THE EFFECT OF TRACE ELEMENTS ON DISEASE RESISTANCE IN CROPS

(1) The effect of manganese on blast disease resistance of rice.

by

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INTRODUCTION

Many researches[1~18] have been made regarding the effect of chemicals on disease resistance of crop plants: Salmon[19] (1904–1905) reported that copper sulphate did not affect the resistance of wheat to Powdery mildew, Gassnes and Hassobrauk[20] (1936) tested 176 organic compounds and proved that some changed disease resistance. According to Akai[21] (1953), a spray of 10^{-3} Mol. of Mn could stop the prevalence of sesame leaf spot disease to some extent. Since Nozu and Yokogi[22] (1925) found that the application of Bordeaux mixture into soil can reduce the prevalence of rice blast disease, the effect of chemicals on this disease have attracted wide interest. Tasugi[23] (1956) reported that various elements can be classified into three groups according to their effect on blast disease resistance, i. e. the first group decreases plant disease the second group give no effect to the resistance, the third group promotes prevalence of the disease. Manganes belongs to the first group.

Experiments formerly conducted in this Institute[24] (1942) showed that the application of calcium cyanamide, Sodium Silicaterice-straw-ash and copper sulphate into soil could generally increase disease resistance of various crops. Hashioka's[25] (1950) result also showed that copper sulphate, copper nitrate and copper chloride could stop the prevalence of blast disease to some extent, though they gave unfavourable effects on rice plants if the dosage was high.

This experiment was made in order to investigate the effect of manganess on blast disease in some detail. It was found that, if the amount of Mn exceeded a certain limit the growth of rice seedlings were markedly reduced and at the same time, the development of blast lesions after inoculation was inhibited.

The authors wish to express their sincere thanks to the members of the Laboratory of plant Nutrition, Taiwan Agriculture Research Institute, for their kind helps in chemical analysis.

MATERIALS AND METHOD

Seeds of Taichung No. 65 (Japonica type) each plot consisting of 100 grains were grown on absorbent gauze placed on the top of 500 cc. glassbeakers, and the beakers were filled with water-culture solution containing the following, components per 1,000 cc.: $(NH_4)_2SO_4$......70.8 mg; KH_2PO_4......19.2 mg; KCl......8.5 mg; $CaCl_2 \cdot 2H_2O$......8.8 mg;

$MgSO_4 \cdot 7H_2O$......18.4 mg; $FeCl_3 \cdot 6H_2O$......1.7 mg.

Ten different concentrations of ($Mn\ SO_4 \cdot 4H_2O$) i. e., 0.5, 1, 2, 5, 10, 20, 50, 200 and 500 ppm, were then added to the above-mentioned culture solution. The solution was renewed at a seven-day interval during the experiment.

The blast pathogens preserved in the writers laboratory are cultured on an artificial medium containing rice panicle and cane sugar. After a 12 to 14 day culture, when an enough number of spores were produced, they were washed out with distilled water to make pathogenic suspension. The inoculum was then sprayed onto the leaves of seedlings 25–30 days after germination. After the inoculation, seedlings were kept in a chamber with a certain humidity and temperature for a night and then were replaced in a glasshouse. The degree of disease infection was determined 7–10 days after the inoculation, on the basis of number and size of lesions appearing on the leaves.

In addition to the above experiment, a sample of 200 gr. of leaves taken from each plot was boiled in 1,000 cc. distilled water for about 10 minuts. The juice filtered and added to 18 gr. of agar was placed in petridishes. The inoculum was then transfered into this artificial medium. The diameters of pathogenic colonies were measured to see the effect of different concentrations of manganese on the growth of the fungus.

Further, samples of leaves and stems of seedlings cultured as mentioned above were chemically analyzed with regared to the contents of N and Mn and the results were compared with the growing status of pathogen on artificial medium.

