TARC Note

A Nutritional Disorder of Rice Plants Observed in Brunei

The "Akagare" type symptoms[5] were observed in a field of Birau Agricultural Station in Brunei in 1984. At first, the symptoms were attributed to Tungro disease, but this assumption was not substantiated by subsequent virological studies.* Then, the possibility of iron toxicity was considered, and the present study was taken up in 1985.

The symptoms observed on flag leaves were classified by their type and grade. Of the total of 262 varietal plots including 223 varieties, A type (no symptoms) involved 22.9% of them, B type (spot type symptoms) 67.1%, and C type (stripe type symptoms with spot type) 3.7% (Table 1). "Disobok", a recommended variety in Brunei, showed the C type symptoms.

On the basis of these symptoms and field observations, as well as information** about field management and growth of rice plants in early stages, it was considered that these symptoms were caused by iron toxicity combined with phosphorus deficiency. Therefore, we analyzed mainly the iron and phosphorus contents in soils and rice plants.

Table 1. Percentage of rice varieties classified by the type and grade of symptoms appeared on the flag leaf

Symptoms			Variety plots	
	Type[1)]	Grade[2)]	No.	%
A		—	60	22.9
B	B-1	+	91	34.7
	B-2	++	58	22.1
	B-3	+++	27	10.3
C	C-1	+	3	1.1
	C-2	++	5	1.9
	C-3	+++	2	0.7
Others			16	6.3
Total			262	100.0

1) A: No symptoms, B: Spot type symptoms
C: Stripe type with spot type symptoms
Others: Symptoms were not examined because rice was harvested or flag leaf dried up.

2) +: Slight, ++: Medium, +++: Severe

Table 2 shows some of the chemical characteristics of soils sampled from the root zone of rice plants showing typical symptoms. The A type symptoms were observed in plants growing on F1-22 soil and slight spot symptoms (B type) in plants growing on F1-22 soil. Severe B type symptoms occurred in plants growing on F1-32 and F2-32 soils. F1-1 and F2-1 showed severe C type. Same varieties were grown on F1-1 and F2-1 soils, F1-22 and F2-22, and F1-32 and F2-32 soils, respectively. The F1 group such as F1-1, F1-22 and F1-32 was sampled from plots without fertilizer application, and the F2 group, F2-1, F2-22 and F2-32, were taken from the plots to which 70 kg P_2O_5/ha had been applied.

Air-dried samples of those soils were strongly acidic (pH 4.4–4.8) and showed very low available phosphorus contents (less than 1 mg/100 g dried soil) determined by the Bray No. 2 method. Free iron contents were not significantly high. These results agreed with those reported by Kyuma[1)] on Sarawak soils. Ferrous iron contents in fresh soils were high. It is considered that the phosphorus absorption coefficients of soils are not associated with the occurrence of the nutritional problems of rice plants.

Phosphorus and iron contents in each part of rice plants grown under these soil conditions are shown in Fig. 1.

The growth of rice plants on F1-22 and F2-22 soils seemed to be satisfactory but that of plants on other soils was poor. Lower leaves of plants of F1 group were considered to be deficient in phosphorus (4B in Fig. 1). No appreciable varietal differences in phosphorus contents were detected.

Iron contents in leaf blade exceeded 24 mg/

* Personal communication from Drs. Umeya, Hirao, and Ohmura.

** Information given by Mr. Imai.

Table 2. Chemical characteristics of soils in field of Birau Station

(mg/100 g dry soil)

Sample[1)]	pH (a)[2)]	pH (b)[3)]	Fe^{++} (a)	Free iron (b)	Av. P_2O_5 (a)	Av. P_2O_5 (b)	P. A. C.[4)] (b)
F1–1 (C–2)	6.1	4.8	402	1770	1.29	0.63	791
F1–22 (A)	6.3	4.6	393	1720	1.44	0.41	736
F1–32 (B–3)	6.3	4.6	441	1750	0.65	0.33	738
F2–1 (C–3)	6.1	4.4	470	1750	3.02	0.45	820
F2–22 (B–1)	6.1	4.6	422	1670	0.02	0.44	817
F2–32 (B–3)	6.1	4.8	465	1750	2.18	0.38	787

1) Soil samples were collected from the root zone of rice plants showing typical symptoms. Upper 3 samples were collected from field plots without fertilizer application, and lower 3 samples from plots to which 70 kg P_2O_5/ha had been applied.
2) (a) Determined on fresh sample.
3) (b) Determined on air-dry sample.
4) Phosphorus absorption coefficient.

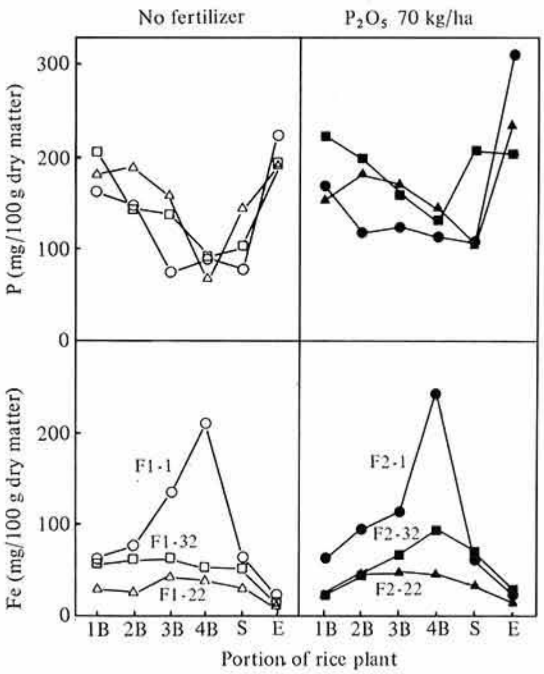

Fig. 1. Phosphorus and iron contents in rice plants grown in the field of Birau Station
1B: Flag leaf blades
2B: Second leaf blades
3B: Third leaf blades
4B: Fourth and other leaf blades
S: Sheaths and culms E: Ears

