Evaluating the Effects of Organic Manures and Fertilizer N on Soil Properties in Rice Cultivation

Abstract

A field experiment was conducted during *kharif* 2020 Chaudhary Charan Singh Haryana Agricultural University, Krishi Vigyan Kendra farm, Fatehabad, (Haryana) to evaluate the effect of combined application of organic manures and fertilizers on the soil nutrients status under the rice cultivation. The experiment comprised of 14 treatments combination of organic manures and chemical fertilizers *viz.* T_1 (Control), T_2 (100% RDN (through urea)) + 50% RDN through FYM), T_3 (75% RDN + 25% N through FYM), T_4 (50% RDN + 50% N through FYM), T_5 (25% RDN + 75% N through FYM), T_6 (100% N through FYM), T_7 (75% RDN + 25% N through Vermicompost), T_8 (50% RDN + 50% N through Vermicompost), T_9 (25% RDN + 75% N through Vermicompost), T_{10} (100% N through Vermicompost), T_{11} (75% RDN + 25% N through Poultry manure), T_{12} (50% RDN + 50% N through Poultry manure), T_{13} (25% RDN + 75% N through Poultry manure) and T_{14} (100% N through Poultry manure) which were replicated thrice each. The results revealed that soil nutrient status was influenced variably by the application of different sources. Different combinations had no significant effect on soil pH and EC while the organic carbon (OC) increased with increased application of organic manures. The significantly higher macronutrients were observed under treatment 100 % N through Poultry manure i.e., N (120.30 kg ha^{-1}), P (19.13 kg ha^{-1}), K (237.20 kg ha^{-1}) and S (34.50 kg ha^{-1}) as compared to control which recorded N (98.97 kg ha^{-1}), P (12.63 kg ha^{-1}), K (200.90 kg ha^{-1}) and S (30.33 kg ha^{-1}) while the significantly higher DTPA extractable micronutrients (Zn, Fe, Cu, Mn) were observed under the treatment where 100 % N was applied through Vermicompost.

Keywords: RDN, Poultry manure, Vermicompost, FYM, DTPA

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Introduction

Rice (*Oryza sativa* L.) is the most extensively grown crop in India which is known as the hub of food security of the worldwide population. Widespread nutrient deficiency in soils, disturbed soil reaction, development of nutrient imbalance in plants, increased susceptibility to plant diseases, reduced soil organic matter, lesser occurrence of soil microorganisms and increased environmental pollution as well as human health hazards are the results of indiscriminate use of chemical fertilizers. The chemical fertilizers are out of the reach of small farmers because there is enormously increase in the cost of chemical fertilizer. The integrated application of different nutrient sources is very useful in this context. So as to achieve and to sustain the optimum yield and to enhance the soil physical, biological and chemical properties the use of combined application of different organic and inorganic nutrient sources in a specific crop, cropping system and climatic situation is necessary (Das et al 2015).

Tiwari (2002) reported that there was fertilizer consumption of 18 million tonnes in India in 2000 while the NPK removal by crops was about 28 million tons which created a gap of 10 million tonnes nutrients. The higher the grain yield targeted, the greater is the amount of nutrient required for rice plant. It is reported that the nutrient use efficiency of N, P and K is 30-50, 15- 20 and 60-70 per cent, respectively (Pathak, *et al.*, 2002). Further the NPK ratio of 4:2:1considered optimum but in reality, a wide ratio of 10:2.9:1 is prevalent in the country (Tandon, 2001). Using combined application organic sources such as FYM, vermicompost, and poultry manure are necessary for sustained production and better resource utilization in integrated nutrient management. INM technology is sustainable as compared to modern chemical farming as the farmer relies more on organic sources (Singh *et al.*, 2001). Addition of organic manure improves overall physical condition of the soil which is very essential under aerobic condition. Animal manures are valuable sources of plant nutrients and yield-increasing effect of manure is well known (Wakene *et al.*, 2005).

