarely from basidiospores. Ikata and Hitomi (1930), Singh and Pavgi (1969) and Anon. (1973) observed basidiospores on diseased plants in the field, suggesting another possible means of disease dissemination.

The causal organism

There is considerable confusion concerning the nomenclature of the sheath blight fungus. Miyake (1910) named the fungus as Sclerotium irregulare. Sawada (1912) and Butler (1918) described the fungus as Hypochnus sasakii Shirai. Palo (1926) grouped it under Rhizoctonia solani. Endo (1927, 1931) and Malaguti (1951) was of opinion that the fungus was Corticium sasakii. Gadd and Bertus (1928) suspected it to be Corticium vagum Berk. and Curt. According to Park and Bertus (1932), Corticium solani (Prill and Del) Bourd and Galz, was the perfect stage of Rhizoctonia solani Kuhn. which was pathogenic to rice. Matsumoto, Yamamoto and Hirane (1932, 1933) and Matsumoto (1934) made extensive studies of different strains of Hypochnus sasakii and Rhizoctonia solani and compared morphological differences in the perfect and imperfect stages. Matsumoto (1934) considered the name Corticium sasakii (Shirai) Matsumoto, as the most acceptable. Matsumoto's description of the perfect state of C. sasakii would permit its inclusion in Thanatephorus cucumeris (Frank) Donk. (Talbot, 1970). Exner (1953) came to the same conclusion and considered C. sasakii as a forma specialis of Thanatephorus cucumeris based on cultural and vegetative characters rather than on any differences in their perfect states. Studies conducted at I.R.R.I. Philippines on the perfect stage of C. sasakii also revealed its close resemblance to _T._ _cucumeris_ (Anon., 1973). Based on this the fungus should be called _Thanatephorus_ _cucumeris_ rather than _Corticium_ _sasakii_ in the present day nomenclature.

The perfect stage of _C.sasakii_ causing sheath blight disease on rice has been reported for the first time from India by Singh and Pavgi (1969). The basidial stage of _C.sasakii_ was discovered in the sheath blight nursery at I.R.R.I. Farm, Philippines (Anon., 1973).

Ikata and Hitomi (1930) described the morphology of the perfect state of the fungus. According to them the hymenia are formed only on the host plants at the booting stage. It appears as a white powdery or frosty layer on healthy leaf sheaths and occassionally on leaves near the infected tissues under extremely moist conditions. The perfect stage as described by Anon. (1973) has the measurements: basidia 11-15 /um; and spores 9-12 x 5-7 /um. According to Matsumoto _et_ _al_. (1932) the measurements are: basidia 10-6 x 8-9 /um; sterigmata 5-8 x 2.2 - 2.7 /um; basidiospores 6-10 x 4.7 /um.

Variability in _Corticium_ _sasakii_ has been studied by different workers. Chien and Chung (1963) studied 300 isolates from Taiwan. They classified the 300 isolates into 7 cultural types and 6 physiologic races based on the degree of pathogenicity. About 40 isolates from rice collected in Philippines were found to vary in size and number of sclerotia, colour of mycelium and in other characters when grown in culture (Ou, 1972). Variation in cultural characters has been observed in about 180 single-basidiospore cultures of T. cucumeris tested at I.R.R.I. (Anon., 1973).

Sherwood (1970) reported that many pathogenic isolates of T. cucumeris fruit on soil but not on agar. But some non-pathogenic isolates fruit on both soil and agar. Kotila (1947) reported that T. cucumeris fruited on 2 per cent distilled water agar. Garza-chapa and Anderson (1966) cultured T. cucumeris on marmite-PDA for 72 hours at 25°C. Mycelial discs, 3 mm diameter, were transferred from the colony edge to dishes of 2 per cent water agar. The cultures were incubated in dark at 25°C for 8 days and then transferred to laboratory where they received diffuse light at 21 - 25°C. Basidia were formed 6 - 9 days later. Stretton et al. (1964) obtained fruiting of T. cucumeris on soil surface by two methods (1) Isolates were grown on marmite-PDA in 9 cm petri dishes for 7 - 10 days. Tops were removed and cultures were covered 1 cm depth with steamed soil. The soil was watered 1 - 3 times daily.

The soil was previously treated with aerated steam at 71°C for 30 minutes. Fructifications formed under light periods varying from 8 - 24 hours, but formed most profusely at 12 - 16 hours. Garza-chapa and Anderson (1966) reported formation of basidiospores in many isolates on soil by this method. Pitt (1964), Valdez (1955) and Papavizas (1965) reported negative results.

CONTROL OF THE DISEASE

Effect of silica on the incidence of the disease

Silica has been implicated repeatedly as a factor influencing the degree of susceptibility of rice to the blast disease caused by *Piricularia oryzae* Cav. Miyake and Adachi (1922) first reported that the variety bozu, resistant to blast, contains a larger amount of silicon than a susceptible variety. The degree of resistance was found by Miake and Ikeda (1932) to increase in proportion to the amount of silicates applied and also to the amount of silicon accumulated in the plants. Many investigators confirmed this and further found that heavy nitrogen applications induced more blast and decreased silicon accumulation. Also the number of silicified cells was larger in older leaves which were also more resistant to blast than younger leaves with less silicified cells (Ou, 1972). Onodera (1917), Hemmi (1933) and Suzuki (1934) observed that rice plants with a high silica content showed slight damage from blast disease. Kawashima (1927), Akai (1939), Ishizuka and Hayakawa (1951) and Tasugi and Yoshida (1958) reported that the application of silica increased the resistance of rice plants to blast disease. Adayanthaya and Rangaswami (1952) reported greater number of silicated epidermal cells in blast resistant rice varieties than in susceptible varieties. The same observation was recorded by Venkatachalam (1954) in the case of blast disease of rice. Several other workers (Akai, 1953; Akimoto, 1939 b; Sawada, 1935; and Yoshi, 1941) have claimed that susceptibility to blast fungus was diminished by increasing the supply of absorbable silicon. Studies conducted by Volk *et al*. (1958) revealed that silicon content of rice plant and its susceptibility to blast were inversely related.

Numerous investigations have been made on the physiological function of silica for disease resistance. Hemmi (1933), Suzuki (1934) and Ito and Sakamoto (1939-'43) believed that the silicated epidermal layer acted as a physical barrier and prevented penetration of the fungus. Yoshida *et al*. (1962) found that 90 per cent or more of the silicon was in the form of silica gel, accumulating in layers in the epidermis, vascular bundles and sclerenchyma. The function of silica gel in the epidermis may be to control transpiration and to protect the plant from fungus and insect invasion. Ishibashi and Akijima (1960) reported that the most important function of silica seemed to be to protect the plant against disease organisms. Lanning et al. (1958) and Yoshida et al. (1962) considered that the silicon was absorbed and accumulated in epidermal cells and silicified the cell wall and thus protected the plant against fungus invasion. However, Ishibashi (1936), Akimoto (1939 a), Yoshii (1941) and Ishizuka and Hayakawa (1951) pointed out that the resistance induced by silica may be ascribed only in part to the physical barrier and more significantly to the lower absorption of nitrogen. In the case of blast disease, Tasugi and Yoshida (1958) demonstrated the accumulation and deposition of silica around cells, injured by fungus penetration at a very early stage of invasion. They assumed that this accumulation served as a barrier against further mycelial growth.

Not much wrk has been done on the effect of silica in the incidence of sheath blight caused by *Corticium sasakii*. In the review made by Kozaka (1970) it was stated that application of phosphorus or silica fertilizer does not affect susceptibility of the disease caused by C. sasakii.

Effect of fungicides on the incidence of the disease

Control of sheath blight with chemical fungicides has been attempted for many years by different workers. In the past copper and mercury compounds were recommended (Hashioka and Saito, 1953; Yoshimura, 1954). Later organic arsine compounds were found to be more effective (Hashioka, 1956). Kozaka et al. (1957 b) reported that an organo arsenic compound "urbazid" (Methyl arsine bis-dimethyl dithiocarbamate) was found to be highly effective in controlling Corticium sasakii. Hashioka and Makino (1961) reported that 10 ppm methyl arsine sulphide when applied in irrigation water, killed the sclerotia of C. sasakii and reduced primary infection when a non-toxic concentration of 3 ppm was sprayed. Kozaka (1961) and co-workers made extensive and comprehensive studies on the chemical control of sheath blight disease of rice. They tested 3 commercial inorganic copper fungicides, 13 organic mercury compounds and several organic sulphur compounds. Of these fungicides tested, the organic arsine compounds were found to be the most effective in inhibiting mycelial growth, infection and enlargement of lesions. Among the organic arsine compounds, methyl arsine sulphide and urbacid were particularly more effective in concentrations of about 50 ppm. The phytotoxicity of organic arsine compounds was reported to be reduced by adding a small amount of iron as ferric chloride or ferric sulphate (Takita et al. 1965). Chu and Chen (1964) also reported that methyl arsine sulphide was tried successfully at the end of tillering phase either as a spray at 100 - 200 ppm or as a dust 1 in 300 of the active ingredient. Abeygunawardena and DeSilva (1964) reported that natural infection of C.sasakii was reduced by organo arsenic sprays (Ziram + methyl arsine-bis-dimethyl dithio-carbamate) at 0.1 - 0.2 per cent and to a lesser extent by dodine or Triphenyltin hydroxide at the same concentration. Of the dithio-carbamates tested by them ferbam was found to be better than maneb while copper oxide and oxychloride were inferior to the organic compounds. At least two sprays were recommended, one applied at maximum and again at the end of tillering. Ishikura (1967) stated that the organo-arsenicals such as ferric and calcium methane arsenates, methyl arsine bis-lauryl sulphide were effective against sheath blight. Tamura (1965) tested many organic tin fungicides and found that 1:500 - 1:1000 'BP' controlled the fungus in pot and field tests and 10 ppm 'BP' in agar inhibited the growth of the fungus.

