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Response of Summer Green Manuring and Nutrient Management on Log Phase of Growth in Unpuddled Transplanted Hybrid Rice (*Oryza sativa* L.)

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ABSTRACT: A two-year experiment was conducted on sandy clay loam soil of Indo-Gangetic plain to investigate the effect of summer green manuring and nitrogen management on unpuddled transplanted hybrid rice (*Oryza sativa* L.) during its log phase of growth. The experiment was laid out in split plot design with four green manuring treatment in main plot viz. fallow, water hyacinth, *Sesbania aculeata*, sudan grass and three treatments in sub plot viz. 60 % RDN, 80 % RDN, and 100 % RDN with three replications. The results reported that the higher growth parameters *viz.* plant height, number of tillers/m^2, dry matter accumulation, and number of leaves were recorded under *Sesbania aculeata* as compared to sudan grass and fallow, however, it was statistically at par with water hyacinth during both the years of experimentation. Among nitrogen management treatments, 100% RDN recorded higher growth parameters which was followed by 80% RDN during both the years. These results also imply that use of chemical fertilizers only might adversely affect the growth attributes during crop log phase leading to yield loses of rice, and that situation could be escaped by an integrated use of green manure along with judicial nitrogen fertilizer management.

Keyword: Green manuring, nitrogen, growth, water hyacinth

INTRODUCTION

Rice provides more than half the daily food for one of every three persons in the world, especially for South Eastern Asia, where 90% of the world production of rice are grown and consumed. In India, rice is grown on an area about 43.79 million hectares with production 116.42 million tons and is ranked first with respect of area and second with respect to production, only after China but the productivity of rice is very low i.e. only2.65 tons/ha (Anonymos, 2019). The rice-wheat cropping system is found on 13.5 million ha in south Asia and is one of the most important cropping systems for food self-security in Indo-Gangetic region which reveals the importance of this region in the country's food security. This system is found in the fertile, hot semi- arid to hot subhumid regions of the Indus and Gangetic alluvial plains of Bangladesh, India, Nepal and Pakistan. But, continuous cultivation of rice-wheat cropping system in Indo-Gangetic plains in recent decades has caused multiple hazardous effects on soil health, ecological cycle, and reduced income of the farmers due to higher cost of cultivation and lesser partial factor productivity Bhatt *et al.* (2016). Also, availability of nutrients in the soil has become a limiting factor in the production of crops even though all other resources are under optimum condition, as the soil's capacity to supply the required nutrients has been challenged by many factors. Among all those nutrients, nitrogen is one of the primary plant food nutrients which plays a vital role in the plant system for the synthesis of protein and nucleic acid that are responsible for the optimum development of chlorophyll and plant growth. In Northern India, during extreme summer conditions after the harvest of winter crops from mid-April to first week of June, land generally remains vacant which can be used for growing green manure crops for nitrogen economy and improving productivity. Green manuring is an age-old practice from ancient period and there has been a lot of study done on this topic. Green manure crops absorb nutrients from deeper layers of soil and converts them to biomass which when incorporated into soil adds immense amount of available nutrients into the soil. Also, green manuring can improve soil health and consequently crop yields (Meena, (2019). Some weeds like water hyacinth that have good source of nutrients can also be used as green manure. It was reported that incorporation of *Sesbania aculeata* into soil resulted in higher N recovery percent and N response ratio and gave increased growth attributes of low land rice compared to the growth obtained due to the application of no fertilizers and only chemical fertilizers Asagi *et al.* (2010). Further, green manuring in conjunction with FYM and chemical fertilizers application may carry nutrients for succeeding crop in rotation due to improved soil fertility through nutrient cycling. It had been reported that the application of FYM 10 tons/ha or press mud 5 tons/ha or *Sesbania* 2.5 tons/ha along with 50 per cent of recommended NPK through inorganic fertilizers gave significantly higher growth of rice over 100 per cent recommended NPK through inorganic fertilizers Singh *et al.* (2002). But not all crops can be used as green manuring crops, some cause hazardous effect on succeeding crops due to immobilization and other allelopathic chemicals. After decomposition, crop residues produce a variety of allelopathic chemical such as phytotoxins, particularly the phenolics, in the soil which cause hazardous effects on the subsequent crops (Nelson, 1996) and these toxins have the potential which causes a chemical as well as a physical effect on the growth and development of succeeding crops. All green manure differ in their physio-chemical composition which affect its rate of decomposition and availability of nutrients in soil and also the removal of nutrients by main crops. The nutritional effect of green manure on crop plants depends on residue quality. High quality materials release the nutrients to improve the growth attributes as well as the nutritive value of the plant, whereas, low quality residues have adverse effect on the growth and nutritional value of plant. Well nodulated *Sesbania* plants can derive up to 90% N from fixation (Pareek *et al.*1990) and consequently contribute N in rice growth which ultimately leads to higher rice yield. So far, many studies have been done on the green manuring crops but it is been mostly concentrated on the fate of N in the soil. Also, many integrated nutrient management and soil fertility studies have been carried out in rice but, little information is available regarding rice log phase growth responses to green manure substitution fertilizer regimes. Therefore, efforts to clarify the influences of green manure substitution regimes under different organic-inorganic substitution ratios are needed to be developed for effective nutrient management strategies. Therefore, the present study reported in this research sought to compare the effect of different green manuring along with different doses of nitrogen fertilizer on log phase of rice grown in Indo-Gangetic plain.

