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Effect of ferrous and zinc nutrient management practices on rice under aerobic condition

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ABSTRACT : A field experiment was conducted in medium black soil with slightly alkaline in reaction in 2011, 2012 and 2013 at Upland Paddy Research Scheme, Research Farm, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S.). Rice variety 'Parag' was sown with 30 cm row spacing and 60 kg seed rate/ ha. Experiment was laid out in Randomized Block Design with three replications. Ten treatments were tested *viz.*, N-P-K only 80-50-50 kg/ha (recommended dose of fertilizer-RDF) (N_1), NPK (RDF)+ $ZnSO_4$ @10 kg/ha through soil (N_2), NPK (RDF)+ $ZnSO_4$ @10 kg/ha + $FeSO_4$ @10 kg/ha thorough soil (N_3), farm yard manure (FYM) @ 5 t/ha + NPK (RDF) (N_4), FYM @ 5 t/ha + NPK (RDF) + $ZnSO_4$ @10 kg/ha thorough soil (N_5), FYM @ 5 t/ha + NPK (RDF) + $ZnSO_4$ @10 kg/ha + $FeSO_4$ @10 kg/ha thorough soil (N_6), NPK (RDF) + two foliar sprays of $ZnSO_4$ @ 0.5 per cent at 20 and 45 DAS (N_7), NPK (RDF) + two foliar sprays of $ZnSO_4$ @ 0.5 per cent + $FeSO_4$ @ 0.5 per cent at 20 and 45 DAS (N_8), FYM @ 5 t/ha + NPK (RDF)+ two foliar sprays of $ZnSO_4$ @ 0.5 per cent at 20 and 45 DAS (N_9) and FYM @ 5 t/ ha + NPK (RDF) + two foliar sprays of $ZnSO_4$ @ 0.5 per cent + $FeSO_4$ @ 0.5 per cent at 20 and 45 DAS (N_{10}). Soil was low in nitrogen, ferrous and zinc; medium in phosphorous and rich in potash. Rainfall during experimental period was 636 mm, 678 mm, 1134 mm in cropping season during 2011, 2012 and 2013, respectively. In pooled analysis the significantly highest rice seed yield was obtained when recommended dose of N-P-K (80 - 50 - 50 kg/ha) and farm yard manure @ 5 t/ha with soil application of both the micronutrients *i.e.* $FeSO_4$ and $ZnSO_4$ @ 10 kg/ha (N_6) was used, however, it was at par with recommended dose of fertilizer and farm yard manure with two foliar applications of both the micronutrients *i.e.* $FeSO_4$ and $ZnSO_4$ at 20 and 45 DAS (N_{10}) and use of recommended dose of fertilizer and soil application of both the micronutrients *i.e.* $FeSO_4$ and $ZnSO_4$ @ 10 kg/ha (N_3). However, significantly highest net monitory returns were obtained with the application of N-P-K @ 80-50-50 kg/ha, respectively, with $FeSO_4$ and $ZnSO_4$ through soil @ 10 kg/ha than rest of the nutrient management treatments in 2011, 12 and 13.

KEY WORDS : Drilled/direct seeded upland rice, Fe and Zn management in rice, INM in upland drilled rice

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Direct seeding of rice refers to the process of establishing the crop from seeds sown in the field rather than by transplanting seedlings from the nursery (Farooq *et al.*, 2011). Direct seeding avoids three basic operations, namely, puddling (a process where soil is compacted to reduce water seepage), transplanting and maintaining standing water. Huge water inputs, labour costs and labour requirements for transplanted rice have reduced profit margins (Pandey and Velasco, 1999). During the past decade or so, there have been numerous efforts to find alternatives to the conventional practice of conventional till transplanted rice (CT-TPR) (Ladha *et al.*, 2009). Thus, low wages and adequate availability of water favour transplanting, whereas high wages and low water availability favour DSR (Pandey and Velasco, 2005). Under present situation of water and labour scarcity, farmers are changing either their rice establishment methods only (from transplanting to direct seeding in puddle soil *i.e.* Wet-DSR) or both tillage and rice establishment methods (puddle transplanting to dry direct seeding in unpuddled soil *i.e.* Dry-DSR). Dry-DSR production is negligible in irrigated areas but is practiced traditionally in most of the Asian countries in rainfed upland ecosystems. At present, 23, 26 and 28 per cent of rice is direct-seeded globally, in South Asia and in India, respectively (Rao *et al.*, 2007). In Asia, dry seeding is extensively practiced in rainfed lowlands, uplands, and flood-prone areas, while wet seeding remains a common practice in irrigated areas (Azmi *et al.*, 2005; De Dios *et al.*, 2005). Direct seeding of rice saves water (30 %), labour, labour cost and gives comparable yields to that of transplanted rice (Joshi *et al.*, 2013). Moreover, direct seeding also offers the option to resolve edaphic conflicts (between rice and the subsequent non-rice crop) and enhance sustainability of the rice-based cropping system and succeeding winter crops (Farooq *et al.*, 2008) in India. However, Singh *et al.* (2005) reported lower yield in DSR than TPR principally due to poor crop stand, high percentage of panicle sterility, higher weed and root-knot nematode infestation. In direct seeding, availability of several nutrients including N, P, S and micronutrients such as Zn and Fe, is likely to be a constraint (Ponnamperuma, 1972). Nonetheless, farmers are inclining to adopt DSR and the area under DSR is increasing as it is more productive and profitable to compensate the production costs. In view of this, field trial was carried out on integrated nutrient management of major nutrients *viz.*, N, P and K with or without organic manure along with soil application of Fe or/and Zn or foliar application of Fe or/ and Zn to evaluate the performance of various nutrient management practice under direct seeded upland irrigated rice in 2011, 12 and 2013.

