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STUDIES ON THE INFECTION OF *PIRICULARIA* *ORYZAE* BR. ET CAV. ON MALTREATED RICE PLANTS

By

Yoshihiko TOCHINAI and Shonosuke KOMIYA

Introduction

An outbreak of "Imochi", the rice blast disease, seems to follow a depression in the resistance of rice plants to attack by the parasite owing to their physiological disorder caused by some unfavorable influences. In reality, several epidemics of the disease have broken out, which accompanied unfavorable climatic conditions, an excess of nitrogensous manure, poor drainage, or after a drought and so forth.

SALMON (5) found that some biologic forms of *Erysiphe graminis* DC. parasitic on *Bromus spp.* could infest the leaves of normally immune species immediately after some maltreatment. He demonstrated experimentally that the immunity of some host species to certain biologic forms of the powdery mildew fungus was temporarily lost after some maltreatment, namely by giving wounds, by exposing to vapor of narcotics, by immersing in diluted alcohol or by immersing in hot water at certain temperature, and that they were affected by normally indifferent biologic forms of the fungus. He expressed this parasitic phenomenon by the term "Xenoparasitism".

The present writers intended to study what happens to the resistance of rice plants to the "Imochi" disease as a result of maltreatment, purposing practically to throw light on the problem of the "Imochi" resistance of rice plants.

With this aim in view experiments were carried out to learn how and to what extent the percentage of the blast infection increases on the rice plants which were maltreated in the following ways:

- a) Giving various external wounds, or mechanical shocks;
- b) Keeping under abnormally dry or humid conditions;
- c) Exposing to the narcotic vapors of ether, chloroform, and absolute alcohol;
- d) Keeping at abnormally high temperature;
- e) Immersing in hot water at certain temperatures.

1. Experiments on the Influence of External Wounds or Mechanical Shocks upon the Blast Susceptibility of Rice Plants

It is practically possible that the rice plants grown in field may frequently be wounded by various agencies. Therefore if the external injury increases the susceptibility of rice plant to the blast disease, it is connected somewhat deeply with the outbreak of the disease. The hereafter described experiments were carried out to learn whether or how the giving wounds increases the percentage of infection of the "Imochi" fungus on rice plants, with the other meaning than the wound infection.

As the host plants, "Bozu" No. 5, the resistant variety, and "Akage" No. 3, the susceptible variety, were used in these experiments. The rice seeds used were the yields of 1935 in the experimental fields of the Hokkaido Agricultural Experiment Station.

The rice blast fungus used for inoculation was the strain isolated by Mr. M. SHIMAMURA from the diseased spikes harvested in Shimo-ina, Prov. Shinano in 1930, and cultured on steamed rice straw medium for 30 to 50 days.

EXPERIMENT 1.

On June 10, 1936, 100 grains each of "Bozu" and "Akage" varieties were superficially sterilized by means of immersing in 0.1% aqueous solution of mercuric chloride for 3 minutes, and having been washed thoroughly with sterilized water, they were allowed to germinate in Petri dishes at 23°C. in a thermostat to secure the seedlings for examination.

On July 15, the seedlings were planted in pots which were filled with loam soil fertilized with ammonium sulphate 2.3 g., calcium superphosphate 1.2 g. and potassium sulphate 0.3 g. Ten seedlings

were planted in each pot which measured 15 cm. both in diameter and in depth, and then they were placed outdoors.

On August 21, the pots bearing the rice plants were divided into 2 lots, A and B, and the plants other than the control were wounded by needle-prickings.

Lot A: Control, with no special treatment.

Lot B: Plants were given wounds on every leaf by pricking with a sharp sterilized needle.

Inoculation was made immediately after the treatment. The spore suspension of the rice blast fungus was prepared by taking the conidia produced in 30-50 days cultures on the steamed rice straw medium in sterilized water. The spore suspension was sprayed by an atomizer on the plants. After the inoculation the plants were placed in a moist chamber of saturated humidity for 48 hours, and then they were taken out and placed outdoors.

On September 4, the results of the inoculation experiment were examined by observing the spots which had appeared on the leaf-blades in consequence of infection of the fungus and comparisons were made between the wounded plants and the untreated controls. The experimental results are shown in the following Table I.

TABLE I. Results of inoculation experiments on rice plants pricked by needles.

Variety of rice plants	Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)	
Lot A Control	Bozu	13	81.23	7.7	0.0400	0.3784	0.55
	Akage	17	80.25	8.6	0.2483	2.6439	0.58
Lot B Treated	Bozu	19	76.03	5.8	0.3091	2.3543	0.53
	Akage	19	77.02	5.5	0.5095	3.6354	0.56

In these results it was recognized that the percentage of infection was evidently higher on the leaves of the maltreated plants than that on those of the controls. The contrast between the control and the treated plants was especially remarkable in "Bozu", the resistant variety.

EXPERIMENT 2.

On July 15, 100 grains each of sterilized seeds of "Bozu" and "Akage" varieties were sown in sterilized sand in pots measuring 11 cm. both in diameter and in depth, and the seedlings were raised in a greenhouse.

On July 25, the seedlings were planted in pots which were filled with loam soil fertilized with 2.5 g. of ammonium sulphate, 1.4 g. of calcium superphosphate, and 0.5 g. of potassium sulphate. Ten seedlings were planted in each pot which measured 18.5 cm. both in diameter and in depth.

On September 14, the pots bearing the rice plants were divided into 3 lots, A, B, and C, and the plants other than the control were maltreated.

Lot A: Control, with no special treatment.

Lot B: Leaves were pricked with sharp needles.

Lot C: Leaves were struck and rubbed with a flat piece of wood.

Inoculation was made immediately after the treatments by spraying spore suspension with an atomizer. The plants after having been kept in a moist chamber for 48 hours, were placed outdoors.

On September 25, the results of the inoculation experiment were examined by counting the lesions caused by the infection of the fungus. The results are shown in the following Table II.

TABLE II. Results of inoculation experiments on rice plants pricked with needles or struck with a flat piece of wood.

Variety of rice plants	Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)	
Lot A Control	Bozu	19	60.48	12.6	0.0375	0.7832	0.55
	Akage	19	61.85	18.1	0.0385	1.1060	0.67
Lot B Pricked	Bozu	20	56.57	13.5	0.0720	1.6750	0.56
	Akage	20	61.24	16.5	0.0727	1.6330	0.68
Lot C Struck	Bozu	20	54.30	13.6	0.0812	2.0280	0.67
	Akage	20	56.36	15.1	0.0825	2.2170	0.70

A higher percentage of the infection occurred on the maltreated plants with no exception; it was especially remarkable on the plants which had been struck with a flat piece of wood.

EXPERIMENT 3.

On August 19, 100 grains each of sterilized seeds of "Bozu" and "Akage" varieties were sown in pots filled with sterilized sand, and the seedlings were raised in a greenhouse.

On August 29, the seedlings were planted in square cornered zinc boxes which were filled with loam soil fertilized with 7.5 g. of ammonium sulphate, 4.4 g. of calcium superphosphate, and 1.6 g. of potassium sulphate. Fifteen seedlings were planted in each box of 40 by 30 cm. in dimensions and 15 cm. in depth, and they were placed outdoors.

On September 17, the boxes bearing the rice plants were divided into 2 lots, A and B, and the seedlings other than the control were struck and rubbed with a flat piece of wood.

Lot A: Control, with no special treatment.

Lot B: Maltreated plants.

Inoculation was made immediately after the treatments by atomizing the spore suspension. The plants after having been kept in a moist chamber for 48 hours, were placed outdoors.

On September 27, the results of the inoculation experiments were examined by counting the lesions caused by the infection of the fungus. The experimental results are shown in the following Table III.

TABLE III. Results of inoculation experiments on rice plants bruised with a flat piece of wood.

Variety of rice plants	Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)	
Lot A Control	Bozu	48	30.50	3.1	0.4166	4.0984	0.34
	Akage	48	29.50	4.0	0.4010	5.4380	0.33
Lot B Treated	Bozu	48	29.00	3.0	0.8333	8.6207	0.33
	Akage	48	28.00	4.0	0.7551	10.7886	0.32

In these results it was clear that a high percentage of infection was obtained on the maltreated plants.

EXPERIMENT 4.

On September 21, 100 grains each of the sterilized seeds of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 23°C.

On September 25, the seedlings were planted in pots which were filled with loam soil fertilized with ammonium sulphate 2.3 g., calcium superphosphate 1.2 g., and potassium sulphate 0.3 g. Ten seedlings were planted in each pot which measured 15 cm. in diameter and 15.5 cm. in depth, and they were placed outdoors at first, but after October 13 they were placed in a greenhouse because the weather became cold.

On November 14, the pots bearing the rice plants were divided into 2 lots, A and B, and the plants other than the control were maltreated by cutting off a part of every leaf with a sharp razor.

Lot A: Control, with no special treatment.

Lot B: Leaves injured by cutting off a part of every leaf-blade with a razor.

The inoculation was made immediately after the treatment by atomizing the spore suspension. The plants after having been kept in a moist chamber for 48 hours, were placed in a greenhouse.

On November 25, the results of the inoculation experiments were examined by counting the lesions caused by the infection of the fungus. The experimental results are shown in the following Table IV.

TABLE IV. Results of inoculation experiments on rice plants injured by cutting off a part of every leaf-blade with a razor.

