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Effect of zinc and nitrogen fertilization on yield and nutrient uptake of summer rice (*Oryza sativa*)

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ABSTRACT

A field experiment was conducted during summer 1991 and 1992 with 2 sources of zinc ($ZnSO_4$ and Zn-EDTA), 2 methods of application (soil and foliar) and 4 levels of nitrogen (0, 30, 60, 90 kg/ha) along with 4 levels of sole nitrogen in shallow lowlands with suboptimal (0.84 ppm) zinc level at Bhubaneshwar. Rice (*Oryza sativa* L.) variety 'Sarathi' (120 days) was used in the experiment. Combined application of zinc and nitrogen recorded grain and straw yields of 40.1 and 51.5 q/ha respectively compared with 37.4 and 45.6 q/ha obtained from nitrogen alone, giving an additional income of Rs 619/ha. The uptake of nitrogen and zinc increased progressively with increased levels of nitrogen. Among the methods of application, soil application of zinc was superior to foliar spray.

Deficiency of zinc in field crops is one of the major soil-fertility problems in many areas of the country. Zinc deficiency is recognized as the third most important factor after nitrogen and phosphorus limiting growth and yield of rice (Ponnamperuma, 1977). Krishnamurthy (1979) reported synergistic effect between applied N and zinc in rice (*Oryza sativa* L.). The present investigation was made in shallow lowland condition at Bhubaneshwar, to study the effects of nitrogen, zinc and their interactions on yield, nutrient uptake at different growth stages and economics of production to summer rice.

MATERIALS AND METHODS

Total 20 treatment combinations comprising 2 forms of zinc (S_1, $ZnSO_4$; and S_2, Zn-EDTA), 2 methods of application (M_1, soil application; and M_2, foliar application) supplemented with 4 levels of nitrogen (0, 30, 60, 90 kg/ha) along with 4 levels of sole nitrogen were tried in randomized block deisgn with 3 replications at the Central Research Station, OUAT, Bhubaneshwar, during summer 1991 and 1992. Both $ZnSO_4$ (22% Zn) @ 25 kg/ha and Zn-EDTA (Chelamin, 12% Zn) at 500 g + 10 kg carrier/ha were applied basal. Zinc sulphate at 0.4% and Zn-EDTA at 0.05% concentration were given as foliar sprays at 25 and 35 days after transplanting. The soil of the experimental site was sandy loam, slightly acidic in reaction (pH 6.5), medium in available N (322 kg/ha), P (14.5 kg Olsen's P) and K (156 kg k/ha) and had suboptimal Zn status (0.84 ppm DTPA-extractable Zinc). Nitrogen was applied in 3 splits (25% basal + 50% at active tillering + 25% at panicle-initiation stage), while P and K were applied @ 40 kg P_2O_5 and K_2O/ha at transplanting. Rice variety 'Sarathi' (120 days) was transplanted on 10 and 15 Febru-

ary in 1991 and 1992 respectively at 15 cm x 10 cm spacing.

RESULTS AND DISCUSSION

Yield

The grain and straw yields were significantly influenced by the increased levels of nitrogen in both the years. The maximum mean grain and straw yields of 45.8 and 62.1 q/ha were obtained at 90 kg N/ha. The increase over 0,30 and 60 kg N was 49.8, 20.7 and 7.3% for grain; and 56.1, 25.2 and 10.1% for straw respectively.

Application of Zn significantly increased the grain and straw yields over no zinc application, which might be due to better utilization of N and P for grain yield through increased metabolic activities. Combined application of N and Zn increased the grain yield by 7.2% and straw yield by 12.9% over sole N. Similar results have been reported earlier by Vyas *et al.* (1990).

