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Effect of integrated nutrient management on yield and soil properties of rice (*Oryza sativa*)

Neeraj Kumar, Atik Ahamad and Arika Rajkumar

Abstract
The field experiment was conducted at Main Experimental Station of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) during the *Kharif*, 2014 to Effect of integrated nutrient management on soil properties, growth and yield of rice (*Oryza sativa*). Ten treatments *viz.* T_1 (control), T_2 (100% RDF) T_3 (125% RDF), T_4 (100% RDF + FYM @ 5 t ha^{-1}), T_5 (100% RDF+ Brown Manuring), T_6 (100% RDF + BGA@ 10 kg ha^{-1}), T_7 (100% RDF + PSB), T_8 (Farmers practice (N_{100}:P_{40}:K_0), T_9 (100% RDF + FYM @ 5 t ha^{-1} + PSB+*Azatobacte*r + BGA) and T_{10} (100% RDF + FYM @ 5 t ha^{-1} + PSB + *Azatobacter* + Brown Manuring) were comprised in Randomized Block Design with three replication. Significantly higher plant height, higher grain and straw yield was recorded under treatment having 100% RDF+FYM @ 5 t ha^{-1}+ PSB+ *Azotobacter* + Brown Manuring as compared to control which was and statistically at par with treatment 100% RDF+ FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + BGA). Whereas the maximum significant of organic carbon, available N, P, K and Zn estimated under the treatment having 100% RDF+FYM @ 5 t ha^{-1}+ PSB+ *Azotobacter* + Brown Manuring as compare to control. The maximum net income (Rs. 29566 ha^{-1}) and benefit cost ratio (0.76) were obtained with the treatment having (100% RDF+ FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + BGA) followed by treatment 100% RDF + FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + Brown Manuring.

Keywords: INM, Yield, Soil Properties

Introduction
Rice (*Oryza sativa* L.) is the most important staple food crop in the World. Rice is the rich source of energy and contains reasonable amount of protein (6-10%), carbohydrate (70-80%), mineral (1.2-2.0 %) and vitamin (Riboflavin, Thiamine, Niacin and Vitamin E). More than 90 per cent of the world's rice is grown and consumed in Asia (rice bowl of the world), where 16 per cent of the earth's people and two third of world's poor live. It is used in several preparations and has commercial and industrial importance. Besides grains, its straw is also used as fodder, packing and insulation material and in the manufacture of card board etc. Asia's Future food security, therefore, required research and development efforts aimed increasing yield potential of rice and diversification of its production system with the possible genetic approached to meet this challenge. Cultivation of high yielding dwarf varieties responsive to fertilizer and irrigation in intensive cropping after green revolution with continuous and excess use of inorganic fertilizers has depleted the inherent soil fertility. The decline or stagnation in yield has been attributed to nutrient mining and reduced use of organics (John *et al.*, 2001). Integrated nutrient management favorably affects the physical, chemical and biological properties of soil. Organics supply nutrients at the peak period of absorption and also provide micro nutrients and modify soil physical behaviors well as increase the efficiency of applied nutrients (Pandey *et al*., 2007). Farmyard manure (FYM) is being used as major source of organic manure in field crops as it supplies all essential plant nutrients and increases activities of microbes in soil (Sutaliya and Singh, 2005). Limited availability of FYM is however an important constraints in its uses as source of nutrients. *Brown Manuring* has been introduced as green manure crop before rainy rice season. It is broadcasted in mid may and incorporated into soil after 45-50 days. Rice is then transplanted 2-3 days after Sesbania incorporation. The organic matter and nitrogen produced by *Sesbania* help to improve the soil health and enhance the subsequent crop growth. *Sesbania* can produce up to 80-100 kg N ha^{-1}. Green manuring and farmyard manuring may help in reducing the deleterious effects of rice cultivation on soil physical properties. The necessity of organic manure increases many folds in salt-affected soils because of their poor structure and low fertility.

