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Response of Levels and Split Application of Nitrogen in Green Manured Wetland Rice (*Oryza sativa* L.)

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Abstract: A field experiment was conducted during *kharif* 2006 and 2007 at crop research center, Meerut comprising combination of three levels of nitrogen (viz. 90, 120 and 150 kg N ha^{-1}) and four methods of nitrogen application (viz. ½ basal, ¼ at tillering and ¼ at PI; ¼ basal, ½ at tillering and ¼ at PI; ¼ each at basal, tillering, PI and flowering; ½ at tillering, ¼ at PI and flowering) in green manured wetland rice field. The experiment was laid down in Randomized Block Design with three replications. The grain yield of rice was highest with 120 kg N ha^{-1} (47.82 q/ha), which was statistically at par with 150 kg N ha^{-1} (49.71 q ha^{-1}) and among different methods of nitrogen application, ½ basal, ¼ at tillering and ¼ at PI it was recorded 49.76 q ha^{-1}. In general, nitrogen application up to 120 kg N ha^{-1} in green manured wetland rice field had significant effect on growth characters (viz. plant height, shoot numbers and dry matter accumulation), yield attributes, yield and N-uptake. The above character recorded maximum values with nitrogen application as ½ basal, ¼ at tillering and ¼ at PI followed by nitrogen application as ¼ basal, ½ at tillering and ¼ at PI stages. In the light of above findings it can be concluded that nitrogen application of 120 kg N ha^{-1} applied in three splits as ½ basal, ¼ at tillering and ¼ at PI stage in green manured wetland rice field is beneficial for rice crop.

Key words: Green manure, level, nitrogen, rice, split

INTRODUCTION

On a global basis, rice ranks second only to wheat in terms of area harvested, but in terms of its importance as a food crop, rice provides more calories per ha than any other cereal food. In Asia, irrigated rice is often a part of annual double cropping systems where upland crops such as wheat, maize, vegetables, or legumes follow rice, with rice-wheat as the major cropping system. Production of rice and wheat has responded to N rates up to 120 kg N ha-1 on these subtropical, semiarid soils (Maskina *et al*., 1988), which are inherently low in organic matter and N levels.

grain. In recent years, fertilizer cost and concern for sustainable soil productivity and ecological stability in relation to chemical fertilizer use have emerged as important issues (Aulakh and Pasricha, 1997a, b; Aulakh and Bijay-Singh, 1997).

There is a renewed interest in organic manures, such as farmyard manures, composts, and green manures, as sources of plant nutrients (Yadvinder-Singh *et al*., 1988; Aulakh, 1994). Farmyard manures and composts are in limited supply and may have low and variable nutrient contents. The more readily available green manures constitute a valuable source of both N and organic matter

It was opined that in India, 45% of lower yield obtained with modern technology, over traditional methods, could be attributed to a single factor viz., fertilizer material used or applied at a wrong time or in appropriate application method adopted. To meet this challenge of increased food demand, the productivity per unit area per unit time has to be necessarily increased while all other approaches are obviously static. Enhancing productivity from the existing rice areas of India has to be achieved by with effective N management. In addition, altering the split doses according to the crop requirement is also need to be analysed under green manaured wetland rice and optimization of nitrogen level as well as split doses to different crop growth stages is more important to produce higher grain yield. Considering the above facts, field experiment was conducted at Wetland Farm of C.R.C. of S.V. Patel University of Agriculture and Technology, Meerut to find out the optimum nitrogen level and better split application for rice cultivation.

MATERIALS AND METHODS

A field experiment was conducted at C.R.C. of S.V. Patel University of Agriculture and Technology, Meerut during *kharif* season of 2006 and 2007 on clay loam with

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pH 7.8, Organic carbon 1.2%, total soil N 2112 kg ha^{-1}, Available P 33 kg/ha and Available K 256.6 kg ha^{-1}. The green manure crop (*Sesbania aculeate*) was incorporated into the soil after 57 days of sowing. The experiment was laid out in two factor randomized block design with 12 treatments and 3 replications. Urea was applied to supply 90 (N_1), 120 (N_2) and 150 (N_3) kg N ha^{-1} as: ½ basal, ¼ at tillering and ¼ at PI (M_1), as ¼ basal, ½ at tillering and at ¼ PI (M_2), as ¼ basal, ¼ at tillering, at ¼ PI and at ¼ flowering (M_3), and at ½ tillering, at ¼ PI and ¼ at flowering (M_4). A basal dose of 60 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} was also applied through SSP and MOP, respectively. The soil was kept submerged to about 5 cm depth with water from trandplanting to 20 days before harvesting. Twenty five days old seedlings of rice variety (IR 64), maturing in about 110 days, were transplanted with 2-3 seedlings/hill at a spacing of 20x15 cm. The crop was planted during the last week of June and harvested in October. At harvest, grain and straw yields were recorded from each plot, total N in the plants was estimated by using the standard method given by Jackson (1973).

