



Effect of Foliar Application of Nutrients on Yield and Nutrient Uptake by Rice Crop

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during 2018 and 2019 at the Agronomy Research farm of A.N.D. University of Agriculture and Technology, Kumarganj, Ayodhya, UP to evaluate the effect of foliar application of macro and micronutrients on yield and nutrient uptake of rice (*Oryza sativa* L.). The experiment consists of 10 treatment combinations with some foliar application macro and micronutrients two foliar spray tillering stages and a panicle initiation stage which were laid out in

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randomized block design with three replications. The results revealed maximum grain yield (38.50 and 40.40 q ha⁻¹), straw (51.90 and 54.60 q ha⁻¹), and harvest index (42.64 and 42.53 %) with treatment T₁₀-75% RDF + WSCF @ 0.5 % (19:19:19) + ZnSO₄ @ 0.5 % + Boron @ 0.25 % which was statistically at par with T₃- 125 % RDF and significantly superior over rest of the treatments during both the years ., was recorded Similarly significant improvement in nutrient uptake (N, P, K, S, Zn, and B) by rice was observed in T₁₀. Thus, it can be concluded that the application of 75% RDF + WSCF @ 0.5 % (19:19:19) + ZnSO₄ @ 0.5 % + Boron @ 0.25 % can improve the yield and nutrient uptake.

Keywords: Rice; foliar spray; nutrient uptake; yield.

1. INTRODUCTION

“The genus *Oryza* has two domesticated species and 22 wild species. Rice (*Oryza sativa* L.) is a member of the Gramineae family. *Oryza sativa* and *Oryza glaberrima* are the two cultivars. In contrast to *Oryza glaberrima*, which has been grown in West Africa for the past 3500 years, *Oryza sativa* is grown all over the world. About 3 billion people depend on rice, the most significant food crop in the world, for their daily needs” [1]. “It is different in terms of how it is grown and utilised by people. Because it can thrive in humid conditions where other crops cannot, rice is exceptional. With an annual production of 109.69 million tonnes and an average productivity of 2249 kg ha⁻¹, rice is grown on an area of 43.99 million hectares in India. In Uttar Pradesh, the area of rice is about 13.84 million hectares and production is 23.64 million tonnes, with productivity of 2358 kg per hectare” [2]. “Two-thirds of the world's population eat it as a staple. In Asia alone, almost 2 billion people rely on rice, which has 80% carbs, 7-8% protein, 3% fat, and 3% fibre, to meet their energy needs. Despite its small size, rice protein has a great nutritional value. Animal and bird feed is made from rice bran”. Chaudhari et al. [3]. “Rice protein, though small in amount, is of high nutritional value. Rice bran is used as cattle and poultry feed. Intensive cultivation with high-yielding crop varieties, use of high analysis NPK fertilizers devoid of secondary and micronutrients, loss of topsoil by erosion, loss of micronutrients through leaching, liming of acid soils, limited use of organic manures and restricted recycling of crop residues accelerated the exhaustion of secondary and micronutrients from the soil” [4]. “One method to increase absorption effectiveness and decrease leaching losses in rice fields, which eventually lowers production costs, is to apply fertilisers topically. On the other hand, soil application of basic fertilizers (N, P, and K) in excess quantity causes water pollution, soil toxicity and negative effects on the environment and humans” [5]. So,

foliar application of macro elements may enhance the yield and reduce production costs to attain sustainable agriculture. Thus, fertilizing the crop combined with reduced soil application saves the farming systems from the inherent challenges posed by low or declining nutrient use efficiencies. Keeping given the above points, this study was framed to assess the impact of foliar application of macro and micronutrient uptake on the yield and nutrient uptake of transplanted rice.

2. MATERIALS AND METHODS

A field experiment was conducted at the Agronomy Research farm of A.N.D. University of Agriculture and Technology Kumarganj Ayodhya, UP to evaluate the effect of foliar application of macro and micronutrients on yield and nutrient uptake of rice (*Oryza Sativa* L.). The experiment comprises of ten treatment combinations, some foliar applications of macro and micronutrients, two foliar sprays during the tillering stage, and the commencement of panicles, all of which were set up in a randomised block design with three replications. There are 10 treatments viz. T₁-control, T₂ 100 %, RDF, T₃ 125% RDF, T₄ 75% RDF, T₅ 75 RDF + 25 % Nitrogen through FYM, T₆ 75 % RDF + Urea @ 2.0 % (Two spray at tillering + panicle in all treatments), T₇ 75 % RDF + WSCF @ 0.5 % (19:19:19), T₈ 75 % RDF + ZnSO₄ @ 0.5 % + Boron @ 0.25 % and T₉ 75 % RDF + Urea @ 2.0 % + ZnSO₄ @ 0.5 % + Boron @ 0.25 % and T₁₀ 75% RDF + WSCF @ 0.5 % (19:19:19) + ZnSO₄ @ 0.5 % + Boron @ 0.25 %. The total biomass of each plot was threshed and cleaned, and the seeds obtained were weighed and converted into q ha⁻¹. Straw yield was also recorded from each plot by subtraction the grain yield from the total biological yield and expressed in q ha⁻¹. Plant samples at harvest from each plot were collected and oven-dried at 70°C. The samples were grounded into fine powder using a Willey mill and analysed for N, P, K, S, Zn and B content using standard procedures Singh et al. [6]. The total

