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Effect of Organics and Inorganics Amendments on Soil Physical, Chemical and Biological Properties of Alluvial Soil under Maize Cultivation.

Enkhbold Erdenebat[1], Balkrishna Sopan Bhople[1], and Arun Kumar[1]*.

School of Agriculture, Lovely Professional University, Phagwara, Punajab 144411, India.

ABSTRACT

The objective of this experiment was to study the effect of applications of inorganics and manure amendments on soil physical and chemical properties of alluvial soil under the hybrid maize variety of (31Y45). The research was conducted at agricultural field of Lovely Professional University, Punjab India in 2014. Treatments included a control and application of farmyard manure, poultry manure, urea, diammonium phosphate, muriate of potash and combinations of these fertilizers. Soil properties were analyzed as initial samples and sample after harvested to study the effect of inputs. Soil organic carbon content and available N were increased significantly due to the addition of manure and inorganic fertilizers. However, there were no significant difference in soil pH and EC. The beneficial residual effect observed in soil bulk density and pore spaces. The study reveals that the combine use of organic and inorganic amendements improve soil biological health. Principal Component Analysis (PCA) explain the variation in nutrient availability due to different combination of organic and inorganic fertilizers. This results showed that the importance of integrated nutrient management on soil physical, chemical properties and biological properties.

Keywords: soil, alluvial soil, maize cultivation.

**Corresponding author*

INTRODUCTION

Use of inorganic fertilizers has been intensified for cereal crops [1] majorly due to conveniently available cheap fertilizers [2] specifically in developing countries like India. Long-term inorganic fertilizers usages are detrimental for soil biological and biochemical processes as well as unsafe to the ground water due to leaching of nitrate [3]. Evading such environmental problems is very crucial to maintain soil health, but at the same time sufficient nitrogen should also be amended to maintain the soil quality. Application of organic fertilizers such as farmyard manure and poultry manure are apposite methods that may limit and reduce the usage and impact of inorganic amendments. Though organic amendments have slow plant nutrient releasing potential [4], combining inorganic amendments may swift the process and improve the soil quality. Organic amendment rich in humus have high soil water holding capacity and aggregate stability [5] which the decisive factors in soil nutrient transformation. In a long term study over eighteen years in Kabete, Kenya shows that the soil nitrogen and phosphorus were decreased in red soil when there was no application of any fertilizers under maize, common bean rotation continuously [6]. On other hand studies on maize plantation shows the increased production in the field applied with farmyard manure. Moreover when farmyard manure combined with inorganic amendments was amended the production increased further [7]. In country like India where majority of small farm holders are generally high and need for soil sustainability is very high, the nutrient deficiency may be easily managed by the application of inorganic and organic fertilizers. The aim of present study is to find out the impact of organic and inorganic amendments on physical, chemical and biological properties of alluvial soils and to identify the treatment having sufficiently good impact on soil quality and nutrient release.

MATERIAL AND METHOD

This experiment was conducted on agricultural research field of the Lovely Professional University Department of Agriculture, Phagwara, Punjab, India at latitude of 31° 13' 4N and longitude of 75° 46' 10E and at an altitude of 233m above from sea level in autumn to winter of 2014. During the experiment the annual mean temperature was about 20°C and about 200 mm rainfall.

