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EFFECTS OF ORGANIC MANURE, INORGANIC FERTILIZERS AND FLY ASH ON PHYSICAL AND ELECTROCHEMICAL PROPERTIES OF SOIL UNDER MAIZE CULTIVATION

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Abstract

A field experiment was conducted to study the effect of recommended fertilizers, fly ash, vermicompost and farm yard manure (FYM), alone or in combination, on physical and electrochemical properties of soil under maize (*Zea mays* L.) cultivation during *kharif* season, 2017 in a Randomized Block Design (RBD) with three replications. All treatments were found to decrease soil pH with gradual passage of time and presence of fly ash, in different combinations of recommended dose of fertilizer (RDF) and vermicompost or alone, showed more pH as compared to other treatments. Present investigation revealed that application of organic manure along with chemical fertilizers and fly ash in different combinations helps in improving soil physical and electrochemical properties of soil.

Key words : fly ash, vermicompost, farm yard manure, bulk density, porosity, pH, EC.

Introduction

Maize (*Zea mays* L.) is a heavy feeder of nutrients, so its productivity is largely dependent on nutrient management. (Singh *et al.,* 2003). In addition to inorganic fertilizers, it is a common practice to use eco-friendly and non-toxic products like vermicompost (VC) and farm yard manure (FYM) which not only supply macronutrients and micronutrients but also improves soil health from physical, chemical and biological points of view. (Reddy and Reddy, 2003). VC and FYM contain considerable amount of nutrients with huge amount of beneficial microbial population, cytokinins, auxins, and gibberellins like biological active growth promoting substances (Arancon *et al.,* 2006; Pawar and Patil, 2007; Jack *et al.,* 2011). Recently fly ash (FA) is also used in agricultural field as soil conditioner. FAcontributes a larger role to modify soil pH and it contains many nutrients, especially the secondary (Ca, Mg & S) and the micronutrients (Fe, Mn, Zn & Cu). Therefore, it may be used as nutrient source to plants and to improve the physicochemical properties of soils, although it may also contain toxic substances (Lee *et al.,* 2006, Tiwari *et al.,* 2008). The presence of these toxic elements is restricted in such a low level of their availability that they do not exert any harmful role on the soil and crop quality. For these reasons, it becomes a practice to use FA as a useful soil amendment to enhance the productivity of crops and fertility of soils by improving the physicochemical and biological properties of soil (Inam, 2007; Kishore *et al.,* 2010). In the present investigation attempts are made to examine the effect of FA alone and in combination with organic amendments (VC) and inorganic fertilizers on the physical and electrochemical properties of soil under maize cultivation, taking bulk density, porosity, pH and electrical conductivity of soil into consideration.

Materials and Methods

A field experiment was conducted at the experimental farm of School of Agriculture, Lovely Professional University during Kharif season 2017-2018, in Randomized Blocked Design with three replications. Average value of temperature (highest and lowest) and rainfall during the field experimental period of July, August, September, and October in 2017 have been 17.3 – 35.4 ^{0}C and 27-197 mm, respectively.

Recommended dose of fertilizers (RDF) for N, P and K were used as 180, 60 and 40 kg ha^{-1}, respectively.

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FYM, VC and FA were applied to the field @16, 5 and 20 tones ha^{-1}. These treatments include control (T_0, no RDF, no manures and no FA), T_1 (100 % RDF + 100 % VC), T_2 (100 % RDF + 100 % FYM), T_3 (100 % FA), T_4 (20 % FA + 80 % RDF + 80 % VC), T_5 (40 % FA + 60 % RDF + 60 % VC), T_6 (60 % FA + 40 % RDF + 40 % VC), T_7 (80 % FA + 20 % RDF + 20 % VC). The FA, VC, FYM and full dose of diammonium phosphate and muriate of potash were added during the last preparation of field and urea was applied as basal and 2 splits.

Maize seeds (Kawari 50) were sown by dibbling method, keeping plant to plant and row to row distance as 20 cm and 60 cm, respectively. Soil samples were taken before application of any soil amendment and after soil treatments at different time intervals (30, 60, 90 DAS and at harvest). The soil samples were air dried, ground and screened through a 2 mm sieve. Bulk density, porosity, pH and EC values for VC, FYM, and FA are summarized in Table 1. Soil bulk density, pH and electrical conductivity (EC) and porosity were determined using established methods (Jackson,1987).

Statistical analysis

Duncan Multiple Range Test (DMRT) was applied to identify the most efficient treatment. Anova was done to test the significance of difference for each parameter. Calculation was done at 5 % significant level.