Materials and Methods
The present investigation was under taken during kharif 2014 at Main Experimental Station of

Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad. The experimental site falls under subtropical climate in Indo-Gangetic plains having alluvial calcareous soil and lies between 26°47' North latitude and 82°12' East longitude at an altitude of 113 m from mean sea level. The region receives annual rainfall ranging from 1000-1200 mm and 90 per cent of which is received in Mid-June to end of September. The soil of the experimental field was silt loam, having pH 7.9, EC 0.38 Organic carbon 0.30, Available N, P and K 130.96 kg ha^{-1}, 16.90 kg ha^{-1} and 220.75 kg ha^{-1} respectively. The transplanting was done on 22 June, 2014 using 20 days old seedlings of rice cultivar NDR-97 at the spacing of 20x10 cm using 2-3 seedlings per hill. There were ten treatment combinations as detailed below: T_1 (control), T_2 (100% RDF) T_3 (125% RDF), T_4 (100% RDF + FYM @ 5 t ha^{-1}), T_5 (100% RDF+ Brown Manuring), T_6 (100% RDF + BGA@ 10 kg ha^{-1}), T_7 (100% RDF + PSB), T_8 (Farmers practice (N_{100}:P_{40}:K_0), T_9 (100% RDF + FYM @ 5 t ha^{-1} + PSB+*Azatobacte*r + BGA) and T_{10} (100% RDF + FYM @ 5 t ha^{-1} + PSB + *Azatobacter* + Brown Manuring). The recommended dose of fertilizer for 100% was 120 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1}. Threshed grains were separated out manually and grains were sun dried to moisture of 14% before recording their weight. Straw yield was recorded by subtracting the weight of grains from the weight of each net plot. Electrical conductivity was determined with the help of EC meter in 1:2.5 soil water suspensions as described by Jackson (1973). Organic carbon was determined with the help Walkley and Black's rapid titration method as advocated by Walkley and Black's (1934). The available nitrogen content in soil samples was determined by alkaline permanganate method as described by Subbiah and Asija (1956). The available phosphorus in soil determined by Olsen's method as per procedure described by Olsen's *et al*. (1954). The available potassium in soil was determined by Morgan's method as advocated by Jackson (1973). Zinc content in soil was analyzed by DTPA (Diethylene triamine penta acetic acid) extract method (Lindsay and Norwell, 1978) and the intensity of colour was measured on automatic absorption spectrophotometer.

Results and discussion

Plant height:

Plant height is a direct index to measure the growth and vigour of the plant. The plant height at the time of harvest were significant indicating that all the tested planting methods showed at par effect on growth of rice after establishment (Table 1). The effect of INM practices on plant height at harvest revealed that application of 100%RDF+FYM @ 5t ha^{-1}+PSB+*Azotobacter*+ Brown Manuring was significantly registered taller plants over the other treatments. The mineralization during the decomposition of organic manures (FYM and green manure) due to integrated use of inorganic fertilizers might have enhanced nitrogen availability in the *rhizosphere* resulting in increased nitrogen uptake by the crop which in turn promoted the increase in plant height in the above treatments. availability of essential plant nutrients to the crop for a longer period with use of organic manures along with inorganic fertilizers has increased plant height as the crop growth advanced Harish *et al.* (2011).

Yield:

The yield attribute data are presented in Table 1 which clearly shows that the Treatment T_{10} (100% RDF + FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + Brown Manuring) was the best treatment amongst all of rest treatments. Integrated nutrient management (INM) treatments were found significantly superior over control as well as all other treatment combinations at harvest. Grain and straw yield of rice were found increased with increasing doses of nutrients (NPK) up to 100% RDF applied either through inorganic fertilizer or with integration of organic sources. The maximum rice grain yield (47.07 q ha^{-1}) and straw yield (59.90 q ha^{-1}) was obtained in T_{10} (100% RDF + FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + Brown Manuring) which was significantly at par with T_9 (100% RDF+ FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + BGA). The increase in grain, straw yield and harvest index were affected with the supplement of supplied the nutrient in combination through organic, green manure, biofertilizer and inorganic fertilizers. Thereby improving the efficiency in utilization of nutrient as well as applied nutrients which ultimately improved the yield attributing characters and yield of crop. These results are also corroborate with the findings of Khairnar and Thakur (2011), Khursheed *et al.* (2013), and Swarup and Yaduvanshi (2013) FYM acts as a store-house for macro and micro nutrients both which may enhanced the metabolic process vis-à-vis enlarged source and sink capacity ultimately increased the grain and straw yields. The results are in agreement with those of the finding of Sowmya *et al.* (2011), Singh *et al.* (2011) and Majumdar et al. (2007), who have reported for sustained production in a rice-wheat cropping system, integrated nutrient management involving both organic manures/residue and chemical fertilizers.