The experiment is planned as total 24 plots 3 replications with 8 treatments including control treatment as a 100% of the recommended dose of fertilizers and 2 irrigation channels in between 3 replications and 6 ridges in each plot for maize hybrid (variety of 31Y45) with weed free field (manual weeding has done throughout the experiment) and proper irrigations. The design of the experiment was randomized complete block design (RCBD). Each plot size was 4.8m x 3.6m. Experimental plots were treated with different fertilizers (T1) control, (T2) 5 tons ha^{-1} FYM + 50% RDF, (T3) 5 tons ha^{-1} PM + 50% RDF, (T4) 5 tons ha^{-1} FYM + 100% RDF, (T5) 5 tons ha^{-1} PM + 100% RDF, (T6) 5 tons ha^{-1} FYM + 5 tons ha^{-1} PM + 50% RDF, (T7) 2.5 tons ha^{-1} FYM + 2.5 tons ha^{-1} PM + 50% RDF, (T8) 2.5 tons ha^{-1} FYM + 2.5 tons ha^{-1} PM + 100% RDF. Farmyard manure (FYM) and poultry manure (PM) were applied to each plot with different doses depending on treatments detail. The manures were applied 35 days before sowing and mixed well into the soil. The inorganic fertilizers were applied as urea, diammonium phosphate (DAP) and muriate of potash (MOP) as a recommended dose of 120 kg ha^{-1} N, 60 kg ha^{-1} P and 40 kg ha^{-1} K. The half dose (50%) of urea and full dose of DAP and MOP were applied at the time of sowing and remaining half of urea was applied at 25% and 25% at the knee height and tasseling stage.

Sampling and analysis of soil

Soil samples were collected randomly from the field then mixed well and sieved through a 2mm sieve to determine initial nutrients status of soil. Samples were taken at the depth of 0-15cm which represents for top soils and 15-30cm for subsoil then analyzed for physical and chemical properties of soil. pH, Electrical conductivity, Bulk density and porosity was determined using standard methodologies [8], Soil dehydrogenase activity was determined using the method of Klein [9]. MBC was determined using the chloroform fumigation method [10]. Soil organic carbon was determined using the Walkley-Black chromic acid wet oxidation method [11]. Available nitrogen was determined using methods of Subbiah and Asija [12], available phosphorus was determined using method of Olsen [13] and available potash was determined by standard method as described by Gupta [14]. After the maize was harvested 2 samples (0-15cm, 15-30cm) were collected from each plot and soil properties were analyzed to compare initial (Table 1) and final nutrient status of soil (Table 2 and Table 3)

Table 1: Physical and chemical properties of initial soils

Observation	Top soil (0-15cm)	Sub soil (15-30cm)
Chemical analysis		
pH	7.98	7.83
EC (dS/m)	0.215	0.204
Organic carbon (%)	0.36	0.29
Organic matter (%)	0.62	0.50
Available nitrogen (kg/ha)	428.26	352.64
Available phosphorus (kg/ha)	15.68	11.2
Available potassium (kg/ha)	449	337
Physical analysis		
Sand (%)	54	64
Silt (%)	32	30
Clay (%)	14	6
Textural class	Sandy clay loam	
Bulk density (g/cm^3)	1.51	1.54
Porosity (%)	43	42

Statistical analysis

For all the parameters, the individually analyzed treatments were subjected to variance analysis (ANNOVA), component of variation with Fisher's LSD as post-hoc tests using the SPSS 16.0 for test of significance. The mean thus obtained were subjected to principal component analysis using PAST 3.x Software. Unless otherwise stated, the level of significance referred to in the results is P < 0.05.

Table 2: Physical and chemical properties of soil after harvested

	pH		EC (dS/m)		Bulk density (g/cm^3)		Porosity (%)	
Treatments	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)
T1- 100% RDF (Control)	8.49^a	8.21^a	0.378^a	0.370^a	1.46^a	1.47^a	45^a	44^a
T2- 5 tons per/ha FYM + 50% RDF	8.38^a	8.18^a	0.508^a	0.419^a	1.44^a	1.46^a	46^b	45^b
T3- 5 tons per/ha PM + 50% RDF	8.27^a	8.13^a	0.432^a	0.335^a	1.44^a	1.46^a	46^b	45^b
T4- 5 tons per/ha FYM + 100% RDF	8.40^a	8.36^a	0.382^a	0.355^a	1.45^a	1.45^a	45^a	45^b
T5- 5 tons per/ha PM +100% RDF	8.48^a	8.20^a	0.419^a	0.365^a	1.44^a	1.46^a	46^b	45$_b$
T6- 5 FYM +5 PM + 50% RDF	8.28^a	8.12^a	0.412^a	0.391^a	1.42^a	1.44^a	46^b	46^c
T7- 2.5 FYM +2.5 PM +50%RDF	8.33^a	8.08^a	0.415^a	0.382^a	1.43^a	1.45^a	46^b	45^b
T8- 2.5 FYM +2.5 PM +100% RDF	8.46^a	8.23^a	0.530^a	0.387^a	1.42^a	1.45^a	46^b	45^b
S±Em	0.3264	0.2952	0.1377	0.1462	0.4603	0.6273	0.2264	0.2319
CD @ 5%	0.9900	0.9866	0.4178	0.4238	0.1396	0.1902	0.7683	0.7750

