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Effect of foliar application of macro and micro nutrients on yield and economics 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 *Rabi* season 2018 and 2019 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 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 % and T_9 75 % RDF + Urea @ 2.0 % + $ZnSO_4$ @ 0.5 % + Boron @ 0.25 %, T_{10} 75% RDF + WSCF @ 0.5 % (19:19:19) + $ZnSO_4$ @ 0.5 % + Boron @ 0.25 %. The result 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 %) during 2018 and 2019 respectively, were recorded with treatment T_{10}-75% RDF + WSCF @ 0.5 % (19:19:19) + $ZnSO_4$ @ 0.5 % + Boron @ 0.25 % which was statistically at par with T_3- 125 % RDF and significantly superior over rest of the treatments. The minimum grain yield, straw and harvest index were recorded with the treatment T_1 (control).Maximum values of gross return (Rs. 88135/ha and 95166.0/ha), net returns (Rs. 49230.10/ha and 54840.10/ha) and benefit cost ratio (1.26 and 1.35)during both the year was found with foliar fertilization *i.e* T_{10}-75% RDF + WSCF @ 0.5 % (19:19:19) + $ZnSO_4$ @ 0.5 % + Boron @ 0.25 % followed by the treatment T_3 - 125 % RDF.

Keywords: foliar application, yield, Economics

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 2249 kg 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. Foliar sprays are widely used to apply nutrients, especially nitrogen, iron and manganese for many crops. 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. Farm Yard Manure (FYM) is not only supply plant nutrients but also improves the soil physical environment influencing plant growth and also forms chelates which also help for the nutrient of rice crop plant. It helps to increase the biological and physical yields, resistance against pest and improved grain quality.

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 @ 0.5 % (19:19:19),T_8 75 % RDF + $ZnSO_4$ @ 0.5 %+ Boron @ 0.25 % and 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 total biomass of each plot was threshed and cleaned, 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 qha^{-1}.The economics of various treatments was calculated by converting the total yield into money value.The cost of cultivation was computed on the prevailing market of expenditure.Net income was calculated by with the following formulae: Net income (Rs ha^{-1}) = Gross income (Rs ha^{-1})- cost of cultivation.Benefit cost ratio was calculated by dividing net return to the cost of cultivation of the individual treatment combination.

$$\text{BCR} = \frac{\text{Net return (Rs.)}}{\text{Cost of cultivation (Rs.)}}$$

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.

Results and Discussion

Grain and straw yield and harvest index

The grain and straw yield and harvest index as influenced by various treatments have been presented in Table-1. 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 %) during 2018 and 2019 respectively, were recorded with treatment T_{10}-75% RDF + WSCF @ 0.5 % (19:19:19) + $ZnSO_4$ @ 0.5 % + Boron @ 0.25 % which was statistically at par with T_3- 125 % RDF and significantly superior over rest of the treatments. The minimum grain yield, straw and harvest index were recorded with the treatment T_1 (control). The better response of combined foliar application of zinc and Boron on rice Grain and straw yield and harvest index might be due the fact that both nutrients are involved in various physiological functions of the plant. Moreover, under aerobic condition availability ofboth the nutrients reduced as the soil of the experimental site was alkaline pH which leads B and Zn to get precipitated in the hydroxide forms and thus external application helped in better growth and development of the plant. The increased yield attributes might be due to role of Zn in biosynthesis of Indole acetic acid (IAA) and especially due to its role in initiation of primordial reproductive parts and partitioning of photosynthates towards them (Wear and Haghler, 1968) [8]. Increase in yield might be attributed to improvement in yield components, due to better partitioning of carbohydrates from leaf to reproductive parts resulting in increased yield. The increase in yield due to zinc application may be attributed to its role in various enzymatic reactions and its action as catalyst in various growth processes and hormone production and protein synthesis. It may be also ascribed to its improvement in metallo enzymes system regulatory function and growth promoting auxin production (Sachdev *et al.*, 1988) [5]. Singh and Sharma (1994) reported that straw yield was significantly higher due to soil application of $ZnSO_4$ and it was attributed to higher growth characters and more numbers of tillers m^{-2}. Similar results were also obtained by Jena *et al*. (2006). Baktear Hossain *et al*. (2001) [2] reported combined application of NPK and Zn increased the growth and yield of rice crop. Ali *et al.* (2016) observed that foliar application of B @ 20 mg L^{-1}recorded the highest grain yield. Foliar nutrition of Zn enhanced the grain yield in rice (Potarzycki and Grzebisz, 2009) [4]. Grain yield was significantly improved by foliar spray of one per cent B and 1.5 per cent (Ahmad *et al*., 2012) [1].

