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Changes in soil fertility under integrated use of farm yard manure, green manure, crop residue and fertilizer on sustaining productivity of rice-wheat system

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Abstract
A field experiment was conducted to study the long-term effect of inorganic fertilizers coupled with farm yard manure, green manure and wheat cut straw on organic carbon, and available N, P, K. in soil. The rice-wheat cropping system significantly improved the organic carbon content and available N, P, K status of the soil by integrated use of fertilizer and organics. The highest grain and straw yield of rice and wheat were obtained with farm yard manure or *Sesbania aculeata* as green manure to meat 50 per cent N in conjunction with 50 per cent RDF in rice and 100% recommended dose of NPK through fertilizers (RDF) in wheat. The organic carbon content, available N, P and K were significantly influenced by the use of 50 per cent N through organic sources of nutrients in conjunction with 50 per cent RDF under rice-wheat cropping system.

Keywords: Rice-wheat cropping system, organic carbon, available N, P and K

Introduction
Cereal crop generally require a good supply of major nutrients especially N during most of their growth period. The availability of N in the soil has been known to be a prime factor in determining the overall growth and yield. Nitrogen is usually added through fertilizers. Judicious application of inorganic N along with organic source and green manure is one of the concepts gaining importance. The mineralizable N in the soil plays a dominant role in the nutrition of crops. Incorporation of organic materials with fertilizer N is known to stimulate the mineralizable factions (Subehia and Sepehya, 2012) [3]. The objective of present study is to investigate the changes in organic carbon, available N, P and K and yield of rice and wheat under integrated nutrient management.

Materials and Methods
The present investigation was carried out during 2012-13 and 2013-14 in a long-term nutrient management experiment initiated during *Kharif*, 1984 at Agronomy Research Farm, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad, Uttar Pradesh. The soil of experimental site was silty loam in texture with pH 8.8, organic carbon 3.7 g ha^{-1}, available N, P and K 102, 13.8 and 355 kg ha^{-1}, respectively, before start of experiment in 1984-85. Rice cultivar Sarjoo-52 and wheat cultivar HUW-234 were grown in a sequence at the same site with twelve treatments in randomized block design having four replications. Out of twelve, six promising treatments were selected for discussing the results in this paper. The treatment details for *Kharif* and *Rabi* are given in Table 1. The recommended fertilizer doses of N, P and K were 120, 60 and 60 kg ha^{-1} for rice and wheat both separately. The source of N, P and K were urea, diammonium phosphate and muriate of potash, respectively. Wheat cut straw was incorporated in the moist soil about two weeks prior to rice transplanting, while well decomposed FYM and 45-50 days old chopped *Sesbania aculeata* (*Dhaincha*) were incorporated in the soil 2-3 days before transplanting of rice under puddled conditions in *Kharif* season, every year. The average N content of FYM, wheat cut straw and green manure (*Sesbania aculeata*) on oven dry basis was 0.81%, 0.51% and 2.4%, respectively. After completion of 30^{th} crop cycle, soil samples were collected and analysed for organic carbon and available macronutrients following standard procedures.

Results and Discussion
Grain yield
The grain yield data revealed that maximum grain yield of rice (5.39 t ha^{-1}) and wheat (3.59 t ha^{-1}) were obtained in the treatment received incorporation of FYM to meet 50 per cent N in

combination with 50 per cent RDF in rice and 100% RDF in wheat followed by the treatment received *Sesbania* green manure to meet 50 per cent N along with 50 per cent RDF in rice (5.14 t ha^{-1}) and 100 per cent RDF in wheat (3.38 t ha^{-1}), which remained at par to the treatment received 100 per cent RDF in rice and wheat both. Similar to grain yield, the maximum straw yield of rice (7.75 t ha^{-1}) and wheat (4.85 t ha^{-1}) were recorded with the treatment of FYM to meet 50 per cent N plus 50 per cent RDF in rice and 100 per cent RDF in wheat followed by *Sesbania* green manure to meet 50 per cent N with 50 per cent RDF in rice and 100 per cent RDF in wheat. Maximum rice grain equivalent yield (9.58 t ha^{-1}) of system was also obtained by substitution of 50 per cent N through FYM in rice under rice-wheat system which was at par to sole application of 100 per cent recommended NPK through fertilizers in both crops. The findings indicated that the combined application of well decomposed organic nutrient source and chemical fertilizers proved to be superior to sole inorganic fertilizer application. The higher yield may be attributed to release of plant nutrients in balanced way which might have facilitated better crop growth (Pathak *et al.*, 2005) [2].

Organic carbon

Organic carbon content of surface soil (Table 2) increased significantly with incorporation of FYM or *Sesbania aculeata* in conjunction with fertilizer. There was significant increase of 56.7] 40.5 and 45.9 per cent in organic carbon by incorporation of FYM, WCS and *Sesbania* GM, respectively, after completing cycles of rice-wheat system. The increase in organic carbon content may be attributed to addition of organic materials and better root growth resulting in higher biomass, crop stubbles and residues. The subsequent decomposition of these might have resulted in increase of organic carbon of the soil (Moharana *et al.*, 2012) [1].

