The Ecoscan 10(3&4): Supplement on Rice: 431-435, 2016
AN INTERNATIONAL QUARTERLY JOURNAL OF ENVIRONMENTAL SCIENCES

RESPONSE OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD AND SOIL PROPERTIES OF TRANSPLANTED RICE (*Oryza sativa* L.) IN EASTERN PLAIN ZONE OF UTTAR PRADESH

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ABSTRACT

A field experiment was conducted at Agricultural Research Farm of Banaras Hindu University, Varanasi to explore the possibility of substituting fertilizer N with organic manure in an integrated manner. The experiment was conducted in Randomized Block Design with 12 different INM modules. T_6-25% N through green leaf manure + 75% N through fertilizer recorded highest grain (49.65, 51.37 q ha^{-1}) and straw (73.65, 75.33 q ha^{-1}) yield, which was significantly higher over rest of the treatment except T_3, T_7, T_9 and T_{12}. Soil physico-chemical properties differed non-significantly and found decreased in all INM modules over control. Highest organic carbon (0.54, 0.53 %) maximum CEC (16.30, 16.34 cmol p+ kg^{-1}), water holding capacity (45.43, 46.60 %) and available nitrogen (241, 240 kg ha^{-1}) phosphorus (24.66, 25.60 kg ha^{-1}) was recorded in T_8-75% N through green leaf manure + 25% N through fertilizer, while available potassium (238, 240 kg ha^{-1}) was reported in T_{11}-75% N through poultry manure + 25% N through fertilizer. Hence, it can be concluded that use of chemical fertilizers with green leaf manure increased the crop yield but, increased amount of green leaf manure further improved the soil health by increasing organic carbon, CEC, water holding capacity, available N, P and K.

KEY WORDS
Organic Manure
FYM
Green Leaf Manure
Poultry Manure

Received : 21.02.2017
Revised : 27.05.2017
Accepted : 29.06.2017

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INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important stable food crop in the world. It is the major source of calories for 40 percent of the world population (Virdia and Mehta, 2009). Currently, the world population is increasing at alarming rate but there is no scope to increase the net cultivable land for crop production. Exploiting the production potential of high yielding rice through agronomic management is one of the alternatives to feed the burgeoning population. For this, fertilizers have contributed substantially to the spectacular increase in rice yield. Production of rice with indiscriminate use of fertilizers has however, resulted into degradation of lands owing to low yields with poor quality of produce. The use of inorganic fertilizer to sustain crop production was found to increase yield only for few years but on long-term, it has not been effective and leads to soil degradation (Satyanarayana *et al.,* 2002). On the other hand, continuous application of organic fertilizer alone on rice field resulting low yield and low N and K content at the mid-tillering stage of rice plant (Javier *et al.*, 2004). This implies that, the need of integrated nutrient management for rice production. The use of adequate dose of organic source coupled with chemical fertilizers is expected to ensure optimum growth condition under intensive agriculture using rice hybrid (Singh, *et al.,* 2004). Kumar *et al.,* 2014 reported significantly highest grain (69.16 q ha^{-1}) and straw (83.12 q ha^{-1}) yield with 75% RDF + 25% FYM-N over 75% RDF and 50% RDF + 50 % FYM-N. Similarly, Chaudhary *et al.* (2017) also observed that, 50 % NPK through mineral fertilizer + 50 % N through FYM found at par to chemical fertilizer alone in okra production. Integrated Nutrient Management (INM) not only minimize the land degradation and environmental pollution but, also reduce the use of inorganic fertilizer, increasing their use efficiency, save farmer's money, increase organic matter in soil, enhance the quality of environment and over all judicious use of all the major sources (Farouque and Takeya, 2007). It has been well established that organic sources not only increase soil fertility but also improve soil physical conditions, nutrient holding capacity and decreased bulk density and soil crusting due to the continuous use of organic manure (Das, 2011). Gill and Walia, (2014), reported that, combined use of organic and inorganic fertilizers, stabilized yield through correction of marginal deficiencies of secondary and micronutrients. Therefore, the present experiment was undertaken to study the Integrated Nutrient Management on Yield and Physic-chemical Properties of Soil in Transplanted Rice in Eastern Plain Zone of Uttar Pradesh to explore the possibility of substituting fertilizer N with organic manure (FYM, green leaf manure, poultry manure and BGA) in an integrated manner.

