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Research Paper

Green manuring management in combination with inorganic nitrogen in rice-wheat cropping system under calcareous soil of Bihar

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ABSTRACT

Field study was conducted during the *kharif-rabi* season of 2016–17 to 2019–20 for 4 consecutive years at research farm of Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur (Bihar) to assess the effect of green manuring and nitrogen on rice and its residual effect on succeeding wheat. This was laid out in RBD, comprising seven treatments of green manuring (three age of *sesbania* with two seed rate along with one control) and five levels of nitrogen with three replications. Green manuring with *sesbania* at the age of 45 days with 30 kg seed rate recorded the maximum grain and straw yield of rice. This treatment recorded the maximum uptake of NPK by rice crop. This treatment also maintained the superiority in terms of B:C ratio. Application of graded level of nitrogen increased the grain and straw yield upto 120 kg/ha. However, interaction effect revealed that green manuring at 45 DAS with 30 kg seed rate coupled with 60 kg N/ha gave significantly maximum grain yield. Residual effect on succeeding wheat was maximum when age of *sesbania* for green manuring in rice was 65 days with 30 kg seed rate. This treatment also excelled in terms of NPK uptake by wheat crop along with higher B:C ratio.

***Key words*:** Green Manuring, Inorganic Nitrogen, Rice-Wheat cropping system etc

Intensive cropping with imbalance use of chemical fertilizer has put a question mark on the sustainability of the rice-wheat system. Soil productivity and soil health issues for food security in the state is a major concern and rice-wheat is a important component in securing food security. Besides other agronomic management practices, proper nutrient supply is a major constraints in sustaining system productivity in view of escalating cost of chemical fertilizers and emergence of one or more micro-nutrient deficiency and chemical fertilizers, particularly nitrogen driven rice production has created a imbalance in soil nutrient status affecting soil health adversely (Chaudhary *et al.*, 2014). Green manuring has been very much emphasized in recent years to address the concern of soil health issues and declining factors productivity in rice-wheat system (Paikaray *et al*., 2002). Green manuring management has to be prioritized not only to bring in sustainability to system but also to minimize the environmental pollution arising out of indiscriminate use of inorganic nitrogen. No doubt the use of chemical fertilizer is inevitable to meet the growing demand for rice and wheat. However, green manuring provides an economical opportunity to reduce external inputs. Moreover, despite having beneficial effect of puddling on rice growth, there is evidence of increased bulk density and reduced hydraulic conductivity hence it has serious issue of soil health due to creation of hard pan in the root zone thereby affecting adversely the normal root growth of subsequent crops. Green manuring is helpful in minimizing the ill effect and improves soil physical, chemical and biological condition. Soil enzymes catalyse various biochemical reactions which get affected by microbial population in soil system consequently affecting nutrient cycling (Dinesh *et al*., 2000). Its deep root system increases soil porosity, reduces bulk density and enhance hydraulic conductivity of soil (Chaudhary *et al*., 2014). However, a comprehensive evaluation of aspect like age and seed rate of Green manure crop and its integration with chemical source of nitrogen in rice was lacking. Hence, the present study was carried out to develop efficient green manuring practices in rice-wheat cropping system.

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MATERIALS AND METHODS

The field experiment was conducted for four consecutive years during rainy (*kharif*) and winter (*rabi*) seasons of 2016–17 to 2019–20 at the Research Farm of Dr Rajendra

