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Effect of integrated nitrogen management on NPK uptake in basmati rice (*Oryza sativa* L.)

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Abstract: A field experiment entitled NPK uptake influenced by integrated nitrogen management in basmati rice (*Oryza sativa* L.) was conducted at Punjab Agricultural University, Ludhiana during *kharif* 2010. The experiment was conducted in randomized block design with 13 treatment combinations of chemical fertilizer, green manuring (GM) with *Crotalaria juncea*, farmyard manure (FYM) and organic preparations [OP (*Jeevamrit* and *Panchagavya*)] in four replications. The highest grain yield (34.9±0.54 q ha^{-1}) was obtained with combined application of FYM and 50 per cent of recommended nitrogen (RN) followed by GM+FYM+OP (33.7 q ha^{-1}) and GM+FYM (33.4±0.99 q ha^{-1}). Straw yield (63.1 q ha^{-1}) increased significantly (P<0.01) in treatment where FYM combined with 50 per cent of RN was applied. Among different nitrogen management treatments, the maximum N, P and K uptake in grain and straw were observed under treatment T_8 (FYM +50 per cent of RN) *viz.* integrated nitrogen treatment followed by T_{11} (GM+FYM+OP) and T_9 (GM+FYM). Thus, combined application of FYM @ 19.76 t ha^{-1} with reduced fertilizer dose (50 % of RN) increased the yield and NPK uptake in basmati rice.

Keywords: Basmati rice, FYM, Green manure, Grain yield, NPK uptake.

INTRODUCTION

Nutrient uptake by a crop refers to the product of crop yield and per cent content of that very nutrient in crop. It is another way to express the growth and yield of crop and can prove helpful in determining the nutrient requirement for the maximization of yields. Rice is kingpin in responding to nutrient uptake from the soil but its Nitrogen-use efficiency is very low due to N leaching, denitrification, surface runoff and volatilization losses (Kumawat *et al*., 2016). The low nitrogen requirement of basmati rice and coincidence of its growing season with the rains are good for the conservation of natural resources and environmental health. Therefore, integrated application of organics and inorganics exhibited higher grain and straw yields of rice with high nutrient uptake over application of inorganics only. Integrating nutrient management (INM) aims for efficient and judicious use of all the major sources of plant nutrients in an integrated manner (Farouque and Takeya, 2007). Application of organic manure not only improves the soil organic carbon for sustaining the soil physical quality but also increases the soil N. Keeping these aspects in mind, a study was carried out to study the NPKuptake influenced by integrated nitrogen management in basmati rice.

MATERIALS AND METHODS

The field experiment entitled NPK uptake influenced by integrated nitrogen management in basmati rice (*Oryza sativa* L.) was conducted at Punjab Agricultural University, Ludhiana, during *kharif* 2010. The experiment site is situated at 30°56' N latitude and 75°52' E longitude with a mean height of 247 meters above the mean sea level. The total rainfall received during the crop season was 542.1 mm and the mean monthly air temperature ranged from 20.9^{0}C to 30.6^{0}C with mean relative humidity of 65 to 90 per cent. The experiment was laid out in randomized block design with 13 treatment combinations of chemical fertilizer, green manuring (GM) with *Crotalaria juncea*, farmyard manure (FYM) and organic preparations [OP (*Jeevamrit* and *Panchagavya*)] in four replications. The details of treatments are given in Table 1. The soil of experiment site was loamy sand with pH (7.5), organic carbon (0.45 %), available nitrogen (162.6 kg ha^{-1}), available phosphorus (17.1 kg ha^{-1}) and potassium (185.7 kg ha^{-1}). Basmati variety Punjab Basmati-2, with seed rate of 20 kg ha^{-1} was transplanted with spacing of 20´15 cm (33 plants m^{-2}) on July 15, 2010. Nitrogen, as urea, was applied in two equal splits, at three and six weeks after transplanting the crop as per the treatments. As the recommended dose of phosphorus (62.5 kg ha^{-1}) had been applied to the preceding wheat, so it was not applied to basmati rice. *Jeevamrit* @ 500 litre ha^{-1} was applied as per the treatments at 15, 30, 45 and 60 days after transplanting (DAT) the crop and *panchagavya*

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(10%) was sprayed at tillering, panicle initiation and grain filling stage of the crop. A well-rotten farmyard manure @ 19.76 t ha^{-1} (1.1% N) was evenly spread and incorporated into the soil as per the treatments. Sunnhemp (*Crotalaria juncea*) as green manure crop having 3.15 t ha^{-1} dry mass was incorporated in the soil after 50 days of its sowing as per the treatments that contributed 69.3 kg N ha^{-1}. All the recommended package of practices was followed under Punjab conditions for raising the crop. The crop was harvested manually on November 12, 2010 with the help of sickle when grains had almost matured and straw had turned yellow. The grain and straw samples were analyzed for N (Modified-Kjeldehal's method, Piper 1966), P by using Vanado-molybdate phosphoric yellow colour method in nitric acid system (Page *et al*.,1982), K concentration by using Lange's Flame photometer described by Jackson (1967) and their uptake was calculated.