RESULTS AND DISCUSSION

Growth parameters: Various growth characters like Plant height, shoot numbers and dry matter accumulation are directly or indirectly responsible for formation of yield contributing characters, Plant height increased significantly with the increase of nitrogen levels from 90 to 120 Kg N ha^{-1} and highest value was recorded at 150 Kg N ha^{-1} in green manured wetland rice field at different crop stage except at 20 days after transplanting (Table 1) while number of shoots per metre row length increased significantly with increasing levels from 90 to 150 kg N ha^{-1}, at 40 and 60 days after transplanting. The dry matter accumulation per 50 cm row length increased significantly with increasing nitrogen levels up to 150 kg N ha^{-1} at harvest stage. However at harvest dry matter accumulation with 150 kg N ha^{-1} was at par to the dry matter accumulation at 120 kg N ha^{-1} (Table 1). This might be due to more number of shoot per unit area and more vegetative growth with increasing nitrogen levels (Verma, 1971; Kumar, 1998; Mahato *et al.*, 2007). The method of nitrogen application as ½ basal, ¼ at tillering and ¼ at panicle initiation stage had higher value of Plant height, number of shoots per metre row length and dry matter accumulation than all other methods of nitrogen application. This shows that nitrogen requirement is more during earlier transplanting to tillering stage in rice (Vaiyapuri *et al.*, 1998; Sathiya and Ramesh, 2009) also made similar observations. This was reported earlier (Yadvinder-Singh *et al.*, 1988; Aulakh *et al.*, 1991) and was confirmed in a recent laboratory incubation study, where Khera *et al.* (1999) observed 36% mineralization of sesbania green manures-nitrogen within 15 days.

Yield and yield attributes: Rice grain yield increased with increase in nitrogen levels from 90 to 150 kg ha^{-1} in green manured wetland rice field. However, significant improvement was noticed only up to 120 kg N ha^{-1} with an increase of 13.2% over 90 kg N ha^{-1} (Table 2). The response to lower dose (below 120 kg ha^{-1}) could be accounted for the substantial contribution of green manure (*S. aculeata*) to soil available nitrogen (Rashid *et al.*, 1992). Similarly, Deshmukh and Tiwari, (1996) found significant improvement in rice grain yield with increase in nitrogen levels from 40 to 160 kg N ha^{-1} and nitrogen application as ½ basal, ¼ at tillering and ¼ at panicle initiation stage had highest grain yield (4976 kg ha^{-1}) which was statistically at par with nitrogen applied as ¼ basal, ½ at tillering and ¼ at panicle initiation stage. These two methods of nitrogen application where ¾ of total nitrogen was given at transplanting to tillering stage of crop gave significantly higher yield than rest two methods of nitrogen application where ½ of total nitrogen was applied up to tillering stage of crop. This shows that nitrogen requirement of the crop is more from transplanting to tillering stage of crop these results were accordance with the findings of Wada *et al.* (1986) and Singh and Singh (1998) and Singh *et al.* (2006) Splits application maintained continuous supply of nutrients which might have favored the crop for good growth, yield attributes and finally the yield of rice.

Tanaka *et al.* (1964) observed that the productive tiller, panicle length and number of filled grain per panicle increased with increase in N levels. However, significant increase was noticed only for panicle length and number of filled grain per panicle up to 120 kg N ha^{-1}. The numbers of panicles are associated with the tiller production which is most important yield attributing character. The use of *Sesbania* in green manureing and 120 kg N ha^{-1} fertilizer N, Therefore, might have maintained the optimum condition throughout the crop growth period resulting in more number of panicle per unit area. The methods of nitrogen application had significant effect on number of productive tillers per metre row length. There are two methods of nitrogen application produce significantly higher number of productive tillers than rest of the two methods. The number of filled grain are the next important component of rice yield. The number of filled grain per panicle was significantly increase up to 120 kg N ha^{-1} and number of filled grain per panicle (124) were obtained with nitrogen application as ½ basal, ¼ at tillering and ¼ at panicle initiation stage. The 1000-grain weight was not influenced significantly due to different treatments. The test weight is a stable varietal character because the grain size rigidly controlled by the hull. Hence, the grain can not grow to a size greater than that permitted by the hull despite the favorable weather condition and abundant nutrients supply also play a major role (Yoshida, 1981).

