

Original Research Article

<https://doi.org/10.20546/ijcmas.2019.810.144>

Effect of Zinc and Iron Fertilization on Yield, Nutrient Content and Uptake of Direct Sown Rice

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ABSTRACT

Keywords

N, P, K, Zn, Fe, Mn
and Cu Content and
Uptake

Article Info

Accepted:
10 September 2019
Available Online:
10 October 2019

A field experiment entitled “Response of Direct Sown Rice to Zinc and Iron Nutrition” was conducted at Agriculture College Farm, Bapatla, during *kharij*, 2017. The experiment was laid out in randomized block design (RBD) with seven treatments replicated thrice. The results revealed that, The nutrient content (N, P, K, Mn and Cu) of direct sown rice at tillering, panicle initiation and harvest was not significantly influenced by the treatments and zinc and iron contents were significantly influenced by the treatment that received RDF + ZnSO₄ @ 50 kg ha⁻¹ + FeSO₄ @ 25 kg ha⁻¹ through soil application. Lower values of all the nutrients were recorded with RDF. Uptake of nutrients at tillering, panicle initiation and at harvest was markedly influenced by the treatment that receive RDF + ZnSO₄ @ 50 kg ha⁻¹ + FeSO₄ @ 25 kg ha⁻¹ through soil application. While, lower values were recorded with RDF.

Introduction

Rice (*Oryza sativa* L.) is a staple food for more than one third of the world population (Zhao *et al.*, 2011). In India, it is grown in an area of 44.1 million hectares with a production of 108.9 million tonnes and productivity of 2391 kg ha⁻¹. In Andhra Pradesh, it is grown in an area of 2.394 million hectare with a production of 7.24 million tonnes and productivity of 3022 kg ha⁻¹ (Ministry of

Agriculture, Govt. of India, 2016-17). In India, rice occupies one-quarter of the total cropped area contributing about 40 to 43 per cent of total food grain production and continues to play vital role in the national food security system (Viraktamath *et al.*, 2011).

Direct seeding of rice (DSR) 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). Agriculture is the primary source of providing all nutrients required for crops and for human health, and fertilization is the key point of integrated nutrient management (INM) in agronomic approaches to enhance crop quality and quantity. Fertilization therefore, could be one of the sustainable and low cost strategies in improving Fe and Zn concentration in edible portions of staple food crops (Rengel *et al.*, 1999).

Micronutrients, particularly zinc and iron have attained a great significance in today's intensive and exploitive agriculture which is aiming at higher crop productivity. The total iron and zinc content of Indian soils varies from 0.8-1.96 mg kg⁻¹ and 0.2-6.9 mg kg⁻¹, respectively (Singh, 2009).

In direct seeding, availability of several nutrients including N, P, S and micronutrients such as Zn and Fe, is likely to be a constraint. Nonetheless, farmers are inclining to adopt direct sown rice and the area under direct sown rice is increasing year after year. Keeping the point in view a field study was undertaken to assess the effect of zinc and iron on nutrient content, uptake and yield of direct sown rice.

Materials and Methods

The experiment was conducted at the Agricultural College Farm, Bapatla situated in Krishna zone of Andhra Pradesh. The experiment was laid out in randomized block design with seven treatments replicated thrice. The treatments comprises of T₁- RDF (180 :60 :40 N-P₂O₅ -K₂O (kg ha⁻¹); T₂- RDF + ZnSO₄ @ 50kg ha⁻¹ through soil application; T₃- RDF + FeSO₄ @ 25kg ha⁻¹ through soil application; T₄ - RDF + ZnSO₄ @ 50 kg ha⁻¹ + FeSO₄ @ 25 kg ha⁻¹ through soil application; T₅- RDF + foliar spray of ZnSO₄ @ 0.2% at 20 and 45 DAS; T₆- RDF + foliar spray of FeSO₄ @ 0.5% at 20 and 45 DAS; T₇- RDF + foliar

spray of ZnSO₄ @ 0.2% and FeSO₄ @ 0.5% at 20 and 45 DAS. The variety used for the experiment is BPT 5204. For all the treatments at the time of sowing half of the recommended dose of nitrogen and full dose of P and K was applied. Remaining dose of nitrogen was applied 45 DAS. Urea, SSP & MOP was used as a source of N, P and K. ZnSO₄ was used as a source of zinc fertilizer and FeSO₄ was used as a source of iron fertilizer. Foliar application was done at different growth stages such as 20 and 45 DAS. For foliar application 0.2% ZnSO₄ and 0.5% FeSO₄ solution was prepared.

