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Effect of integrated nutrient management on yield of rice and its residual effect on wheat in rice-wheat system under lowland

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ABSTRACT

A field experiment was conducted for three Kharif seasons of 2013, 2014 and 2015 at Crop Research Station, Ghaghraghat, Bahraich, U.P. Application 75% RDF as inorganic fertlizers alongwith green manuring of dhaincha insitu incorporated in alternate year recorded significantly higher values of growth and yield attributes over rest of the treatments except 100% RDF as inorganic fertilizers. This treatment also recorded significantly highest grain and straw yield (45.04 and 72.0 q ha^{-1} respectively) followed by 75% RDF as inorganic fertilizers along with green manuring of sunhemp insitu incorporated in alternate years and100% RDF. The uptake of nitrogen, phosphorus and potassium by rice crop was followed the same trend as in case of grain and straw yield. The net income (Rs. 57648 ha^{-1}) and benefit: cost ratio (1.45) was recorded highest with 75% RDF as inorganic fertilizers alongwith green manuring of dhaincha followed by 75% RDF along with sunhemp green manuring treatment with net income of Rs.56868 ha^{-1} and benefit: cost ratio (1.43). All fertilizer treatments reduced the bulk density and improved the organic carbon, available N, P and K as compared to initial values. However, the improvements in above components were much higher with 75% RDF as inorganic sources alongwith green manuring of dhaincha insitu. Application of 75% RDF as inorganic sources alongwith green manuring of dhaincha to preceding rice and no fertilizer to succeeding wheat gave the highest grain yield (16.87 qha^{-1}) as compared to rest of the treatments.

Key wards: INM, green manure crops, nutrient uptake, soil fertility, rice-wheat system

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple food crops in the world. It is the major source of calories for 40 percent of the world population. Its cultivation is of immense importance to food security to Asia, where more than 90% of the global rice is produced and consumed. India occupied 44.1 million hectares of rice area with a production of 105 million tonnes and average yield 2.4t ha^{-1}. Currently, the population is increasing at alarming rate but there is no scope to increase the net cultivable land for rice production. To meet the demands of increasing population and to maintain self sufficiency, the present production level of 105 million tonnes needs to be increased up to 125 million tonnes by the year 2020. Exploiting theproduction potential of high yielding rice varieties through agronomic management is one of the alternatives to feed the ever raising population. For this, fertilizers have contributed substantially to the spectacular increase in rice yield. However, growing crop with indiscriminate use of fertilizer over the years has resulted in deterioration of soil quality and decline in crop yield with poor quality of produce.

Rice-wheat cropping system being cereal-cereal crop rotation having the high fertilizers demand, exhausted the soil fertility consequently decline in the organic carbon and soil productivity. On the other hand, application of sub-optimal and imbalance doses of nutrients created multinutrient deficiency in the soil resulted in deterioration in soil fertility. Integrated nutrient management (INM) aims for efficient and judicious use of all the major sources of plant nutrients in an integrated manner. Therefore, the combined use of organic manure and inorganic fertilizer help in maintaining yield stability through correction of marginal deficiencies of secondary and micronutrients enhancing efficiency of applied nutrients and providing favorable soil physical condition (Gill and Walia, 2014, Singh, 2017).Use of inorganic sources with green manuring crops was found to be the best option to restore the fertility and improved productivity of crops. After decomposition of green manure crops, the nutrient release quickly in the soil in available forms. In addition, organic

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acids released during the course of decomposition of green manure crops favour the mobilization of other soil nutrients. An attempt was thus made to study the effect of inorganic fertilizer and green manuring on rice and its residual effect on wheat in rice-wheat system in lowlands.