Table 1: Effect of integrated nutrient management on growth, yield and soil physco- chemical properties of rice crop

Treatments	Plant height (cm)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)	pH	EC (dSm^{-1})
T_1: Control	70.85	21.20	28.21	42.91	7.88	0.32
T_2: 100% RDF	81.28	38.26	48.27	44.22	7.86	0.30
T_3: 125% RDF	82.72	43.16	54.38	44.25	7.87	0.31
T_4 : 100% RDF + FYM @ 5 t ha^{-1}	84.10	42.87	52.73	44.84	7.82	0.30
T_5: 100% RDF+ Brown Manuring	83.52	41.98	52.11	44.62	7.83	0.30
T_6: 100% RDF + BGA @10 kg ha^{-1}	82.65	42.72	52.92	44.67	7.85	0.31
T_7: 100% RDF +PSB	81.99	39.95	49.42	44.70	7.86	0.31
T_8: Farmers pracice (N_{100}:P_{40}:K_0)	79.00	28.12	35.46	44.23	7.87	0.31
T_9: 100% RDF+ FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + BGA	85.11	46.90	59.16	44.22	7.83	0.29
T_{10}:100% RDF + FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + Brown Manuring	86.95	47.07	59.90	44.00	7.81	0.28
SEm$\pm$	2.96	1.22	1.49	1.45	0.02	0.01
CD (P= 0.05)	8.08	3.61	4.46	NS	0.06	NS

Soil properties

The results revealed that improved soil physical conditions reflected by lower bulk density of soil, when applied organic and inorganic sources of nutrients continuously. Integration of organic sources with inorganic fertilizer were found more effective as compared to single application in building up fertility and improving physical status of soil.

The maximum reduction in soil pH and EC was noticed under treatment T_{10} (100%RDF+FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + Brown Manuring) followed by 100% RDF+ FYM @ 5t ha^{-1} + PSB +*Azotobacter* + BGA) which might be due to the production of organic acid from FYM and green manure decomposing resulting lowering of this property. However, a difference in EC was found non-significant (Table 2). The application of FYM, brown manure and BGA increased the formation of humic acid and humus soil and these decrease the soil pH and Electrical conductivity. The reduction in EC of the soil with application of FYM, green manure and BGA may ascribed to salt leaching facilitated by improved permeability of soil and formation of weak salts as a result reduction in electrical conductivity. The maximum reduction in pH with organic manure might be due to formation of organic acid during decomposing of organic manure which neutralized the sodium salt present in soil and increase the hydrogen ion concentration. These results closely corroborate with the findings of Datta *et al.* (2008) and Koushal *et al.* (2011).

Maximum organic carbon was observed with application of treatment consisting T_{10} (100%RDF+FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + Brown Manuring (Table 2). Application of FYM and green manure increase humus carbon in soil. Better crop growth was observed with FYM, green manure and BGA treated plots might be due to the improvement of physical and chemical properties of the soil and providing good soil environment to plant and enhance root growth leading to accumulation of more organic residues in the soil while its increase with the treatment combination is ascribed to direct incorporation of organic matter through organics. These results closely corroborates with the findings of Kumar *et al.* (2007) and Prakash and Nikhil (2014).

