Seed Treatment for Control of Seed-Borne *Fusarium roseum* on Wheat

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Wheat scab, caused by *Fusarium roseum*, occurs severely during the period from the flowering to milk-ripe stage of wheat in years of high temperature and high humidity (Plate 1). In the warm southwestern region of Japan, the flowering to harvesting stage of wheat coincides with the rainy season (so-called Bai-u), and hence the disease often outbreaks. The disease occurs mainly on panicles, and directly affects grain yields. In addition, the pathogen of the disease produces trichotecenes mycotoxin harmful to men and beasts. Feed containing scab-infected grains at more than 10% was toxic to livestock[1].

The scab is an air-borne disease, but it is known that it performs seed transmission. Mycelia grown from diseased seeds infect adjacent healthy seeds, causing the damping off in severe cases[9] (Plate 2). Therefore, to prevent the seed transmission and disease occurrence in the early growth stage of wheat, the use of healthy seeds and seed disinfection are indispensable. In this connection, the authors conducted seed disinfection experiments on diseased seeds[5,6]. In the present paper separation of healthy seeds from diseased ones by specific gravity. and various methods of seed disinfection will be described.

Separating healthy seeds from diseased ones by specific gravity

Diseased seeds, infected with scab, are not fully ripened: weight of each seed is lighter than that of healthy seeds. The seed selection using salt solution of specific gravity higher than 1.16 was effective to reduce the percentage of diseased seeds, but not enough to remove completely diseased seeds (Table 1). As Asuyama pointed out, it is desirable to practice seed disinfection with chemicals after the seed selection by specific gravity, in order to get complete effectiveness.

For rice Bakanae disease, Kitamura[3] recognized that seed selection by specific gravity could not completely prevent the disease occurrence, but removal of seeds infected with the pathogen could increase the effectiveness of fungicidal seed disinfection.

As to the seed selection for wheat scab, it was reported that seeds with specific

Table 1. Effect of seed selection with salt solution in separating healthy seeds from seeds infected with *Fusarium roseum*

Specific gravity	Percentage of infected seeds[a]					
	Floated seeds			Sunk seeds		
	Days after sowing			Days after sowing		
	3	6	10	3	6	10
Water (1.01)	48.9[b]	55.5	55.5	4.5	10.5	12.0
1.04	35.2	54.7	56.4	3.0	11.0	16.5
1.07	47.5	53.4	58.3	3.5	10.5	15.0
1.10	51.3	51.4	52.2	3.5	13.0	15.0
1.13	45.3	64.0	64.5	4.0	10.0	15.0
1.16	35.8	51.8	53.8	3.0	5.0	6.5
1.19	50.0	56.3	59.8	1.0	4.5	5.0
1.22	35.7	56.1	61.5	1.0	4.0	4.5
1.25	15.9	29.0	33.7	0.5	4.0	5.5
1.27	12.2	20.9	24.6	0.0	1.5	2.5

a) : Cultivar Gabo. b) : Numerals indicate the means of 4 replications.

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Plate 1. Symptoms of wheat scab on cultivar Gabo

Plate 2. Symptoms of seedlings infected with *Fusarium roseum* by seed transmission

gravity higher than 1.20 were selected[2]. As shown above, in our experiment, selection of seeds with specific gravity higher than 1.16 remarkably lowered the percentage of diseased seeds. This difference may be due to a varietal difference of wheat.

Methods of seed disinfection

1) Disinfection with dry heat

This method is employed to various kinds of diseases caused by virus (lettuce mosaic disease, tomato mosaic disease, etc.), bacteria (tomato bacterial canker, bacterial spot of cucumber, etc.), and fungi (Fusarium wilt of bottle gourd) and its effectiveness is generally recognized[4].

Lethal temperature to *Fusarium roseum* in dry heat disinfection is given in Fig. 1. The temperature treatment at 30–45°C did not kill the pathogen even when the treatment was done for 10 days. On the contrary, at the temperature of 50–75°C the rate of survival of the pathogen decreased with the increase of treatment period and finally reached 0% of survival. However, at the temperature of 60–75°C, germination percentage of wheat seeds was reduced seriously.

Effect of the dry heat treatment on naturally infected seeds and artificially infected seeds with scab is shown in Table 2. Percentage of infected seeds decreased in all the treatment plots with the increase of the number of days of treatment, reaching less than a half