The experimental soil was sandy clay in texture, neutral in reaction (7.48) and non-saline (0.53) in nature and low in organic carbon (4.0 g/kg), low in available nitrogen (224 kg ha⁻¹), medium in available phosphorus (38.8 kg ha⁻¹) and medium in available potassium (285 kg ha⁻¹). Nutrient uptake (kg ha⁻¹) by rice was calculated using the values of percent nutrient concentrations and dry matter production (kg ha⁻¹)

The plant samples collected at tillering, panicle initiation stage and harvest stage washed with dilute HCl and then with distilled water. The samples were shade dried initially and then oven dried at 60 °C temperature and powdered in willey mill and analyzed for various nutrients.

The nitrogen content in rice plants was estimated by micro Kjeldahl distillation method. One gram of powdered plant sample was taken in 150 ml Erlenmeyer flask and digested with diacid mixture (HNO₃ and HClO₄ in 9: 4 ratio). The sample digest was filtered through Whatman No. 42 filter paper by washing the residue with double glass distilled water till chloride free and made upto 100 mL volume and the clear extract was used for the determination of P, K, Zn, Fe, Mn and Cu.

Micronutrients Uptake (kg ha⁻¹)

$$= \frac{\text{Nutrient content (mg kg}^{-1}) \times \text{Yield (kg ha}^{-1})}{100}$$

Results and Discussion

Nutrient content (%)

Nutrient content (N, P and K) at any stage of crop growth was not significantly influenced by zinc and iron fertilization (Table 1). The highest nitrogen content of 2.49, 1.45, 0.81 and 1.86 per cent and the highest phosphorus content (0.37, 0.33, 0.22 and 0.44 per cent) at tillering, panicle initiation, in straw and grain at harvest, respectively), and the highest potassium content in straw 2.92, 2.50, 1.43 and 0.96 per cent at tillering, panicle initiation, straw and grain at harvest, respectively was observed with application of RDF+ ZnSO₄@ 50 kg ha⁻¹ + FeSO₄@ 25 kg ha⁻¹ through soil application and the lowest N, P and K content was recorded in (RDF). The combined soil application of zinc and iron fertilization increased nitrogen content at tillering stage and later stages (at panicle initiation and harvest). The nitrogen content in rice straw was found to decrease from tillering stage to maturity with the maximum nitrogen content recorded at tillering in all treatments. This might be due to higher absorption of N by growing plants initially and also due to effect of increased dry matter production with growth (Keram *et al.*, 2012).

The P content was found to decrease from tillering to maturity with maximum P content recorded at tillering stage. At harvest the phosphorus content in grain was higher as compared to that of straw, however, the zinc and iron fertilization did not affect the P content significantly in grain and straw of rice plant. The P content decreased from tillering

to panicle initiation. It might be due to the dilution effect of nutrient. Similar findings were reported by Ghoneim *et al.*, (2016) who, stated that P reacts with zinc in soil which reduces the translocation of zinc from roots to shoots and also imbalances the P : Zn ratio in plant. The potassium content was found to decrease from tillering to maturity. Further it is also interesting to note that K content was higher in straw than grain of at harvesting stage rice as compared to N and P, which indicated that rice straw is useful as a source of potassium.

Micronutrient content (mg kg⁻¹)

The maximum zinc and iron content at tillering, panicle initiation, straw and grain at harvest stage (69, 62, 45 and 41 mg of Zn kg⁻¹ and 466, 441, 431 and 210 mg Fe kg⁻¹) was recorded under (RDF+ ZnSO₄@50kg ha⁻¹ + FeSO₄@ 25kg ha⁻¹ through soil application). The minimum zinc and iron content (54, 47, 27 and 22 mg Zn kg⁻¹ and 428, 415, 383 and 164 mg Fe kg⁻¹) was recorded with (RDF) (Table 2). With regard to Manganese and Copper content at all stages of crop growth was not significantly influenced by zinc and iron fertilization. The results indicated that combined application of zinc and iron fertilization enhanced zinc and iron concentration at all stages of crop growth which was significantly superior to control. The results are in agreement with those of Tahir and Kausar (1994). The increase in content of iron might be due to more favourable conditions and continued flooding leading to the reduction of higher oxides and hydroxides of Fe into soluble form either through an increase in solubility in soil solution or possible stimulation of root activity. The results are in accordance with those of Antil *et al.*, (1989). Soil application of higher level iron significantly increased iron content in straw and grain at harvest (Gohil *et al.*, 2017).

