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National Academy of Agricultural Science (NAAS) Rating : 3.03

Enhance the soil health, nutrient uptake and yield of crops under rice-wheat cropping system through green manuring

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Abstract: *A field experiment was conducted at agricultural research farm at Baba Raghav Das Post Graduate College, Deoria during two continuous years of 2009-10 and 2010-11. The main objective of experiment was to assess the response of different summer green manuring on soil health, crops yield and nutrient uptake under rice-wheat cropping system. The green manure crops viz. sunnhemp (Crotolaria juncea L.), dhaincha (Sesbania aculeate Poir.) and green gram (Phaseolus aureus Roxb.) were grown as summer green manuring during April to June. Fresh weight of organic matter added by dhaincha, sunnhemp and green gram was 30.35, 33.15 and 15.10 tonneha^{-1} and dry matter added 5.65, 5.52 and 3.71tonneha^{-1}, respectively. Nitrogen supplying capacity of sunnhemp, dhaincha and green gram was recorded 125.3, 120.2 and 78.4kgha^{-1}, respectively. Summer green manuring alone and in combination with nitrogenous fertilizer increase the grain yield of rice and wheat (residual) as well as N, P, K and S uptake, respectively. The highest grain yield of rice ware obtained when sunnhemp grown as green manures crop incorporated along with 120kg nitrogenha^{-1} followed by dhaincha and green gram. In case of wheat, incorporated dhaincha gave highest grain yield followed by sunnhemp and green gram. The same trend with respect to N< P< K and S uptake was observed in both the crops. Soil after harvesting of rice-wheat crops showed reduced bulk density and pH, whereas organic carbon and cation exchange capacity slightly increased due to summer green manuring. The nutrient balance sheet of soil after harvest of rice crop in green manuring plot showed positive balance of nutrients whereas wheat crop almost all nutrients had negative balance in soil.*

Keywords: *Cropping system, Green manuring, Nutrient, Rice, Soil health and Wheat.*

INTRODUCTION

Rice-Wheat is the most predominant cropping system in Indo-Gangatic Alluvial belt of the country and contributes major portion to the food basket. Intensive cultivation and growing of exhaustive crop have made the soil deficient in macro as well as in micronutrients (Nambiar *et al*. 1992). The nutrient removal per unit area in the rice- wheat cropping system at an average productivity level is much higher the average fertilizer application for the same. Unless the system is provided with adequate amount of required plant nutrient there will be greater drain of native soil fertility and the will not be able to sustain the high productivity on long term basis. The value of leguminous green manure crop for improving soil fertility has been recognized since very early times. The benefit credited to them increasein organic matter content and available plant nutrient and improvement in the physical, chemical and biological properties of soil. The addition of organic matter in the form of green manures greatly influences the transformation and availability of nitrogen and several other essential plant nutrients through its impact on the chemical and biological properties of soil (Tiwari *et al*.). Therole of green manuring as integrated nutrient management system in sustaining food production and improving environmental quality. Use of chemical fertilizer alone may not keep pace with time in maintenance of soil health for sustaining crop productivity.

MATERIALS AND METHODS

A field experiment was conducted during 2009-10 and 2010-11 for two consecutive years on the sandy loam