The use of antibiotics has also been investigated by many workers (Yamamoto et al.,1965). Fukunaga (1966) reported that an antibiotic "Polyoxin" is almost as effective as the organic arsenicals and is not phytotoxic. Thirumalachar et al.(1969) reported the use of aureofungin in the control of C.sasakii in the field.

Systemic fungicides like benlate were also tried. Chien and Hung (1971) found that lesion development was inhibited by the treatment of 400 dilute benlate @ 13.6 kg/ha. Chien et al. (1972), based on green house study and field experimentation, concluded that benlate was most effective. A new systemic fungicide BAS 3050 F (2-methyl benzoic acid anilide) was tried in Japan against sheath blight of rice and found to be effective in controlling the disease (Pomer and Zwick, 1973). Trials conducted at I.R.R.I. Philippines (Anon., 1973) showed that benlate, BAS 3050 F, and hinosan were effective in the order of preference against the incidence of sheath blight. Muneera (1973) observed that benlate was effective in reducing the intensity of the disease.

Penta chlorophenol (PCP) used for weed control in rice fields has also been found useful in controlling sheath blight as a side effect (Endo, Shinohara and Hara, 1965; Inoue and Uchino, 1963; Takatsu and Nishimura, 1962; and Ono and Iwata, 1961).

MATERIALS AND METHODS

MATERIALS AND METHODS

Effect of fungicides on the incidence and intensity of sheath blight at three levels of silica

A field experiment was laid out in the wet lands of Agricultural College Farm, Vellayani in the crop season February to May 1974 to study the effect of fungicides on the incidence and intensity of sheath blight of rice at three levels of silica. The details are as follows:

Lay out	: Randomised Block Design (Fig.1)			
Treatments	: 9 combinations of 3 levels of silica and 3 fungicides			
Levels of silica	: (i)	S_0	:	No silica
	(ii)	S_1	:	250 kg/ha
	(iii)	S_2	:	500 kg/ha
Fungicides	: (i)	F_0	:	No fungicide
	(ii)	F_H	:	Hinosan 0.04 per cent (active ingredient) (O-ethyl-S-S-diphenyl-dithio phosphate 50 per cent E.C.)
	(iii)	F_D	:	Dithane M-45 0.3 per cent (active ingredient) Zinc-Manganese ethylene bis-dithiocarbamate 80 per cent W.P.)

LAY OUT – EFFECT OF FUNGICIDES ON THE INCIDENCE OF SHEATH BLIGHT AT 3 LEVELS OF SILICA

R. I.

S_0F_0	S_1F_0	S_1F_H
S_2F_H	S_0F_D	S_0F_H
S_1F_D	S_2F_D	S_2F_0

R. II

S_0F_D	S_1F_H	S_0F_0
S_1F_0	S_2F_0	S_0F_H
S_2F_D	S_1F_D	S_2F_H

R. III

S_1F_H	S_1F_0	S_2F_0
S_0F_D	S_1F_D	S_0F_0
S_2F_H	S_2F_D	S_0F_H

S_0 – NO SILICA
S_1 – SILICA @ 250 Kg./ha.
S_2 – SILICA @ 500 Kg./ha.

F_0 – NO FUNGICIDE
F_H – HINOSAN
F_D – DITHANE M-45

GROSS PLOT SIZE 5.4×4.4 Sqm
NET PLOT SIZE 5×4 Sqm.
SPACING 10×10 Cm.
VARIETY: ANNAPURNA.

FIG: 1

Combinations	:	$S_0\ F_0$	$S_1\ F_0$	$S_2\ F_0$
		$S_0\ F_H$	$S_1\ F_H$	$S_2\ F_H$
		$S_0\ F_D$	$S_1\ F_D$	$S_2\ F_D$
Replications	:	3		
Variety	:	Annapurna		
Spacing	:	10 x 10 cm		
Gross plot size	:	5.4 x 4.4 m		
Net plot size	:	5 x 4 m		

Rice seeds of the variety Annapurna were obtained from the College Farm. Annapurna is high yielding, photo-insensitive, moderately susceptible to sheath blight, having a duration of 90 days.

Nursery

Ten kg of seeds were sown on 9-2-1974 in a wet nursery of 150 sq.m. The nursery was given a top dressing with ammonium sulphate @ 15 kg N/hectare on 19-2-1974. Two prophylatic sprayings were given with folidol at 0.05 per cent concentration. The first spraying was given 10 days after sowing and the second two days before transplanting.

Schedule of operations in the main field

The main field was prepared well and laid out into different plots as per the lay out (Fig.1). Dolomite

@ 1000 kg/ha was applied in all the plots, five days before transplanting. Each plot was given a basal dressing of ammonium sulphate 0.534 kg (@ 45 kg N/ha), superphosphate 0.668 kg (@ 45 kg P_2O_5/ha) and muriate of potash 0.180 kg (@ 45 kg K_2O/ha). Silica was applied in the form of sodium silicate as basal dressing according to the levels fixed for each treatment.

The seedlings were transplanted on the 18th day of sowing. Controlled irrigation was given uniformly and excess water drained off whenever found necessary. All the plots were uniformly top dressed with ammonium sulphate @ 45 kg N/ha, 20 days after transplanting. Weeding was also done on the same day.

The crop was sprayed with hexavin 50 per cent W.P. on the 20th and 30th day of planting against pest attack. To ward off the attack of brown plant hopper furadan granules were applied on the 35th day of planting. All the plots were dusted with hexavin 5 per cent at the dough stage to protect the crop from the attack of rice bug.

Fungicidal application

The plants were given three sprayings with fungicides as per the treatments fixed. The first spraying was given on the 40th day of sowing. The second and third sprayings were given on the 55th and 70th day respectively. Spraying of fungicides were done after observing necessary precautions against falling the spray fluid in adjacent plots.

Harvest

The crop was ready for harvest on the 90th day of sowing and harvest was made on 9-5-1974. Produce from each plot was threshed separately and plot-wise wet and dry weight of grain and straw were recorded.

Observations on disease intensity

Ten hills were selected from each plot at random and the total number of tillers were noted. The intensity of disease development (Fig.2) were graded as follows:

Grade	Infection intensity (per cent)	Details of symptoms
1	1 - 15	Small greenish grey spots 0.5 cm diameter but no necrotic lesions. One or two spots/sheath.
2	16 - 40	Small ellipsoidal, necrotic greenish spots about 0.5 - 1 cm diameter surrounded by greenish brown margins. Less than 10 per cent of sheath area affected.


SHEATH BLIGHT INFECTION GRADES
FIG. 2
1
2
3
4
5

3	41 - 60	Typical sheath blight lesions ellipsoidal 1 - 2 cm long with large necrotic greyish white centre with a purplish brown margin. Less than 25 per cent of sheath area affected.
4	61- 80	The number of lesions increased which are often larger and broader with irregular margins. Total area affected not more than 50 per cent.
5	Above 80	Lesions get coalesced and spread to the culms, leaves and side tillers. Lesions on leaves, watery greenish grey. The infected parts break off and succumb to the disease. The affected area vary from 50 per cent and above.

Observations on disease intensity were taken on the 40th, 60th, 75th and 85th day of sowing.

Observations on per cent incidence of the disease

Observations on the per cent incidence of the disease was taken on the 40th, 60th, 75th and 85th day of sowing of the crop. Ten hills were selected at random from each plot and the number of healthy and diseased tillers were counted and per cent calculated.

Observation on the rate of spread of infection in the hill

The rate of spread of infection was arrived at from the data on intensity of the disease recorded on the 75th and 85th day and by taking the difference in intensity between these days.

Determination of loss in yield due to the disease incidence

Random samples of 100 healthy and 100 diseased tillers, in lots of 25 tillers each from the control plots were collected and the per cent loss in grain and straw yield was determined.

Analysis of silica content

Samples of plant materials were collected from each plot on the 40th, 60th and 80th day of sowing. The samples were washed, blotted and dried in an incubator at 60°C. The dried samples were powdered and the crude silica content was determined by the method described by Yoshida et al. (1972).