Economics

The maximum cost of cultivation (Rs. 42464.9/ha and 43885.9/ha during 2018 and 2019, respectively) was incurred in the treatment T_5 - 75 RDF + 25 % Nitrogen through FYM, might be due to higher cost of FYM, while the lowest cost of cultivation of system (Rs. 32973.3/ha and 34394.3/ha during 2018 and 2019, respectively) was associated with T_1 – ControlTable-2. The data showed that treatments with combined application of soil and foliar applied treatment provided least cost of cultivation as compared to alone application of chemical fertilizer and or in combination with organics. The maximum gross return was calculated in (Rs. 88135 ha^{-1} and 95166 ha^{-1} during 2018 and 2019, respectively) T_{10}-75% RDF + WSCF @ 0.5 % (19:19:19) + $ZnSO_4$ @ 0.5 % + Boron @ 0.25% followed by T_3 - 125 % RDF. The highest net income of (Rs. 49230.1 ha^{-1} and 54840.10 during 2018 and 2019, respectively) was noted under T_{10}-75% RDF + WSCF @ 0.5 % (19:19:19) + $ZnSO_4$ @ 0.5 % + Boron @ 0.25 %might be due to the highest grain yield of rice. Similarly, maximum benefit: cost ratio was also observed with T_{10} followed by T_3 with the ratio of 1.26 and 1.35 during both the years of 2018 and 2019, respectively. The minimum (0.49 and 0.54) benefit: cost ratio was recorded in T_1 during 2018 and 2019, respectively. The results showed that integrated approach of foliar and soil applied nutrients proved to be more profitable in rice cultivation. Mallesha (2014) observed that the net returns were higher in foliar spray than the soil application and control. These results are in agreement with findings of Duraisami and Mani (2001).

Table 1: Effect of foliar application 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^{-1} ha)	33.00	34.65	46.52	48.90	79.52	83.55	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	42.25	68.20	73.20	41.90	42.28
T_6- 75% RDF +two foliar spray 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 spray 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 ofUrea @ 2.0% + $ZnSO_4$ @ 0.5% + Boron @ 0.25%	33.50	35.20	45.90	48.30	79.40	83.50	42.25	42.15
T_{10}-75% RDF + two foliar spray ofWSCF @ 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 of foliar application on economics of rice

Treatments	Cost of cultivation (Rs.)		Gross return (Rs.)		Net return (Rs.)		B:C ratio	
	2018	2019	2018	2019	2018	2019	2018	2019
T_1-Control	32973.3	34394.3	49325	53202.25	16351.7	18807.95	0.49	0.54
T_2- 100% RDF(N 120:P 60:K 40 kg^{-1} ha)	38428.9	39849.9	76110	82209.75	37681.1	42359.85	0.98	1.06
T_3- 125% RDF	39791.9	41212.9	83265	89871.5	43473.1	48658.60	1.09	1.18
T_4- 75% RDF	37064.9	38485.9	61952	67033.75	24887.1	28547.85	0.67	0.74
T_5- 75 RDF + 25% Nitrogen through FYM	42464.9	43885.9	65755	72894.25	23290.1	29008.35	0.54	0.66
T_6- 75% RDF + twofoliar spray of Urea @ 2.0% (Two spray)	37268.9	38689.9	68550	74049.5	31281.1	35359.60	0.83	0.91
T_7-75% RDF +twofoliar spray ofWSCF @ 0.5% (19:19:19)	37784.9	39205.9	72620	78498.0	34835.1	39292.10	0.92	1.00
T_8-75% RDF +twofoliar spray of$ZnSO_4$ @ 0.5%+ Boron @ 0.25%	38184.9	39605.9	68431	73828.0	30246.1	34221.10	0.79	0.86
T_9-75% RDF + twofoliar spray ofUrea @ 2.0% + $ZnSO_4$ @ 0.5% + Boron @ 0.25%	38376.9	39797.3	77233	83448	38856.7	43650.70	1.01	1.09
T_{10}-75% RDF +twofoliar spray of WSCF @ 0.5% (19:19:19) + $ZnSO_4$ @ 0.5% + Boron @ 0.25%	38904.9	40325.9	88135	95166	49230.1	54840.10	1.26	1.35

Conclusion

On the basis of above discussion it may concluded that the application of T_{10}-75% RDF + WSCF @ 0.5 % (19:19:19) + $ZnSO_4$ @ 0.5 % + Boron @ 0.25% treatment recorded maximumgrain, straw and harvest index and gave maximum values of gross return, net returns and benefit cost ratio which is closely followed by T_3, hence this treatment can be recommended for higher yield and may be opted for getting higher benefit: cost ratio.

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