The major causes for declining crop production in developing countries is due to low soil fertility because of monoculture cereal production systems, inadequate fertilizer application, biomass removal, soil erosion, nutrient losses through runoff and leaching (Negassa *et al*. 2007). According to Bationo *et al.*, 2007 the most efficient way to correct soil nutrient depletion and improve crop production is the application of inorganic fertilisers as they supply nutrients in plant available form. Continuous use of chemical fertilizers in intensive cropping systems leads to nutrient imbalance and increased soil acidity which adversely affects soil health due to their susceptibility to loss in the gaseous form and by leaching to deeper layer (Amoah *et al.*, 2012). These effects can be improved\mitigated through the use of organic fertilizers which can improve soil physical and chemical properties. Organic manure improved soil organic matter and nutrient availability (N, P and K) through controlling net mineralisation-immobilisation patterns of different nutrients (Palm *et al.*

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1997). Among different sources poultry manure is considered as one of the best organic manures as it contains both macro-and micronutrients (Dekisissa *et al.*, 2008). However, due to their relatively low nutrient content and slow release of nutrients, application of organic manure alone to sustain soil and crop productivity is inadequate (Negassa *et al.*, 2007). Hence, under highly intensive cropping systems neither the chemical fertilizers nor the organic sources can exclusively achieve the sustainable productivity of soils as well as crops. To attain sustainability of soil fertility and crop productivity, combined use of organic manures and inorganic fertilizers are very important. Integrated use of poultry manure and inorganic fertilizer has shown to improve soil pH, organic matter content, cation exchange capacity and soil N, P, and K status (Amusan *et al.*, 2011). An ideal method to meet nutrient requirements of crops is integrated application of organic sources and inorganic fertilizers rather than a sole application of either source. Keeping in view the above facts, the present study was planned to study the effect of different sources of nitrogen on soil properties under rice cultivation.

Materials and methods

A field experiment was conducted in kharif 2020 at Krishi Vigyan Kendra, Fatehabad (Haryana) to study the effect of different sources of nitrogen on soil properties under plot experiment having clay loam texture soil. The initial soil fertility levels were pH (8.00), EC (0.74 dSm^{-1}), organic carbon (0.64 %), available nitrogen (114.4 kg ha^{-1}), available phosphorus (15.5 kg ha^{-1}), available potash (28.3 ha^{-1}). The experiment was laid out in a randomized complete block design with fourteen *viz.*T_1 (Control), T_2 (100% RDN (through urea)) + 50% RDN through FYM), T_3 (75% RDN + 25% N through FYM), T_4 (50% RDN + 50% N through FYM), T_5 (25% RDN + 75% N through FYM), T_6 (100% N through FYM), T_7 (75% RDN + 25% N through Vermicompost), T_8 (50% RDN + 50% N through Vermicompost), T_9 (25% RDN + 75% N through Vermicompost), T_{10} (100% N through Vermicompost), T_{11} (75% RDN + 25% N through Poultry manure), T_{12} (50% RDN + 50% N through Poultry manure), T_{13} (25% RDN + 75% N through Poultry manure) and T_{14} (100% N through Poultry manure) with different organic and inorganic sources of nitrogen and each replicated three times. The organic sources of nitrogen used were FYM (Farm yard manure), Vermicompost, Poultry manure with nitrogen content of 0.63 per cent, 1.89 per cent and 2.80 per cent on dry weight basis respectively. Nutrient equivalent basis of organic sources to meet the required quantity of N were incorporated in the soil one week before planting. Complete dose of P and K and $1/3^{rd}$ of inorganic N was applied at the time of planting in the form of SSP, MOP and Urea respectively. The

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remaining dose of nitrogenous fertilizer was applied in two split doses *viz.* 1/3rd at 21 days after transplanting and remaining 1/3rd at 42 days after transplanting. Soil samples were collected after the harvest of crop from each plot at 0-15 cm depth, dried under shade. The samples were analysed in laboratory for soil texture, soil pH, Electrical conductivity (EC), soil organic carbon, available nitrogen, available phosphorus, available potassium, available sulphur and micronutrients (Zn, Fe, Cu and Mn) by using International Pipette Method, pH meter, EC meter, wet digestion method, alkaline potassium permanganate method, Olsen method, Neutral normal ammonium acetate method, Calcium chloride dehydrate method and DTPA extraction method, respectively. The data collected during the course of this investigation was subjected to randomized block design analysis of variance. The critical difference (CD) was used to compare the effect of the treatment at $p<0.05$ using OPSTAT software.