MATERIALS AND METHODS

A field experiment was conducted for 3 consecutive seasons of kharif 2013, 2014 and 2015 at the Crop Research Station, Ghaghraghat, Bahraich (U.P.). The soil of experimental field was sandy clay loam in texture having bulk density 1.39 Mg m^{-3}, pH 7.9, Soil organic carbon 4.2 g kg^{-1}, available (N 220 kg ha^{-1}), phosphorus (14.8 kg ha^{-1}) and K (203 kg ha^{-1}). The experiment was conducted with eight treatments comprised of; control (T_1), 100% RDF-IF (T_2), 50% RDF-IF + sunhemp green manuring insitu incorporation every year (T_3), 75% RDF-IF + sunhemp green manuring insitu incorporation in alternate year (T_4), 50% RDF-IF + dhaincha green manuring insitu incorporation every year (T_5), 75% RDF-IF + dhaincha green manuring insitu incorporation in alternate year (T_6), 50% RDF - IF + green gram green manuring insitu incorporation every year (T_7), 75% RDF-IF + green gram green manuring insitu incorporation in alternate year (T_8) were tested in randomized block design replicated 3 times. The green manuring crops like sunhemp (*Crotalaria juncea* L.), dhaincha (*Sesbania acculiata*) and Green gram (*Vigna radiata* L.) were sown in respective treatments after harvest of wheat in summer and incorporated at 35 days after sowing. The recommended dose of fertilizer (100 N+ 60 P_2O_5 + 40 K_2O kg ha^{-1}) were applied to rice using urea, single superphosphate and muriate of potash and no fertilizer was applied to succeeding wheat crop. The half dose of nitrogen and full P and K were applied at the time of transplanting of rice, remaining dose of nitrogen was top dressed in two equal splits at tillering and panicle initiation stage (PIS). Rice variety “NDGR-201” was transplanted on 10-12 July in all the years and wheat “PBW-343” was sown in first week of December in each year. The yield attributes like panicle length, panicle weight, grains $panicle^{-1}$was recorded on 10 panicles selected randomly for each plot before harvest of rice. The 1000-grain weight was recorded treatment wise in each plot at threshing of rice crop. The grain and straw samples collected at harvest was analyzed for N, P and K contents in grain and straw by adopting standard procedures (Jackson 1973). Soil samples (0-15cm) collected before and after harvest of the crop were analyzed for available N (Subbiah and Asija, 1956), P (Olsen *et al.,* 1954), K (1 N NH_4OAc) and organic carbon (Jackson 1973). Bulk density was measured by core method. The data pertaining to yield and yield attributes were subjected to statistical analysis as per standard procedure.

RESULTS AND DISCUSSION

Growth studies

Growth parameters like dry matter accumulation, leaf area index and plant height at 90 DAT were affected significantly due to different treatments (Table 1). Among the green manuring crops, dhaincha followed by sunhemp and green gram resulted higher dry matter accumulation, LAI and taller plant. The highest values of dry matter accumulation (57.60 q ha^{-1}), LAI (6.57) and plant height (169.0 cm) were recorded with 75% RDF as fertilizers alonwith green manuring of dhaincha insitu (T_6) followed by75% RDF as fertilizers alongwith green manuring of sunhemp (T_8). The higher values of these growth parameters with green manuring of dhaincha may be attributed to higher availability of nutrients as compared to sunhemp or green gram green manuring. Similar beneficial effect of green manuring of dhaincha was also reported by Kalaiyarasan and Lokanadhan (2015).

Yield attributes

The values of yield attributes like panicle weight, grain weight $panicle^{-1}$, 1000-grain weight and panicle length were affected significantly due to various organic and inorganic treatments (Table 1). Application of 75% RDF as inorganic fertilizers alongwith incorporation of green mauring of dhaincha, sunhemp and green gram gave significantly higher values of these attributes as compared to 50% RDF as inorganic fertilizers with green manuring of dhaincha, sunhemp and green gram. This was mainly due to additional 25% NPK had more pronounced effect on availability of nutrients to rice crop

where green manuring was added in alternate years as compared to later treatments where green manuring was added every year. Application of 100% RDF as inorganic fertilizers recorded significantly higher values of yield attributes as compared to 50% RDF as inorganic fertlizers alongwith green manuring of dhaincha, sunhemp and green gram incorporated every year. However, 75% RDF as inorganic fertlizers alongwith green manuring crops of dhaincha, sunhemp and green manure incorporated in alternate years gave significantly higher values of all yield attributes as compared to rest of the treatments except 100% RDF as inorganic fertlizers. The combined application of inorganic fertlizers with green manure gave significantly maximum value of number of panicle m^{-2} and 1000- grain weight as reported by Khan *et al.* (2007), Larijani and Hoseini (2012).