An acid mixture containing 750 ml concentrated nitric acid, 150 ml concentrated sulphuric acid and 300 ml perchloric acid (60 - 62 per cent) was prepared. Ten ml of the acid mixture was added to 1 gm of dried, ground plant

plant material in a 75 ml pyrex test tube. This was allowed to pre-digest under a fume hood for 2 hours and then heated over a low gas flame until the mixture turned clear. The content of the test tube was then made up to 50 ml mark with distilled water and filtered through Whatman No.44 ashless filter paper. The filter paper with the residue of the sample extract was first dried in an oven at 80°C and then charred with a naked flame under a fume hood. The charred material was then placed in a muffle furnace for 2 hours at 550°C and allowed it to become ash. Weighed the ash after cooling it in a desiccator for 2 hours and recorded the value which was equivalent to the amount of crude silica contained in one gm of the dried plant sample.

Laboratory assay of fungicides against *Corticium sasakii*

The poisoned food technique described by Lilly and Barnett (1951) was used with slight modification for the laboratory assay of hinosan and dithane M-45 at 100, 200, 500, 1000, 2000, 3000 and 4000 ppm concentrations. The fungicide solutions were added separately to the potato-dextrose agar (PDA) medium so as to make the volume 50 ml and to get the desired concentrations of the fungicide. The poisoned medium, after mixing thoroughly was poured aseptically into sterile petri-dishes and a sclerotium of C. sasakii from a 15 day old culture was inoculated in the centre of each dish. A non-poisoned medium was used as control. The same experiment was repeated using host extract agar medium (HEM) also. The growth of the colony was measured after three days and the per cent inhibition was calculated.

Studies on the perfect stage of Corticium sasakii (Thanatephorus cucumeris)

In order to discover the perfect stage of the organism in the field and under laboratory conditions the following methods were tried.

In the field

A thorough search was made in the naturally infected rice fields of the Agricultural College Farm, Vellayani during the period from February to May 1974. The infected material collected during day time and night was brought into the laboratory and examined for the presence of basidiospores.

In the laboratory

Isolate of Corticium sasakii (Shirai) Matsumoto used for the study was obtained from naturally infected rice plants, collected from the rice fields of the Agricultural College Farm, Vellayani, Kerala.

1. Forty five day old rice plants of the variety Annapurna were inoculated with sclerotia obtained from a 15 day old culture. The plants were then placed inside a humid chamber in which 90 - 95 per cent relative humidity was maintained. The plants were examined from the third day onwards and continued upto 45 days for the formation of the perfect stage of the organism.

2. The above experiment was repeated by covering the plants with polythene bags and allowing a thin stream of ice cold water to flow over through the polythene bags, thrice during day time for 15 days.

3. Fifteen day old cultures of C.sasakii was grown on marmite (yeast-vegetable extract) PDA for 72 hours at 25°C. Mycelial discs, 3 mm in diameter, were transferred from the colony edge to dishes containing 2 per cent water agar. The cultures were then incubated in dark at 25°C for 8 days and then transferred to the laboratory where they received diffuse light at 21 - 25°C. Microscopic examination of the cultures were made after the 6th day and continued upto the 14th day (method followed by Garza-chapa and Anderson, 1966).

4. Isolates were grown on marmite-PDA in 9 cm petri-dishes for 7 days. The petri dish tops were removed and cultures were covered 1 cm depth with soil previously treated with aerated steam at 71^{o}C for 30 minutes. The soil was moistened 3 times daily. Microscopic examination of the cultures were made after 3 days upto 14 days.

5. Seven day old marmite-PDA cultures were mixed with 300 gm soil previously treated with aerated steam placed in a drinking cup and watered 3 times daily. Microscopic examination of the cultures were made after 3 days upto 14 days (Methods 4 and 5 were described by Stretton et al. (1964).

Statistical analysis

The analysis of variance technique evolved by Fisher (1924) and described in Snedecor (1961) was adopted in analysing the data. The arc sin transformation (Snedecor, 1961) was used in the analysis of data relating to the proportion of plant infected.

RESULTS

RESULTS

Effect of fungicides on the incidence and intensity of sheath blight of rice at three levels of silica

The experiment was laid out in a randomised block design with two fungicides, three levels of silica and control. Rice variety Annapurna was used for the experiment. The plants were sprayed with fungicides on the 40th, 55th and 70th day of sowing. Observations on the intensity and per cent infection of the disease were recorded on the 40th, 60th, 75th and 85th day of sowing the crop.

The results of the observation on the intensity of disease are presented in Table 1 and Table 2 and the per cent infection in Table 3 and Table 4. The effect of fungicides on the intensity of infection were graphically represented in Fig.3. Data on the rate of spread of the disease in the hill are presented in Table 5. Results relating to the yield of grain and straw are given in Table 6 and Table 7 and illustrated in Fig.4 and Fig.5.

The experimental plots were left for natural infection of the fungus. There was no incidence of the

Table 1

Effect of fungicides on the intensity of infection at 3 levels of silica (75th day)

Fungicides	Levels of silica			
	No silica S_0	250 kg/ha S_1	500 kg/ha S_2	Mean
Hinosan	0.248	0.199	0.198	0.215
Dithane M.45	0.615	0.555	0.571	0.580
No fungicide (Control)	1.110	0.565	0.680	0.785
Mean	0.658	0.440	0.483	

C.D. for comparison between marginal means - 0.139

C.D. for comparison between combinations of silica and fungicide - 0.242

F_H F_D F_O

$\overline{S_1 \quad S_2}$ S_0

Table 2

Effect of fungicides on the intensity of infection at three levels of silica

(85th day)

Fungicides	Levels of silica			
	No silica S_0	250 kg/ha S_1	500 kg/ha S_2	Mean
Hinosan	0.633	0.347	0.436	0.472
Dithane M.45	0.942	1.001	0.775	0.906
No fungicide (Control)	1.620	1.684	1.149	1.484
Mean	1.065	1.011	0.786	

C.D. for comparison between marginal means - 0.353

C.D. for comparison between combinations of silica and fungicide - 0.611

$F_H \quad F_D \quad F_0$

$\overline{S_2 \quad S_1 \quad S_0}$

EFFECT OF FUNGICIDES ON THE INTENSITY OF INFECTION

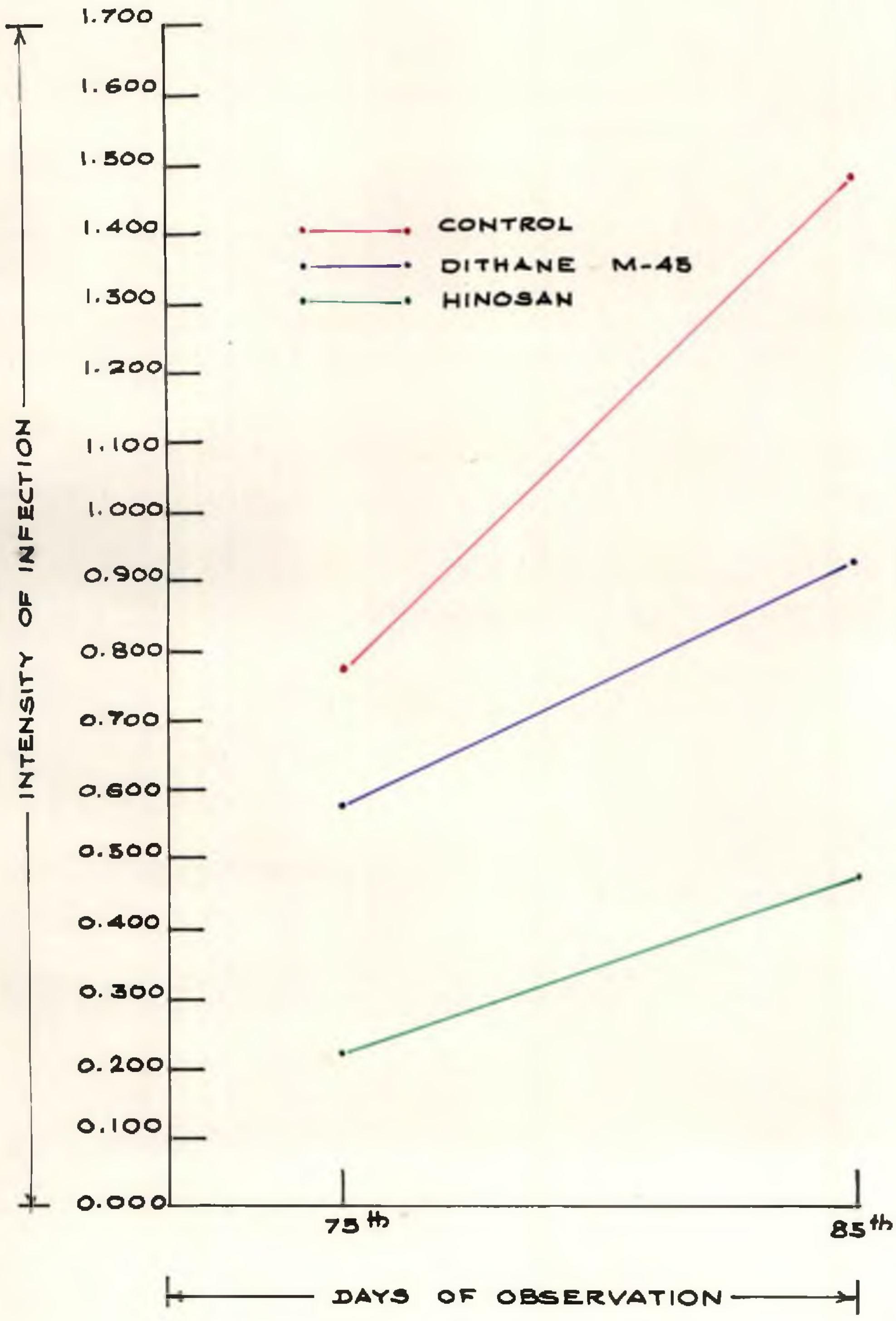

FIG: 3

disease on the 40th and 60th day in any of the plots at the time of observation.