Research Procedure

A field experiment was conducted in medium black soil with slightly alkaline in reaction in 2011, 2012 and 2013 at Upland Paddy Research Scheme, Research Farm, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S.). Rice variety 'Parag' was sown with 30 cm row spacing and 60 kg seed rate/ ha. Experiment was laid out in Randomized Block Design with three replications. Ten treatments were tested *viz.*, N-P-K only 80-50-50 kg/ha (recommended dose of fertilizer-RDF) (N_1), NPK (RDF) + $ZnSO_4$ @10 kg/ha through soil (N_2), NPK (RDF) + $ZnSO_4$ @10 kg/ha + $FeSO_4$ @10 kg/ha thorough soil (N_3), farm yard manure (FYM) @ 5 t/ha + NPK (RDF) (N_4), FYM @ 5 t/ha + NPK (RDF) + $ZnSO_4$ @10 kg/ha thorough soil (N_5), FYM @ 5 t/ha + NPK (RDF) + $ZnSO_4$ @10 kg/ha + $FeSO_4$ @10 kg/ha thorough soil (N_6), NPK (RDF)+ two foliar sprays of $ZnSO_4$ @ 0.5 per cent at 20 and 45 DAS (N_7), NPK (RDF) + two foliar sprays of $ZnSO_4$ @ 0.5 per cent + $FeSO_4$ @ 0.5 per cent at 20 and 45 DAS (N_8), FYM @ 5 t/ha + NPK (RDF) + two foliar sprays of $ZnSO_4$ @ 0.5 per cent at 20 and 45 DAS (N_9) and FYM @ 5 t/ha + NPK (RDF) + two foliar sprays of $ZnSO_4$ @ 0.5 per cent + $FeSO_4$ @ 0.5 per cent at 20 and 45 DAS (N_{10}). Soil was low in nitrogen, ferrous and zinc; medium in phosphorus and rich in potash. Rainfall during experimental period was 636 mm, 678 mm, 1134 mm in cropping season during 2011, 2012 and 2013, respectively.

Research Analysis and Reasoning

The results obtained from the present investigation as well as relevant discussion have been summarized under the following heads :

Rice seed yield :

Highest rice seed yield was obtained when recommended dose of N-P-K and farm yard manure @ 5 t/ha with soil application of both the micronutrients *i.e.* $FeSO_4$ and $ZnSO_4$ @ 10 kg/ha each (N_6) over rest of the nutrient management practices except recommended dose of fertilizer and farm yard manure with two foliar applications of both the micronutrients *i.e.* $FeSO_4$ and $ZnSO_4$ at 20 and 45 DAS (N_{10}) in all the three years and pooled analysis, moreover, it was at par with recommended dose of fertilizer with soil application of both the micronutrients *i.e.* $FeSO_4$ and $ZnSO_4$ @ 10 kg/ha (N_3) in 2011-12, 2013-14 and pooled analysis; the treatment of recommended dose of N-P-K with FYM and soil application of $ZnSO_4$ @ 10 kg/ha (N_5) in the first, second and third year of experimentation and application of N-P-K with foliar sprays of Zn and Fe in 2013-14 (Table 1). Results indicated that soil and foliar application of Fe and Zn produced comparable seed yields in all the years of experimentation and pooled data. Positive effect of Fe and Zn on rice grain yield might be attributed to emergence of zinc (Zn) deficiency in most of the rice growing soils. Reasons for Zn deficiency in rice fields include low redox potential, high carbonate content and high pH (Mandal *et al.*, 2000). Moreover, in aerobic soils, Fe oxidation by root-released oxygen limits release of Zn from highly insoluble fractions for availability to the rice plant (Kim and Bajita, 1995). Basal application of zinc to the soil or topdressing up to 45 days or foliar application of 0.5 per cent zinc sulphate two to three times at intervals of 7-15 days just after the appearance of deficiency symptoms is also recommended by Joshi *et al.* (2013). Response to Fe through soil or foliar application might be attributed to deficiency of iron (Fe) in unaerobic condition due to oxidation of available ferrous form to unavailable ferric form in soil. For correction of Fe deficiency, drilling of 0.5 kg of librel Fe into the soil at sowing time or foliar application found promising (Joshi *et al.*, 2013). Moreover, foliar application of Fe found better over soil application of Fe (Joshi *et al.*, 2013) as foliar applied Fe is easily translocated acropetally and even retranslocated basipetally. A total of 9 kg Fe per ha in three splits (40, 60, and 75 DAS) as foliar application (3 % of $FeSO_4.7H_2O$ solution) has been found to be effective (Pal *et* *al.*, 2008). These findings suggest the vulnerability of Fe and Zn in upland rice to various factors and also the key role of these micronutrients in breaking the yield barrier under upland (aerobic) rice.