Prasad Central Agriculture University, Pusa, Samastipur (Bihar). The soil was silty loam having organic carbon content 0.47%, available N, P and K 233.2, 21.4 and 141.7 kg/ha, respectively with alkaline reaction (pH 8.3). The treatment comprised of 7 treatments on age of *Sesbania* (dhaincha) and seed rate for green manuring viz; D_1-45 days after sowing (DAS) with seed rate of 20 kg/ha, D_2-45 DAS @ 30 kg/ha, D_3-55 DAS @ 20 kg/ha, D_4-55 DAS @ 30 kg/ha, D_5-65 DAS @ 20 kg/ha, D_6-65 DAS @ 30 kg/ha, D_7-No green manuring and 5-levels of nitrogen, vizy; N_o-0 kg N/ha, N_1-30 kg/ha, N_2-60 kg/ha, N_3-90 kg/ha and N_4-120 kg/ha. The experiment was laid out in a randomized block design with 3 replications. *Sesbania* was sown at 20 and 30 kg seed rate and were incorporated for green manuring at 45, 55 and 65 DAS as per treatment. Nitrogen was applied as ¼ basal, ½ active tillering +1/4 at panicle initiation. The field was uniformly supplied with basal dose of 60 and 40 kg of P_2O_5 and K_2o respectively. The dry matter of *Sesbania* was observed to be 3.75, 4.67, 7.73, 8.47, 10.28, 10.59 t/ha under D_1, D_2, D_3, D_4, D_5, and D_6, respectively with N, P and K contents ranging 2.07-2.34, 0.29-0.32 and 1.91-1.96 %, respectively. The test varieties were 'Rajendra Mahsuri1' for rice and HD 2967 for wheat. Twenty five days old seedlings of rice was transplanted during first week of july every year at 20×15 cm spacing with 2-seedlings /hill two days after incorporation of *Sesbania* every year. The succeeding wheat was sown during last week of November every year with RDF of 120-60-40 kg/ha along with 120 kg/ha seed rate. Post-harvest available N, P, K and organic carbon of samples were analyzed for uptake of nutrients by standard procedures.

RESULTS AND DISCUSSION

Green manuring (GM) Schedule at different levels significantly influenced the growth and yield attributes of rice. Among GM treatments, maximum value of LAI (Table 1) was recorded when *Sesbania* was incorporated at 45 DAS with 30 kg seed rate /ha (D_2) and it was 16.09% higher than Control (without GM), and 10.26 and 5.87% higher over 65DAS (D_6) and 55. DAS (D_4) with the same level of seed rate i.e. 30 kg/ha, respectively. The crop performance with respect to yield attribute like, panicles/m², grains/panicle and test weight (g) were significantly improved by GM (Table 1). The effect of GM on yield attributes of rice varied depending upon seed rate and time of its incorporation due to differential amount of green biomass and N addition to rice (Table1). In general, yield attribute and yield of rice were comparatively higher when green manuring was done at 45 DAS with 30 kg seed rate and it was minimum at 65 DAS @ 20 kg/ha seed rate. There were no significant differences among the GM treatments involving 45 DAS and 55 DAS at either seed rate for yield attributes and yield of rice. Maximums number of panicles/m² (299m²) was recorded with GM at 45 DAS with 30kg seed (D_2) which was significantly superior over all other treatments except GM at 55 DAS at the same level of seed rate (D_4). Moreover, this value was 30.57% higher over D_6 when GM was done at 65 DAS at the same level of seed rate while 48.76% superior over control.

Table 1. Yield attributes, yield and economics of rice as affected by different treatments (pooled data over 4 years)

Treatments	LAI at flowering	Panicles/ m²	Grains/ panicle	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	B:C ratio
Age of *dhaincha* & seed rate (kg/ha)							
D_1, 45 DAS @ 20 kg/ha	5.0	275	118	24.25	5.37	6.28	1.39
D_2, 45 DAS @ 30 kg/ha	5.05	299	124	24.93	5.64	6.54	1.51
D_3, 55 DAS @ 20 kg/ha	4.73	270	111	23.74	5.26	6.26	1.20
D_4, 55 DAS @ 30 kg/ha	4.77	286	113	23.86	5.4	6.37	1.27
D_5, 65 DAS @ 20 kg/ha	4.55	222	105	23.42	4.61	5.49	0.94
D_6, 65 DAS @ 30 kg/ha	4.58	229	105	23.46	4.72	5.57	0.98
D_7, Control (No organic)	4.35	201	82	22.83	3.41	4.04	0.48
SEm±	0.15	7.56	2.93	0.42	0.13	0.18	0.07
CD (P=0.05)	0.43	21.4	8.43	1.21	0.36	0.51	0.19
N-levels (kg/ha)							
N_0, 0.0	4.31	204	80	22.84	3.52	4.22	0.52
N_1, 30.0	4.55	231	106	23.62	4.5	5.27	0.99
N_2, 60.0	4.65	265	111	23.81	5.23	6.07	1.18
N_3, 90.0	5.01	283	120	24.14	5.56	6.56	1.41
N_4, 120.0	5.09	291	125	24.29	5.78	6.84	1.46
SEm±	0.14	6.36	2.58	0.41	0.12	0.16	0.06
CD (P=0.05)	0.41	18.57	7.69	1.19	0.35	0.46	0.17