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(Inceptisol Type Ustochrept) at Agricultural Research farm of Baba Raghav Das Post Graduate College Deoria Uttar Pradesh. The initial physical, chemical properties of soil are given in Table 1. All the package of practices of Rice and Wheat applied as normal recommendation.Twenty treatment combinations including one fallow and three legume crops, viz. greengram (*Phaseolus aureus* Roxb.), sunnhemp (*Crotolaria juncea* Linn.) and dhaincha (*Sesbania aculeata* Poir.) with five levels of nitrogen control, 30, 60, 90 and 120 kgha^{-1} were applied. Experiment consisted under split plot design with three replications. Summer green gram in mid of April and other two crops sunnhemp and dhaincha in the mid of May were sown. The green manures crops were fertilized with 40 kg P_2O_5, 30 kg K_2O ha^{-1} and nitrogen as per treatment through urea. 50% nitrogen applied at transplanting, 25 % at tillering and 25% at panicle initiation stage. Rice crop was transplanted at 20x10 cm spacing and basal applications of 60 kg P_2O_5 and 60 kg K_2O ha^{-1} through single superphosphate and potassium chloride were applied, respectively. The same fertilizer doses were applied to wheat crop also. The soil sample was taken just after harvest of the crops. Standard method and procedures were followed for analysis of soil and plant materials, such as organic carbon in soil sample by wet chromic acid digestion method (Walkley and Black, 1934), Bulk density by core cutter method (Jackson 1973), pH and electrical conductivity (EC) in 1:2.5 soil and distilled water suspension with help of pH and EC meter cation exchange capacity (CEC) by neutral ammonium acetate extract method (Jackson 1973) , available N P K in soil by alkaline permagnate method (Subbiah and Asija 1956), Olsen"s method (Olsen *et al*. 1954), neutral narmal ammonium acetate extract method (Jackson 1973) respectively and available Cu, Zn, Fe and Mn in DTPA extract by Atomic Absorption Spectrophotometer (Lindsay and Norvell 1978). NPK content in plant material was determined in H_2SO_4 + salisylic acid digest (Wallinga *et al*. 1989). The pool data of two year observations has been summarized and discussed here.

Table 1
Physico- Chemical properties of experimental soil

Parameters	*Values*
Bulk density (Mgm^3)	1.5
Textural soil	Sandy loam
pH	7.8
CEC [Cmol (p+)kg^{-1}]	17.3
EC (dSm-1)	0.25
Organic carbon (g kg^{-1})	4.0
Available N (kg ha^{-1})	216.4
Available P (kg ha^{-1})	18.9
Available K(kg ha^{-1})	230.1
Available Cu (mg ha^{-1})	3.6
AvailableZn (mg ha^{-1})	2.8
Available Fe (mg ha^{-1})	20.2
AvailableMn (mg ha-1)	16.8

RESULTS AND DISCUSION

Rice–Wheat crop yield: The data pertaining to rice and wheat crop yield (Table 2) revealed that maximum yield was recored from the plot receiving sunhemp green manuring in rice while dhaincha green manuring in wheat incorporated plots along with recommended dose of N (ie. 120 kg ha^{-1}) followed by 90, 60 and 30 kg N ha^{-1} during both the crop. The higher rice grain yield was obtained in sunnhemp followed by dhaincha and green gram incorporated plots respectively. The highest rice straw yield was observed same trend whereas in case of wheat was recorded in dhaincha followed by sunnhemp. The narrow C: N ratio of green manures to fast mineralization might have released nutrient of faster rate resulting in to higher yield of rice. The maximum number of tiller and test weight resulted in higher grain yield of rice and wheat due to significant improvement in wet soil NH_4-N and NO_3-N and oxidized soil NO_3-N at different growth stage of crop. Goswami *et al.* (1988) working on effect of green manuring also observed a significant favourable effect on crop.

Physico-chemical properties of soil: Data given in table 3 reveal that BD of soil was decreased significantly sunnhemp incorporated plot followed by dhaincha and green gram after harvest of rice while in case of wheat significantly reduced in BD recorded in dhaincha plot followed by sunnhemp and green gram. During decomposition of organic matter various organic polysaccharides, and humus are produced which may be responsible for binding of soil particles resulting in more stable aggregates and causing reduction in bulk density. De Haan (1977) had reported that green manures added to sandy soil decreased bulk density.