Table 3: Nutrient status of soil after harvested

	N (kg/ha)		P (kg/ha)		K (kg/ha)	
Treatments	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)
T1- 100% RDF (Control)	476.7^b	363.8^a	13.08^c	9.41^e	426.55^f	404.1^g
T2- 5 tons per/ha FYM + 50% RDF	564.5^e	514.3^g	13.44^d	7.79^b	328.6^d	306.15^f
T3- 5 tons per/ha PM + 50% RDF	577.0^f	401.4^c	14.96^e	13.44^h	291.85^b	224.5^d
T4- 5 tons per/ha FYM + 100% RDF	489.2^c	388.9^b	11.65^a	7.17^a	291.85^b	246.95^e
T5- 5 tons per/ha PM +100% RDF	464.1^a	451.6^e	20.61^g	8.96^c	314.3^c	179.6^b
T6- 5 FYM +5 PM + 50% RDF	489.2^c	439.0^d	15.77^f	9.06^d	179.6^a	157.15^a
T7- 2.5 FYM +2.5 PM +50%RDF	539.4^d	401.4^c	12.54^b	9.77^f	314.3^c	202.05^c
T8- 2.5 FYM +2.5 PM +100% RDF	564.5^e	501.8^f	13.44^d	12.54^g	404.1^e	246.95^e
S±Em	0.2088	0.2174	0.6519	0.3409	0.2112	0.3049
CD @ 5%	0.6334	0.6638	0.1977	0.1034	0.7059	0.9249

RESULT AND DISCUSSION

Soil pH, Electrical Conductivity, Bulk Density and Porosity

In all the treatment where organic and inorganic amendments were used, soil pH not varied significantly (P<0.05) (Table 2). Similar results of constant pH in organic and inorganic amended soils were observed by Mugwe [15], Tolanur and Badanur [16] and Kaur [17], though many studies shows slight increase in soil pH when organic and inorganic inputs.

Similarly electrical conductivity was also non-significant and only slight increase in all treatments may be due to fertilizer leaching (Table 2). Similar results were observed by Singh and Yadav [18] when soil receive both organic and inorganic amendments. Many studies reported the slight increase in EC value when FYM is added to inorganic fertilizers as soil amendment [19]. The effect of inorganic and organic resulted in slightly decrease on soil bulk density which is beneficial to soil quality (Table 2). The maximum reduction on soil bulk density was observed in T8 as well as in T6. Similarly [20] in a study reported all plots that received organic manures resulted decrease on bulk density may be due to the root development of maize crops loosen the soil to support development of root during plant growth period. In addition, organic amendments are generally rich in organic carbon which makes microbes more active which is beneficial for bulk density as well as porosity. In a similar finding in long term combined use of organic and inorganic fertilizers shows significant impact on lowering bulk density and increased soil porosity [21] (Table 2). Maximum improvement of porosity observed in T6 and T8. Hussain [22] noticed the beneficial effect on porosity when organic and inorganic fertilizers were applied together.