Table.1 Effect of zinc and iron fertilization on nitrogen, phosphorus and potassium content (%) of direct sown rice

Treatments	Nitrogen				Phosphorus				Potassium			
	Tillering	Panicle initiation	At harvest		Tillering	Panicle initiation	At harvest		Tillering	Panicle initiation	At harvest	
			Grain	Straw			Grain	Straw			Grain	Straw
T₁	1.87	1.18	1.37	0.63	0.26	0.22	0.36	0.14	2.41	1.62	0.79	1.29
T₂	2.31	1.35	1.77	0.75	0.32	0.29	0.39	0.19	2.85	1.96	0.86	1.38
T₃	2.21	1.29	1.70	0.70	0.30	0.27	0.38	0.17	2.82	1.85	0.89	1.35
T₄	2.49	1.45	1.86	0.81	0.37	0.33	0.44	0.22	2.92	2.50	0.96	1.43
T₅	2.26	1.31	1.72	0.72	0.29	0.28	0.39	0.18	2.84	1.90	0.88	1.37
T₆	2.19	1.28	1.69	0.69	0.34	0.27	0.38	0.17	2.80	1.82	0.84	1.33
T₇	2.34	1.41	1.79	0.77	0.35	0.31	0.42	0.20	2.87	2.17	0.91	1.40
S.Em(±)	0.14	0.07	0.11	0.03	0.02	0.02	0.02	0.01	0.10	0.11	0.05	0.05
CD (0.05%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V(%)	11.12	9.48	11.54	9.23	13.27	14.56	11.36	14.79	6.50	10.12	11.23	6.35

Table.2 Effect of zinc and iron fertilization on zinc, iron, manganese and copper content (%) of direct sown rice

Treatments	Zinc				Iron				Manganese				Copper			
	Tillering	Panicle initiation	At harvest		Tillering	Panicle initiation	At harvest		Tillering	Panicle initiation	At harvest		Tillering	Panicle initiation	At harvest	
			Grain	Straw			Grain	Straw			Grain	Straw			Grain	Straw
T₁	54	47	22	27	428	415	164	383	246	225	72	193	21	18	7	11
T₂	64	57	35	40	435	423	191	416	256	242	89	224	29	24	8	15
T₃	58	52	30	35	451	435	205	426	255	241	80	220	26	23	9	14
T₄	69	62	41	45	466	441	210	431	259	246	94	227	31	28	10	17
T₅	62	54	33	38	432	420	186	415	255	241	82	223	26	23	9	14
T₆	58	50	29	33	450	429	199	422	254	240	80	219	24	21	8	14
T₇	67	58	38	43	455	438	207	427	258	244	93	225	30	25	9	17
S.Em (±)	2.61	2.25	1.74	1.61	5.67	3.86	3.96	3.51	12.28	11.41	5.54	9.39	2.27	1.83	0.60	1.20
CD (0.05%)	8	7	5	5	17	12	12	11	NS	NS	NS	NS	NS	NS	NS	NS
C.V (%)	7.36	7.22	9.23	7.52	6.12	5.41	6.47	5.56	8.36	8.24	11.39	7.36	14.71	13.69	12.36	14.21

Table.3 Effect of zinc and iron fertilization on nitrogen, phosphorus and potassium uptake (kg ha⁻¹) of direct sown rice

Treatments	Nitrogen				Phosphorus				Potassium			
	Tillering	Panicle initiation	At harvest		Tillering	Panicle initiation	At harvest		Tillering	Panicle initiation	At harvest	
			Grain	Straw			Grain	Straw			Grain	Straw
T₁	40.56	60.48	52.05	36.36	5.59	11.39	13.67	7.89	52.83	82.97	29.45	74.87
T₂	59.28	77.54	85.89	53.34	8.19	16.59	21.37	13.50	73.32	112.47	44.55	98.19
T₃	52.88	71.10	80.76	47.54	7.16	14.64	18.84	11.38	67.50	102.04	41.55	91.87
T₄	68.97	88.63	98.96	62.93	10.37	19.87	28.09	17.05	81.32	153.04	51.14	110.72
T₅	55.57	73.30	82.36	49.66	7.19	15.81	19.81	12.70	69.64	106.18	42.08	94.74
T₆	51.65	69.54	79.62	47.05	8.03	14.80	18.56	11.75	66.27	98.78	39.51	90.55
T₇	63.13	83.54	87.68	54.76	9.40	18.28	23.67	14.04	77.36	129.22	47.32	99.81
S.Em (±)	3.71	3.83	5.94	2.34	0.68	1.22	1.74	1.08	4.54	6.50	1.56	4.03
CD (0.05%)	11.44	11.82	18.30	7.22	2.10	3.77	5.38	3.34	13.99	20.04	4.83	12.44
C.V (%)	11.48	8.88	12.69	8.08	14.79	13.31	14.70	14.89	11.28	10.05	6.43	7.41

Table.4 Effect of zinc and iron fertilization on zinc, iron, manganese and copper uptake (g ha⁻¹) of direct sown rice