Results and Discussion

Soil pH

It is obvious from the data (Table 1) that different treatments had no significant effect on the soil pH. Highest value of pH (8.00) was observed in in T_1 (control) while lowest (7.93) was recorded in the treatment T_6 and T_{10}. In the soil samples collected after the harvest of the crop, soil pH slightly decreased in all the treatments except control. This could be due to high buffering capacity of the soil, as reported by Gallani *et al.* (2013). Although, the combined application of chemical fertilizer and manures slightly reduced the soil pH as compared to chemical fertilizer alone. Gudadhe *et al*. (2015) reported that substitution of RDN through vermicompost registered minor change in pH. Walia *et al.* (2010) also reported that soil pH decreased in treatments where inorganic sources applied alone as compared to the initial value. This might be attributed to proper fertilization which resulted in more biomass production which increased the crop residue addition, helping in increased organic carbon and thus more organic acid production causing reduction of soil pH. The decrease in pH may also be attributed to the production of organic acids during the decomposition of manures.

Soil EC

A critical observation of the data revealed that different treatments had no significant effect on the EC (Table 1). Highest value of EC (0.74 dS m^{-1}) was observed in treatment T_2, T_7, T_{11}, T_{12} and T_{13} while lowest (0.72 dS m^{-1}) was observed in treatment T_5, T_6 and T_{10}. The value of EC remained same in treatment T_2, T_7, T_{11}, T_{12} and T_{13} while it decreased in control

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as compared to its initial value. Ghayal (2016) reported that poultry manure showed its superiority in increasing electrical conductivity of soil over other manures *i.e.,* vermicompost and FYM. Natsher and Schwetnmann (1991) reported increase in EC due to the salts in the poultry manure which are released during microbial decarboxylation.

Soil Organic Carbon

A perusal of the data (Table 1) revealed that the soil organic carbon content in soil increased from 0.62 % to 0.68 %. Highest value of organic carbon (0.68 %) was observed in the treatments T_6, T_{10} and T_{14} which was statistically at par with all the treatments except T_1 and T_2. However, the content of organic carbon decreased in control and T_2 as compared to its initial value and similar content of organic carbon was recorded in the treatments (T_3, T_7 and T_{11}) where 25% N was replaced with manures. Kulmi and Tiwari (2006) reported similar increase in organic carbon content of soil due to continuous addition of organic manures. Organic carbon content of soil showed an increasing trend in the treatment with increasing level of nitrogen through organic sources like FYM, vermicompost and poultry manure, (Phogat *et al.*, 2004; Ravankar *et al.*, 2004). Highest organic carbon was observed in the treatment T_6, T_{10} and T_{14}. It may be attributed to the slow decomposition of the organic source and increased microbial activity in the soil. The difference in the organic carbon content in treatments involving FYM, vermicompost and poultry manure may be due to their organic carbon content.

Table 1. Effect of different nitrogen sources on physico-chemical properties of soil

Treatments	**pH**	**EC (dS m^{-1})**	**Organic Carbon (%)**
T_1: Control	8.00	0.73	0.62
T_2: 100% RDN (through urea)	7.97	0.74	0.63
T_3: 75% RDN + 25% N through FYM	7.96	0.73	0.64
T_4: 50% RDN + 50% N through FYM	7.95	0.73	0.65
T_5: 25% RDN + 75% N through FYM	7.94	0.72	0.67
T_6: 100% N through FYM	7.93	0.72	0.68
T_7: 75% RDN + 25% N through Vermicompost	7.96	0.74	0.64
T_8: 50% RDN + 50% N through Vermicompost	7.95	0.73	0.66
T_9: 25% RDN + 75% N through Vermicompost	7.94	0.73	0.67

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T_{10}: 100% N through Vermicompost	7.93	0.72	0.68
T_{11}: 75% RDN + 25% N through Poultry manure	7.97	0.74	0.64
T_{12}: 50% RDN + 50% N through Poultry manure	7.96	0.74	0.65
T_{13}: 25% RDN + 75% N through Poultry manure	7.95	0.74	0.67
T_{14}: 100% N through Poultry Manure	7.95	0.73	0.68
SEm±	0.02	0.01	0.02
CD (P= 0.05)	**NS**	**NS**	0.04
Initial	8.00	0.74	0.64

