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COMPARATIVE EVALUATION OF SOIL PROPERTIES IN RESPONSE TO DIFFERENT NUTRIENT MANAGEMENT OPTIONS AND BASMATI RICE VARIETIES IN WESTERN UTTAR PRADESH, INDIA

Ashutosh Kumar Rai[1]*, U.P. Shahi[1], B.P. Dhyani[1], Aditya Kumar[2], Ashishnath[1] and Adesh Singh[3]

[1]Department of Soil Science & Agricultural Chemistry, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, U.P., India.
[2]Department of Agricultural Chemistry & Soil Science, Udai Pratap College Varanasi, U.P., India.
[3]Department of Agronomy, Sardar Vallabh Bhai Patel University of Agriculture & Technology, Meerut, U.P., India.
*Corresponding author E-mail : ashutoshraiw@gmail.com
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ABSTRACT

In this experiment, the response of soil properties to different nutrient management options and basmati rice varieties in western Uttar Pradesh are evaluated for two consecutive years (2020 and 2021). For this, field trial was conducted in split plot design with three basmati rice varieties *viz.*; V_1- Pusa basmati-1121, V_2- Pusa basmati-1509 and V_3- Pusa basmati-1718 in the main plot and five nutrient management options *viz.* T_1 (control), T_2 (100% inorganic fertilizer), T_3 (INM- 50% inorganic fertilizer (*viz.* urea, DAP, and MOP) and 50% organic manure (*viz.* FYM, vermicompost and poultry manure), T_4 (100% organic manure through 1/3rd of each component, *viz.*; FYM, vermicompost and poultry manure), T_5 (5% jeevamrut) in sub plots at crop research centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram . The soil samples were collected at 30, 60 days after transplanting and, at harvest of the crop. The integrated application of inorganic fertilizer and organic manure significantly increased soil physical, chemical and biological properties of soil and under Pussa basmati-1121 was found better for soil health since higher soil organic carbon and other soil parameters were observed in compared to Pusa Basmati-1718 and Pusa Basmati-1509.

Key words : Basmati Rice, Integrated Nutrient Management, Poultry Manure, Vermicompost.

Introduction

Indiscriminate use of chemical fertilizers results in the emission of greenhouse gases, reduced efficiency of applied nutrients and the depletion of soil organic matter (SOM) in long term (Choudhary and Kennedy, 2004; Ju *et al*., 2009). Hence, integration of organic manures and bio-inoculants with chemical fertilizers is a viable alternative to mitigate such problems. In terms of soil fertility enhancement and sustainable agriculture, the effects of organic manures and inorganic fertilizers are complementary to each other. Therefore, in order to harvest better yields of different crops in the cropping sequence and to preserve soil fertility, it is important to make judicious use of them in the right proportion. Integrated nutrient management (INM) helps to preserve and retain soil fertility and productivity of crops. It also helps to fix emerging macro, secondary, and micronutrient deficiencies favourably by improving the physical, chemical and biological environment of soil and achieving economical and productive fertilizer usage. There is an immediate need to follow the INM principle to achieve the aim of environmentally and economically sustainable agriculture with regard to the reduction of land resources for farming, the short supply and growing costs of chemical fertilizers, environmental degradation, and adverse effects on soil, animals, and human health. Sustainability in crop production is not a viable proposition either through use of organic manures or chemical fertilizers alone (Singh *et al*., 2009). The balance fertilization through integrated use of manure, inorganic fertilizer and biofertilizer along with micronutrients has been found useful in rice crop (Yadav *et al*., 2013). Integrated nutrient management (INM) aims to preserve and retain the fertility of soils and the productivity of crops. It also helps to address the emerging macro, secondary and micronutrient deficiencies favourably by optimizing the soil's physical, chemical and biological environment and achieving fertilizer economy and efficiency.

