Factors of the Rice Blast Outbreak in Nile Delta, Egypt

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Introduction

In 1984 at Nile Delta in Egypt, blast disease widely occurred on a Japanese variety, Reiho, over an area of 20,000 ha, of which 19,000 ha were sprayed with fungicides for blast. Reiho (Giza 173), which was introduced into Egypt from Japan in 1980, was severely attacked by the blast disease in 1984. To make clear factors which induced such a severe outbreak of blast disease in Egypt, meteorological conditions, pathogenic specialization of blast fungus in paddy fields and chemical control of blast disease were investigated at the Rice Mechanization Center (R.M.C.) in 1986 to 1987.

Temperature, air humidity, and dew formation on rice leaves in paddy fields

Temperature, sunshine hour, air humidity and the length of dew period can influence multiplication and infection of the causal fungus to host plants. Especially, the length of dew period on the rice leaf surface is essential for spore germination, appressoria formation and infection to rice plants as well as for survival of blast spores. The period of leaf surface wetness and quantity of leaf surface water considerably influence epidemic blast occurrence. Accordingly, the length of the dew period on host plants is very important in predicting the degree of severity of blast occurrence. Therefore, the length of the dew period on rice leaves, the maximum and minimum temperatures during dew formation and the maximum air humidity were recorded in the paddy field of R.M.C., using a self-recording dew detector, MH-040 type (Eko Instruments Trading Co., Ltd. Tokyo, Japan) and a self-recording thermo-hygrograph, 3-1125-01 type (Isuzu Seisakusho Co., Ltd. Tokyo, Japan).

It was found that the length of dew period ranged from 13.0 to 17.0 hr at the experimental field (Table 1). Hashimoto[1] reported in Japan that rice blast spores can not germinate and develop when they do not come into contact with water for more than 3 hr. It can be said that the dew period from 13.0 to 17.0 hr is long enough for germination and development of causal fungus spores under the ambient climatic condition. Mean temperature during dew formation ranged from 22.0 to 27.0°C during the period from the end of August to September 20. The minimum and maximum temperatures recorded at the paddy field were 17 and 30°C, respectively (Table 1). It was reported[3,10] that the fungus sporulated at 12 to 34°C with the optimum temperature at 28°C, and that the infection percentage of germinated spores

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Table 1. The length of dew period, mean temperature during dew formation, maximum air humidity and maximum temperature in the paddy field of R. M. C., Nile Delta

Date	Length of dew period (hr)	Mean temperature during dew period (℃)	Maximum air humidity* (%)	Maximum temperature (℃)
	pm am			
Aug. 28-29	14.0 (7:00- 9:00)	23.0 (18-28)	85	32
Aug. 29-30	14.0 (7:30- 9:30)	22.5 (17-28)	96	32
Aug. 30-31	14.0 (7:30- 9:30)	24.0 (19-29)	93	31
Aug. 31-Sep. 1	13.5 (7:30- 9:00)	24.0 (19-29)	97	31
Sep. 1- 2	13.0 (8:00- 9:00)	24.5 (20-29)	95	32
Sep. 2- 3	14.5 (7:00- 9:30)	24.5 (20-29)	95	32
Sep. 3- 4	13.5 (8:00- 9:30)	24.5 (21-28)	96	31
Sep. 4- 5	14.5 (7:30-10:00)	23.5 (20-27)	97	30
Sep. 5- 6	13.5 (8:00- 9:30)	23.0 (19-27)	94	29
Sep. 6- 7	15.0 (7:00-10:00)	22.5 (18-27)	96	30
Sep. 7- 8	14.5 (7:30-10:00)	22.0 (18-26)	96	31
Sep. 8- 9	13.5 (8:00- 9:30)	22.0 (18-26)	96	30
Sep. 9-10	14.0 (7:30- 9:30)	23.5 (20-27)	95	30
Sep. 10-11	13.5 (8:00- 9:30)	23.5 (20-27)	95	29
Sep. 11-12	13.5 (8:00- 9:30)	24.0 (21-27)	97	29
Sep. 12-13	14.0 (7:30- 9:30)	25.5 (22-29)	97	29
Sep. 13-14	14.5 (7:30-10:00)	24.0 (21-27)	97	32
Sep. 14-15	14.5 (7:00- 9:30)	24.5 (22-27)	97	33
Sep. 15-16	15.5 (7:00-10:30)	25.5 (23-28)	97	31
Sep. 16-17	17.0 (6:30-11:30)	26.5 (24-29)	97	31
Sep. 17-18	16.0 (7:00-11:00)	27.0 (24-30)	96	33
Sep. 18-19	15.5 (7:00-10:30)	26.5 (24-29)	97	32
Sep. 19-20	15.5 (7:00-10:30)	26.5 (24-29)	97	31

