On the hot bath water treatment of wheat seed for the control of loose smut, *Ustilago tritici* Rostrup*

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A. Bath water seed soaking method

First of all we shall have to explain about our usual manner of taking a bath and about

Fig. 1. Iron bath-tub

some kinds of bath-tubs which are common in the Japanese countryside (Fig. 1 and Fig. 2). We are accustomed to washing ourselves outside the tub as though taking a shower, then using the tub two or three times, usually 1 to 2 minutes per person. The temperature of water is usually kept at about 42° to 44° C., and the tub is heated gently by the attached oven during the bathing.

The bath water seed soaking method for the control of loose smuts of wheat and barley was devised at about 1920(1,2). Owing to its high validity and simplicity the method was soon accepted by many farmers. The method is as follows: After the temperature of the

water has risen to 45° to 46° C., the oven fire is entirely put out. Wheat or barley seed in a package whose capacity is about 15 liters, is suspended in the water and the container, with a slightly opened lid, is allowed to remain there for about 10 hours until the water temperature descend down to about 25° C.

B. Temperature depression of bath water

We intended to ascertain the mode of depression of water temperature under the above stated method with

Fig. 3. Plan of mortar-tub

Fig. 4. Section of iron-tub

bathtubs of several different structures and water depths, and to ascertain the time required for seed soaking for the control of loose smut of wheat. We employed for this purpose three kinds of bath-tubs, namely a mortar-tub (Fig. 3), an iron-tub (Fig. 4), and a wooden-tub (Fig. 5). Each of them had about 300 liters capacity.

Fig. 5. Wooden bath-tub

The results obtained from the experiment concerning the rate of temperature depression of water, in cases of wooden-tubs with several different kinds of water depths, are given in Table 1 and Fig. 6. From the results, it is evident that the velocity of temperature fall of water at a definite time is proportional to the temperature at that time, and the depression curve of water temperature (θ) will be represented (4) by the exponential formula, $\theta = \theta_0 e^{-\alpha t}$ where θ_0 is the initial temperature of water, t is the time elapsed from the beginning, and α is a constant. In case the quantity of water in the tub is larger the temperature

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Fig. 5. Section of wooden-tub.

Fig. 6. Water temperature depression curves of wooden-tubs, when water depths were varied.

tubs were nearly filled with water, no decided difference between the temperature fall curves of these three kinds of tubes was observed, though the data were not presented here.

C. Wheat seed soaking experiment with bath water

The bath-tub employed for the wheat seed soaking experiment was a wooden-tub nearly equal in size to the one above, and was nearly filled with water. Wheat seed, which had been infected with loose smut on the previous year by the partial vacuum method of Oort (3) was used for the experiment.

After the water temperature was adjusted at 46°C., 21 packages each filled with 10g. of smut affected seed, were suspended in the water. At each time interval as given in

depression is smaller as it is presented in Fig. 6.

Table 1. Temperature depression of water wooden-tubs of various water depths.

Water depth	54.5 cm		39.5 cm		20 cm	
Hours after soaking	Observed	Calculated	Observed	Calculated	Observed	Calculated
0	58.0	58.0	59.0	59.0	57.0	57.0
1	54.0	55.0	53.0	54.5	48.0	50.5
2	51.0	52.1	48.9	50.4	43.0	44.6
3	48.6	49.3	45.0	46.3	38.0	39.5
4	46.0	46.8	41.5	43.0	34.0	35.0
5	44.0	44.3	39.0	39.7	31.0	30.9
6	42.0	42.0	36.6	36.7	27.4	27.4
7	40.0	39.8	34.0	33.9	24.0	24.2
8	38.1	37.7	31.5	31.4	21.8	21.4
9	35.6	35.7	28.9	29.0	19.8	19.0
10	33.6	33.8	26.8	26.8	18.0	16.8
11	31.8	32.1	25.4	24.7	16.6	14.9
12	30.1	30.4	24.0	22.9	15.4	13.1
13	28.8	28.8	23.0	21.1	14.4	11.6
14	27.6	27.3	21.7	19.5	13.4	10.3
15	26.5	25.8	20.6	18.0	13.2	9.1
Room temp	7.5-16.5		7-11		6.75-10	

Calculated numbers were obtained from the formula $\theta = \theta_0 e^{-at}$

Fig. 7 shows the results of the experiment when these three kinds of tubs were compared. In this case, each tub was kept nearly half of full water. This figure shows that the temperature depression curves are somewhat different from each other.

In the case when

Fig. 7. Water temperature depression curves of three kinds of bath-tubs, when each was half filled with water. N: mortar-tub, I: iron-tub, W: wooden-tub

Table 2, three packages were pulled out from the tub and drenched in cold water for 5 minutes. Wheat seed steeped for 5 minutes in cold water was used for the control. On Dec. 12th 200 grains from each of the packages were sown in field. At the heading time the number of the smut affected plants was counted. The results are given in Table 2 and Fig. 8. It is obvious from these data that the hot bath water method is quite effective when seed soaking time is kept not less than 5 hours. While no ill-effect on the germination capacity is observed even when smut affected seed is soaked for 10 hours as given in Table 3.

Table 2. Seed soaking hours by the bath water method and the percentage of the smutted wheat plants.

Soaked hours	0	1	2	3	4	5	10
I	49.5	33.1	10.8	2.9	2.7	0	0
II	54.3	29.9	11.3	3.7	2.4	0	0
III	—	31.2	24.3	13.6	2.3	1.7	1.2

Table 3. Germination percentage of the smut affected seed (50 grains) treated with the bath water method.

Soaked hours	0	1	2	3	4	5	10
I	90	78	98	90	100	84	74
II	100	92	84	90	100	94	96
III	—	98	84	100	96	90	98

Fig. 8. Seed soaking hours by the hot bath water method and their efficiencies for the control of loose smut of wheat.

Summary

1) The bath water seed disinfection method, which is widely used in Japan for the control of loose smut of wheat, *Ustilago tritici*, is as follows:

After temperature of the bath water has risen to 45° or 46°C., the oven fire is put out. Wheat seed in a package is suspended in the hot water in a container with a slightly opened lid for about ten hours until the water temperature descends down to about 25°C.

2) Present experiments were carried out to ascertain the rate of decrease of water temperature under above stated method with bath-tubs of several different structures and water depths, and the time required for seed soaking for the control of loose smut of wheat. Three kinds of bath-tubs were used, namely, a mortar-tub, directly heated with side oven, an iron-tub directly heated from below, and the common wooden-tub directly heated with side oven. Each of them had about 300 liters capacity. Wheat seed which had been inoculated with the fungus by the partial vacuum method of Oort was used.

3) The results obtained were as follows:

- i) The rate of temperature decrease at a definite time was proportional to the temperature of bath water at that time.
- ii) In case when the quantity of water was larger the rate of temperature decrease was smaller.
- iii) When the initial temperature of hot water was kept between 46°C. to 50°C., and the bath-tubs were filled with water, the difference of the rate of temperature fall due to the structure of bath-tubs was not so great as to disturb the practical use of the bath water soaking method.
- iv) It was found that five hours' soaking was sufficient for the control of the loose smut of wheat in case the initial temperature was kept at 46°C.
- v) No ill-effect for the germination of wheat seed was found when the initial temperature of bath water was kept at 46°C. and the fire was put out, even if the seed was soaked for ten hours

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