Both the sources and methods of application of zinc significantly influenced the

Table 1. Effect of zinc and nitrogen fertilization on yield and economics

Tteatment	Grain yield (q/ha)		Straw yield (q/ha)		Economics	
	1991	1992	1991	1992	Net return (Rs/ha)*	Net return/ rupee invested*
N (kg/ha)						
0	33.0	32.7	39.9	39.4	2,148	0.31
30	39.5	38.8	49.7	48.8	3,724	0.51
60	42.5	42.7	55.0	54.5	4,609	0.61
90	46.0	45.6	62.1	62.1	5,321	0.69
CD (P = 0.05)	0.4	0.9	0.5	1.2		
Zn source						
$ZnSO_4$	40.7	40.5	52.9	52.1	4,013	0.54
Zn-EDTA	39.8	39.4	50.4	50.3	3,826	0.52
CD (P = 0.05)	0.3	0.6	0.4	0.9		
Method of application						
Soil	40.5	40.3	52.2	51.8	3,931	0.53
Foliar	39.9	39.6	51.1	50.6	3,907	0.53
CD (P = 0.05)	0.3	0.6	0.4	0.9		
Sole N(kg/ha)						
0	29.8	28.5	35.0	34.8	1,368	0.20
30	36.4	35.7	43.3	43.6	3,030	0.43
60	41.6	39.6	50.7	48.3	4,077	0.56
90	44.7	42.4	57.3	51.7	4,725	0.63
N	38.1	36.6	46.6	44.6	3,330	0.46
N + Zn	40.3	39.9	51.7	51.2	3,919	0.53
CD (P = 0.05)	0.3	0.6	0.4	0.8		

* Mean data of 2 years

yield. Among the sources, $ZnSO_4$ increased the grain yield by 2.5% and straw yield by 4.2% over Zn-EDTA, probably due to optimal supply of zinc from $ZnSO_4$. Among the methods of application, soil application increased the grain and straw yields by 1.5 and 2.2% over foliar application. Similar results were obtained by Mawardi *et al.* (1984).

Economics

Nitrogen and Zn fertilization incurred an additional income of Rs 619/ha and Re 0.07/ rupee invested compared with N fertilization alone, which were owing to synergistic action of nitrogen and zinc. Among the N levels, 90 kg/ha recorded the maximum net return of (Rs 5,321/ha) and a net return of Re 0.69 rupee invested.

The highest level of 90 kg N/ha recorded higher net return of Rs 3,357, 1,695 and 648 over 0, 30 and 60 kg N/ha respectively. Both foliar and soil applications gave more or less similar net return but among the sources, $ZnSO_4$ proved superior to Zn-EDTA with respect to net return. In soils of sub-optimal Zn status, zinc has to be supplemented with N fertilization for maximizing the rice yields. In the present investigation the combination of 90 kg N applied in 3

Table 2. Effect of zinc and nitrogen fertilization on N content and its uptake at different growth stages of rice

Treatment	Active tillering (%)	Panicle initiation (%)	Harvest		N uptake (kg/ha)		
			Grain (%)	Straw (%)	Grain	Straw	Total
N (kg/ha)							
0	1.55	1.33	0.98	0.53	21.04	32.24	53.28
30	1.86	1.69	1.12	0.61	30.07	43.90	73.97
60	2.10	1.72	1.21	0.67	36.72	51.55	88.27
90	2.31	1.92	1.30	0.74	45.95	59.54	105.49
CD (P = 0.05)	0.04	0.03	0.02	0.04	0.56	0.71	0.56
Zn source							
$ZnSO_4$	2.00	1.70	1.18	0.65	34.13	47.90	82.03
Zn-EDTA	1.90	1.65	1.13	0.63	31.75	44.75	76.40
CD (P = 0.05)	NS	0.02	NS	NS	0.40	0.50	0.40
Method of application							
Soil	1.97	1.69	1.17	0.65	33.80	47.27	81.07
Foliar	1.93	1.67	1.14	0.63	32.07	45.37	77.44
CD (P = 0.05)	NS	NS	NS	NS	0.40	0.50	0.40
Sole N(kg/ha)							
0	1.45	1.21	0.92	0.48	16.75	26.77	43.52
30	1.74	1.61	1.06	0.58	25.23	38.27	63.50
60	2.02	1.69	1.18	0.64	31.68	47.91	79.59
90	2.18	1.86	1.24	0.79	43.05	54.06	97.11
N	1.85	1.59	1.10	0.62	28.27	41.14	69.41
N + Zn	1.95	1.68	1.15	0.64	32.96	46.12	7.08
CD (P = 0.05)	0.03	0.02	0.02	0.03	0.46	0.58	0.46

splits and 25 kg $ZnSO_4$/ha basal proved the best combination for yield and economics.