Soil microbial biomass carbon, dehydrogenase assay and organic carbon as affected by different organic and inorganic combination treatments

Microbial biomass C ranges from 166.74-296.91 mg kg $^{-1}$ at surface soil and 94.04-221.62 mg kg $^{-1}$ at surface soil. Highest microbial biomass carbon was recorded for the treatment T3 in surface (0-15cm) soil and T5 in subsurface (15-30cm) soil (Fig 1). Li [23] reported that amendment of poultry litter increase soil microbial biomass carbon; however by this study we further refine that in addition to poultry manure, 50% RDF increase the microbial biomass carbon. Similar study by Jing & Xing [24] also shows that poultry manure mixed with inorganic fertilizer increases the soil microbial biomass carbon. Generally soil enzymes are efficient indicators of agricultural management and land use changes [25]. Dehydrogenase enzyme activity is proportionally related to soil microbial activities. In the present study dehydrogenase enzyme assay ranges from 2.81-5.27 µg TPF g^{-1} at surface soil and 1.22-4.5 µg TPF g^{-1} at subsurface soil. Highest value of dehydrogenase assay was shown by T6 i.e. the combination of FYM, PM and RDF at surface soil. The result confirms that organic and inorganic nutrient in combination influence the microbial activity. Dehydrogenase assay were also higher in T3, a combination of PM and RDF. At lower depth dehydrogenase assay ranges 1.22-4.5 µg TPF g^{-1}. Organic carbon was found high in T3, combination of poultry manure and RDF followed by T8, combination of FYM, PM and RDF at surface soil. Study by Roy and Kashem [26] propose that organic carbon content in poultry manure are generally more as compared to cow dung or FYM prepared by cow dung. Our finding suggests that combine use of FYM and PM with inorganic fertilizer also have the capacity to increase organic carbon (Figure 1). Similar results were proved by Krishnamurthy [27] as addition of organic manures results in increase in soil organic carbon. However the combine uses of organic and inorganic amendments also result in marginal reduced, but significant increase in organic carbon as explained by studies of Mathur [28]. The organic carbon content can be increased due to the decomposition of animal residues that are added to the soil. Pearson correlation signifies and positively correlates macronutrient (NPK) availability and on soil organic carbon, microbial biomass carbon and dehydrogenase assay (Table 4). The microbial biomass carbon strongly correlated with soil dehydrogenase assay (R2=0.93) than organic carbon (R^2= 0.84) while correlating microbial biomass carbon and organic carbon with soil dehydrogenase assay of organic and inorganic treatments on XY graph (Figure 2). Our findings are similar to study by Sharma [29] as microbial biomass carbon and organic carbon is strongly correlated (Table 4)

Macronutrient availability as affected by different organic and inorganic combined treatments

The status of available nitrogen in T2, T3, T7 and T8 were significantly increased. T3 was resulted maximum increase where poultry manure where added (Table 3). Similarly Duncan [30] reported that judicious use of poultry manure can improve soil fertility status. Reddy and Reddy [31] observed similar results when soil was treated with poultry manure and FYM along with inorganic fertilizers. Goyindan and Thirumurugan [32] reported similar increased content of available N when soil there was input of combined organic manures and inorganic fertilizers. The status of available N increased because of added inorganic fertilizers and organic manures which contains N. However in our study no significant ($P<0.05$) increase in soil available nitrogen were found in treatments T1, T4, T5 and T6.