Materials and Methods

Experiment site and treatment details: The field Trail experiment was conducted during *kharif* season of two consecutive years 2020 and 2021 at Crop Research Centre (Main Campus) of Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut ($29^0 04'$ N latitude and $77^0 42'$ E longitude). Soil of experimental field was sandy loam in texture having pH 8.10, low in available N and organic carbon, but medium available P and K. The experiment was laid down in split-plot design having three basmati rice varieties *viz.* V_1- Pusa basmati-1121, V_2- Pusa basmati-1509, and V_3- Pusa basmati-1718 in the main plot, and five nutrient management options *viz.* T_1 (control), T_2 (100% inorganic fertilizer) T_3 (INM- 50% inorganic fertilizer and 50% organic manure *viz.*; FYM, vermicompost , poultry manure), T_4 (100% organic manure through 1/3rd of each component, FYM, vermicompost , poultry manure), T_5 (5% jeevamrut) in sub plot and replicated thrice. At final puddling 40 kg phosphorus and 30 kg potash through DAP and MOP, respectively were applied as per treatments, T_2 (100% inorganic) and half dose in T_2 and T_3 (50% inorganic + 50% organic sources), and no addition of manures and fertilizers in T_1 (control). In T_3 & T_4, organic manures were applied on the basis of their nitrogen content. Nitrogen was applied @ 100 kg ha^{-1} as urea into three splits; half at the time of transplanting, and remaining half at the time of maximum tillering and at panicle initiation stage equally as per the treatments. Organic sources of fertilizer *viz.* FYM, vermicompost, and poultry manure were applied 15 day before the transplanting of crop and mixed well in the soil.

Soil sampling: Soil samples were collected at 30, 60 days after transplanting, and at harvest of the crop from 0-15 cm depth and then analysed for different soil parameters.

Statistical analysis: The data were statistically analysed as suggested by Gomez and Gomez (1984) for split-plot design. Wherever the treatment differences were found significant, critical differences were worked out at 5% probability level and values were furnished.

Results and Discussion

Effect on soil physical properties

A significant variation was observed in bulk density (BD) under different rice varieties and nutrient management options at harvest of the crop. Lowest BD (1.56 Mg m^{-3}) was recorded in the plot supplied with 100% organic manure, followed by T_3 (1.60 Mg m^{-3}) and T_5 treated with 5% jeevamrut (1.69 Mg m^{-3}) (Table 1). This decrease in BD of soil may be ascribed to the addition of OM, which results in better soil aggregation and ultimately improving soil porosity (Dash *et al.* 2023). Our result corroborated with finding obtained by Sheeba and Chellamuthu (2002), Bhatt *et al.* (2019). Unlike different basmati varieties nutrient management options showed a significant decrease in the particle density (PD) of surface soil. Lowest PD was observed with application of 100% organic manure (T_4) (2.61 Mg m^{-3}) and highest particle density under control (2.71 Mg m^{-3}). Our findings align with the results reported by Nandapure *et al.* (2014) and Dhaliwal *et al.* (2015) (Table 1). Maximum soil porosity of 40.37% was recorded in the plot where only organic manure was applied *i.e.*; T_4 followed by T_3 (39.16%) and T_5 (36.17%) (Table 1). In T_4 supply of fresh organic matter in the form of manure helped for build-up of water-stable soil aggregates. Released polysaccharides and organic acids during decomposition of OM, helped in binding of soil particles and prevented disintegration, which promoted aggregation and porosity (Dash *et al.*, 2023). Increase in soil porosity with organic fertilization has also been reported by Bhatia and Shukla (1982).