During three years of experimentation, significantly lowest seed yield was obtained with only application of recommended dose of N-P-K (N_1), however it was at par with application of recommended dose of NPK and foliar application of $ZnSO_4$ (N_7), application of recommended dose of NPK with organic matter (N_4) and recommended dose of NPK with soil application of $ZnSO_4$ (N_2), respectively in all the years and pooled analysis.

Number of panicles m^2:

Number of panicles m^{-2} were not significantly influenced due to various nutrient management practices under study in all the years of experimentation (Table 1).

Gross monitory returns :

Recommended dose of N, P and K with FYM and soil application of Fe and Zn gave significantly more gross monitory returns than rest of the nutrient management treatments except, recommended dose of fertilizer with both the micronutrients *i.e.* Fe and Zn through soil application only in first and second year of experimentation and recommended dose of N, P and K with FYM and foliar application of Fe and Zn in 2011, 12 and 13, respectively. This showed comparable performance of Fe and Zn with soil application and foliar sprays, respectively. The lowest gross monitory return was obtained due to

Table 1 : Rice seed yield and no. of panicles as influenced by nutrient management treatments (2011-12, 12-13, 13-14 and pooled)

	Treatment details	Grain yield (kg/ha)				Straw yield (kg/ha)			No. of panicles m^{-2}		
		2011-12	2012-13	2013-14	Pooled	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14
N_1	NPK only	2549	2808	2550	2633	3140	3370	2858	163	179	168
N_2	NPK+ $ZnSO_4$ (Soil)	2658	2848	2625	2725	3320	3440	2975	166	183	175
N_3	NPK+ $ZnSO_4$ +$FeSO_4$ (Soil)	2791	3058	2842	2917	3450	3735	3083	168	185	183
N_4	OM + NPK	2633	2952	2600	2708	3290	3580	2917	164	180	179
N_5	OM + NPK + $ZnSO_4$ (Soil)	2783	3067	2792	2875	3411	3830	3058	166	183	185
N_6	OM + NPK+$ZnSO_4$+$FeSO_4$ (Soil)	2916	3208	2875	3000	3580	4009	3250	169	186	195
N_7	NPK + Zn (two 0.5% sprays)	2599	2858	2583	2683	3219	3510	2958	161	177	178
N_8	NPK + Zn + Fe (0.5% two sprays)	2757	2992	2750	2850	3350	3640	3058	165	183	187
N_9	OM + NPK + Zn (two 0.5% sprays)	2716	3033	2667	2800	3280	3710	3000	163	179	192
N_{10}	OM + NPK + Zn +Fe (two 0.5% sprays)	2874	3158	2867	2975	3430	3920	3225	168	185	189
	S.E. ±	47.11	50.33	51.7	30.17	52.85	60.40	41.7	5.94	6.38	7.23
	C.D. (P=0.05)	139.7	149.2	153.3	105	158.9	182.5	125	NS	NS	NS
	MEAN	2728	3000	2717	2817	3347	3531	3033	165	182	183

NS = Non–significant

Table 2 : Soil nutrient studies as influenced by different nutrient management treatments

	Available N (kg/ha)			Available P (kg/ha)			Available K (kg/ha)		
	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14
N_1	108	109	111	5.4	5.6	5.8	480	478	495
N_2	111	110	110	6.0	6.1	6.5	545	540	552
N_3	115	114	113	5.8	6.0	5.9	520	518	527
N_4	107	115	107	5.5	5.8	5.6	495	499	500
N_5	109	113	108	5.9	6.2	6.0	510	515	515
N_6	104	105	107	6.0	6.1	6.3	490	497	493
N_7	117	16	117	5.5	5.6	5.6	535	530	540
N_8	112	114	111	5.2	5.3	5.3	489	485	494
N_9	118	122	118	6.2	6.4	6.2	511	516	510
N_{10}	114	117	111	5.8	5.9	5.7	520	529	507
SE ±	2.68	2.74	2.7	0.45	0.48	0.192	8.2	9.4	8.7
CD (P=0.05)	NS	NS	Ns	NS	NS	NS	NS	NS	NS
MEAN	111.5	103.5	111.4	5.73	5.9	5.9	509.5	510.7	513
Initial	107	144	103	5.6	6.2	5.8	485	510	496

NS = Non–significant

recommended N-P-K only and was at par with N-P-K with foliar application of Zn in all the years; N-P-K with soil application of Zn during 2011, 2012 and 2013 and N-P-K with FYM in first and second year of investigation (Table 4).

