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CHEMICAL CONTROL OF RICE BLAST CAUSED BY PIRICULARIA ORYZAE CAV

Part II.—Fungicidal Effect of Selected Fungicides Against Rice Blast in-Vivo

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The performance of several foliar fungicides against rice blast was determined under greenhouse and field conditions. Because of the varying degrees of phytotoxicity observed, the maximum concentration of each of the candidate fungicides causing little or no phytotoxicity was determined. Actidione was phytotoxic even at a rate as low as 25 ppm. PMA caused slight injury at 75 ppm and was very injurious at 150 ppm. Du-Ter W-50 was slightly phytotoxic at 250 ppm and injurious at 500 ppm. Blasticidin-S was essentially nontoxic at 40 ppm. Phytotoxicity was enhanced when the treated plants were held in a humidity chamber. Blasticidin-S, Du-Ter W-50 and PMA were all protectants and significantly controlled leaf blast. In field trials, Blasticidin-S, PMA and Du-Ter W-50 reduced neck infection. In a moderate blast epiphytotic, the yield was significantly increased by these fungicides. In general, two-spray applications were better than one. A single application of Blasticidin-S was more effective than two applications of each of the other materials except Du-Ter W-50. An interval of 6 days between first and second spray applications was found to be a realistic time interval for application of fungicides. Mild outbreaks of blast are related to fewer conidia in the atmosphere and no striking build-up of conidia developed through the susceptible stages of plant growth.

Introduction

The evaluation of chemicals in the greenhouse for the control of plant disease is an important intermediate step in the development of a new fungicide. The *in vitro* laboratory test usually determines which chemicals tested are sufficiently lethal or inhibitory to certain plant pathogens to warrant further study with them. In an earlier communication the results of laboratory evaluation of 20 potentially effective foliar fungicides against *Piricularia oryzae* were discussed.[1] Certain fungicides which are less effective *in vitro* can control disease *in vivo*.[2] In view of this, 14 of the 16 chemicals were included for comparative study *in vivo* conditions in 1965. Two new experimental chemicals, Fungicide 1991 and EL-33 of the 4 materials, received later, were included in the experiments of 1967.

In the disease control programme it is necessary to use the maximum concentration of the chemicals having little or no toxicity in order to give the maximum protection to the plant against the pathogen. In the laboratory tests some chemicals may be found effective against a pathogen at a higher concentration while others may be similarly effective at lower concentrations. Further, the chemicals which are effective at low concentrations may be highly phytotoxic. In these situations it may be necessary to use less effective but less phytotoxic chemicals. So greenhouse experiments were designed to determine: (1) whether the test fungicides were phytotoxic and to use these data to establish dosages for subsequent greenhouse and field experiments (2) whether the fungicidal activity, as determined in the laboratory, is related to disease control in the greenhouse.

Acceptance of fungicides for commercial use depends on field performance. Therefore, a portion of this study was designed to determine the relative performance of the test fungicides under field conditions.

The effective and efficient control of plant diseases depends upon the ability to anticipate their outbreak. The forecasting of rice blast in Japan is based on (a) over-wintering of the fungus, (b) variety of rice, (c) conidial production, (d) time of appearance and prevalence of conidia in the field, and (e) weather in relation to development of rice plants.[3] In consideration of an eventual need for forecasting, an experiment was designed to estimate the spore population of the experimental area.

Literature Review

Every year several hundred new fungicides are prepared and are evaluated in the greenhouse against various diseases for their effectiveness as a surface protectant,[4,5] but only limited greenhouse tests have been made using *P. oryzae*. In Japan[6]

and China,[7] however, *P. oryzae* has been used for greenhouse evaluation of candidate fungicides. Suitable methods for controlling blast in commercial fields have been devised in Japan.

