CROP AND RESOURCE MANAGEMENT

Soil microbiology and biological N fertilizer

Effect of blue-green algae (BGA) inoculation and urea supergranule (USG) on rice yields in sodic soils

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We studied the effect of BGA inoculation in a sodic soil (pH 9.01, EC 0.33 dS/m, and exchangeable sodium percentage 32) at 4 levels of N (0, 75, 100, and 125% of recommended) applied as USG.

The field experiment was conducted Sep-Jan 1985-86. Plots were 3 × 1.75 m with 3 replications of 8 treatments, in a randomized block design. Soil test showed the need for 127.5-80-87.5 kg NPK/ha. All the plots were treated basally with superphosphate (16% P_2O_5), muriate of potash (60% K_2O), and 25 kg $ZnSO_4$/ha.

Inoculation of BGA significantly increased grain and straw yield over the control and in the treatment with 100% fertilizer N (see table). □

Effect of BGA inoculation on rice grain and straw yield.[a] Trichy, India.

N level (%)	Grain yield (t/ha)		% increase	Straw yield (t/ha)		% increase
	Without BGA	With BGA		Without BGA	With BGA	
0	2.0	2.3	15*	4.6	5.4	17*
75	2.6	2.7	ns	6.1	6.8	ns
100	2.9	3.6	12*	7.0	7.9	12*
125	3.3	3.4	ns	7.5	7.7	ns
CD (0.05)	0.2			0.8		

[a] * = significant difference, ns = not significant.

Physiology and plant nutrition

Influence of iron on nutrient uptake by rice

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Brazil has about 30 million ha of lowland areas suitable for rice. But after 1 or 2 yr cultivation, Fe toxicity builds up in flooded rice because of a decrease in soil fertility. Nutrient imbalance may be the main cause.

A solution culture experiment with increasing Fe concentrations was conducted to understand the nutrient uptake behavior of lowland rice cultivars. With slight modifications, the nutrient solutions were those developed by IRRI. The macronutrient composition in mM follows: 2.85 NH_4NO_3, 0.13 NaH_2PO_4, 1.03 K_2SO_4, 1 $CaCl_2$, 1.64 $MgSO_4 \cdot 7H_2O$. Micronutrient composition in μM is 9.1 Mn as $MnCl_2 \cdot 4H_2O$, 0.52 Mo as $(NH_4)_6 \cdot Mo_7O_{24} \cdot 4H_2O$, 18.48 B as H_3BO_3, 0.15 Zn as $ZnSO_4 \cdot 7H_2O$, and 0.16 Cu as $CuSO_4 \cdot 5H_2O$. Fe was

Table 1. Uptake of nutrients in the roots and shoots of rice cultivars.[a]

Nutrient	Fe 0.09 mM		Fe 0.89 mM		Fe 1.78 mM	
	Concn % or ppm	Content (mg or µg/4 plants)	Concn % or ppm	Content (mg or µg/4 plants)	Concn % or ppm	Content (mg or µg/4 plants)
Roots						
N	2.82 a	23 a	2.76 a	11 b	2.53 b	6 b
P	0.33 ab	2.66 a	0.27 b	1 a	0.39 a	0.96 b
K	2.95 a	25 a	1.73 b	6 b	1.46 b	4 b
Ca	0.08 a	0.65 a	0.10 a	0.38 b	0.11 a	0.26 c
Mg	0.12 a	1 a	0.11 b	0.42 b	0.11 a	0.26 b
Zn	44 a	37 a	26 c	10 b	38 b	10 b
Cu	19 b	15 a	22 a	8 b	23 a	6 c
Mn	22 c	18 a	27 b	10 b	38 a	9 b
Fe	2258 c	1806 c	12717 b	4658 b	37458 a	9202 a
Shoots						
N	4.09 b	186 a	3.38 c	51 b	4.18 a	50 b
P	0.48 a	21 a	0.18 c	3 b	0.26 b	3 b
K	2.95 a	133 a	1.94 c	26 b	2.17 b	25 b
Ca	0.17 b	8 a	0.24 a	3 b	0.22 a	3 b
Mg	0.43 a	19 a	0.39 b	5 b	0.22 c	5 b
Zn	24 a	109 a	18 c	24 b	21 b	25 b
Cu	14 b	62 a	16 ab	22 b	17 a	20 b
Mn	199 a	874 a	139 c	183 b	152 b	184 b
Fe	350 c	1578 c	2008 b	2627 b	4233 a	4988 b

[a] Values are mean of 12 cultivars. Concentrations of macronutrients are in % and micronutrients in ppm. Similarly, macronutrient contents are in mg and micronutrients in µg. Under each Fe level, values for each nutrient followed by a common letter are not significantly different at the 0.05 level by Duncan's multiple range test.

supplied as Fe EDTA in amounts required for Fe concentrations of 0.09, 0.89, and 1.78 mM. Nutrient solutions were changed weekly. Solution pH was adjusted to 4 ± 0.2 initially, then once every 2 d with 0.1 N NaOH or 0.1 N HCl.

