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Influence of varieties and integrated nitrogen management on productivity and nutrient uptake in aerobic rice (*Oryza sativa*)

S K SHARMA[1], Y V SINGH[2], SURUCHI TYAGI[3] and B S TOMAR[4]

Indian Agricultural Research Institute, New Delhi 110 012

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ABSTRACT

A field experiment was conducted during the wet (*kharif*) seasons of 2009 and 2010 at New Delhi to study the influence of Basmati varieties and integrated nitrogen management on productivity and nutrient uptake in aerobic rice (*Oryza sativa* L.). The treatments included two Basmati rice varieties, viz. Pusa Basmati 1 and Pusa Basmati 1121 and eight integrated nitrogen management (INM) practices such as N control (N_0); 100% recommended dose of nitrogen (RDN, i.e. 120 kg N/ha through urea); 75% RDN+25% N through farmyard manure (FYM); 75% RDN+ 25%N through green manuring (GM); 75% RDN+ 25% N through *Azotobacter* biofertilizers (BF); 75% RDN+25% N through vermicompost(VC); 100% N through FYM+GM+BF+VC and 100% N through FYM+GM+BF+VC+ $ZnSO_4$. The results showed that Basmati rice variety Pusa Basmati 1 produced significantly higher grain yield as compared to Pusa Basmati 1121. Among the N management treatments, highest grain and straw yield was obtained through 100% N through FYM+GM+BF+VC+Zn followed by 100 % N through FYM+GM+BF+VC and 75% RDN+25% VC. Nutrient uptake in grain was higher in Pusa Basmati 1 over Pusa Basmati 1121. However, straw of Pusa Basmati 1121 showed higher N, Zn, Fe, Mn and Cu uptake than Pusa Basmati 1. Total N, Zn and Fe uptake in grain and straw was higher in Pusa Basmati 1 as compared to Pusa Basmati 1121. Total uptake of Mn and Cu was inclined in rice variety Pusa Basmati 1121 than Pusa Basmati 1. Application of RDN and INM showed significantly increased N, Zn, Fe, Mn and Cu uptake in grain as well as straw as compared to control.

Key words: Aerobic rice, Integrated nitrogen management, Micronutrient uptake, N uptake

Among the crop production inputs, water and nitrogen (N) have special importance in increasing crop yield. Irrigated 'aerobic rice' system is being developed for areas having water shortage with access to supplementary irrigation. It entails the cultivation of nutrient responsive cultivars in non-saturated soil with sufficient external inputs to reach yield comparable with high input flooded rice. However, dry seeding and subsequent aerobic cultivation of rice (*Oryza sativa* L.) create several maladies including the deficiency of micronutrients (Singh *et al.* 2002, Bouman *et al*. 2005). Rice crop is very sensitive to water stress and reduction in water inputs can result in decline of yield (Tuong *et al*. 2004). Nitrogen is the most important nutrient to the productivity of rice. Worldwide N recovery efficiency for cereal production including rice is approximately 35%. The N recovery efficiency for lowland rice is even lower than that reported for other arable crops (De Datta and Crasswell 1981). Among the micronutrients, Zn deficiency is occurring in both crops and humans (White and Zasoski 1999). Zn deficiency results in the inability of rice plant to support root respiration during flooded conditions (Slaton *et al*. 2005). In developing countries including India, the need to maximize and sustain food production is very urgent and so increased productivity of the land is essential in the present scenario. Application of organics as a source of nutrient increases the crop growth and yield because of improvement of soil biota and release of nutrients due to their mineralization. The combined use of organics along with inorganic fertilizers is also beneficial for getting sustained crop yields, improves soil biota and had residual effect on the productivity of succeeding crop. Besides, it had beneficial influence on physico-chemical properties of the soil in respect of lowering bulk density and pH and improving the organic carbon as well as available nutrient status of soil in general and N in particular apart from improving N use efficiency in rice (Raut and Mahapatra 2006). With this background an experiment was conducted to evaluate the effect of different sources of nitrogen and varieties on productivity and nutrient uptake in aerobic rice.