* No rain during the whole period from Aug. 28 to Sep. 20, 1986.

reached the maximum 18 hr after spore deposition at 21, 24 and 27°C, and 21 hr at 18°C. The maximum air humidity was 85%–97% during these periods. It was also reported that[5] release of spores occurred experimentally at 80 to 100% of relative humidity, and that[2] sporulation occurred at the relative humidity 89% higher than with the optimum relative humidity higher than 93%. On the basis of these reports and the climatic data obtained in the paddy field of R.M.C. (Table 1), it may be concluded that the maximum air humidity in paddy fields in Nile Delta is most favorable to rice blast occurrence.

In addition the authors carried out a rice blast infection experiment, using two varieties, Reiho and Shin-2. Healthy seedlings grown in plastic cases were placed on blast-infested paddy fields for 24 hr (starting from 5:00 pm), and then returned into a vinyl house. After 7 days blast lesions were counted. The result (Table 2) indicates that blast infection and lesion development actually occurred under the climatic conditions in the paddy field.

Table 2. Infection of healthy seedlings exposed to a blast-infested paddy field for 24 hr

Date	Length of dew period (hr)	Number of lesions per rice seedling
	pm am	
Sep. 9-10	14.0 (7:30-9:30)	10.3*
Sep. 10-11	13.5 (8:00-9:30)	8.5
Sep. 11-12	13.5 (8:00-9:30)	7.0
Sep. 12-13	14.5 (7:00-9:30)	10.6

* Counted 8 days after starting the exposure.

Race distribution of rice blast fungus in Egypt in 1987

In Nile Delta, Giza 173 (Reiho) was

Table 3. Pathogenic races of blast fungus, *Pyricularia oryzae* isolated in paddy fields of Nile Delta

Governorate	Number of isolates	Pathogenic races								
		001	003	007	017	077	103	107	177	203
Kafr El Sheikh	9	4				1		2		2
Dakahlia	21	3	1	1	1	1	5	4	3	2
Gharbia	9			3	1			2	2	1
Beheira	3				1				1	1
Total	42	7	1	4	3	2	5	8	6	6

severely infected with the blast fungus in 1984. It has been known to be resistant for about 4 years, and suddenly became very susceptible, then, studies on pathogenic races were initiated in Egypt. Information on factors affecting the race distribution of the blast fungus is important in forecasting which races are likely to become prevalent in the future, for helping breeders in selecting sources of blast resistant genes. To clarify pathogenic specialization and race distribution of blast fungus in Egypt, experiments were conducted at the R.M.C.

Forty-two isolates sampled from four Governorates and ten Japanese differential varieties were used as experimental materials. Every differential variety represents each of main vertical resistance genes identified by Yamasaki, Kiyosawa, and others[4,9], as effective to Japanese blast fungus. Blast diseased leaves were sampled at 145 points selected from rice cropping areas of about 200,000 ha with the random sampling method. Of 145 lesions of leaf blast, only 42 strains were isolated with the spore isolation method, and races were identified. The lower isolation rate seems to be due to that the lesions sampled at the harvesting season were old, and blast fungi might not be alive.

Forty-two isolates were divided into nine pathogenic races as shown in Table 3. Nine races identified here are considered as the major races in Egypt. In addition to these nine races, it is also considered that some other pathogenic races exist in paddy fields of Nile Delta in Egypt. Races to virulent *Pi-z*^{t} and *Pi-b* varieties (Toride 1 and BL 1) seemed not to be distributed in 4 Governorates of Nile Delta. Such races as 001, 003, 007, 103 and 107 are identical to or closely resemble those found in Japan in their pathogenicity to Japanese differentials[8]. The most prevalent race was 107, followed by 001, 203, and 103 in that order. Race 203 was found in each Governorate, while race 103 was collected in only Dakahlia Governorate. As mentioned already, blast disease has widely and severely spread on a Japanese variety, Reiho, at Nile Delta in 1984. It was reported in Japan that race 103 was widely distributed in Fukuoka Prefecture, where Reiho was widely cultivated[8]. Reiho (Giza 173) is described to have resistance genes, *Pi-a* and *Pi-ta*^{2}, and if it is true, race 103 avirulent to *Pi-ta*^{2}, should be avirulent to Reiho. Yamada[8], however, also reported that Reiho is highly susceptible to the isolate identified as race 103. It was also reported so far that the distribution of blast fungus races is determined by vertical resistance genes of main rice varieties planted widely in a given area, and prevalent races alter with a change in the planted area of varieties with special vertical blast resistance. Based on the result shown in Table 3, it was recognized that blast fungus races virulent to each differential variety except Toride 1 (*Pi-z*^{t}) and BL 1 (*Pi-b*) were commonly distributed in Nile Delta. Therefore, it is concluded that the introduction of *Pi-z*^{t} or *Pi-b* varieties into Egypt and the introduction of these two genes to Egyptian rice varieties by breeding techniques are quite essential and generally recommended in order to control rice blast