RESULT AND DISCUSSION

Effects of different concentrations of manganese on plant growth and the prevalence of disease are shown in Table 1. The data in Table 1 show averages of the results of two experiments; one seeded on march 16, inoculated on April 13, and observed on April 25, 1961, and the other seeded on May, 8, inoculated on May 31 and observed on June 12, 1961. The result of variance analysis of the data are shown in Table 2.

Table 1. Effect of manganese on the growth of rice seedlings and the resistance to blast disease

Treatment ppm	Culm height	leaf No.	leaf length (cm)	width of 2nd leaf blade (cm)	root length (cm)	root No.	Degree of disease infection	
							mean No. of lesion	length of lesion
0	16.56	2.53	15.71	0.25	3.93	7.44	1.46	0.22
	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)
0.5	13.50	2.71	15.62	0.30	4.04	6.59	0.90	0.14
	(81.5)	(107.1)	(99.4)	(120.0)	(102.8)	(88.6)	(61.7)	(63.6)
1	13.22	2.87	18.18	0.31	3.84	6.13	1.47	0.22
	(79.8)	(113.4)	(115.7)	(124.0)	(97.7)	(82.4)	(100.7)	(100.0)
2	12.88	2.86	15.71	0.26	4.26	5.67	1.49	0.19
	(77.8)	(113.0)	(100.0)	(104.0)	(108.4)	(76.2)	(102.1)	(86.4)

5	13.84	2.77	16.76	0.30	4.26	6.22	0.98	0.17
	(83.6)	(109.5)	(106.7)	(120.0)	(108.4)	(83.6)	(67.1)	(77.3)
10	13.43	2.77	15.12	0.28	3.67	6.03	1.44	0.18
	(81.1)	(109.5)	(96.2)	(112.0)	(93.4)	(81.0)	(98.6)	(81.8)
20	12.98	2.97	15.18	0.29	5.09	4.95	1.59	0.22
	(77.8)	(117.4)	(96.6)	(116.0)	(129.0)	(66.5)	(108.9)	(100.0)
50	13.66	2.44	13.53	0.26	5.35	6.08	1.20	0.18
	(82.5)	(96.4)	(98.7)	(104.0)	(136.1)	(81.7)	(82.2)	(81.8)
200	10.22	2.12	6.60	0.19	2.33	4.75	0.05	0.15
	(61.7)	(83.8)	(42.0)	(76.0)	(59.3)	(63.8)	(3.4)	(68.2)
500	3.83	2.17	4.55	0.15	1.01	2.72	0.07	0.20
	(23.1)	(25.8)	(28.9)	(60.0)	(2ɔ.7)	(36.6)	(4.8)	(90.9)

Note 1. Numbers on upper part show mean value of two experiments.
2. Numbers in Parenthesis show index numbers.

Table 2. F values for various characters due to treatments of manganese

	D. F.	culm hight		Leaf numbers		Leaf length		Leaf width	
		M. S.	F	M. S.	F	M. S.	F	M. S.	F
Treatment	9	22.808	15.910**	0.158	0.745	39.627	23.708**	0.007	7.386**
Replication	1	37.895	26.318	2.926	13.822	0.958	0.573	0.021	24.091
Error	9	1.434		0.212		1.672		0.009	
Total	19								

	D. F.	Root length		Root number		No. of disease		Point of significance	
		M. S.	F	M. S.	F	M. S.	F	5%	1%
Treatment	9	3.233	11.711**	0.304	2.026	0.759	3.339*	3.18	5.30
Replication	1	3.144	11.388	19.582	12.007	4.618	20.315		
Error	9	0.276		1.631		0.227			
Total	19								

* Significant at 5% level.
** Significant at 1% level.

As the data in Table 1, show the height of rice seedlings was greatly reduced by the manganese. The reduction in height was especially remarkable when treated with more than 200 ppm of $MnSnO_4 \cdot 4H_2O$; for instance, in the 500 ppm plot, height became only 1/5 of that of the control plot. Leaf number increased slightly in plots treated with 0.5–20 ppm but decreased in 200 and 500 ppm plots. These increases or decreases were not significant statistically, however. Length and width of the second leaf were also greatly affected by the treatment. Root number was insignificantly affected.