MATERIALS AND METHODS

A field experiment was conducted at Banaras Hindu University's Agricultural

Research Farm, during *kharif* season of 1999 and 2000. The soil of the experimental field was sandy loam having pH 7.8, EC (0.38 dS/m), CEC (12.70 c mole p+kg^{-1}), organic carbon 0.40 %, Available N, P and K 201, 19.40 and 221 kg ha^{-1} respectively. The experiment was laid out in a randomized block design with 12 different INM modules involving different levels of Nitrogen *viz.*, T_1-Control, T_2-100%N through fertilizer, T_3-25% N through FYM +75% N through fertilizer, T_4-50% N through FYM +50% N through fertilizer, T_5-75% N through FYM +25% N through fertilizer, T_6-25% N through green leaf manure + 75% N through fertilizer, T_7-50% N through green leaf manure + 50% N through fertilizer, T_8-75% N through green leaf manure + 25% N through fertilizer, T_9-25% N through poultry manure + 75% N through fertilizer, T_{10}-50% N through poultry manure + 50% N through fertilizer, T_{11}-75% N through poultry manure + 25% N through fertilizer and T_{12}-25% N through FYM + 50% N through fertilizer + BGA@10kg ha^{-1}. After proper field preparation the experiment was laid out according to plan, required quantity of fertilizer nitrogen, phosphorus, and potassium were applied to rice through, single super phosphate (SSP) and muriate of potash (MOP), respectively. 120 kg ha^{-1} of nitrogen was considered as full dose (100%) of nitrogen. Part of recommended doses of P_2O_5 (60 kg ha^{-1}) and K_2O (60 kg ha^{-1}) each were applied uniformly as basal dose to all the plots. The N P K content in various organic manures was analyzed and their required quantity were substituted by organics as per the treatments were calculated. Full dose of FYM, poultry manure and green leaf manure were incorporated 20 days before transplanting of rice seedling, whereas, half dose of required nitrogen (Urea) was given as basal application, remaining half dose of nitrogen was applied in two equal splits at tillering and flowering stages and BGA was applied as biofertilizer @ 10 kg ha^{-1}. The soil samples were processed and analyzed for various soil properties; bulk density (Pycnometer as described by Chopra and Kanwar, 1982), water holding capacity (Keen-Roczknowski box, described by Chopra and Kanwar, 1982), pH and EC (described by Chopra and Kanwar, 1982), organic carbon determined by Walkley and Black's rapid titration method (Jackson, 1973), CEC (as described by Jackson, 1973). The determination of available nitrogen was done by alkaline permanganate method (Subbiah and Asija, 1956), available phosphorus by Olsen's (1954) method (as described Houba *et al.,* 1988), and potassium by flame photometer described by (Jackson, 1973). The data were analyzed as per the standard procedure for Analysis of Variance (ANOVA) as described by Gomez and Gomez (1984). The significance of treatments was tested by 'F' test (Variance ratio). Standard error of mean (SEm±) was computed in all cases. The difference in the treatment mean was tested by using critical difference (CD) at 5% level of probability.

RESULTS AND DISCUSSION

Grain and Straw Yield

Data regarding the effect of various integrated nutrient management on grain and straw yield have been presented in Table 1. Inorganic fertilizer and their combination with FYM, green manure and poultry manure influenced the grain and straw yield of rice significantly over control. It is obvious from the data that maximum grain (49.65, 51.37 q ha^{-1}) and straw (73.65, 75.33 q ha^{-1}) yield of crop was found under the treatment T_6 receiving 25% N through green manure + 75% N through fertilizer, followed by T_3. Grain yield of rice (Ramaakshmi *et al.,* 2012) found higher with INM practices, especially when vegetable market waste compost was applied. The higher grain yields of rice with integrated use of green leaf manure and chemical fertilizers might be attributed to higher availability of N P K and facilitating uptake by plants resulting in better growth and dry matter production and also occurrence of different beneficial microorganisms. Similar results were reported by Barik *et al.*(2008) and Datta and Singh

Table 1: Effect of integrated nutrient management on grain and straw yield of rice.

Treatments	Grain Yield (q ha^{-1})		Straw Yield (q ha^{-1})	
	1999	2000	1999	2000
T_1	20.8	18.47	40.15	39.33
T_2	46.5	47.17	70.85	71.15
T_3	48.53	49.73	72.6	73.12
T_4	46.4	47.33	70.98	71.43
T_5	46.1	46.93	70.35	70.88
T_6	49.65	51.37	73.65	75.33
T_7	48.15	49.05	71.66	73.09
T_8	46.53	47.67	70.9	71.95
T_9	47.93	49.63	72.1	73.05
T_{10}	46.13	47.03	70.8	71.12
T_{11}	45.05	46.05	68.98	70.12
T_{12}	47.6	48.93	71.23	72.63
SEd±	1.26	1.29	0.98	1.61
CD (P=0.05)	2.62	2.67	2.01	3.35

Table 2 : Effect of integrated nutrient management on pH, EC, organic carbon and available nutrients in the soil.