Results and Discussion

Bulk Density

In general, soil bulk density, monitored during different growth stages of the crop, decreased with different manures and fertilizers applications supplemented with fly ash at different levels, when those were compared with initial bulk density value of soil (1.38 g/cm^3) before applying any soil amendments (Table 2). At 30 DAS, highest decrease in bulk density was observed in T_1 (1.28 g/cm^3) followed by T_4 (1.29 g/cm^3), T_2 (1.30 g/cm^3), T_5 (1.32 g/cm^3), T_3 (1.34 g/cm^3), T_6 (1.34 g/cm^3) T_7 (1.36 g/cm^3) and T_0 (1.39 g/cm^3). Same trend was also found in 60, 90 DAS and after harvesting. Low bulk density in applied FYM, VC and FA (0.55, 0.74 and 0.92 g/cm^3, respectively; Table 1) played a pivotal role in reducing the soil bulk density in all treatments over control. Incorporation of FA and manures generally leads to lowering of bulk density of a soil (Mittra *et al.,* 2005; Sharma and Kalra, 2006) and eventually such change in soil bulk density may directly or indirectly influence soil aeration, soil porosity, water holding capacity, root growth and its penetration in soil, and microbial activity and ultimately boost crop growth.

Porosity

The soil porosity monitored in the present investigation under different treatments at different crop growth stage is illustrated in Table 2. The porosity value of the soil significantly increased in the treatments where FA, organic and inorganic fertilizers were applied, alone or in combination. However, all treatments including control showed a slight decrease in porosity at 60 DAS and 90 DAS. This might be due to mineralization of organic carbon. Highest porosity was obtained in T_1 (43.34%-55.57%) followed by T_4 (41.58% - 54.47%) and minimum in the control. It was found that the per cent increase in porosity in T1 treatment was 22.7%, 40.76%, 22.83% and 21.67% at 30 DAS, 60 DAS, 90 DAS and after harvesting, respectively. Therefore, total porosity in T_1 treatment, where soil was amended with 100% RDF + 100%VC, was found to be maximum, conforming earlier findings (Azarmi *et al.,* 2008; Kalantari *et al.,* 2010). Among FA treatments, T_4 (20 % FA + 80 % RDF + 80 % VC) containing lower concentration of FA increased porosity more than other treatments containing higher concentration of FA. Porosity is the air space between soil particles, which is usually occupied by water when available. So, increased porosity induces more water holding capacity (Gupta *et al.,* 2002). Porosity follows an inverse relationship with the soil bulk density. In the present investigation, porosity increased with decrease in bulk density when soil was amended with manures and FA table 2, which is considered beneficial for crop growth.

Soil pH

The soil pH after 30, 60, 90 DAS and after harvesting were found in the range of 7.86 – 8.06, 7.75 – 8.02, 7.08 – 7.80 and 6.84 – 7.43, respectively against the initial pH value of 7.73 before application of any treatment (Figure 1). At 30 DAS, T_0, T_1, T_2 and T_4 behaved similarly with slight increase in pH, while T_3, T_5, T_6 and T_7 treatments showed comparatively more increase in pH without any significant difference within themselves. FA is mostly alkaline in nature as it contains lime and thereby, it can increase soil pH (Cetin and Pehlivan, 2007; Kishore *et al.,* 2010; Sarkar *et al.,* 2013). However, non-significant

Table 1: Physiochemical properties of VC, FYM, and FA.

Properties	VC	FYM	FA	Soil (before any treatment)
Bulk density (g/cm^3)	0.74	0.55	0.92	1.38
Porosity (%)	53.6	56.4	49.7	44.3
Soil pH	7.37	6.32	7.85	7.73
EC (dSm^{-1})	0.538	0.225	0.235	0.289

Table 2: Effect of FA, organic manures and inorganic fertilizers on soil bulk density and porosity.