Variety of rice plants	Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)	
Lot A Control	Bozu	20	76.00	4.7	0.0753	0.4605	0.50
	Akage	19	72.95	5.1	0.2268	1.5871	0.59
Lot B Treated	Bozu	19	75.50	4.6	0.1609	0.9759	0.80
	Akage	17	72.78	4.9	0.5422	3.6373	0.59

In the present experiments a high percentage of the infection occurred on the maltreated plants. The contrast between the controls

and the treated plants was especially remarkable in "Akage", the susceptible variety.

2. Experiments on the After Effects of Drought of Soil on the Blast Susceptibility of Rice Plants

The relation of soil moisture to the development of plant diseases has been studied by many investigators, and numerous papers in this connection have been published. In the present investigations, however, the problem was whether or how the percentage of blast infection alters on the rice plants grown for a while under dry condition of soil. For this purpose, rice seedlings grown under dry soil conditions for varying length of time were inoculated with the fungus spores immediately after being restored to a normal condition of soil moisture, and the fluctuations of the number of lesions caused by the infection of the fungus were observed comparing the controls and the treated plants.

EXPERIMENT 5.

On July 15, 100 sterilized seeds each of "Bozu" and "Akage" varieties were sown in pots of measuring 11 cm. both in diameter and in depth, which were filled with sterilized sand, and the seedlings were raised in a greenhouse.

On July 27, the seedlings were planted in square cornered zinc boxes filled with loam soil fertilized with ammonium sulphate 7.5 g., calcium superphosphate 4.4 g., and potassium sulphate 1.6 g. Sixty seedlings were planted in each 40 × 30 × 15 cm. box, and they were placed outdoors.

On August 30, these boxes were divided into 2 lots, A and B, and the plants other than the controls were subjected to an abnormally dry condition of soil.

Lot A: Control, plants watered as usual.

Lot B: Plants subjected to a dry soil condition without watering for 3 days, until September 2.

On September 2, inoculation was made by atomizing the spore suspension. The plants in Lot B were watered immediately after the inoculation, and then, after having been kept in a moist chamber for 48 hours, were placed outdoors.

On September 16, the results of the inoculation experiments were examined by observing the lesions appearing on the leaf-blades caused by the infection of the fungus and by comparing the controls and the treated plants. The experimental results are shown in the following Table V.

TABLE V. Results of inoculation experiments on rice plants subjected to dry soil condition for 3 days.

Variety of rice plants		Number of plants	Average height of plants (c.m.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (c.m.)
Lot A Control	Bozu	51	66.08	8.6	0.0297	0.3859	0.60
	Akage	51	53.44	10.6	0.0241	0.4770	0.50
Lot B Treated	Bozu	48	67.63	9.3	0.0224	0.3080	0.57
	Akage	48	58.34	12.0	0.3189	6.5704	0.58

In these experiments it was noticeable that the treatment by drought for 3 days exerted no particular effect upon the blast susceptibility of "Bozu", the resistant variety, but in "Akage", the susceptible variety, a very remarkable contrast was observed between the control and the treated plants.

EXPERIMENT 6.

On September 21, 50 grains each of the sterilized seeds of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 23°C.

On September 24, the seedlings were planted in pots which were filled with loam soil fertilized with ammonium sulphate 1.3 g., calcium superphosphate 0.7 g. and potassium sulphate 0.3 g. Eight seedlings were planted in each pot which measured 11 cm. both in diameter and in depth. These pots were first placed outdoors, but after October 12 they were kept in a greenhouse owing to too cold weather.

On November 13, the pots were divided into 2 lots, A and B, and the plants other than the controls were subjected to dry soil condition for 4 days without watering till November 17.

Lot A: Control, plants watered as usual.

Lot B: Plants subjected to drought for 4 days.

On November 17, inoculation was made by atomizing the spore suspension. The plants in Lot B which had been kept under dry soil condition for 4 days were watered immediately after the inoculation. All plants, following 48 hours in a moist chamber, were placed in a greenhouse.

On November 28, the results of the inoculation experiments were examined by observing the lesions which had appeared on the leaf-blades caused by the infection of the fungus and by comparing the control and the treated plants. The results of the experiments are shown in the following Table VI.

TABLE VI. Results of inoculation experiments on the rice plants subjected to soil drought for 4 days.

Variety of rice plants		Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)
Lot A Control	Bozu	10	77.75	4.5	0.0889	0.5286	0.40
	Akage	9	78.06	5.2	0.2553	1.7082	0.42
Lot B Treated	Bozu	12	78.65	4.6	0.1818	1.0596	0.46
	Akage	15	77.17	5.3	0.4051	2.7661	0.49

In the present experiments it was observed that the percentage of the blast infection clearly increased on the treated plants both in "Bozu" and "Akage" varieties.

EXPERIMENT 7.

On October 29, 200 grains each of sterilized seeds of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 23°C.

On November 4, the seedlings were planted in square cornered zinc boxes which were filled with loam soil fully fertilized. Fifty seedlings were planted in each 40 × 30 × 15 cm. box, and they were placed in a greenhouse.

On November 21, the boxes bearing the rice plants were divided into 2 lots, A and B, and the plants other than the control were subjected to a dry soil condition for 6 days without watering, until November 27.

On November 27, inoculation was made by atomizing the spore suspension. The plants in Lot B were watered immediately after the inoculation. All the plants, after having been kept in a moist chamber for 48 hours after the inoculation, were placed in a greenhouse.

On December 7, the results of the inoculation experiments were examined by observing the lesions which had appeared on the leaf-blades caused by the infection of the fungus and by comparing the control and the treated plants. The experimental results are shown in the following Table VII.

TABLE VII. Results of inoculation experiments on rice plants subjected to dry soil condition for 6 days.

Variety of rice plants		Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)
Lot A Control	Bozu	40	34.15	3.0	0.0750	0.6589	0.42
	Akage	35	33.10	3.1	0.1273	1.2085	0.52
Lot B Treated	Bozu	38	36.45	3.2	0.0661	0.5502	0.75
	Akage	29	34.22	3.1	0.1444	1.3099	0.61

It was observed in the results of the present experiments that the percentage of the infection in "Akage" variety was increased by the drought treatment, and on the contrary it decreased in "Bozu" variety. However, this decrease and increase of the percentage of the infection was so trivial as to be rather negligible practically.

EXPERIMENT 8

On December 4, 200 grains each of sterilized seeds of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 25°.

On December 10, the seedlings were planted in square cornered zinc boxes filled with fully fertilized loam soil. Thirty-five seedlings were planted in each 40 × 30 × 15 cm. box, and they were placed in a greenhouse.

On January 9, 1937, the boxes bearing the rice plants were divided into 2 lots, A and B, and the plants other than the controls were subjected to a dry soil condition for 6 days without watering till January 15.

Lot A: Control, with no special treatment.

Lot B: Plants subjected to drought for 6 days.

On January 15, inoculation was made by atomizing the spore suspension. After the inoculation the plants in Lot B were watered, and the all plants, after having been kept in a moist chamber for 48 hours, were placed in a greenhouse.

On January 26, the results of the inoculation experiments were examined by observing the lesions appearing on the leaf-blades caused by the infection of the fungus and by comparing the control and the treated plants. The data obtained as the results of the experiments are shown in the following Table VIII.

TABLE VIII. Results of inoculation experiments on rice plants subjected to dry soil condition for 6 days.

Variety of rice plants	Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)
Lot A { Bozu	26	38.79	3.0	0.1266	0.9914	0.53
Control { Akage	23	36.30	3.3	0.2667	2.3956	0.50
Lot B { Bozu	29	33.71	3.2	0.2128	2.0460	0.55
Treated { Akage	15	35.90	3.3	0.9184	8.3565	0.49

In the present inoculation experiments remarkable increases of the percentage of blast infection were observed on the plants in treated lot; the most striking contrast presented between the controls and the treated plants was observed in "Akage", the susceptible variety.

Among these inoculation experiments in No. 5 to No. 8, on the rice plants subjected to dry soil condition during 3 to 6 days before inoculation of the fungus spores, the percentage of the blast infection generally increased. In "Bozu", the resistant variety, the increase of the blast infection on the treated plants was only sometimes, not always, noticed, but in "Akage", the susceptible variety, it was almost always remarkable.

From these results it would be concluded that the drought of soil brings a blast susceptible disposition to rice plants especially to those of the susceptible variety.

In nature it is a fact that the blast disease of rice plants frequently occurs after a spell of drought. This seems to coincide with the results obtained in the present experiments. It would be suggested that the cultivation of the blast resistant rice varieties, at least "Bozu" variety in Hokkaido, may contribute to the prevention of the blast disease as promoted by a drought.

3. Experiments on After Effects of High Atmospheric Humidity upon the Blast Susceptibility of Rice Plants

High atmospheric humidity generally favors the infection of parasites. Accordingly it is evident that an outbreak of plant diseases is likely to occur under humid conditions. From another viewpoint it is also a problem whether or not an abnormally moist atmospheric condition may influence the susceptibility of host plants to the diseases.

In the present studies the authors intended to examine whether or not, or how, the blast susceptibility or resistance of rice plants would be influenced by keeping them temporarily in saturated atmospheric humidity for a certain period before artificial inoculation of the fungus.

EXPERIMENT 9

On September 15, 1936, 200 grains each of sterilized seeds of "Bozu" and "Akage" varieties were sown in pots which were filled with sterilized sand, and they were placed in a greenhouse.

