Physico-Chemical Properties of Soil as Influenced by Combined Application of Organic and Inorganic Sources to Fodder Oat and Succeeding Residual Fodder Maize

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ABSTRACT

An experimental trial was carried out during 2018-19 and 2019-20 at Banaras Hindu University, Varanasi, to assess the direct and residual effect of varying levels of fertility and organic sources on different soil chemical properties. Application of fertility levels had non-significant direct a~~s well as residual effect on soil health in both the~~nd residual effects on soil health in both years, though maximum values were obtained with ~~the application of~~ 100% RDF. ~~Maximum values of available NPK in soil after fodder oat harvest~~After fodder oat harvest, the maximum values of available NPK in the soil were observed ~~with the application of~~using vermicompost over poultry manure and FYM. Application of 50 kg nitrogen ha^{-1} through organic sources recorded distinctly higher soil available N, P, and K after the harvest of fodder oat. However, the residual effect of nitrogen levels and organic sources failed to touch the ~~level of significance on soil health parameters after harvesting of~~significant level of soil health parameters after harvesting fodder maize.

Key words- *Fertility, Organic, Residual, Soil Health, and Vermicompost.*

1. INTRODUCTION

India supports about 17% of the human population and 15% livestock population from 2.3% geographical area and 4.2% water resources of the world~~'s~~ [1]. Livestock production is a ~~major~~ significant component of the Indian farming system which contributes 7% to the national GDP and provides employment and livelihood for 70% population in rural areas [2]. Recent reports ~~clearly~~ indicated that India faces a net deficit of green fodder by 61.1%, dry crop residues by 21.9%~~ and for~~, and feeds as high as 64% [1]. To sustain the fodder production, oats ~~is~~ are the prominent fodder crop due to ~~its~~ their fast-growing nature, ~~nutritive~~ nutritional value grown in the winter ~~season~~ while taking fodder maize in summer is one of the promising options. However, nutrient~~s~~ management in intensive cereals- cereals cropping system is a major challenge. Soil nutrients supplied through sole usage of mineral NPK fertilizers in a continuous intensive cropping system may deplete soil fertility, especially micronutrients [3] and organic carbon, because fertilizers have no direct effect on soil physical properties [4]. The strategic use of organic and inorganic sources ~~showed positive impact on~~positively impacted soil organic carbon, available nutrient status, and soil quality indicators [5]. The higher soil available N, P, K, and micronutrient~~s~~ status can be maintained ~~with integrated use of~~using vermicompost, compost, and biofertilizers with inorganic fertilizers [6]. Supplementation of the recommended dose of nutrients through vermicompost and compost enhances the total uptake of macro (N, P, and K) and micronutrients (Zn, Cu, Fe, and Mn) [7]. Organic ~~source of nutrients enhances~~nutrient sources enhance microbial proliferation leading to better nutrient mobilization for crop assimilation~~.~~.

Additionally, manure may directly enhance soil physical properties such as aggregate stability [8] and water retention [9]. Diacono and Montemurro (2010) [10] opined that adding organic manure to cropland could enhance~~addition of organic manure to cropland can lead to enhancement in~~ soil biological functions for more than 15 years after ~~using~~use~~, but~~. Still, they concluded that repeated applications or regular additions were needed ~~in order~~ to elicit effects. ~~The use of organic sources in crop nutrition provides balance~~Using organic sources in crop nutrition provides a balanced supply of mineral nutrients to the main crop and has some additional influence on the succeeding crop. Residual effects of organic sources on the chemical properties of soil were studied by Tabibian*et al.* (2012) [11] and reported significant improvement in organic matter and soil health. Residual amendment effects on total nitrogen and phosphorus were apparent even after 11.5 years of application [12]. ~~In view of~~Given the above facts, the present study was conducted ~~with the aim of comparing~~to compare three organic sources, viz., farmyard manure, poultry manure, and vermicompost, for their direct and residual effects on soil ~~physico~~Physico-chemical properties on fodder oat and succeeding fodder maize.

