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Grain Yield and Nutrient Uptake of Direct Seeded Rice as Influenced by Application of Micronutrients

Manjunatha Bhanuvally[1], Y.M. Ramesha[2*], D. Krishna Murthy[2] and H. Yogeeshappa[3]

[1]Department of Soil Science and Agricultural Chemistry, UAS, Raichur, India
[2]Department of Agronomy, University of Agricultural Sciences, Raichur, India
[3]Department of Soil Science and Agricultural Chemistry, UHS, Bhagalkot, India
*Corresponding author

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ABSTRACT

An experiment was conducted during *Kharif* 2014 and 2015 at Agricultural Research Station, Dhadesugur, University of Agricultural Sciences, Raichur, Karnataka, India, to study the grain yield and nutrient uptake of direct seeded rice as influenced by application of micronutrients. Results revealed that, application of RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha) + 1 % $FeSO_4$ spray at 25 DAS recorded significantly higher grain yield (6069 kg/ha) and straw yield (7270 kg/ha) and which was onpar with the application of RDF + Zn (25 kg/ha) + $FeSO_4$ at 5 kg/ha (5911 and 7185 kg/ha, respectively) over the other treatments. However, application of RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha) + 1 % $FeSO_4$ spray at 25 DAS recorded significantly higher uptake of nitrogen (65.0 kg/ha), phosphorus (13.4 kg/ha), potassium (108.7 kg/ha) and sulphur (13.4 kg/ha). Further, application of RDF + $FeSO_4$ (5 kg/ha) recorded significantly least grain (5264 kg/ha) and straw yield (6588 kg/ha) compared to other treatments.

Introduction

An alarming rate of ground water depletion and increasing labour scarcity are major threats to future rice production in India. Management strategies that reduce the irrigation amount and labour requirement while maintaining or increasing yield are urgently needed. Dry seeded rice (DSR) is the alternating method to achieve these objectives (Yadav *et al.,* 2011). The direct seeding offers certain advantages i.e. saves labour, faster and easier planting helps in timely sowing, less drudgery, early crop maturity by 7-10 days, less water requirements, high tolerance to water deficit, often higher yield, low production cost and more profit, better soil physical conditions for following crops and less methane emission (Balasubramanian and Hill, 2002). Rice is the staple food crop for more than half of the world's population; unfortunately the rice is a poor source of many essential micronutrients (Stalin *et al.*, 2011). Thus, a rice-based diet is the primary causes of micronutrient malnutrition throughout worldwide mainly the developing world. Iron, zinc, deficiencies are common in rice consuming regions. These micronutrients are required in small amounts and they affect directly or indirectly photosynthesis, vital processes in plant such as respiration, protein synthesis, reproduction phase and have effect on grain yield (Marschner, 1995). The foliar feeding of micronutrients is an effective method to yield improvement and grain nutrient enrichment (Johnson *et al.,* 2005). Concentration of iron, boron and zinc contents increased significantly in rice grain with combined foliar application of these nutrients (Jin *et al.,* 2008). With the foliar application of micronutrients particularly zinc and Iron in small amounts had significant positive effect on test weight, plant growth and yield attributes (Babaeian *et al.,* 2011), and growth of rice (Oosterhuits *et al.,* 2010). Direct seeded rice crop has a higher nutrient requirement as compared to a transplanted crop because of the higher plant density and greater production of biomass in the vegetative phase (Dingkuhn *et al.,* 1990). Thus, direct seeded rice crops tend to develop nutrient deficiency at the reproductive stage of growth and senesce earlier. Rice varieties exhibit wide variation in the production of high density grains which showed maximum potential for grain filling and test weight (Murty *et al.,* 1992). Keeping these facts in view, the present investigation was undertaken as effects of foliar feeding of micronutrients on the grain yield and nutrient uptake of direct seeded rice.