On September 24, the seedlings were planted 50 each in square cornered zinc boxes which were filled with loam soil fully fertilized. They were first placed outdoors and after October 12 removed to a greenhouse owing to the cool weather.

On November 18, the boxes in which the rice plants were growing were divided into 2 lots, A and B, and the plants other than the controls were kept in a chamber under the condition of saturated atmospheric humidity for 24 hours.

Lot A: Control, with no special treatment.

Lot B: Plants subjected to saturated atmospheric humidity for 24 hours.

On November 19, the plants were taken out from the moist chamber, and all were inoculated by atomizing the spore suspension.

After the inoculation the plants were kept in a moist chamber to foster infection by the fungus, and then they were placed in a greenhouse.

On November 30, the results of the inoculation experiments were examined by observing the lesions which had appeared on the leaf-blades caused by the infection of the blast fungus and by comparing the control and the treated plants. The experimental results are shown in the following Table IX.

TABLE IX. Results of inoculation experiments on rice plants kept in saturated atmospheric humidity for 24 hours.

Variety of rice plants	Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)	
Lot A Control	Bozu	48	78.65	4.5	0.2315	1.8542	0.50
	Akage	48	77.80	5.5	0.5075	3.5883	0.49
Lot B Treated	Bozu	50	78.55	4.4	0.3000	1.6804	0.52
	Akage	50	77.10	5.1	0.4549	3.0091	0.47

The results obtained in the present experiments clearly showed certain decreases in the infection in the plants subjected to a highly humid condition before the inoculation.

EXPERIMENT 10

On September 22, 100 sterilized seeds each of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 25°C.

On September 26, the seedlings were planted 10 each in pots of 18.5 cm. diameter and depth, which were filled with loam soil fertilized with ammonium sulphate 2.5 g., calcium superphosphate 1.4 g. and potassium sulphate 0.5 g. The plants were first placed outdoors and later removed into a greenhouse on account of the cool weather.

On November 14, the pots bearing the rice plants were divided into 2 groups, Lot A and Lot B, and the plants other than the controls were submitted to a condition of saturated atmospheric humidity for 72 hours.

Lot A: Control, with no special treatment.

Lot B: Plants submitted to a saturated humidity for 72 hours.

On November 17, inoculation was made by atomizing the spore suspension. After the inoculation the plants were kept in a moist chamber for 48 hours to promote the infection of the fungus and were then placed in a greenhouse.

On November 28, the results of the inoculation experiments were examined by observing the lesions which had appeared on the leaf-blades caused by the infection of the fungus, and comparing the controls and treated plants. The experimental results are shown in the following Table X.

TABLE X. Results of inoculation experiments on rice plants subjected to a saturated moist condition for 72 hours.

Variety of rice plants		Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)
Lot A Control	Bozu	30	75.50	4.0	0.7750	4.1060	0.46
	Akage	30	74.45	4.8	0.9028	5.8204	0.45
Lot B Treated	Bozu	35	75.55	4.0	0.7000	3.7062	0.47
	Akage	34	74.09	4.5	0.8170	4.9757	0.43

The results of this experiment also showed the diminution of the infection in the plants treated under saturated moisture condition for 72 hours before inoculation.

According to the results of these experiments, on the rice seedlings which had been kept under a condition of saturated moisture for 24 and 72 hours just before the inoculation of the conidia of the blast fungus, the infection was clearly lessened in comparison with the control plants. In these cases the difference of the circumstances in the treated plants from the controls was only in being kept in saturated moist chamber for certain periods before the inoculation, therefore the diminution of the infection should be attributed to a temporary increase of the blast resistance in the plants treated by keeping in atmosphere saturated with moisture.

4. Experiments on the Influence of Narcotics upon the Blast Resistance in Rice Plants

In the present experiments, the influences of ether, chloroform and absolute alcohol upon the resistance of rice plants to the infec-

tion of the blast fungus were studied by treating the plants with the vapor of these narcotics for a certain length of time before the inoculation.

For the purpose of the experiment a narcotizing apparatus was designed. It was prepared with an air-tight wooden box of about 156 litres in volume, the inside of which was furnished with glass plates. Sheets of blotting paper were put on the glass walls of the box, and another sheet of blotting paper was hung in the middle of the box in order to protect the plants from direct contact with the spray of the narcotics. A certain amount of the narcotics would be applied to the blotting paper put on the walls of the box by means of spraying with an atomizer through a hole in the wooden wall of the vacant half of the box. The rice seedlings growing in pots being placed in the narcotizing apparatus, the narcotics can be sprayed without direct contact with the plants. After the spraying of narcotics the hole having been closed, the plants to be treated were kept in the apparatus with the narcotic vapor for a definite length of time. When the treatment was finished, the plants were taken out, and inoculated immediately with the spore suspension.

a) Experiment with Ether

EXPERIMENT 11

On November 10, 1936, 100 sterilized seeds each of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 25°C.

On November 14, the seedlings were planted in pots which were filled with loam soil fertilized with ammonium sulphate 2.5 g., calcium superphosphate 1.4 g. and potassium sulphate 0.5 g. Ten seedlings were planted in each pot of 18.5 cm. diameter and depth, and they were placed in a greenhouse.

On December 11, the pots bearing the rice seedlings were divided into 4 lots, A, B, C, and D, and the plants other than the controls were treated with vapor of various amounts of ether in the narcotizing apparatus for 5 minutes. The temperature in the box at the time of the treatment was 13°C.

Lot A: Control, with no special treatment.

Lot B: Twenty c.c. of ether was applied.

Lot C: Thirty c.c. of ether was applied.

Lot D: Forty c.c. of ether was applied.

After these treatments the plants were taken out of the box and immediately inoculated by atomizing the spore suspension. All the plants, after being kept in a moist chamber for 48 hours to promote the infection, were placed in a greenhouse.

On December 21, the results of the inoculation experiments were examined by observing the lesions which had appeared on the leaf-blades caused by the infection of the fungus, and comparing the controls and the treated plants. The experimental results are shown in the following Table XI.

TABLE XI. Results of inoculation experiments on rice plants narcotized with the vapor of various amounts of ether.

Variety of rice plants		Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)
Lot A Control	Bozu	10	40.40	3.3	0.3636	2.9703	0.48
	Akage	7	38.50	3.4	0.4583	4.0816	0.40
Lot B (20 c.c.)	Bozu	10	42.90	3.5	0.4200	3.4965	0.49
	Akage	8	31.94	3.9	0.1935	2.3482	0.38
Lot C (30 c.c.)	Bozu	10	42.40	3.9	0.6154	5.6604	0.50
	Akage	10	37.90	3.2	0.8125	6.8338	0.47
Lot D (40 c.c.)	Bozu	9	35.65	3.8	0.2056	2.1818	0.49
	Akage	10	33.30	3.0	0.4667	4.2042	0.44

In these experiments the results were diverse and complicated. In "Bozu", the resistant variety, the percentage of the infection increased in proportion to the volume of ether applied until the maximum was reached in Lot C to which 30 c.c. of ether was applied, but in Lot D to which 40 c.c. of ether was applied the percentage of the infection suddenly became less than that which occurred in Lot A, the control. In "Akage", the susceptible variety, the percentage of the infection decreased in Lot B to which 20 c.c. of ether was applied to a point than that shown in Lot A, the control, and in Lot C to which 30 c.c. of ether was applied the infection increased suddenly and reached the maximum, but in Lot D to which 40 c.c. of ether was applied it decreased again, although it was a little higher than that in the control lot.

EXPERIMENT 12

On November 19, 100 sterilized seeds each of "Bozu" and "Akage" varieties were sown in sterilized sand in pots of 11 cm. diameter and depth, and the seedlings were raised in a greenhouse.

On November 26, the seedlings were planted in pots which were filled with loam soil fertilized with ammonium sulphate 2.3 g., calcium superphosphate 1.2 g. and potassium sulphate 0.3 g. Fifteen seedlings were planted in each pot which measured 17 cm. both in diameter and in depth. These pots bearing the rice plants were placed in a greenhouse.

On December 22, the rice plants growing in the pots were divided into 4 lots, A, B, C, and D, and the plants other than the controls were treated with the vapor of equal amounts of ether for various lengths of time in the narcotizing apparatus.

Lot A: Control, with no special treatment.

Lot B: Plants were narcotized with the vapor of 30 c.c. of ether for 3 minutes.

Lot C: Plants were narcotized with the same for 5 minutes.

Lot D: Plants were narcotized with the same for 10 minutes.

The temperature in the narcotizing apparatus at the time of the treatments was 17°C.

After the treatments the plants were taken out of the box and immediately inoculated by atomizing the spore suspension. The plants having been kept in a moist chamber after the inoculation for 48 hours to promote the infection were placed in a greenhouse.

On January 6, 1937, the results of the inoculation experiments were examined by observing the lesions appearing on the leaf-blades caused by the infection of the fungus, and by comparing the controls and the treated plants. The experimental results are shown in the following Table XII.

In these data obtained in the present experiments, it was clear that the percentage of the blast infection was greater on the leaf-blades of the plants treated with ether vapor than on those of the control plants. In "Bozu", the resistant variety, the highest percentage of infection was obtained in Lot D, in which the plants had been narcotized with ether vapor volatilized from 0.14 gram of ether per litre of the volume of the narcotizing apparatus for 10 minutes. In "Akage", the susceptible variety, the highest percentage of infec-

TABLE XII. Results of inoculation experiments on rice plants narcotized with ether vapor for various lengths of time.