uptake by the plant (grain + straw) was calculated using the formula:

$$\text{Macronutrient uptake (kg ha}^{-1}\text{)} = \text{Macronutrient concentration (\%)/100} \times \text{Yield (kg ha}^{-1}\text{)}$$

$$\text{Micronutrient uptake (g ha}^{-1}\text{)} = \text{Micronutrient concentration (mg kg}^{-1}\text{)/1000} \times \text{Yield (kg ha}^{-1}\text{)}$$

The data recorded was statistically analysed using the analysis of variance (ANOVA) technique at 5% probability level as described by Gomez [7] to draw valid conclusions.

3. RESULTS AND DISCUSSIONS

3.1 Yield

Data depicted in the Table -1 shows that the treatment T₁₀-75% RDF + two foliar sprays of WSCF @ 0.5% (19:19:19) + ZnSO₄ @ 0.5% + Boron @ 0.25% had the highest grain, straw yield, and harvest index; it was statistically equal to T₃- 125% RDF and considerably better than the other treatments. The treatment T₁ (control) yielded the lowest amount of grain. Zinc and boron applied together in the foliar may have a higher effect on rice grain and straw production and harvest index since both minerals are important for a variety of physiological processes in plants. Furthermore, because of the alkaline pH of the soil at the experimental site, which causes B and Zn to precipitate in the hydroxide forms, the availability of both nutrients decreased under aerobic conditions. External application therefore aided in the plant's improved growth and development. According to Wear and Haghler [8], "the higher yield characteristics may be attributable to Zn participation in the biosynthesis of Indole acetic acid (IAA) and, in particular, to its role in the commencement of primordial reproductive parts and the partitioning of photosynthates towards them". "A greater partitioning of carbohydrates from the leaf to the reproductive regions led to an increase in yield, which may be attributed to improvement in yield components" [9]. "Zinc participation in a variety of enzymatic processes, as well as its involvement as a catalyst in numerous growth processes, hormone production, and protein synthesis, may be responsible for the increase in yield brought on by its administration. It could

also be attributed to improvements in auxin production and the regulation of the metalloenzyme system" Sachdev et al. [10]; Udayasoorian [11]; Kumar et al. [12]; [13]. The soil application of ZnSO₄ increased straw yield significantly, according to Singh and Sharma [9], and this was attributable to higher growth characteristics and more (tillers m⁻²) in the field. Jena et al. [14] and Uddin et al. [15] both found similar results. According to Hossain et al. [16], the growth and yield of the rice crop were boosted by the combination application of NPK and Zn. The highest grain production was reported by foliar treatment of B @ 20 mg L⁻¹, according to Ali et al. [17]. Rice grain production was improved by Zn foliar feeding [18].

3.2 Nutrient Uptake by Crop

Nutrient uptake by the crop is a function of total biomass produced and percent nutrient concentration in biomass. The differences in uptake by grain and straw due to different treatments are associated mainly with yield differences and partly with nutrient content in grain and straw. The ability of plants to absorb nutrients and grow is better when there are more nutrients available in the soil. Thus, the uptake of NPK by hybrid rice was higher due to application T₁₀- 75% RDF + two foliar sprays of WSCF @ 0.5 % (19:19:19) + ZnSO₄ @ 0.5 % + Boron @ 0.25 % lower uptake was recorded in control (Table- 2 and 3). The higher uptake was attributed to improved availability of nutrients upon fertilization and also due to higher yield of grain and straw in the fertilized treatment compared to the control. This might be due to the easy transformation of urea into available N with the addition of zinc, which is very critical for biomass production (Singh and Abrol, 1982, Mali and Shaik, 1994, Kamalakumari and Singaram [19]; Kumar et al. [12] and better translocation of applied nutrients due to correction of Zn deficiency in soil. Increase in P and K content in grain as well as in straw might be due to favorable soil condition which enhanced nutrient availability and nutrient uptake as well as better growth and activity of roots. Similar findings were also observed by Singh et al. [20]. The increase in total N, K and Zn uptake could be attributed to the synergistic effect between N and Zn and due to the positive interaction of K and Zn, respectively. The present findings support the results of Ashoka et al. [21]; [22].