Materials and Methods

An experiment was conducted during *Kharif* 2014 and 2015, at Agricultural Research Station, Dhadesugur, University of Agricultural Sciences (UAS), Raichur, Karnataka, India, (situated at 15.6' N latitude and 76.8' E longitude with an altitude of 358 m above mean sea level). The soil was deep black clay in texture having a pH of 8.1, organic Carbon (0.21%), total N (160 kg/ha), available P_2O_5 (26.0 kg/ha) and available K_2O (486 kg/ha). The experiment was laid out in a randomized block design with seven treatments, *viz.* T_1: RDF (150:75:75 NPK kg/ha) + Zn (25 kg/ha), T_2: RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha), T_3: RDF + $FeSO_4$ (5 kg/ha), T_4: RDF + $FeSO_4$ (5 kg/ha) + Borax (2.5 kg/ha), T_5: RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha) + 1 % $FeSO_4$ spray at 25 DAS, T_6: RDF + $FeSO_4$ (5 kg/ha) + 0.4 % Borax spray at 25 DAS and T_7: RDF + $FeSO_4$ (5 kg/ha) + 0.4 % Borax spray at PI and replicated thrice. The rice variety used was *'BPT-5204'* of 150 days duration. The crop was sown in the 1st week of June in both the years. The recommended dose of fertilizer and micronutrients were applied as per the treatments. Rice from each net plot in each replication was harvested and dried. The grains after threshing were weighed and recorded as grain yield per net plot. Further, this net plot grain yield was converted to grain yield per hectare.

Chemical analysis of plant sample

The plant samples used for recording dry matter production at harvest were used for analyzing nutrients present in the plant. After recording the dry weight from each treatment the samples were powdered in a micro Willey mill. The samples were analyzed for concentration of different nutrients (N, P. K and S) present in the plant parts. Nitrogen content of grain and straw were estimated by modified micro-kjeldhal's method as outlined by Jackson (1967) and expressed in per cent. Nitrogen uptake (kg/ha) by crop was calculated for each treatment separately using the following formula.

Nitrogen uptake (kg/ha) = (Nitrogen concentration (%)/100) X Dry matter yield (kg ha^{-1})

The phosphorus content of grain and straw were determined by Vanadomolybodo phosphoric acid yellow colour method and absorbance of the solution was recorded at 430 nm using spectrophotometer (Jackson, 1967) and then computed the total uptake by crop as detailed under N uptake by the crop. Potassium content in plant sample (grain and straw separately) was determined by flame photometer method (Jackson, 1967) and expressed in kg per ha as explained under N uptake by the crop.

Chemical analysis of soil

Representative soil samples from the experimental plot were drawn from the top 15 cm depth before sowing of the crop. Similarly, the surface soil samples from 0 to 15 cm depth were also collected from each experimental plot at harvest. Soil samples thus collected were air dried under shade, powdered with wooden mallet and passed through 2 mm sieve and analyzed for nitrogen, phosphorus, potassium and sulphur content. Available nitrogen was determined by alkaline permanganate method as outlined by Subbiah and Asija (1959). Available phosphorus was determined by Bray's method as outlined by Jackson (1967). Available potassium was determined by neutral normal ammonium acetate solution using flame photometer as outlined by Jackson (1967).

Statistical analysis and interpretation of data

Data recorded on various parameters of the experiment was subjected to analysis by using Fisher's method of analysis of variance (ANOVA) and interpreted as outlined by Gomez and Gomez (1984). The levels of significance used in 'F' and 't' test was P= 0.05. Critical difference values were calculated where F test was found significant.

Results and Discussion

Dry matter accumulation

The data on dry matter production per plant is presented in Table 2. Application of RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha) + 1 % $FeSO_4$ spray at 25 DAS recorded significantly higher dry matter production per plant (8.61 g/plant) and which was onpar with the application of RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha). This may be due to better growth and development of rice which indicated periodic plant height, more periodic dry matter accumulation, and more LAI (Roosta and Hamidpour, 2011). Further, application of RDF + $FeSO_4$ (5 kg/ha) recorded significantly least dry matter production (6.95 g/plant). Similar results were also reported by Naguib *et al.,* (2007).

Grain and straw yield

The data on yield parameters of DSR as influenced by the application of micronutrients is presented in Table 2. Grain and straw yield were significantly higher in the treatment with the application of RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha) + 1 % $FeSO_4$ spray at 25 DAS (6069 and 7270 kg/ha, respectively) and which was onpar with the application of RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha). The positive effects of micronutrients application by foliar sprays on grain yield of basmati rice might be due to increase in chlorophyll content of leaves of basmati rice which might have increased photosynthesis and resulted in more dry matter accumulation and LAI and hence led to more capture of solar radiation that resulted in enhanced values of growth parameters and yield attributing characters and ultimately resulted in higher grain yield (Jagjot Singh Gill and Sohan Singh Walia, 2015). Further, application of RDF + $FeSO_4$ (5 kg/ha) recorded significantly least grain (5264 kg/ha) and straw yield (6588 kg/ha).