Nitrogen concentration in grain and straw: Nitrogen uptake by crop is function of total biomass produced and

Table 1: Plant height, Number of shoots and Dry matter accumulation as influenced by nitrogen levels and methods of application in green manured wetland rice

	Plant height (cm)					Number of shoots m^{-1} row length					Dry matter accumulation g/50 cm row length				
	Day After Transplanting					Day After Transplanting					Day After Transplanting				
Treatments	20	40	60	80	At harvest	20	40	60	80	At harvest	20	40	60	80	At harvest
Nitrogen levels (kg/ha)															
90	47.7	74.9	94.8	101.7	104.1	85	100	115	76	69	17.59	49.83	113.55	144.41	163.16
120	48.2	78.2	100.0	107.5	112.6	88	117	129	80	74	18.51	66.50	127.32	156.50	183.15
150	48.3	80.6	103.7	109.6	115.6	91	125	137	84	79	19.96	74.16	132.7	164.58	164.58
Sem±	1.2	1.00	1.60	1.10	1.10	1.9	2.60	2.50	1.80	1.90	1.13	1.17	2.01	2.14	3.02
CD at 5%	NS	3.12	4.70	3.41	3.21	NS	7.60	7.41	5.21	5.55	NS	3.40	5.89	6.28	8.85
Methods of application															
B ½ , T ¼ ,PI ¼ ,F_0	49.4	82.7	104.9	111.0	115.0	94	121	135	86	81	19.43	68.11	129.69	162.66	187.93
B ¼ ,T ½ ,PI ¼ ,F_0	48.9	79.8	102.8	108.7	113.0	90	118	133	84	77	18.73	67.66	128.18	160.55	184.47
B ¼ ,T ¼ ,PI ¼ ,F ¼	48.7	75.6	95.8	103.4	109.1	86	109	123	76	70	18.23	60.55	122.54	150.44	174.97
B_0,T ½ ,PI ¼ ,F ¼	45.3	73.5	94.5	101.9	106.0	82	108	117	74	68	18.36	57.66	117.68	147.00	168.43
Sem±	1.4	1.20	1.80	1.30	1.20	2.5	3.0	2.90	2.00	2.20	1.31	1.35	2.32	2.46	3.48
CD at 5%	NS	3.60	5.43	3.94	3.70	NS	8.8	8.46	6.01	6.41	NS	3.98	6.81	7.25	10.22

Table 2: Yield attributes and yield as influenced by nitrogen levels and methods of nitrogen application in green manured wetland rice

Treatments **Nitrogen levels ($kgha^{-1}$)**	Productive tillers (m^{-1})	Panicle length (cm)	Filled grain per panicle	1000-grain weight (g)	Grain yield (kg ha^{-1})	Straw yield ($kgha^{-1}$)
90	69	25.4	102	25.6	4224	5258
120	70	25.7	119	25.9	4782	5838
150	74	25.9	124	26.3	4971	6106
Sem±	2.0	0.09	2.1	0.32	65.2	92.2
CD at 5%	NS	0.25	6.2	NS	191.2	270.3
Methods of application						
B ½ , T ¼ ,PI ¼ ,F_0	76	26.0	124	26.2	4976	5992
B ¼ ,T ½ ,PI ¼ ,F_0	75	25.9	121	26.1	4815	5890
B ¼ ,T ¼ ,PI ¼ ,F ¼	68	25.5	110	25.9	4564	5552
B_0,T ½ ,PI ¼ ,F ¼	65	25.3	105	25.6	4281	5502
Sem± 2.3	0.10	2.3	0.37	75.2	106.4	
CD at 5%	6.68	0.30	7.15	NS	220.7	312.1

Table 3: Nitrogen concentration in grain and straw, N-uptake by grain and straw, total N uptake, nitrogen use efficiency and total N in soil as influenced by nitrogen levels and methods of nitrogen application in green manured wetland rice

	Nitrogen concentration (%)		Nitrogen uptake (kg ha^{-1})				
Treatments	Rice grain	Rice straw	Grain	Straw	Total N Uptake (Kg ha^{-1})	Nitrogen use efficiency	Total N in soil (Kg ha^{-1})
Nitrogen levels ($kgha^{-1}$)							
N_1 90	1.45	0.43	62.0	22.6	84.8	7.7	2053
N_2 120	1.54	0.45	74.0	26.2	100.3	10.50	2058
N_3 150	1.59	0.47	79.4	28.5	107.7	9.68	2071
Sem± 0.02	0.006	0.8	1.4	1.5	0.65	38.0	
CD at 5%	0.06	0.02	2.4	4.2	4.6	1.9	NS
Methods of application							
Methods of application							
M_1 B ½ , T ¼ ,PI ¼ ,F_0	1.53	0.45	77.3	74.0	104.2	11.95	2045
M_2 B ¼ ,T ½ ,PI ¼ ,F_0	1.50	0.44	72.6	79.4	99.4	10.64	2062
M_3 B ¼ ,T ¼ ,PI ¼ ,F ¼	1.55	0.45	71.1	25.0	95.9	8.50	2065
M_4 B_0,T ½ ,PI ¼ ,F ¼	1.54	0.45	66.2	24.9	90.9	6.19	2070
Sem±	0.01	0.02	0.9	1.1	1.1	0.75	44.0
SD at 5%	0.03	NS	2.7	NS	3.3	2.2	NS