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[1]Senior Technical Officer, Seed Production Unit; [2]Principal Scientist, Centre for Conservation and Utilization of Blue Green Algae (E-mail: yvsingh63@yahoo.co.in); [4]Principal Scientist, Seed Production Unit; [3]Reader and Head, MMH College, Ghaziabad, UP

MATERIALS AND METHODS

The field experiment was conducted during rainy (*kharif*) seasons of 2009 and 2010 at the seed production area of Indian Agricultural Research Institute, New Delhi situated at a latitude of 28°40' N and longitude of 77°12' E, altitude of 228.6 meters above the mean sea level. The initial soil sample of experimental field had 160.0 kg/ha alkaline permanganate oxidizable N, 15.0 kg/ha available P, 262.0 kg 1 N ammonium acetate exchangeable K, 0.40% organic carbon and 8.2 pH. The experiment was laid out in split plot design with sixteen treatment combinations comprising two rice varieties, viz. Pusa Basmati 1 and Pusa Basmati 1121 and eight integrated nitrogen management (INM) practices, viz. N control (N_0); 100 % recommended dose of nitrogen (RDN), i.e. 120 kg N/ha through urea); 75% RDN + 25% N through farmyard manure (FYM); 75% RDN+ 25% N through green manuring(GM); 75% RDN+ 25% N through *Azotobacter* biofertilizers (BF); 75% RDN + 25% N through vermicompost (VC); 100 % N through FYM +GM+BF+VC and 100 % N through FYM+GM+ BF+ VC+ $ZnSO_4$. A common dose of P (26.2 kg P_2O_5/ha) and K (33 kg K_2O/ha) was applied in all the plots as basal through single super phosphate (SSP) and muriate of potash (MOP) fertilizers. Nitrogen was applied as per treatments and given through urea, vermicompost, FYM, *Sesbania aculeata* and *Azotobacter* biofertilizer. Doses of FYM, vermicompost and dhaincha (*Sesbania aculeata)* were calculated on the basis of their N concentrations and these were applied as basal. Vermicompost contained (on dry weight basis) 1.65 and 1.71 % N, FYM had 0.45 and 0.47% N and *Sesbania aculeata* had 2.47 and 2.65% N in 2009 and 2010, respectively. Biofertilizers (*Azotobacter)* was applied through seed treatment @ 500 g/ha. N through urea was applied in 3 equal splits at basal, active tillering and panicle initiation stage. The experiments were sown in first week of July and before sowing, the field was ploughed, harrowed, leveled and furrowed. Rice seeds were manually drilled in plots with a row spacing of 25 cm. Seed rate of 60 kg/ha were maintained for both the varieties. The field was kept under non-saturated aerobic condition throughout the whole growing season and data on water use was recorded. Supplemental surface irrigations were applied when crop leaves started to roll due to drought stress and drainage was conducted whenever heavy rains resulted in ponding. For weed-management pre-emergence Pendimethalin (Stomp) @ 3.3 liter/ha was sprayed two days after seeding.

At maturity, crop was harvested, dried for 3 days, weighed and after threshing grain yield was adjusted to a moisture content of 14%. Straw yield was calculated by deducting grain yield from the total yield. Plant samples collected at harvest were dried in air oven at 60°C for 24 hours after sun drying. The oven dried samples of plants and air dried sample of grain having moisture content (12%) were ground to pass through 40 mesh sieve in a Macro-Wiley mill. From each replication, 0.5 g samples were taken for chemical analysis to determine the N concentration. The nitrogen concentration in grain and straw of rice samples was determined by modified Kjeldahl method (Prasad *et al*. 2006). Nitrogen uptake was calculated by multiplying grain and straw yields with corresponding values of N concentration and expressed in kg/ha. The Fe, Zn, Mn and Cu in of grain and straw of rice crop were determined by DTPA extractable method (Lindsay and Norvell 1978). Uptake of N, Zn, Fe, Mn and Cu in rice grain and straw were calculated by multiplying the grain and straw yield of rice with their respective concentrations. All the data obtained from the experiment, conducted under split plot design were statistically analyzed using the *F*-test as per the standard procedure and LSD values at P = 0.05 used to determine the significance of difference between treatment means.

