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Effect of foliar application of macro and micro nutrients on growth and yield of rice (*Oryza sativa* L.)

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Abstract
A field study was carried out at Agronomy research Farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) during *Kharif season* 2018 and 2019 to evaluate the effect of foliar application of macro and micro nutrients on growth attributes of rice (*Oryza sativa* L.). The Experiment consist of 10 treatments *viz.* T_1- Control, T_2 100% RDF, T_3 125% RDF, $T_4$75% RDF, T_5 75 RDF + 25% Nitrogen through FYM, T_6 75% RDF + Urea @ 2.0% (Two spray at tillering + panicle in all treatments), T_7 75% RDF + WSCF @ 0.5% (19:19:19),T_8 75% RDF + $ZnSO_4$ @ 0.5%+ Boron @ 0.25%, T_9 75% RDF + Urea @ 2.0% + $ZnSO_4$ @ 0.5% + Boron @ 0.25% and T_{10} 75% RDF + WSCF @ 0.5% (19:19:19) + $ZnSO_4$ @ 0.5% + Boron @ 0.25%. The result revealed that among all the treatments, T_{10} treatment registered maximum Plant height, No. of tillers, dry matter accumulations, crop growth rate and net assimilation rate.

Keywords: foliar application, growth attributes, net assimilation rate

Introduction
Rice (*Oryza sativa* L.) belongs to the family graminae, genus *Oryza* has two cultivated and 22 wild species. The cultivated species are *Oryza sativa* and *Oryza glaberrima*. *Oryza sativa* is grown all over the world while *Oryza glaberrima* has been cultivated in West Africa for the last 3500 years. In India, rice is cultivated in the area of 43.99 M ha with an annual production of 109.69 million tonnes and average productivity of 2249kg per ha. 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 Nutrient deficiency is considered as one of the major causes of the declining productivity trends, observed in rice growing countries. Sodic upland and calcareous coarse-textured soils with low organic matter content suffer from Fe deficiency. Correction of deficiency symptoms usually occurs within the first several days and then the entire field could be sprayed with the appropriate nutrient source. There is a close association between the amount of N fertilizer applied to rice and the yield level. Yield responses of 20 kg or more of paddy or rice per kg of N are frequently obtained. The amount of N that can be applied to traditional, tall rice varieties is limited because of their susceptibility to lodging and low yield potential.

Materials and Methods
A field experiment was conducted at 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 micro nutrients on yield and economics of rice (Oryza Sativa L.). The experiment consist of 10 treatment combination with some foliar application macro and micro nutrients two foliar spray tillering stage and panicle initiation stage which were laid out in randomized block design with three replication. There are 10 treatments *viz.* T_1- control, T_2 100%, RDF, T_3 125% RDF, $T_4$75% RDF, T_5 75 RDF + 25% Nitrogen through FYM, T_6 75% RDF + Urea @ 2.0% (Two spray at tillering + panicle in all treatments), T_7 75% RDF + WSCF(19:19:19) @ 0.5%, T_8 75% RDF + $ZnSO_4$ @ 0.5%+ Boron @ 0.25%, T_9 75% RDF + Urea @ 2.0% + $ZnSO_4$ @ 0.5% + Boron @ 0.25% and T_{10} 75% RDF + WSCF (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5% + Boron @ 0.25%. The data recorded on various parameters were subjected to statistical analysis following analysis of variance technique and were tested at 5% level of significance to interpret the significant differences.

Result and Discussion

Plant height (cm)

The maximum plant height (Table-1) was recorded in the treatment applying T_{10}75% RDF + two foliar spray of WSCF (19:19:19)@ 0.5% + $ZnSO_4$ @ 0.5% + Boron @ 0.25% which was significantly higher to rest of treatment except treatment having 125% RDF (T_3) which found statistically at par. Increase in plant height may be attributed remarkable effect of zinc on plant height may be attributed to its role in synthesis of tryptophan and IAA, which plays an important role in cell enlargement. These results are in conformity with Tahir *et al.* (2009) [10], Fageria *et al.* (2003) [3] and Ghatak *et al.* (2005) [5].