Treatments	30 DAS	60 DAS	90 DAS	After harvesting
Bulk density (g/cm³)				
T_0	$1.39^{a}\pm0.005$	$1.42^{a}\pm0.005$	$1.41^{ab}\pm0.005$	$1.41^{b}\pm0.005$
T_1	$1.28^{f}\pm0.005$	$1.31^{e}\pm0.005$	$1.34^{d}\pm0.003$	$1.34^{e}\pm0.003$
T_2	$1.30^{de}\pm0.008$	$1.34^{d}\pm0.005$	$1.37^{c}\pm0.005$	$1.37^{cd}\pm0.005$
T_3	$1.34^{c}\pm0.003$	$1.38^{b}\pm0.005$	$1.41^{ab}\pm0.005$	$1.41^{b}\pm0.005$
T_4	$1.29^{ef}\pm0.005$	$1.32^{e}\pm0.005$	$1.35^{d}\pm0.005$	$1.35^{de}\pm0.003$
T_5	$1.32^{d}\pm0.005$	$1.35^{cd}\pm0.005$	$1.38^{c}\pm0.003$	$1.38^{c}\pm0.005$
T_6	$1.34^{c}\pm0.005$	$1.36^{c}\pm0.003$	$1.40^{b}\pm0.005$	$1.42^{b}\pm0.005$
T_7	$1.36^{b}\pm0.003$	$1.39^{b}\pm0.003$	$1.42^{a}\pm0.005$	$1.43^{a}\pm0.003$
Soil porosity (%)				
T_0	$45.29^{d}\pm1.29$	$40.76^{f}\pm0.45$	$34.64^{d}\pm0.60$	$35.62^{c}\pm0.66$
T_1	$55.57^{a}\pm0.67$	$51.74^{a}\pm0.47$	$42.55^{a}\pm0.53$	$43.34^{a}\pm0.41$
T_2	$53.46^{ab}\pm0.65$	$49.55^{bc}\pm0.45$	$39.57^{b}\pm0.55$	$40.60^{b}\pm0.57$
T_3	$48.60^{c}\pm0.83$	$44.45^{e}\pm0.63$	$35.61^{d}\pm0.56$	$36.54^{c}\pm0.74$
T_4	$54.47^{ab}\pm0.72$	$50.46^{ab}\pm0.53$	$40.46^{b}\pm0.51$	$41.58^{ab}\pm0.55$
T_5	$52.73^{b}\pm0.60$	$48.37^{c}\pm0.71$	$38.80^{bc}\pm0.58$	$39.72^{b}\pm0.79$
T_6	$49.13^{c}\pm0.73$	$45.38^{de}\pm0.56$	$37.53^{c}\pm0.59$	$35.28^{c}\pm0.78$
T_7	$50.18^{c}\pm0.65$	$46.23^{d}\pm0.45$	$34.81^{d}\pm0.18$	$33.0^{d}\pm0.38$

The mean followed by different letters are significantly different at $p< 0.05$, according to DMRT (Duncan's Multiple Range Test) for separation of means. Values are mean ± SE.

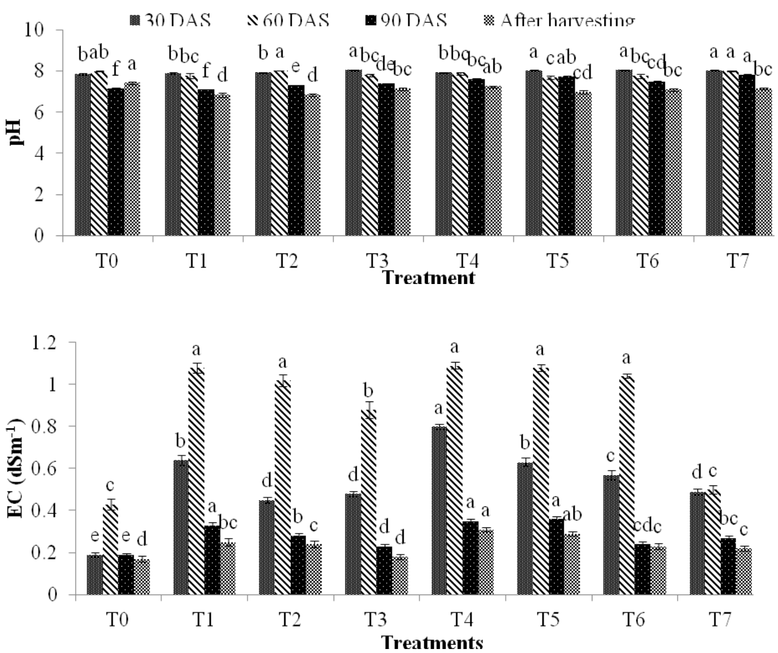

Fig. 1: Effect of various soil amendments on soil pH and EC.

changes on soil pH with FA application were also reported earlier (Sikka and Kansal, 1995). With progress of time a slight decrease in pH was observed in all treatments, as evidenced by the data obtained during 60 & 90 DAS and after harvesting; it might be due to inherent soil buffering capacity.

Electrical Conductivity

An increase in EC value over control for different treatments throughout the experimental period was noticed (Fig. 1). Initially soil EC increased with application of organic and inorganic fertilizers along with FA at different levels up to 60 DAS and then decreased significantly. This might be due to the leaching down of salts with water. A significant increase in EC was earlier noticed with incorporation of FA in soil (Das *et al.,* 2013). An increase in EC value with incorporation of organic manures/inorganic fertilizers / FA is quite common, as they are rich in soluble salts. In the present study, however, no treatments showed an increase in soil EC value up to a harmful level for crop growth.

Conclusion

All treatments of soil amendments showed significant positive influence over control treatment in improving bulk density and porosity of soil. Although EC value in all treatments increased, it did not exceed its harmful level in any treatments. FA addition to soil increased soil pH because of its alkaline nature. The present investigation revealed that application of organic manure along with chemical fertilizers and FA helps in improving soil properties which might be instrumental to improve soil fertility and crop yield

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