Table 1. Effect of foliar application of nutrients on yield of rice

Treatments	Yields (q ha ⁻¹)							
	Grain yield		Straw yield		Biological yield		Harvest Index (%)	
	2018	2019	2018	2019	2018	2019	2018	2019
T ₁ -Control	21.10	22.15	31.00	32.50	52.10	54.65	40.49	40.59
T ₂ -100 % RDF (N 120:P 60: K 40 kg ha ⁻¹)	33.00	34.65	45.90	48.30	78.90	80.55	41.47	41.45
T ₃ -125 % RDF	36.30	38.10	49.35	51.80	85.65	89.90	42.35	42.32
T ₄ -75 % RDF	26.80	28.25	37.63	39.40	64.43	67.65	41.76	41.96
T ₅ -75 RDF + 25 % Nitrogen through FYM	28.50	30.95	39.70	41.80	68.20	71.75	41.90	41.75
T ₆ -75 % RDF + two foliar sprays of Urea @ 2.0 %	29.80	31.30	41.00	43.10	70.80	74.40	42.11	42.07
T ₇ -75 % RDF + two foliar spray of WSCF @ 0.5 % (19:19:19)	31.60	33.20	43.30	45.60	74.90	78.80	42.19	42.11
T ₈ -75 % RDF + two foliar sprays of ZnSO ₄ @ 0.5 %+ Boron @ 0.25 %	29.70	31.20	41.14	43.00	70.84	74.20	42.14	42.02
T ₉ -75 % RDF + two foliar spray of Urea @ 2.0 % + ZnSO ₄ @ 0.5 % + Boron @ 0.25 %	33.50	35.20	46.52	48.30	80.02	83.50	42.25	42.15
T ₁₀ -75% RDF + two foliar spray of WSCF @ 0.5 % (19:19:19) + ZnSO ₄ @ 0.5 % + Boron @ 0.25 %	38.50	40.40	51.90	54.60	90.40	95.00	42.64	42.53
SEm±	1.13	1.44	2.14	1.47	2.45	2.25	1.54	1.26
C.D. (P=0.05)	3.35	4.27	6.37	4.38	7.29	6.67	NS	NS

Table 2. Effect foliar application of nutrients on uptake of N and P in grain, straw and total

Treatments	Nutrient uptake (kg ha ⁻¹)											
	Nitrogen						Phosphorus					
	Grain		Straw		Total		Grain		Straw		Total	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
T ₁ -Control	23.42	24.81	25.42	26.98	48.84	51.79	8.22	8.86	6.36	6.73	14.58	15.59
T ₂ -100 % RDF (N 120:P 60: K 40 kg ha ⁻¹)	40.59	42.97	42.33	44.99	82.92	87.96	14.52	15.25	10.61	11.25	25.13	26.50
T ₃ -125 % RDF	45.37	48.39	45.90	48.69	91.27	97.08	15.97	17.14	11.45	12.17	27.56	29.45
T ₄ -75 % RDF	31.08	33.05	32.25	33.88	63.34	66.93	10.98	11.86	8.06	8.47	19.16	20.20
T ₅ -75 RDF + 25 % Nitrogen through FYM	33.63	35.94	34.54	37.20	68.17	73.14	11.97	12.87	8.65	9.32	20.62	22.19
T ₆ -75 % RDF + two foliar spray of Urea @ 2.0 %	35.76	37.87	36.49	38.79	72.25	76.66	12.81	13.44	9.14	9.70	21.95	23.14
T ₇ -75 % RDF + two foliar spray of WSCF @0.5 % (19:19:19)	38.24	40.50	39.10	41.04	77.21	81.54	13.58	14.27	9.74	10.26	23.32	24.53
T ₈ -75 % RDF + two foliar sprays of ZnSO ₄ @ 0.5 %+ Boron @ 0.25 %	35.64	37.75	36.49	38.27	72.13	76.02	12.77	13.40	9.02	9.55	21.79	22.95
T ₉ -75 % RDF + two foliar spray of Urea @ 2.0 % + ZnSO ₄ @ 0.5 % + Boron @ 0.25 %	40.87	43.65	42.22	44.44	83.09	88.08	14.74	15.48	10.33	11.11	25.81	26.60
T ₁₀ -75% RDF + two foliar spray of WSCF @0.5 % (19:19:19) + ZnSO ₄ @ 0.5 % + Boron @ 0.25 %	48.12	50.50	48.26	51.60	96.38	102.10	17.32	18.18	11.94	13.17	29.26	31.35
SEm±	0.42	2.67	1.31	3.93	3.71	4.65	0.33	1.13	3.62	0.42	1.18	1.31
C.D. (P=0.05)	1.25	7.95	3.88	8.52	8.05	13.81	0.98	3.35	10.77	1.25	3.49	3.88