Number of tillers (m^{-2})

Different treatments significantly affect the number of tillers m^{-2} at all stages of crop growth in both the year of experimental trial. Data (Table-2) revealed that maximum number of tillers m^{-2} was recorded with treatment T_{10} (75% RDF + WSCF (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5% + Boron @ 0.25%) which was at par with T_3 (125% RDF) during both year of experimental trial of rice at all stages of plant growth. The higher number of tillering results higher grain production and there by an important aspect in rice yield. Mirza *et al.* (2010) reported increase in number of tillers in rice plant due to influence of different fertilizers combinations. Higher number of tillers might be due to more availability of nitrogen which plays a vital role in cell division. Organic sources after more balanced nutrition to the plants especially micronutrients which positively affect number of tillers in plants.

Dry matter accumulation

Data (Table-3) revealed that maximum dry matter accumulation was recorded with treatment T_{10} (75% RDF +two foliar spray of WSCF(19:19:19)@ 0.5% + $ZnSO_4$ @ 0.5% + Boron @ 0.25%) which was at par with T_3 (125% RDF), T_9 (75% RDF + Urea @ 2.0% + $ZnSO_4$ @ 0.5% + Boron @ 0.25%) at 90 DAT and at harvest and T_2 (100% RDF (N 120:P_2O_5 60:K_2O 40 kg^{-1} ha) at 90 DAT and at harvest during both year of experimental trial The improvement in growth attributes such as dry matter accumulation as a result of B application may be due to the enhanced photosynthetic and metabolic activity which leads to an increase in various plant metabolic pathways responsible for cell division and elongation (Hatwar *et al.*, 2003) [7] because the chlorophyll contents increased considerably in Zn and B treated plants.

Yield (q ha^{-1})

Maximum grain yield (38.50 and 40.40 during 2018 and 2019, respectively) were recorded with treatment T10-75% RDF + WSCF (19:19:19) @ 0.5% + ZnSO4 @ 0.5% + Boron @ 0.25% which was statistically at par with T3- 125% RDF and significantly superior over rest of the treatments. The minimum grain yield (21.10 and 22.15 during 2018 and 2019, respectively), were recorded with the treatment T1 (control). However, grain yield received from RDF 125% (T3) was significantly superior over treatment having T4- 75% RDF as well as 75% RDF+ 25% FYM ha^{-1}(T5) and statistically at par with T2 -100% RDF (N 120: P_2O_5 60: K_2O 40 kg ha^{-1}). Further, it is evident that on addition of WSCF @ 0.5% (19:19:19) in combination with RDF in place of urea @ 2.0% in combination with RDF increased the yield by 14.91% and 14.77% during 2018 and 2019 respectively. Application of foliar application treatments consisting 75% RDF + Urea @ 2.0% (Two spray), 75% RDF + WSCF (19:19:19)@ 0.5%,75% RDF + ZnSO4 @ 0.5%+ Boron @ 0.25%, 75% RDF + Urea @ 2.0% + ZnSO4 @ 0.5% + Boron @ 0.25%, 75% RDF + WSCF (19:19:19)@ 0.5% + ZnSO4 @ 0.5% + Boron @ 0.25% increased grain yield by 41.23%, 49.76%, 40.75%, 58.76% and 82.46-% and 41.30%, 49.88%, 40.85%, 58.91%, 82.39% compare to over control (T1) during 2018 and 2019 respectively. Application of 75 RDF + 25% Nitrogen through FYM, 100% RDF (N 120: P 60: K 40 kg ha^{-1}), 125% RDF increased grain yield by 6.34% 23.13%, 35.44%,-and 9.55%,22.65%,34.86% over 75 RDF alone during 2018 and 2019 respectively.

Leaf area index (LAI)

Data (Table-4) revealed that highest leaf area index was recorded with treatment T_{10} (75% RDF + two foliar spray of WSCF (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5% + Boron @ 0.25%) which was at par with T_3 (125% RDF) during both year of experimental trial of rice at all stages of plant growth. The variation in LAI is an important physiological parameter that eventually determines ultimate crop yield because it influences the light interception by the crop canopy. While, Zn plays an important role in synthesis of tryptophan and IAA, which are responsible for increasing the leaf area. These results are in conformity with Ali *et al.* (2006) [1] and Johnson *et al.* (2005) [8].