RESULTS AND DISCUSSION

Grain and straw yield

Rice variety PB 1 gave significantly higher grain yield (3.80 and 4.04 tonnes/ha) as compared to PB 1121 (Table 1). Application of RDN and INM significantly increased the grain yield of rice compared to control. Maximum grain yield was observed with application of 100% N by FYM+GM+BF+VC+Zn followed by 100 % N through FYM+GM+BF+VC and 75% RDN+25% VC. N application with 75% RDN+25% FYM inclined grain yield than 100% RDN. Application of 100% RDN and 75% RDN+25% GM showed significantly increased grain yield than 75% RDN+25%BF. Rice variety PB 1121 produced higher straw yield as compared to PB 1 but the difference was significant in 2010 only (Table 3). Treatments with INM and RDN significantly increased straw yield of rice as compared to control. Maximum straw yield was observed due to the application of 100% N by FYM+GM+BF+VC+Zn and it was followed by 100 % N by FYM+GM+BF+VC and 75% RDN+25% VC. Treatment with 75% RDN+25% BF showed minimum influence on straw yield as compared to all other treatments having INM with FYM, GM or VC alone or in combination. Similarly enhanced grain and straw yield of rice due to the application of different organic amendments either applied alone or in combinations has been reported by many researchers (Singh *et al*. 2011, Acharya *et al*. 2012, Kadiyala *et al*. 2012). Organic manures increased the fertilizer use efficiency and improved the physical and chemical properties of soil hence making better utilization of nutrients might also be a reason toward increased grain and straw yield.

Uptake of nitrogen in grain and straw

N uptake by grains of Pusa Basmati 1 was significantly higher than Pusa Basmati 1121 but in straw, N uptake was statistically at par in both the varieties. Total N uptake by grain and straw was found maximum in rice variety Pusa Basmati 1 as compared to Pusa Basmati 1121 (Table 1). Application of RDN and INM showed significantly increased N uptake in grain as well as straw and total uptake as compared to control. 100% N application through FYM+GM+BF+VC+Zn showed the maximum N uptake in grain as well as straw and total uptake and it was followed by 100% N by FYM+GM+BF+VC and 75% RDN+25% VC. Application of 75% RDN + 25% FYM was observed

Table 1 Effect of varieties and integrated nitrogen management on yield and nitrogen uptake in grain and straw of aerobic rice

Treatment	Yield (tonnes/ha)				N uptake (kg/ha)			
	Grain		Straw		Grain		Straw	
	2009	2010	2009	2010	2009	2010	2009	2010
Variety								
Pusa Basmati 1	3.80	4.04	6.43	7.57	53.38	55.88	38.00	43.24
Pusa Basmati 1121	3.60	3.87	6.65	8.35	49.94	52.90	38.26	46.73
SEm ±	0.06	0.05	0.13	0.17	0.93	0.88	0.85	1.36
LSD (P=0.05)	0.18	0.15	NS	0.50	2.67	2.53	NS	NS
Integrated nitrogen management (INM)								
N control	2.52	2.80	4.95	6.28	32.40	35.28	22.76	25.85
100% RDN (120 kg N/ ha)	3.67	4.00	6.47	8.00	50.89	54.55	36.56	43.93
75% RDN+25% N through FYM	3.92	4.21	6.83	8.22	55.23	58.47	40.28	46.72
75% RDN+25% N through GM	3.45	3.89	6.17	7.89	46.96	51.66	32.93	41.03
75% RDN+ N through 25% BF	3.27	3.50	5.78	7.67	42.97	45.06	29.28	36.53
75% RDN+ N through 25% VC	4.13	4.35	7.07	8.33	59.36	61.80	44.32	50.63
100% N through FYM+GM+BF+VC	4.23	4.39	7.23	8.50	61.33	62.91	46.98	54.68
100% N through FYM+GM+BF+ VC+$ZnSO_4$	4.40	4.50	7.80	8.78	64.17	65.38	51.94	60.49
SEm ±	0.12	0.11	0.26	0.347	1.84	1.754	1.709	2.71
LSD (P=0.05)	0.37	0.31	0.75	1.00	5.34	5.07	5.03	7.84