The maximum availability of N, P, K, S and Zn were estimated under the treatment having T_{10}-100%RDF+FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + BGA) was significantly superior over the treatments T_4 (100% RDF + FYM @ 5 t ha^{-1}), T_5(100% RDF +Brown Manuring), T_3(125% RDF), T_6 (100%RDF+BGA @ 10 kg ha^{-1}), T_2(100% RDF), T_7 (100% RDF+ PSB), T_8(Farmers practice(N_{100}:P_{40}:K_0) and T_1(control) while statically at par with treatment T_9 (100% RDF+ FYM @ 5 t ha^{-1}+PSB+*Azotobacter*+ BGA) value of 141.28 kg ha^{-1} was recorded. Better crop growth was observed with FYM, green manure and BGA treated plots might be due to the improvement of physical and chemical properties of the soil and providing good soil environment to plant and enhance root growth leading to accumulation of more organic residues in the soil while its increase with the treatment combination is ascribed to direct incorporation of organic matter through organics. Available Zinc content in soil was significantly increased under treatment having FYM, green manure and BGA along with combination of inorganic fertilizers. Increased in availability of zinc in soil may be a scribed due to additive supply of zinc through FYM, brown manure, BGA and $ZnSO_4$ fertilizer which increased the availability of zinc under treatment having Brown manuring, FYM and biofertilizer along with inorganic fertilizers. Similar findings were observed by Singh and Singh (2007).

Table 2: Effect of integrated nutrient management on OC (%), Available N, P, K (kg ha^{-1}) and Zn (ppm) content in soil at harvest of rice crop

Treatments	OC	N	P	K	Zn
T_1: Control	0.30	111.94	14.12	216.15	0.48
T_2: 100% RDF	0.29	126.71	17.25	226.47	0.55
T_3: 125% RDF	0.30	132.07	17.30	231.55	0.54
T_4 : 100% RDF + FYM @ 5 t ha^{-1}	0.32	139.39	19.41	236.63	0.58
T_5: 100% RDF+ Brown Manuring	0.31	136.33	19.36	233.80	0.57
T_6: 100% RDF + BGA@ 10 kg ha^{-1}	0.30	130.10	18.55	225.42	0.54
T_7: 100% RDF +PSB	0.29	124.28	19.52	225.10	0.53
T_8: Farmers pracice(N_{100}:P_{40}:K_0)	0.30	120.28	16.80	214.95	0.47
T_9: 100% RDF+ FYM @ 5t ha^{-1} + PSB +*Azotobacter* + BGA	0.32	141.28	20.76	235.90	0.59
T_{10}:100%RDF+FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + Brown Manuring	0.34	148.96	21.30	238.76	0.60
SEm$\pm$	0.01	3.08	0.61	4.78	0.02
CD (P= 0.05)	0.02	9.14	1.86	12.16	0.06

Economics

The variation in the cost of cultivation was found due to various doses of RDF, FYM, brown manure and BGA the major inputs (Table 3). Grain yield was major output factor, which caused difference in net income and net return per rupees invested. highest net return (Rs. 29566 ha^{-1}) was computed under the treatment T_9 (100% RDF+ FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + BGA) followed byT_{10} (100% RDF + FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + Brown Manuring) The variation in nutrition might be due to increased cost of cultivation. This trend in economic return is mainly due to the treatment effect on the grain and straw yield of rice. The maximum benefit cost ratio (0.76) was computed under the treatment T_9 (100% RDF+ FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + BGA) followed by T_{10}, T_3, T_6 and T_4. These results also corroborated with the findings of Parasuraman (2005).

Table 3: To work out the economics of various treatments.

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
T_1: Control	28900	32150.5	2190.5	0.08
T_2: 100% RDF	36177	57890.5	19800.5	0.55
T_3: 125% RDF	37996	65301	25147	0.66
T_4 : 100% RDF + FYM @ 5 t ha^{-1}	38677	64798	23977.5	0.62
T_5: 100% RDF+ Brown Manuring	38052	63476.5	23325.5	0.61
T_6: 100% RDF + BGA @10 kg ha^{-1}	37777	64590	24677	0.65
T_7: 100% RDF +PSB	36302	60398.5	22099	0.61
T_8: Farmers pracice (N_{100}:P_{40}:K_0)	32673	42547	8468	0.26
T_9: 100% RDF+ FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + BGA	39052	70963	29566	0.76
T_{10}:100% RDF + FYM @ 5 t ha^{-1} + PSB + *Azotobacter* + Brown Manuring	40802	71246.5	28091	0.69

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