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DEPARTMENT OF THE ARMY
Fort Detrick
Frederick, Maryland

Part A-1

ON RELATION OF SOIL MOISTURE TO DEVELOPMENT OF RICE BLAST DISEASE WITH SPECIAL REFERENCE TO INOCULATION EXPERIMENTS ON PLANTS GROWN IN SOILS DIFFERING IN MOISTURE AND AMOUNTS OF NITROGENOUS MANURE.

by

Hashio Suzuki

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Kyoto University

Plant Pathological Laboratory

I. INTRODUCTION

The fact that the susceptibility of the rice plant to rice blast disease is closely related to soil humidity, and that dryness of the soil increases the suceptibility while wetness of the soil has the opposite effect, has been reported frequently by Prof. Itsumi and the author(1)(2)(7)(8). Further investigation by the author(9) revealed that the susceptibility of the plant to rice blast disease varied with the time of infection in the growth period of the plant, for instance: that with blast disease of the leaf in the seedling, the effect of soil humidity on susceptibility to the disease was more pronounced during the first half stage of plant growth compared to the second half of seedling growth; while with the blast disease of the rice pedicel, the effect of soil humidity on disease susceptibility was larger for the growth period following flowering compared to the period preceeding the flowering.

With respect to the fact that excessive nitrogenous fertilizer will increase the incidence of rice blast disease, this phenomenum has been frequently discussed since it was first pointed out by Hori(3), and today there is no argument about the fact that the susceptibility of the rice plant to the disease increases proportionally with the amount of nitrogenous fertilizer used.

Knowing these two facts, the author thought it would be interesting to investigate the effect of nitrogenous fertilizer, which is known to increase susceptibility to the disease, on the susceptibility due to soil dryness or wetness. The author conducted inoculation experiments on the seedlings and spike pedicels of plants grown on soils with varying soil humidity conditions and amounts of nitrogenous fertilizer and with respect to the ash figures of these specimens, the anatomical differences were also investigated.

In writing this paper, the author would like to thank Prof. Itsumi for his kind guidance and advice.

II. INOCULATION EXPERIMENTS ON RICE SEEDLINGS GROWN ON SOILS WITH VARYING SOIL HUMIDITY AND AMOUNTS OF NITROGENOUS FERTILIZER

This experiment consisted of filling zinc cans, 14 cm in diameter and 13 cm high, or 1/50,000 size Wagner pots with sandy dirt fertilized in the following manner: one-third of the cans or pots were fertilized with 107.25 kgs of soya-bean lees, 35.63 kgs of ammonium sulfate, 28.88 kgs of calcium superphosphate, and 52.13 kgs of wood ash to the tan (= 0.245 acres); in the other two-thirds of the cans or pots, the amount of soya-bean lees and the ammonium sulfate were doubled. In the experiments, the former was referred to as the standard fertilized plot, while the second lot was referred to as doubly fertilized. After preparation of the soil in the above manner, all of the cans or pots were seeded. The seed used was of the late-growing "Asahi" variety developed on the Kyoto University farms, this same variety being used throughout the entire course of the present experiments. After the seedlings developed to about one centimeter in height, all of the cans or pots with standard fertilizer and one-half of the cans or pots with doubly fertilized soil were watered only enough to keep the plants alive. The remaining containers in the doubly fertilized group were well irrigated so that the water level was always within a centimeter or two from the surface of the dirt. When the seedlings attained heights ranging from 20 to 40 centimeters, they were all sprayed with a liquid suspension of spores of the rice blast disease (Culture No. 9 stored in the laboratory). The containers were then stored for 24 hours in a 28°C Kyoto University type constant temperature inoculation chamber, and subsequently returned to shelves in the greenhouse and water was sprinkled on the leaves from time to time. A similar number of pots or cans were planted and cultivated without inoculation for control purposes. These experiments were conducted in the greenhouse during the period from December 1930 to March 1931, with the results being examined 7 to 10 days after inoculation. The results of the experiment are shown in Tables 1 and 2.

Table 1. Result of Inoculation Experiment With Rice Seedlings Grown in Soil Varying in Moisture Content and Nitrogenous Fertilizer. (Case where zinc cans were used.)