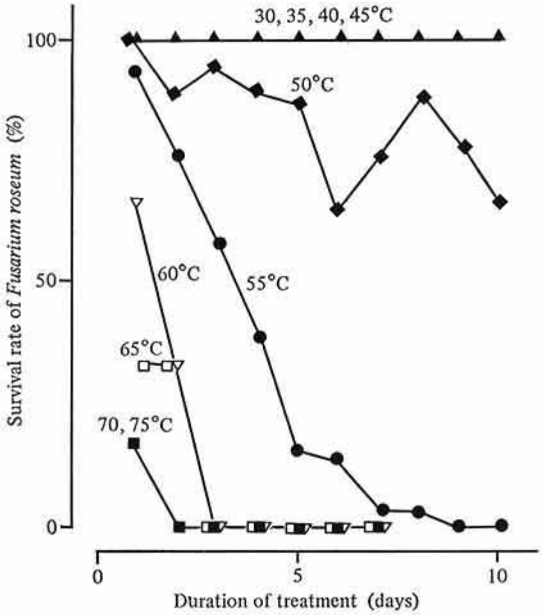

Fig. 1. Effect of temperature and duration of dry heat treatment on survival rate* of *Fusarium roseum*

* Survival rate was measured as follows: *F. roseum* was incubated for 7 days on PSA in a petri dish. Mycelia were cut into 1 cm square and treated with dry heat for 0 to 10 days. Three pieces of treated mycelia disk were placed on other PSA and incubated for 3 days at 25°C.
Data are the means of 3 replications.

Table 2. Effect of dry heat treatment on wheat seeds infected with *Fusarium roseum*

Seeds used[a]	Treatment temperature	Percentage of infected seeds after treatment[d]									
		Treatment periods (days)									
		1	2	3	4	5	6	7	8	9	10
Naturally infected seeds[b]	50°C	72.0[e]	74.0	69.0	56.0	56.0	64.0	44.0	33.0	44.0	31.0
	55°C	72.0	55.0	52.0	43.0	53.0	58.0	23.0	35.0	46.0	37.0
	Control	78.0									
Artificially infected seeds[c]	50°C	17.5[f]	12.7	17.3	6.7	14.0	10.7	8.0	6.7	14.0	6.7
	55°C	29.3	11.3	6.7	9.3	10.7	5.3	2.7	2.7	5.3	5.3
	Control	22.2									

a) : Cultivar Gabo. b) : Seriously infected seeds were collected in the field.
c) : Healthy seeds were dipped in spore suspension containing sticker at 0.03 % for a few min and air-dried. The spore suspension was prepared from the barley medium culture incubated for 7 days at 25°C.
d) : At 10 days after sowing. e) : Means of 2 replications. f) : Means of 3 replications.

Table 3. Effect of fungicides on wheat seeds infected with *Fusarium roseum*

Fungicide	Application	Percentage of infected seeds after treatment	
		Naturally infected seeds	Artificially infected seeds
Thiuram-benomyl	Dry dressing (0.5% of seed weight)	5.3 b	1.3 b
Thiuram-thiophanate-methyl	Dry dressing (0.5% of seed weight)	8.7 b	0.7 b
Thiuram-benomyl	Soaking in solution (diluted : ×200) for 24 hr	0.0 b	2.7 b
Thiuram-thiophanate-methyl	Soaking in solution (diluted : ×200) for 24 hr	0.0 b	1.3 b
Control (Dry seeds)	—	60.3 a	33.3 a

Means followed by a common letter within a colum are not significantly different at the 5% level.

of that of the control plot after 10 days of treatment, but never reached 0%. This result indicates that the temperature lower than 55°C which gives no adverse effect on seed germination can prevent, to some extent, the disease occurrence from the diseased seeds, but it seems not enough as a method of seed disinfection.

2) Disinfection with fungicides

As fungicidal disinfection, thiuram-benomyl wettable powder (active ingredient: thiuram 20%, benomyl 20%) and thiuram-thiophanate-methyl wettable powder (active ingredient: thiuram 30%, thiophanate-methyl 50%) were used, each in two application forms: dressing seeds with fungicide powder, and soaking seeds in fungicide solution. The dressing was done by shaking the conical flask containing seeds and fungicide (0.5% of the weight of the dry seeds) to make even dressing on seed surface. For the soaking treatment, seeds were placed in fungicide solution (diluted: ×200) at 15°C or higher, at the volume ratio of 1 : 2 for 24 hr. After the treatment, seeds were air-dried without rinsing with water.

Table 3 shows effect of fungicidal disinfection on wheat seeds infected with scab. Although the dressing treatment appeared somewhat less effective, the result of statistical treatment shows that all the disinfection treatments are very effective without significant differences among different treatment plots.

3) Dual disinfection with cold and hot water treatment and fungicidal treatment

In the former treatment, wheat seeds were soaked in tap water for 10 hr, and then placed in hot water (50°C) in a water-bath for 1 min, followed by hot water (54°C) for 5 min. Then, the seeds were cooled with tap water for 1 hr, and air-dried.

After the cold and hot water treatment, the air-dried seeds were subjected to the fungicidal treatment. As shown in Table 4, the fungicides used and methods of application were the same as given in the foregoing section *2)*.

Effects of the cold and hot water treatment, and of the dual treatment on the scab-diseased wheat seeds are shown in Table 4. The cold and hot water treatment appears to be less effective than the dual disinfection method. However, the result of statistical treatment indicates that there is no significant difference between them. Very high effectiveness of disinfection was recognized in all the treatment.