MATERIAL AND METHODS

The experiment was laid out during 2018 and 2019 at Agricultural Research Farm, Institute of Agricultural Sciences, and Banaras Hindu University, Varanasi of Northern Gangetic Alluvial Plain of India (Plate 1) (82° 59′36″ E longitude; 25° 15′19″ N latitude and an altitude of 75.7 meters above sea level) in a split plot design with four summer green manuring treatments viz., fallow, water hyacinth 5 t/ha (dry weight basis), *Sesbania aculeata* incorporated at 45 DAS, and sudan grass incorporated at 45 DAS in main plots and three nitrogen management treatments, viz., 60% RDN (50% N through FYM + 50% N through inorganic), 80% RDN (50% N through FYM + 50% N through inorganic) and 100% RDN (50% N through FYM + 50% N through inorganic) in sub plots. The field was ploughed during summer and leveled, and the layout of the main treatments was done as per the technical plan of an experiment. Summer green manure crops were sown 47 days before the rice transplanting in fields.

All the green manure crops were cut manually, and then experimental field was ploughed mechanically. The green manuring residue and required amount of FYM was placed in the furrow (ridge made by furrow maker) and then covered by soil for decomposition. In rice nursery, hybrid cultivar "Arize- 6444" was sown 20 kg/ha for nursery raising under dry seedbed condition. Pre-soaked seeds were sown in the raised nursery bed by *kudal* at 15 cm row to row spacing followed by irrigation for proper germination. For unpuddled transplanting, green manure treated plots were inundated up to 3-5 cm of standing water for 48 hours to make the land sufficiently soft for transplanting. 22-25 days old seedlings were transplanted in the field by using 2 seedlings per hill at the spacing of 20 cm × 15 cm in all the experimental plots. The recommended dose of nitrogen used was 150 kg/ ha, applied as 50 % through FYM and 50 % through urea (46 % N) and DAP based on treatments. The part of chemical nitrogen applied based on treatments, under 60 % RDN (50 % N through FYM + 50 % N through inorganic) 29.3 kg/ha chemical nitrogen was applied through DAP as basal and remaining 15.7 kg/ha through urea was applied at active tillering stage, under 80% RDN (50% N through FYM + 50% N through inorganic) 29.3 kg/ha chemical nitrogen was applied through DAP as basal and remaining 30.7 kg/ha applied through urea at active tillering, and under 100% RDN (50 % N through FYM + 50 % N through inorganic) 29.3 kg/ha chemical nitrogen through DAP and 8.2 kg/ha N through urea was applied as basal, remaining nitrogen 37.5 kg/ha was applied at active tillering. The entire dose of P_2O_5 (75 kg/ha) in the form of DAP and K_2O (60 kg/ha) through muriate of potash along with 15 kg/ha zinc (H_2O_5SZn) before transplanting. Data were recorded on plant height, number of tillers/m^2, number of leaves/running meter, dry matter accumulation/hill, dry matter of leaves/hill, and dry matter of shoots of unpuddled transplanted rice.

