

Control of Seedling Blight of Rice caused by *Fusarium moniliforme* Sheld (*Gibberella fujikuroi* (Saw) Wr.)

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Introduction

POOR GERMINABILITY of the seed and post-emergence seedling diseases of rice are caused by several seed and soil borne fungi. Among these *Helminthosporium oryzae*. Breda de Haan, *Piricularia oryzae* Cav. and *Fusarium moniliforme* Sheld. (*Gibberella fujikuroi* (Saw) Wr.) are to a large extent seed transmitted and are of economic importance in Ceylon. Primary infection of seedlings by these fungi may be prevented by seed disinfection with suitable materials. A great variety of organo-mercury formulations, copper compounds and fungicides containing thiram have been tested by several workers against seed-borne organisms of cereals and their relative effectiveness in controlling seedling diseases ascertained. In the present investigation a number of more recent proprietary seed dressings have been tested against *F. moniliforme* (*G. fujikuroi*) and the phytotoxic properties of these materials and their effect on root and shoot growth ascertained.

Historical

A considerable measure of control of the primary infection of *F. moniliforme*

(*G. fujikuroi*) has been obtained by Ito and Kimura (1931) by disinfection of the seed with formalin. Subsequently Ito (1932) reported that the conidial death point of *F. moniliforme* (*G. fujikuroi*) subjected to mercuric chloride and formalin was 0.1 per cent. and 0.7 per cent. respectively. The use of formalin, however, requires great care as a slight increase in the concentration may adversely affect germination of the seed. Thomas (1933) tested a number of wet and dry seed disinfectants and concluded that most of the treatments reduced primary infection to a considerable extent. He obtained promising control of the disease with the commercial seed dressings Uspulun, Ceresan and Tillantin, Semesan and Granosan. Copper sulphate was inferior to these preparations and inhibited germination of the seed. Sundararaman (1936) obtained better control of the disease with the organo mercury product Ceresan than with copper sulphate or Bordeaux mixture. Peiris (1951) reported that seed dressing with Agrosan GN at 2 ounces per bushel effectively controlled the disease.

Materials and Methods

The following seed dressings were tested :—

Seed Dressing	Active Ingredient
Agrosan GN ..	Mixture of phenyl mercury acetate and ethyl mercury chloride
Ceresan ..	Methoxethyl mercury chloride
Tillex ..	Ethyle mercury chloride
Fernasan A ..	bis (dimethylthiocarbonyl) disulphide
Yellow Cuprocid	Cuprous oxide
Perenox ..	Cuprous oxide
Cerenox ..	Systemic fungicide, active ingredient unknown

The seed of the variety *Heenati 309* which is susceptible to attack by *Fusarium moniliforme* (*Gibberella fujikuroi*) was inoculated with a heavy spore suspension of the fungus and air dried for a week at the room temperature. Each fungicide was applied to the seed in a 250 ml. Erlenmeyer flask; uniform application of the material was ensured by shaking the flask for 2 minutes. The liquid seed disinfectant was applied by the immersion process; the seed was immersed in the disinfectant for 30 minutes, air dried and stored in conical flasks. The effectiveness of seed protectants was assessed by the following methods :—

1 Laboratory Method. This is based on the Ulster method of testing seeds for the presence of seed-borne organisms described by Muskett and Malone (1941). In this method untreated seed and those treated with fungicides were

plated on 2 per cent. dextrose agar at the rate of 100 seeds per treatment and per cent. colonies of *F. moniliforme* (*G. fujikuroi*) produced estimated. The method is especially useful for rapid laboratory evaluation and elimination of unpromising seed protectants. However, conditions obtained in vitro tests were considered too severe for final evaluation and the materials were tested further by the pot culture method.

2 Pot Culture Method. Unsterile clay soil was placed in pots 5½ inches diameter; the moisture content of the soil was adjusted and maintained at 100 per cent. saturation. Untreated seed and those treated with different protectants was germinated and shown at the rate of twenty-five seedlings per pot. Each treatment was replicated three times and the pots were arranged on a greenhouse bench. The experiment was continued for a period of two weeks; infected seedlings were periodically removed to prevent secondary infection. The results are given in Table I and II. The results of the pot culture experiment were analysed statistically after transforming the data to the inverse sine scale. The mean equivalent angles thus obtained are shown in the last column of Table I. The mean percentage seedlings diseased and the mean equivalent angles of the protectants irrespective of concentration used is shown in Table II. The analysis of variance of the transformed data is shown at the bottom of Table II.