Table 3. Effect foliar application of nutrients on uptake of K and S in grain, straw and total

Treatments	Nutrient uptake (kg ha ⁻¹)											
	Potassium						Sulphur					
	Grain		Straw		Total		Grain		Straw		Total	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
T ₁ -Control	12.88	13.73	37.51	39.98	50.39	53.71	1.68	1.77	1.95	2.06	3.43	3.83
T ₂ -100 % RDF(N 120:P 60:K 40 kg ha ⁻¹)	22.44	23.56	62.80	66.50	85.24	90.06	3.63	3.81	4.60	4.88	8.23	8.69
T ₃ -125 % RDF	24.68	25.98	68.10	72.00	92.78	97.98	3.67	4.19	5.16	5.47	8.86	9.66
T ₄ -75 % RDF	17.15	18.08	47.63	50.04	64.78	68.12	2.41	2.14	2.89	3.06	5.30	5.20
T ₅ -75 RDF + 25 % Nitrogen through FYM	18.52	19.76	51.21	55.18	69.73	74.94	2.56	2.69	3.31	3.52	5.87	6.21
T ₆ -75 % RDF + two foliar spray of Urea @ 2.0%	19.67	20.97	54.12	57.32	73.79	78.29	2.98	3.13	3.82	4.06	6.80	7.19
T ₇ -75 % RDF + two foliar spray of WSCF @0.5 % (19:19:19)	21.17	22.24	57.59	60.65	78.76	82.89	3.16	3.32	4.22	4.49	7.38	7.81
T ₈ -75 % RDF + two foliar sprays of ZnSO ₄ @ 0.5 %+ Boron @ 0.25 %	19.60	20.90	54.12	56.76	73.72	77.66	2.97	3.12	3.78	4.01	6.75	7.13
T ₉ -75 % RDF + two foliar spray of Urea @ 2.0 % + ZnSO ₄ @ 0.5 % + Boron @ 0.25 %	22.78	23.93	61.05	65.69	83.83	89.62	3.68	3.87	4.58	4.87	8.26	8.74
T ₁₀ -75% RDF + two foliar spray of WSCF @0.5 % (19:19:19) + ZnSO ₄ @ 0.5 % + Boron @ 0.25 %	26.56	28.28	71.62	76.31	98.18	104.59	4.62	4.84	5.74	6.10	10.36	10.94
SEm±	0.82	1.04	2.67	2.35	3.93	3.62	0.19	0.19	0.16	0.17	0.36	0.42
C.D. (P=0.05)	2.43	3.10	7.95	7.00	11.68	10.77	0.55	0.57	0.48	0.50	1.07	1.24

Table 4. Effect foliar application of nutrients on uptake of Zn and B in grain, straw and total