Forecasting outbreaks of rice blast based on spore trapping procedures was first worked out by Kuribayashi in 1934 and in 1937 by Ikata and his colleagues.[8] The relation between the quantity of disseminated spores and the severity of outbreaks of neck blast is highly significant. A rapid increase in the spore concentration for 7 to 8 days, about 25 to 30 days before heading, usually permits heavy infection, whereas a light increase or no increase of spores indicates that there will be little damage.[9] Except in Japan, very little epidemiological forecasting of rice blast has been initiated in the United States and other rice growing countries.

Materials and Methods

Phytotoxicity Test:

In order to evaluate the toxic action of the fungicides, metal flats measuring $8\frac{1}{2} \times 11$ in were filled with three kg of field soil. One g of rice seed of a susceptible variety (glulfrose) was sown per flat and covered with one kg of soil. Three g of granular ammonium sulphate was added to each flat and it was watered regularly to keep the soil moist. Duplicate flats of three-week old rice seedlings were sprayed with a fungicide solution or suspension. One flat was held in a humid chamber for 48 hr after the fungicidal treatment while the other flat was transferred to the greenhouse immediately after spraying. Each fungicide was tested at different concentrations after diluting the stock solution until it produced little or no phytotoxicity. Control seedlings were sprayed with water.

Seedlings were examined 6 days after treatment for necrotic lesions, scorching, yellowing and rolling of leaves. Over all phytotoxcity was assessed according to the following scale:

—	No damage
+	1–10% of leaf destroyed
++	10–30% of leaf destroyed
+++	30–70% of leaf destroyed
++++	Above 70% of leaf destroyed

Protection Test:

(a) *Greenhouse Experiment.*—All chemicals[1] except Actidione were included in this test. Actidione was excluded because of its extreme toxicity. Gulfrose seedlings (susceptible to blast) were grown in soil-filled metal flats as in the preceding test and thinned to 50 plants per flat. 15 to 20-day old seedlings were sprayed with fungicide preparations using a glass atomizer. Air pressure was supplied by an electric pump. The seedlings were sprayed to the point of run-off which required about 20 ml per flat. Four drops of Triton (alkyl aryl polyether alcohol) was added to each 20 ml solution to serve as an adhesive. The plants were then dried in the greenhouse. The control plants were sprayed with water and Triton. All seedlings were inoculated by spraying them with 10 ml of a standard spore suspension per flat. The spores were suspended in a solution of gelatin (0.25%) and sodium oleate (0.05%)[10] and the concentration of spores was adjusted to 10–15 per optical field (430×). The gelatinsoap solution was used to improve spore dispersion and to provide better wetting of the foliage. Immediately after inoculation the flats were placed in a humidity chamber. The experiment was repeated thrice and each replicated 4 times. The inoculation was made in the the afternoon and the plants were incubated for 36–48 hr at room temperature. Later the plants were removed to the greenhouse and left 6 days for the development of blast lesions. Second and third leaves which received fungicidal sprays were checked for the number of typical blast lesions. The protective effective of the fungicides was evaluated by comparing the percentage disease control in different treatments.

(b) *Field Experiments.*—Field experiments were conducted in small and large plots.

(1) Small Plot Test:—A small nursery bed was seeded with a susceptible variety (CI-9205) in continuous rows of 18 in long and 4 in apart. Two border rows of the same variety ran lengthwise on either side of the small rows. The border rows helped to retain higher and more uniform relative humidity in the treatment rows as well as to facilitate natural infection by increasing the inoculum potential. Twelve of the 13 fungicides evaluated in the greenhouse were included in this test. The fungicides were applied to seedlings at the 4–5 leaf stages of development. Each treatment plot consisted of two rows alternated with a control row. Each treatment was replicated 4 times. To avoid drift of the fungicides, the two rows in a treatment were enclosed by a rectangular wooden barrier during spray application. Ten days after spraying the number of blast lesions on 100 leaves (third leaf from the top), collected at random from each replication, was counted. The relative merits of the fungicides were evaluated by comparing the percentage disease control in different treatments.