4) Effect of the seed disinfection on germination and growth of wheat

Any seed disinfectant which gives adverse effect, such as phytotoxicity, to seeds or plants can not be of practical use, even

Table 4. Disinfection effect of cold and hot water and water-chemical treatment on wheat seeds infected with *Fusarium roseum*

Treatment	Percentage of infected seeds after treatment	
	Naturally infected seeds	Artificially infected seeds
Cold and hot water treatment, 50°C for 1 min, 54°C for 5 min.	6.7 b	2.7 b
Cold and hot water treatment and seed dressing with thiuram-benomyl	0.0 b	0.0 b
Cold and hot water treatment and seed dressing with thiuram-thiophanate-methyl	0.0 b	0.0 b
Cold and hot water treatment and seed soaking with thiuram-benomyl at 200 times for 24 hr	0.0 b	0.0 b
Cold and hot water treatment and seed soaking with thiuram-thiophanate-methyl at 200 times for 24 hr	0.0 b	0.0 b
Control (Water soaking for 24 hr)	46.7 a	33.3 a

See the footnote of Table 3.

Table 5. Effect of seed disinfection on seed germination of some wheat cultivars

Cultivar	Treatment	Germination (%)		
		Days after sowing		
		3	7	10
Norin 61	TB soaking	100	100	100
	TT soaking	100	100	100
	Hot water	62	100	100
	Control	96	98	98
Shirogane-komugi	TB soaking	98	100	100
	TT soaking	100	100	100
	Hot water	84	98	98
	Control	98	98	98
Shirasagi-komugi	TB soaking	98	100	100
	TT soaking	100	100	100
	Hot water	100	100	100
	Control	100	100	100
Omase-komugi	TB soaking	98	100	100
	TT soaking	88	100	100
	Hot water	84	96	96
	Control	100	100	100
Gabo	TB soaking	72	82	84
	TT soaking	74	84	86
	Hot water	16	68	68
	Control	68	80	80

TB : Thiuram-benomyl, TT : Thiuram-thiophanate-methyl, Hot water : cold and hot water treatment, Control : Water soaking for 24 hr.

though how high its fungicidal effect is. In view of this, effect of the cold and hot water treatment and two kinds of fungicides, which are found very effective as seed disinfectants against scab, on seed germination and initial growth of wheat was examined, using five different varieties as test plants (Tables 5 and 6). The cold and hot water treatment showed a little lower germination percentage three days after sowing, but the percentage after seven days from sowing became as high as that of the untreated control. The fungicides used were also recognized to have no adverse effect on wheat germination. A variety, Gabo, showed lower germination rate than other varieties, because its seeds used were harvested in the previous year.

Regarding the seedling growth (in length), the effect of the cold and hot water treatment was similar to that observed with germination percentage: slightly retarded initial growth recovered after 14 days from sowing, except Omase-komugi. In general, it can be considered that all these methods of seed disinfection exert almost no adverse effect on germination and growth of wheat seedlings.

Conclusion

At present in Japan, the following fungicides are registered as seed disinfectants of wheat or barley[7].

To loose smut: Thiuram-benomyl wettable

Table 6. Effect of seed disinfection on seedling growth in some wheat cultivars

Age	Cultivar	Seedling length (cm)			
		TB soaking	TT soaking	Hot water	Control
7 days after sowing	Norin 61	8.9	8.5	6.5	8.4
	Shirogane-komugi	9.1	9.6	7.8	9.8
	Shirasagi-komugi	8.9	8.5	7.9	9.7
	Omase-komugi	8.6	7.9	6.0	9.0
	Gabo	8.1	8.0	4.6	8.1
14 days after sowing	Norin 61	17.8	18.5	17.8	20.0
	Shirogane-komugi	19.6	18.9	19.1	19.6
	Shirasagi-komugi	18.8	17.0	18.3	20.0
	Omase-komugi	17.5	17.3	14.5	16.9
	Gabo	15.8	15.2	15.0	16.4

See the footnote of Table 5.

powder.

To stinking smut and stripe: Thiuram-thiophanate-methyl wettable powder and thiuram-benomyl wettable powder.

On the other hand, seed distinfection by the cold and hot water treatment or hot bath-water treatment (hot-bath disinfection) is adopted for various kinds of smut and stripe diseases of wheat and barley[8]. Since the seed disinfection is highly effective in controlling these diseases, the seed disinfection has become an important pest-control technique in the cultivation of wheat and barley.

The present study made clear that the selection of healthy seeds by specific gravity and dry heat treatment of seeds are less effective in controlling scab, whereas the cold and hot water treatment and fungicidal treatment (thiuram-benomyl and thiuram-thiophanate-methyl) are highly effective, and very much advantageous for saving expenses and labor of controlling scab. Although we did not carry out any experiment on barley scab, we consider that the result obtained with wheat scab may be applicable to barley scab.

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