Available nitrogen

Available nitrogen content of surface soil (Table 2) in rice-wheat rotation varied significantly with application of FYM/ *Sesbania* green manure/ wheat cut straw in combination with fertilizer. The highest available nitrogen in surface soil (210 kg ha^{-1} and 215 kg ha^{-1}) was recorded with incorporation of FYM along with fertilizer after harvest of rice and wheat, respectively followed by *Sesbania* GM. Increase in available nitrogen with FYM and *Sesbania* green manure application might be attributed to the direct addition of nitrogen through FYM and *Sesbania aculeata* (*Dhaincha*) to the available pool of the soil. The increase in available nitrogen due to organic materials application resulted in the greater multiplication of soil microbes due to the addition of organic materials which enhanced the conversion of organically bound N to inorganic forms (Walia *et al.*, 2010) [5].

Table 1: Grain yield of rice and wheat as affected by different sources of nutrients (pooled for two years, 2012-13 and 2013-14)

Treatment		Yield (t ha^{-1})				
Rice	Wheat	Rice		Wheat		Rice grain equivalent
		Grain	Straw	Grain	Straw	
T_1-Control	Control	1.50	2.40	0.70	1.03	2.32
T_2-50% NPK	50% NPK	3.29	5.05	1.91	2.75	5.53
T_3-100% NPK	100% NPK	5.02	7.32	3.36	4.58	8.94
T_4-50% NPK + 50% N through FYM*	100% NPK	5.39	7.75	3.59	4.85	9.58
T_5-50% NPK + 50% N through WCS**	100% NPK	4.02	6.08	3.36	4.58	7.94
T_6-50% NPK + 50% N through GM***	100% NPK	5.14	7.56	3.38	4.54	9.08
CD (P=0.05)		0.39	0.53	0.28	0.38	0.73

* Farm yard manure, ** Wheat cut straw, *** Green manuring of *Sesbania aculeata*

Table 2: Effect of different sources of nutrients on available nutrient status of soil after 30 cropping cycles

Treatment		Organic carbon (g kg^{-1})		Macronutrients (kg ha^{-1})					
Rice	Wheat	AR	AW	N		P		K	
				AR	AW	AR	AW	AR	AW
T_1-Control	Control	2.6	2.5	95	101	6.0	5.3	198	188
T_2-50% NPK	50% NPK	4.0	3.7	133	144	16.3	15.3	233	219
T_3-100% NPK	100% NPK	5.0	4.8	194	201	25.3	24.0	266	252
T_4-50% NPK + 50% N through FYM*	100% NPK	6.3	5.8	210	215	28.6	27.1	274	259
T_5-50% NPK + 50% N through WCS**	100% NPK	5.5	5.2	178	198	22.4	21.3	278	272
T_6-50% NPK + 50% N through GM***	100% NPK	6.0	5.4	206	213	26.7	25.5	258	255
CD (P= 0.05)		0.38	0.42	8.9	10.5	2.4	1.8	10.4	11.7
Initial in 1984		3.7		102		13.8		355	

AR= After rice harvest, AW- after wheat harvest

Available phosphorus

Incorporation of FYM or *Sesbania aculeata* (*Dhancha*) in combination with chemical fertilizer recorded significantly higher phosphorus content in surface soil under rice-wheat crop rotation. The result indicate that available P content of soil increased significantly with incorporation of FYM in conjunction with 50 per cent RDF over 100 per cent NPK through fertilizers alone. The increased available P content of soil might be due to release of organic acids during decomposition which in turn helped in releasing phosphorus. Increase in available P with FYM application might also be due to solubilization of the native P in the soil through release of various organic acids (Urkurkar *et al.* 2010) [4]. The organic materials also forms a protective cover on sesquioxides and thus reduces the phosphate fixing capacity of the soil (Bharadwaj *et al.*, 1994).

Available potassium

Available potassium content of surface soil in rice-wheat crop rotation differed significantly due to various organic materials in combination with inorganic sources of nutrients. Wheat cut straw in conjunction with fertilizer recorded highest amount of available potassium followed by FYM and *Sesbania* green manure. The incorporating organic materials *viz.*, wheat cut straw and FYM resulted higher available potassium content than sole application of 100 per cent NPK through fertilizers alone in rice-wheat cropping system. The beneficial effect of organics on available potassium may be ascribed to the reduction of potassium fixation and release of potassium due to the interaction of organic matter with clay, besides direct addition to the potassium pool of the soil (Subehia and Sepehya, 2012) [3].

Thus, it may be concluded that integrated nutrient management coupled with farm yard manure or green manure of *Sesbania aculeata* and chemical fertilizers sustains the productivity of rice-wheat cropping system and enhances soil fertility in long run.

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