Variety of rice plants		Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)
Lot A Control	Bozu	13	36.50	3.8	0.2245	2.3211	0.46
	Akage	9	30.83	3.4	0.3548	3.9643	0.45
Lot B (3 min.)	Bozu	14	34.57	3.4	0.2766	2.6861	0.45
	Akage	8	37.88	4.0	0.4483	4.2925	0.45
Lot C (5 min.)	Bozu	9	34.00	3.2	0.4483	4.2482	0.46
	Akage	8	36.25	3.5	0.5714	5.5172	0.45
Lot D (10 min.)	Bozu	14	38.11	3.5	0.5306	4.8730	0.46
	Akage	8	36.63	3.5	0.5000	4.7775	0.46

tion was obtained in Lot C, in which the plants had been narcotized by 0.14 gram of ether per litre of air for 5 minutes. The contrast between the controls and the treated plants was especially remarkable in "Bozu", variety.

EXPERIMENT 13

On December 4, 100 sterilized seeds each of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 25°C.

On December 10, the seedlings were planted in pots filled with loam soil fertilized with ammonium sulphate 2.3 g., calcium superphosphate 1.2 g. and potassium sulphate 0.3 g. Ten seedlings were set in each pot of 15 cm. diameter and 15.9 cm. depth, and they were placed in a greenhouse.

On January 18, 1937, the pots bearing the rice plants were divided into 4 lots, A, B, C, and D, and the plants other than the control were treated with the vapor of various amounts of ether for 5 minutes in the narcotizing apparatus. The temperature in the box at the time of the treatment was 14°C.

Lot A: Control, with no special treatment.

Lot B: The plants were narcotized with 20 c.c. of ether.

Lot C: The plants were narcotized with 30 c.c. of ether.

Lot D: The plants were narcotized with 40 c.c. of ether.

After the treatments the plants were taken out of the box and placed in a room at 20°C. for one hour, and then they were inoculated by atomizing the spore suspension.

On January 29, the results of the inoculation experiments were examined by observing the lesions which appeared on the leaf-blades caused by the infection of the fungus, and by comparing the controls and the treated plants. The data obtained in the present experiments are shown in the following Table XIII.

TABLE XIII. Results of inoculation experiments on rice plants narcotized with various amounts of ether vapor for 5 minutes.

Variety of rice plants	Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)	
Lot A Control	Bozu	10	51.70	4.1	0.3659	2.9014	0.49
	Akage	6	45.92	4.5	0.4444	4.3554	0.38
Lot B (20 c.c.)	Bozu	10	49.85	3.6	0.4722	3.4102	0.41
	Akage	8	47.46	4.3	0.3824	3.4239	0.37
Lot C (30 c.c.)	Bozu	8	53.63	4.3	0.7353	5.8270	0.35
	Akage	10	45.40	3.5	0.6000	4.6256	0.33
Lot D (40 c.c.)	Bozu	8	52.75	4.1	0.6061	4.7393	0.35
	Akage	7	45.64	4.1	0.8621	7.8251	0.35

From these results it was clear that the percentage of the infection was higher in the treated plants than in the controls. In "Bozu" variety the percentage of the infection increased in proportion to the volume of ether applied, until it reached the maximum in Lot C to which 30 c.c. ether was applied, but a set back took place in Lot D to which 40 c.c. ether was applied. In "Akage" variety the percentage of the infection on the plants in Lot B, to which 20 c.c. of ether was applied, was a little smaller than that on the control, but it increased gradually in proportion to the volume of ether applied until it reached the maximum in Lot D to which 40 c.c. of ether was applied.

b) Experiments with Chloroform

EXPERIMENT 14

On November 10, 100 sterilized seeds each of "Bozu" and

"Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 25°C.

On November 14, the seedlings were planted in pots filled with loam soil fertilized with ammonium sulphate 2.5 g., calcium superphosphate 1.4 g. and potassium sulphate 0.5 g. Fifteen seedlings were planted in each pot of 18.5 cm. diameter and depth, and they were placed in a greenhouse.

On December 17, the pots bearing the rice plants were divided into 4 lots, A, B, C, and D, and the plants other than the control were narcotized by applications of various amounts of chloroform for 5 minutes in the narcotizing apparatus.

Lot A: Control, with no special treatment.

Lot B: Thirty c.c. of chloroform were applied.

Lot C: Forty c.c. of chloroform were applied.

Lot D: Fifty c.c. of chloroform were applied.

The temperature in the box at the time of the treatment was 15°C. Immediately after the treatments the plants were inoculated by atomizing the spore suspension, and after having been kept in a moist chamber for 48 hours, they were taken out and placed in a greenhouse.

On December 27, the results of the inoculation experiments were examined by observing the lesions which appeared on the leaf-blades caused by the infection of the fungus, and by comparing the controls and the treated plants. The experimental results are shown in the following Table XIV.

TABLE XIV. Results of inoculation experiments on rice plants narcotized for 5 minutes with chloroform vapor of varying amounts.

Variety of rice plants	Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)
Lot A { Bozu	13	33.92	2.9	0.1579	1.3606	0.25
Control { Akage	9	32.48	3.0	0.2222	2.0339	0.25
Lot B { Bozu	15	34.87	3.0	0.2222	1.9120	0.26
(30 c.c.) { Akage	13	35.69	3.0	0.2432	1.9398	0.26
Lot C { Bozu	12	31.46	2.7	0.3750	3.1786	0.28
(40 c.c.) { Akage	10	33.10	2.6	0.3333	3.6254	0.27
Lot D { Bozu	15			All plants were killed		
(50 c.c.) { Akage	15			All plants were killed		

In the present experiment the highest percentage of infection was obtained in Lot C both on "Bozu" and "Akage" varieties, in which lot the plants had been narcotized with the vapor volatilized from 0.39 gram of chloroform per litre of the volume of the narcotizing apparatus for 5 minutes. All plants in Lot D were killed, in which lot 0.49 gram of chloroform per litre was applied, and this was possibly due to the lethal effect caused by an excess of chloroform.

EXPERIMENT 15

On November 19, 100 sterilized seeds each of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 25°C.

On November 24, the seedlings were planted in pots which were filled with loam soil fully fertilized. Ten seedlings were planted in each pot of 16.5 cm. diameter and depth, and they were placed in a greenhouse.

On December 19, the pots bearing the experimental rice plants were divided into 4 lots, A, B, C, and D, and the plants other than the control were narcotized by an application of the vapor of 20 c.c. of chloroform in the narcotizing apparatus for varying lengths of time at 14.5°C.

Lot A: Control, with no special treatment.

Lot B: The plants were narcotized for 5 minutes.

Lot C: The plants were narcotized for 10 minutes.

Lot D: The plants were narcotized for 15 minutes.

Immediately after the treatments the plants were inoculated by atomizing the spore suspension, and after having been kept in a moist chamber for 48 hours, they were placed in a greenhouse.

On December 29, the results of the inoculation experiments were examined by observing the lesions appearing on the leaf-blades caused by the infection of the fungus, and by comparing the controls and the treated plants. The experimental results are shown in the following Table XV.

In this experiment many plants of "Akage" variety were poor in growth, and as they were unsuited to the inoculation, a majority of them were omitted, and the experiments were carried out on the remaining few plants.

TABLE XV. Results of inoculation experiments on rice plants narcotized with the vapor of 20 c.c. of chloroform for various lengths of time.

Variety of rice plants		Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)
Lot A Control	Bozu	10	40.35	3.7	0.2973	2.7261	0.50
	Akage	5	38.40	3.6	0.3333	3.1250	0.47
Lot B (5 min.)	Bozu	10	46.95	3.6	0.5278	4.0469	0.46
	Akage	7	38.14	3.4	0.7083	6.3676	0.43
Lot C (10 min.)	Bozu	10	44.95	3.7	0.6757	5.5620	0.48
	Akage	6	41.58	4.0	1.4583	14.0291	0.41
Lot D (15 min.)	Akage	5	41.80	3.8	0.1579	1.4354	0.37

The highest percentage of infection was obtained in Lot C, in which the plants were narcotized for 10 minutes with the vapor volatilized from 0.2 gram of chloroform per litre of the volume of the narcotizing apparatus. The contrast presented between the controls and the treated plants was especially remarkable in "Akage", the susceptible variety. In Lot D, in which "Akage" variety alone was used, an apparent deterioration of development of the plants occurred possibly due to the prolonged exposure to the vapor of chloroform, and a remarkable set back was observed in the percentage of the infection.

EXPERIMENT 16

On January 6, 1937, 100 sterilized seeds each of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 25°C.

On January 11, the seedlings were planted in pots which were filled with loam soil fully fertilized. Ten seedlings were set in each pot which measured 17 cm. both in diameter and in depth, and they were placed in a greenhouse.

On January 28, the pots bearing the experimental rice plants were divided into 4 lots, A, B, C, and D, and the plants other than the control were narcotized by an application of various amounts of chloroform in the narcotizing apparatus for 5 minutes at 17°C.

- Lot A: Control, with no special treatment.
 Lot B: Twenty c.c. of chloroform were applied.
 Lot C: Thirty c.c. of chloroform were applied.
 Lot D: Thirty-five c.c. of chloroform were applied.

After the treatments the plants were immediately inoculated by atomizing the spore suspension, and after having been kept in a moist chamber for 48 hours, they were placed in a greenhouse.