(1) 試験回數	(2) 施肥量	(5) 土壤乾濕	(8) 接種試驗	(11) 供試稻苗數	(12) 稻苗一個的高平均 (cm.)	(13) 總病斑數	(14) 稻苗一個當平均病斑數	(15) 發病比率
第1回實驗	(3) 原量	(6) 乾燥區	(9) 標準區	118	24.32	0	0	1.33
			(10) 接種區	162	24.18	116	71.00	
	(4) 2倍量	(6) 乾燥區	(9) 標準區	150	24.29	0	0	1.67
			(10) 接種區	152	24.32	137	90.13	
		(7) 灌水區	(9) 標準區	107	20.24	0	0	1.00
			(10) 接種區	189	20.80	102	53.07	

(1) 實驗回數	(2) 施肥量	(5) 土壤乾濕	(8) 接種試驗	(11) 供試稻苗數	(12) 稻苗一個體當平均草丈 (cm.)	(13) 總病斑數	(14) 稻苗一個體當平均病斑數	(15) 發病比率
第2回實驗	(3) 原量	(6) 乾燥區	(9) 標準區	165	22.13	0	0	1.01
			(10) 接種區	210	22.14	73	34.29	
	(4) 2倍量	(6) 乾燥區	(9) 標準區	150	25.20	0	0	2.42
			(10) 接種區	140	26.82	122	81.88	
		(7) 湛水區	(9) 標準區	138	30.82	0	0	1.00
			(10) 接種區	210	20.55	71	33.81	
第3回實驗	(3) 原量	(6) 乾燥區	(9) 標準區	225	20.60	0	0	1.58
			(10) 接種區	418	20.57	501	119.86	
	(4) 2倍量	(6) 乾燥區	(9) 標準區	204	21.06	0	0	1.95
			(10) 接種區	258	21.05	382	148.06	
		(7) 湛水區	(9) 標準區	250	22.00	0	0	1.00
			(10) 接種區	294	21.77	223	75.85	
第4回實驗	(3) 原量	(6) 乾燥區	(9) 標準區	124	23.00	0	0	1.01
			(10) 接種區	269	22.87	250	92.04	
	(4) 2倍量	(6) 乾燥區	(9) 標準區	154	23.15	0	0	1.67
			(10) 接種區	175	23.00	268	153.14	
		(7) 湛水區	(9) 標準區	118	25.00	0	0	1.00
			(10) 接種區	244	24.50	224	91.80	
第5回實驗	(3) 原量	(6) 乾燥區	(9) 標準區	150	20.95	0	0	1.01
			(10) 接種區	185	20.87	493	266.49	
	(4) 2倍量	(6) 乾燥區	(9) 標準區	180	21.00	0	0	1.20
			(10) 接種區	213	21.02	674	316.43	
		(7) 湛水區	(9) 標準區	128	23.00	0	0	1.00
			(10) 接種區	176	22.37	466	264.77	

(1) No. of series of experiment; (2) Amounts of fertilizer; (3) Standard fertilizer; (4) Doubly fertilized; (5) Moisture condition of soil; (6) Dry; (7) Irrigated; (8) Inoculation; (9) Control group; (10) Inoculated group; (11) No. of seedlings in experiment; (12) Average grass height per seedling; (13) Total number of disease mottles; (14) Average number of disease mottles per hundred seedlings; (15) Rate of infection.

Table 2. Result of Inoculation Experiment With Rice Seedlings Grown in Soil Varying in Moisture Content and Nitrogenous Fertilizer. (Case where Wagner pots were used.)

實驗回數	施肥量	土壤乾濕	接種試驗	供試稻苗數	稻苗一個的平均草丈 (cm.)	總病斑數	稻苗百個的平均病斑數	發病比率
第1回實驗	原量	乾燥區	標準區	220	21.80	0	0	1.68
			接種區	250	22.96	138	55.20	
	2倍量	乾燥區	標準區	220	22.67	0	0	2.23
			接種區	227	22.61	166	73.13	
		灌水區	標準區	207	29.00	0	0	1.10
			接種區	250	28.87	82	32.80	
第2回實驗	原量	乾燥區	標準區	120	22.33	0	0	4.21
			接種區	120	22.42	230	191.67	
	2倍量	乾燥區	標準區	125	22.45	0	0	4.08
			接種區	120	22.31	223	185.83	
		灌水區	標準區	132	27.00	0	0	1.00
			接種區	180	26.59	82	45.56	
第3回實驗	原量	乾燥區	標準區	142	25.24	0	0	1.16
			接種區	120	26.01	92	76.67	
	2倍量	乾燥區	標準區	148	25.00	0	0	1.29
			接種區	108	24.65	92	85.19	
		灌水區	標準區	123	28.25	0	0	1.00
			接種區	154	28.16	102	66.23	