percent nitrogen concentration in the biomass. The differences in uptake in grain and straw due to different treatments were associated mainly with yield differences and partly with nitrogen content in grain and straw (Table 3). The nitrogen concentration in grain increased significantly with the increase in nitrogen level from 90 to 120 kg N ha^{-1} through highest value was recorded at 150 kg N ha^{-1}. Whereas, significant increase in nitrogen content of straw was recorded up to 150 kg N ha^{-1}. Nitrogen concentration particularly in grain is higher when fraction of nitrogen was applied at flowering stage of crop (Table 3). The top dressing at flowering stage resulted in marked increase in protein content of rice grain (Perez *et al.*, 1996).

Nitrogen uptake by rice crop: Nitrogen removal by grain and total uptake increase significantly with increase in levels from 90 to 150 kg N ha^{-1} where as incase of straw significant increase of nitrogen uptake was observed up to 120 kg N ha^{-1} only (Table 3). This was due to higher grain yield and nitrogen content in grain at higher levels. The nitrogen application as ½ basal, ¼ at tillering and ¼ at panicle initiation stage resulted in highest nitrogen uptake by grain and straw as well as total nitrogen uptake followed by nitrogen application as ¼ basal, ½ at tillering and ¼ panicle initiation stage. Additional nitrogen supply by fertilization during maximum growth period of crop plants, might have favored the higher nitrogen uptake by crop plants (Patel and Thakur, 1997).

N use efficiency: The application of 120 kg N ha^{-1} in green manured wetland rice field resulted in significantly higher nitrogen use efficiency of applied nitrogen as compared to 90 kg N ha^{-1} and statistically at par with 150 kg N ha^{-1}. The application of entire quantity of nitrogen during growth period resulted in higher nitrogen use efficiency (Table 3). It shows that in green manured wetland rice field, application of 150 kg N ha^{-1} and nitrogen applied during reproductive stage of crop, resulted in more nitrogen losses (Morris *et al.*, 1989). This suggests that green manures may enhance yield potential above that of fertilizer nitrogen alone, indicating a benefit of green manure beyond N supply. Possible explanations for this enhanced yield potential may include more favorable physical, chemical, and biological conditions, and nutrient availability in soils amended with green manuring (Yadvinder-Singh *et al.*, 1988; Walters *et al.*, 1992; Aulakh, 1994).

Total nitrogen in soil: The different nitrogen levels and their methods of nitrogen application in green manured wetland rice field did not bring any appreciable change in total nitrogen content of soil after harvest of rice (Table 3). This may be due to rapid mineralization of *S. aculeate* in entire experiment field. The green manuring and different nitrogen levels did not bring any significant change in total nitrogen of soil after harvesting of rice crop (Singh *et al.*, 1995).

On the basis of results obtained it can be concluded that nitrogen level of 150 kg N ha^{-1} did not bring any significant change in yield, yield attributes and nitrogen use efficiency over 120 kg N ha^{-1}. Because of the green manures can not only substitute the costly nitrogenous fertilizer but also increase the efficiency of applied nitrogen by slowing its release by tying up mineralized soil N and prevnt its losses (Lowendorf, 1982). However, in green manured wetland rice nitrogen dose 120 kg N ha^{-1} and method of nitrogen application as ½ basal, ¼ at tillering and ¼ at panicle initiation stage had significant beneficial effect on yield and yield attributing characters of rice along with better nitrogen use efficiency of the applied nitrogen.

CONCLUSION

However, since these practice can not meet the total need of modern agriculture, integrated use of nutrients from fertilizers and organic sources seem to be the need of time. Optimum level and timely nitrogen application are the pioneer agronomic technique of overall nitrogen management in rice for efficient utilization of nutrients along with enhanced biological activity in the soil, provide an abounded supply of plant-essential minerals annually. The green manuernig probably supplied nitrogen to rice crop from its early growth stages and maintain it up to maturity but maximum availability was supposed to be at earlier growth stage of rice crop. Efficient use of green manure-nitrogen may be due to the synchrony between nitrogen release from incorporated green manures and crop plant nitrogen demand. Also, unlike fertilizer-nitrogen, green manure-nitrogen is less prone to losses through leaching of NO_3 beyond the rooting zone .

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