Plate 1. Photo of experimental field.

RESULTS AND DISCUSSIONS

Green manuring caused significant variations in growth attributes *viz.* plant height (Table 1), number of tillers/m^2, (Table 1) number of leaves/running meter (Table 2), dry matter accumulation/hill (Table 2), dry matter of leaves/hill (Table 3), and dry matter of shoot/hill (Table 3) at 30 and 60 DAT the stages of observation during both the years of experimentation. At 30 and 60 DAT, *Sesbania aculeata* incorporated at 45 DAS recorded maximum growth attributes amongst all the green manuring crops treatment (Plate 2), however, it was found statistically at par with water hyacinth 5 t/ha incorporation during both the years. Further analysis of data revealed that, sudan grass incorporated at 45 DAS recorded significantly minimum growth attributes and it was statistically at par with summer fallow during both years of experimentation. It was noted from the results, growth attributes were increased slowly in initial stage then increased rapidly between 30 to 60 DAT indicating that, this period is the log period of rice growth. Water hyacinth was the second-best treatment in terms to height where 97.3 and 96.6 percent reduction was found during 2018 and 2019 in comparison to *Sesbania*. Analysis of data clearly shown that the green manuring with *Sesbania aculeata* incorporated at 45 DAS followed by water hyacinth 5 t/ha in compression to fallow and sudan grass incorporated at 45 DAS during both years of field study. *Sesbania* is the main organic source of nitrogen which main constituent of protoplasm, protein, chlorophyll, nucleotides, alkaloids, hormones and vitamins helps to promote the growth of crops.

Plate 2.

Table 1: Effect of green manuring crops and nitrogen management on plant height and number of tillers at log phase of growth of unpuddled transplanted rice (*Oryza sativa* L.).

Treatment	Plant height (cm)				number of tillers/m^2			
	30 DAT		60 DAT		30 DAT		60 DAT	
	2018	2019	2018	2019	2018	2019	2018	2019
Green manuring crops								
Fallow	45.04	43.13	96.67	95.33	246.20	246.36	298.07	277.98
Water hyacinth 5 t/ ha (DWB)	52.43	48.34	113.11	111.67	318.43	318.43	367.75	395.65
Sesbania aculeata (Incorporated at 45 DAS)	54.44	50.46	123.11	124.00	376.02	327.74	380.69	423.41
Sudan grass (Incorporated at 45 DAS)	44.00	42.49	93.11	92.11	232.41	246.57	270.29	272.91
SEm±	2.363	1.605	5.41	5.105	12.938	17.555	19.769	20.205
CD (P=0.05)	8.177	5.554	18.74	17.666	44.770	60.748	68.411	69.919
CV (%)	14.47	10.44	15.25	14.48	13.23	18.49	18.02	17.70
Nitrogen management								
60% RDN (50% N through FYM + 50% N through inorganic)	46.21	44.07	96.67	95.50	259.03	244.72	284.69	300.89
80% RDN (50% N through FYM + 50% N through inorganic)	49.21	45.48	109.00	108.00	295.21	291.65	335.24	343.34
100% RDN (50% N through FYM + 50% N through inorganic)	51.53	48.78	113.83	113.83	325.56	317.96	367.67	383.23
SEm±	1.223	0.720	2.73	2.341	8.031	9.811	10.037	8.646
CD (P=0.05)	3.665	2.158	8.17	7.019	24.077	29.414	30.092	25.922
CV (%)	8.65	5.41	8.87	7.67	9.49	11.93	10.56	8.75

Table 2: Effect of green manuring crops and nitrogen management on number of leaves and dry matter accumulation/hill at log phase of growth of unpuddled transplanted rice (*Oryza sativa* L.).

