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Effect of integrated nutrient management and plant geometry on soil properties and availability of nutrients under SRI technique of rice

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Abstract
The present investigation was conducted for two consecutive years with objective to know the various integrated nutrient management and rice varieties on soil chemical properties. The present study comprised six integrated nutrient modules *viz.*, F_0 (control), F_1 [RDF (120:60:60)], F_2 (50% RDF + 50% N through vermicompost), F_3 (75% RDF + 25% N through vermicompost), F_4 (50% RDF + 50% N through FYM) and F_5 (75% RDF + 25% N through FYM), two varieties (NDR-359 and Sarju-52) and plant geometry S_1 (20cm × 20cm) and S_2 (30cm × 30cm). The investigation revealed that the build up of neutral soil pH, reduction in EC and increasing OC were found in INM treatments in varieties and plant geometry as compared to sole inorganic fertilizer treatment (F_1) and maximum reduction in pH was observed with the application of F_2 (50% RDF + 50% N through vermicompost). Whereas, the maximum increase of organic carbon also recorded with the application of the treatment F_2. Varieties and plant geometry did not build up of pH, EC and organic carbon. The higher availability of nutrients N, P and K in soil after harvest was recorded in all the INM treatments as compared to inorganic fertiliser application treatments and control. Whereas, the maximum availability of N, P and K after crop harvest were estimated under the treatment having F_2 (50% RDF + 50% N through vermicompost), which was closely followed by F_4 and F_3. Therefore, the maximum availability N, P and K were found in variety NDR-359 under plant geometry S_2 (30 cm × 30 cm) followed by Sarju-52and S_1 (20 cm × 20 cm), respectively.

Keywords: INM, EC, organic carbon, NPK availability

Introduction
Rice (*Oryza sativa* L.) is a member of poaceae family chromosome number (2n=24) and most important staple food crop of millions of mankind from down of civilization. Among the cereal crops, it serves as the principal source of nourishment for over half of the global population.
The total area of rice crop in India is 44.11 m ha, production is 104.79 million tonnes and average productivity is 2.38 t ha^{-1} (Anonymous, 2015) [1]. Uttar Pradesh is an important rice growing state in the country. The area and production of rice in this state is about 5.86 million hectares and production 15.30 million tonnes with an average productivity of 2.57 tonnes per hectare, respectively (Anonymous, 2015) [1].
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) [7]. This implies that the need of integrated nutrient management for rice production. Therefore the combined use of organic manures and inorganic fertilizers help in maintaining yield stability through correction of marginal deficiencies of secondary and micronutrients, enhancing efficiency of applied nutrients and providing favourable soil physical conditions (Gill and Walia, 2014) [6]. Integrating nutrient management aims for efficient and judicious use of all the major sources of plant nutrients in an integrated manner (Farouque and Takeya, 2007) [5].
Nitrogen has the quickest and most pronounced effect on cereal production. It increased size and number of grains per panicle and protein percentage. It also improves the utilization of phosphorus and potassium to an appreciable extent (Brady, 1999). Inadequate nutrition, especially limitation of nitrogen, is one of the major bottlenecks of rice production in the world where about one third of the total N applied to crop is used for rice (Raun and Johnson, 1991). Rice is very responsive to N fertilization and high yield potential of modern varieties can not be realized without N supply to the plant during the entire growing season.
In association with this most of the scientist concluded that 50% organic sources and 50% from inorganic sources and 50% from inorganic sources is the best combination in rice based

cropping system to improve soil physico-chemical properties, yield and nutrient uptake capacity of rice.

Materials and Methods

The field experiment was conducted during *Kharif* 2015 and 2016 at Agronomy Farm of Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.). The experimental site located at Kumarganj is situated 42 km away from Faizabad city on Faizabad-Raibarely road. Geographically the experimental site is situated at 26.47^0 North latitude and 81.12^0 East longitude with is an elevation of about 113 m. from mean sea level in the Indo Gangatic Plain Zone of eastern Uttar Pradesh.

The climate in this region is humid and characterized with high rainfall (300 cm $year^{-1}$). The soil is sandy to sandy loam with a pH of 5.05 and 0.72% organic C. Soil low in available N (127.92 kg ha^{-1}), medium in available P (21.59 kg ha^{-1}) and low in available K (122.46 kg ha^{-1}).

The treatment was carried out with 24 treatment combination formed with six nutrient management levels, two varieties and two levels of plant geometry, in rice which were allocated in split plot design with three replications. The six irrigation levels (a) N_0: Control (b) N_1: RDF (120:60:60) (c) N_2: 50% RDF + 50% Vermicompost (d) N_3: 75% RDF + 25% Vermicompost (e) N_4: 50% RDF + 50% FYM (f) N_5: 75% RDF + 25% FYM with two varieties namely NDR-359 and Sarju 52 and two plant geometry (a) S_1: 20 cm X 20 cm. (b) S_2: 30 cm X 30 cm.

The crop was fertilised with anuniform dose of 60 kg P_2O_5/ha through single super phosphate, 40 kg K_2O/ha through muriate of potash and half dose of the Nitrogen management as per treatments with organic and inorganic.