2.- MATERIALS AND METHODS

2.1 Site and soil conditions

The field trial was conducted during the summer season of 2019 and 2020 after the harvest of fodder oat to study the residual effect of varying fertility and organic sources on nutrient content and uptake of maize fodder. The experiment was laid out in the IFS block of Agricultural Research Farm, Banaras Hindu University, Varanasi, under an assured irrigation facility. The experimental site was located at 5^0 ~~18'N~~ 18'N latitude and 88^0 ~~03'E~~ 03'E longitudes at an altitude of 128.93 meters above the mean sea level at the ~~centre~~ center of North- alluvial Gangetic plain. Climatologically, Varanasi lies under a subtropical zone having extreme climatic features such as scorching summer and chilling winter. The region falls under a ~~semi-~~semi-arid to ~~sub-~~sub-humid climate, having a mean annual rainfall and potential evapo-transpiration (PET) of 1102.4 mm and 1550 mm, respectively, with a moisture deficit index ranging between -20 to -40. The soil of the experimental site was Gangetic alluvial having uniform fertility and leveled topography. The initial ~~physico~~Physico-chemical properties of the experimental site are presented in Table.1.

Table 1: Initial ~~physico~~Physico-chemical properties of experimental field

Particulars	Value		Method employed
Soil properties (%)	2015	2016	
Mechanical analysis			
Sand	48.74	48.47	Hydrometric method [13]
Silt	28.72	28.88	
Clay	22.54	22.65	
Textural class	Sandy clay loam		
Taxonomy	Ustochrept		
Physical analysis			
Bulk density (Mg/m^3)	1.39	1.35	Core sampler [14]
Chemical analysis			
Soil pH (1:2.5 soil: water suspension)	7.34	7.32	Glass electrode pH meter [15]
Electrical Conductivity (dS/m at 25°C)	0.221	0.223	Systronics electrical conductivity meter [15]

Organic Carbon (%)	0.41	0.42	Walkley and Black method (Jackson, 1973) [16]
Available Nitrogen (N kg/ha)	180.44	182.67	Alkaline permanganate method [17]
Available Phosphorus (P kg/ha)	17.12	18.85	0.5 M $NaHCO_3$ Olsen's Colorimetric method [18]
Available Potassium (K kg/ha)	194.5	196.86	Flame Photometer method (Jackson, 1973) [15]

2.2 Experimental Design, treatment details, and crop management

During the *rabi* (winter) season of both the experimental years fodder oat cv. Kent was grown in a ~~split~~ split-plot design ~~in plot size of 4.5cm×4.0cm comprising of~~with a plot size of 4.5cm×4.0cm comprising eighteen treatment combinations. The main plot was allocated with three fertility levels (100%, 75%, and 50% RDF). In contrast, ~~whereas~~ the subplot was comprised of combinations of three organic sources (FYM, Poultry manure, and Vermicompost) and two nitrogen levels (25 and 50 kg N ha^{-1}) applied through the above-mentioned organic sources. In fodder oat, nitrogen is ~~applied~~ used in three splits, *i.e.*, 50% at basal, 25% at first irrigation, and 25% after the first cut in the form of urea. The entire doses of phosphorus and potassium were applied through Di-ammonium phosphate (DAP) and Muriate of potash (MOP) at the time of final land preparation. The recommended dose of NPK (100% RDF) represents 120-60-60 kg NPK ha^{-1}. Organic manures are ~~incorporated fresh in each plot two weeks prior to~~fresh in each plot two weeks before sowing of fodder oat. The required quantities of organic manures were calculated on the basis of their nitrogen content. ~~The moisture and nitrogen content of each organic manure~~Each organic manure's moisture and nitrogen content was estimated on a dry weight basis, and ~~required amount of fresh manure was worked out. After harvesting of fodder oat,~~the required amount of fresh manure was worked out after harvesting fodder oat and fodder maize cv. African Tall was taken as a residual crop on the same experimental set-up after applying a light ~~pre~~ pre-sowing irrigation without disturbing the lay-out during the summer season of both the years. A spacing of 30cm×10cm was maintained with a seed rate of 40 kg ha^{-1}. In ~~all~~ the plots, nutrients were applied at 50% RDF (120-60-60 kg NPK ha^{-1}). Half of the nitrogen and ~~full~~ total doses of P and K were ~~applied~~ used as basal, and the rest, 50%, was ~~top~~ top-dressed at the ~~knee~~ knee-high stage of the crop. All other agronomic packages were kept normal and invariable for all the treatments. Plant protection measures were adopted to ~~keep the crop free~~protect the crop from insect~~-~~ pests, weeds, and diseases. The crop was harvested at 70 DAS before tassel emergence, *i.e.*, 7th and 4th of June in 2019 and 2020, respectively.