S_0 level of silica

The data recorded on the 75th day (Table 1) showed that hinosan was superior over dithane M-45. The intensity and per cent infection was the minimum in the plots treated with hinosan. There was significant difference among the fungicides with regard to the intensity of infection and both the fungicides were effective in reducing intensity of the disease. The effect of hinosan and dithane M-45 on the per cent incidence of the disease was observed to be not significant on the 75th day (Table 3).

The same trend was noted in the intensity and per cent infection on the 85th day (Table 2). Among the fungicides hinosan was again superior in reducing the intensity. With regard to the per cent infection it was observed that the difference between the fungicides was not significant.

The data (Table 5) on the rate of spread of the disease in the hill showed that the effect of fungicides was significant under the S_0 level of silica.

Table 3

Effect of fungicides on the per cent infection at 3 levels of silica

(75th day)

(Means in angles)

Fungicide	Levels of silica			
	No silica S_0	250 kg/ha S_1	500 kg/ha S_2	Mean
Hinosan	16.03	9.90	9.39	11.83
Dithane M.45	18.62	20.33	16.01	18.32
No fungicide (Control)	26.89	23.70	29.39	26.66
Mean	20.51	17.98	18.32	

C.D. for comparison between marginal means - 8.160

C.D. for comparison between combinations of silica and fungicide - 14.130

$F_H \quad F_D \quad F_O$

$\overline{S_1 \quad S_2 \quad S_0}$

Table 4

Effect of fungicides on the per cent infection at 3 levels of silica

(85th day)

(Means in angles)

Fungicides	Levels of silica			
	No silica S_0	250 kg/ha S_1	500 kg/ha S_2	Mean
Hinosan	31.62	19.43	27.36	26.14
Dithane M.45	28.09	30.60	25.56	28.08
No fungicide (Control)	43.10	39.14	36.91	39.72
Mean	34.27	29.73	29.95	

C.D. for comparison between marginal means - 6.631

C.D. for comparison between combinations of silica and fungicide - 11.485

$\overline{F_H \quad F_D} \quad F_0$

$\overline{S_1 \quad S_2 \quad S_0}$

The effect of fungicides on the yield of grain (Table 6) was found to be significant under the S_0 level of silica. Plots treated with hinosan recorded a mean grain yield of 3306.7 kg/ha while those for dithane M-45 and control plots were 3101.7 and 2830.8 kg/ha respectively. The difference in yield between hinosan and dithane M-45 was not statistically significant.

With regard to the yield of straw (Table 7) significant increase was noted in the plots treated with hinosan followed by dithane M-45. The difference in effect between the fungicides was also significant under the S_0 level.

<u>S_1 level of silica</u>

Among the fungicides tested under the S_1 level of silica, hinosan recorded a significantly lower intensity of infection on the 75th day (Table 1). The difference in intensity between hinosan and dithane M-45 was significant, but the effect of dithane M-45 was on a par with control. The trend in the per cent infection recorded on the 75th day was the same as in the case of the intensity of infection (Table 3).

From the data of observation recorded on the 85th day it was found that hinosan was very effective in reducing the intensity (Table 2) as well as the per cent infection (Table 4). The effect of dithane M-45 was on par with control. Hinosan recorded a lower grade of intensity and infection per cent followed by dithane M-45.

The rate of spread of the disease in the hills treated with fungicides was less when compared to the control. The effect of hinosan on the rate of spread of the disease was on a par with dithane M-45 (Table 5).

Under the S_1 level of silica there was significant difference among the fungicides with regard to the yield of grain (Table 6). Plots treated with hinosan gave the highest yield of 3391.7 kg/ha while that of dithane M-45 and control were 3130.0 and 2824.2 kg/ha respectively. The increase in grain yield between the treatments was also significant.

There was no significant increase in the yield of straw in the fungicide treated plots over the control (Table 7). The difference in straw yield between hinosan and dithane M-45 was also not significant.

Table 5

Effect of fungicides on the rate of spread, in terms of intensity in the hills, at 3 levels of silica

Fungicides	Levels of silica			
	No silica S_0	250 kg/ha S_1	500 kg/ha S_2	Mean
Hinosan	0.384	0.148	0.237	0.257
Dithane M.45	0.326	0.446	0.204	0.326
No fungicide (Control)	0.510	1.118	0.468	0.699
Mean	0.407	0.571	0.303	

C.D. for comparison between marginal means - 0.349

C.D. for comparison between combinations of silica and fungicide - 0.604

$\overline{F_H \quad F_D} \quad F_O$

$\overline{S_2 \quad S_0 \quad S_1}$

Table 6

Effect of fungicides at 3 levels of silica on the yield of grain

(kg/hactare)

Fungicides	Levels of silica			
	No silica S_0	250 kg/ha S_1	500 kg/ha S_2	Mean
Hinosan	3306.7	3391.7	3882.5	3526.9
Dithane M.45	3101.7	3130.0	3200.0	3143.9
No fungicide (Control)	2830.8	2824.2	2959.2	2871.4
Mean	3079.7	3115.3	3347.2	

C.D. for comparison between marginal means - 143.950

C.D. for comparison between combinations of silica and fungicide - 249.550

$F_H \quad F_D \quad F_O$

$S_2 \quad \overline{S_1 \quad S_O}$

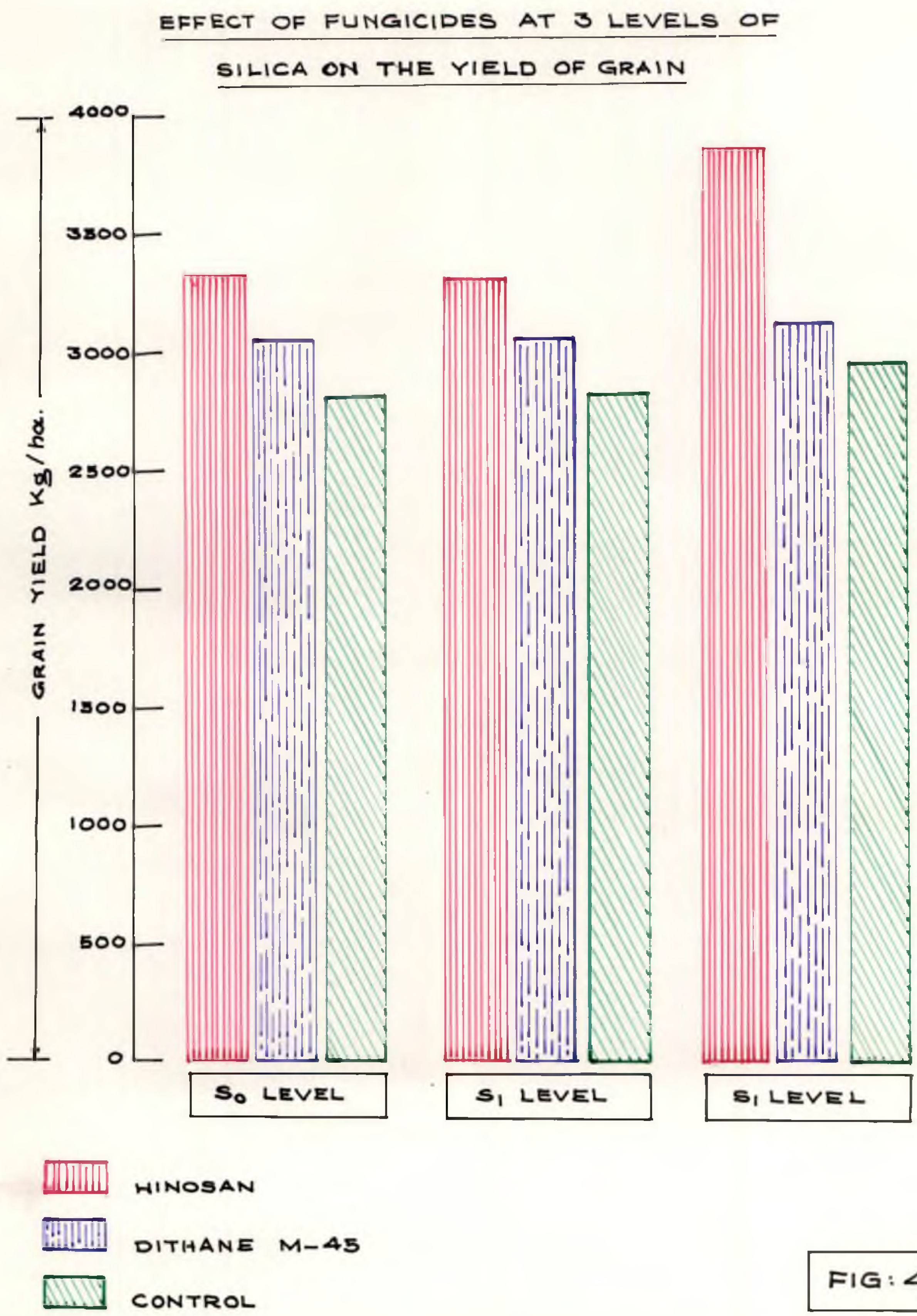
EFFECT OF FUNGICIDES AT 3 LEVELS OF
SILICA ON THE YIELD OF GRAIN
GRAIN YIELD Kg/ha.
4000
3500
3000
2500
2000
1500
1000
500
0
S_0 LEVEL
S_1 LEVEL
S_1 LEVEL
HINOSAN
DITHANE M-45
CONTROL