Table 2. Interaction effect of organic and nitrogen level on grain yield (t/ha) of rice (pooled over 4 years)

Treatment	Nitrogen (kg/ha)				
	0	30	60	90	120
Age of dhaincha and Seed rate (kg/ha)					
D_1, 45 DAS @ 20 kg/ha	3.89	4.96	5.79	6.05	6.18
D_2, 45 DAS @ 30 kg/ha	4.09	5.24	6.2	6.31	6.34
D_3, 55 DAS @ 20 kg/ha	3.72	4.94	5.63	5.92	6.08
D_4, 55 DAS @ 30 kg/ha	3.83	5.09	5.85	6.04	6.2
D_5, 65 DAS @ 20 kg/ha	3.56	4.18	4.69	5.15	5.46
D_6, 65 DAS @ 30 kg/ha	3.64	4.29	4.86	5.25	5.55
D_7, Control (No organic)	1.91	2.78	3.57	4.18	4.63
SEm±			0.15		
CD (P=0.05)			0.43		

The beneficial effect of green manuring gets manifested through improvement in grains/panicle and test weight. Green manuring at 45 DAS with 30 kg seed recorded maximum number of grains/panicle (124) and it was 19, 9.73 and 51.22% higher over green manuring at 65 DAS (D6), 55 DAS (D_4) at the same level of seed rate and control (D_7), respectively. Similar trend was observed in test weight. Enhanced growth and yield parameters under early age of green manuring may be attributed to slow and synchronus availability of nutrients, meeting the nutrient requirement of rice crop at critical stages of growth. This might have also favored the solubilization of applied and fixed P along with other micro-nutrient in soil (Basak *et al*., 2017, Chaudhary *et al*., 2014). This is evident from these results (Table 1) that significantly enhanced value of most of the growth and yield attributing characters were recorded due to N scheduling with 60 kg N (N_2) and it was statistically at pat with successive higher N Level. This may be attributed to beneficial effect of N on various physiological activities. This may also be accounted to increased availability of N supply for better crop growth under green manuring coupled with inorganic N supply (Bar *et al*., 2000). Nitrogen has also major role in chlorophyll content thereby increasing the photosynthetic rate etc.

Rice grain yield was significantly get affected due to the combination of different treatments. Practice of green manuring at 45 DAS with 30 kg seed (D_2) contributed maximum yield of rice (5.6 4t/ha) and it was statistically superior over all other treatments except treatment D4. This treatment maintained superiority of 4.4, 19.5 and 65.47% over 55 DAS, 65 DAS at the same level of seed rate, and control (no organics), respectively. The enhanced rice grain yield under the influence of green manuring was mostly a manifestation of improved growth and yield attributes (Yadav *et al*., 2018). Application of N at Successive higher rates recorded remarkable improvement in rice grain and straw yields and maximum value (5.75 t/ha) being at 120 kg N/ha (N_4). However, the yield increase was significant only up to 60 kg N/ha (N2). Since green manuring contains a appreciable amount of essential plant nutrients and growth regulators, when combined with inorganic fertilizer N, it significantly improved the yield attributes and finally grain yield.Green manuring have good amount of K and Ca which can increase the stem strength making plant more input responsive due reduced lodging susceptibility (Ghos *et al*., 2007).

Interaction effect

A positive interaction was found between green manuring and inorganic N Levels for grain yield. Though maximum grain yield (6.34 t/ha) was recorded with combined application of green manuring at 45 days age of *Sesbania* (30 kg seed/ha) with 120 kg N/ha. However, significant response was only up to 60 kg N/ha (6.20 t/ha) thereby indicating a net saving of 60 kg fertilizer N. The yield increase with D over no organic at the same level of N i.e. 0, 30, 60, 90 and 120 kg N/ha was 114, 88.5, 73.7, 51.0 and 37% , respectively. In all other treatment of green manuring at either seed rate, significantly maximum grain yield was at 90 kg N/ha. Thus a net saving of 30kg of fertilizer N. It is evident that green manuring in combination with chemical N fertilizer is crucial for rice grain yield due to its ability of supplying of synchronized need of rice plant at various growth stages. Proper management of green manuring can reduce the over dependence on inorganic fertilizer N leading to development of environment friendly management practices for sustainable rice production. (Chaudhary *et al.,* 2018)