100 g dry matter, especially those in the third and fourth leaves of plants on F1-1 and F2-1 soils were very high (more than 100 mg). Varietal differences in iron contents were clearly observed. Iron contents in F1-22 soil with plants showing the A type symptoms and in F2-22 soil with plants showing the B type symptoms (slight symptoms) were lower than those in the other soils, and there was a relationship between the grade of symptoms and iron contents in rice leaves.

As mentioned above, it appears that ferrous iron and available phosphorus contents in soils, iron and phosphorus contents in rice plants, and the grade of symptoms were related to each other. Table 3 shows iron and phosphorus contents in rice plants from Kilanas Research Center. Although the variety was the same as that grown in the F1-1 and F2-1 soils, it showed less "Akagare" type symptoms. Except the ears, the iron contents

Table 3. Phosphorus and iron contents in rice plants from Kilanas Research Center

(mg/100 g dry matter)

Portion	P	Fe
Flag and second leaf blades	300	58
Third leaf blades	217	79
Fourth and other leaf blades	200	108
Ears	267	25

Table 4. Characteristics of soils from different types of paddy fields

(mg/100 g dry soil)

Sample[1]	pH (a)[2]	pH (b)[3]	Fe^{++} (a)	Free iron	Av. P_2O_5 (a)	Av. P_2O_5 (b)	P. A. C.[4] (b)
W	6.3	5.1	100	1190	3.33	3.46	1303
SI	6.3	4.1	257	1070	11.3	0.74	1144
I	6.0	3.9	558	1350	35.7	1.53	1468

1) Soil samples were collected from a well-drained field (W), semi-ill-drained field (SI), and ill-drained field (I) planted IR 841.
2) (a) Determined on fresh sample.
3) (b) Determined on air-dry sample.
4) Phosphorus absorption coefficient.

of rice plants from Kilanas Research Center were less than 80% of those of plants cultivated on the F1-1 and F2-1 soils, and phosphorus contents were 1.8 to 3 times higher. These findings suggest that rice plants with higher phosphorus and lower iron contents may not show the symptoms. Therefore, the assumption that the symptoms are associated with iron toxicity combined with phosphorus deficiency appears to be correct, as far as the field used in this study is concerned.

As for the amendment of iron toxicity in the soil of Birau Agricultural Station, there are several methods[3,4] to be taken into account. It is known that the amount of available phosphorus increases with the reduction of ferric phosphate[2] under flooded (reduced) conditions (see Table 2). As iron is more reducible under a low pH condition, it is considered that more phosphorus may be released from ferric phosphate under low pH conditions than under high pH conditions. However, the amount released is limited when the phosphorus content of soil is low. Furthermore, a part of the phosphorus released is combined with ferric oxides and becomes unavailable to plants again. The effect of increase of ferrous iron is much more significant than that of phosphorus increase under low pH conditions. Thus it is important to improve the low pH and phosphorus content conditions. Continuous application of large amounts of phosphorus and calcium for several years is one of the amendment methods proposed.

Drainage is also considered to be important. Table 4 and Fig. 2 show some characteristics of the soils collected from a well-drained field, semi-ill-drained field and ill-drained field planted with IR841 in Kilanas Research Center, together with phosphorus and iron contents in leaves of IR841. Ferrous iron contents in soils became lower with the improvement of the drainage condition. This fact is reflected in the iron contents of the leaves

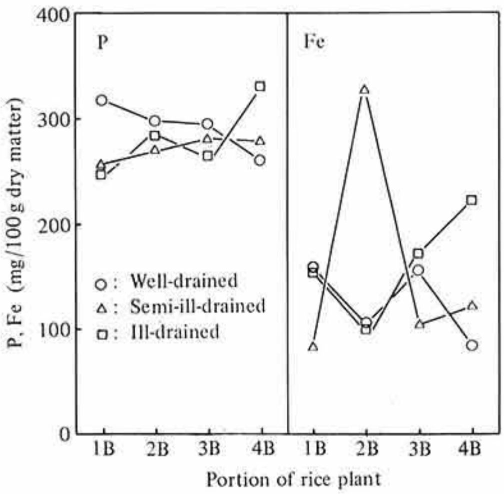

Fig. 2. Phosphorus and iron contents in rice plants grown in paddy fields of different types
1B: Flag leaf blades
2B: Second leaf blades
3B: Third leaf blades
4B: Fourth and other leaf blades

located below the third leaf. Iron content in leaves from the ill-drained field was three times higher than that in leaves from the well-drained field and severe symptoms were observed in leaves below the second leaf in the ill-drained field. Few symptoms were observed in the well-drained field, although iron contents in leaves from the well-drained field were very high. Therefore, iron toxicity symptoms may appear, if the drainage condition deteriorates. Thus, we should improve the drainage condition along with correcting the low pH and low phosphorus content conditions.

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