On February 8, the results of the inoculation experiments were examined by observing the lesions appearing on the leaf-blades caused by the infection of the fungus, and by comparing the controls and the treated plants. The experimental results are shown in the following Table XVI.

TABLE XVI. Results of inoculation experiments on rice plants narcotized with various amounts of chloroform for 5 minutes.

Variety of rice plants	Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)	
Lot A Control	Bozu	16	38.31	3.6	0.0852	0.8157	0.58
	Akage	13	33.77	3.5	0.1778	1.8223	0.55
Lot B (20 c.c.)	Bozu	16	35.29	3.1	0.7143	1.7710	0.55
	Akage	8	31.56	2.9	1.6667	1.9804	0.44
Lot C (30 c.c.)	Bozu	14	36.00	3.6	0.2857	2.3808	0.53
	Akage	7	35.29	3.7	0.5000	4.0481	0.54
Lot D (35 c.c.)	Bozu	17	All plants were severely injured by the narcotic vapor, and some of them were entirely killed				
	Akage	11					

In the present experiment the deleterious influence of the narcotic was comparatively severe on the treated plants owing possibly to the high temperature (17°C.) at the time of the treatments and to the youngness of rice plants. Especially in Lot D, 6 plants of "Bozu" variety and 4 plants of "Akage" variety were entirely killed, and the leaves of the surviving plants withered and curled so severely that the results of the inoculation could not be accurately assessed.

A high percentage of infection was obtained in Lot C both on "Bozu" variety and on "Akage" variety, in which 30 c.c. of chloroform were applied.

EXPERIMENT 17

On January 6, 100 sterilized seeds each of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 25°C.

On January 11, the seedlings were planted in pots which were filled with loam soil fully fertilized. Ten seedlings were set in each pot which measured 17 cm. both in diameter and in depth, and they were placed in a greenhouse.

On January 30, the pots bearing the experimental rice plants were divided into 4 lots, A, B, C and D, and the plants other than the control were treated in the narcotizing apparatus for 5 minutes with varying amounts of chloroform. The temperature in the box at the time of the treatments was 17.5°C.

Lot A: Control, with no special treatment.

Lot B: Applied 20 c.c. of chloroform.

Lot C: Applied 30 c.c. of chloroform.

Lot D: Applied 35 c.c. of chloroform.

After the treatments, the plants were placed in a room at 20°C. for about one hour, and then inoculated by atomizing the spore suspension. The plants being inoculated were kept in a moist chamber for 48 hours, and then placed in a greenhouse.

On February 10, the results of the inoculation experiments were examined by observing the lesions which had appeared on the leaf-blades caused by the infection of the fungus, and by comparing the controls and the treated plants. The experimental results are shown in the following Table XVII.

In the present experiment almost all plants were injured directly by the narcotizing treatment as severely as in the previous experiment. This may possibly have been due to the youngness of the rice plants and also to the high temperature during the treatments. In the present and previous experiments the rice plants used were very young and the temperature in the narcotizing apparatus during the treatment was comparatively higher than in any other experiments. Owing to the direct injury of the narcotic vapor the results

TABLE XVII. Results of inoculation experiments on rice plants narcotized for 5 minutes with the vapor of various amounts of chloroform.

Variety of rice plants	Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)	
Lot A Control	Bozu	15	32.33	2.7	0.1250	1.0309	0.57
	Akage	6	33.33	3.2	0.2105	2.0003	0.55
Lot B (20 c.c.)	Bozu	11	32.50	3.0	0.8000	1.1188	0.56
	Akage	6	29.75	3.3	0.7500	1.6807	0.55
Lot C (30 c.c.)	Bozu	11	30.77	3.4	0.5714	1.1817	0.52
	Akage	9	26.25	2.8	1.6667	2.1166	0.54
Lot D (35 c.c.)	Bozu	8	32.50	3.3	0.6667	0.7692	0.53
	Akage	7	All plants were severely injured				

of the inoculation could hardly be assessed with accuracy. No remarkable difference in the percentage of the infection was recognized between the controls and the treated plants.

EXPERIMENT 18

On January 6, 100 sterilized seeds each of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 25°C.

On January 12, they were planted in pots filled with loam soil fertilized with ammonium sulphate 1.3 g., calcium superphosphate 0.7 g. and potassium sulphate 0.3 g. Ten seedlings were planted in each pot of 11 cm. diameter and depth, and they were placed in a greenhouse.

On February 16, the pots in which the experimental rice plants were growing were divided into 3 lots, A, B, and C, and the plants other than the control were narcotized with the vapor of 20 c.c. of chloroform for 10 minutes in the narcotizing apparatus in which the temperature was 16.5°C. during the treatment. After the treatment the plants were inoculated by atomizing the spore suspension immediately or after a lapse of one hour in a room at 20°C.

Lot A: Control, with no special treatment.

Lot B: The plants were inoculated immediately after the narcotizing treatment.

Lot C: The plants were inoculated after one hour had elapsed from the narcotizing treatment.

After the inoculation the plants were kept in a moist chamber for 48 hours to promote infection, and then they were taken out and placed in a greenhouse.

On February 27, the results of the inoculation experiments were examined by observing the lesions appearing on the leaf-blades caused by the infection of the fungus. The experimental results are shown in the following Table XVIII.

TABLE XVIII. Results of inoculation experiments on rice plants narcotized with the vapor of chloroform by inoculating immediately or 1 hour after the treatment.

Variety of rice plants	Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)	
Lot A Control	Bozu	6	38.78	3.0	0.3889	3.0085	0.50
	Akage	5	35.70	3.0	0.3333	2.8011	0.44
Lot B Treated	Bozu	9	40.06	—	1.0000	1.6643	0.62
	Akage	7	36.21	—	0.4286	1.1837	0.53
Lot C Treated	Bozu	9	38.75	—	0.5000	1.2908	0.57
	Akage	5	34.20	—	—	—	—

In the present experiment, almost all plants were injured severely by the narcotic vapor, and the leaves withered and curled. Accordingly, as the observations were made on the remaining few healthy leaves, the results of the experiments could hardly be very accurate.

It was noteworthy in the present experiment that the plants were injured severely by exposure to the narcotic vapor volatilized from 0.2 gram of chloroform per litre of the volume of the narcotizing apparatus for 10 minutes. On the other hand, in Experiment 15 the plants had not been so severely injured as in the present cases by the similar treatment. This might possibly be due to the difference of temperature during the narcotization. It was 14.5°C. in

Experiment 15 and 16.5°C. in the present experiment. The injurious influence of chloroform to the rice plant seemed to become more severe in coordination with the rise of temperature.

The difference of the percentage of the infection between the controls and the treated plants in the present experiment could not be clearly recognized because the direct injury of chloroform vapor predominated.

c) Experiments with Absolute Alcohol

EXPERIMENT 19

On November 25, 1936, 100 sterilized seeds each of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 25°C.

On November 30, the seedlings were planted in pots filled with loam soil fertilized with ammonium sulphate 1.3 g., calcium superphosphate 0.7 g. and potassium sulphate 0.3 g. Ten seedlings were set in each pot, 11 cm. both in diameter and in depth, and they were placed in a greenhouse.

On December 27, the pots in which the rice plants were growing were divided into 6 lots, A, B, C, D, E, and F, and the plants other than the control were treated with the vapor of various amounts of absolute alcohol for various lengths of time. The temperature in the narcotizing apparatus during the treatments was 13.5°C.

- Lot A: Control, with no special treatment.
- Lot B: The plants were treated with the vapor of 20 c.c. of absolute alcohol for 10 minutes.
- Lot C: The plants were treated with the vapor of 20 c.c. of absolute alcohol for 20 minutes.
- Lot D: The plants were treated with the vapor of 30 c.c. of absolute alcohol for 10 minutes.
- Lot E: The plants were treated with the vapor of 30 c.c. of absolute alcohol for 20 minutes.
- Lot F: The plants were treated with the vapor of 40 c.c. of absolute alcohol for 20 minutes.

After the treatments the plants were inoculated by atomizing the spore suspension, and after having been kept in a moist chamber for 48 hours to promote the infection they were placed in a greenhouse.

On January 8, 1937, the results of the inoculation experiments were examined by observing the lesions which had appeared on the leaf-blades caused by the infection of the fungus, and by comparing the controls and the treated plants. The experimental results are shown in the following Table XIX.

TABLE XIX. Results of inoculation experiments on rice plants treated with the vapor of varying amounts of absolute alcohol for various lengths of time.

Variety of rice plants		Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)
Lot A Control	Bozu	7	31.50	3.7	0.1538	1.8140	0.48
	Akage	5	28.80	3.2	0.2500	2.7778	0.43
Lot B (20 c.c.) (10 m.)	Bozu	9	34.89	3.1	0.1786	1.5924	0.46
	Akage	6	36.08	3.5	0.2381	2.3096	0.42
Lot C (20 c.c.) (20 m.)	Bozu	8	36.25	3.1	0.2000	1.7241	0.46
	Akage	6	30.58	3.3	0.2500	2.7250	0.44
Lot D (30 c.c.) (10 m.)	Bozu	6	37.67	3.2	0.1577	1.3273	0.43
	Akage	7	31.79	3.3	0.2174	2.2469	0.38
Lot E (30 c.c.) (20 m.)	Bozu	6	31.42	2.8	0.1765	1.5913	0.40
	Akage	7	34.93	3.0	0.2381	2.0447	0.40
Lot F (40 c.c.) (20 m.)	Bozu	9	35.33	3.2	0.1724	1.5726	0.44
	Akage	6	27.42	3.0	0.2222	2.4314	0.45

In the data obtained in the present inoculation experiments, as shown in the above table, no remarkable difference of the percentage of infection was observed between the controls and the treated plants. In other words, the vapor of absolute alcohol seemed to exert no particular influence on the resistance of rice plants to the blast infection.