(2) Large Plot Tests: Tests for chemical control of blast were conducted in field plots over a period of 3 years. In 1965 and 1967 split plot design was employed while in 1966 the design was randomized block. Each treatment plot had six 18-foot rows of susceptible plants in 1965 and 1966: In 1967 the rows were 9 ft long. The rows were 6 in apart. In 1965 and 1966 the seeding rate was 0.74 g per linear row-foot while in 1967, 1.0 g of seeds were used per linear row-foot. In 1966 the blast susceptible variety, CI-9205, was heavily infested with the nematode (*Aphelenchoides besseyi*) causing white tip disease. As a result, in 1967, CI-9205 was replaced by Bluebelle (resistant to white tip disease). The field was heavily fertilized with nitrogen (100 lb/acre) to induce a heavy incidence of blast. Each fungicide was tested as a single and double application. The single application was made at the first-head whereas the two applications treatment was at the first-head and at the full-head stages of development. Each treatment was replicated 4 times. Dosage rates used for the fungicides were those which produced no toxic action on plants, as determined through prior phytotoxicity tests. All of the fungicide applications were made with a Hudson Knapsack sprayer. They were applied at the rate of 125 gallons/acre in aqueous preparations. Five drops of Triton B (wetting agent) were added per liter of fungicidal preparations before application. For fungicide 1991, "surfactant" was used as the wetting agent. Plants in the centre two rows of each test plot were examined for infection. Disease intensity was determined by counting the number of infected necks from the centre two rows. The grain yield from the centre two rows was determined.

Spore-trapping—a Method of Determining the Concentration of Spores in the Air.—Spore concentration of *P. oryzae* in the atmosphere was determined by trapping and counting the spores from representative areas in the experimental field. In 1966, several wind vanes with slide-holding devices were fixed at different places of the field. Vaseline coated glass slides were fixed to wind vanes at an angle of 45° with referencte to the prevailing wind and set approximately 3 in above the plants. Each morning (until grain maturity) the slides were examined and the number of spores per 22×22 mm^2 area was counted. In 1967, an automatic 24-hr spore sampler[11] was used to determine the number of spores disseminated at different hours throughout the day.

Results

Phytotoxicity Test:

The symptoms of phytotoxicity appeared 3 days after treatment and fullest expression was noticed after 5 days. It was possible to divide the symptoms into two categories. (1) Lesion Type: This was the less serious of the two and took the form of brown spots which ranged in dia from pin-head width to 5 mm. Sometimes the spots assumed an irregular shape and at times they had yellow halos. Often they closely resembled *Helminthosporium oryzae* or blast lesions. No lesion developed on newly emerged leaves. (2) Systemic Type: This phytotoxicity severely injured the plant. The treated leaves became scorched or yellowed, were frequently spotted and rapidly became flaccid. The newly-emerged, untreated leaves were sometimes pale yellow.

The growth slowed temporarily so that these plants appeared to be stunted. Actidione, PMA and Du-Ter W-50 were highly phytotoxic (Table 1). Actidione was phytotoxic at concentrations as low as 25 ppm. PMA caused slight injury at 75 ppm and was very injurious at 150 ppm. Du-Ter W-50 was slightly toxic at 250 ppm and injurious at 500 ppm. TH 204-F, TH 174-F, Dithane M-22, Phygon-XL and Dithane M-22 Sp. were moderately toxic, while the rest of the chemicals were essentially non toxic.

Seedlings in a humid chamber may not tolerate the same concentration of a fungicide as they would in a drier atmosphere. So a different set of experiments was conducted to determine optimum dosages for greenhouse and field tests. With toxic chemicals, the degree of toxicity increased when the treated seedlings were incubated in a humid chamber. In the design of subsequent greenhouse and field tests, fungicides were used at the maximum concentration that caused little or no visible plant injury.

Protection Test:

(a) *Greenhouse Experiment.*—The combined analyses data of three experiments showed that leaf blast was significantly reduced. Blasticidin-S, PMA and Du-Ter W-50 were statistically superior in controlling blast as compared to other chemicals (Table 2). Blasticidin-S appeared to be the most effective fungicide for leaf blast control in this experiment; however, the Blasticidin-S-PMA fungicide combination used in the first experiment was superior to Blasticidin-S alone.