Crop growth rate (g $m^{-2}day^{-1}$)

Data (Table-5) revealed that highest Crop growth rate was observed in T_{10} which is at par with T_3 and significantly superior to other treatments during 2018. Similarly, during 2019 highest Crop growth rate was observed in T_{10} which is at par with T_3 and significantly superior to other. Higher crop growth rate under micronutrients treatment might be because of important role of zinc in combination with iron in photosynthesis process that because more leaf expansion resulted in improved plant growth. These results are in conformity with findings of Foy (1992) [4].

Relative growth rate (g $g^{-1}day^{-1}$)

Data (Table-6) revealed that different treatments does not have any significant effect on RGR and it is found non-significant at all stages of crop growth. The top leaves of a plant began to shade lower leaves which might have resulted in non-significant effect of micronutrient and organic treatments over alone dose of RDF. Similar results were also reported by Halder *et al.* (2009) [6] and Dhital (2011) [2].

Net assimilation rate (g $m^{-2}day^{-1}$)

It increased with the advancement of crop age. Data (Table-6) revealed that during 30-60 DAT highest net assimilation rate was observed in T_{10} which is at par with T_3 and significantly superior to other treatments. During 60-90 DAT, highest net assimilation rate was observed in T_{10} and significantly superior to other treatments. During 2019, at 60-90 DAT highest net assimilation rate was observed in T_{10} which is at par with T_3 and significantly superior to other treatments.

Table 1: Effect of foliar application of nutrient son plant height at various growth stages

Treatments	Plant height (cm)							
	30 DAT		60 DAT		90 DAT		At Harvest	
	2018	2019	2018	2019	2018	2019	2018	2019
T_1-Control	28.70	30.00	42.80	44.70	60.90	66.30	58.30	64.10
T_2-100% RDF(N120:$P_2O_5$60: K_2O40 kgha^{-1})	36.60	38.50	54.90	57.75	79.80	82.40	76.20	79.10
T_3-125% RDF	39.40	41.40	59.10	62.10	99.10	99.20	96.8	96.95
T_4-75% RDF	29.60	31.20	44.40	46.80	65.30	70.60	63.20	68.10
T_5-75RDF+25%NitrogenthroughFYM	31.40	33.00	47.10	49.50	72.80	76.10	70.15	74.05
T_6-75% RDF + two foliar spray of Urea @2.0%	32.60	34.20	48.90	51.30	76.20	80.50	74.10	77.80
T_7-75% RDF + two foliar spray of WSCF(19:19:19) @0.5%	34.50	36.30	51.75	54.45	81.60	85.20	79.15	83.10
T_8-75% RDF + two foliar spray of $ZnSO_4$ @ 0.5%+Borax@ 0.25%	32.60	34.20	49.06	51.30	72.85	76.30	70.15	73.20
T_9-75% RDF + two foliar spray of Urea @ 2.0% +$ZnSO_4$@0.5%+Borax@ 0.25%	36.20	38.30	54.30	57.45	80.60	83.80	78.20	81.10
T_{10}-75% RDF+two foliar spray of WSCF(19:19:19) @0.5%+$ZnSO_4$@ 0.5%+Borax@0.25%	41.60	43.70	62.40	65.55	99.20	99.80	96.90	97.10
SEm±	1.47	1.82	2.10	2.51	2.53	2.51	3.45	3.34
C.D.(P=0.05)	4.36	5.42	6.25	7.45	7.63	7.82	10.24	10.97

Table 2: Effect of foliar application of nutrients on number of tillers at various growth stages.