Treatment	No. of leaves/running meter				Dry matter accumulation/hill			
	30 DAT		60 DAT		30 DAT		60 DAS	
	2018	2019	2018	2019	2018	2019	2018	2019
Green manuring crops								
Fallow	22.44	20.65	47.34	49.15	277.33	261.56	266.13	238.00
Water hyacinth 5 t/ ha (DWB)	26.33	25.80	60.16	63.18	348.33	368.56	328.35	353.11
Sesbania aculeata (Incorporated at 45 DAS)	27.37	26.52	70.05	71.72	364.89	382.22	339.90	362.44
Sudan grass (Incorporated at 45 DAS)	22.95	21.00	48.45	47.97	251.22	241.33	243.89	221.44
SEm±	1.042	1.019	2.973	3.137	20.684	30.099	16.309	22.999
CD (P=0.05)	3.607	3.526	10.289	10.854	71.577	104.158	56.437	79.587
CV (%)	12.62	13.01	15.79	16.22	14.07	21.42	17.19	15.93
Nitrogen management								
60% RDN (50% N through FYM + 50% N through inorganic)	22.57	21.81	47.48	49.09	239.33	250.75	261.61	247.83
80% RDN (50% N through FYM + 50% N through inorganic)	24.82	23.51	55.98	57.10	320.50	326.83	296.50	296.50
100% RDN (50% N through FYM + 50% N through inorganic)	26.92	25.16	66.04	67.83	371.50	362.67	325.59	336.92
SEm±	0.876	0.864	1.566	1.667	15.118	17.475	10.029	6.833
CD (P=0.05)	2.625	2.591	4.695	4.999	45.324	52.390	30.067	20.486
CV (%)	12.25	12.75	9.60	9.96	9.29	13.62	9.35	5.84

Table 3: Effect of green manuring crops and nitrogen management on dry matter of leaves/hill and dry matter of shoot/hill at log phase of growth of unpuddled transplanted rice (*Oryza sativa* L.).

Treatment	Dry matter of leaves/hill				Dry matter of shoot/hill			
	30 DAT		60 DAT		30 DAT		60 DAT	
	2018	2019	2018	2019	2018	2019	2018	2019
Green manuring crops								
Fallow	0.51	0.51	3.09	3.51	1.14	1.17	6.47	7.02
Water hyacinth 5 t/ ha (DWB)	0.98	0.89	3.64	4.75	2.02	2.23	8.43	9.51
Sesbania aculeata (Incorporated at 45 DAS)	1.08	0.95	4.33	5.22	2.19	2.66	10.41	10.44
Sudan grass (Incorporated at 45 DAS)	0.46	0.48	2.99	3.29	1.07	0.82	6.43	6.58
SEm±	0.051	0.03	0.20	0.22	0.081	0.13	0.46	0.45
CD (P=0.05)	0.177	0.11	0.70	0.77	0.281	0.46	1.59	1.54
CV (%)	20.26	13.93	17.23	15.93	15.20	23.35	17.40	15.93
Nitrogen management								
60% RDN (50% N through FYM + 50% N through inorganic)	0.65	0.60	2.98	3.78	1.42	1.52	6.20	7.56
80% RDN (50% N through FYM + 50% N through inorganic)	0.74	0.71	3.54	4.22	1.63	1.72	8.13	8.43
100% RDN (50% N through FYM + 50% N through inorganic)	0.88	0.80	4.02	4.58	1.76	1.93	9.49	9.17
SEm±	0.025	0.02	0.09	0.07	0.054	0.10	0.23	0.14
CD (P=0.05)	0.074	0.07	0.28	0.21	0.162	0.30	0.70	0.42
CV (%)	11.25	12.22	9.15	5.84	11.68	10.33	10.20	5.84