Table 2 Effect of rice varieties and integrated nitrogen management on uptake of Zn and Fe in grain and straw of rice

Treatment	Zn uptake (g/ha)				Fe uptake (kg/ha)			
	Grain		Straw		Grain		Straw	
	2009	2010	2009	2010	2009	2010	2009	2010
Variety								
Pusa Basmati 1	86.65	88.13	253.14	291.44	141.56	145.95	343.89	399.12
Pusa Basmati 1121	78.96	78.34	254.57	308.28	129.79	135.14	351.67	435.98
SEm ±	1.620	1.021	5.345	7.429	2.635	1.943	8.030	9.823
LSD (P=0.05)	4.681	2.951	NS	NS	7.611	5.613	NS	28.377
Integrated nitrogen management (INM)								
N Control	40.17	42.50	140.89	174.03	72.67	74.80	198.70	248.26
100 % RDN (120 kg N /ha)	79.77	83.06	239.13	287.54	126.84	135.94	331.66	402.98
75% RDN+25% N through FYM	90.53	92.05	267.22	311.40	141.65	149.00	363.54	431.91
75% RDN+25% N through GM	69.37	76.06	212.28	273.01	108.59	118.66	303.27	384.94
75% RDN+25% N through BF	56.87	57.98	177.59	229.32	97.47	99.71	254.84	331.32
75% RDN+25% N through VC	99.44	95.25	296.15	342.19	164.87	169.10	392.93	457.56
100% N through FYM+GM+BF+VC	105.10	101.06	323.25	369.66	177.85	181.82	440.77	513.10
100% N through FYM+GM+ BF+ VC+$ZnSO_4$ Zn$ZnSO_4$throughFYM+ GM+BF+VC+$ZnSO_4$	121.20	117.93	374.34	411.72	195.48	195.37	496.57	570.33
SEm ±	3.24	2.04	10.69	14.86	5.27	3.89	16.06	19.65
LSD (P=0.05)	9.36	5.90	30.88	42.93	15.22	11.23	46.40	56.76

increased N uptake than 100% RDN. N application with 100% RDN also showed increased N uptake than 75% RDN+25% GM during both the years. N application with 75% RDN+25% BF indicated significantly decreased N uptake than all other treatments during both the years. These findings were also in accordance to Munda *et al*. (2008) and Davari and Sharma (2010). They also reported increased N uptake in rice due to the application of different inorganic and organic sources of nutrients over control. Kadiyala *et al*. (2012) reported increased N uptake in grain of aerobic rice due to increasing doses of N. The increased N concentration might be due to the sufficient and continued availability of N from inorganic and organic source that eventually led to higher N uptake (Dixit and Gupta 2000). Singh *et al*. (2013) also observed that application of the recommended dose of chemical fertilizers and INM significantly increased uptake of N in grain and straw of rice as compared to the control.

Table 3 Effect of rice varieties and integrated nitrogen management on uptake of Mn and Cu in grain and straw of rice