Treatments	Number of Tillers (m^{-2})							
	30 DAT		60 DAT		90 DAT		At Harvest	
	2018	2019	2018	2019	2018	2019	2018	2019
T_1-Control	145.62	146.63	319.47	335.10	336.28	352.74	332.95	349.25
T_2-100% RDF (N 120:P_2O_5 60: K_2O 40 kg ha^{-1})	176.04	177.10	470.52	492.99	495.29	518.93	490.38	513.80
T_3-125% RDF	181.30	182.80	504.69	528.38	531.26	556.19	526.00	550.69
T_4-75% RDF	158.60	153.30	385.68	404.36	407.33	425.64	401.96	421.42
T_5-75RDF+25% Nitrogen through FYM	159.40	160.98	407.42	427.21	428.86	449.69	424.62	445.24
T_6-75% RDF +two foliar spray of Urea @2.0%	165.60	166.80	421.91	441.98	444.12	465.24	439.72	460.64
T_7-75% RDF + two foliar spray of WSCF (19:19:19)@0.5%	168.80	170.60	444.77	466.51	468.18	491.06	463.54	487.82
T_8-75% RDF+twofoliar spray of $ZnSO_4$ @0.5% + Borax@ 0.25%	164.40	166.40	421.36	440.87	445.01	464.07	439.14	459.48
T_9-75% RDF + two foliar spray of Urea @2.0% + $ZnSO_4$ @0.5%+Borax@ 0.25%	173.80	176.00	469.85	492.71	494.58	518.64	489.69	513.51
T_{10}-75% RDF + two foliar spray of WSCF (19:19:19)@0.5% +$ZnSO_4$@0.5%+Borax@0.25%	195.80	197.00	531.17	556.81	559.13	586.12	553.59	580.32
SEm±	5.74	6.63	14.38	16.20	18.17	16.47	20.88	19.39
C.D.(P=0.05)	17.06	19.89	42.72	48.60	54.51	48.92	62.64	57.61

Table 3: Effect of foliar application of nutrients on Dry matter accumulation.

Treatments	DMA(g per running m)							
	30 DAT		60 DAT		90 DAT		At harvest	
	2018	2019	2018	2019	2018	2019	2018	2019
T_1-Control	33.91	35.913	68.30	72.84	122.86	156.68	539.02	552.11
T_2-100% RDF(N120:$P_2O_5$60: K_2O40 kgha^{-1})	54.65	57.47	108.95	114.93	203.63	207.90	828.50	854.50
T_3-125% RDF	58.85	63.04	117.17	124.78	252.66	259.80	879.20	908.01
T_4-75% RDF	44.24	47.21	88.79	93.64	172.93	164.97	721.22	741.51
T_5-75 RDF + 25% Nitrogen through FYM	47.61	49.78	94.36	99.48	129.05	162.77	751.52	773.50
T_6-75% RDF + two foliar spray of Urea @2.0%	48.91	51.52	97.85	102.71	153.70	172.98	777.02	799.53
T_7-75% RDF + two foliar spray of WSCF (19:19:19) @0.5%	51.96	54.56	103.07	109.14	156.60	175.20	780.00	803.50
T_8-75% RDF + two foliar spray of $ZnSO_4$ @0.5% + Borax @ 0.25%	48.57	50.15	96.97	102.06	164.96	164.73	788.63	810.01
T_9-75% RDF + two foliar spray of Urea @ 2.0% + $ZnSO_4$@0.5%+Borax@ 0.25%	55.59	57.82	110.24	115.36	211.433	215.63	836.52	862.51
T_{10}-75% RDF + two foliar spray of WSCF (19:19:19)@0.5%+$ZnSO_4$@0.5%+Borax@0.25%	62.48	65.58	125.00	131.59	256.66	262.23	883.30	910.51
SEm±	2.47	2.91	3.79	6.18	26.07	29.19	27.41	23.75
C.D.(P=0.05)	7.41	8.73	11.37	18.5	78.07	83.67	82.09	71.13

Table 4: Effect of foliar application of nutrients on Leaf area index.

Treatments	Leaf area index					
	30 DAT		60 DAT		90 DAT	
	2018	2019	2018	2019	2018	2019
T_1-Control	1.71	1.80	3.12	3.25	3.17	3.32
T_2-100% RDF(N120:$P_2O_5$60: K_2O40 kgha^{-1})	2.16	2.27	4.45	4.63	4.55	4.72
T_3-125% RDF	2.81	2.80	4.51	4.70	4.60	4.80
T_4-75% RDF	1.88	1.90	3.82	3.97	3.90	4.05
T_5-75RDF+25% Nitrogen through FYM	2.25	2.28	3.90	4.06	3.98	4.15
T_6-75% RDF +two foliar spray of Urea @2.0%	2.00	2.10	4.16	4.32	4.25	4.41
T_7-75% RDF+two foliar spray of WSCF (19:19:19)@0.5%	2.05	2.15	4.25	4.42	4.35	4.51
T_8-75% RDF+two foliar spray of $ZnSO_4$@0.5% + Borax@ 0.25%	1.99	2.08	4.05	4.21	4.15	4.30
T_9-75% RDF+two foliar spray of Urea @2.0% + $ZnSO_4$ @0.5%+Borax@0.25%	2.15	2.25	4.43	4.62	4.52	4.73
T_{10}-75% RDF+two foliar spray of WSCF (19:19:19) @0.5%+$ZnSO_4$@0.5%+Borax@0.25%	2.90	2.88	4.57	4.75	4.65	4.85
SEm±	0.06	0.10	0.20	0.21	0.17	0.18
C.D.(P=0.05)	0.18	0.30	0.60	0.63	0.51	0.54