RESULTS

Grain and straw yield: It is evident from the Table 2 that the grain yield of basmati rice was highest (34.9±0.54 q ha^{-1}) where FYM application was followed by 50 per cent of RN (T_8) through fertilizer. It was statistically at par with treatments T_{11} (33.7±0.74 q ha^{-1}) and T_9 (33.4±0.99 q ha^{-1}). The straw yield was highest (63.1±0.74 q ha^{-1}) in treatment T_8 where FYM was followed by 50 per cent of RN application and it was statistically at par with treatments T_{11} (62.8±0.78 q ha^{-1}), T_9 (62.6±0.82 q ha^{-1}), T_5 (61.9±0.73 q ha^{-1}), T_2 (61.7±0.66 q ha^{-1}), T_1 (61.5±0.89 q ha^{-1}), T_7 (61.3±0.92 q ha^{-1}), T_3 (61.2±0.83 q ha^{-1}) and T_4 (61.0±0.98 q ha^{-1}).

N, P, K uptake (grains): The data (Table 2) showed that FYM followed by 50 per cent of the RN (T_8) resulted significantly higher N-uptake (44.8 kg ha^{-1}) that was statistically at par with T_{11} (43.4 kg ha^{-1}) and T_9 (42.9 kg ha^{-1}) and significantly higher than the other treatments. The basmati rice grains removed 40.3 kg N ha^{-1} with recommended level of nitrogen (T_1) which was 1.2 times more than the unfertilized control. Recommended N and green manure alone had statistically similar N uptake. The P and K uptake was also influenced by the treatments applied and the maximum value was recorded where FYM followed by 50 per cent of RN was applied (T_8), which was statistically at par with treatments T_{11} and T_9 where GM followed by FYM coupled with OP and GM followed by FYM were applied, respectively but was significantly higher ($P<0.01$) than the other treatments. The magnitude of increasein treatment T_8 was 3.7 and 5.6 per cent (P uptake) and was 2.3 and 4.7 per cent (K uptake) over T_{11} andT_9, respectively.

N, P, K uptake (straw): The data (Table 2) showed that FYM followed by 50 per cent of RN (T_8) resulted in significantly higher N-uptake (42.4 kg ha^{-1}), which was statistically at par with treatments T_{11} (41.4 kg ha^{-1}) and T_9 (40.9 kg ha^{-1}) where GM followed by FYM coupled with OP and GM followed by FYM were applied, respectively. FYM followed by 50 per cent of RN (T_8) increased the straw yield The application of FYM followed by 50 per cent of RN (T_8) removed 9.4 kg ha^{-1} phosphorus and 76.0 kg ha^{-1} potassium that was statistically at par with T_{11} and T_9 where GM followed by FYM coupled with OP and GM followed by FYM were applied, respectively but was significantly higher ($P<0.01$) than the other treatments.

DISCUSSION

Grain and straw yield: The significantly higher yield in these treatments might be due to continuous supply of nutrients throughout the crop growth period as chemical fertilizer and GM supply nutrients at early stage and FYM make their release slow. The integration of organic and inorganic sources might have synergistic effect to produce maximum grain yield of basmati rice. Increase in straw yield with integrated nutrient treatments could partly be attributed to its direct influence on dry matter production of vegetative part and indirectly through increased morphological parameters of growth. Dixit and Gupta (2000) reported that straw yield of rice was significantly higher (59.7 q ha^{-1}) with application of FYM along with chemical fertilizer as compared to chemical fertilizer alone (56.2 q ha^{-1}). The results are also in conformity with the findings of Pandey *et al*. (2007).

N, P, K uptake (grains): Higher N-uptake in treatment where FYM followed by 50 per cent of the RN might be due to more grain yield. N availability and better translocation of available N ultimately resulted into more grain yield and higher N concentration in grains. Uptake of nitrogen increased because it was utilized for metabolism of various substances required for the growth of plants which produced more dry matter. Pandey *et al* (2015) reported that integration of organic fertilizer with reduced dose of recommended nitrogen significantly increased the N-uptake in rice (32.0 kg ha^{-1}). The higher NPK uptake by rice might be due to higher yield received in these treatments (Kumar *et al*., 2014).The combined application of

Table 1. Details of treatments studied under experiment.

Symbols	Treatments
T_1	Recommended nitrogen (RN) @ 40 kg N ha^{-1}
T_2	Green manure (GM)
T_3	Green manure + 25% RN
T_4	Green manure + 50% RN
T_5	Green manure + Organic preparations (OP)- *Jeevamrit* and *Panchagavya*
T_6	Farmyard manure(FYM)to supply 40 kg N ha^{-1}
T_7	FYM+ 25% RN
T_8	FYM+ 50% RN
T_9	Green manure+ FYM
T_{10}	FYM+ OP
T_{11}	GM+FYM+ OP
T_{12}	Organic preparations (OP)
T_{13}	Unfertilized (Control)

Table 2. Effect of different treatments on yields and N, P and K uptake (grain and straw) by basmati rice.