Seeds of rice cultivars were germinated in nutrient solution using 2-liter plastic pots. At 17 d, uniform seedlings were transplanted to acrylic discs with holes in the center and held in place with cotton. Discs were transferred to plastic pots containing about 8 liters nutrient solution with different Fe treatments. Each treatment was replicated twice.

After 35 d growth in Fe-treated solutions, plant shoots and roots were harvested separately and washed in distilled water. Plant material was dried at about 80 °C to a constant weight. Dry matter was ground and digested with a 2:1 mixture of nitric and perchloric acids. Composite samples of 12 rice cultivars per treatment were analyzed chemically for N, P, K, Ca, Mg, Zn, Cu, Mn, and Fe. The P concentration in the digest was determined colorimetrically; other elements were determined by atomic absorption spectroscopy. Total N in the tissue was determined using a Tecator 1016 digester and 1004 distilling unit.

In general, uptake of all nutrients was reduced with increasing Fe concentration in the growth medium (Table 1). Among macronutrients, P uptake was most highly affected, followed by K and N. Among micronutrients, absorption of Mn and Zn was most affected. Nutrient inhibition by Fe can be put in the following order (Table 2):

macronutrients — P>K>N>Mg>Ca

micronutrients — Mn>Zn>Cu.

Among macronutrients, P uptake was highly inhibited and Ca uptake was least affected. Among micronutrients, Mn was most inhibited and Cu least affected. The results suggest that with higher Fe concentrations in lowland rice, P, K, and Zn deficiencies will be the first to appear. Fe toxicity problem in lowland rice could be alleviated by increased P, K, and Zn fertilization. □

Table 2. Inhibition of nutrient uptake by higher concentrations of Fe in rice cultivars shoots.

Nutrient	Cultivars (no.) under each group					
	Fe 0.89 mM			Fe 1.78 mM		
	Low	Medium	High	Low	Medium	High
N	–	6	6	–	7	5
P	–	–	12	–	–	12
K	–	1	11	–	1	11
Ca	2	10	–	2	10	–
Mg	–	8	4	–	8	4
Zn	–	5	7	1	3	8
Cu	1	10	1	1	8	3
Mn	–	1	11	–	4	8

$$\text{Inhibition} = \frac{\text{nutrient content at optimum Fe level} - \text{nutrient content at high Fe levels}}{\text{nutrient content at optimum Fe level}} \times 100$$

Optimum Fe level was 0.09 mM.

Soil fertility and fertilizer management

Effect of integrated nitrogen management in rice on soil organic carbon and on succeeding wheat crop yield

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We studied the residual effect of applied N (organic + inorganic) in lowland rice on soil organic C content and grain yield of the succeeding wheat crop grown without fertilizer on a Mollisol of the Tarai region of Uttar Pradesh.

The silty clay loam soil had pH 7.2, 1.20% organic C, 0.116% total N, 42.5 kg available P/ha, 214 kg available K/ha, and bulk density 1.33 g/cc. Soil

Soil organic C after wet season rice harvest and wheat yield after integrated N management in rice.[a] Pantnagar, India, 1984-85 and 1985-86.

Treatment[b]	N (kg/ha)	Soil organic C (%) after wet season rice harvest		Wheat grain yield (t/ha)	
		1984-85	1985-86	1984-85	1985-86
No N	0	1.16	1.16 a	1.0 c	1.3 c
USG	58	1.17	1.17 a	1.2 b	1.9 b
USG + fresh wheat straw (29+29)	58	1.17	1.21 ab	1.2 b	2.2 b
PU + azolla (58+29)	87	1.20	1.20 ab	1.3 ab	1.9 b
PU + fresh wheat straw (58+29)	87	1.19	1.24 abc	1.3 ab	2.1 b
USG + azolla (58+29)	87	1.24	1.25 abc	1.4 a	2.0 b
USG + fresh wheat straw (58+29)	87	1.19	1.29 bc	1.3 ab	3.3 a
PU	120	1.17	1.20 ab	1.3 ab	1.9 b
USG + azolla[c] (60+60)	120	1.26	1.31 c	1.6 a	3.5 a
CD (0.05)		–	0.09	0.11	0.45

[a]In a column, values followed by the same letter do not differ significantly. [b]Figures in parentheses are kg N/ha. Treatment of rice crop only in both years. Azolla was incorporated. Prilled urea (PU) was best split. USG placed 10-12 cm deep 7 d after planting rice. Fresh wheat straw incorporated at puddling. In the first year, azolla with PU or USG showed more increase in organic C content. Azolla left on the surface at incorporation multiplied and added organic matter throughout rice growth. In other treatments, variations were 0.01-0.03%. [c]Half the azolla N incorporated at planting and half inoculated 7 d after planting rice.