2.3 Soil analysis

The soil samples from 0-15 cm depth were collected ~~prior to~~before sowing to determine the initial physic-chemical properties and after the harvest of fodder oat and fodder maize to analyze various soil chemical properties. The samples were ~~air~~ air-dried, grounded, and sieved through a 2mm sieve and analyzed for pH, EC, available N, P, and K in soil. The soil pH and EC ~~was~~ were estimated with the help of pH meter ad EC meter. The analysis ~~for~~ of soil nutrient status was accomplished by following the standard alkaline permanganate (Subbiah and Asija, 1956) [17], ~~Olsen’s~~ Olsen's method [18] (Olsen *et al.,* 1954), flame photometer method (Jackson, 1973) [15] for nitrogen, phosphorus and potassium analysis, respectively.

2.4 Statistical data analysis

The data ~~pertaining to~~of each character of the test crop was sorted out, tabulated, and finally analyzed statistically ~~by~~ using the analysis of variance technique for ~~split~~ split-plot design as described by Gomez and Gomez (1984) [19]. Critical difference values at P=0.05 were used for determining the significance of differences between mean values of treatments.

3. RESULT AND DISCUSSION

3.1 Soil pH and EC

<u>3.1.1 Direct effect of treatments</u>

Results (Table. 2) revealed that ~~direct effect of fertility levels on soil failed to show considerable effect on soil pH and EC after harvesting of fodder oat during both the~~the direct impact of fertility levels on soil failed to show considerable effect on soil pH and EC after harvesting fodder oat during both years of investigation. However, it showed an increasing trend with ~~increase in fertility levels from 50% to 100% RDF in soil pH as well as~~an increase in fertility levels from 50% to 100% RDF in soil pH and EC. A perusal of the data ~~clearly~~ indicated that none of the

Table 2. Residual effect of fertility levels, organic sources and nitrogen levels on soil health after harvesting of fodder oat

Treatment	pH		EC (dS/m)		Av. N (kg ha^{-1})		Av. P (kg ha^{-1})		Av. K (kg ha^{-1})	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Fertility levels										
100% RDF	7.33	7.31	0.220	0.218	201.2	209.8	18.88	19.38	199.57	200.40
75% RDF	7.30	7.29	0.216	0.215	199.4	204.5	18.73	19.02	195.31	196.11
50% RDF	7.27	7.26	0.209	0.209	195.7	199.9	18.52	18.70	189.90	189.93
SE m±	0.19	0.21	0.007	0.010	2.9	3.4	0.34	0.47	3.62	2.72
CD 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Organic sources										
FYM	7.34	7.33	0.218	0.217	194.6	199.4	18.14	18.32	188.61	188.93
Poultry manure	7.30	7.29	0.215	0.214	198.6	205.5	18.72	19.00	195.51	197.33
Vermicompost	7.27	7.25	0.211	0.211	203.1	209.3	19.27	19.77	200.66	200.21
SE m±	0.14	0.17	0.007	0.009	2.1	2.5	0.30	0.40	2.91	2.19
CD 5%	N.S.	N.S.	N.S.	N.S.	6.1	7.1	0.85	1.14	8.42	6.32
Nitrogen levels										
25 kg N ha^{-1}	7.32	7.31	0.217	0.216	196.1	201.7	18.28	18.42	191.41	192.35
50 kg N ha^{-1}	7.28	7.27	0.213	0.212	201.4	207.7	19.14	19.65	198.44	198.62
SE m±	0.12	0.14	0.006	0.007	1.7	2.0	0.24	0.32	2.38	1.79
CD 5%	N.S.	N.S.	N.S.	N.S.	5.0	5.8	0.70	0.93	6.87	5.16

three organic sources ~~able to influence significantly on~~can significantly influence soil pH and EC after the harvest of fodder oat (Table. 2). Notwithstanding, vermicompost proved to be better among the different sources as the values tend to be near neutral. Similarly, the direct effect of nitrogen application through organic sources did not touch the significance level concerning soil pH and EC during both~~application of nitrogen through organic sources did not touch the level of significance with respect to soil pH and EC during both the~~ years~~,~~ ~~though~~. However, it was slightly decreased with the application of 50 kg N ha^{-1} compared to

25 kg N ha^{-1}(Table. 2). The results are in agreement with earlier work done by Kumar *et al.*~~,~~ (2022) [20] and Kashyap *et al.*~~,~~ (2017) [21].