Chemical properties of soil pH

Soil pH was determined with the help of glass electrode pH meter in 1:2.5 soil water suspensions as described by Jackson (1973) [19].

Electrical conductivity (dSm^{-1} at 25^{0}C)

Electrical conductivity was determined with the help of electrical conductivity meter in 1:2.5 soil water suspensions as described by Jackson (1973) [19].

Organic carbon (%)

Organic carbon was determined with the help of Walkley and Black's rapid titration method as advocated by Walkley and Black's (1934).

Available nutrients in soil (kg ha^{-1})

The available nitrogen content in soil samples was determined by alkaline permanganate method as described by Subbiah and Asija (1956) [20]. The available phosphorus in soil determined by Olsen's method as per procedure described by Olsen *et al.* (1954) [18]. The available potassium in soil was determined by Morgan's method as advocated by Jackson (1973) [19].

Results and Discussion

Soil pH

Results revealed that continuous application of various organic manures (FYM, vermicompost), and inorganic fertilizers resulted in decline of soil pH. The decline was more in organic manures plots over inorganic fertilizers alone in a span of 2 years. The integrated use of FYM along with fertilizers (50:50) in rice crop over 2 years also reduced the soil pH faster as compared to inorganic fertilizers alone. The decline in pH might be ascribed to the acidic nature of inorganic fertilizers and decomposition of organic manures (Sharma *et al.*, 2000). Mehdi *et al.* (2011) [12] also reported that the long-term application of organic manures reduced the soil pH rapidly as various acid and acid forming compounds were released during decomposition of organic materials.

Electrical conductivity

The regular incorporation of organic materials (FYM, VC) over 2 years showed appreciable reduction (0.02-0.06 dSm^{-1}) in electrical conductivity. While the application of chemical fertilizers alone increased electrical conductivity by 0.03 dSm^{-1}. The results are in conformity with findings of Kumar *et al.*, (1995). Bellakki *et al.*, (1998) [3] also reported that use of organic materials lowered the electrical conductivity of vertisol over chemical fertilizers separately in rice-rice cropping system (Table-1). The reduction in EC during cultivation of rice under puddled (saturated) condition was due to more leaching of soluble salts (Swarup and Singh, 1989).

Table 1: Effect of integrated nutrient management, varieties and plant geometry on chemical properties of soil of rice under SRI technique.

Treatment	pH			EC (dSm^{-1})			OC (%)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Integrated Nutrients Management									
F_0	8.29	8.28	8.28	0.36	0.36	0.36	0.34	0.34	0.34
F_1	8.24	8.03	8.14	0.34	0.33	0.34	0.36	0.37	0.37
F_2	8.19	7.80	8.00	0.32	0.30	0.31	0.39	0.41	0.40
F_3	8.24	7.97	8.11	0.34	0.33	0.34	0.37	0.38	0.38
F_4	8.23	7.89	8.06	0.33	0.31	0.32	0.38	0.40	0.39
F_5	8.28	8.04	8.16	0.33	0.32	0.32	0.37	0.38	0.38
SEm ±	0.16	0.16	0.11	0.01	0.01	0.00	0.01	0.01	0.01
CD at 5%	NS	NS	NS	0.02	0.02	0.01	0.02	0.02	0.01
Varieties									
V_1	8.25	7.98	8.12	0.34	0.33	0.33	0.37	0.37	0.37
V_2	8.25	8.00	8.12	0.33	0.33	0.33	0.37	0.37	0.37
SEm±	0.09	0.09	0.07	0.01	0.01	0.01	0.00	0.00	0.00
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Plant geometry									
S_1	8.25	7.98	8.12	0.34	0.33	0.33	0.37	0.37	0.37
S_2	8.25	8.00	8.12	0.33	0.33	0.33	0.37	0.37	0.37
SEm±	0.09	0.09	0.06	0.01	0.01	0.01	0.00	0.00	0.00
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Organic carbon

The role of organic carbon content of soil in improving soil fertility and productivity has been well recognized from time immemorial and its maintenance in the soil is of almost concern under modern intensive farming.

The regular incorporation of organic manures (FYM, vermicompost) over two years increased organic carbon content by 0.10-0.15 per cent. The integrated application of FYM and fertilizers (50:50) also showed an increase of 20.58 per cent in two years over control, while the 100% fertilizer treatment showed minimum increase of 8.83% only in organic carbon during same period. This could be attributed to direct addition of organic substances in soil and due to better root growth, more plant residues after crop harvest and their indirect influence on physico-chemical characteristics of the soil (Kaushik *et al.*, 1984, Bellakki *et al.*, 1998, Sharma *et al.*, 2000 and Khursheed *et al.*, 2013) [8, 3, 9].

Results revealed that in general the organic carbon content increased during rice cultivation. This may be ascribed to the alternate anaerobic and aerobic conditions during rice growth probably enhanced the organic carbon mineralization in soil (Boparai *et al.*, 1992) [4].