EXPERIMENT 20

On January 6, 100 sterilized seeds each of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 25°C.

On January 11, the seedlings were planted in pots filled with loam soil fertilized with ammonium sulphate 2.5 g., calcium superphosphate 1.4 g. and potassium sulphate 0.5 g. Ten seedlings were set in each pot of 18.5 cm. both in diameter and in depth, and they were placed in a greenhouse.

On February 1, the pots in which the experimental rice plants were growing were divided into 4 lots, A, B, C, and D, and the plants other than the control were treated with the vapor of various amounts of absolute alcohol for 30 minutes at 18°C.

Lot A: Control, with no special treatment.

Lot B: Applied 20 c.c. of absolute alcohol.

Lot C: Applied 30 c.c. of absolute alcohol.

Lot D: Applied 40 c.c. of absolute alcohol.

After the treatments the plants were inoculated by atomizing the spore suspension, and after having been kept in a moist chamber for 48 hours they were placed in a greenhouse.

On February 12, the results of the inoculation experiments were examined by observing the lesions appearing on the leaf-blades caused by the infection of the fungus, and comparing the controls and the treated plants. The experimental results are shown in the following Table XX.

TABLE XX. Results of inoculation experiments on rice plants treated for 30 minutes with the vapor of various amounts of absolute alcohol.

Variety of rice plants	Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)	
Lot A Control	Bozu	10	27.90	2.8	0.1786	1.7921	0.50
	Akage	6	27.00	3.0	0.3333	3.7037	0.47
Lot B (20 c.c.)	Bozu	10	34.20	3.0	0.4000	1.1694	0.48
	Akage	10	26.40	2.4	0.7143	3.7879	0.48
Lot C (30 c.c.)	Bozu	10	36.80	3.0	0.1333	1.0870	0.49
	Akage	10	27.10	2.2	0.7143	3.6900	0.48
Lot D (40 c.c.)	Bozu	9	30.14	2.1	1.0000	1.4220	0.50
	Akage	8	26.33	2.7	0.7500	3.7979	0.45

In the present experiment the temperature in the box was kept as high as 18°C. during the treatment in order to realize a quick evaporation of alcohol. The direct injury of alcohol vapor on the plants treated was unavoidably severe. In Lot B, 5 plants each of "Bozu" and "Akage" varieties were killed. In Lot C, 5 plants of "Akage" variety were killed, while all plants of "Bozu" variety remained healthy. In Lot D, 2 plants of "Bozu" variety and 5 plants of "Akage" variety were killed. This lethal injury might possibly be due to the deleterious effect of alcohol vapor invigorated by high temperature. However, no remarkable difference in the percentage of the blast infection having been observed between the controls and the treated plants, it seemed that the vapor of absolute alcohol exerted no particular influence on the resistance or susceptibility of rice plants to the blast infection.

EXPERIMENT 21

On January 6, 100 sterilized seeds of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 25°C.

On January 11, the seedlings were planted in pots filled with loam soil fertilized with ammonium sulphate 2.3 g., calcium superphosphate 1.2 g. and potassium sulphate 0.3 g. Ten seedlings were set in each pot of 17.5 cm. diameter and depth, and they were placed in a greenhouse.

On February 18, the pots bearing the rice plants for the experiment were divided into 4 lots, and the plants other than the control were treated for 30 minutes at 20°C. with the vapor of various amounts of absolute alcohol.

Lot A: Control, with no special treatment.

Lot B: Applied 10 c.c. of absolute alcohol.

Lot C: Applied 20 c.c. of absolute alcohol.

Lot D: Applied 30 c.c. of absolute alcohol.

After these treatments the plants were taken out of the narcotizing apparatus and placed in a room at 20°C. for 40 minutes, and then the inoculation was made by atomizing the spore suspension. After the inoculation, the plants were kept in a moist chamber for 48 hours and then placed in a greenhouse.

On March 1, the results of the inoculation experiments were examined by observing the lesions appearing on the leaf-blades caused

by the infection of the blast fungus, and comparing the controls and the treated plants. The experimental results are shown in the following Table XXI.

TABLE XXI. Results of inoculations on rice plants 40 minutes after treatment with the vapor of various amounts of absolute alcohol for 30 minutes.

Variety of rice plants	Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)	
Lot A Control	Bozu	9	46.39	3.9	0.2857	2.3951	0.50
	Akage	6	47.92	3.8	0.2174	1.7389	0.48
Lot B (10 c.c.)	Bozu	10	46.75	3.7	0.2162	1.7112	0.49
	Akage	6	43.42	3.5	0.2857	2.3031	0.52
Lot C (20 c.c.)	Bozu	10	42.15	3.4	0.5588	4.5077	0.57
	Akage	7	41.86	3.1	0.3618	2.7303	0.54
Lot D (30 c.c.)	Bozu	10	50.00	2.9	0.2414	1.4000	0.51
	Akage	4	47.25	3.3	0.6923	4.7619	0.48

In the course of the present experiments, *Thrips tabaci* LINDEMAN, the noxious thrips parasitic commonly on *Allium fistulosum* L. and also on rice plants in Hokkaido, occurred in abundance. It seemed that the harm done by the thrips more or less promoted the blast infection on rice plants. Probably on this account the data concerning the percentage of infection were diverse in the present experiments according to the difference of the lots.

In "Bozu" variety, the results of the experiment were quite ambiguous. The highest percentage of the infection was observed in Lot C, in which 20 c.c. of absolute alcohol, i.e. 0.1 gram per litre of the volume of the narcotizing apparatus was applied. In the other two treated lots, B and D, the percentage of infection was lower than in the control plants. The plants in Lot C were poor in growth and small in height possibly due to the severe attacks of the thrips, and therefore it would seem reasonable that the high percentage of the blast infection was not a result of the influence of the absolute alcohol vapor but a result of the harm done by the abundant thrips.

In "Akage" variety, however, an obvious increase of the percentage of infection was observed coordinate with the increase of

the amount of absolute alcohol applied with the lowest percentage of infection occurring in the control lot. Therefore, under the circumstance of an outbreak of the thrips, the infection promoting influence of the vapor of absolute alcohol on "Akage" variety might be claimed.

In the present experiments temperature in the narcotizing apparatus during the treatments was 20°C., which was higher than that in the previous experiment, but yet the plants were not severely injured. This was possibly due to the age of the rice plants examined.

5. After Effects of High Temperature on the Blast Susceptibility of Rice Plants

Studies on the direct relations of temperature to plant diseases have been rather superfluously reported. The temperature affects either the pathogenic activities of the parasites or the susceptibility or resistance of the host plants. In the latter case the considerations should be extended to the influences of temperature on the histological and functional developments as connected with the susceptibility or resistance of the host plants to diseases. In the present experiments rice plants were subjected to a high temperature for a while before the inoculation of the blast fungus, and after they were restored to a normal condition of temperature, the inoculation having been carried out, the resulting infection was observed, with the intention to examine the after-effects of the high temperature treatments on the functional resistance of the plants.

The treatments were carried out by applying hot air or by immersing in hot water. The equipment and the methods of the treatments were as follows:

A wooden box, about 91 litres in volume, the inside of which was lined with sheet glass was used for the purpose of hot air treatments. At the central part of the wooden bottom of the box a circular portion about 16 cm. in diameter was replaced by a tin plate. A pot bearing the rice plants to be treated was put just upon the tin plate being lifted with the aid of a wooden stand, and the plants were covered with a bell-jar of about 25 litres volume. The temperature inside the bell-jar was gradually raised by heating the tin plate with a gas flame from the under side until the temperature reached the required degree. The temperature in the bell-jar was indicated by a thermometer put in the top hole of the bell-jar.

As another method of heating, the whole temperature in the box was raised directly by an electric heater placed in the box in which case the bell-jar was not used.

The hot water treatment was done by immersing the whole plant body growing in a pot into hot water, of which the temperature was regulated to the desired degree, in a metal vessel of 31 cm. diameter and 35 cm. depth, furnished with a heater, for the desired length of time.

EXPERIMENT 22. Hot air treatments with bell-jar

On November 14, 1936, 100 sterilized seeds each of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 25°C.

On November 18, the seedlings were planted in pots filled with loam soil fertilized with ammonium sulphate 1.3 g., calcium superphosphate 0.7 g. and potassium sulphate 1.5 g. Ten seedlings were set in each pot of 11 cm. both in diameter and in depth, and they were placed in a greenhouse.

On December 5, it was found that some plants had been killed by an attack of *Fusarium sp.* in certain pots, and the affected plants were eliminated.

On December 14, the pots bearing the rice plants were divided into 5 lots, A, B, C, D, and E and the plants other than the control were treated at various temperatures for 5 minutes.

Lot A: Control, with no special treatment.

Lot B: Plants treated by gradual heating up to 40°C. and kept for 5 minutes at that temperature.

Lot C: Plants treated by gradual heating up to 45°C. and kept for 5 minutes at that temperature.

Lot D: Plants treated by gradual heating up to 50°C. and kept for 5 minutes at that temperature.