FIG: 4

Table 7

Effect of fungicides at 3 levels of silica on the yield of straw

(kg/hectare)

Fungicides	Levels of silica			
	No silica S_0	250 kg/ha S_1	500 kg/ha S_2	Mean
Hinosan	3500.0	3416.7	4333.3	3750.0
Dithane M.45	3166.7	3333.3	4083.3	3527.8
No fungicide (Control)	2833.3	3166.7	3833.3	3277.8
Mean	3166.7	3305.5	4083.3	

C.D. for comparison between marginal means - 184.440

C.D. for comparison between combinations of silica and fungicide - 319.450

F_H F_D F_O

S_2 $\overline{S_1 \quad S_0}$

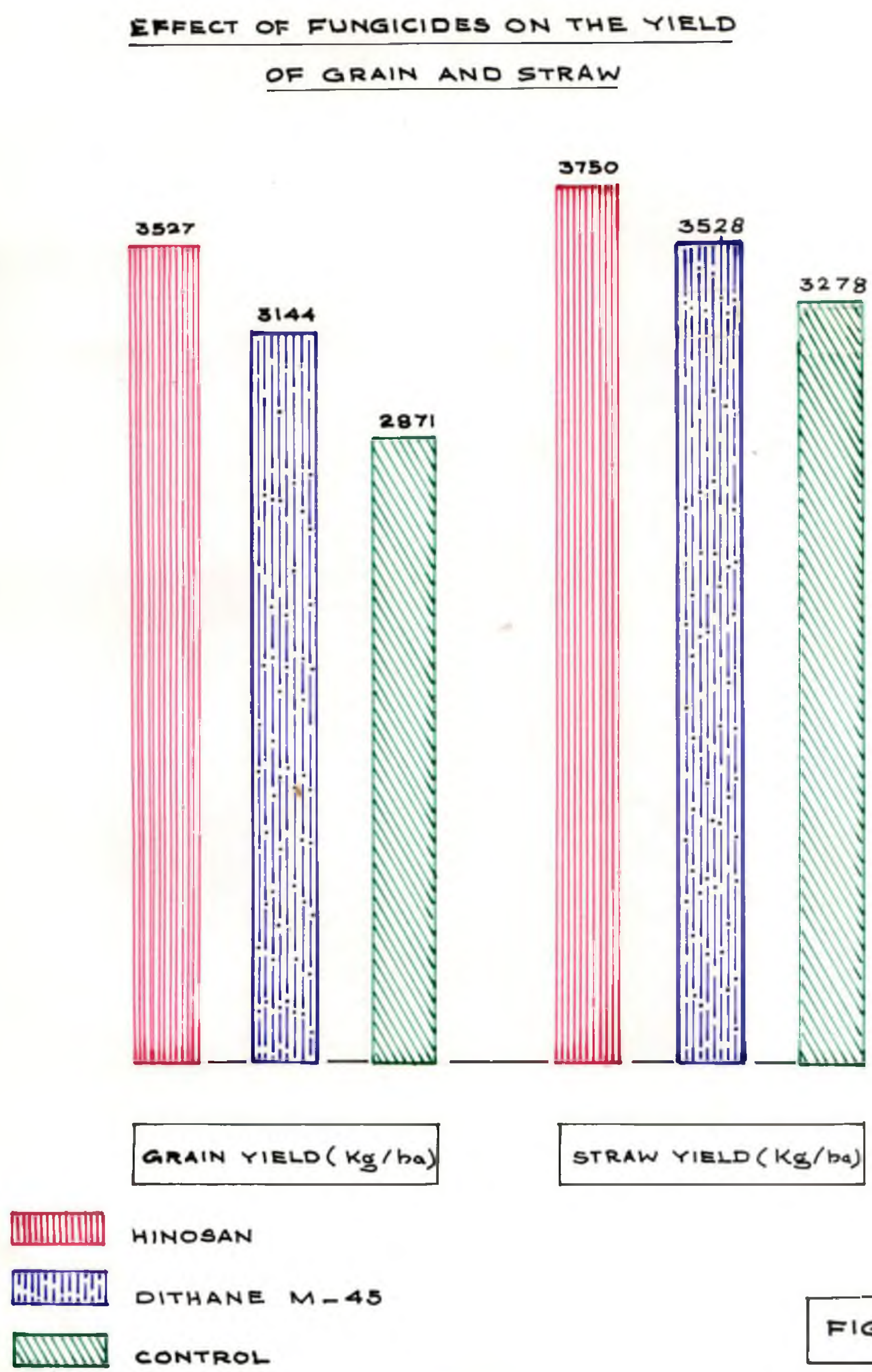
EFFECT OF FUNGICIDES ON THE YIELD
OF GRAIN AND STRAW
3527
3144
2871
3750
3528
3278
GRAIN YIELD (Kg/ha)
STRAW YIELD (Kg/ha)
HINOSAN
DITHANE M-45
CONTROL

FIG: 5

S_2 level of silica

As in the S_1 level of silica, the data recorded on the 75th day showed that the intensity of the disease was the least in the plots treated with hinosan (Table 1). The effect of hinosan was significant over dithane M-45 and control. No significant difference was observed between dithane M-45 and control in respect of the intensity of the disease. The effect of hinosan on the per cent infection was significant over control and that of dithane M-45 was not significant (Table 3).

Under S_2 level of silica on the 85th day, there was significant difference in intensity of disease between the plots treated with hinosan and the control. Hinosan treated plots recorded lowest intensity of infection. The intensity was calculated to be 62.1 per cent less in the plots treated with hinosan and 32.5 per cent less in the dithane M-45 treated plots than that of control (Table 2). The hinosan treated plots showed significant reduction in the per cent infection on the 85th day (Table 4). However the difference in effect between dithane M-45 and control was not statistically significant.

The effect of fungicides on the rate of spread of the disease in the hills was not found significant at the higher level of silica (Table 5).

Significant increase in grain yield was noted in the plots treated with hinosan under the higher level of silica (Table 6). In grain yield, plots treated with hinosan ranked first, with an increase of 31.2 per cent over control. Difference in grain yield between hinosan and dithane M-45 was also significant. The yield of plots treated with dithane M-45 was only on par with control.

With regard to the yield of straw, treatment with hinosan gave a significantly higher yield over control, and there was no significant difference between dithane M-45 and control (Table 7).

Effect of different levels of silica on the incidence of sheath blight and yield of rice

The effects of different levels of silica on the incidence of sheath blight and yield of rice was assessed using Annapurna as the test variety and the results are presented in Table 8 and Table 9. A graphical representation on the yield of grain and straw under different levels of silica were given in Fig. 7.

There was no incidence of the disease in any of the plots on the 40th and 60th day of sowing of the crop. The incidence was noted on the 75th day and gradually increased as the plants matured.