(b) *Field Experiment.*—(1) Small-plot Test: Disease symptoms appeared throughout the nursery in the control plots within a week after treatment. Disease intensity varied with treatments, because some fungicidal sprays reduced the amount of disease considerably. PMA and the mixture of PMA and Blasticidin-S were slightly phytotoxic.

TABLE 1.—RELATIVE PHYTOTOXICITY OF FUNGICIDES ON 3-WEEK OLD GULFROSE RICE SEEDLINGS GROWN IN THE GREENHOUSE.

Fungicide	Spray concentration (ppm)	Degree of toxicity*		Type of reaction
		Seedlings incubated in a humid chamber	Seedlings not incubated in a humid chamber	
Actidione	150	++++	++++	Systemic type
	25	+++	++	
	12	+	—	
	5	—	—	
Blasticidin-S	40	+	—	Systemic type
	30	—	—	
Dithane M-22 Sp	1600	++	+	Lesion and
	800	+	—	systemic type
	400	—	—	
Dithane M-45	3200	+	—	Systemic type
	2400	—	—	
Dithane M-22	1600	++	+	Lesion and
	800	+	—	systemic type
	400	—	—	
Du-Ter W-50	500	+++	++	Lesion type
	250	++	+	
	100	+	—	
EL-331	660	+	—	Systemic type
	330	—	—	
Fungicide 328	3000	+	—	Systemic type
	2250	—	—	
Fungicide 1991	2000	+	+	Systemic type
	1000	—	—	
Manzate	3200	+	—	Systemic type
	2400	—	—	
Phygon-XL	1000	++	+	Systemic type
	500	+	—	
	250	—	—	
Pipron 25W	1000	+	—	Systemic type
	750	—	—	
Pipron E.C.	980	+	—	Systemic type
	740	—	—	
PMA	150	++++	++	Lesion and
	75	++	+	systemic type
	30	+	—	
	15	—	—	
TH 204-F	1500	++	+	Systemic type
	500	—	—	
TH 174-F	1500	++	—	Systemic type
	500	—	—	

* Toxicity scale: —=no injury; +=1–10%; ++=10–30%; +++=30–70; ++++=greater than 70.

TABLE 2.—AVERAGE NUMBER OF BLAST LESIONS PER 100 LEAVES OF GULFROSE RICE SEEDLINGS SPRAYED WITH DIFFERENT FUNGICIDES.

Fungicide	Greenhouse test			Small plot test		
	Concentration (ppm)	Average number of lesions†	Statistical significance††	Concentration (ppm)	Average number of lesions**	Statistical significance††
Blasticidin-S	30	15.4	a	40	60	a
Blasticidin-S+PMA	—*	—	—	40	80	ab
PMA	30	16.0	a	75	90	ab
Du-Ter W-50	100	17.9	a	250	160	bc
TH 174-F	500	21.0	b	1500	240	de
Dithane M-45	2400	21.2	b	3200	220	cd
Dithane M-22	400	22.0	bc	800	340	efg
TH 204-F	500	22.2	bc	—	—	—
Manzate	2400	22.9	bc	3200	190	c
Phygon-XL	250	23.0	bc	500	330	def
Fungicide 328	2250	23.3	bc	3000	200	c
Dithane M-22 Sp.	400	23.4	bc	800	370	fg
Pipron E.C.	740	25.5	bc	980	450	g
Pipron 25 W	750	26.8	c	1000	350	fg
Control	0	27.0	c	0	450	g

*Chemicals not included in the test; †Based on lesion counts on 100 leaves from each of the three experiments; **Based on lesion counts from 400 leave per treatment; ††Means not followed by the same letter differ significantly at the 1% level (Duncan's multiple range test).

TABEE 3.—AVERAGE INCIDENCE OF NECK ROT IN RICE (CI-9205) SPRAYED WITH FUNGICIDES AT (FIRST-HEAD AND FULL-HEAD STAGES OF DEVELOPMENT IN THE FIELD IN 1965.