Organic carbon and cation exchange capacitystatus of soil after harvest of rice and wheat (Table 3) summer green manures along with fertilizer N through urea increased organic carbon and CEC of soil as compared to control plots. The maintenance of organic matter in soil is dependent several factor soil and climatic factor affecting microbial activity. CEC of soil increased due to accumulation of organic matter content in soil. Addition of organic matter along with fertilizer increased the CEC of soil

Table 2
Effect of green manuring and levels of N on yield attributes of rice and wheat (Pooled of two years)

Treatment	*Rice*				*Wheat*			
	No. of grains spike^{-1}	*Test weight*	*Grain yield (kg ha^{-1})*	*Straw yield (kg ha^{-1})*	*No. of grains spike^{-1}*	*Test weight*	*Grain yield (kgha^{-1})*	*Straw yield (kg ha^{-1})*
Green manure crops								
Fallow	147	23.1	4227	6720	45.5	40.2	3440	4273
Greengram	152	23.9	4793	7093	47.2	41.4	3740	4587
Sunnhemp	174	24.7	5120	7040	48.8	42.2	4100	4940
Dhaincha	172	24.5	4900	7347	51.2	43.3	4200	5113
CD (P=0.05)	15.81	1.01	124	132	2.78	0.98	116	102
Nitrogen levels (kg ha^{-1})								
Control	139	22.0	4122	6230	41.1	37.4	2097	3072
30	147	23.5	4513	6780	43.8	41.0	3536	4170
60	166	24.1	4735	7046	48.5	42.8	4180	4968
90	175	24.9	5130	7467	52.2	43.4	4655	5538
120	180	25.6	5280	7730	54.0	46.6	4865	5888
CD (P=0.05)	7.62	0.66	117	160	3.12	0.86	239	206

Table 3
Effect of green manuring and levels of N on soil characteristics (Pooled of two years)

Green Manures	*Rice*				*Wheat*			
	BD (Mgm^{-3})	*pH*	*OC (g kg^{-1})*	*CEC [Cmol(p+) kg^{-1}]*	*BD (Mgm^{-3})*	*pH*	*OC (gkg^{-1})*	*CEC [Cmol (p+) kg^{-1}]*
Fallow	1.50	7.80	4.2	17.4	1.50	7.80	4.0	17.6
Green gram	1.44	7.75	5.2	18.6	1.48	7.78	4.5	18.5
Sunnhemp	1.38	7.72	5.4	19.8	1.46	7.76	4.6	19.4
Dhaincha	1.40	7.73	5.3	20.6	1.44	7.75	4.8	20.6
C D (P=0.05)	0.06	NS	0.60	1.24	0.04	NS	0.3	1.02
Nitrogen levels								
0.00	1.45	7.72	5.9	18.0	1.49	7.74	5.2	18.6
30.00	1.42	7.72	5.4	19.2	1.48	7.72	4.8	19.4
60.00	1.40	7.71	5.2	19.8	1.46	7.70	4.8	19.9
90.00	1.40	7.73	5.0	20.6	1.46	7.70	4.6	20.4
120.00	1.39	7.74	4.8	20.8	1.45	7.66	4.2	20.6
C D (P=0.05)	0.04	NS	0.30	0.56	0.02	NS	0.02	0.47

Table 4
Effect of green manuring and levels of N on total nutrient uptake kg ha^{-1}(Pooled of two years)

Green Manures	*Rice*			*Wheat*		
	N	*P*	*K*	*N*	*P*	*K*
Fallow	97.8	17.2	62.4	71.2	15.9	86.1
Green gram	99.4	20.4	67.1	79.4	18.1	94.3
Sunnhemp	125.2	22.6	69.2	89.8	19.7	104.0
Dhaincha	120.4	21.2	71.0	93.7	20.1	107.3
C D (P=0.05)	1.67	0.72	1.84	1.92	0.47	1.21
Nitrogen levels						
0.00	63.5	15.2	56.6	29.2	7.1	52.1
30.00	104.3	18.4	64.1	73.1	17.2	88.9
60.00	119.4	20.4	68.0	90.7	20.1	105.3
90.00	133.7	23.4	72.6	108.1	23.0	118.1
120.00	145.6	24.6	77.2	116.7	25.4	126.4
C D (P=0.05)	1.42	0.64	1.52	1.32	0.63	1.12

