J. Indian bot. Soc. **62** : 54—58, 1983

INTERACTION OF IRON SOURCE AND NITROGEN SUPPLY IN RICE[1]

C. CHATTERJEE, N. NAUTIYAL AND S. C. AGARWALA

Botany Department, Lucknow University, Lucknow

ABSTRACT

Study has been made of growth, chlorophyll concentration and activities of catalase and peroxidase in rice plants supplied nitrogen in three forms-nitrate, ammonium nitrate and urea and iron as graded levels of Fe-citrate, Fe-EDTA and Fe-EDDHA. It has been observed that irrespective of iron source, iron requirement for normal growth of plants receiving nitrogen in the form of nitrate or urea is about four times that for plants receiving nitrogen as ammonium nitrate.

INTRODUCTION

Compared to inorganic forms of iron such as ferric chloride, ferric phosphate and ferrous sulphate, organic forms of iron such as ferric citrate and ferric tartrate have been reported to be better sources of iron for rice plants grown with nitrate as the source of nitrogen (Gericke, 1930). Asana (1945) found ferrous sulphate and ferric tartrate as good iron sources with nitrate as nitrogen source. Agarwala *et al.*, (1976, 1978) observed typical iron deficiency effects when rice plants were grown with nitrate or urea as nitrogen source regardless the form in which iron was supplied, even at normal (5.6 ppm) level. Rice plants showed normal growth if supplied nitrogen as ammonium nitrate and iron at 5.6 ppm in the form of ferric EDTA but developed iron deficiency effects when iron was supplied at this level in the form of ferric citrate or ferric EDDHA (Agarwala and Chatterjee, 1978). This suggested that quantitative requirement of iron depended on the source of nitrogen. In this paper, we have examined the quantitative requirement of iron supplied as ferric citrate, ferric EDTA or ferric EDDHA to plants grown with nitrate, ammonium nitrate or urea as nitrogen sources.

MATERIALS AND METHODS

Rice (*Oryza sativa* L. var. Jaya) plants were raised in refined sand culture with three different sources of nitrogen-nitrate, ammonium nitrate and urea-supplied at 15 meq/l. Iron was supplied at 5.6, 11.2, 16.8, 22.4 and 28 ppm as ferric citrate, ferric ethylene diamine tetra-acetic acid (ferric EDTA) and ferric ethylene diamine (di) o-hydroxy phenyl acetic acid (ferric EDDHA) with each source of nitrogen. Plants were estimated for dry matter yield at 21, 32 and 80 days growth and for chlorophyll, catalase and peroxidase at 30 days growth. Chlorophyll and enzymes were estimated in comparable young leaves. The details of the culture technique and estimation of dry matter yield, chlorophyll and iron enzymes-catalase and peroxidase have been described earlier (Agarwala *et al.*, 1976).

1. Accepted for publication on January 17, 1982.

RESULTS

Visual effects :

Within a week of sowing, plants grown with nitrate or urea showed iron deficiency type of chlorosis when the source of iron was ferric citrate or ferric EDDHA at 5.6 and 11.2 ppm iron supply. Chlorosis decreased with increase in iron supplied as ferric citrate or ferric EDDHA supplied with nitrate or urea as nitrogen source. Mild chlorosis was observed with ferric EDTA with aforementioned nitrogen sources. After a few days, chlorosis became more intense and the whole leaf becoming bleached and developed marginal necrosis. Plants died after 40 days growth in treatments receiving nitrogen as nitrate or urea and iron at 5.6 or 11.2 ppm as ferric citrate or ferric EDDHA.

Dry matter yield :

Plants grew normally irrespective of the iron source and level of supply when the source of nitrogen was ammonium nitrate, but when the source of nitrogen was nitrate or urea, plants showed very poor yield upto 11.2 ppm if iron was supplied as ferric citrate or ferric EDDHA (Table I). Yield was somewhat better

TABLE I

EFFECT OF IRON AND NITROGEN SOURCES ON THE DRY WEIGHT YIELD OF RICE VAR. JAYA PLANTS GROWN AT FIVE GRADED LEVELS OF IRON IN SAND CULTURE.