Net monitory returns :

Perusal of the data (Table 4) revealed that recommended dose of N-P-K with soil application of Fe and Zn only (N_3) proved significantly beneficial over rest of the treatments in all three years. It was closely followed by recommended dose of N, P and K with both micronutrients *i.e.* Fe and Zn through foliar application (N_8) in all the three years. Higher cost in application of FYM and marginal reduction in non FYM treatments resulted in better net returns of NPK with Zn and Fe either through soil or foliar application over rest of the combinations.

Soil nutrient studies :

Three year study on nutrient management in upland drilled rice (aerobic rice) revealed that there was not significant change in available N, P, K, Fe and Zn status of soil due to application of NPK or NPK + FYM with Zn and/or Fe either through soil or foliar spray, this might be attributed to loss of N due to denitrification, volatilization and leaching which is likely to be higher in drilled rice than in conventional transplanted rice (Davidson, 1991; Singh and Singh, 1988). Moreover, oxidation of soil in upland situation might have resulted in lower available Zn and Fe although both were applied through soil application (Kim and Bajita, 1995). Even addition of organic matter did not influence significantly the available nutrient status in soil after

Table 3 : Soil nutrient studies as influenced by different nutrient management treatments

	Fe (mg/kg)			Zn (mg/kg)		
	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14
N_1	2.18	2.34	2.50	0.89	0.85	0.91
N_2	2.23	2.32	2.33	1.02	2.16	1.4
N_3	2.44	2.46	2.78	0.93	2.06	0.97
N_4	2.46	2.56	2.88	1.05	1.54	1.3
N_5	2.53	2.42	2.99	0.96	3.14	1.03
N_6	2.52	2.81	2.93	0.88	3.01	0.91
N_7	2.14	2.26	2.38	1.08	0.98	1.14
N_8	2.55	2.48	2.57	0.96	0.89	0.96
N_9	2.49	2.16	2.48	0.98	1.65	1.02
N_{10}	2.52	2.21	2.54	1.03	1.54	1.30
S.E. ±	0.07	0.11	0.09	0.08	0.07	0.054
C.D. (P = 0.05)	NS	NS	NS	NS	NS	NS
Mean	2.69	2.70	2.92	1.0	1.8	1.1
Initial	2.47	2.8	3.0	1.27	2.2	1.38

NS = Non-significant

Table 4 : Gross monitory return and net monitory return as influenced by nutrient management treatments (2011-12, 12-13, 13-14)

	Gross monitory return (Rs.)			Net monitory return (Rs.)		
	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14
N_1	30041	39930	37283	9601	17580	13643
N_2	31362	40159	38412	11222	17869	14472
N_3	32903	43543	41450	11663	22203	16700
N_4	31068	42011	38017	5628	14161	8377
N_5	32785	43747	40750	7145	15647	10810
N_6	34357	45761	42037	8117	16961	11204
N_7	30644	40713	37828	9554	17588	13298
N_8	32456	42591	40183	11216	19291	15453
N_9	31957	43192	39004	5867	14567	8474
N_{10}	33783	45024	41954	7543	16224	11307
S.E. ±	508.8	661.3	697.9	127.6	165.5	176.8
C.D. (P=0.05)	1501.2	1957.9	2065.5	375.8	489.8	516.7
Mean	32139	42598	39713	8709	17104	12395

the harvest of drilled rice crop. This indicted the necessity of not only adding the nutrients but also to monitor pH, redox potential and carbonate content of the soil for better availability of important micronutrients like Zn and Fe in case of drilled rice and enhancing the nutrient balance of soil (Table 2 and 3).

Conclusion :

From the studies on nutrient management practices it is revealed that recommended dose of nitrogen, phosphorus and potash *i.e.* 80 : 50 : 50 N-P-K kg/ha and FYM with soil application of Fe and Zn produced significantly higher rice seed yield.

However, application of N-P-K with soil application of Zn and Fe gave significantly more net monitory returns (NMR) over rest of the treatments in all three years and pooled analysis. This was closely followed by recommended dose of NPK *i.e.* 80 : 50 : 50 NPK kg/ha with two foliar sprays of Zn and Fe @ 0.5 per cent at 20 and 45 days after sowing for higher net returns under upland irrigated situation.

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