Symbols	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Nutrient uptake by grains (kg ha^{-1})			Nutrient uptake by straw (kg ha^{-1})		
			N	P	K	N	P	K
T_1	32.6±0.88	61.5±0.89	40.3±0.53	5.0±0.24	7.7±0.32	39.0±0.61	8.6±0.16	70.3±0.96
T_2	32.8±0.85	61.7±0.66	40.4±0.55	5.1±0.29	7.9±0.22	38.9±0.59	8.8±0.10	70.6±0.77
T_3	32.4±0.17	61.2±0.83	40.1±0.79	4.9±0.07	7.3±0.18	39.0±0.19	8.4±0.07	69.4±0.09
T_4	32.3±0.23	61.0±0.98	40.5±0.28	4.8±0.07	7.1±0.05	39.5±0.63	8.3±0.16	68.8±0.47
T_5	32.9±0.36	61.9±0.73	40.3±0.49	5.1±0.05	8.0±0.14	38.6±0.64	8.8±0.38	72.1±0.41
T_6	30.1±0.91	59.4±0.63	36.5±0.79	4.3±0.41	6.4±0.61	36.3±0.92	8.0±0.22	66.2±0.51
T_7	32.4±0.33	61.3±0.92	39.3±0.46	4.9±0.12	7.5±0.05	37.8±0.68	8.6±0.13	70.0±0.96
T_8	34.9±0.54	63.1±0.74	44.8±0.79	5.6±0.12	8.9±0.19	42.4±0.59	9.4±0.34	76.0±0.47
T_9	33.4±0.99	62.6±0.82	42.9±0.80	5.3±0.17	8.5±0.32	40.9±0.91	9.0±0.31	73.1±0.66
T_{10}	30.6±0.46	59.4±0.95	36.9±0.85	4.5±0.46	6.6±0.40	36.4±0.64	8.0±0.10	66.8±0.99
T_{11}	33.7±0.74	62.8±0.78	43.4±0.57	5.4±0.07	8.7±0.27	41.4±0.31	9.2±0.06	75.5±0.41
T_{12}	28.6±0.56	54.3±0.23	33.9±0.84	4.1±0.09	6.0±0.12	31.6±0.22	6.9±0.04	51.7±0.23
T_{13}	28.3±0.24	53.9±0.74	33.5±0.24	4.0±0.07	5.8±0.08	30.2±0.35	6.0±0.06	51.0±0.80
CD (p=0.05)	1.6	2.5	2.0	0.3	0.4	1.6	0.4	3.0

FYM+50 per cent of RN and FYM+GM increased the P and K-uptake in crop, which might be attributed to higher grain yield, increased availability of phosphorus and potassium from organic sources and to solubility action of organic acids produced during degradation of organic materials that resulted into more release of native P and K in soil. A significant increase in the P-uptake (11.8 kg ha^{-1}) with application of GM+FYM as compared to unfertilized control (2.2 kg ha^{-1}) has been reported by Kumari *et al*. (2010) in rice. Srinivas *et al*. (2010) reported that the uptake of potassium in the rice grain was significantly influenced by the combined application of FYM and chemical fertilizers.

N, P, K uptake (straw): Application of organic manures along with N fertilizers and combination of different organic manures increased the N-uptake in basmati rice, which may be attributed to higher yield and increased N availability in the soil. The increased N-uptake may be due to better availability of N due to low C:N ratio of green manure and its quick decomposition and fast rate of N mineralization. Increased N-uptake in rice straw with the application of 50 per cent additional N through FYM along with RN was also reported by Walia (2007). The results are also in tune with findings of Kumar *et al*. (2010).The application of organic manures along with inorganic N fertilizers might have enhanced the P-uptake through positive interaction between nitrogen and phosphorus. Like nitrogen, P and K-uptake also increased significantly with the application of inorganic fertilizers along with organic manures. Similar results have been reported by Rani and Sukumari ((2013),Yadav *et al*. (2005) and Walia (2007) in rice crop. They reported that GM and FYM application had complementary effect on P-uptake. The integrated use of FYM with GM significantly increased the K-uptake (73.0 kg ha^{-1}) by preventing the leaching and other losses (Kumari *et al*., 2010).

Conclusion

The results of field study showed that the maximum uptake of N, P and K in grains and straw of basmati rice was obtained in treatment where FYM followed by 50 per cent of RN was applied and it was statistically at par with GM followed by FYM coupled with OP and GM followed by FYM but was significantly more than the other treatments. The uptake of N, P and K by the basmati rice increased significantly with application of organic manures combined with lower dose of RN. RN and GM alone had statistically similar N, P and K uptake in grains and straw and was significantly higher than FYM alone and its combination with OP. Therefore, use of organic source of nutrition along with chemical fertilizers (FYM+50% RN in proportion of 19.76 t ha^{-1}+20 kg ha^{-1}, respectively) has been found effective in improving yields and increasing NPK uptake by basmati rice.

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