This might be due to the fact that higher nutrient supply rapidly converted the carbohydrates into proteins which in turn elaborated into protoplasm. The slow release of nitrogen from organic source also increased the proportion of protoplasm to cell wall material and had several consequences one of them being an increase in size of cell, which expressed morphologically in increased plant growth. Similar results were also reported by Singh and Dhillon (2020) who reported higher plant height and number of tillers/m^2 under *Sesbania* green manuring soil incorporation. Sarkar *et al.* (2004) has revealed that *Sesbania* spp. as green manuring was recorded the higher dry matter accumulation as compared to *Crotalaria juncea*. Soil incorporation of green manuring was enhanced plant height by 7.2-7.5 cm as compared to chemical fertilizer plot Kim *et al.* (2011) higher plant growth of rice was increased with the green manuring. Pramanik *et al.*, (2004) reported that higher growth was observed with *Sesbania* spp. soil incorporation at all the stages of observation. The data revealed that the plant growth nevertheless remained slower at initial stage but, increase markedly thereafter.

The plant growth of rice taken at the interval of 30 days and data taken at the stage of 30 and 60 DAT in both year of experimentation. It was further noticed that integrated nitrogen management by 100% RDN (50% N through FYM + 50% N through inorganic) recorded significantly growth attributes *viz.* plant height (Table 1), number of tillers/m^2 (Table 1), number of leaves/running meter (Table 2), dry matter accumulation/hill (Table 2), dry matter of leaves/hill (Table 3), and dry matter of shoot/hill (Table 3) at 30 and 60 DAS stages of observation as compared to 80% RDN (50% N through FYM + 50% N through inorganic) and 60% RDN (50% N through FYM + 50% N through inorganic) during both the years might be due to nitrogen as major constituent cell plays a vital role in cell elongation by virtue of being an essential part of diverse type of metabolic active compound like amino acid, protein, nucleic acid, etc. Application of organic manures alone not full fill the demand of crop due to slow release of nutrients. Integration nutrient management with vermicompost and chemical fertilizers increased organic matter and soil microbial biomass carbon which lead to enhanced the plant height, number of leaves, stem weight and root weight of *Agrimonia Pilosa* Ledeb (Le *et al.* 2018). Chemical nitrogen at the rate of 100 kg/ha along with 15 tons/ha FYM enhanced the plant growth in rice crop Usman *et al.* (2003). Maiti *et al.* (2006) reported that maximum plant height, number of tillers/m^2, dry matter accumulation/hill was highly influenced due to application of 125% recommended dose of nitrogen along with 5 tons/ha of FYM 5 tons/ha. An experiment conducted at silty loam soils of Mallan by Mankotia (2007) revealed that application of FYM 5 tons/ha in combination with 50% N recorded significantly taller plants in rice crop as compared to alone FYM or chemical treatments. Maiti *et al.* (2006) reported that maximum dry matter accumulation was highly influenced due to application of 125% recommended dose of nitrogen along with 5 tons/ha of FYM 5 tons/ha. Application of 75% RDF + 25% FYM recorded significantly higher dry matter production/plant as compared to other combination of chemical and organic combination in rice crop Tomar *et al.* (2018). Harish *et al.* (2017) integrated nutrient management (50% RDF through fertilizers + remaining 50% RDF through FYM and rock phosphate) recorded higher dry matter accumulation (DMA) as compared to inorganic nitrogen, organic manure and control in rice cultivation.

CONCLUSION

The results of two years of field study indicated that *Sesbania aculeata* incorporated at 45 DAS in soil recorded significantly higher growth attributes *viz.* plant height, number of tillers/m^2, number of leaves/running meter, dry matter accumulation/hill, dry matter of leaves/hill, and dry matter of shoot/hill as compared to other green manuring treatments. Among all nitrogen management treatments, 100 % RDN (50 % nitrogen through FYM and 50 % nitrogen through inorganic) recorded significantly higher growth attributes as compared to other nitrogen management during both the years. The results clearly indicated the need of integrated use of green manuring in addition to chemical fertilizers to meet the nutrient need for optimum growth of rice.

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