Table 3. Mean values for various character due to treatments of manganese

Treatment	culm-height	Treat-ment	Leat length (cm)	Treat-ment	Leaf width (cm)	Treat-ment	Root length (cm)	Treat-ment	No. of disease lesion
0	16.56	1	18.18	0.5	0.30	50	5.35	20	1.59
5	13.84	5	16.76	1	0.31	20	5.09	1	1.49

50	13.66	0	15.71	5	0.30	5	4.26	1	1.47
0.5	13.50	2	15.71	20	0.29	2	4.26	0	1.46
10	13.43	0.5	15.62	10	0.28	0.5	4.04	10	1.44
1	13.22	20	15.18	2	0.26	0	3.93	50	1.20
20	12.98	10	15.12	50	0.26	1	3.84	5	0.98
2	12.88	50	13.53	0	0.25	10	3.67	0.5	0.90
200	10.22	200	6.60	200	0.19	200	2.33	500	0.07
500	3.83	500	4.55	500	0.15	500	0.01	200	0.05
L. S. D. 5%	2.692		3.048		0.072		1.240		1.126
L. S. D. 1%	3.867		4.193		0.097		1.708		1.549

Table 4. Comparison of significance of differences in disease lesion numbers

Treatment (ppm)	mean	difference								
20	1.59									
2	1.49	0.10								
1	1.47	0.12	0.02							
0	1.46	0.13	0.03	0.01						
10	1.44	0.15	0.05	0.03	0.02					
50	1.20	0.39	0.29	0.27	0.26	0.24				
5	0.98	0.61	0.51	0.49	0.48	0.46	0.22			
0.5	0.90	0.69	0.59	0.57	0.59	0.54	0.30	0.08		
500	0.07	1.52*	1.42*	1.40*	1.39*	1.37*	1.13	0.91	0.83	
200	0.05	1.54*	1.44*	1.42*	1.41*	1.39*	1.15	0.93	0.85	0.02

* Significant at 5% level

As for the effect of $MnSO_4 \cdot 4H_2O$ on disease prevalence, it was found that the average number of disease lesions per plant slightly increased in 10 ppm and 20 ppm plots but in other plots of higher dosages they were much reduced. As the data in Table 1 show, taking the control to be 100. The index numbers for 0.5, 5, 50, 200 and 500 ppm plots were 61.7, 67.1, 82.2, 3.4 and 4.8 respectively. As shown in Table 4, the differences in lesion numbers between treatments were generally significant. These facts indicated that though a small amount of $MnSO_4 \cdot 4H_2O$ is favourable for the fungus, a large amount prohibits the growth. It seems that disease resistance may proportionate with the increase of manganese applied. However, differences in lesion size between treatments was not significant, since it widely varies within plants.

Though high concentration of $MnSO_4 \cdot 4H_2O$ increases the resistance to blast disease the growth of plant as shown by plant height, leaf lenght, leaf width and root length, were also greatly reduced. In addition to this, the leaves of plants treated with 200 and 500 ppm appeared roundish and there appeared lesions with blackish coloration which were apparently due to chemical injury. Roots also showed a similar brown color and were shortened.

According to Tasugi[26] (1956) when plants absorb manganese, the nitrogen content in various organs is decreased. He considers that manganese does not reduced the disease resistance directly but physiologically promotes the healthy growth of plants resulting in an increase of resistance indirectly. In order to confirm this view, rice seedlings in respective plots were chemically analyzed with regard to N and Mn. The contents of N and Mn were then compared with the growing status of blast pathogen cultured on artificial media containing plant juice taken from respective plots. The results are given in Table 5.