Fungicide	Concentration (ppm)	Number of sprays	Average number of infected necks*	Statistical significance†
Du-Ter W-50	250	2	4.7	a
Blasticidin-S	40	2	5.5	ab
Blasticidin-S	40	1	5.7	abc
PMA	75	2	8.2	abcd
Fungicide 328	3000	2	8.5	abcd
Dithane M-22	800	2	10.7	abcde
Pipron E.C.	980	2	11.2	abcde
TH 174-F	1500	2	12.2	abcdef
Phygon-XL	500	2	14.2	abcdef
Manzate	3200	2	15.0	abcdef
Dithane M-45	3200	2	16.5	abcdef
Manzate	3200	1	17.7	abcdefg
Pipron 25W	1000	2	18.0	abcdefg
Dithane M-22 Sp	800	2	18.5	abcdefg
Du-Ter W-50	250	1	19.7	abcdefg
Control	0	0	24.7	bcdefg
PMA	75	1	26.0	bcdefg
Fungicide 328	3000	1	28.5	bcdefg
Dithane M-22	800	1	29.7	bcdefg
TH 174-F	1500	1	30.0	cdefg
Dithane M-22 Sp	800	1	31.0	defg
Phygon-XL	600	1	32.2	defg
Dithane M-45	3200	1	33.7	efg
Pipron 25W	1000	1	36.0	fg
Pipron E.C.	980	1	40.7	g
Control	0	0	41.2	g

*Based on the plants from the center 2, 18-foot long rows in each of 4 replications.
†Means not followed by the same letter differ significantly at the 1% level (Duncan's multiple range test).

Reduction of leaf blast with Blasticidin-S was significantly superior to all other treatments except PMA, and Blasticidin-S plus PMA (Table 2). The performance of Du-Ter W-50 was nearly comparable with that of PMA and of Blasticidin-S plus PMA.

(2) Large-plot Test: In 1965, blast was abundant on the foliage and on the heads and necks while in 1967 leaf blast was less abundant than neck blast. In 1967 favourable weather conditions for blast infection existed in the early part of the heading stage of development. Thus, the evaluation of the relative merits of different fungicides was possible in the large field plots during 1965 and 1967. Blast was too light for evaluation of the fungicides in 1966. Neck infection was substantially reduced by some fungicides while others gave partial control in 1965 and 1967.

In 1965 the use of fungicides provided for a significantly increased yield by significantly reducing neck infection. Two applications of fungicides were significantly more effective against neck infection than one alone (Table 3). However, two applications of fungicides did not significantly increase yields as compared to just one application. The interaction between fungicides and number of the spray treatment was highly significant indicating that some fungicides reduced neck infection in one spray while others gave a comparable control with two applications. One application of Blasticidin-S and Manzate was superior to two applications of some fungicides.

Du-Ter W-50 (two applications) and Blasticidin-S (one and two applications) were the best treatments tested. Although Blasticidin-S, PMA, Du-Ter W-50, and Fungicide 328 treatments increased the yield considerably, only Blasticidin-S was statistically different from the control (Table 4).

In 1967, Blasticidin-S, PMA, Fungicide 1991, Fungicide 328, Du-Ter W-50, Actidione and Dithane M-45 significantly reduced neck infection (Table 5). Manzate, which effectively controlled neck-rot in 1965, did not control neck infection in 1967. In contrast to the findings of 1965, there was no significant difference between one and two spray applications in 1967. In 1965 the second spray was made six days after the first spray. In 1967, due to unfavourable weather conditions, the first spray application was delayed by 2 days. This shortened interval between the first and second applications may have been responsible for the reduced effectiveness of a two-spray schedule.

TABLE 4.—AVERAGE YIELD OF RICE (CI-9205) SPRAYED WITH FUNGICIDES AT FIRST-HEAD AND FULL-HEAD STAGES OF DEVELOPMENT IN THE FIELD IN 1965.

