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Effect of phosphorus management on nutrient uptake of plant and nutrient content in soil on rice (*Oryza sativa* L.)

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Abstract

A field experiment was conducted Crop Research Centre of S.V. P. University of Agriculture and Technology, Meerut (U.P.). to study the Effect of phosphorus management on Nutrient uptake of plant and nutrient content in soil on Rice (*Oryza sativa* L.) during *kharif* season of 2022. The soil of the experimental field was well drained sandy loam in texture. The completely Randomized Block Design (CRBD) with three replications. The rice variety Pusa basmati 1121. Results obtained from the study revealed that yield attributes characters and grain yield in rice were significantly superior with the application of $N_{100}P_{30}K_{40}$ + Root dipping with 2% DAP + Foliar application of 2% Nano DAP at MT & PI stage as compared to rest of the treatments. Incurred highest of Rs 116584 and 60588 ha^{-1} gross and net returns treatment (T_{10}), respectively. Results obtained from the study revealed that nutrient uptake in rice were significantly superior with the T_{10} as compared to rest of the treatments. The rice also nutrient uptake significantly maximum total N, P and K (100.5, 29.9 and 118.7 kg ha^{-1}), respectively as compared to T_3 ($N_{100}P_0K_{40}$) and T_2 ($N_{100}P_{60}K_{40}$. Besides, PFP (150.33 kg grains/kg P), AE (65.33 kg grains increase/kg P) and ARE (55.66%) are maximum under $N_{100}P_{30}K_{40}$ + Root dipping with 2% DAP + Foliar application of 2% Nano DAP at MT & PI stage and significantly superior to rest of the treatments. Soil residual fertility exhibited significant variation under different nutrient management practices attributed to differential crop removals and additions. Increased the available nutrient nitrogen, phosphorus, potassium and zinc, respectively after harvest of rice crop. Available soil nutrients (N, P, K and Zn) were significantly lower in unfertilized plots as against highest in plots receiving $N_{100}P_{30}K_{40}$ + Root dipping with 2% DAP + Foliar application of 2% Nano DAP at MT & PI stage.

Keywords: Growth, yield, nutrient uptake in plant and soil properties

Introduction

Rice (*Oryza sativa* L.) is one of the most important stable food crops in the world. About 90% of the rice production takes place in the tropical/sub-tropical Asia where 60% of the world population lives. Rice is second most important cereal crop in world covering 164.19 million hectare with annual production of 513.02 million tonnes of grain with average productivity of 31.24 quintal per hectare (*Anonymous*, 2021) [1]. In India, rice is grown on around 43.86 million hectares area with record production of 127.93 million tonnes and productivity of about 23.90 quintal per hectare. Uttar Pradesh is the largest rice growing state after West Bengal in India, though its productivity is low. Rice is grown over an area of 5.95 mha with the production of 15.52 mt with average productivity of about 26.34 quintal per hectare in Uttar Pradesh. The ever increasing population of the country is forcing the planners to produce more and more with ever shrinking natural resources. Continuous use of high analysis fertilizers accelerated the mining of micro and secondary nutrients which brought down the productivity. Declining trend in productivity due to continuous use of chemical fertilizers alone has been observed. Therefore, emphasis should be to optimize the use of chemical fertilizers and to improve their use efficiency. Enhancing the productivity and soil fertility to feed the ever growing population from shrinking natural resources. In addition to saving of available nutrients integrated nutrient management also improved the soil organic carbon and nutrient status of the soil.

Methods and Materials

The present investigation entitled "Response of Basmati Rice (*Oryza sativa* L.) to Efficient Phosphorus Management" has been carried out during *kharif* season of 2022 at the Crop Research Centre (CRC, Chirori) of S.V.P. University of Agriculture & Technology, Meerut (U.P.) India. The soil of experimental field was sandy loam in texture. Soil samples from a depth of 0-15 cm were collected from each plot of the experimental field prior to transplanting and a composite sample was drawn for determining its physical and chemical properties using the methods. The experimental soil was low in organic carbon, available nitrogen, phosphorus, potassium and zinc medium. Field experiment was conducted in completely randomized block design (CRBD) with three replications and 10 treatments. (T_1) Control, (T_2) $N_{100}P_{60}K_{40}$(RDF), (T_3) $N_{100}P_0K_{40}$, (T_4) $N_{100}P_{30}K_{40}$ + Root dipping with 2% DAP, (T_5) $N_{100}P_{30}K_{40}$ + Root dipping with 2% Nano DAP, (T_6)