Table 5: Effect of foliar application of nutrients on crop growth rate

Treatments	Crop growth rate (gm^{-2} day^{-1})			
	30-60 DAT		60-90 DAT	
	2018	2019	2018	2019
T_1-Control	4.32	4.61	7.15	7.37
T_2-100% RDF (N120:P_2O_5 60: K_2O 40 kg ha^{-1})	6.81	7.21	6.98	10.75
T_3-125% RDF	7.31	7.75	11.13	11.37
T_4-75% RDF	5.59	5.81	8.12	8.65
T_5-75 RDF + 25% Nitrogen through FYM	5.85	6.23	8.71	8.83
T_6-75% RDF +two foliar spray of Urea @2.0%	6.14	6.42	9.09	9.52
T_7-75% RDF + two foliar spray of WSCF (19:19:19) @0.5%	6.40	6.87	9.60	9.99
T_8-75% RDF + two foliar spray of $ZnSO_4$ @0.5% + Borax @0.25%	6.07	6.54	9.07	9.51
T_9-75% RDF + two foliar spray of Urea @2.0%+ $ZnSO_4$ @0.5%+Borax@0.25%	6.84	7.21	10.10	10.62
T_{10}-75% RDF + two foliar spray of WSCF (19:19:19)@0.5%+$ZnSO_4$@ 0.5%+Borax@0.25%	7.79	8.29	11.63	11.99
SEm±	0.26	0.36	0.37	0.47
C.D.(P=0.05)	0.78	1.07	1.09	1.39

Table 6: Effect of foliar application of nutrients on RGR and NAR

Treatments	RGR(g $g^{-1}day^{-1}$)				NAR($gm^{-2}day^{-1}$)			
	30-60		60-90		30-60		60-90	
	2018	2019	2018	2019	2018	2019	2018	2019
T_1-Control	19.63	19.65	16.95	16.23	1.88	1.98	0.08	0.11
T_2-100% RDF (N120:$P_2O_5$60: K_2O 40 kg ha^{-1})	19.82	19.92	17.35	17.56	3.57	3.72	0.11	0.15
T_3-125% RDF	20.04	20.07	17.95	17.77	3.80	4.00	0.16	0.17
T_4-75% RDF	19.65	19.64	17.82	17.64	3.24	3.10	0.12	0.13
T_5-75 RDF + 25% Nitrogen through FYM	19.68	19.73	17.94	17.63	3.26	3.24	0.13	0.14
T_6-75% RDF + two foliar spray of Urea @2.0%	19.88	19.95	17.75	17.59	3.25	3.35	0.16	0.14
T_7-75% RDF + two foliar spray of WSCF (19:19:19)@0.5%	19.90	19.93	17.83	17.72	3.38	3.58	0.16	0.15
T_8-75% RDF + two foliar spray of $ZnSO_4$@0.5%+Borax@ 0.25%	19.87	19.96	17.88	17.75	3.13	3.34	0.16	0.15
T_9-75% RDF + two foliar spray of Urea @2.0%+ $ZnSO_4$ @0.5%+Borax@ 0.25%	19.93	19.98	17.90	17.76	3.58	3.76	0.15	0.15
T_{10}-75% RDF + two foliar spray of WSCF (19:19:19)@0.5%+$ZnSO_4$@0.5%+Borax@0.25%	20.16	20.25	18.37	18.50	3.97	4.23	0.18	0.18
SEm±	0.93	0.95	0.66	0.67	0.13	0.11	0.00	0.01
C.D.(P=0.05)	NS	NS	NS	NS	0.40	0.33	0.01	0.02

Conclusion

From the above it may be concluded that the application ofT_{10} 75% RDF + WSCF(19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5% + Boron @ 0.25% registered maximum Plant height, No. of tillers, dry matter accumulations, leaf area index, crop growth rate and net assimilation rate and may be opted for sustainable rice productions.

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