Nutrient concentration

Among the treatment, the nitrogen, phosphorus, potassium and sulphur content in grain and straw as influenced by application of micronutrients were not differed significantly (Table 1).

Table.1 Effect of micronutrient application on nutrient concentration of Direct Seeded Rice (Mean of 2014 and 2015)

Treatments	**Nitrogen (%)**			**Phosphorus (%)**			**Potassium (%)**			**Sulphur (%)**		
	Grain	**Straw**	**Total**	**Grain**	**Straw**	**Total**	**Grain**	**Straw**	**Total**	**Grain**	**Straw**	**Total**
T_1: RDF (150:75:75 NPK kg/ha) + Zn (25 kg/ha)	1.05	0.5	1.55	0.19	0.13	0.32	0.56	2.31	2.87	0.16	0.15	0.31
T_2: RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha)	1.12	0.51	1.63	0.2	0.14	0.34	0.57	2.32	2.89	0.17	0.16	0.33
T_3: RDF + $FeSO_4$ (5 kg/ha)	0.85	0.45	1.30	0.18	0.1	0.28	0.50	1.88	2.38	0.15	0.14	0.29
T_4: RDF + $FeSO_4$ (5 kg/ha) + Borax (2.5 kg/ha)	0.98	0.48	1.46	0.19	0.13	0.32	0.55	2.30	2.85	0.16	0.15	0.31
T_5: RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha) + 1 % $FeSO_4$ spray at 25 DAS	1.21	0.53	1.74	0.21	0.15	0.36	0.58	2.33	2.91	0.18	0.18	0.36
T_6: RDF + $FeSO_4$ (5 kg/ha) + 0.4 % Borax spray at 25 DAS	0.95	0.47	1.42	0.19	0.12	0.31	0.53	2.22	2.75	0.16	0.15	0.31
T_7: RDF + $FeSO_4$ (5 kg/ha) + 0.4 % Borax spray at PI	0.94	0.46	1.40	0.19	0.11	0.30	0.51	2.12	2.63	0.15	0.14	0.29
C.D. at 5 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

NS: Not Significant

Table.2 Effect of micronutrient application on DMA and grain yield of Direct seeded rice (Mean of 2014 and 2015)

Treatments	DMA (g/plant)	DMA (kg/ha)	Grain yield (kg/ha)	Straw yield (kg/ha)
T_1: RDF (150:75:75 NPK kg/ha) + Zn (25 kg/ha)	7.69	3592	5804	7027
T_2: RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha)	8.31	3666	5911	7185
T_3: RDF + $FeSO_4$ (5 kg/ha)	6.95	3318	5264	6588
T_4: RDF + $FeSO_4$ (5 kg/ha) + Borax (2.5 kg/ha)	7.51	3530	5698	6911
T_5: RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha) + 1 % $FeSO_4$ spray at 25 DAS	8.61	3734	6069	7270
T_6: RDF + $FeSO_4$ (5 kg/ha) + 0.4 % Borax spray at 25 DAS	7.23	3464	5586	6783
T_7: RDF + $FeSO_4$ (5 kg/ha) + 0.4 % Borax spray at PI	7.61	3412	5477	6706
C.D. at 5 %	**0.62**	**68.5**	**251.2**	**238.5**

Note: DMA: Dry matter accumulation

Table.3 Effect of micronutrient application on uptake of Direct Seeded Rice (Mean of 2014 and 2015)