$N_{100}P_{30}K_{40}$ + Foliar application of 2% DAP at MT & PI stage, (T_7) $N_{100}P_{30}K_{40}$ + Foliar application of 2% Nano DAP at MT & PI stage, (T_8) $N_{100}P_{30}K_{40}$ + Root dipping with 2% DAP + Foliar application of 2% DAP at MT & PI stage, (T_9) $N_{100}P_{30}K_{40}$ + Root dipping with 2% Nano DAP + Foliar application of 2% Nano DAP at MT & PI stage and (T_{10}) $N_{100}P_{30}K_{40}$ + Root dipping with 2% DAP + Foliar application of 2% Nano DAP at MT & PI stage were tested in Randomized Block Design (RBD) with three replications.

Results and Discussion

Yield Parameter

The maximum yield was recorded (50.9 q ha^{-1}) and straw yield (78.2 q ha^{-1}) was significantly higher in the treatment T_{10}- $N_{100}P_{30}K_{40}$ + Root dipping with 2% DAP + Foliar application of 2% Nano DAP at MT & PI stage as compared to T_2 and T_3. The highest grain yield under treatment T_{10} was increased by 44.1% which was closely followed by treatment T_9, T_8 and T_7. The improvement in yield attributes under T_{10} could be responsible for increase in grain and straw yield. The combination of RDF + Root dipping with 2% DAP + Foliar application of 2% Nano DAP at MT & PI stage balanced amount of essential nutrients into the soil and release the available nutrients for a longer period of time and thereby producing higher grains and straw yield *Biswas et al*. 2020 [3]. The highest B:C ratio (2.08) was in the crop grown with (T_{10}) and lowest (1.12) under (T_1). The effect of different nutrient management options was observed on various yield attributes and yield of rice. *Rama Krishna Reddy et al*. (2017) [6].

Nutrient Uptake in Plant

The maximum total nutrient uptake was recorded Nitrogen (100.5 kg/ha^{-1}), Phosphorus (29.9 kg/ha^{-1}), Potassium (118.8 kg/ha^{-1}) and zinc (264.1 g/ha) respectively T_{10} N_{100} P_{30} K_{40} + Root dipping with 2% DAP + Foliar application of 2% Nano DAP at MT & PI Stage. Favourable effects of NPK application on nutrient uptake by rice has also been reported. Though, the lowest uptake of NPK was recorded in control plots (T_1). The uptake of N, P, K and Zn was significantly highest with application of $N_{100}P_{30}K_{40}$ + Root dipping with 2% DAP + Foliar application of 2% Nano DAP at MT & PI stage. The increase in uptake of nutrients may be due to better availability and absorption of these nutrients in balanced quantity because of good proliferation of root system. Delayed maturity of rice at highest and balanced phosphorus level could trap more phosphorus for longer period of time which resulted into higher uptake of phosphorus in these treatments T_{10} and T_9. *Yadav et al.* (2020) [12]. The nutrient uptake of rice was found to be increased with the foliar application of nano urea which might be due to nano fertilizer have large surface area and particle size is less than the pore size of root and leaves of the plant which can increase their penetration into the plant from applied surface and improve nutrient uptake *Lahari et al*. 2021 [15].

Nutrient Content in soil

Soil residual fertility exhibited significant variation under different nutrient management practices attributed to differential crop removals and additions. Available nitrogen, phosphorus, potassium and zinc varied from 232.8 kg ha^{-1}, 18.7 kg ha^{-1}, 216.2 kg ha^{-1} and 0.92 mg kg^{-1}, respectively after harvest of rice crop. The highest available N, P, K and Zn with the application of $N_{100}P_{30}K_{40}$ + Root dipping with 2% DAP + Foliar application of 2% Nano DAP at MT & PI stage. Available soil nutrients (N, P, K and Zn) were significantly lower in unfertilized plots as against highest in plots receiving $N_{100}P_{30}K_{40}$ + Root dipping with 2% DAP + Foliar application of 2% Nano DAP at MT & PI stage. A positive nutrient balance in soil with application of NPK has been noticed by *Nandi and Mandal* 2020 [4].