Uptake of nutrients

The uptake of N increased significantly with increasing levels of N (Table 2). The N concentration was maxmum at active tillering stage, as 75% of the required N was applied up to that stage. The maximum mean uptake of 105.49 kg N/ha was recorded at 90 kg N/ha which might be due to greater absorption of N and higher grain and straw yields. Application of Zn increased the uptake of N during all the growth stages. Combined application of N and Zn increased the N uptake by 13.9% over the sole N. Application of $ZnSO_4$ resulted in greater uptake of N over Zn-EDTA which was in the line of grain and straw yields. The N concentration did not differ significantly by the methods of application at any stage of growth. However, the total uptake of N was significantly higher with soil application than that of foliar spray. This confirms the findings of Sahu (1989).

The concentration and uptake of Zn increased significantly with increasing levels of N (Table 3), as it had synergistic effect on Zn absorption. Maximum mean Zn concentration of 88.25 ppm was recorded at active

Table 3. Effect of zinc and nitrogen fertilization on zinc content and its uptake at different growth stages of rice (pooled data)

Treatment	Active tillering (ppm)	Panicle initiation (ppm)	Harvest		Zn uptake (kg/ha)		
			Grain (ppm)	Straw (ppm)	Grain	Straw	Total
N (kg/ha)							
0	57.75	50.75	39.75	46.75	0.130	0.186	0.316
30	71.75	63.25	45.75	58.25	0.179	0.287	0.466
60	82.50	75.25	50.50	69.75	0.215	0.397	0.694
90	88.25	83.25	53.25	78.75	0.244	0.476	0.720
CD (P = 0.05)	0.42	0.30	0.56	0.42	0.011	0.008	0.008
Zn source							
$ZnSO_4$	76.25	55.88	48.25	64.25	0.196	0.337	0.533
Zn-EDTA	74.14	53.13	46.63	61.50	0.185	0.310	0.495
CD (P = 0.05)	0.30	0.20	0.40	0.30	0.008	0.006	0.006
Method of application							
Soil	75.75	53.12	47.75	63.62	0.193	0.330	0.523
Foliar	74.62	53.88	47.13	62.13	0.188	0.316	0.504
CD (P = 0.05)	NS	NS	NS	NS	0.008	0.006	0.006
Sole N(kg/ha)							
0	35.00	32.00	28.00	30.00	0.081	0.104	0.185
30	47.00	45.00	38.00	42.00	0.137	0.182	0.319
60	58.00	56.00	45.60	47.00	0.185	0.232	0.417
90	66.00	64.00	48.00	51.00	0.222	0.278	0.500
N	51.50	49.25	39.75	42.50	0.148	0.194	0.342
N + Zn	75.19	54.50	47.44	62.88	0.190	0.324	0.514
CD (P = 0.05)	0.35	0.20	0.46	0.36	0.009	0.007	0.007

tillering stage with 90 kg N/ha level, as rice plant required higher amount of Zn during the active vegetative growth stage. Application of Zn increased it uptake significantly over no zinc application. The combined application of Zn and nitrogen increased the Zn uptake by 50% over sole N. Application of $ZnSO_4$ resulted in significantly higher content and uptake of Zn than Zn-EDTA at all stages. The Zn concentration was not influenced significantly by the methods of application at any stage of growth. However, the total uptake of Zn was significantly higher with soil application than foliar spray. Similar results were reported by Moharana (1992).

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