Nutrient uptake

The data concerning to NPK uptake by rice plant (grain + straw) varied significantly due to varying age of *Sesbania* green manuring and N level. Maximum uptake of N (102.12 kg/ha) was recorded with treatment D2 (45 days

age with 30 kg/ha seed) which was 4.76, 8.0, 5.36, 30.7, 28.6 and 93% higher over D_1, D_3, D_4, D_5, D_6 and D_7 respectively. Total P and K uptake also followed the similar pattern. Each increase in Levels of N significantly increased N, P and K uptake by rice crop. However, significant value was recorded only up to 90 kg N/ha. Enhancement in N uptake due to 30, 60, 90 and 120 kg over control was to the extent of 34.4, 67.5, 82.4 and 93.6%, respectively. More or less similar pattern was followed in case of P & K uptake. Green manuring coupled with inorganic fertilizer contributed to the enhance uptake of nutrients by plants. Also enhance uptake of nutrient like P may also be accounted to solubilizing effect of green manuring on available P in the soil. Improve uptake of nutrient may also be ascribed to the better root development in green manured crop due to the enhanced availability of P and Ca (Acharya and Mondal, 2007). Increased uptake of N, P and K may be accounted for better availability of nutrient in rice rhizosphere promoting better proliferation of root encouraging better grains and straw yield resulting into higher uptake (Yang *et al.,* 2018).

Residual effect on wheat

Residual effects of green manuring treatments applied to the preceding crop of rice were significant on yield attributes and yield of wheat. Significantly higher values of yield attributes like spikes/m^2, grain/spike and test weight (g) were recorded when green manuring of *Sesbania* at 65 days age at either seed rate (D_5 & D_6) to rice was done whereas, it was minimum when green manuring was done with 45 days age at either seed rate besides no green manuring treatment (D_7) (Talgre *et al*., 2012). The per cent increase in spikes/m^2 and grains/spike were about 14 and 19%, respectively between these two treatments (Table 3). The grains and straw yields were also significant between these treatments. The differences in grains yield was to the tune of 17% between these two treatments of green manuring (D_1 & D_6) whereas it was 23% over no green manuring. The value concerning to varying N level was significant only between control (No) and 120 kg N/ha (N4). This may be ascribed to the higher amount of woody material contained when green manuring was done at 65 days of *Sesbania*.

Nutrient uptake in wheat

The total NPK uptake by wheat crop also varied due to green manuring treatment applied to rice. The significantly maximum values were obtained in D_6 green manuring at 65 days of age. Since green manuring at 65 days *Sasbania* contained more woody biomass as compared to 45 days age that mineralized slowly in the subsequent *rabi* season (Pooniya and Shivay, 2018).

Post-harvest soil-nutrient status

At the end of completion of fourth cycle of rice-wheat-Sequence, there was appreciable improvement in organic

Table 3. Residual effect of different treatments on yield attributes, yield and economics of succeeding wheat (pooled over 4 years)

Treatment	Spikes/ m^2	Grains/ spike	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	B:C ratio
Age of *dhaincha* & seed rate(kg/ha)						
D_1, 45 DAS @ 20 kg/ha	301	37	40.39	3.94	4.77	1.57
D_2, 45 DAS@ 30 kg/ha	310	38	40.52	4.06	4.75	1.63
D_3, 55 DAS@ 20 kg/ha	323	41	40.69	4.28	4.79	1.73
D_4, 55 DAS@ 30 kg/ha	328	42	40.83	4.31	4.81	1.76
D_5, 65 DAS@ 20 kg/ha	335	42	41.62	4.51	5.03	1.86
D_6, 65 DAS@ 30 kg/ha	343	44	41.93	4.60	5.13	1.91
D_7, Control (No organic)	298	36	40.07	3.74	4.34	1.51
SEm±	8.56	1.26	1.10	0.11	0.17	0.053
CD (P=0.05)	24.47	3.57	NS	0.31	0.47	0.15
N levels (kg/ha)						
N_0, 0.0	307	36	40.76	4.06	4.71	1.63
N_1, 30.0	313	38	40.8	4.15	4.69	1.72
N_2, 60.0	320	41	40.86	4.21	4.72	1.72
N_3, 90.0	327	41	40.93	4.29	4.80	1.75
N_4,120.0	330	44	40.99	4.34	5.12	1.74
SEm±	7.08	1.0	1.06	0.08	0.14	0.041
CD (P=0.05)	21.11	2.93	NS	0.22	0.41	0.12