3.1.2 Residual effect of treatments

The treatments applied to fodder oat have been concerned for their residual effect on succeeding fodder maize. Data presented in the Table.3 showed that the residual effect of fertility levels had a non-significant effect on soil pH and EC after harvesting ~~of~~ fodder maize in both the years. Nevertheless, it was recorded maximum with the application of 100% RDF compared to 75% and 50% RDF, respectively. Appl~~ication of~~ying organic sources failed to show the appreciable residual effect on soil pH and EC (Table. 3). However, among the three organic sources, the residual effect of vermicompost reported a marginal decrease in soil pH and EC, thus improving ~~the~~ soil health. ~~Study~~ A study of the data revealed that the soil pH a~~s well as~~nd EC did not differ significantly due to the residual effect of the application of nitrogen through organic sources in either of the ~~two~~ two-year ~~experimentation~~ experiments (Table. 3). Appl~~ication of 50 kg N ha^{-1} through organic sources improved the soil health by bringing the soil reaction near neutral Sharma *et al.*, (2007) [22] also reported that there was~~ying 50 kg N ha-1 through organic sources improved soil health by bringing the soil reaction near neutral (Sharma et al., 2007) [22] also reported a decrease in pH in all the integrated nutrient management practices involving FYM @10 t ha^{-1}.

3.2 Available nitrogen, phosphorus, and potassium in soil (kg ha^{-1})

3.2.1 Direct effect of treatments

Data presented ~~on~~ in (Table.2) revealed that application of 100% RDF resulted in improved availability of soil nutrients such as nitrogen, phosphorus, and potassium as compared to lower levels of fertility through the differences among the fertility levels did not able to exert significant effect on soil available nitrogen, phosphorus and potassium after the harvest of fodder oat during both the years of study. The results corroborate the findings of Raghuveer and Bohra (2020) [23].

Application of organic sources resulted in lucid improvement in soil nutrient status after harvesting of fodder oat. Among different organic sources, vermicompost recorded significantly higher soil available nitrogen, phosphorus, and potassium ~~compared to~~than FYM. However, the differences between the application of vermicompost and poultry manure remained comparable during both the years of experimentation (Table. 2). This could be attributed to the addition of organic manures, which slowly released the nutrients (NPK) to the soil and produced organic acids during the faster decomposition of manures due to enhanced activity of beneficial soil microbes, which helped in better mineralization and solubilization of nutrients thus improving soil NPK status. More availability of soil nutrients may be ascribed to ~~the efficiency of vermicompost~~vermicompost efficiency, which ~~increased~~ increases soil porosity and water holding capacity, thus allowing more nutrients to retain [24]. The findings are similar to th~~e findings~~ose of Malik and Singh [25] (2016). They ~~who~~ reported that available nitrogen, phosphorus, and potassium content in soil was more when nutrients were supplied through FYM or vermicompost along with inorganic fertilizers to the preceding crops.

Increasing the dose of nitrogen from 25 to 50 kg ha^{-1} applied through organic sources resulted in a ~~distinct~~ specific enhancement in soil available nutrients. Appl~~ication of 50 kg N ha^{-1} significantly increased the soil available nitrogen, phosphorus and potassium when applied through organic manures during the course of~~ying 50 kg N ha-1 significantly increased the available soil nitrogen, phosphorus, and potassium when applied through organic manures during the study (Table. 2). The increase in soil nitrogen, phosphorus and potassium was 2.7%, 4.9% and 4.1%, respectively in 2018-19 and 3.0%, 7.2% and 3.56%, respectively in 2019-20. This might be due to appl~~ication of higher doses of nitrogen through organic sources~~ying higher doses of nitrogen through organic sources, which resulted in an enhanced soil microbial population ~~which~~ that converted the organically bound nitrogen to inorganic form through mineralization. Higher ~~availability of phosphorus~~phosphorus availability may be ascribed to the addition of nitrogen in ~~the form of~~ organic manures, which not only improved the solubilization of fixed soil phosphorus but also restricted its fixation. Similarly, greater ~~availability of potassium might be due to addition of~~potassium availability might be due to adding a higher amount of potassium from the exchangeable pool to the available pool [26]. Similar results have also been reported by Pandey (2018) [27].