Table 5
Effect of green manuring and levels of N on available major nutrient kg ha^{-1}after harvest of crops (Pooled of two years)

Green Manures	*Rice*			*Wheat*		
	N	*P*	*K*	*N*	*P*	*K*
Fallow	210.6	20.1	233.1	200.1	19.1	235.2
Green gram	216.8	21.3	241.3	208.2	20.8	237.6
Sunnhemp	221.2	23.0	243.8	209.1	22.3	241.4
Dhaincha	219.8	22.1	247.1	211.6	21.0	239.7
C D (P=0.05)	3.92	1.56	5.09	3.84	1.31	2.10
Nitrogen levels						
0.00	209.3	19.2	226.9	184.8	18.0	215.4
30.00	217.9	21.3	241.8	204.1	20.1	239.5
60.00	215.9	22.9	243.2	210.6	21.5	242.3
90.00	221.7	23.6	245.1	215.3	22.6	248.0
120.00	230.8	24.2	249.6	221.3	23.9	250.7
C D (P=0.05)	2.43	1.16	2.51	3.01	1.16	1.80

compared to control. These finding are in agreement with reported by Sharma *et al*. (2001).

Nutrient uptake by Rice and Wheat: The data reveal that (Table 4) maximum nutrient uptake in sunnhemp followed by dhaincha and green gram in the case of rice while higher uptake of nutrients in dhaincha followed by sunnhemp and green gram in the case of wheat crop. A significant increase in total uptake of NP and K were obtained with increasing in N doses over control. The uptake of NPK by rice and wheat crops due to incorporation of green manures along with 120 kg N ha^{-1} followed by 90 kg N ha^{-1}.The uptake and translocation of NPK to rice and wheat crops. The increased in uptake of major nutrients may be better released of these nutrient through additional supply and prolific root system of green manuring crops resulting better absorption of water and nutrients. The integrated use of green manures combination with fertilizer has been beneficial in the NPK uptake by rice and wheat crops. These result were find a support as reported by Mahapatra and Jee (1993).

Available NPK status: The data reveals that available NPK status of soil after harvest of rice and wheat crop is given in table 5 the N content of surface soil increased significantly with incorporation of sunnhemp along with chemical fertilizer followed by dhaincha and green gram. Legumes crop increased Ncontent of soil. The favorable soil condition under green manuring might have helped in more mineralization of soil nitrogen leading to build op more available N. The green manuring influence solubility of native phosphorus and increased the availability. Releasing of organic acid and CO_2 after decomposition of green manures tend to lover the pH in neutral and alkaline soil and raise solubility of calcium phosphate.The beneficial effect of green manure on available K may be released of K due to interaction of organic matter. The result of study revealed that available NPK buildup was higher in sunnhemp plot, P and K in dhaincha plots. Talanur and Badanur (2003) also reported NPK increase in soil due to incorporation of organic manures and along with fertilizers.

Three leguminous crops viz. green gram (Phaseolus aureus Lin.), sunnhemp (Crotolaria juncea L.) and dhaincha (Sesbania aculeate Poir.) were grown in summer season to study the response of rice – wheat and soil characteristics in relation to grain yield and nutrient uptake by crop. Sunnhemp and dhaincha supplied treatments along with 120 kg nitrogen ha^{-1} gave maximum yield of rice and wheat. Further, summer green manuring along with inorganic fertilizers decrease bulk density and pH of soil, whereas organic carbon, cation exchange capacity are increased. Summer green manuring practice has applied as best alternative of inorganic fertilizers for sustaining rice – wheat yield and soil health in alluvial soil. After harvesting of wheat mostly field is left fallow, it may be use for growing of summer green manures and maximum yield of rice – wheat will be obtained.

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