Table1: Growth and yield attributes of rice as affected by integrated nutrient management practices

Treatment	Growth parameters				Yield attributes			
	Panicle m^{-2}	Dry matter at 90 DAT	L A I at 75 DAT	Plant height (cm) at 90 DAT	Panicle length (cm)	Panicle weight (g)	Grain weight $panicle^{-1}$	1000-grain weight
T_1	250	23.08	3.73	141.6	25.80	3.07	2.10	24.07
T_2	387	53.42	5.61	165.6	27.03	4.03	2.80	26.19
T_3	340	51.08	5.43	154.8	26.20	3.57	2.52	25.62
T_4	389	57.03	6.15	168.4	27.09	4.13	2.81	26.21
T_5	350	51.80	5.93	157.0	26.28	3.67	2.59	25.79
T_6	394	57.60	6.57	169.0	27.32	4.17	2.94	26.25
T_7	332	45.89	5.05	150.4	26.10	3.40	2.38	25.32
T_8	373	50.80	6.08	160.7	26.97	3.87	2.73	25.64
CD (P=0.05)	20.9	4.27	0.53	8.4	0.88	0.32	0.25	0.40

IF – Inorganic fertilizer, GM – Green manuring, Treatments: T_1- control, T_2- 100% RDF (IF), T_3- 50% RDF (IF) +sunhemp (GM) incorporation every year, T_4- 75% RDF (IF) + sunhemp (GM) incorporation in alternate year, T_5- 50% RDF (IF) + dhaincha (GM) incorporation every year, T_6- 75% RDF (IF) + dhaincha (GM) incorporation in alternate year, T_7- 50% RDF (IF) + greengram (GM) incorporation every year, T_8- 75% RDF (IF) + greengram (GM) incorporation every year

Yields

Application of 100% RDF as fertlizers produced significantly higher grain and straw yield over control as reported by Singh (2017). Application of 50% RDF as fertilizers with green manure of dhaincha, sunhemp and green gram insitu incorporated every year resulted lower yield as compared to 100% RDF as fertilizers. These increases in yield with 100% RDF could be attributed to higher value of growth and yield attributes. Rice crop fertilized with 75% RDF as fertilizers alongwith green manuring of dhaincha, sunhemp and green gram incorporated in alternate year produced significantly higher grain and straw yield as compared to 50% RDF as fertilizers alongwith green manures like dhaincha, sunhemp and green gram incorporated in every year. The percent increases in grain yield due to 75% RDF as fertilizers alongwith green manures of dhaincha, sunhemp and green gram insitu incorporated alternate year were to the tune of 15.3, 14.8 and 12.6 over 50% RDF alongwith green manure of dhaincha, sunhemp and green gram, respectively. The effect of green mauring with dhaincha incorporated either in each year or alternate year was found superior to sunhemp and green gram. Green manuring of green gram was less effective as compared to dhaincha. This might be due to adequate biomass production and better nutrient uptake which might have resulted higher straw yield in these treatments. Steady and adequate supply of nutrients by the enhanced biochemical activity of micro organisms coupled with more photosynthesis surface would have helped in the production of more tillers and dry matter with enhanced supply of assimilates to the sink resulting in higher yield. Similar results were obtained by Kumar and Singh (2010) and Mehdi *et al.,* (2011), Kumar, *et al.* (2011), Ranjitha *et al.,* (2013), Kalaiyarasan and Lokanadhan (2015).

Table 2: Yield, economics and nutrient uptake by rice as affected by different integrated nutrient management practices (mean of 3 years)

Treatment	Yield (qha^{-1})		Economics			Nutrient uptake (kg ha^{-1})		
	Grain	Straw	Cost of cultivation (Rs. ha^{-1})	Net income (Rs. ha^{-1})	B:C ratio	N	P	K
T_1	16.92	28.76	33551	26029	0.77	30.8	6.8	53.9
T_2	42.67	66.78	38673	54543	1.41	93.3	16.7	132.9
T_3	38.51	63.86	39592	49405	1.25	81.3	18.8	123.7
T_4	44.42	71.29	39713	56868	1.43	95.6	22.2	143.9
T_5	39.13	64.76	39592	50194	1.27	83.4	19.5	125.4
T_6	45.04	72.00	39713	57648	1.45	97.5	22.8	145.4
T_7	34.32	57.37	39592	44052	1.11	71.3	16.5	109.1
T_8	38.66	63.51	39713	49567	1.25	83.2	19.2	126.7
CD (P=0.05)	4.04	7.61	-	-	-	11.0	1.24	9.17

Residual effect on wheat

The green manuring of dhaincha, sunhemp and green gram incorporated in alternate year alongwith 75% RDF as fertilizers had significantly higher residual grain and straw yield of wheat as compared to 50% RDF as fertilizers alongwith green manuring of dhaincha, sunhemp and green gram. Application of 100% RDF to preceding rice crop produced significantly higher grain and straw yield of wheat as compared to 50% RDF alongwith green manuring of dhaincha, sunhemp and green gram incorporated.