Table 8

Effect of different levels of silica on the yield of grain and straw

(kg/hectare)

Amount of silica applied as sodium silicate kg/ha	Mean grain yield kg/ha	Mean straw yield kg/ha
0	3079.7	3166.7
250	3119.3	3305.5
500	3347.2	4083.3

C.D. for comparison between levels of silica:

1. Grain yield - 143.950
2. Straw yield - 184.440

EFFECT OF DIFFERENT LEVELS OF SILICA ON THE YIELD OF GRAIN AND STRAW

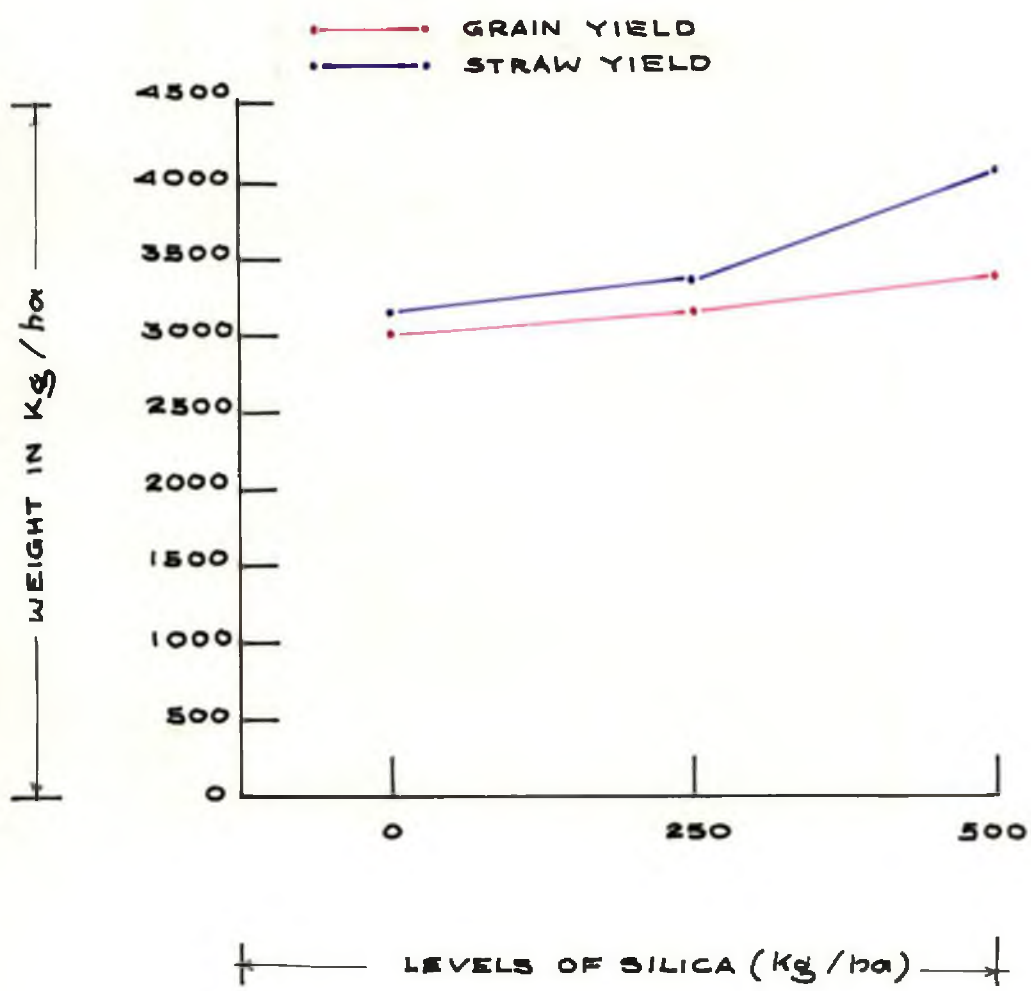

FIG: 7

Table 9

Effect of different levels of silica on the intensity of infection

Levels of silica kg/ha	Mean intensity				
	40th day	60th day	75th day	85th day	Mean
0	0.0	0.0	0.658	1.065	0.862
250	0.0	0.0	0.440	1.011	0.725
500	0.0	0.0	0.483	0.786	0.635

C.D. for comparison between levels of silica:

1- 75th day - 0.139

2- 85th day - 0.353

From the observation recorded on the 75th day (Table 2) it was found that there was significant reduction in intensity in the plots where silica was applied as compared to control. It was observed that the intensity of infection was lower in the S_1 level of silica. However the difference in intensity between the lower and higher level of silica was not statistically significant. Application of silica was found to have no effect on the per cent infection on the 75th day (Table 3).

The observation taken on the 85th day, on the disease intensity (Table 2) as well as the per cent infection (Table 4) under different levels of silica, were not statistically significant. Application of silica fertilizer was observed to have no effect in reducing the intensity as well as the per cent infection on the 85th day.

Treatment with silica was also found to have no significant effect on the rate of spread of the disease in the hills (Table 5).

Data on the grain yield (Table 6) revealed that there was significant effect for the application of silica fertilizer at the higher level. The higher level of silica gave a total mean grain yield of 3347.2 kg/ha with an increase of 267.5 kg/ha over control and this difference was significant. The difference in yield between S_1 and S_0 level was not significant.

The effect of silica on the yield of straw (Table 7) was quite similar to that recorded for grain yield. The yield of straw was 3165, 3300 and 4150 kg/hectare in S_0, S_1 and S_2 levels of silica respectively. The increase of straw yield in the higher level (S_2) of silica was significant over other treatments but the difference between S_0 and S_1 levels was not significant.

The effects of interaction between silica and fungicides in respect of intensity, per cent infection, rate of spread, grain yield and straw yield were also tested. Eventhough the effects of interaction was significant on the 75th day in respect of intensity (Table 1), it was not significant subsequently.

Per cent loss in yield due to the sheath blight disease

Samples of 100 healthy and 100 infected hills were collected at random from the control plots and the yield was determined. The data are presented in Table 10. From the data it can be seen that there was a reduction of 27.3 per cent of grain yield and 21.9 per cent of straw yield due to sheath blight disease.

Table 10

Per cent loss in yield of grain and straw due to sheath blight disease

(Average yield of 25 tillers in gms)

	Weight of grain	Weight of straw
Healthy	44	64
Diseased	32	50
Per cent loss	27.3	21.9

Determination of crude silica content of plant material

Samples of plant materials were collected at different stages of plant growth and crude silica content was determined. The results are presented in Table 11 and graphically represented in Fig.6. The data revealed that the content of crude silica was higher at the initial stage of sampling (40th day, active tillering phase) and at the dough stage (80th day). There occurred a reduction in the crude silica content during the flowering period (60th day).

Observation on the 40th day (active tillering phase)

The data revealed that there was significant increase in the crude silica content of plant tissues with incremental doses of silica fertilizer. The amount of crude silica was greater at the S_2 level followed by S_1 and control. The difference between the treatments and control was statistically significant at this stage.

Observation on the 60th day (flowering phase)

The same trend of increase in crude silica content was observed with incremental doses of silica and the difference was statistically significant. But the total crude silica was lower than the silica content

Table 11

Silica content of plant material at different growth stages

(mg/gm)

Day of observation	S_0	S_1	S_2	Mean
40th day	69.22	75.44	95.33	80.00
60th day	45.55	59.11	65.55	56.74
80th day	60.56	64.67	69.33	64.85
Mean	55.18	65.52	76.74	

C.D. for comparison between levels of silica:

1. 40th day - 5.49
2. 60th day - 3.82
3. 80th day - 1.92

SILICA CONTENT IN PLANT MATERIAL AT DIFFERENT STAGES OF GROWTH

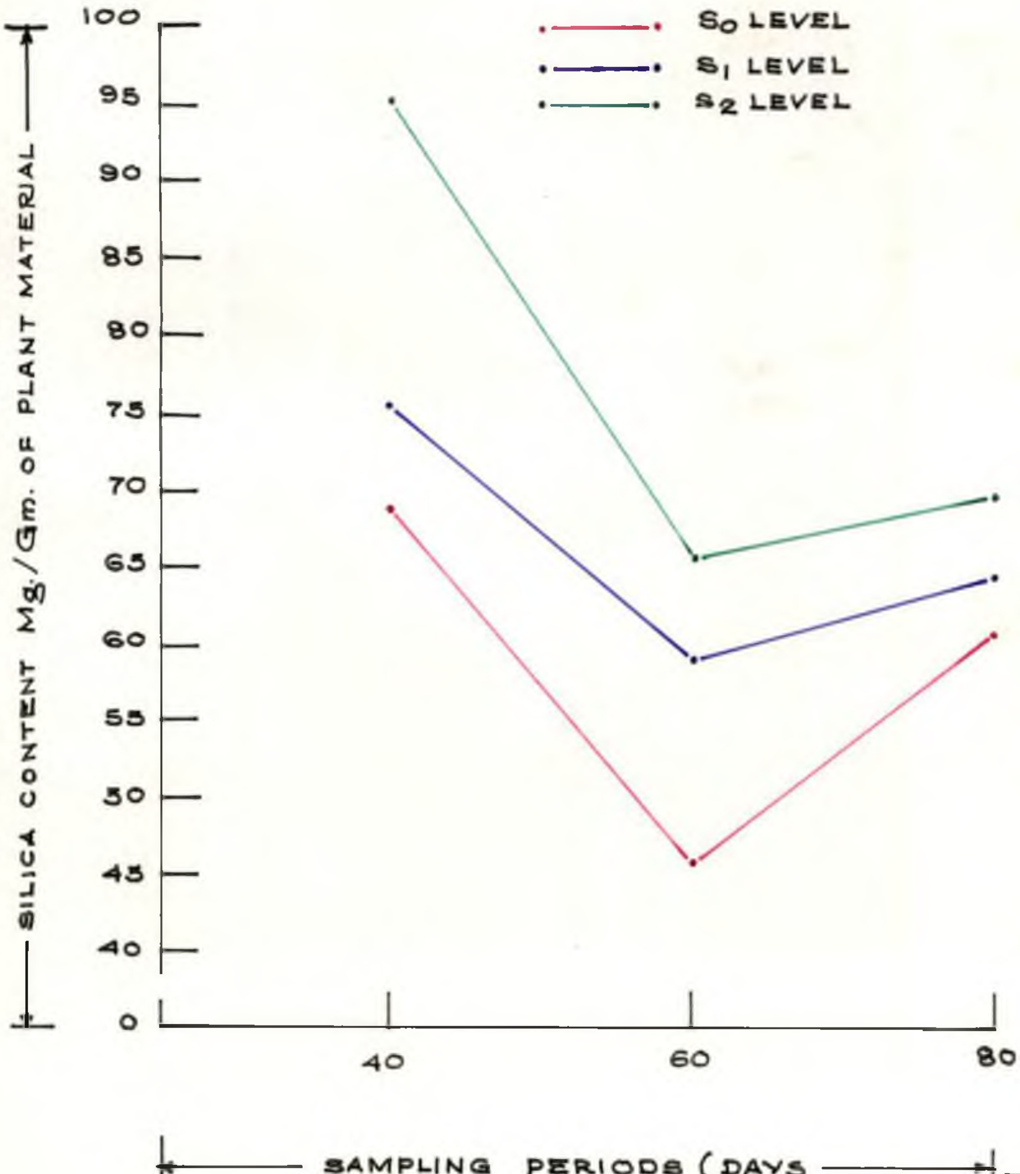

FIG: 6

recorded on the 40th day.