Effect on soil chemical properties

The maximum pH was observed in control (8.02) and minimum in T_4 (7.41). However maximum EC of 0.39 dSm^{-1} was recorded in T_4 at harvest stage (Table 1). Similar results were reported by Singh *et al.* (2009), Babbar and Dongale (2013). Pusa basmati 1121, showed maximum soil organic carbon (SOC). In case of nutrient management options order of SOC content was $T_4 > T_3 > T_5 > T_2 > T_1$ (Table 2). The present results corroborate the findings of Yaduvanshi *et al.* (2013), Chesti *et al.* (2015), Srinivas *et al.* (2015), Roy *et al.* (2017), Singh *et al.* (2005), Laxminarayana (2006), Desi *et al.* (2009) and Singh *et al.* (2009a). The maximum and minimum available N was observed under Pusa basmati 1121 and Pusa basmati 1509, respectively (Table 2). Among nutrient management treatments, maximum available N in soil was recorded under T_3 (205.18 kg ha^{-1}) followed T_2 (199.56 kg ha^{-1}) and T4 (194.19 kg ha^{-1}) with minimum in T_1 (162.79 kg ha^{-1}). Similar results were as also reported

Table 1 : Response of different nutrient management options on soil physical properties at harvest and chemical properties of basmati rice field at different stages (Pooled mean of 2 years).

Treatments	At harvest			pH			EC (dS m^{-1})		
	Bulk density (Mg m^{-3})	Particle density (Mg m^{-3})	Porosity (%)	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest
Varieties									
Pusa basmati-1121 (V1)	1.62	2.65	38.84	7.75	7.78	7.62	0.20	0.38	0.36
Pusa basmati-1509 (V2)	1.73	2.67	35.24	7.84	7.86	7.82	0.21	0.39	0.37
Pusa basmati-1718 (V3)	1.67	2.66	37.07	7.75	7.79	7.66	0.20	0.39	0.37
SEm±	0.02	0.01	0.28	0.07	0.07	0.07	0.01	0.01	0.01
CD (P=0.05)	0.06	NS	0.28	NS	NS	NS	NS	NS	NS
Nutrient management options									
Control (T_1)	1.81	2.71	33.37	7.95	7.96	8.02	0.19	0.39	0.37
100 % Inorganic (T_2)	1.72	2.69	36.17	7.89	7.91	7.88	0.21	0.40	0.39
INM (50% OS* + 50% IS*) (T_3)	1.60	2.63	39.16	7.78	7.81	7.75	0.21	0.38	0.36
100% Organic (T_4)	1.56	2.61	40.37	7.65	7.70	7.41	0.22	0.38	0.37
Jeevamrit (5%) (T_5)	1.69	2.65	36.17	7.63	7.66	7.45	0.20	0.38	0.36
SEm±	0.01	0.01	0.48	0.17	0.17	0.17	0.01	0.01	0.01
CD (P=0.05)	0.03	0.02	1.42	NS	NS	NS	NS	NS	NS

by Jat *et al*. (2019), Nayak *et al*. (2017), Das *et al*. (2014), Babar and Dongale (2013). Highest and lowest available P was observed under Pusa basmati 1121 and Pusa basmati 1509, respectively. Among nutrient management options order of P availability was in the order of $T_3 > T_4 > T_2 > T_5 > T_1$. Phosphorus availability in soil increased due to use of organics. During decomposition of organic manure, various organic acids are produced which solubilize inorganic and fixed phosphates, thereby lower the phosphate fixation and increase its availability. Manna *et al.* (2006) reported that available P content increased due to addition of FYM over initial and control. The available K content in soil was significantly varied with varieties of basmati rice in both year of investigation. The available K was observed in Pusa basmati 1121. The highest available potassium (283.40 kg ha^{-1}) in soil was recorded with INM and minimum in control. This might be due to the build-up of soil available K due to application of poultry manure, vermicompost and FYM through the solubilizing action of certain organic acids produced during decomposition and its greater capacity to hold K in the available form.

In addition to the direct addition of potassium to the soil's potassium pool, the effects of FYM, vermicompost, and poultry manure on accessible potassium may be attributed to the decreased potassium fixation, solubilization and release caused by the interaction of organic matter with clay (Jat *et al*., 2019; Babar and Dongale, 2013).