実験回数	施肥量	土壌乾湿	接種試験	供試稲苗数	稲苗一個体当平均草丈 (cm.)	総病斑数	稲苗個体当平均病斑数	発病比率
第4回実験	原量	乾燥区	標準区	120	20.45	0	0	1.03
			接種区	150	27.88	126	84.60	
	2倍量	乾燥区	標準区	154	27.21	0	0	1.65
			接種区	160	26.80	204	127.50	
		灌水区	標準区	140	34.00	0	0	1.00
			接種区	150	34.33	116	77.33	
第5回実験	原量	乾燥区	標準区	152	24.80	0	0	1.06
			接種区	148	20.53	195	131.76	
	2倍量	乾燥区	標準区	165	20.50	0	0	1.18
			接種区	133	26.34	195	146.62	
		灌水区	標準区	162	38.02	0	0	1.00
			接種区	180	40.35	224	124.44	

/Same as Legend for Table 1./

As the results in Tables 1 and 2 clearly show, the rate of infection was least for the doubly-fertilized irrigated group. This was followed by the standard-fertilized, dry group, with the doubly-fertilized, dry group having the highest rate of infection. Comparing the rates of infection of the doubly-fertilized, irrigated group and the standard-fertilized, dry group, one notes that only with the 4th and 5th series with the Wagner pots does the rate of infection slightly exceed the rates of infection in the corresponding series with the zinc cans, including the 2nd series with the cans. In all of the other series, the rate of infection with the Wagner pots was anywhere from 1.2 times to 4.2 times that with the zinc cans. In comparing the dry and irrigated plots which are doubly-fertilized, one finds that irrespective of whether cans or pots were used, the dry plots showed rates of infection 1.2 times to 4 times that of the irrigated plots.

The results indicate that under the conditions of the experiment, the rate of infection was always higher with the dry soil irrespective of the amount of fertilizer used. When the amount of nitrogenous fertilizer was doubled, the rate of infection could be lowered below that for the case with standard fertilizer and dry soil by means of proper irrigation.

III. STUDY OF NATURAL INFECTION OF ADULT PLANT LEAVES OF PLANTS GROWN ON SOIL WITH VARYING MOISTURE CONTENTS AND AMOUNT OF NITROGENOUS FERTILIZER

Into zinc cans 28 cm in diameter and roughly 19 cm high, sandy soil fertilized in the manner already described was heaped, and rice seedlings were then transplanted into these cans. The soil was kept well irrigated until the seedlings took root, but then on 30 June 1932, in all of the cans with standard fertilizer mix and half of those cans with the double fertilizer mixture, the water was allowed to drain from the soil. The remaining one-third of the cans was put outdoors and kept irrigated. After reasonable growth, the author had contemplated inoculation experiments with the leaves of the rice plant, but since there was an outbreak of rice blast disease near the end of July, it was decided to take this opportunity to study the nature of natural infection of the disease. This experiment was performed in 1932, with examination of infection being conducted the first time on 1 August, the second time on 2 August, and finally for the third time on 5 August. The results of the examinations are shown in Table 3.

Table 3. Results of Investigation of Natural Occurrence of Rice Blast Disease of Leaves of Adult Rice Plants Grown in Soils with Varying Humidity and Amounts of Nitrogenous Fertilizer.

實驗回數 (1)	施肥量 (2)	土壤乾濕 (5)	調査稻葉數 (8)	平均葉身長 (cm) (9)	總病斑數 (10)	稻葉百枚當平均病斑數 (11)	發病比率 (12)
(13) 第1回調查	(3) 標量	(6) 乾燥區	299	23.89	324	108.36	2.01
	(4) 2倍量	(6) 乾燥區	300	21.60	390	130.00	2.42
		(7) 湛水區	301	23.23	162	53.82	1.00
(14) 第2回調查	(3) 標量	(6) 乾燥區	132	25.98	159	120.45	3.11
	(4) 2倍量	(6) 乾燥區	145	24.14	206	142.07	3.66
		(7) 湛水區	116	25.03	45	38.79	1.00
(15) 第3回調查	(3) 標量	(6) 乾燥區	236	21.20	198	83.90	1.81
	(4) 2倍量	(6) 乾燥區	204	25.34	167	81.86	1.77
		(7) 湛水區	199	25.77	92	46.23	1.00

(1) No. of examination; (2) Amount of fertilizer; (3) Standard Fertilization; (4) Doubly fertilized; (5) Soil humidity; (6) Dry plots; (7) Irrigated plots; (8) No. of leaves examined; (9) Average height of leaves; (10) Total number of disease mottles; (11) Average percentage of mottles per leaf; (12) Rate of infection; (13) First examination, (14) Second examination; (15) Third examination.