Uptake of nutrients

The uptake of N, P and K by rice crop was affected significantly due to various treatments. Combined use of green manuring alongwith inorganic fertilizers improved the uptake of nutrients (NPK) over control. Rice fertilized with 75% RDF as fertilizers with green manuring of dhaincha incorporated in alternate year had significantly higher uptake of (97.5 kg N ha^{-1}), (22.8 kg P ha^{-1}) and (145.4 kg K ha^{-1}) followed by 75% RDF as inorganic fertilizers alongwith green manuring of sunhemp added alternate year and 100% RDF as inorganic fertilizers. Application of 100% RDF resulted significantly higher uptake of N (93.3 kg ha^{-1}), P (16.7 kg ha^{-1}) and K (132.9 kg ha^{-1}) as compared to 50% RDF as fertilizers alongwith green mauring of dhaincha, sunhemp and green gram. The higher uptake of N, P and K with incorporation of green manuring alongwith inorganic fertlizers may be attributed to higher contents of N, P and K in rice grain and straw coupled with higher yields. Satish *et al.* (2011), Virdia and Mehta (2009) also reported similar higher uptake of N, P and K by rice.

Soil properties

The bulk density of soil was reduced in all treatments as compared to its initial value except control treatment (Table 3). The maximum reduction in bulk density was recorded with incorporation of green manuring of dhaincha followed with green manuring of sunhemp and green gram. The contents of organic carbon improved significantly in all the treatments except control, however, magnitude of improvement was higher with incorporation of dhaincha followed by green manuring of sunhemp and green gram. The increase in contents of organic carbon with green manures in rice-wheat system has also been reported by Kumar and Singh (2010) and Kumar and Prasad (2008). Application of green manuring either every year or alternate year alongwith either 75% or 50% RDF as fertilizers significantly improved the amount of available N, P and K in soil as compared to initial values. However, maximum increase was recorded with green manuring alongwith 75% RDF as fertlizers incorporated in alternate year. The increase in available N in soil with incorporation of green manure may be attributed to the fact that green manuring might have helped in mineralization of soil N leading to buildup of higher available nitrogen. Increase in available P in soil may be attributed to decomposition of organic matter accompanied by the release of abundant quantities of CO_2 where CO_2 production plays a dominant role in enhancing the phosphorus

availability. The long-term incorporation of green manure crops significantly increased the available K contents of soil as compared to NPK added as fertilizers alone. Application of green manuring with fertilizers improves the soil organic carbon and reduced the bulk density. Dubey *et al.* (2014) also reported improvement in bulk density, organic carbon, available P and K content in soil as compared to its initial value with integrated nutrient sources.

Table3: Effect of integrated nutrient management practices on soil properties.

Treatment	Bulk density Mg m^{-3}	Soil organic carbon (g kg^{-1})	Available nutrients (kg ha^{-1})			Yield of wheat (q ha^{-1})	
			N	P	K	Grain	Straw
T_1	1.42	3.9	217	13.9	192	12.80	16.57
T_2	1.35	4.8	247	16.8	235	15.20	18.82
T_3	1.25	5.5	250	17.2	229	13.75	17.43
T_4	1.26	5.7	254	17.7	236	16.65	19.52
T_5	1.24	5.6	252	17.5	232	14.50	18.26
T_6	1.25	5.8	258	17.9	240	16.87	20.84
T_7	1.28	5.1	239	15.8	224	13.50	17.18
T_8	1.27	5.4	248	16.3	231	14.25	18.04
CD (P=0.05)	0.03	0.05	015	0.7	011	1.64	1.91
Initial values	1.41	4.3	245	15.3	202	-	-

Economics

Application of 75% RDF as fertilizers along with green manuring of dhaincha incorporated in alternate year gave highest net income (Rs. 57648 ha^{-1}) and benefit: cast ratio (1.45) followed by sunhemp green manuring incorporated in alternate year with75% RDF as fertilizers and 100% RDF as fertilizers. The lower profitability was recorded with control treatment owing to lower yield as compared to higher cost involved. The higher net income and benefit: cost ratio with 75% RDF as fertilizers along with green manuring of dhaincha incorporation in alternate year was mainly due to lower cost involved and higher yield as compared to 50% RDF as inorganic fertilizers alongwith green manuring of dhaincha incorporation every year.

It is concluded from the results that rice crop should be fertilized with 75% RDF as fertilizers alongwith green manuring of dhaincha insitu incorporated in alternate year to obtain higher yield, net income, benefit: cost ratio and sustainability of soil fertility.

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