The maximum concentration of DTPA extractable elements (Fe, Mn, Zn and Cu) was found in Pusa basmati 1121, while the lowest was found in Pusa basmati 1509. The sequence of soil micronutrient availability among nutrients management options was $T_3 > T_2 > T_4 > T_5 > T_1$. Since the SOM stores all of the nutrients and uses FYM, vermicompost and poultry manure have increased the amount of micronutrients that are

Table 2 : Response of different nutrient management options on soil organic carbon , Available N, P and K of basmati rice field (Pooled mean of 2 years).

Treatment	Soil organic carbon (%)			Available N (kg ha^{-1})			Available P (kg ha^{-1})			Available K (kg ha^{-1})		
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest
Varieties												
Pusa basmati-1121 (V1)	0.38	0.33	0.40	217.60	246.51	190.67	16.61	18.90	19.89	285.64	279.70	275.77
Pusa basmati-1509 (V2)	0.34	0.29	0.35	206.95	234.34	188.63	13.24	15.04	16.02	268.36	262.77	259.08
Pusa basmati-1718 (V3)	0.37	0.32	0.38	211.72	241.13	190.52	14.08	16.11	17.15	278.66	272.86	269.03
SEm±	0.01	0.01	0.01	1.44	1.78	1.99	0.21	0.12	0.25	2.54	2.58	2.56
CD(P=0.05)	0.02	0.02	0.03	5.79	7.18	NS	0.87	0.47	1.00	10.24	10.42	10.31
Nutrient management options												
Control (T_1)	0.31	0.27	0.32	164.00	183.42	162.79	11.44	12.94	13.78	242.35	237.31	233.97
100 % Inorganic (T_2)	0.34	0.30	0.36	239.40	271.26	199.56	14.68	16.73	17.81	289.38	283.35	279.37
INM (50% OS* + 50% IS*) (T_3)	0.37	0.32	0.39	242.28	274.98	205.18	18.45	21.22	22.21	293.55	287.44	283.40
100 % Organic (T_4)	0.43	0.37	0.45	226.04	258.63	194.19	16.35	18.58	19.79	287.67	281.69	277.72
Jeevamrit (5%) (T_5)	0.36	0.31	0.37	188.72	213.35	186.35	12.28	13.93	14.84	274.82	269.11	265.32
SEm±	0.01	0.01	0.01	3.79	4.37	2.93	0.63	0.51	0.70	6.39	6.16	6.30
CD (*P=0.05*)	0.03	0.02	0.03	11.13	12.99	8.60	1.84	1.51	2.05	18.76	18.07	18.50

Table 3 : Response of different nutrient management options on DTPA extractable micronutrients in basmati rice field (Pooled mean of 2 years).

Treatment	Fe (ppm)			Cu (ppm)			Zn (ppm)			Mn (ppm)		
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest
Varieties												
Pusa basmati-1121 (V1)	11.03	10.88	10.43	1.96	1.92	1.83	0.84	0.77	0.70	4.33	4.42	4.53
Pusa basmati-1509 (V2)	10.39	10.26	9.55	1.75	1.68	1.63	0.72	0.66	0.59	3.36	3.16	3.23
Pusa basmati-1718 (V3)	10.35	10.24	9.59	1.87	1.79	1.72	0.78	0.71	0.65	4.04	4.13	4.24
SEm±	0.01	0.05	0.09	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.04	0.04
CD (*P=0.05*)	0.39	0.39	0.37	0.06	0.06	0.05	0.03	0.03	0.02	0.08	0.14	0.15
Nutrient management options												
Control (T1)	6.64	6.54	6.14	1.49	1.45	1.40	0.55	0.51	0.44	2.69	2.75	2.81
100 % Inorganic (T2)	13.27	13.16	12.52	1.95	1.88	1.79	0.89	0.82	0.75	4.29	4.38	4.49
INM (50% OS* + 50 % IS*) (T3)	13.53	13.38	12.67	2.44	2.33	2.26	0.96	0.90	0.83	4.99	5.11	5.22
100 % Organic (T4)	11.99	11.88	11.09	1.85	1.81	1.71	0.83	0.76	0.69	3.66	3.74	3.84
Jeevamrit (5%) (T5)	7.51	7.34	6.89	1.58	1.53	1.47	0.65	0.60	0.53	3.47	3.54	3.63
SEm±	0.26	0.26	0.24	0.05	0.04	0.04	0.02	0.02	0.02	0.05	0.05	0.05
CD (*P=0.05*)	0.76	0.75	0.71	0.13	0.13	0.12	0.06	0.05	0.05	0.15	0.28	0.28