Observation on the 80th day (Milky or dough stage)

It was observed from the data that crude silica content of the plant increased with incremental doses of silica fertilizer. Crude silica content of 60.56, 64.67 and 69.33 mg/gm were obtained from the plants treated with 0, 250 and 500 kg/ha of silica respectively. The increase in crude silica content between the different levels of silica was found to be statistically significant. It was also observed from the data that the crude silica content in the plant tissue tend to increase on the 80th day.

Results of the laboratory evaluation of fungicides against *Corticium sasakii*

The efficacy of hinosan and dithane M-45 at concentrations of 100, 200, 500, 1000, 2000, 3000 and 4000 ppm were tested by the poisoned food technique described by Lilly and Barnett (1951). PDA and host extract agar was used as the basal medium in the experiment. The desired concentrations of the fungicide was added to the melted medium and 15 ml of each were poured into petridishes. The plants were inoculated with sclerotium

Table 12

Results of the laboratory evaluation of fungicides against *C. sasakii*

Fungicide	Concentration in ppm	Mean diameter of the colony in mm after 3 days of seeding		Per cent inhibition over control	
		PDA	HEM	PDA	HEM
Hinosan	100	6	8	92.5	90.6
	200	6	7	92.5	91.8
	500	Nil	Nil	100.0	100.0
	1000	,,	,,	100.0	100.0
	2000	,,	,,	100.0	100.0
	3000	,,	,,	100.0	100.0
	4000	,,	,,	100.0	100.0
Dithane M.45	100	24	20	70.0	75.0
	200	14	10	83.0	87.5
	500	8	7	90.0	91.3
	1000	+	+	+	+
	2000	+	+	+	+
	3000	Nil	Nil	100.0	100.0
	4000	,,	,,	100.0	100.0
Control	..	80	85	--	--

\+ Sclerotium viable since there was upward mycelial growth and incubated at laboratory temperature. The diameter of the colony was measured after 3 days and the per cent inhibition over control was calculated. The results are given in Table 12.

The results indicated that hinosan at 500, 1000, 2000, 3000 and 4000 ppm concentrations was completely inhibitory to the growth of the fungus in both the medium. There was germination and growth of the fungus at 100 and 200 ppm concentrations of hinosan with an inhibition per cent of 92.5 in PDA. In host extract agar medium the inhibition per cent was 90.6 and 91.8 at 100 and 200 ppm concentrations respectively.

Dithane M-45 at 3000 and 4000 ppm concentrations was completely inhibitory to the growth of the fungus. At 1000 and 2000 ppm it showed scanty mycelial development in both the medium which grew upwards indicating that the sclerotia were viable. There was germination and growth of the organism at 100, 200 and 500 ppm concentration in both the media and as such dithane M-45 was not completely inhibitory at these concentrations. The percentage of inhibition was found greater in the host extract agar medium than in PDA. The laboratory assay of the two fungicides showed that hinosan was effective at

500 ppm where as dithane M-45 was effective only at 3000 ppm in completely inhibiting the growth of the fungus.

Studies on the perfect stage of *Corticium sasakii* (*T. cucumeris*)

Investigations were made on the basidial formation of the sheath blight fungus in the laboratory and in the field. Five different methods were tried so as to induce the perfect stage in the laboratory. None of the trials conducted turned to be fruitful. The perfect stage of the organism could not be observed in the field on naturally infected rice plants also.

DISCUSSION

DISCUSSION

Sheath blight of rice caused by *Corticium sasakii* (Shirai) Matsumoto was recently found to occur in a serious form in Kerala. In view of the seriousness of the disease, studies were made to evolve a suitable control measure for the disease. Mahendra Prabhath (1971) studied the effect of certain fungicides in the control of the disease. Muneera (1973) studied the effect of fungicides and different levels of nitrogen and potash fertilizers on the incidence and intensity of the disease. The effect of silica in imparting resistance to infection by fungal diseases in rice is well known. Bearing these in mind a field experiment was conducted to determine the effect of two fungicides at three levels of silica. Attempts were also made to study the basiodiospore formation and its role in the spread of the disease. The results of the findings are discussed.

Eventhough rice plant was found to be susceptible to the disease at any stage of its growth, (Mahendra Prabhath, 1971), visible symptoms of the disease were observed only at the flowering stage. There was no incidence of the disease in any of the plots during the early stages of the crop growth. Studies conducted at I.R.R.I., Philippines on the age of the rice plant for the development of the disease (Anon., 1973) revealed that rice plants were most susceptible to the disease after they had flowered and were approaching maturity which substantiate the present observation. They also reported that the susceptibility or resistance reactions of the plant to sheath blight disease at different stages of growth was a varietal character. However, Muneera (1973) observed the incidence of disease when the crop was 40 days old; but in the present study the incidence was noticed only on 75th day. This variation in the incidence of the disease can be attributed to climatic factors, particularly temperature and humidity. This aspect warrants further study.

Among the fungicides tried, hinosan have been shown to be more effective in reducing the intensity, per cent infection and the rate of spread of the disease in the hill. The results of observation on the intensity of the disease made on the 75th and 85th day showed that there was significant difference between hinosan and dithane M-45. With regard to the per cent infection and the rate of spread of the disease in the hill, hinosan was on a par with dithane M-45 but significantly superior over control. The yield of grain and straw was also increased by the application of hinosan; the increase being 22.8 and 14.4 per cent respectively over control. The increase in yield of grain and straw was attributed to the low intensity of the disease in the hinosan treated plots.

The results emphasised the superiority of hinosan in the control of sheath blight of rice. The superior effect of hinosan may be due to its protective and curative action which prevented the spread of the disease. The efficacy of hinosan in the control of sheath blight of rice has been reported from I.R.R.I., Philippines (Anon., 1973) and by Muneera (1973). Hinosan has been found to be effective against stem rot disease on rice by Jain (1971; 1973) and blast disease of rice by Kameswar Rao (1970), Mohanty and Dash (1971), Subramanian and Ramaswamy (1973) and Reddy and Pandit (1973). Scheinflung and Jung (1968) reported that organophosphorus compounds with specific action against rice diseases include hinosan.

The results of the experiment to determine the effect of silica on the incidence and intensity of disease revealed that the intensity of the disease on the 75th day was reduced by the application of silica, and it was statistically significant over control. However there had no significant difference in effect between the higher and lower level of silica. The data indicated that silica induced some sort of resistance in reducing the intensity of infection, but the per cent infection and rate of spread within the hill was unaffected. From the results of observation recorded on the 85th day it was found that application of silica fertilizer had no effect in reducing intensity, per cent infection and the rate of spread within the hills. Similar results have been reported by Kozaka (1970) in the case of sheath blight of rice.

There was an increase in the yield of grain and straw at the higher level of silica. Eventhough there was no significant difference in the intensity of disease at later stages of growth of the crop, the data on yield of grain revealed a significant increase at higher levels of silica. This increase in grain yield can be attributed to the effect of silica in reducing the intensity of infection at early stage of crop growth and its fertilizing value. Russel (1950) and Imaizumi (1958) reported about increased rice yields by the application of silica fertilizer.

The results of analysis of plant material showed that the per cent of crude silica was high at the active tillering phase and at the milky or dough stage. A decrease in crude silica content was observed during the formation of flower primordia and stem elongation (60th day of sowing). Similar results were obtained by Yoshiaki Ishisuka (1964) in the case of rice plants.

The data on the crude silica content of plant material also revealed that there was a significant increase in crude silica content with incremental doses of silica fertilizer. The increase of crude silica in the plant tissue at S_2 level was 26.11, 20.00 and 8.77 mg/gm over S_0 level on the 40th, 60th and 80th day respectively. Volk et al.(1958) reported increase in silioon content of rice plant material with incremental doses of silica. There was no correlation between the amount of silica contained in the plant material and the intensity of incidence of the disease.