As can be seen from the results in the above table, the rate of infection was lowest in the irrigated group which was doubly-fertilized. With the exception of the third examination, for the dry soil group, the doubly-fertilized plots always had a higher rate of infection than the plots with standard-fertilization.

The results obtained here with respect to natural infection of the leaf of the adult rice plant coincided with the results obtained previously with the seedling inoculation experiments. That is, irrespective of the amount of fertilizer, the rate of infection was always lower with the irrigated plots, also even with doubly-fertilized soil, irrigation reduced the rate of infection to a value lower than that for a dry plot with standard fertilization.

IV. INOCULATION EXPERIMENT ON SPIKE PEDICELS OF RICE PLANTS GROWN IN SOILS WITH VARYING HUMIDITY AND AMOUNTS OF NITROGENOUS FERTILIZER

For this experiment, rice plants grown in exactly the same manner as that previously described for the preceeding experiments were allowed to grow to the stage of spike formation. At this point, absorbent cotton was wrapped around the stem below the spike pedicel articulation, and about 0.5 cc of a water suspension of rice blast disease spore was titrated onto the cotton wad with a dropper. The plants were kept in a humid room for 36 hours after which they were returned to the greenhouse with frequent sprinkling of water on the leaves and the spike pedicels. The first, second, and third series of experiments were conducted in 1931. Inoculation was performed on 10 September in the first series of experiments, 14 September in the second series, and on 15 September in the third series. The plants were examined for infection on 26 September in the first series of experiments and on 27 September in the second and third series. The fourth series of experiments was undertaken in 1932 with water being drained from the soil on 27 July, the inoculation being performed on 2 October and the results being examined on 18 October. The results of these experiments are given in Table 4.

Table 4. Results of Inoculation Experiments on Spike Pedicels of Rice Plants Grown in Soil with Varying Humidity and Amounts of Nitrogenous fertilizer.

試験回數 (1)	施肥量 (5)	土壤乾濕 (9)	接種試驗 (12)	供試穗數 (1)	發病總穗數 (1)	百本當發病穗數 (1)	發病比率 (18)
(2) 第1回試驗	(7) 標肥	(10) 乾燥區	(13) 標準區	62	0	0	1.71
			(14) 接種區	78	12	15.38	
	(8) 2倍量	(10) 乾燥區	(13) 標準區	80	0	0	2.78
			(14) 接種區	76	19	25.00	
		(4) 湛水區	(13) 標準區	73	0	0	1.00
			(14) 接種區	100	9	9.00	
(3) 第2回試驗	(7) 標肥	(10) 乾燥區	(13) 標準區	53	0	0	1.15
			(14) 接種區	63	19	30.16	
	(8) 2倍量	(10) 乾燥區	(13) 標準區	38	0	0	1.46
			(14) 接種區	47	18	38.30	
		(11) 湛水區	(13) 標準區	42	0	0	1.00
			(14) 接種區	103	27	26.21	

Table 4 (Continued).

実験回数	施肥量	土壌乾湿	接種試験	供試穂頸数	発病穂頸数	百本当発病穂頸数	発病比率
(4) 第3回実験	(7) 原量	(10) 乾燥区	(13) 標準区	82	0	0	1.10
			(14) 接種区	67	15	22.39	
	(8) 2倍量	(10) 乾燥区	(13) 標準区	45	0	0	1.44
			(14) 接種区	82	24	29.27	
		(11) 灌水区	(13) 標準区	32	0	0	1.00
			(14) 接種区	59	12	20.34	
(5) 第4回実験	(7) 原量	(10) 乾燥区	(13) 標準区	56	0	0	1.10
			(14) 接種区	115	59	51.30	
	(8) 2倍量	(10) 乾燥区	(13) 標準区	48	0	0	1.01
			(14) 接種区	131	62	47.33	
		(11) 灌水区	(13) 標準区	78	0	0	1.00
			(14) 接種区	235	110	46.81	