Lot E: Plants treated by gradual heating up to 55°C. and kept for 5 minutes at that temperature.

After these treatments all plants were inoculated immediately by atomizing the spore suspension. The inoculated plants, after having been kept in a moist chamber for 48 hours to promote the infection, were placed in a greenhouse.

On December 25, the results of the inoculation experiments were examined by observing the lesions which had appeared on the leaf-

blades caused by the infection of the fungus, and by comparing the controls and the treated plants. The experimental results are shown in the following Table XXII.

TABLE XXII. Results of inoculation experiments on rice plants treated by gradual heating up to 40°-55°C.

Variety of rice plants		Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)
Lot A Control	Bozu	6	31.50	2.8	0.2942	2.6454	0.34
	Akage	5	30.30	2.6	0.4615	3.9604	0.32
Lot B (40°C.)	Bozu	8	32.00	3.0	0.6000	5.6250	0.36
	Akage	5	25.75	2.5	0.6000	5.4369	0.32
Lot C (45°C.)	Bozu	9	28.50	2.7	0.3684	3.5088	0.34
	Akage	5	30.75	2.8	0.3636	3.2520	0.33
Lot D (50°C.)	Bozu	10	29.50	2.0	0.2500	1.6949	0.35
	Akage	6	27.33	1.7	0.4000	2.4394	0.30
Lot E (55°C.)	Bozu	9	24.63	2.8	0.0909	1.0150	0.40
	Akage	7					

All plants were quite killed

The highest percentage of the infection occurred in Lot B on both varieties, in which lot the plants had been treated by gradual heating up to 40°C.; the plants in Lot C and the control "Akage" plants were affected next most severely. In Lot B and Lot C the percentage of the infection was higher on "Bozu", the resistant variety, than on "Akage", the susceptible variety, despite the fact that in the control lot it was markedly less on "Bozu" variety than on "Akage" variety. In Lot D and Lot E, the treated plants were severely injured by high temperature, and especially in Lot E all "Akage" plants were quite killed. In these lots the results of the inoculation experiments were by no means satisfactory owing to the predominance of the direct injuries of the high temperature treatments.

EXPERIMENT 23. Hot air treatment with bell-jar

On January 6, 1937, 100 sterilized seeds each of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 25°C.

On January 11, the seedlings were planted in pots filled with fully fertilized loam soil. Ten seedlings were set in each pot of 11 cm. in diameter and in depth, and they were placed in a greenhouse.

On February 4, the pots bearing the rice plants were divided into 4 lots, A, B, C, and D, and the plants other than the control were treated by gradual heating up to a certain degree of temperature, and when the required temperature was reached they were immediately taken out of the heating equipment.

Lot A: Control, with no special treatment.

Lot B: Heated up to 40°C.

Lot C: Heated up to 45°C.

Lot D: Heated up to 50°C.

After these treatments the inoculation was made immediately by atomizing the spore suspension. The inoculated plants were kept in a moist chamber for 48 hours and then placed in a greenhouse.

On February 15, the results of the inoculation experiments were examined by observing the lesions which had appeared on the leaf-blades caused by the infection of the fungus, and comparing the controls and the treated plants. The experimental results are shown in the following Table XXIII.

TABLE XXIII. Results of inoculation experiments on rice plants treated by gradual heatings up to 40° to 50°C. before the inoculation.

Variety of rice plants		Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)	
Lot A Control	Bozu	10	32.05	2.8	0.2143	1.8721	0.55	
	Akage	7	31.14	2.9	0.2500	2.2938	0.48	
Lot B (40°C.)	Bozu	9	34.28	2.9	0.4231	3.5653	0.51	
	Akage	9	27.67	3.0	0.1851	2.0080	0.48	
Lot C (45°C.)	Bozu	10	33.35	3.0	0.4000	3.5982	0.49	
	Akage	8	26.19	2.5	0.2500	2.3864	0.47	
Lot D (50°C.)	Bozu	10	All plants were killed by heating					
	Akage	10						

In Lot B and Lot C, marked increases in percentage of the infection were observed on the plants of "Bozu" variety, but no such

remarkable effect of the treatment was seen on the plants of "Akage" variety. In Lot D, in which the temperature had been raised up to 50°C., all plants of both varieties were entirely killed as a direct result of the high temperature treatments.

In the present and previous experiments, the rice plants were covered with bell-jar in the heating equipment, and the temperature in the bell-jar was raised gradually by heating the tin plate in the bottom of the apparatus with gas flame. In such treatments, the inside of the bell-jar became extremely humid by the evaporation of water from the soil in the pot owing to the rise of temperature. It is highly probable that the hot and humid condition inside the bell-jar would be seriously deleterious to the plants. To avoid this undesirable maleficence another method of hot air treatment was employed in the next experiment.

EXPERIMENT 24. Hot air treatments without bell-jar

On January 6, 100 sterilized seeds each of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 25°C.

On January 11, the seedlings were planted in pots filled with fully fertilized loam soil. Ten seedlings were set in each pot of 11 cm. in diameter and in depth, and they were placed in a greenhouse.

On February 13, the pots bearing the rice plants were divided into 4 lots, A, B, C, and D, and the plants other than the control were treated with hot air directly in the heating box without using the bell-jar as a covering. The whole temperature inside the box was raised by an electric heater. Several holes were provided through the upper wall of the box for ventilation in order to keep the interior of the box comparatively dry.

Lot A: Control, with no special treatment.

Lot B: Temperature was raised gradually to 37°C.

Lot C: Temperature was raised gradually to 40°C.

Lot D: Temperature was raised gradually to 43°C.

When the temperature in the box reached the required degree, the plants were taken out of the box and inoculated at once by atomizing the spore suspension. The plants inoculated, having been kept in a moist chamber for 48 hours, were placed in a greenhouse.

On February 24, the results of the inoculation experiments were examined by observing the lesions which had appeared on the leaf-blades caused by the infection of the fungus, and by comparing the controls and the treated plants. The experimental results are shown in the following Table XXIV.

TABLE XXIV. Results of inoculation experiments on rice plants treated by gradual heating up to 37°–43°C.

Variety of rice plants	Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)	
Lot A Control	Bozu	9	39.72	2.9	0.4615	3.3567	0.40
	Akage	6	46.67	3.2	0.2105	1.4285	0.38
Lot B (37°C.)	Bozu	8	41.19	3.1	0.6400	4.8555	0.44
	Akage	8	35.94	3.3	0.8846	7.9994	0.47
Lot C (40°C.)	Bozu	10	40.40	3.3	0.3636	2.9703	0.41
	Akage	10	40.55	4.0	0.6500	6.4118	0.39
Lot D (43°C.)	Bozu	7	38.14	3.0	0.1905	1.4982	0.45
	Akage	8	39.56	3.4	0.2593	2.2106	0.39

In the present experiment the highest percentage of infection occurred on both varieties in Lot B, in which the temperature had been raised to 37°C. In "Bozu" variety the control plants were affected next most severely, and the lowest percentage of infection was found in Lot D, in which the temperature was raised to 43°C. In "Akage" variety the next most severe infection was presented in Lot C, in which the temperature was raised to 40°C., the third occurred in Lot D, in which the temperature was raised to 43°C., and the least infection was observed on the control plants which had been inoculated without any special treatment.

EXPERIMENT 25. Hot water treatments

On January 6, 100 sterilized seeds each of "Bozu" and "Akage" varieties were sown in Petri dishes, and the seedlings were raised in a thermostat at 25°C.

On January 12, the seedlings were planted in pots filled with fully fertilized loam soil. Eight seedlings were set in each pot of 11 cm. diameter and depth, and they were placed in a greenhouse.

On February 16, the pots bearing the rice plants were divided into 4 lots, A, B, C, and D, and the plants other than the control were treated by immersing in hot water of definite temperature for one minute.

Lot A: Control, with no special treatment.

Lot B: Treated at 43°C.

Lot C: Treated at 45°C.

Lot D: Treated at 47°C.

After the treatments the plants were taken out of the hot water, quickly dried with blotting paper, and the inoculation was made by atomizing the spore suspension. The inoculated plants were kept in a moist chamber for 48 hours and then placed in a greenhouse.

In this experiment the plants of "Bozu" variety were mostly examined and only in Lot C was the "Akage" variety used in parallel for comparison.

On February 27, the results of the inoculation experiments were examined by observing the lesions on the leaf-blades caused by the infection of the fungus, and comparing the controls and the treated plants. The results of the experiments are shown in the following Table XXV.

TABLE XXV. Results of inoculation experiments on the rice plants treated by immersion in hot water of 43°–47°C. for one minute.

Variety of rice plants		Number of plants	Average height of plants (cm.)	Average number of leaves per plant	Number of spots per leaf	Number of spots per 100 cm. height	Average length of spots (cm.)
Lot A Control	Bozu	5	43.50	3.6	0.1111	0.9195	0.55
Lot B (43°C.)	Bozu	5	41.50	3.4	0.3529	2.8913	0.53
Lot C (45°C.)	Bozu	7	38.57	3.1	1.2727	10.3345	0.60
	Akage	4	37.75	1.8	1.8571	8.6093	0.56
Lot D (47°C.)	Bozu	6	38.17	2.8	0.4118	3.0566	0.59

The highest percentage of infection in the present experiments was observed in Lot C, in which the plants were treated by immers-

ing for one minute in hot water at 45°C., and the next most severe infection occurred in Lot D on the plants treated at 47°C. The severity of the infection in Lot B was the third, and the least infection was observed on the control plants. The contrast in the severity of the infection between the control and the treated plants was very remarkable in this experiment.