Table 4. Severity of natural infection of leaf blast on leading varieties in farmers' fields of Kafr El Sheikh Governorate

Variety	Site	Stage of plant	Application of chemicals	Disease index*
Giza 171	1. Baklola	Booting	—	2.2
	2. Kallin	Booting	—	1.8
	3. Kallin	Booting	—	2.1
	4. Ahmed Lekhtiar	Booting	—	1.9
	5. Ahmed Lekhtiar	Flowering	—	2.5
	Average			2.1
Giza 172	1. Kallin	Booting	Once (EDDP)	1.9
	2. Kafr El Tayfa	Flowering	—	2.6
	3. Kallin	Booting	Once (EDDP)	2.5
	4. Kallin	Booting	—	2.3
	5. Kafr El Sheikh	Flowering	—	2.7
	Average			2.4
Giza 173 (Reiho)	1. Baklola	Flowering	Once (EDDP)	4.6
	2. Baklola	Flowering	—	3.7
	3. Baklola	Flowering	Once (Tricyclazole)	5.3
	Average			4.5

* Each figure except average is the mean of 30 hills.
Rating of disease index: 0; no lesion, 1; 1-3 lesions/hill, 3; 4-10 lesions/hill, 5; more than 10 lesions/hill or some leaves dried up, 7; some tillers stunted or many leaves dried up, 9; more than 50% of tillers stunted or dried up, 10; all tillers stunted or dried up.

in future by the use of vertical resistance of rice. Horizontal resistance, however, should be also considered in any genetic and pathological approach, since horizontal resistance may reduce damage caused by the breakdown of vertical resistance.

Observation of leaf blast occurrence on leading rice varieties in farmers' paddy fields

Leading varieties in farmers' fields in Nile Delta are Giza 171, Giza 172 and Giza 173 (Reiho). It can be said that these three varieties are susceptible to rice blast at different degrees according to the survey carried out at Kafr El Sheikh Governorate. Table 4 shows the severity of natural infection of leaf blast on these varieties. The average disease index of Giza 171 was low, while that of Giza 173 was high, and Giza 172 showed a slightly higher index than Giza 171. It was also observed that the degree of infection of these varieties in farmers' fields was higher than that in experimental fields of the R.M.C. This difference may be explained as follows:

(1) Farmers do not use fungicides for seed disinfection.

(2) Farmers apply too much nitrogenous fertilizer or sometimes animal manure to

Table 5. Leaf blast occurrence on rice plants (Giza 172), transplanted with a mechanized or traditional method at Kallin district in Kafr El Sheikh Governorate

Item surveyed	Mechanized	Traditional
Number of hills/m²	24	16
Number of seedlings/hill	5	20
Number of tillers/hill*	22	28
Transplanting date	June 15	June 29
Average disease index**	2.3	3.8

* Number of tillers/hill was counted one month after transplanting.
** See the footnote of Table 4.

their paddy fields.

(3) Farmers practice late transplanting after the end of June. This seems to be the most important factor inducing severe occurrence of leaf blast.

In addition, it must be noted here that the traditional practice of transplanting rice seedlings results in extremely high planting density, which induces increased disease infection (Table 5), because the higher is the planting density, the more the blast fungus spores stay within the plant population[7].

Chemical control of rice blast disease

To examine effectiveness of fungicides available on the domestic market (Tricyclazole 20%, EDDP 30% and IBP 17%) and those expected to be introduced into Egypt (Isoprothiolane 12%, Probenazole 8%, and Futhalide 2.5%), a chemical control experiment was carried out. Giza 172 which is susceptible to blast disease was transplanted two weeks later than the normal planting date. In addition, nitrogen fertilizer was applied at the rate of two times normal dose. However, leaf blast occurred unexpectedly less. Fungicides were sprayed only once at the maximum tillers stage (August 20, 1987). Ten hills were sampled from each plot (21 m²) and the number of blast lesions on uppermost two leaves and of neck and rachis blast was counted on October 17 to 18.