(1) No. of series of experiment; (2) First series; (3) Second series; (4) Third series; (5) Fourth series; (6) Amount of fertilizer; (7) Standard fertilization; (8) Doubly fertilized; (9) Humidity of soil; (10) Dry; (11) Irrigated; (12) Inoculation experiment; (13) Control group; (14) Inoculated group; (15) Number of spike pedicels in experiment; (16) Total number of infected spike pedicels; (17) No. of infected spike pedicels per one hundred samples; (18) Rate of infection.

The results clearly indicate that throughout the experiments, the rate of infection was highest with the dry plots doubly-fertilized, this being followed in rate of infection by the dry plots with standard fertilization, with the lowest rate of infection being shown by the doubly-fertilized irrigated plots. These results are identical with those obtained in the inoculation experiments with the rice plant leaves previously described in this report, and the results of the inoculation experiments with the spike pedicels of the rice plant are seen to follow the same general trend.

V. ASH FIGURE OF LEAVES OF RICE PLANTS GROWN IN SOILS WITH VARYING HUMIDITY AND AMOUNTS OF FERTILIZER

The author and others[(4)(5)(6)(9)] have shown that there is a close correlation between the susceptibility of the rice plant to rice blast disease and the anatomical characteristics which contribute to the toughness of the tissue, and experiments were performed which showed that there was more silicification of the epidermal tissue of leaves and spike pedicels of rice plants grown in well irrigated soils as compared to dry soils.

According to the results of the experiments described in the previous section, even with double the amount of nitrogenous fertilizer, if the soil was well irrigated, the results showed that the plant leaves were more resistant to rice blast disease infection than when the plant was grown in dry soil with the standard fertilizer mixture. In order to clarify this phenomenon and the cause or causes of the change in susceptibility to the disease brought about by a change in the amount of nitrogenous fertilizer, a comparative study was made of anatomical characteristics with respect to the ash figure of the rice plant leaf. The rice plants used for this experiment were grown in a greenhouse in a 1/10,000 Wagner pot in the same manner in which specimens were grown in the previous experiment. The differences from the previous experiment were that a plot was grown with standard fertilizer mixture and irrigation, and also the doubly-fertilized-dry plot was omitted.

1. Number of stomata formed by silicification of guard cells.

In accordance with the definition used in previous papers by the author and others[(4)(5)(6)], we shall consider as a single silicified stoma any stoma which has one or two guard cells that are extremely silicified. We related that a count of such silicified stoma per unit area of the leaf would serve as an indicator of the degree of silicification of the epidermal tissue. We took leaf samples from plants grown in standard-fertilized dry and irrigated soils, and also in the doubly-fertilized irrigated soil. With respect to the ash figure of about one centimeter of the middle part of the leaf, the number of stomata viewable in the field of a Zeiss DDx4 microscope were counted, the results of which are given in Table 5. The sets of figures in the table represent the maximum, minimum, and average of about twenty separate measurements.

Table 5. Results of Measurement of Number of Silicated Stomata per Unit Area of Leaf Epidermal Tissue from Plants Grown in Soils with Varying Humidity Conditions and Amount of Nitrogenous Fertilizer

(1) 施肥量	(2) 標準量						(3) 2倍量		
(4) 土壤乾濕	(5) 乾燥區			(6) 灌水區			(6) 灌水區		
(7) 供試材料番號	最(8)多	最(9)少	平(10)均	最(8)多	最(9)少	平(10)均	最(8)多	最(9)少	平(10)均
I	1	0	0.15	20	2	9.10	19	0	4.85
II	5	0	0.70	10	0	3.05	6	0	1.00
III	10	0	2.10	10	0	3.35	13	0	3.70
IV	1	0	0.05	10	1	4.40	6	0	2.55
V	1	0	0.05	10	0	2.20	7	0	1.40
(10) 平均	3.60	0	0.61	13.20	0.60	4.42	10.00	0	2.88

(1) Amount of fertilizer; (2) Standard fertilizer; (3) Doubly fertilized; (4) Humidity of soil; (5) Dry; (6) Irrigated; (7) No. of sample; (8) Maximum; (9) Minimum; (10) Average.