ppm iron Supply	Nitrate			Ammonium nitrate			Urea			L. S. D
	Ferric citrate	Ferric EDTA	Ferric EDDHA	Ferric citrate	Ferric EDTA	Ferric EDDHA	Ferric citrate	Ferric EDTA	Ferric EDDHA	(P=0.05)
	mg dry matter per plant : 21 days growth									
5.6	19	43	18	115	120	104	17	61	19	
11.2	22	63	27	117	122	115	18	77	33	9
16.8	33	88	42	119	118	118	27	84	45	
22.4	64	104	65	125	122	119	51	97	71	
28.0	114	104	109	119	92	117	101	114	106	
	mg dry matter per plant : 32 days growth									
5.6	54	168	32	472	571	496	31	185	46	
11.2	58	210	38	549	595	510	45	195	51	29
16.8	185	310	200	554	604	525	183	245	195	
22.4	308	370	301	535	643	535	285	345	285	
28.0	401	455	395	535	435	509	378	470	385	
	g dry matter per plant : 80 days growth									
5.6	*	1.70	*	4.32	4.30	4.33	*	1.79	*	
11.2	*	2.04	*	4.28	4.41	4.33	*	2.19	*	0.18
16.8	1.82	2.60	1.92	4.38	4.44	4.35	1.88	2.37	1.88	
22.4	2.50	3.45	2.79	4.36	4.33	4.39	2.36	3.37	2.46	
28.0	3.46	4.07	3.58	4.38	4.45	4.34	3.58	5.48	3.54	

*Dry weight not taken as the plants died after 40 days growth.

with ferric EDTA at these levels of iron supply with nitrate or urea as the source of nitrogen. At higher (>11.2 ppm) levels of iron supply, growth improved and became almost normal at 28 ppm iron supply even with nitrate or urea. After 40 days growth, plants died at 5.6 and 11.2 ppm iron, when iron was supplied as ferric citrate or ferric EDDHA and the source of nitrogen was nitrate or urea.

Chlorophyll :

Plants grown with ammonium nitrate had almost normal levels of chlorphyll with all levels of iron supplied as ferric citrate, ferric EDTA and ferric EDDHA (Table II). There was depression in chlorophyll content when plants were grown with nitrate or urea and iron in all the different forms but the depression was found upto 22.4 ppm iron supply in case of ferric citrate and ferric EDDHA and upto 11.2 ppm iron supply in case of ferric EDTA.

Enzymes :

Catalase : Compared to catalase activity at 11.2 ppm and higher levels of iron supply, there was slight depression in catalase activity at 5.6 ppm iron supplied as ferric citrate and ferric EDTA when the source of nitrogen was ammonium nitrate (Table III). But when the source of nitrogen was nitrate or urea, there was marked and significant decrease in catalase activity of plants supplied 5.6 ppm iron as ferric citrate or ferric EDDHA as compared to that at 28 ppm iron supply. With increase in iron supply, catalase activity increased in both nitrate and urea series with ferric citrate and ferric EDDHA as iron sources. With ferric EDTA there was less marked depression in catalase-about 2/3rd of that at the highest level of iron supply. At 28 ppm iron supply, catalase activity of plants grown with nitrate or urea was nearly the same as that with ammonium nitrate. The results were similar on both fresh weight and protein basis.

TABLE II

EFFECT OF IRON AND NITROGEN SOURCES ON THE CHLOROPHYLL CONTENT OF RICE VAR. JAYA PLANTS GROWN AT FIVE GRADED LEVELS OF IRON IN SAND CULTURE

ppm iron supply	Nitrate			Ammonium nitrate			Urea			L.S.D
	Ferric citrate	Ferric EDTA	Ferric EDDHA	Ferric citrate	Ferric EDTA	Ferric EDDHA	Ferric citrate	Ferric EDTA	Ferric EDDHA	(P=0.05)
	mg chlorophyll per 100 g fresh weight									
5.6	19	65	21	95	98	100	20	63	19	
11.2	24	81	32	97	99	104	26	74	33	7
16.8	34	89	43	98	100	105	45	87	45	
22.4	57	90	70	98	103	102	61	89	73	
28.0	93	93	88	102	103	103	95	89	93	

TABLE III

EFFECT OF IRON AND NITROGEN SOURCES ON THE ACTIVITIES OF CATALASE AND PEROXIDASE, MEASURED IN CRUDE TISSUE EXTRACTS OF THE LEAVES OF RICE VAR. JAYA PLANTS GROWN IN SAND CULTURE.