Table 5. Change of nitrogen and manganese contents in rice seedlings due to different treatments and its relation to the growth of blast fungus

Treatment (ppm)	N		Mn		Diameter of fungus colony (mm)
	content (%)	mg/pot	content (%)	mg/pot	
0	2.691	67.275	0.0040	0.100	70.33
0.5	2.727	68.175	0.0085	0.213	80.00
1	2.572	61.728	0.0056	0.134	80.50
2	2.572	61.728	0.0172	0.413	85.25
5	2.608	62.592	0.0382	0.437	68.00
10	2.512	65.312	0.0714	1.856	66.50
20	2.536	65.936	0.1380	3.588	66.50
50	2.512	62.700	0.2640	6.600	62.00
200	2.452	58.848	0.4980	11.952	64.00
500	2.093	48.139	0.4100	9.430	—

As the data in Table 5 show, the nitrogen of plants content was reduced with the increase of manganese application. This is similar to what Tasugi[26] reported, suggesting that effect of Mn is indirect. However, the amount of absorbed became higher with the increase of application of manganese, that in 200 and 500 ppm treated plot being one million times as high as that of controls. In view of such a marked difference in Mn content, one may doubt whether the increase of disease resistance is due merely to the decrease of N content, or to direct effect of Mn. As shown in Table 5, the pathogenic culture experiment proved that the diameter of colonies in 0.5, 1 and 2 ppm plots were larger than control. though plants in those plots were contained smaller amount of N and larger amount of Mn. It may be infered from these facts, that Mn exerts a direct effect on the resistance plants to blast disease, Further, It is found from the table that the contents becomes high, the growth of fungus was greatly reduced. Tasugi and Mori[23] (1955) reported that more than 10^{-3} Mol. of Mn inhibited the growth of blast and sesame leaf-spot fungi According to Hsu and Dough[27] (unpublished) when 10^{-3} Mol. of Mn was added to the potato agar medium, the growth of blast fungus was inhibited, though it was promoted when treated with less than 10^{-3} Mol. These results agree well with the present studies.

It may then be concluded that though a small of Mn promotes the growth of blast fungus, if the amount exceeds a certain limit, the growth is checked. However, rice plants are also damaged. At the present situation, $MnSO_4 \cdot 4H_2O$ may not be used for blast disease control.

SUMMARY

If the amount of Mn applied exceeded a certain limit (about 200 ppm), the growth of rice seedlings were markedly reduced, and at the same time, the development of blast lesion after inoculation was inhibited. However, a small amount of Mn promoted both. By chemical analysis of the plant, it was found that the N content was reduced with the increase of Mn application.

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微量元素對於作物疾病抵抗性之研究

第一報 Mn 對於水稻稻熱病抵抗性之影響

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摘要

本試驗係水耕液中加注不同濃度之 Mn，觀察對於稻熱病之發生與稻苗生長之影響而舉辦者。茲將其結果摘要如下：

1. 加注 Mn 區之草高均比標準區（無加注區）爲不良，如加注高濃度（200 ppm，500 ppm）時其差異更顯著。葉長如加注 Mn 0.5～20 ppm 者與標準區之差異不顯著，但加注 50 ppm 以上時有顯著之差異。

2. 根長及葉寬除高濃度（200 ppm，500 ppm）有顯著之差異外，其他處理區均與標準區略爲相同。

3. 對稻熱病發生之影響，如 Mn 濃度低（50 ppm 以下），則無顯著之影響，但濃度高（200 ppm 以上）則顯著減少稻熱病之發生，並同時呈現相當之藥害。

4. 處理後之稻苗將分析其莖葉內之 N, Mn 含有量，則 Mn 之含有量添加區均較無添加區爲高，N 之含有量除 0.5 ppm 區外均比無加注區較低。

5. 稻苗莖葉的煎汁調製培地，培養稻熱病菌時，加注 Mn 0.5, 1 及 2 ppm 區之發育較無添加區稍爲優，其他比 2 ppm 較高濃度區在培地上均會抑制稻熱病菌之發育。