TABLE I—Effect of Seed Protectants on Emergence and Control of Seedling Blight of Rice caused by *F. moniliforme* (*G. fujikuroi*)

Treatment	Dosage	Per Cent. Emergence	Per Cent. Colonies on Agar	Mean Per Cent. Seedlings diseased	Mean equivalent Angle of Seedlings diseased
Agrosan GN	2 oz./cwt.	97	0	2.67	5.47
	4 oz./cwt.	96	0	1.33	3.83
	6 oz./cwt.	69	0	0	0
Ceresan Dry	2 oz./cwt.	98	0	0	0
	4 oz./cwt.	76	0	0	0
	6 oz./cwt.	66	0	0	0
Ceresan Wet	$\frac{1}{2}$ lb./100 gals.	98	4	1.33	3.83
	1 lb./100 gals.	99	0	1.33	3.83
	$1\frac{1}{2}$ lb./100 gals.	99	0	1.33	3.83
Tillex Dry	2 oz./cwt.	99	0	1.33	3.83
	4 oz./cwt.	98	0	1.33	3.83
	6 oz./cwt.	92	0	0	0
Tillex Wet	$1\frac{1}{2}$ fl. oz./13 gal.	99	2	2.67	5.47
	$2\frac{1}{2}$ fl. oz./13 gal.	99	0	0	0
	$3\frac{3}{4}$ fl. oz./13 gal.	98	0	0	0
Fernasan A	2 oz./cwt.	95	25	5.33	10.93
	4 oz./cwt.	98	16	2.67	7.67
	6 oz./cwt.	92	8	1.33	3.83
Perenox	2 oz./10 gal.	97	44	18.67	25.40
	4 oz./10 gal.	98	23	13.33	21.40
	6 oz./10 gal.	97	14	8.00	15.53
Yellow Cuprocide	2 oz./cwt.	82	42	18.67	25.40
	4 oz./cwt.	71	38	10.67	18.80
	6 oz./cwt.	88	31	6.67	14.77
Cerenox	150 gms./100 kgs.	100	76	41.33	39.90
	300 gms./100 kgs.	96	76	37.33	37.60
	450 gms./100 kgs.	98	72	37.33	37.57
Control		99	87	58.67	50.10
Significant difference at $P = .05$					8.96

TABLE II—Effect of Seed Protectants on Control of Seedling Blight of Rice caused by *F. moniliforme* (*G. fujikuroi*)

Fungicide	Mean Per Cent. Seedlings diseased	Mean equivalent Angle
Ceresan Dry	0	0
Tillex Wet	0.89	1.82
Tillex Dry	0.89	2.25
Agrosan GN	1.33	3.10
Ceresan Wet	1.33	3.83
Fernasan A	3.11	7.48
Yellow Cuprocide	12.00	19.60
Perenox	13.33	20.78
Cerenox	38.66	38.36
Control	58.67	50.10
Significant difference between control and seed protectants at $P = .05$	—	7.32
Significant difference between seed protectants at $P = .05$	—	5.24

Analysis of Variance of Percentage Seedlings Diseased

DATA TRANSFORMED TO INVERSE SINE SCALE, $\Theta = \sin^{-1} \sqrt{P}$

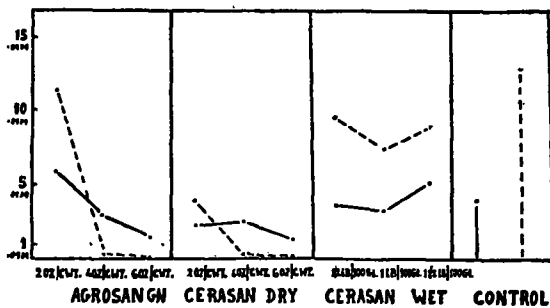
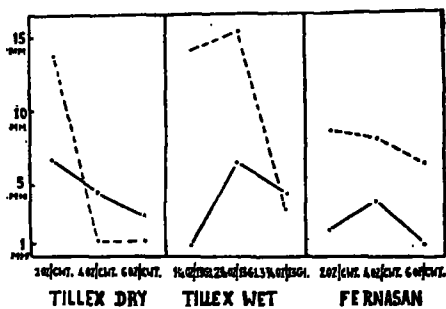
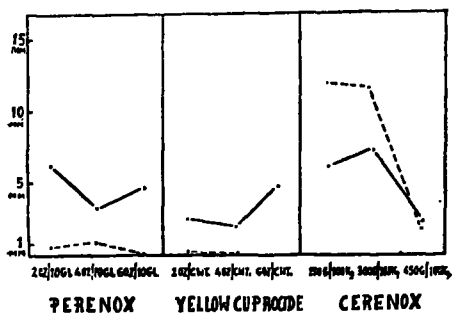
		Degrees of freedom	Sums of squares	Mean Square	F
Treatments ..	..	27	16894.11	6257.08	207.48
Within treatments ..	..	56	1688.77	30.157	—
Total ..	..	83	18582.89		

At all three dosages the organomercury formulations gave good control of seedling blight. At the low dosage tested, that is, 2 ounces of the material per cwt. of seed, the performance of Ceresan Dry was superior to other organomercury dry seed dressings. The differences obtained are however not statistically significant and it would be difficult to evaluate the relative efficacy of the different organomercury formulations. The performance of Fernasan A was promising both in vitro and in the pot experiment but was less effective than the organomercury protectants; the effectiveness of this material increased progressively with the increasing quantity used for disinfection. Although Perenox, Yellow Cuprocide and Cerenox diminished fungus growth on agar and decreased seedling blight considerably they were less efficient than either the organomercury formulations or Fernasan A.