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Available Nitrogen

A perusal of the data revealed (Table 2) that available N content was observed significantly increased in all the treatments as compared to control. Highest available N content (120.30 kg ha^{-1}) was observed in the treatment T_{14} which was statistically at par with T_{10} and T_6 and significant over the rest of treatments while lowest content (98.97 kg ha^{-1}) was found in the control. Available N content decreased over its initial value in treatments T_1 (98.97 kg ha^{-1}) and T_2 (112.37 kg ha^{-1}) and the magnitude of decrease was 13.7 and 1.77 %, respectively. Highest available N was observed in the treatment where complete nitrogen was applied through poultry manure. Poultry manure has ability to quick supply of nutrients than FYM and they help in conversion of non-available form of nitrogen to available form of nitrogen (Thavaprakash *et al.*, 2005). It may be attributed to that the addition of organic manure improves the availability organic matter to microorganisms which causes increased activity of micro-organisms and soil enzymes by which the availability of N in the soil is increased. The availability of N increased with the increasing application of the nitrogen through organic source. It may be attributed to the slow decomposition of the organic manure and lesser uptake by the plants. Among manures, poultry manure is easily mineralized because it contains high amount of uric acid and urea substance which readily release NH_4-N and its availability is faster as compared to vermicompost and FYM (Theulie and Tola, 2020). Low availability of nitrogen in FYM might be due to that nutrient releasing pattern of FYM is slow and further the nutrient content also low when compared with other organic manures (Balamurugan *et al.*, 2020)

Available Phosphorous

A critical observation of the data revealed that there was a significant increase in the available P content in all the treatments as compared to the control (Table 2). All the treatments showed higher available P content over its initial value except control. Highest value of available P content (19.13 kg ha^{-1}) was recorded in the treatment T_{14} which was statistically at par with T_5, T_6, T_9, T_{10}, and T_{13} and lowest value of available P content (13.63 kg ha^{-1}) was observed in the control. It might be due to increased availability of nutrients due to production of organic acid under combined application of organic and inorganic sources and mineralization of soil organic matter and solubilizing effect of acids produced during respirations (Rai *et al.*, 2015; Desai *et al.*, 2020). Due to low phosphorus use efficiency, most of the applied phosphorus get fixed in soil but in due course of time a small quantity becomes available for plant use (Thakur *et al.*, 2011). The organic matter produced due to decomposition of organic manures reduces the phosphate fixing capacity of the soil by forming a cover on sesquioxides and makes them inactive, which ultimately, helps in release of ample quantity of phosphorus. The organic acids and CO_2 produced during decomposition of organic matter also helps in solubilizing native P (Katyal *et al.*, 2002).

1.6 Available Potassium

A critical observation of the data (Table 2) revealed that significantly higher content of available K was observed in all the treatment as compared to the control. The content of available K was recorded lowest (200.90 kg ha^{-1}) in the T_1 (control). Highest content of available K (237.20 kg ha^{-1}) was observed in the treatment T_{14} which was statistically at par with treatment T_{10} and T_6. The available K content decreased in T_1 (200.90 kg ha^{-1}) and T_2 (228.23 kg ha^{-1}) over its initial value (228.30 kg ha^{-1}). An application of organic manure in the soil showed higher build-up of available K in soil due to the reduction of potassium fixation, release of potassium due to the interaction of organic matter with clay, and direct addition of K to the available pool of soil (Akhila *et al.*, 2018; Dhiman *et al.*, 2019).

Table 2. Effect of different nitrogen sources on macronutrient content of the soil

Treatments	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Available S (kg ha^{-1})
T_1: Control	98.97	12.63	200.90	30.33
T_2: 100% RDN (through urea)	112.37	16.00	228.23	31.92
T_3: 75% RDN + 25% N through FYM	113.10	16.10	229.40	32.25

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T_4: 50% RDN + 50% N through FYM	114.30	17.17	231.00	32.33
T_5: 25% RDN + 75% N through FYM	116.87	17.93	233.57	32.70
T_6: 100% N through FYM	119.63	18.30	235.97	33.35
T_7: 75% RDN + 25% N through Vermicompost	113.70	16.13	229.90	32.42
T_8: 50% RDN + 50% N through Vermicompost	114.77	17.53	232.43	32.67
T_9: 25% RDN + 75% N through Vermicompost	117.37	18.20	234.07	33.03
T_{10}: 100% N through Vermicompost	119.97	19.07	236.57	33.70
T_{11}: 75% RDN + 25% N through Poultry manure	113.87	16.17	230.87	32.80
T_{12}: 50% RDN + 50% N through Poultry manure	114.97	17.63	232.93	32.97
T_{13}: 25% RDN + 75% N through Poultry manure	117.57	18.30	234.57	33.39
T_{14}: 100% N through Poultry Manure	120.30	19.13	237.20	33.91
SEm±	0.71	0.48	0.90	1.72
CD (P= 0.05)	2.09	1.40	2.62	**NS**
Initial	114.4	15.5	228.3	31.5