As can be seen from the above results, the number of silicated stomata viewable in the field of the Zeiss DDx4 instrument was largest for the sample grown on irrigated soil with standard fertilizer, followed by the irrigated plot with double the nitrogenous fertilizer, with the smallest number being found in the samples from plants grown on dry soil with standard fertilizer.

These results show that the degree of silicification of the epidermal tissue is much more advanced in the samples from the doubly-fertilized irrigated plot than in the dry plot with standard fertilizer, this difference corresponding to the previously related difference in the rates of infection of plants grown on these two types of plots. If we also consider the fact that silicification of the epidermal tissue is more progressed in the irrigated, standard-fertilized plot than in the doubly-fertilized, irrigated plot, it can be assumed that there must be some relation between the increase in susceptibility caused by doubling the amount of nitrogenous fertilizer on one hand, and on the other hand, the decrease in silicification of the epidermal tissue.

2. Size of Reiszelle (rice-cell).

The authors(4)(5)(6) have previously shown that the degree of silicification of the epidermal tissue can also be measured by means of measuring the size of the rice cells. The size of the rice-cells measured from the ash figures previously used for the determination of the silicified stomata count are given in Table 6. The figures in the table are averages of 30 separate measurements.

Table 6. Average Measured Size of Rice Cells of Leaves of Rice Plants Grown in Soils with Varying Humidity Conditions and Amounts of Nitrogenous Fertilizer

(1) 施肥量	(2) 標準量		(3) 2倍量
(4) 供試材料番號	(5) 乾燥區	(6) 湛水區	(6) 湛水區
I	6.17×3.70	6.62×3.60	7.72×4.35
II	7.12×3.15	6.90×3.40	6.67×3.08
III	3.72×3.22	7.23×3.95	6.93×3.72
IV	5.95×3.65	7.90×3.45	7.12×3.43
V	6.75×3.88	7.15×3.95	6.17×3.62
(7) 平均	6.54×3.50	7.16×3.67	6.92×3.64

(1) Amount of fertilizer; (2) Standard fertilizer; (3) Doubled fertilizer; (4) No. of sample; (5) Dry plot; (6) Irrigated plot; (7) Average.

As can be seen from the above results, with some variation from sample to sample, the size of the rice-cell was largest with the plants grown on irrigated soil with standard fertilizer, next largest with the plants grown on irrigated soil with double the amount of nitrogenous fertilizer, and smallest with the plants grown on dry soil with standard fertilizer. The order of rice-cell size determined in this experiment coincides with the order of silicified stomata count determined in the previous experiment. The results show that the degree of silicification of the epidermal cells is greater with plants grown in the doubly-fertilized, irrigated plot than in the dry plot with standard fertilizer, and also larger with plants grown in the irrigated plot with standard fertilizer than in the irrigated plot with double the amount of nitrogenous fertilizer.

As can be seen from these experiments, the excessive use of nitrogenous fertilizer strongly inhibits the silicification of the epidermal tissue, and this apparently increases the susceptibility of the plant to rice blast disease. The effect of excessive nitrogenous fertilizer is however less than the effect of arid soil; that is, at least within the range of the author's experiments, the adverse effect o arid soil was found to be larger than the effect of doubling the amount of nitrogenous fertilizer coupled with adequate irrigation of the soil.

VI. DISCUSSION

The susceptibility of the rice plant to rice blast disease as a result of dryness or wetness of the soil can be expected to vary with various environmental conditions, and the variation in susceptibility to the disease at different stages of growth of the plant was previously reported by the author[5].

There is no doubt that nitrogenous fertilizer tends to enhance the susceptibility of the rice plant to rice blast disease, but the problem of how a combination of the amount of nitrogenous fertilizer and the condition of soil humidity would effect susceptibility to the disease at different stages of plant growth has been of considerable interest to the author. In order to investigate this problem, the author performed a series of experiments in which the soils were grouped into four plots formed by doubling the standard amount of nitrogenous fertilizer as one variable, and using dry or well irrigated soil as the other variable in the experiments. Inoculation experiments were performed on the seedlings, the adult leaves, and the spike pedicels, and the rates of infection found in the plants grown in the different plots were compared. Naturally the rate of infection would be expected to be lowest with plants grown on irrigated soil with standard fertilizer, and if we disregard this particular grouping, then, a comparison of the remaining three plots, namely the two dry plots with standard or double strength nitrogenous fertilizer, and the other irrigated plot with double the nitrogenous fertilizer should warrant our attention.