Fungicide	Concentration (ppm)	Average yield (g)*	Statistical significance†
Blasticidin-S	40	549.0	a
Fungicide 328	3000	523.5	ab
PMA	75	517.3	ab
Du-Ter W-50	250	511.3	ab
Dithane M-22 Sp	800	493.7	ab
Dithane M-22	800	491.1	ab
TH 174-F	1500	488.0	ab
Dithane M-45	3200	478.2	ab
Manzate	3200	475.1	ab
Phygon-XL	500	474.5	ab
Pipron 25W	1000	471.8	ab
Pipron E.C.	980	469.0	ab
Control	0	406.5	b

*Based on the plants from the center 2, 18-foot long rows in each of 8 plots.

†Means not followed by the same letter differ significantly at the 1% level (Duncan's multiple range test).

In 1967 yield increases were not significantly different from the control but the yield increases with Blasticidin-S and Du-Ter W-50 significantly differ from PMA and Actidione (Table 5).

Yield was decreased in plots treated with PMA and Actidione even though the rice plants had fewer infected necks than the control. It is possible that the phytotoxicity encountered in rice sprayed with these fungicides offset the effect of less neck infection. The leaves treated with PMA showed chocolate-brown spots varying in size, closely resembling *H. oryzae*. The young panicles were also severely injured. The leaves treated with Actidione assumed a scorched, yellowish appearance with tip-drying. In 1965 a lower rate of PMA was used and only a slight bronzing of the flag leaf was observed in the plots treated with two applications. The rice panicles in these treatments were free from symptoms.

Leaf blast and eco-climatological conditions (lower night temperature, 20–25°C, and copious dew formation) are very important for the establishment of neck infection and further spread of disease in the branchlets of panicles.[12] In 1967, an environment favourable for neck infection existed only for a short period during the first heading stage. As a result fewer panicle branches were infected. However, in 1965, favourable conditions for blast infection prevailed over a long

TABLE 5.—FUNGICIDAL EFFECT ON THE CONTROL OF RICE BLAST IN THE FIELD IN 1967 SPRAYED AT FIRST-HEAD AND FULL-HEAD STAGES OF DEVELOPMENT OF RICE (BLUEBELLE).

Fungicide	Concentration (ppm)	Average number of rotten neck*	Average yield (gram)*	Statistical significance of rotten neck†	Statistical significance of yield†
PMA	150	1.9	519.1	a	c
Fungicide 1991	1000	2.4	734.0	a	ab
Blasticidin-S	40	2.9	756.7	a	a
Fungicide 328	3000	6.9	728.5	a	ab
Du-Ter W-50	250	7.5	749.8	a	a
Actidione	12	9.0	663.1	a	b
Dithane M-45	3200	10.0	694.6	a	ab
EL-331	330	12.4	698.1	ab	ab
Manzate	3200	13.6	721.2	ab	ab
Control	0	22.5	680.3	b	ab

*Based on the plants from the centre 2, 9-ft long rows in each of 8 plots.
†Means not followed by the same letter, differ significantly at 1% level (Duncan's multiple range test).

period even after the full heading stage of growth, and as a result, many of the branchlets of the panicles were affected.

Spore-trapping—a Method of Determining the Concentration of Spores in the Air:

In 1966 a few spores, from 7 to 10 per day, were trapped. There was little change in the number of spores trapped during a 7-week period. In 1967 no spores were caught during the early stages of growth of the rice plants. Increasing number of spores were caught during the third and fourth weeks of July when the rice plants were in the booting and first-head stages of growth. The spore-trapping data illustrate the importance of inoculum potential as a factor in the epidemiology of neck infection. Both the number of spores trapped and the amount of disease was low in 1966 and 1967. Similarly Kosaburo[8] reported mild outbreaks during the years in which they trapped 8 spores per slide, moderate outbreaks in years when they collected 24 spores per slide, and when they collected 175 spores per slide, they noted severe outbreaks. Under the prevailing microclimatic conditions in the experimental fields at Beaumont, dissemination of spores occurred exclusively at night between 3–5 a.m. Similarly, Hashioka[13] reported that conidia of *P. oryzae* are disseminated between midnight and daybreak.