Treatments	pH (1:2.5)		EC (dsm^{-1})		Org.-C (%)		Available-N (kg ha^{-1})		Available-P (kg ha^{-1})		Available-K (kg ha^{-1})	
	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
T_1	7.9	7.8	0.39	0.38	0.39	0.38	190	192	18.3	19.5	209	208
T_2	7.8	7.8	0.38	0.37	0.4	0.39	218	221	21.47	22.4	212	213
T_3	7.7	7.6	0.34	0.33	0.46	0.47	223	223	21.7	22.9	215	216
T_4	7.6	7.5	0.33	0.32	0.49	0.48	228	232	22.57	23.6	220	224
T_5	7.5	7.4	0.32	0.31	0.51	0.51	238	239	24.75	25.6	233	236
T_6	7.6	7.6	0.33	0.33	0.48	0.49	226	226	21.62	22.75	216	218
T_7	7.6	7.5	0.32	0.32	0.51	0.51	235	235	22.48	23.45	228	229
T_8	7.4	7.4	0.31	0.31	0.54	0.53	241	240	24.66	25.6	235	238
T_9	7.7	7.6	0.35	0.34	0.45	0.46	220	221	21.58	22.6	218	220
T_{10}	7.6	7.6	0.34	0.33	0.48	0.47	225	228	22.45	23.35	230	232
T_{11}	7.5	7.5	0.32	0.32	0.5	0.5	236	238	24.58	25.55	238	240
T_{12}	7.7	7.6	0.34	0.34	0.47	0.47	227	228	21.68	22.85	218	218
SEd±	-	-	-	-	0.02	0.021	3.14	2.81	0.59	0.7	3.84	4.59
CD (P=0.05)	NS	NS	NS	NS	0.042	0.043	6.51	5.84	1.23	1.47	7.98	9.52

Table 3 : Effect of integrated nutrient management on bulk density, water holding and cation exchange capacity in the soil

Treatments	Bulk Density (Mg cm^{-3})		Water Holding Capacity (%)		CEC (cmol P^{+} kg^{-1})	
	1999	2000	1999	2000	1999	2000
T_1	1.46	1.45	39.10	40.05	12.70	12.75
T_2	1.45	1.44	41.83	42.18	12.80	12.78
T_3	1.46	1.43	42.50	43.55	13.45	13.35
T_4	1.44	1.42	43.65	44.74	14.35	14.39
T_5	1.43	1.41	45.10	46.20	15.28	15.30
T_6	1.44	1.42	42.70	43.80	14.50	14.50
T_7	1.43	1.41	43.90	44.85	15.45	15.51
T_8	1.42	1.40	45.43	46.66	16.30	16.34
T_9	1.45	1.43	42.40	43.50	12.80	12.82
T_{10}	1.43	1.41	43.53	44.65	13.85	13.89
T_{11}	1.43	1.41	45.03	46.13	14.8	14.85
T_{12}	1.45	1.42	43.66	44.72	13.5	13.56
SEd±	-	-	1.40	1.26	0.11	0.091
CD (P=0.05)	NS	NS	2.91	2.63	2.47	1.88

(2010). An integration of available farm manures (compost, *sasbania* green manure and FYM) with mineral fertilizer resulted in significant increases in paddy grain yield and yield attributes (Sarwar *et al.,* 2008; Buri *et al.,* 2012). Kumar *et al.* (2014) also reported that aapplication of organic and inorganic sources of nutrient in combination remarkably increased yield, yield attributes and nutrient uptake of rice than alone.

Changes in Soil chemical properties

The effect of different treatments on change in soil chemical properties like pH, EC, OC, available N, P and K after harvesting of rice crop is shown in the Table 2 and CEC in Table 3. The maximum reduction in pH was less over initial value in the plots receiving chemical fertilizer alone. The higher reduction in pH of soil in the plots receiving organic manures may be due to production of organic acids, during decomposition of organic manures which neutralize the sodium salts present in the soil and increase the hydrogen ions concentration. Maurya and Ghosh, (1972); Swarup and Singh (1989) also reported decrease in the soil pH by 0.3 to 0.9 unit after continuous application of chemical fertilizer along with green manning and FYM. The highest reduction over its initial value of the EC was recorded in the treatment T_8 with application of 75% N through green manure + 25% N through fertilizer. However, the reduction in EC was less over initial values in the plots receiving chemical fertilizer alone. Similar finding was also observed by Chaudhary *et al.*(1992) Kumar and Yadav (1995) also reported that organic plus chemical fertilizer treatments decrease EC at faster rate than inorganic fertilizers alone. Integrated use of organic and inorganic sources improved the cation exchange capacity of soil. The maximum increase in CEC in soil was noticed with the treatment T_8 receiving 75% N through green manure + 25% N through fertilizer, while minimum in control plot (T_1). The increase CEC of soil may be due to formation of more humus due to decomposition of organic matter that might have increased the surface area and developed more negative charge due to dissociation of H ion from functional group which ultimately contributed to increase in CEC of soil and thus maintained higher value than control. Similar finding were also observed by Kumar and Tripathi (1990) Patiram and Singh (1993) and Kumar *et al.* (2001). Application of chemical fertilizer alone did not increase organic carbon content of the soil over its initial content, while, significant buildup was observed where, chemical fertilizer were applied along with organic manure such as FYM, green manure and poultry manure. The maximum reduction was noticed in control plot receiving neither N fertilizer nor organic manure, while, maximum buildup (0.54, 0.53%) was measured with the treatment T_8 receiving 75% N through green manure + 25% N through fertilizer. The improved organic matter content of soil in the treatment having combination of chemical fertilizers and organic manure may be due to enhance root growth leading to accumulation of more organic residues in the soil, while, its increase in the manurial treatment combination is attributed to direct incorporation of the organic matter in the soil. Soil organic carbon reported by (Swarup and Yaduvanshi, 2000), significantly lower in inorganic fertilizer treatments as compared to the treatments involving fertilizer with organic sources. These results corroborated with the finding of Verma *et al.* (1987), Numbiar and Abrol (1989), Bhandari *et al.* (1992) and More (1994).