Treatment	Zn uptake (g/ha)				Fe uptake (kg/ha)			
	Grain		Straw		Grain		Straw	
	2009	2010	2009	2010	2009	2010	2009	2010
Variety								
Pusa Basmati 1	89.80	93.95	418.27	488.40	44.26	43.85	215.85	250.59
Pusa Basmati 1121	83.43	87.61	428.34	533.07	40.57	41.14	222.19	272.39
SEm ±	1.59	1.15	8.57	11.50	0.77	0.62	4.77	6.17
LSD (*P*=0.05)	4.60	3.31	NS	33.23	2.21	1.80	NS	17.83
Integrated nitrogen management (INM)								
N control	47.27	51.20	258.25	323.72	24.85	25.04	132.43	165.63
100 % RDN (120 kg N/ ha)	79.60	85.84	417.00	512.74	39.31	39.18	201.27	244.76
75% RDN+25% N through FYM	88.23	93.43	449.84	538.20	43.70	42.73	223.61	261.77
75% RDN+25% N through GM	73.74	80.85	373.34	476.26	35.72	36.98	184.49	230.68
75% RDN+25% N through BF	65.32	67.40	326.14	425.91	33.41	32.10	164.49	209.69
75% RDN+25% N through VC	103.14	107.18	485.91	567.81	48.81	49.52	257.04	294.52
100% N through FYM+GM+BF+VC	113.28	114.98	507.33	591.55	53.87	53.52	276.72	325.76
100% through FYM+GM+ BF+ VC+$ZnSO_4$	122.34	125.40	568.63	649.67	59.67	60.87	312.10	359.09
SEm ±	3.19	2.29	17.15	23.00	1.53	1.25	9.54	12.35
LSD (*P*=0.05)	9.20	6.63	49.54	66.45	4.43	3.60	27.55	35.67

Uptake of Zn, Fe, Mn and Cu in grain and straw

Zn and Fe uptake in grains of Pusa Basmati 1 was significantly enhanced than Pusa Basmati 1121 but in straw Zn and Fe uptake of Pusa Basmati 1121 was maximum than Pusa Basmati 1. Total uptake of Zn and Fe by rice grain and straw was inclined in Pusa Basmati 1 than Pusa Basmati 1121 in 2009. However, in 2010 total uptake of Zn and Fe was maximum in Pusa Basmati 1121 than Pusa Basmati 1 (Table 2). Mn and Cu uptake in grains of rice variety Pusa Basmati 1 was significantly increased than Pusa Basmati 1121 but in straw Mn and Cu uptake of rice variety Pusa Basmati 1121 was higher than Pusa Basmati 1. Total uptake of Mn and Cu by rice grain and straw in Pusa Basmati 1121 was higher than Pusa Basmati 1 (Table 3). Application of RDN and INM significantly enhanced Zn, Fe, Mn and Cu uptake in grain as well as in straw and total uptake over the control treatment. Nutrient application with 100% N through FYM+GM+BF+VC+Zn showed significant higher Zn, Fe, Mn and Cu uptake and total uptake in grain and straw among the all other treatments. Treatment with 100% N by FYM+GM+BF+VC also showed higher Zn, Fe, Mn and Cu uptake and total uptake than 75% RDN+25% VC and 75% RDN+25% FYM. N application through 100% RDN also showed increased Zn, Fe, Mn and Cu uptake and total uptake in grain and straw than 75% RDN+ 25% GM and 75% RDN+ 25% BF. N application with 75% RDN+25% BF indicated significantly lower Zn, Fe, Mn and Cu uptake and total uptake in grain and straw than all other treatments during 2009 and 2010. Difference in their uptake may be due to difference in concentrations and yield. Davari and Sharma (2010) also observed increased concentration and uptake of Zn, Fe, Mn and Cu in rice grain due to the application of different combination of organic materials and biofertilizers. Gogoi *et al.* (2010) and Singh *et al.* (2011) also reported increased total uptake of micronutrients (Fe, Mn, Zn and Cu) due to the combined application of organic and inorganic sources of nutrients. Maximum uptake of total micronutrients was observed with 50% RDF + 50% N (FYM). They argued that this might be due to chelating action of organic compounds released during decomposition of manures and prevention of these cat ions from fixation, precipitation, oxidation and leaching. Our results are also in conformity of Singh *et al*. 2010 and Jat *et al*. 2011.

CONCLUSION

Based on the research findings it can be concluded that Basmati rice variety Pusa Basmati 1 gave significantly higher grain yield and nutrient uptake as compared to Pusa Basmati 1121 under aerobic rice management. 100% N supplementation through combined application of organic sources like farmyard manure(FYM) + green manuring(GM) + *Azotobacter* biofertilizers(BF) + vermicompost(VC) + Zn was found to be the best nutrient option since it gave higher yield of grain and straw and enhanced the uptake of N, Zn, Fe, Mn and Cu in grain and straw.

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