Discussion and Conclusion

In the present study, rice plants were given wounds or subjected to apparently unfavorable condition in atmosphere or soil, and then they were inoculated artificially with conidia of the blast fungus. In the results of the experiments on the whole, the high percentages of infection were obtained on the treated plants, with the exceptional case of the plants which had been kept in saturated humidity for a while before the inoculation.

In the first experiments, inoculation was made on rice plants given wounds in various ways; a high percentage of infection was obtained, without exception, on the wounded plants. The results indicated that the resistance of rice plants to the blast infection was decreased by giving wounds. In nature the rice plants are very frequently wounded by wind, especially by storms, by various kinds of insects or other animals and sometimes by men themselves in the process of cultivation work. Being injured by such agencies will possibly result in an occasional increase of susceptibility or a decrease of resistance in rice plants to "Imochi", the blast disease. In reality it has been experienced that the blast disease of rice plants as well as other plant diseases frequently break out after the ravages of a storm owing possibly to the mechanical injuries. In this connection, KIKKAWA (4) reported that the development of the rice blast disease often is promoted by strong wind.

In Experiments 2 and 3, the rice plants were struck and rubbed with pieces of wood to give mechanical shocks without intentionally giving external wounds, and the results of the inoculation indicated with no doubt that the percentage of the infection was increased by this operation. From the results of these experiments it seems evident that the development of "Imochi" disease would be increased by the use of "Funagata-ami", the catch net, to exterminate the "Doro-oi-Mushi" (*Lema Oryzae* KUWAYAMA), the noxious insect of rice plants. For this and some other reasons, poisonous preparations

such as calcium arsenate or lead arsenate should be recommended for use in the extermination of this insect.

One reason why the resistance of rice plants to the blast fungus was reduced by giving wounds may be the partial spoiling of protective tissues facilitating the invasion of the pathogen, because the blast fungus infects rice plants by penetrating through the cuticle. Another reason for the depression of the blast resistance by mechanical injuries may be some possible disturbances of the physiological functions of living cells of the plants, resulting in an occasional suppression of the functional resistance to the fungus invasion. On this point further inoculation experiments without giving external wounds or mechanical shocks to rice plants were carried out.

In Experiments 5, 6, 7 and 8, rice plants were kept in extraordinary dry conditions before the inoculation. It was observed that in "Akage" variety a high percentage of infection was obtained with no exception on the plants subjected to dry conditions. In "Bozu" variety, however, the high percentage of infection occurred on the treated plants in Experiments 6 and 8, but in Experiments 5 and 7 it happened on the control plants. The duration of the artificial drought had apparently no marked relation to the fluctuation of the percentage of infection within the scope of the present experiments. In accordance with these observations it would be probable that a certain dry condition rather favors the growth of "Bozu" plants, and their functional resistance to the blast disease seems apt to increase to some extent from this treatment. HIRAYAMA (2) stated that the cell sap concentrations of rice seedlings (Nakate-Shinriki variety) grown on arid soil were always higher than those of the seedlings grown on humid soil, and recognized that the susceptibility of the rice plant to the blast disease has a direct or indirect relation to the cell sap concentrations, but he doubted whether the cell sap concentration has an influence directly on the penetration as well as on the growth of the fungus in the host tissues or indirectly on the germination of the spores in the infection drop. If the resistance of the "Bozu" variety to the blast disease is based on the cell sap concentration, it might be possible that the plants of this variety sometimes happened to increase their resistance by the treatment under dry soil condition.

The increase of the blast susceptibility in "Akage" variety by the drought treatments would be explained apparently by a possible

disturbance of normal physiologic functions, and it seemed to be an ordinary case corresponding to the fact that the outbreaks of the blast disease frequently occur after a drought in rice field in nature.

In Experiments 9 and 10, in which plants were kept in a moist chamber for a certain time before the inoculation, the results revealed a marked tendency of diminution in the percentage of infection on the plants treated in a moist chamber of saturated humidity. This is almost identical with the facts indicated by S. ITO and SHIMADA (3).

On the whole it would be concluded that a temporary humid condition before the inoculation may exert no positively unfavorable influence upon the resistance of rice plants to the invasion of the blast fungus.

In the experiments from No. 11 to No. 21, the plants were treated by the vapor of ether, chloroform and absolute alcohol, and the results of the inoculation generally showed increases of the infection on the treated plants. Recently FISCHER (1) stated that the plants (*Impatiens glanduligera* and *Nicotiana rustica*) treated with the vapor of ether or chloroform showed an increase of nitrogen in leaves and an increase of dry matter. The method of narcotizing treatment used in his experiments was that the plants were kept for a certain time in a bell-jar of 12 litres volume saturated with the vapor of a certain amount of the narcotics. This method was similar in principle to that used in the present experiments. The results of FISCHER's experiments seem to suggest that the influence of these narcotics on the plants was not only temporary. The reason why the narcotized plants were more readily infected by parasitic fungi than the untreated control plants may be concerned directly with the disorder of the physiological function of living protoplasm owing to the deleterious influence of narcotic vapors. So far as it has been found in the present experiments, the influence of the narcotics seems to be somewhat durable, and exerting an anaesthetic effect on the physiological activities of the protoplasm, they might oppress the functional resistance of the plants to the attack of the fungus.

In the experiments from No. 22 to No. 25, the inoculation was made on the rice plants treated at high temperatures by heating the surrounding air or immersing the plants in hot water, and the vicissitudes of the blast infection were examined in comparison to the infection taking place on the untreated control plants. It would be

concluded from the results that the resistance of rice plants to the blast disease has been apparently decreased by the high temperature treatments. Throughout these 4 experiments the interesting fact was observed that the percentage of infection increased owing to a rise in temperature until the maximum was reached, and beyond the maximum point it decreased in consequence of rising temperature and sometimes it became lower than that on the control plants. In fact, some differences in the reaction to high temperature treatments were observed between the resistant "Bozu" variety and the susceptible "Akage" variety. The contrast in the percentage of infection between the control and the treated plants was especially remarkable in "Bozu" variety.

In the present treatments it is important to note that the influence of the high temperature was quite temporary, and moreover that the inoculation was performed immediately after the instantaneous treatment. Therefore, the effects of the treatments upon the structure of cell tissues, upon the development of mechanical cells, or upon the quantitative or qualitative toughness of cell walls could not enter into consideration. It only remained to make the interpretation that the high temperature treatments which promoted the infection might be concerned in a disturbance of the functional resistance of living cells. So the writers believe that the treatments caused a depression in the functional resistance of rice plants and resulted in the increase of the infection.

In a comprehensive view of the experimental results obtained in the present study, it was recognized that giving wounds or mechanical shocks, keeping a few days in a drought condition, treating for a while at a high temperature, and treating with an application of narcotic vapor brought a depression of the blast resistance on rice plants, and the infection increased generally on the treated plants in comparison with the controls. This would be interpreted as occurring on account of some maleficent influences of the treatments upon the functional resistance of rice plants to the blast infection.

In nature, the outbreaks of the blast disease in rice field after inclement weather or unfavorable climatic conditions or such have been frequently experienced, and the present study may afford a suggestion to the theoretical interpretation of those facts.

Summary

1. The present paper deals with xenoparasitic phenomena in the rice blast disease caused by *Piricularia Oryzae* BR. et CAV. on

"Bozu", the resistant variety and "Akage", the susceptible variety in comparison.

2. In the inoculation experiments carried out on the rice plants maltreated by pricking the leaves with sharp needles, by cutting off pieces of leaves with a sharp razor, or by giving mechanical shocks with flat pieces of wood, a higher percentage of infection was generally obtained on the treated plants.

3. In the inoculation experiments on the rice plants subjected to dry conditions for 3 to 6 days without watering, the infection occurred more severely on the treated plants than on the controls in "Akage" variety, but in the case of the resistant "Bozu" variety the occurrence of the infection was sometimes rather reduced on the treated plants.

4. In the inoculation experiments on the rice plants kept in a saturated moist chamber for 24 to 72 hours, no remarkable difference in the severity of infection was observed between the treated plants and the controls, and a somewhat prolonged enclosure in the moist chamber generally resulted in a reduction of the infection.

5. In the inoculation experiments on the rice plants narcotized by an application of the vapor of ether, chloroform, or absolute alcohol in various amounts and for varying lengths of time, the infection increased in general on the treated plants. The most remarkable infection promoting effect of the narcotics occurred when the proportion of a narcotic in the air and the length of time of the treatment held a certain proper limits.

6. In the inoculation experiments on the plants subjected to high atmospheric temperature in an especially designed heating apparatus for a short time or by immersing in hot water for one minute, marked increases of the infection were generally observed on the treated plants in comparison with the untreated controls.

7. The writers concluded from the results of the present experimentations that giving wounds or mechanical shocks, subjection to artificial drought, applications of narcotic vapors, or subjection to unusually high temperature promoted the probability of the infection of rice plants by the blast disease, which would be interpreted as occurring on account of the resulting disturbance of the functional resistance in the treated plants. The writers have further extended their considerations to the facts of frequent outbreaks of the rice blast disease in nature after the occurrence of certain unfavorable

conditions for the growth of rice plants and presumed that these outbreaks may be concerned with the oppression of the functional resistance of the plants to the fungus invasion owing to those maleficent influences.

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