Change in Available Nitrogen, Phosphorus and Potassium

Manure contains many nutrients needed for crop production. Of these nutrients, nitrogen is one of the most important and is the most common added to soil for high yields. Nitrogen undergoes many transformations in soil as it is used, re-used, and made available by soil microbes. Maximum build up of available N (Table 2) was measured under the treatment receiving 75% N through green manure + 25% N through fertilizer. The availability of N in soil increased in the treatments (T_8) because of buildup of organic matters due application of green manure. Since organic matter contains nitrogen also, the increase in N content was found in those treatments where green manure BGA, FYM and poultry manure were added. Similar finding were also observed by Bhandari *et al.* (1992), Kumar and Yadav (1995) and Sharma and Ghosh (2000). Highest reduction in available phosphorus (Table 2) was noticed in control plots, while significant building up was observed in all those treatment where chemical fertilizes were applied along with organic manure such as FYM, green manure and poultry manure. The maximum buildup of available phosphorus (24.75, 25.60 kg ha^{-1}) was observed under the treatment T_5 receiving 75% N through FYM + 25% N through fertilizer in both the years. Increased availability of phosphorus in soil under treatments having different levels of nitrogen with FYM or green manure or poultry manure may be increased solubility due to production of organic acids. FYM and

seasbania green manure were more effective in increasing availability of phosphorus in soil as compared to poultry manure. Similar finding was also observed by Bhandari *et al*. (1992); More (1994) and Kumar *et al*. (2001). Poultry manure or green manure or FYM in conjunction with fertilizer recorded significantly higher amount of available K. The results (Table 2) clearly indicate that the organic material to meet 75% N through organic and 25% N through inorganic recorded significantly higher amount of K (238, 240 kg ha^{-1}). Increase in available potassium due to poultry manure may be attributed to direct addition of potassium to the available pool of the soil. The beneficial effects of poultry manure and green manure on the available K may be ascribed to the reduction of fixation and release of K due to the interaction of organic matter with clay, besides the direct K addition to the available K pool of the soil. Increase in available potassium due to green manure and FYM was reported by many workers Bharadwaj and Omanwar (1994), Tolanur and Badanur (2003).

Change in soil physical properties

Bulk density (Table 3) of soil found less, but didn't differ significantly among all the manorial treatments in combination with fertilizers. Application of 75% N through green manure + 25% N through fertilizer resulted maximum reduction in bulk density (1.42, 1.40 Mg cm^{-3}) during both the years. More crop residues, higher organic matter content and better aggregation may be the possible reasons for decreased bulk density due to the application of organic manure and inorganic fertilizer. Sustainable agricultural management practices are known to influence soil physical properties to maintain functional capacity of soil for crop growth (Scott, *et al.,* 1994; Islam and Weil, 2000-a; Min, *et al,*. 2003). These finding are in close conformity with those of Singh *et al*.(2000). The maximum (45.43, 46.66 %) water holding capacity (Table 3) was also observed in T_8 having 75% N through green manure +25% N through fertilizer and minimum water holding capacity was recorded in control plot during both the years. All the manorial treated plots increase the water holding capacity during both the years. The improvement of physical properties might be attributed to increased organic matter status of the soil and improved soil structure. These results are in agreement with the finding of Bellakki and Badanur (1997).

It can be concluded that use of chemical fertilizers with green leaf manure increased the crop yield. Increased amount of green leaf manure also improved the soil physical and chemical properties by increasing organic carbon, CEC, water holding capacity, available N, P and K.

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