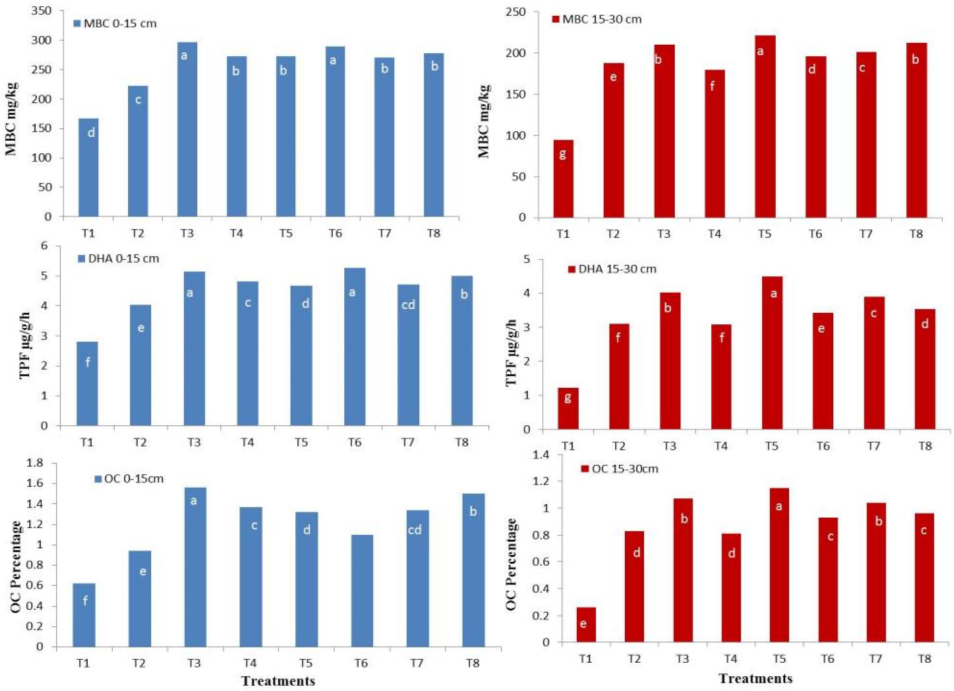

Figure 1: Impact of different treatments on soil microbial biomass carbon (MBC- mg kg^{-1}), dehydrogenase assay (DHA-µg TPF g^{-1} soil h^{-1}), and organic carbon (OC-%).The mean followed by different letters are significantly different at $p<0.05$, according to DMRT (Dun can s Multiple Range Test) for separation of means.

The additional of organic manures and inorganic fertilizers results in significant increase in soil Phosphorus status in treatments T5 and T6 (Table 3). This result is in agreement with Agbede [20] as the amount of P almost doubled in the plots where poultry manure was amendment. Also Yaduvanshi [33] reported that soil available P was significantly increased when soil was received inorganic fertilizers along with either FYM or PM. In our study reduced available soil phosphorus were observed in treatment T4 and T7, may be due to the mass population of maize. In our study significant ($P<0.05$) increase in available potassium is recorded in treatments T2, T5 and T8 (Table 3).

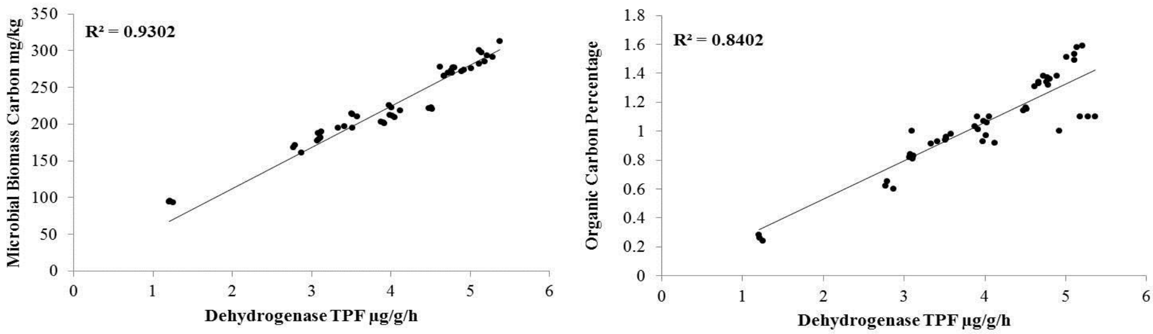

Figure 2: Impact of different organic and inorganic combination treatment on soil biological activity (DHA), (a) Correlation between microbial biomass carbon (MBC) and dehydrogenase assay (DHA), (b) Correlation between organic carbon (OC) and dehydrogenase assay (DHA).