Emergence. A critical factor in chemical seed disinfection is dosage; a slight increase in the quantity of the material may depress emergence and subsequent growth of seedlings. At the high concentration used the organomercury dry treatments Agrosan GN, Ceresan and to some extent Tillex inhibited germination of the seed; wet treatment with Ceresan and Tillex however was not inhibitory at all three

concentrations. Of the copper compounds Yellow Cuprocide gave less consistent emergence; Perenox did not inhibit germination but delayed seedling emergence. Fernasan A at the high concentration inhibited germination slightly whereas Cerenox was not inhibitory at all three dosages tested.

Phytotoxicity. The relative lengths of roots and shoots as influenced by the different treatments are shown in Fig. I, the measurement being taken when seedlings were 10 days old. Certain seed protectants were phytotoxic and had a considerable influence on root and shoot elongation especially during the early stages of emergence and growth. At high dosages tested the organomercury dry treatments depressed root and shoot growth; Agrosan GN, Ceresan and Tillex progressively decreased root and shoot elongation with the increase in concentration of the seed protectant. All three protectants produced stout and stunted shoots when treated at 6 ounces per cwt. of seed. As opposed to dry, the organomercury wet treatments produced better root and shoot growth; Ceresan Wet increased shoot elongation at the concentration of 1½ lb. in 100 gallons of water but had a slight inhibitory effect on root development. Tillex at a concentration of 2½ fluid ounces in 100 gallons of water increased both root and shoot elongation.



Although Fernasan A had no beneficial effect on seedling growth it did not radically depress root and shoot elongation.

Both Perenox and Yellow Cuprocide delayed emergence and root growth. Perenox was more beneficial than Yellow Cuprocide to shoot elongation.

Cerenox increased shoot elongation at low dosages but had little effect on root growth.

Discussion

In this investigation a variety of the more recent seed protectants have been subjected to laboratory and pot culture tests and the ability of these formulations to control the seedling blight disease of rice caused by *F. moniliforme* (*G. fujikuroi*) was assessed. A high degree of correlation exists between the results obtained by the two methods. A correlation coefficient of 0.9607 which is significant even at $P = .001$ has been obtained. The equation connecting per cent. colonies on agar (A) and mean per cent. seedlings diseased (S) is $S = 0.53 A - 0.84$. The laboratory method could therefore be used for rapid evaluations and to eliminate unpromising materials against *F. moniliforme* (*G. fujikuroi*).

Of the protectants tested the only satisfactory ones were the organomercury formulations. The differences between the various organomercury formulations are not statistically significant; the tests employed are not sufficiently sensitive to establish differences between these compounds. Cuprous oxide preparations would be unsuitable for general use as a seed disinfectant on rice. The copper compounds were less effective than

the organomercury formulations and caused a noticeable growth depression of the seedlings. Fernasan A has given promising control of the *Fusarium* disease but its general use as a rice seed disinfectant has to be further investigated. It has however the advantage that it has a comparatively lower mammalian toxicity than the organomercurials.

Use of the correct dosage of the protectant is an important factor in rice seed disinfection. This applies in particular to the poisonous organo mercury compounds where an increase in dosage of the protectant may inhibit emergence and cause growth depression of roots and shoots.

It may therefore be tentatively suggested that a good seed protectant should not allow more than 0.5 per cent. of the disease to escape control in a pot culture test. Although such a requirement is severe the results obtained show that more than one proprietary protectant satisfied these conditions.

Summary

Several seed protectants have been subjected to laboratory and pot culture tests and the efficacy of these compounds to control the seedling blight disease of rice caused by *Fusarium moniliforme* (*Gibberella fujikuroi*) has been evaluated.

A high degree of correlation has been found to exist between the laboratory and pot culture methods. A correlation coefficient of 0.9607 which is significant even at $P = .001$ has been obtained. The results of the pot culture method were transformed to the inverse sine scale and statistically analysed. The performance

of organomercury and thiram formulations was distinctly superior to other materials tested. Statistically significant differences were however not established between the different organomercury formulations.

An important factor in seed disinfection is the dosage of the protectant—slight excess of the material could depress emergence and have phytotoxic effects on root and shoot growth.

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REFERENCES

- ITO, S. (1932). Primary outbreak of the important diseases of the rice plant and common treatment for their control—*Rep. Hokkaido agric. Expt. Sta., Sapporo*, 28, 204 + (7) pp.
- KIMURA, J. (1931). Studies on the 'bakanae' disease of the rice plant —*Rep. Hokkaido agric. Expt. Sta.* 27, 95 + (5) pp.
- MUSKETT, A. E. & MALONE, J. P. (1941). The Ulster method for the examination of flax seed for the presence of seed borne parasites. *Ann. appl. Biol.* 28, 8—12.
- PEIRIS, J. W. L. (1951) Bakanae Disease and Foot Rot of Paddy. *Trop. Agriculturist* 107, 172—175.
- SUNDARARAMAN, S. (1936). Administrative report of the Government Mycologist for the year 1935-36 (Detailed Report) in Administration Reports *Agric., Entom., and Mycol.*, Madras, 1935-36, 31—43.
- THOMAS, K. M. (1933). The 'foot rot' of paddy and its control—*Madras agric. J.*, 21, 263—269.