1) Leaf blast

As shown in Table 6, all the fungicides are effective in controlling leaf blast with statistical significance. Futhalide 2.5% seems to be more effective than EDDT 30% for controlling leaf blast. However, since this result was based on the observation made late for the leaf blast occurrence, further experiments may be needed for confirmation.

2) Neck and rachis blast

The timing of scoring neck and rachis blast seemed to be appropriate. The result indicates that IBP 17%, Futhalide 2.5%, Isoprothiolane 12%, EDDP 30% and Tricyclazole 20% are not appreciably effective, whereas Probenazole 8% is significantly effective. Probenazole is generally known to have strong systemic fungicidal effect against leaf blast. The cost of fungicide application to blast disease was reported to be only 1.5–4.0% of the value of the product[6]. Although the fungicidal treatment is not generally practiced in the tropics, due to technical and socio-economic limitations, the above result indicates that chemical control of rice blast is economically worthwhile.

Table 6. Effect of fungicide spray to control rice blast disease on Giza 172* in a paddy field

Fungicide**	Application rate (formulation/10 a)	Number*** of	
		Leaf blast lesions	Neck blast
Tricyclazole (20% WP), 1000 T	30 l	4.3 bc	4.3 bc
Isoprothiolane (12% G)	3 kg	7.3 bc	5.7 ab
EDDP (30% EC), 1000 T	100 l	9.0 b	5.2 ab
IBP (17% G)	3 kg	7.3 bc	6.7 a
Futhalide (2.5% Powder DL)	3 kg	2.0 c	6.4 ab
Probenazole (8% G)	3 kg	5.0 bc	2.8 c
Control (unsprayed)	—	16.0 a	6.3 ab

* Planted at the density of 24 hills/m² with a 4-rows walking type transplanter. Any phyto-toxic effect was not observed at the dosage adopted.

** WP: wettable powder, EC: emulsifiable concentrate, G: granule, T: dilution times.

*** The number of blast lesions and of neck blast per hill. Mean of three replications each conducted in a field plot of 21m².

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References

1) Hashimoto, A.: Water droplets on rice leaves in relation to the incidence of rice blast. Use of the dew balance for forecasting the disease. *Rev. Plant Protec. Res.*, **14**, 112–126 (1981).
2) Hemmi, T. & Imura, J.: On the relation to air humidity to conidial formation in the rice blast fungus, *Pyricularia oryzae*, and the characteristics in the germination of conidia produced by the strains showing different pathogenicity. *Ann. Phytopathol. Soc. Jpn.*, 9, 147–156 (1939) [In Japanese with English summary].
3) Katoh, H. & Sasaki, T.: Epidemiological studies of rice blast disease, with special reference to reproductive process in lesions on rice plants and disease forecast. *Bull. Nat. Inst. Agr. Sci. Ser.*, **C 28**, 1–61 (1974) [In Japanese with English summary].
4) Kiyosawa, S.: Studies on genetics and breeding of blast resistance in rice. *Bull. Nat. Inst. Agr. Sci. Ser.*, **D 1**, 1–58 (1974) [In Japanese with English summary].
5) Kobayashi, J.: Survey and analysis of actual conditions of rice blast development in Akita Prefecture. *In* Spec. Rept. 6 Proc. Assoc. Plant Prot. North Jpn., 34–48 (1965) [In Japanese].
6) Ou, S. H.: Rice diseases. Commonwealth Mycological Institute, London, 161–169 (1972).
7) Suzuki, H.: Studies on the behavior of rice blast fungus spores and application to outbreak forecast of rice blast disease. *Bull. Hokuriku Nat. Agr. Exp. Sta.*, **10**, 1–118 (1969) [In Japanese with English summary].
8) Yamada, M.: Pathogenic specialization of rice blast fungus in Japan. *JARQ*, **19**, 178–183 (1985).
9) Yamasaki, Y. & Kiyosawa, S.: Studies on inheritance of resistance of rice varieties to blast. I. Inheritance of resistance of Japanese varieties to several strains of the fungus. *Bull. Nat. Inst. Agr. Sci. Ser.*, **D 14**, 39–69 (1966) [In Japanese with English summary].
10) Yoshino, R.: Ecological studies on the infection in rice blast epidemics. Dew temperature and sequent change of infection rate. *Ann. Phytopathol. Soc. Jpn.*, **39**, 186 (1973) [Abstract in Japanese].

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