The data on the loss of yield (Table 10) revealed that the loss in the yields of grain and straw was 27.3 and 21.9 per cent respectively. Hori (1969) also observed 25 per cent loss in yield due to the disease.

The magnitude of loss was found to be more or less the same during the present study also. It was evident from the results that the sheath blight disease can cause heavy loss in yield and hence indicated the necessity to evolve suitable control measures.

The laboratory assay of different fungicides against C.sasakii indicated that hinosan completely inhibited the growth of the fungus at concentrations of 500 ppm and above. At 100 and 200 ppm concentrations there were scanty radial mycelial development which indicated that these concentrations were not inhibitory to the growth of the fungus. Mahendra Prabhath (1971) reported that hinosan gave complete inhibition of C.sasakii at a concentration of 100 ppm and above. Muneera (1973) reported that hinosan gave complete inhibition at a concentration of 500 ppm and above. Dithane M-45 was completely inhibitory only at 3000 and 4000 ppm concentrations and showed scanty upward mycelial growth at concentrations of 1000 and 2000 ppm. It was found ineffective in all other lower concentrations tested. In laboratory tests conducted by Kang and Kim (1972) dithane M-45 W.P. 0.2 per cent gave very good control of P.oryzae, Trichoconis padwickii and Curvularia lunata

(Cochliobolus lunatus). In the present study, it was observed that dithane M-45 was not completely effective in inhibiting the growth of the fungus at concentration below 3000 ppm.

A good correlation was observed between the laboratory assay and field evaluation of the fungicides against C.sasakii. Hinosan (50% E.C.) 0.04 per cent concentration was found to be superior to dithane M-45 in reducing the intensity of the disease and increasing the yield of grain and straw. Kang and Kim (1972) reported that hinosan and kasugamin was very effective against P.oryzae, Trichoconus padwickii and Curvularia lunata (Cochliobolus lunatus) in field conditions. In fungicide trials against P.oryzae, hinosan, dithane M-45 and antracol gave significant increase in yield (Anon., 1968).

The efforts made to encounter the basidial stage of the sheath blight fungus was not successful. Basidia and basidiospore could not be observed under natural conditions or in culture. This may be due to the strain variation of the pathogen occurring at Vellayani or to other factors which interfered in the production of basidiospores. Valdez (1955) could not induce sporulation of a rice sheath-isolate eventhough different methods were tried. Papavizas (1965) succeeded in inducing fruiting in culture only 8 out of 69 clones tested. Sherwood (1970) reported that sufficient information on physical and chemical pre-requisites for fruiting is lacking so as to bring all isolates of *T. cucumeris* to fruit at will. According to him one isolate may form basidiospores in response to a given treatment but not to another. There are differences between isolates and between laboratories which interferes with the fruiting of particular strain of the organism. The problem requires further investigation.

SUMMARY

SUMMARY

A field experiment to determine the effect of two fungicides under three levels of silica on the incidence and intensity of sheath blight of rice was conducted at the Agricultural College Farm, Vellayani during the crop season February to May 1974.

The fungicides, hinosan and dithane M-45, were effective in reducing the intensity, per cent infection and rate of spread of the disease and thereby increasing the yield. Among the fungicides tried hinosan was significantly superior.

Application of silica was found to have significant effect in reducing the intensity of the disease on the 75th day. However, the per cent infection, rate of spread and the intensity on the 85th day indicated that the effect of silica in imparting resistance to infection by the pathogen was not significant.

The crude silica content in the plant was high at the 40th and 80th day of sowing with a reduction on the 60th day. There was positive correlation between the amount of silica fertilizer applied and the crude silica content of

plant material. There was an increase in yield of grain and straw as the dose of silica was increased.

The average loss in yield due to the sheath blight disease was found to be 27.3 per cent of grain and 21.9 per cent of straw.

The laboratory assay of the fungicides against Corticium sasakii indicated that hinosan was effective in completely inhibiting the growth of the fungus at concentrations of 500 ppm and above. Dithane M-45 was effective only at 3000 ppm and above.

The attempts made to induce the formation of the perfect stage of the sheath blight fungus in culture was not successful. The basidial stage of the fungus could not be observed under natural conditions also.

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*Originals not seen

APPENDIX

Appendix I

Analysis of variance table (Table 1)

Intensity of infection on 75th day

Source	S.S	d.f	Variance	F
Total	2.4237	26		
Block	0.0969	2	0.0484	2.420
Silica (S)	0.2401	2	0.1200	6.000*
Fungicide (F)	1.5006	2	0.7503	37.515**
S x F	0.2653	4	0.0663	3.316*
Silica Vs no silica	0.9005	1	0.9005	45.025**
Fungicide Vs no fungicide	0.2316	1	0.2316	11.580**
Error	0.3208	16	0.0200	

**Significant at 0.01 level

*Significant at 0.05 level

Appendix II

Analysis of variance table (Table 2)

(Intensity of infection on 85th day)

Source	S.S	d.f	Variance	F
Total	7.5681	26		
Block	0.2744	2	0.1372	1.1395
Silica (S)	0.3919	2	0.1959	1.6270
Fungicide (F)	4.6440	2	2.3220	19.2857**
S x F	0.3312	4	0.0856	1
Silica Vs no silica	0.1659	1	0.1659	1.3773
Fungicide Vs no fungicide	3.7960	1	3.7960	31.5282**
Error	1.9266	16	0.1204	

**Significant at 0.01 level

*Significant at 0.05 level

Appendix III

Analysis of variance table (Table 3)

(Per cent infection in the hills on 75th day)

Source	S.S	d.f	Variance	F
Total	2270.76	26		
Block	50.57	2	25.28	1
Silica (S)	34.09	2	17.04	0.255
Fungicide (F)	994.65	2	497.32	7.444**
S x F	122.56	4	30.64	0.458
Silica Vs no silica	33.55	1	33.55	1
Fungicide Vs no fungicide	805.03	1	805.03	12.05**
Error	1068.89	16	66.81	

**Significant at 0.01 level

Appendix IV

Analysis of variance table (Table 4)

(Per cent infection in the hills on 85th day)

Source	S.S	d.f	Variance	F
Total	2002.98	26		
Block	0.75	2	0.37	1
Silica (S)	118.26	2	59.13	1.342
Fungicide (F)	970.61	2	485.30	11.012**
S x F	208.29	4	52.07	1.181
Silica Vs no silica	118.04	1	118.04	2.678
Fungicide Vs no fungicide	953.64	1	953.64	21.639**
Error	705.07	16	44.07	

**Significant at 0.01 level

Appendix V

Analysis of variance table (Table 5)

(Rate of spread)

Source	S.S	d.f	Variance	F
Total	4.0221	26		
Block	0.0658	2	0.0329	1
Silica (S)	0.3279	2	0.1639	1.3325
Fungicide (F)	1.0201	2	0.5100	4.1463*
S x F	0.6399	4	0.1599	1.3000
Silica Vs no silica	0.0055	1	0.0055	1
Fungicide Vs no fungicide	0.9980	1	0.9980	8.1140**
Error	1.9684	16	0.1230	

**Significant at 0.01 level

*Significant at 0.05 level

Appendix VI

Analysis of variance table (Table 6)

(Grain yield)

Source	S.S	d.f	Variance	F
Total	2936935.0	26		
Block	22313.0	2	11156.5	1
Silica (S)	379856.0	2	189928.0	9.138**
Fungicide (F)	1952221.5	2	976110.8	46.962**
S x F	249982.5	4	62495.6	1
Error	332562.0	16	20785.1	

**Significant at 0.01 level

Appendix VII

Analysis of variance table (Table 7)

(Straw yield)

Source	S.S	d.f	Variance	F
Total	6110741	26		
Block	31852	2	15926	1
Silica (S)	4393519	2	2196759	64.320**
Fungicide (F)	1004630	2	502315	14.707**
S x F	134259	4	33564	1
Error	546481	16	34155	

**Significant at 0.01 level

Appendix VIII

Analysis of variance table (Table 11)

(Silica content in plant material, 40th day)

Source	S.S	d.f	Variance	F
Total	4654	26		
Block	384	2	192.0	6.34**
Treatment	3785	8	473.1	15.61**
Silica Vs no silica	1568	1	1568.0	51.75**
Error	485	16	30.3	

**Significant at 0.01 level

Appendix IX

Analysis of variance table (Table 11)

(Silica content in plant material, 60th day)

Source	S.S	d.f	Variance	F
Total	2449.2	26		
Block	14.5	2	7.25	1
Treatment	2201.2	8	275.15	18.858**
Silica Vs no silica	1688.9	1	1688.90	115.750**
Error	233.5	16	14.59	

**Significant at 0.01 level

Appendix X

Analysis of variance table (Table 11)

(Silica content in plant material, 80th day)

Source	S.S	d.f	Variance	F
Total	503.40	26		
Block	17.80	2	8.90	2.42
Treatment	426.70	8	53.34	14.49**
Error	58.90	16	3.68	

**Significant at 0.01 level