Treatments	**Nutrient uptake (kg/ha)**			
	N	**P_2O_5**	**K_2O**	**S**
T_1: RDF (150:75:75 NPK kg/ha) + Zn (25 kg/ha)	55.7	11.5	103.1	11.1
T_2: RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha)	59.8	12.5	105.9	12.1
T_3: RDF + $FeSO_4$ (5 kg/ha)	43.1	9.29	78.97	9.62
T_4: RDF + $FeSO_4$ (5 kg/ha) + Borax (2.5 kg/ha)	51.5	11.3	100.6	10.9
T_5: RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha) + 1 % $FeSO_4$ spray at 25 DAS	65.0	13.4	108.7	13.4
T_6: RDF + $FeSO_4$ (5 kg/ha) + 0.4 % Borax spray at 25 DAS	49.2	10.7	95.30	10.7
T_7: RDF + $FeSO_4$ (5 kg/ha) + 0.4 % Borax spray at PI	47.8	10.2	89.70	9.89
C.D. at 5 %	**8.32**	**0.92**	**5.72**	**2.35**

Table.4 Effect of micronutrient application on soil available nutrients after harvest of Direct Seeded Rice (Mean of 2014 and 2015)

Treatments	**Soil available nutrients after harvest of crop (kg/ha)**			
	N	**P_2O_5**	**K_2O**	**S**
T_1: RDF (150:75:75 NPK kg/ha) + Zn (25 kg/ha)	166.2	39.1	268.5	41.5
T_2: RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha)	168.5	40.1	270.5	42.5
T_3: RDF + $FeSO_4$ (5 kg/ha)	172.5	41.5	272.5	50.2
T_4: RDF + $FeSO_4$ (5 kg/ha) + Borax (2.5 kg/ha)	171.2	41.2	271.8	43.6
T_5: RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha) + 1 % $FeSO_4$ spray at 25 DAS	165.4	38.2	267.5	40.2
T_6: RDF + $FeSO_4$ (5 kg/ha) + 0.4 % Borax spray at 25 DAS	167.8	39.8	269.5	44.5
T_7: RDF + $FeSO_4$ (5 kg/ha) + 0.4 % Borax spray at PI	169.3	40.5	270.9	46.8
C.D. at 5 %	**6.23**	**2.23**	**4.23**	**8.65**

Nutrient uptake

Application of RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha) + 1 % $FeSO_4$ spray at 25 DAS recorded significantly higher nitrogen, phosphorus, potassium and sulphur uptake by direct seeded rice (65.0, 13.4, 108.7 and 13.4 kg/ha, respectively) and which was onpar with the application of RDF + Zn (25 kg/ha) + $FeSO_4$ @ 5 kg/ha (59.8, 12.5, 105.9 and 12.1 kg/ha, respectively). More plant population per unit area might have encouraged DSR for more uptake of nitrogen, phosphorus, potassium and sulphur and retention of nutrients in grain and straw (Dingkuhn *et al.*, 1990). However, application of RDF + $FeSO_4$ (5 kg/ha) recorded significantly least nitrogen, phosphorus, potassium and sulphur uptake by direct seeded rice (43.1, 9.29, 78.9 and 9.62 kg/ha, respectively).

Available nutrients in soil after harvest of crop

In soil, after harvest of crop, the available nutrients *viz*., nitrogen, phosphorus, potassium and sulphur were significantly influenced by the application of micronutrients (Table 4). Results revealed that, Application of RDF + $FeSO_4$ (5 kg/ha) recorded significantly higher available nitrogen, phosphorus, potassium and sulphur in soil after harvest of crop (172.5, 41.5, 272.5 and 50.2 kg/ha, respectively) and which was onpar with the application of RDF + $FeSO_4$ (5 kg/ha) + Borax @ 2.5 kg/ha (171.2, 41.2 271.8 and 43.6 kg/ha, respectively).

This might be due to low extraction nutrients by low grain and straw yield. Further, application of RDF + Zn (25 kg/ha) + $FeSO_4$ (5 kg/ha) + 1 % $FeSO_4$ spray at 25 DAS recorded significantly lower available nitrogen, phosphorus, potassium and sulphur in soil after harvest of crop. This might be due higher extraction of nutrients due to higher grain and straw yield. Similar results also reported by Naguib *et al.*, (2007). Results indicated that, Application recommended dose NPK (150:75:75 kg/ha) along with foliar application of Zinc (25 kg/ha), $FeSO_4$ (5kg/ha) + 1 % $FeSO_4$ spray at 25 DAS was significantly increased the grain yield and uptake of nutrients in direct seeded rice.

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