Table 1: Effect of efficient phosphorus management on economic analysis of rice cultivation

Treatments	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
(T_1)-Absolute Control	45198	50770	5572	1.12
(T_2)-N_{100} P_{60} K_{40} (RDF)	49031	86328	37297	1.76
(T_3)-N_{100} P_0 K_{40}	50282	80458	30176	1.60
(T_4)-N_{100} P_{30} K_{40} + Root dipping with 2% DAP	52396	92887	40491	1.77
(T_5)-N_{100} P_{30} K_{40} + Root dipping with 2% Nano DAP	52854	96854	44000	1.83
(T_6)-N_{100} P_{30} K_{40} + Foliar application of 2% DAP at MT & PI stage	52536	100716	48180	1.91
(T_7)-N_{100} P_{30} K_{40} + Foliar application of 2% Nano DAP at MT & PI stage	55974	106331	50357	1.90
(T_8)-N_{100} P_{30} K_{40} + Root dipping with 2% DAP + Foliar application of 2% DAP at MT & PI Stage	52558	108459	55901	2.06
(T_9)-N_{100} P_{30} K_{40} + Root dipping with 2% Nano DAP + Foliar application of 2% Nano DAP at MT & PI Stage	56454	111718	55264	1.98
(T_{10})-N_{100} P_{30} K_{40} + Root dipping with 2% DAP + Foliar application of 2% Nano DAP at MT & PI Stage	55996	116584	60588	2.08
S.Em ±	1633	2939	1416	0.06
C.D. (P=0.05)	4890	8801	4239	0.17

Table 2: Effect of efficient phosphorus management on phosphorus use efficiency of rice

Treatments	PFP (kg grains/kg P)	AE (kg grains increase/kg P)	PE (kg grains/kg P uptake)	ARE (%)
(T_1)-Absolute Control	0.00	0.00	0.00	0.00
(T_2)-N_{100} P_{60} K_{40} (RDF)	66.22	23.72	122.94	19.33
(T_3)-N_{100} P_0 K_{40}	0.00	0.00	0.00	0.00
(T_4)-N_{100} P_{30} K_{40} + Root dipping with 2% DAP	135.55	50.56	138.01	36.66
(T_5)-N_{100} P_{30} K_{40} + Root dipping with 2% Nano DAP	137.78	52.78	145.88	36.66
(T_6)-N_{100} P_{30} K_{40} + Foliar application of 2% DAP at MT & PI stage	140.00	55.00	135.33	41.00
(T_7)-N_{100} P_{30} K_{40} + Foliar application of 2% Nano DAP at MT & PI stage	141.56	56.56	133.51	42.66
(T_8)-N_{100} P_{30} K_{40} + Root dipping with 2% DAP + Foliar application of 2% DAP at MT & PI Stage	145.00	60.00	139.29	43.33
(T_9)-N_{100} P_{30} K_{40} + Root dipping with 2% Nano DAP + Foliar application of 2% Nano DAP at MT & PI Stage	145.89	60.89	130.61	46.66
(T_{10})-N_{100} P_{30} K_{40} + Root dipping with 2% DAP + Foliar application of 2% Nano DAP at MT & PI Stage	150.33	65.33	117.54	55.66
S.Em ±	1.81	1.70	6.68	1.44
C.D. (P=0.05)	5.43	5.10	20.01	4.32

Table 3: Effect of efficient phosphorus management on Total N, P, K and Zinc uptake