Availability of Nutrient in Soil

It is clearly indicates that the maximum available nitrogen, phosphorous and potassium obtained with the application of treatment F_2 (50 % RDF + 50 % N through vermicompost) which was significantly superior over the treatments F_0 (control) and F_1. While it was statistically at par with treatments F^3, F_4 and F_5 during both the year.

Considerable improvement in available nitrogen, phosphorous and potassium content of soil was observed under the treatment supplied with organics over application of inorganic.

Available nitrogen

The regular application of 100% recommended doses of nitrogen either through various organic sources (FYM, VC) or chemical fertilizers alone or in combination of both (FYM + fertilizer) enhanced available nitrogen content in soil by 15.25% in a span of two years. The increase in soil nitrogen might be due to direct addition of N through fertilizer and organic materials and greater multiplication of soil microbes, which converts organically bound nitrogen to inorganic form (Bellakki and Badanur, 1997) [2]. Manjappa (1999) [10] also founded that inclusion of organic manures such as FYM, vermicompost cotton and safflower stalk enhanced the soil available nitrogen more as compared to recommended dose of fertilizers alone. The application of organic manures could reduce N losses and conserve soil N by mineralization, thus maintaining a continuous availability of N in entire life cycle of rice plant (Pandey, 2001) [14].

Available phosphorus

The continuous application of 100% nutrients either through various organic manures (FYM, VC) or chemical fertilizers alone or integration of both (FYM + fertilizers) increased the available phosphorus in soil by 2.16 kg P ha^{-1} in a span of two years, while the application of 50% FYM (Table-2). This may be ascribed to greater mobilization of native soil P by reducing the P fixation capacity of soil minerals due to release of organic acids during decomposition process which ultimately increased the availability of phosphorus. Selvamani *et al.* (2011) [16] reported that phosphorus content in soil increased the significantly by application of organics and bio-inoculants in rice. Organic acids released during decomposition of organic manures increased availability of phosphorus (Mehdi *et al.* 2011) [12]. The organic materials form a protective cover on sesquoxide, thus also reduce the phosphate fixing capacity of soil, and hence, increase available P status of soil (Singh *et al.*, 2006) [17].

A general increase in soil available P (2.16 kg ha^{-1}) during rice cultivation was because the availability of phosphorus increased under submerged conditions needed for rice farming.

Table 2: Effect of integrated nutrient management, varieties and plant geometry on chemical properties of soil of rice under SRI technique.

Treatment	Available N (kg/ha)			Available P (kg/ha)			Available K (kg/ha)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Integrated Nutrients Management									
F_0	179.47	181.26	180.37	13.62	13.78	13.70	206.39	208.45	207.42
F_1	189.95	191.85	190.90	14.44	14.58	14.51	218.44	220.63	213.53
F_2	207.45	209.71	208.67	15.78	15.94	15.86	238.78	241.17	239.98
F_3	200.60	202.63	201.62	15.25	15.40	15.62	230.71	233.02	231.87
F_4	204.46	206.51	205.48	15.54	15.69	15.62	235.13	237.48	236.31
F_5	196.05	198.02	197.03	14.90	15.05	14.67	225.46	227.72	226.59
SEm ±	3.80	3.84	2.70	0.29	0.29	0.21	4.37	4.42	3.11
CD at 5%	10.83	10.94	7.59	0.84	0.85	0.59	12.45	12.79	8.88
Varieties									
V_1	197.34	199.32	198.33	15.00	15.04	16.07	226.94	329.71	228.08
V_2	195.39	197.34	196.37	14.85	15.11	14.92	224.70	226.94	225.82
SEm±	2.20	2.22	1.56	0.17	0.17	0.12	2.53	2.55	1.79
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Plant geometry									
S_1	195.93	197.89	196.91	14.89	15.04	14.97	225.32	227.57	226.44
S_2	196.80	197.77	197.79	14.95	15.11	15.03	226.32	228.58	227.45
SEm±	2.20	2.22	1.56	0.17	0.17	0.12	2.53	2.55	1.79
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Available potassium

The continuous application of 100% nutrients through organic manures (FYM, VC) and chemical fertilizers alone or in combination of FYM and fertilizers increased available potassium is soil by 8.78-11.17 kg K ha^{-1} in a span of two years, while the application of only 100% N through chemical showed a decline of 9.47-11.66 kg K ha^{-1} from its initial level in two years (Table-2). The increase in available potassium

might be due to direct addition of K through organic manures and the solubilization of K from native source during the process of decomposition of organic sources (Naidu *et al*, 2009) [13]. The organic manures have greater capacity to hold K in available form and reduced K-fixation due to interaction of organic matter with clay (Mathur, 1997) [11]. Selvamani *et al.* (2011) [16] reported maximum potassium content in soil with application of 50% RDF through inorganic fertilizers with FYM, vermicompost, neem cake and biofertilizers.
A general increasing trend in availability of potassium (9.47-11.66 kg ha^{-1}) during rice cultivation was due to its submerged (reduced), conditions needed for rice farming.

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