Table 4. Nutrient uptake by rice and wheat and soil properties as affected by different treatments in rice–wheat cropping system (pooled over 4 years)

Treatment	Nutrient uptake by Rice and Wheat (kg/ha)						Available nutrient (kg/ha)			BD (g/cc)	OC (%)
	Rice			Wheat							
	N	P	K	N	P	K	N	P	K		
Age of *dhaincha* & seed rate (kg/ha)											
D_1, 45 DAS @ 20 kg/ha	97.49	14.21	120.03	99.6	21.46	76.58	236.7	20.7	144.2	1.50	0.44
D_2, 45 DAS @ 30 kg/ha	102.13	14.77	124.74	102.98	22.03	78.11	238.4	21.3	144.7	1.49	0.45
D_3, 55 DAS @ 20 kg/ha	94.83	13.49	116.83	106.91	22.93	79.60	238.1	21.5	145.2	1.49	0.47
D_4, 55 DAS @ 30 kg/ha	96.93	14.37	119.03	108.01	23.21	80.54	239.7	22.2	147.1	1.48	0.47
D_5, 65 DAS @ 20 kg/ha	78.13	11.26	95.80	113.96	24.33	84.28	240.2	22.1	146.9	1.48	0.48
D_6, 65 DAS @ 30 kg/ha	79.43	11.49	97.41	116.23	24.86	86.05	241.8	22.6	148.4	1.47	0.49
D_7, Control (No organic)	52.93	7.71	70.07	93.12	20.13	70.51	233.1	18.2	140.8	1.52	0.41
SEm±	3.07	0.40	2.96	3.23	0.60	2.71	-	-	-	0.014	0.038
CD (P=0.05)	8.64	1.14	8.61	9.30	1.69	7.63	-	-	-	0.04	0.11
N-level(kg/ha)											
N_0, 0.0	55.53	8.22	70.48	101.08	21.84	76.17	234.8	19.8	142.6	1.51	0.42
N_1, 30.0	74.62	11.15	92.49	103.38	22.25	77.58	236.2	20.7	144.3	1.49	0.44
N_2, 60.0	93.0	13.33	113.48	105.09	22.57	78.46	238.9	21.4	145.7	1.49	0.47
N_3, 90.0	101.3	14.21	123.6	108.42	23.16	80.46	240.7	22.0	146.7	1.48	0.48
N4, 120.0	107.53	15.44	131.32	111.35	23.79	84.38	241.0	22.2	147.3	1.47	0.49
SEm±	2.70	0.38	2.43	2.84	0.49	2.14	-	-	-	0.014	0.034
CD (P=0.05)	7.93	1.11	7.14	8.41	1.44	6.29	-	-	-	0.04	0.10
Initial value							233.2	21.4	141.7	1.53	0.41

Carbon content, bulk density, available N, P and K content of soil over their respective initial values (Table 4). The maximum improvement in these parameters was more evident when green manuring was at 65 days age of *sesbania* with 30 kg seed rate, presumably due to higher content of woody material and its Subsequent slow mineralization and release of nutrients to wheat crop.

This is evident from these results that green manuring at younger age of 45 and 55 days at either seed rate is more pronounced on rice itself and it has comparatively less residual effect on succeeding wheat. On the other hand, green manuring at later stage of 65 days, the residual effect is large on wheat and less on rice due to lower quantity of green leafy biomass. Thus, it can be inferred that *Sesbania* green manuring at 45-55 days age with 30 kg seed rate along with 60 kg N/ha in rice and 100% N (120 kg N/ha) in subsequent wheat crop is beneficial for their higher yield. This way we can say that green manuring is an effective tool for enhancing system productivity.

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