Treatments	Zinc				Iron				Manganese				Copper			
	Tillering	Panicle initiation	At harvest		Tillering	Panicle initiation	At harvest		Tillering	Panicle initiation	At harvest		Tillering	Panicle initiation	At harvest	
			Grain	Straw			Grain	Straw			Grain	Straw			Grain	Straw
T₁	117	238	83	159	930	2123	610	2232	538	1156	268	1131	46	95	28	67
T₂	163	325	171	285	1117	2425	990	2963	660	1392	431	1594	74	140	43	104
T₃	139	283	145	237	1080	2396	952	2905	612	1328	381	1494	61	124	40	95
T₄	191	377	219	349	1293	2708	1116	3338	720	1513	500	1755	87	172	47	135
T₅	150	303	158	261	1059	2351	948	2878	627	1354	391	1549	64	130	41	99
T₆	136	273	136	220	1063	2334	939	2867	602	1306	376	1487	56	114	39	93
T₇	179	346	184	306	1226	2614	1009	3055	696	1460	454	1604	81	152	43	123
S.Em (±)	8.73	19.52	9.65	12.01	40.85	92.17	41.64	94.90	20.90	40.71	25.79	73.42	5.71	10.90	1.98	8.64
CD (0.05%)	27	60	30	37	126	284	128	292	71	125	79	227	18	34	6	27
C.V (%)	9.82	11.02	10.67	8.00	6.37	6.59	7.69	5.68	6.23	5.19	11.15	8.43	14.73	14.23	8.49	14.60

Nutrient uptake

Major nutrient Uptake (kg ha⁻¹)

At tillering, panicle initiation, straw and grain at harvest stage the maximum nitrogen uptake (68.97, 88.63, 62.93 and 98.96 kg ha⁻¹), phosphorus uptake (10.37, 19.87, 17.07 and 28.09 kg ha⁻¹) and potassium uptake (81.32, 153.04, 110.72, 51.14 kg ha⁻¹) was recorded under RDF+ ZnSO₄@50kg ha⁻¹ + FeSO₄@25kg ha⁻¹ through soil application. The lowest nitrogen, phosphorus and potassium uptake was recorded with RDF (Table 3). The combined soil or foliar application of zinc and iron increased higher nutrient uptake at all stages of crop growth. The higher nutrient uptake may be attributed to enhanced nutrient availability with the external application of micronutrients. Due to the steady and continuous availability of nitrogen in the rhizosphere coupled with enhanced dry matter production resulted in higher uptake of nitrogen. These results were in conformity with those of Mujumdar *et al.*, (2007). The higher P uptake might be due to the solubilization of native phosphorus by the inorganic acids under reduced conditions in addition to applied fertilizers which ultimately resulted in better root growth and increased physiological activity of roots to absorb more phosphorus. Elayaraja and Singaravel, 2012. The massive increase in potassium uptake due to the interaction of K and Zn by the improvement of enzymatic activity and metabolic processes of plant, which might have ultimately facilitated the removal of potassium and consequently the yield. These results was in accordance with those of Khan *et al.*, (2003).

Micronutrient Uptake (g ha⁻¹)

At tillering, panicle initiation, straw and grain at harvest stage the highest zinc uptake (191, 377, 349 and 219g ha⁻¹), iron uptake (1293, 2708, 3338 and 1116 g ha⁻¹), manganese uptake (720, 1513, 1755 and 500 g ha⁻¹) and copper uptake (87, 172, 135 and 47 g ha⁻¹) was recorded under RDF+ ZnSO₄@50kg ha⁻¹ + FeSO₄@25kg ha⁻¹ through soil application. The lowest

micronutrient uptake was recorded with RDF (Table 4). The uptake being the product of content and dry matter production, the increase in Zn uptake by the crop might be due to easy availability of Zn with higher concentrations and rapid rate of absorption caused by greater mobility of zinc when applied through soil. The present findings are in conformity with the findings of Yadav *et al.*, (2011). Application of higher level of zinc significantly increased the Zn uptake by both straw and grain. These results are in agreement with those Gohil *et al.*, (2017). The superiority of treatments might be due to combined application of zinc and iron nutrients as basal or foliar applications along with RDF through which required nutrients were available to the crop throughout growth period at required quantities and so enhanced the nutrient uptake. The increased manganese and copper uptake might be due to zinc and iron fertilization, which might be have increased the manganese availability through enhanced mineralization and chelation action which facilitated greater absorption and utilization of manganese by the plants Latha *et al.*, (2002) and Sumangala (2003).

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How to cite this article:

Janardhan, S. and Usha Rani, I. 2019. Effect of Zinc and Iron Fertilization on Yield, Nutrient Content and Uptake of Direct Sown Rice. *Int.J.Curr.Microbiol.App.Sci*. 8(10): 1226-1234. doi: <https://doi.org/10.20546/ijcmas.2019.810.144>