ppm iron supply	Nitrate			Ammonium nitrate			Urea			L. S. D.
	Ferric citrate	Ferric EDTA	Ferric EDDHA	Ferric citrate	Ferric EDTA	Ferric EDDHA	Ferric citrate	Ferric EDTA	Ferric EDDHA	(P= 0.05)
Catalase : μ moles H_2O_2 split per 100 mg fresh weight										
5.6	70 (24.1)	205 (59.8)	95 (27.7)	363 (95.3)	363 (95.9)	425 (111.9)	45 (13.3)	220 (60.2)	67 (18.3)	
11.2	75 (21.8)	265 (76.4)	145 (41.8)	390 (101.3)	405 (103.6)	400 (104.5)	53 (15.2)	280 (78.0)	70 (19.6)	33 (2.4)
16.8	160 (43.9)	310 (85.9)	290 (81.5)	410 (107.2)	415 (108.3)	420 (108.6)	215 (62.0)	320 (87.2)	265 (72.7)	
22.4	260 (72.9)	350 (93.4)	320 (87.4)	405 (104.9)	395 (99.0)	409 (105.4)	304 (87.8)	353 (93.5)	305 (80.7)	
28.0	385 (106.7)	393 (101.4)	385 (102.7)	410 (106.5)	420 (107.0)	403 (102.9)	383 (106.5)	401 (104.2)	375 (97.7)	
Peroxidase : mg purpurogallin formed per 100 mg fresh weight										
5.6	13 (3.58)	19 (5.40)	12 (3.36)	22 (5.78)	22 (5.69)	26 (6.71)	16 (4.56)	18 (4.80)	13 (3.66)	
11.2	12 (3.35)	20 (5.62)	12 (3.32)	24 (6.23)	21 (5.24)	23 (6.01)	14 (3.92)	17 (4.60)	14 (3.92)	2 (0.53)
16.8	17 (4.54)	21 (5.68)	20 (5.62)	23 (6.01)	25 (6.53)	24 (6.21)	18 (5.04)	19 (5.18)	17 (4.66)	
22.4	19 (5.33)	21 (5.49)	21 (5.60)	24 (6.22)	24 (6.02)	26 (6.70)	20 (5.63)	19 (4.91)	20 (5.16)	
28.0	23 (6.24)	21 (5.30)	23 (6.00)	24 (6.09)	23 (5.86)	25 (6.27)	23 (6.27)	20 (5.07)	22 (5.60)	

Figures in parentheses denote specific activity of the enzymes.

Peroxidase : Plants grown with ammonium nitrate did not show any relation of peroxidase activity with increase in iron supply from 5.6 to 28 ppm with either of the three iron sources on both fresh weight and protein basis (Table III). When plants were grown with nitrate or urea, peroxidase activity depended on the level of iron supply as also on the form of iron supply. The activity of the enzyme was slightly depressed when the source of iron was ferric EDTA upto 11.2 ppm iron supply in case of plants grown with nitrate or urea. Plants grown with nitrate or urea also showed marked and significant depression in peroxidase activity upto 11.2 ppm iron supplied as ferric citrate and ferric EDDHA.

DISCUSSION

Compared to the other iron sources, ferric EDTA was found as the best iron source for growth and yield of rice var. Jaya plants at normal iron supply (5.6 ppm) regardless the form of nitrogen as has been reported for other rice varieties by Agarwala *et al.*, (1976; 1978), Agarwala and Chatterjee (1978), who also observed that ammonium nitrate and Fe-EDTA are the best nitrogen and iron sources respectively for rice plants and that effect of iron sources is less marked with nitrogen supplied as ammonium nitrate than nitrate or urea. It is evident from the results presented here that the effect of iron and nitrogen sources gradually diminish on increasing the iron supply from normal to excess. With nitrate or urea as nitrogen and ferric citrate or ferric EDDHA as iron sources, there was a gradual mitigation of iron deficiency type effects on increasing iron supply. This was borne out by data on chlorophyll content and the iron enzymes-catalase and peroxidase. At 28 ppm, about four times the normal level of iron supply, there remained neither the effect of form of iron nor of nitrogen supply.

REFERENCES

AGARWALA, S. C., B. K. SINHA, C. CHATTERJEE AND C. P. SHARMA 1976. Dependence of iron utilization by rice on nitrogen source in the growth medium. *Geophytology* **6** : 341-349.

AGARWALA, S. C., C. CHATTERJEE AND N. VERMA 1978. Interaction of nitrogen and iron sources in growth and iron metabolism of rice varieties grown in sand culture pp. 195-202. In: *Proc. Nat. Symp. Nitrogen Assimilation and Crop Productivity*. Eds. S. P. Sen, Y. P. Abrol and S. K. Sinha. Associated Publishing Company, New Delhi.

AGARWALA, S. C. AND C. CHATTERJEE 1978. Further observations on the relation of the form of iron supply to the form of nitrogen supply in rice plants grown in refined sand culture. *Phyta* **1** : 1-13.

ASANA, R. D. 1945. Observations on the influence of nitrate, ammonium and iron on the growth and nutrition of the rice plants. *Indian J. Agric. Sci.* **15** : 227-239.

GERICKE, W. F. 1930. Plant Food requirement of rice. *Soil Sci.* **29** : 207-225.