Discussion

Phytotoxicity Test:

Phytotoxicity evaluations were made on one variety. Japonica varieties can tolerate higher dosages of PMA than indica varieties.[6] Similar observations have been made in Taiwan where indica varieties are used extensively.[14] This indicates that varieties of rice might be developed that would tolerate higher application of slightly phytotoxic fungicides. Different dosage rates should be determined for resistance and susceptible plant types.

Protection Test:

(a) *Greenhouse Experiment.*—This study indicates that leaf blast can be controlled reasonably by forming a chemical barrier to infection especially with PMA, Du-Ter W-50 and Blasticidin-S. Similar results reported in Japan,[6] in China[7] and in the United States.[15]

(b) *Field Experiment.*—In general, two sprays were better than one. The experimental evidence that neck infection decreases with an increasing number of spray applications is in agreement with the findings of Lindberg.[16] It seems likely that the protection granted by these chemicals with the exception of Blasticidin-S was very short-lived and perhaps lacked some properties essential for adequate control of blast with merely a single spraying.

The fact that Manzate controlled neck blast in 1965 but was ineffective in 1967 was disappointing. Materials from the same lot were used in both 1965 and 1967; as a result, the material used in 1967 was over two-year old. This age factor may account for its inefectiveness in 1967.

Repeated applications of fungicides are expensive. It may be preferable to use those materials which give reasonable disease control with a single application even though they may be less effective than two applications of others.

There was no difference in the reduction of neck infection between one-spray and two-spray applications of Blasticidin-S. That is, the incidence of disease at the time of first application did not build up further (Table 3). Blasticidin-S remained active during the period of panicle emergence and protected the plant from further infection. This material, in fact, increased the level of resistance to disease, a concept that has been suggested for napthaleneacetic acid, 2,3,5-triiodobenzoic acid, and napthaleneacetic acid in controlling tomato wilt.[17] This property is highly desirable because it minimizes the expense of control measures due to repeated applications.

When applications of fungicides are necessary for controlling neck blast, an interval of 6 days between first and second spray applications provides a realistic time interval. However, a time interval between applications is subject to change with weather conditions.

When leaf blast is low and the weather conditions are unfavourable for disease development, the disease will not spread and a second application of fungicides is unnecessary. Therefore, a spray schedule has to be devised with reference to the intensity of leaf blast in seasons favourable for the spread of blast during heading stages of growth. Knowing when the build-up occurs and being aware of the quantity of spores in the atmosphere (during the critical susceptible stages of plant growth) is useful in establishing these spray schedules.

Conclusion

(1) Although few resistant varieties are grown as minor varieties, large acreages are cultivated

with susceptible varieties. Until such susceptible varieties are replaced by the resistant ones, chemical control must be adopted to save the crop from heavy loss due to blast. (2) The results of 1965 and 1967 are so encouraging that it is anticipated that Research and Extension Pathologists will recommend the use of fungicides if and when they are cleared for commercial use. Blasticidin-S, Du-Ter W-50 and Fungicide 1991 were the best among the test materials. Fungicide 1991 was tested only in 1967, and, so, further trials are necessary for conclusive results. (3) The number of sprays will depend upon the incidence of the disease and its intensity. The spray applications for any stage may be dispensed with altogether if the disease is negligible or absent in that stage. In a season when both leaf and neck infection occur in a moderate form, one spray at first head and a second spray at full head stage with Blasticidin-S and Du-Ter W-50 (at the rate of 1.08 and 0.55 lb/acre, respectively) with 6-day interval is suggested for reasonable control of blast. However, a separate spray schedule has to be devised for severe outbreaks and with striking changes in weather conditions by trial experiments. (4) Although the organization of blast forecast is difficult, the data of spore concentration in the atmosphere will be helpful in monitering local infection pressure. This knowledge should be used for developing a spray schedule.

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