Table 4 : Response of different nutrient management options on soil bacteria and fungi in basmati rice field (Pooled mean of 2 years).

Treatment	Soil bacteria (CFU × 10^5)			Soil fungi (CFU × 10^3)		
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest
Varieties						
Pusa basmati-1121 (V1)	141.73	159.10	161.10	45.03	53.27	55.90
Pusa basmati-1509 (V2)	128.87	141.43	142.90	38.83	46.60	51.67
Pusa basmati-1718 (V3)	139.93	151.33	151.07	44.00	49.40	53.87
SEm±	1.53	1.64	1.74	0.40	0.42	0.41
CD (P=0.05)	6.16	6.61	7.03	1.61	1.71	1.65
Nutrient management options						
Control (T_1)	74.82	80.28	81.94	29.50	34.95	37.50
100 % Inorganic (T_2)	81.37	88.83	89.33	35.11	41.33	44.11
INM (50% OS* + 50% IS*) (T_3)	165.48	181.33	182.83	48.89	57.61	63.61
100 % Organic (T_4)	219.30	243.17	243.83	59.33	68.00	72.50
Jeevamrit (5%) (T_5)	142.65	159.50	159.67	40.28	46.89	51.33
SEm±	3.26	3.65	3.65	1.11	1.13	1.22
CD (*P=0.05*)	9.57	10.72	10.73	3.28	3.33	3.58

available in the soil in the experiment. The susceptibility of micronutrients to adsorption, fixation, and precipitation in the soil is decreased because micronutrients form soluble chelates with well-decomposed FYM, vermicompost and poultry manure (Madhavi *et al.*, 1995; Vidyavathi, 2012).

Effect on soil biological properties

Among the different tested varieties, the maximum microbial population (bacteria and fungi) was observed under Pusa basmati 1121 and minimum under Pusa basmati 1509. In the case of nutrient management options, the maximum microbial population (bacteria and fungi) in soil was recorded in the treatment with 100% organic manure (243.83 CFU × 10^5 and 72.50 CFU × 10^3) and minimum in control plots (81.94 CFU × 10^5 and 37.50 CFU × 10^3). This might be due to the application of organic inputs as well as prohibitions on the applications of fertilizers. The continuous increase in microbial population (bacteria and fungi) in rhizosphere from transplanting to harvesting stage could be attributed to the greater release of root exudates. Varietal difference in microbial population (bacteria and fungi) was not much significant at different crop stages, which might be due to similar kind of morphology of the selected varieties. These results also indicated that using organic and inorganic sources combinedly had increased microbial populations. It is well established that OM act as a substrates upon which microorganisms act and mineralize nutrients for their growth and development. So, addition of organic manure creates favourable condition for the proliferations of microbes in the soil (Roy *et al.*, 2017; Nath *et al.*, 2015; Bahadur *et al.*, 2012; Srinivas *et al.*, 2015).

Conclusion

The findings of this study can be effectively summarized as follows: the application of Integrated Nutrient Management (INM), combining 50% inorganic nutrients (chemical fertilizers) with 50% organic inputs (such as FYM, vermicompost and poultry manure), significantly enhances the soil's physical, chemical and biological properties. This approach creates optimal conditions for the cultivation of basmati rice, promoting sustainable soil health and productivity.

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