Treatments	Nitrogen uptake (kg/ha)	Phosphorus uptake (kg/ha)	Potassium uptake (kg/ha)	Zinc uptake (g/ha)
(T_1)-Absolute Control	49.1	13.2	57.3	351.5
(T_2)-N_{100} P_{60} K_{40} (RDF)	88.3	24.1	100.1	356.2
(T_3)-N_{100} P_0 K_{40}	82.7	21.7	93.3	354.6
(T_4)-N_{100} P_{30} K_{40} + Root dipping with 2% DAP	88.6	24.2	101.5	358.0
(T_5)-N_{100} P_{30} K_{40} + Root dipping with 2% Nano DAP	87.7	24.8	101.2	359.0
(T_6)-N_{100} P_{30} K_{40} + Foliar application of 2% DAP at MT & PI stage	90.6	25.5	108.9	360.4
(T_7)-N_{100} P_{30} K_{40} + Foliar application of 2% Nano DAP at MT & PI stage	92.0	26.0	112.4	360.8
(T_8)-N_{100} P_{30} K_{40} + Root dipping with 2% DAP + Foliar application of 2% DAP at MT & PI Stage	91.8	26.2	111.0	362.0
(T_9)-N_{100} P_{30} K_{40} + Root dipping with 2% Nano DAP + Foliar application of 2% Nano DAP at MT & PI Stage	93.7	27.2	112.5	363.0
(T_{10})-N_{100} P_{30} K_{40} + Root dipping with 2% DAP + Foliar application of 2% Nano DAP at MT & PI Stage	100.5	29.9	118.7	364.1
S.Em ±	2.7	1.0	3.2	10.7
C.D. (P=0.05)	8.0	3.1	9.8	NS

Table 4: Effect of efficient phosphorus management on soil pH, E.C (dS/m), O.C. (%), available N, P, K and Zinc in soil at harvest

Treatments	pH	E.C. (dS/m)	O.C. (%)	Available nutrients in soil			
				N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Zn (mg kg^{-1})
(T_1)-Absolute Control	8.15	0.12	0.323	204.1	11.7	192.7	0.59
(T_2)-N_{100} P_{60} K_{40} (RDF)	8.21	0.14	0.343	212.5	13.8	199.1	0.65
(T_3)-N_{100} P_0 K_{40}	8.17	0.17	0.333	210.4	12.3	197.6	0.66
(T_4)-N_{100} P_{30} K_{40} + Root dipping with 2% DAP	8.25	0.16	0.347	213.5	14.3	203.3	0.72
(T_5)-N_{100} P_{30} K_{40} + Root dipping with 2% Nano DAP	8.34	0.14	0.350	217.2	15.1	209.7	0.74
(T_6)-N_{100} P_{30} K_{40} + Foliar application of 2% DAP at MT & PI stage	8.44	0.17	0.347	221.3	14.9	211.2	0.81
(T_7)-N_{100} P_{30} K_{40} + Foliar application of 2% Nano DAP at MT & PI stage	8.60	0.16	0.360	225.2	15.6	213.5	0.83
(T_8)-N_{100} P_{30} K_{40} + Root dipping with 2% DAP + Foliar application of 2% DAP at MT & PI Stage	8.46	0.15	0.363	221.0	16.1	214.6	0.85
(T_9)-N_{100} P_{30} K_{40} + Root dipping with 2% Nano DAP + Foliar application of 2% Nano DAP at MT & PI Stage	8.51	0.17	0.367	228.9	16.6	215.7	0.89
(T_{10})-N_{100} P_{30} K_{40} + Root dipping with 2% DAP + Foliar application of 2% Nano DAP at MT & PI Stage	8.47	0.18	0.377	232.8	18.7	216.2	0.92
S.Em ±	0.2	0.02	0.01	6.5	0.6	5.5	0.02
C.D. (P=0.05)	NS	NS	0.03	NS	2.0	NS	0.06

Conclusion

On the basis of experimental findings, it can be concluded that application of 100 kg N + 30 kg P_2O_5 + 40 kg K_2O + Root dipping with 2% DAP + Foliar application of 2% Nano DAP at MT and PI stages improves the growth and yield attributes of basmati rice and proves to be best for economic basmati rice production. Besides, it also improves phosphorus use efficiency and available nutrient status in soil.

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