Treatments	Nutrient uptake (g ha ⁻¹)											
	Zinc						Boron					
	Grain		Straw		Total		Grain		Straw		Total	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
T ₁ -Control	261.85	277.31	22.88	24.28	284.73	301.63	151.92	160.86	18.30	19.42	170.22	180.28
T ₂ -100 % RDF(N 120:P 60:K 40 kg ha ⁻¹)	450.12	480.36	38.10	40.49	488.22	520.73	261.16	278.58	30.48	32.50	291.64	311.08
T ₃ -125 % RDF	503.11	542.77	41.31	43.82	544.42	571.88	291.85	306.70	33.04	35.06	324.89	341.76
T ₄ -75 % RDF	347.59	369.53	29.03	30.50	376.62	400.03	201.53	214.41	23.22	24.40	224.75	238.81
T ₅ -75 RDF + 25 % Nitrogen through FYM	375.91	401.81	31.09	33.48	407.07	435.29	218.02	233.01	24.87	26.79	242.89	259.90
T ₆ -75 % RDF + two foliar sprays of Urea @ 2.0 %	399.91	423.42	32.84	34.91	432.64	458.33	231.84	245.70	26.27	27.93	258.11	273.63
T ₇ -75 % RDF + two foliar spray of WSCF@ 0.5 % (19:19:19)	427.53	452.83	35.07	36.94	462.55	489.77	248.06	262.64	28.06	29.55	276.12	292.19
T ₈ -75 % RDF + two foliar sprays of ZnSO ₄ @ 0.5 % + Boron @ 0.25 %	398.57	422.07	32.84	34.44	431.34	456.51	231.06	244.92	26.27	27.55	257.33	272.47
T ₉ -75 % RDF + two foliar spray of Urea @ 2.0 % + ZnSO ₄ @ 0.5 % + Boron @ 0.25 %	460.62	487.98	37.18	39.99	497.80	527.86	267.33	283.00	29.74	31.99	297.07	315.03
T ₁₀ -75% RDF + two foliar spray of WSCF@ 0.5 % (19:19:19) + ZnSO ₄ @ 0.5 % + Boron @ 0.25 %	538.23	560.07	44.11	46.66	582.11	611.45	312.33	332.00	34.38	36.17	346.61	368.17
SEm±	20.02	24.04	1.13	0.78	14.30	15.85	10.06	6.00	1.28	1.61	11.03	5.60
C.D. (P=0.05)	59.48	71.42	3.35	2.31	42.50	47.08	29.90	17.82	3.80	4.77	32.78	16.63

Among treatments, higher total Sulphur uptake were found in T₁₀- 75% RDF + WSCF @ 0.5 % (19:19:19) + ZnSO₄ @ 0.5 % + Boron @ 0.25 %, and recorded at par with T₃- 125 % RDF during both the years (Table-3). Treatment having T₉- 75 % RDF + Urea @ 2.0 % + ZnSO₄ @ 0.5 % + Boron @ 0.25 % and T₈-75 % RDF + ZnSO₄ @ 0.5 %+ Boron @ 0.25 % recorded significantly lower uptake as compared to T₁₀. There were significant differences in total Sulphur uptake between T₂ and T₃, while uptake between T₄ to T₈ was found statistically at par. Minimum Sulphur content recorded with T₁-Control. The increase in uptake might be due to the higher availability of the plant nutrients from the soil reservoir and the additional quantity of nutrients supplied by foliar application and chemical fertilizers. The higher uptake of sulphur was also influenced by zinc sulphate application. The results of this investigation agree with the findings of Sri Ramachandrasekharn et al. [23]. Though the interaction effect was non-significant the combined application of major nutrients with S, Zn and B recorded higher uptake values which was due to the complimentary effect of the combined application of major nutrients with S, Zn and B.

Micronutrient uptake followed a similar trend as observed in primary and secondary nutrient uptake. Among treatments, higher Zinc and Boron was found T₁₀-75% RDF + WSCF @ 0.5 % (19:19:19) + ZnSO₄ @ 0.5 % + Boron @ 0.25 %, and recorded at par with T₃- 125 % RDF during both the years (Table-4). Treatment having T₉-75 % RDF + Urea @ 2.0 % + ZnSO₄ @ 0.5 % + Boron @ 0.25 % and T₈-75 % RDF + ZnSO₄ @ 0.5 %+ Boron @ 0.25 % recorded significantly lower uptake as compared to T₁₀. Minimum Zinc and Boron content recorded with T₁-Control. Such an increase might be attributed to better growth and yield of hybrid rice due to the optimum supply of both major nutrients along with Zn, S and B [24]. These results are in agreement with Charati and Malakouti [25]. Higher uptake of boron was due to the application of boron fertilizer which increased the availability of B in the root zone and concentration in plant. Kumar *et al.* (2017) reported that soil application of ZnSO₄ @ 50 kg ha⁻¹ recorded higher Zn content in grain which was statistically at par with foliar spray of Zn-EDTA equivalent to 0.2 per cent ZnSO₄. Kulhare et al. [26] reported that a foliar spray of one per cent Zn salt significantly increased the Zn uptake by grain. In cultivars Super basmati and Shaheen Basmati, it was discovered that the

amount of boron in the leaves and kernels increased with an increase in the amount of foliar B applied Rehman et al. [27].

4. CONCLUSION

From the above, it may be concluded that combined application of foliar and soil-applied treatment records better over soil-applied treatments. Among the treatments, T₁₀- 75% RDF + WSCF @ 0.5 % (19:19:19) + ZnSO₄ @ 0.5 % + Boron @ 0.25 % registered maximum yield as well as nutrient uptake by crop which was closely followed by T₃- 125 % RDF.

5. FUTURE SCOPE

There is a future scope of foliar application which might help to reduce overdoses of fertilizer application.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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