3.2.2 Residual effect of treatments

A close examination of the data revealed that the application of various fertility levels did not influence ~~the available nitrogen, phosphorus and potassium content in soil~~soil's available nitrogen, phosphorus and potassium content. However, the highest values were obtained at 100% RDF over the lower levels of fertility (Table.3). ~~Application~~ The application of vermicompost recorded maximum soil available nitrogen, phosphorus, and potassium, though the differences among the sources did not touch the level of significance (Table.3). Likewise, appl~~ication of nitrogen through organic sources did not bring any significant difference on soil available nitrogen, phosphorus and potassium during the period of investigation~~ying nitrogen through organic sources did not bring any significant difference on soil available nitrogen, phosphorus and potassium during the investigation period. Nonetheless, maximum available nitrogen, phosphorus, and potassium were registered with 50 kg N ha^{-1} over 25 kg N ha^{-1} (Table.3).

Table 3. ~~Residual~~ The residual effect of fertility levels, organic sources, and nitrogen levels on soil health after harvesting ~~of~~ fodder maize

Treatment	pH		EC (dS/m)		Av. N (kg ha^{-1})		Av. P (kg ha^{-1})		Av. K (kg ha^{-1})	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Fertility levels										
100% RDF	7.32	7.30	0.217	0.215	194.5	196.9	18.16	18.95	196.61	198.91
75% RDF	7.29	7.28	0.213	0.212	191.5	192.6	17.92	18.54	192.82	194.84
50% RDF	7.27	7.24	0.205	0.211	187.0	188.3	17.74	18.25	187.64	188.67
SE m±	0.19	0.20	0.00	0.00	2.45	3.3	0.36	0.43	3.81	2.52

			7	8						
CD 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Organic sources										
FYM	7.33	7.31	0.215	0.213	187.7	188.4	17.46	18.13	186.93	190.45
Poultry manure	7.30	7.28	0.212	0.215	191.0	192.9	17.96	18.45	192.82	195.16
Vermicompost	7.26	7.24	0.208	0.210	194.3	196.5	18.39	19.16	197.42	196.82
SE m±	0.14	0.16	0.007	0.007	1.96	2.3	0.30	0.34	2.97	2.06
CD 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S	N.S	N.S	N.S	N.S
Nitrogen levels										
25 kg N ha^{-1}	7.31	7.30	0.214	0.215	188.8	190.1	17.59	18.19	189.26	192.15
50 kg N ha^{-1}	7.27	7.26	0.209	.210	193.2	195.2	18.29	18.97	195.45	196.13
SE m±	0.11	0.13	0.005	0.006	1.60	1.9	0.24	0.28	2.43	1.68
CD 5%	N.S.	N.S.	N.S.	N.S.	N.S	N.S	N.S	N.S	N.S	N.S

4. CONCLUSION

~~From the above experiment it was~~The above experiment concluded that the direct effect of fertility levels did not s~~how any significant difference on~~ ignificantly affect soil health. Similarly, various organic sources and application of nitrogen level through organic sources failed to ~~bring any significant direct effect on~~directly affect soil pH and electric conductivity in 2018-19 and 2019-20. ~~Whereas~~At the same time,~~,~~ the application of 50 kg N ha^{-1} through vermicompost recorded a significant effect on soil available N, P, and K after the harvest of fodder oat. However, all the treatments failed to exhibit a residual ~~effect~~ impact on soil health during ~~course of~~ the study. Therefore, the application of 100% RDF along with 50 kg N ha^{-1} through vermicompost can be practiced to maintain soil health in eastern Uttar Pradesh.

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