Table 4: Pearson's correlation coefficients among Microbial Biomass Carbon, Dehydrogenase, Organic Carbon, Available Nitrogen, Available Phosphorus and Available Potash for different organic and inorganic amended soils.

Pearson Correlation	DHA	OC	N	P	K
MBC	0.975**	0.939**	0.672**	0.605*	0.628**
DHA		0.938**	0.595*	0.551*	0.563*
OC			0.605*	0.521*	0.493
N				0.458	0.541*
P					0.266

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

Similar results were recorded by Tolanur and Badanur [16] and Sharma [29] as they observed application of organic and inorganic amendment in combination result increase in available N, P and K. All other treatment studied showed reduced available potassium due to the regular nutrient uptake of the crops and similar results were observed by Zeng [21].

Principal component analysis (PCA)

Principal component analysis based on macronutrient availability (NPK) and soil biochemical properties (MBC, OC, Dehydrogenase) identifies 63.02% variation on PC1 and 21.5% variation on PC2. PCA clearly segregate T1 (control) from all other treatments and indicates the similarity between T3, T7 and T5. However treatment T8 and T2 tend to show similar impact on soil (Figure). PCA are efficient statistical tool to infer the discriminate the treatment impact, similarity and dissimilarity of soil functions [34].

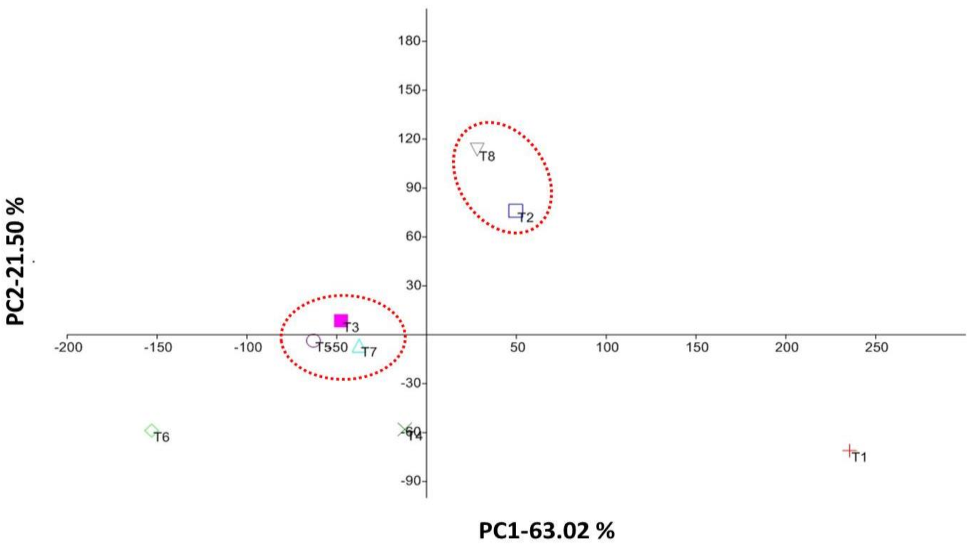

Figure 3: PCA ordination of nutrient availability and soil biological properties of different organic and inorganic treatments. Shorter distances between treatments in PCA ordination indicate high degree of similarity between treatments and soil quality parameters. Component

1 and 2 represents 63.02% and 21.50% of the variation in the data respectively.

CONCLUSION

Due to the application of inorganic fertilizers with organic manures result in slight increase on pH values in all treatments and some treatments on EC values. Input of both inorganic and manures impact are beneficial to soil physical properties like bulk density and porosity. By combined use of organic and inorganic fertilizers shown to increase the content of organic carbon and available N in all treatments. In addition soil biological properties enhances in relation to nutrient availability with the use of organic and inorganic combination treatments.

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