According to the author's experiments, the results showed that with seedlings, adult leaves, and spike pedicels alike, the rate of infection was lowest with the irrigated, doubly-fertilized plot, this being followed in increasing rate of infection by the dry plot with standard fertilizer, and finally the dry plot with double the nitrogenous fertilizer. The results indicated that irrespective of the amount of nitrogenous fertilizer used, the rate of infection was always less with plants grown on well irrigated soils than on dry soils, and also that even with double the standard amount of nitrogenous fertilizer, the rate of infection could be reduced below that for dry soil-grown plants by means of adequate irrigation. Another way of expressing this situation is that the effect of nitrogenous fertilizer on enhancing the susceptibility to rice blast disease is weaker than the effect of soil dryness. There were some cases in the experiments in which in the dry plots, there was little difference between plots with different amounts of nitrogenous fertilizer. This lack of a difference can probably be explained by assuming that under such dry soil conditions, the effect of the fertilizer is probably greatly diminished.

There is a close correlation between the susceptibility of the rice plant to rice blast disease and/or "gomahakarebyo" and the silicification of the epidermal tissue. The degree of this silicification can be judged by either counting the number of silicified stomata or by measuring the size of the rice-cells (4)(5)(6).

In order to determine why the rate of infection was lower in the irrigated doubly-fertilized plot than in the dry, standard-fertilized plot, the number of silicified stomata per unit area and the size of rice-cells were measured with respect to the ash figure of a particular part of the plant leaf in order to compare the degree of silicification of the epidermal tissue. It was found that silicification was always more advanced in the plants grown on the first plot than on the latter plot. Furthermore in order to determine the effect of the amount of nitrogenous fertilizer on the susceptibility of the plant to rice blast disease, similar measurements were made with leaves from plants grown on well irrigated soil but with differences in the amount of nitrogenous fertilizer. It was found that silicification of the epidermal cells was more advanced in the plants grown on soils with the standard amount of nitrogenous fertilizer. These results indicate that there must be some relation between the amount of nitrogenous fertilizer applied, the increase in susceptibility to the disease, and the reduction in silicification of the epidermal cells. The effect of the fertilizer in reducing the silicification of the epidermal cells is however weaker than the effect of dryness of the soil in producing the same result. At least within the range of conditions used in the author's experiments, the effect of doubling the amount of nitrogenous fertilizer was overridden by the effect of adequate irrigation of the soil. In any event, the basic conclusion to be drawn from the results of these experiments is the fact that there is a close correlation between the degree of silicification of the epidermal tissue and the susceptibility of the rice plant to rice blast disease.

VII. SUMMARY

1. In the present paper have been presented the results of inoculation experiments performed on rice plant seedlings and spike [illegible]dicels of plants grown on soils with varying soil humidity and amount of [illegible]trogenous fertilizer, ~~and also~~ the results of investigation of natural infection of the adult leaf. Using the ash figure technique, anatomical differences in the adult leaf were ~~also~~ studied.

2. Irrespective of the amount of nitrogenous fertilizer applied, rice plants grown on well irrigated soils were found to be more resistant to rice blast disease of both the leaf and the spike pedicel, when compared to plants grown on dry soil.

3. Plants grown on soil with double the amount of nitrogenous fertilizer but well irrigated were found to be more resistant to rice blast disease of both the leaf and the spike pedicel than the plants grown on dry soil with only the standard amount of nitrogenous fertilizer.

4. The degree of silicification of the peidermal tissue was determined by counting the number of silicified stomata per unit area and measuring the size of the rice-cells, using the ash figure of the adult leaf. The results showed that the degree of silicification of the epidermal cells was more advanced in the plants grown on the irrigated soil with double the standard amount of nitrogenous fertilizer than in the plants grown on dry soil with the standard amount of nitrogenous fertilizer; and that a similar situation prevailed with respect to plants grown on irrigated soil with the standard amount of nitrogenous fertilizer when compared to plants grown on irrigated soil with double the amount of nitrogenous fertilizer.

5. The silicification of the epidermal tissue seems to vary inversely with the amount of nitrogenous fertilizer applied to the soil. Within the range of conditions used in the author's experiments, however, the effect of nitrogenous fertilizer in reducing the degree of silicification of the epidermal tissue was weaker than the effect of dryness of the soil in producing the same results.

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