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Available Sulphur

Data from the Table 2 revealed that different manures and chemical fertilizer as nitrogen source do not have significant effect on the available S content of the soil. Higher content of available S was recorded in all the treatments as compared to the control. However, its value decreased in control as compared to initial value. Highest content of available S (33.91 kg ha^{-1}) was recorded in the treatment T_{14} while lowest content (30.33 kg ha^{-1}) was found in the T_1 (control). Highest sulphur content was observed in 100% RDN through poultry manure (T_{14}) followed by T_{10} and T_{13}. The increase in available S content in different treatment may be attributed due to the addition of sulphur in soil through the decomposition of the manures *i.e.* FYM, vermicompost and poultry manure, (Pandey *et* *al.*,2016). The highest content in poultry manure treatments may be attributed to the high amount of sulphur in the applied poultry manure.

DTPA Extractable Micronutrients

It was revealed from the data (Table 3) that content of DTPA extractable Zn content was recorded higher in all the treatments as compared to the control. Significantly higher content of DTPA extractable Zn (2.45 mg kg^{-1}), Fe (10.04 mg kg^{-1}), Cu (1.36 mg kg^{-1}) and Mn (6.35 mg kg^{-1}) was observed in the treatment T_{10} as compared to rest of the treatments while lowest content Zn (1.80 mg kg^{-1}), Fe (9.20 mg kg^{-1}), Cu (1.20 mg kg^{-1}) and Mn (5.93 mg kg^{-1}) was recorded in the control(T_1). The increased availability of micronutrients with the addition of organic manures may be attributed to the increased solubility due to decrease the soil pH by the virtue of organic treatments, (Gunjal and Chitodkar, 2017). Application of vermicompost increased the supply of easily assimilated major as well as micronutrients to plants besides mobilizing unavailable nutrients into available form, (Desai et al., 2020). The plots receiving combined application of chemical fertilizer and manures showed higher micronutrients content than the chemical fertilizer alone. This may be attributed to that, during its decomposition organic manures improve the chemical and biological reactions resulting in more availability of nutrients for crop. Moreover, chelating action of the applied organic sources increased availability of micronutrients by preventing their leaching, fixation, oxidation and precipitation (Jha *et al.*, 2013 and Mohrana *et al.*, 2017).

Table 3. Effect of different nitrogen sources on micronutrient content in the soil

Treatments	Zn (mg kg^{-1})	Fe (mg kg^{-1})	Cu (mg kg^{-1})	Mn (mg kg^{-1})
T_1: Control	1.80	9.20	1.20	5.75
T_2: 100% RDN (through urea)	1.82	9.22	1.22	5.80
T_3: 75% RDN + 25% N through FYM	1.86	9.28	1.25	5.84
T_4: 50% RDN + 50% N through FYM	1.90	9.33	1.28	5.91
T_5: 25% RDN + 75% N through FYM	1.96	9.40	1.30	6.02
T_6: 100% N through FYM	2.08	9.50	1.34	6.15
T_7: 75% RDN + 25% N through Vermicompost	1.97	9.48	1.27	5.99
T_8: 50% RDN + 50% N through	2.10	9.61	1.30	6.10

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Vermicompost				
T_9: 25% RDN + 75% N through Vermicompost	2.25	9.81	1.32	6.23
T_{10}: 100% N through Vermicompost	2.45	10.04	1.36	6.35
T_{11}: 75% RDN + 25% N through Poultry manure	1.84	9.25	1.24	5.84
T_{12}: 50% RDN + 50% N through Poultry manure	1.87	9.29	1.26	5.89
T_{13}: 25% RDN + 75% N through Poultry manure	1.92	9.38	1.29	6.01
T_{14}: 100% N through Poultry Manure	1.99	9.47	1.32	6.11
SEm±	0.06	0.16	0.02	0.07
CD (P= 0.05)	0.15	0.40	0.05	0.20
Initial	1.84	9.22	1.27	5.82

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Conclusion

On the basis of present investigation, it may be concluded that organic sources had pronounced effect on the nutrient status of the soil after the harvest of the crop. 100% N through poultry manure was found superior over all the treatment combination. Poultry manure also gave higher residual major nutrients over the FYM and Vermicompost while vermicompost was found superior over the FYM and poultry manure in case of the micronutrient status in the after-harvest soil.

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