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Effect of the Manure Levels , Depth and Method of Applying Using Ditch Opener and Manure Laying Machine on Some of Soil Physical Properties

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Abstract: A field experiment was carried out in silty loam soil at Agricultural research station, College of Agriculture during the corn growing season of 2015. The aim of study was to determine the effect of manure (cattle residues) levels (0, 20 and 40 ton ha^{-1}), the depth of manure application (10, 20 and 30 cm), and the method of manure application (mixing with soil and subsoil laying) on soil bulk density and soil water content. The manure was added at certain treatments by using a ditch opener and manure laying machine which was designed and manufactured in the Agriculture Machines and Equipment Department, College of Agriculture, University of Basrah in 2015. The field was plowed perpendicularly, and the treatments were arranged in RCBD with split-split plot design with three replicated using drip irrigation system. Corn (*Zea mays* L.) seeds were planted on the manure rows. All plots received NPK fertilization with the same levels. At the end of growing season, soil samples (0-30 cm) were collected to examine soil bulk density and soil water content. The results showed that, lower bulk density and higher water content were obtained at level of 40 ton ha^{-1} compared with the levels of 0 and 20 ton ha^{-1}. The soil bulk density decreased from 1.23 to 1.20 Mg m^{-3} and the soil water content increased from 26.33 to 30.23 % when the depth of application increased from 10 to 30 cm. Mixing manure with soil resulted in lower value of bulk density and higher value of water content compared with subsoil laying method. Mixing manure with soil down to the depth of 30 cm amount of 40 ton ha^{-1} improved the soil bulk density which reached lower value of 1.14 Mg m^{-3} and soil water content increased to 36.19% among all other treatments.

Key words: organic fertilizer machine, organic residues, soil bulk density, soil water content.

Introduction

Most of soils in middle and south of Iraq were known as poor-structured soil. Ever-degrading physical soil properties and fertility status resulting in poor crop growth and yield, the main reason of such degradation is related to lower organic matter content due to high ambient temperature, low precipitation, and low vegetation cover (Al-Hadithi and Abdul-Hamza, 2010).

Application of organic residues is a common strategy to improve physical properties by supplying nutrients that affect the soil ecosystem. Regular use of organic residues increases soil organic matter levels, thus improves water holding capacity, porosity, bulk density, drainage and tilth (Koenig and Johuson, 1999). Avnimelech and Kochva (1997) reported that humic compounds and polysaccharides are cap-able of stabilizing soil structure. Haynes and Naidu (1998) reviewed that addition of organic manures into soil resulted in higher water holding capacity, porosity, infiltration capacity, hydraulic conductivity and water stable aggregation then decreased bulk density and surface crusting. Soil bulk density was clearly reduced following the addition of manure due to raise up in the mean weight diameter (MWD) and the low density of the organic matter itself (Al-Delfi, 2013). The organic matter has a water holding capacity almost higher than mineral fractions of soil. Thus, the addition of manure is expected to ensure a relatively high moisture content (Zhang *et al*., 2005). Guo *et al*. (2016) found that soil bulk density and water content were significantly and positively related to application of cattle manure compost with chemical fertilizer compared with application of chemical fertilizer alone.

Organic material always broadcasts on the surface and tilled or applied in narrow band beneath the soil surface using a common fertilizer spreader or by hand, which often work well for applying small quantities of organic materials with less uniformity and rate control. Furthermore, these conventional methods need higher labor and costs and required more time as well as their roles in the pollution of environment, and the workers may exposure to diseases. According to above problems, ditch opener and organic fertilizer laying machine was designed, manufactured, and evaluated in the field. The machine can open ditch to lay the manure in and then buried as subsoil band (layer) or mixed with the soil.

This research was conducted to study the effect of different manure levels, the methods and depth of application of the cattle manure using the manufactured machine on some physical properties of silty loam soil cultivated with corn (*Zea mays* L.).

Materials and methods

The study was carried out in silty loam soil of Agricultural research station, College of Agriculture, field of Garmat Ali during the growing season of 2015. The physical and chemical properties of soil layer (0-30 cm) were analyzed acc-ording to Black (1965), Page *et al*. (1982) and Richards (1954). The results are presented in table (1).

Manure was added using a ditch opener and manure laying machine which designed and manufactured in the Department of Agriculture Machines and Equipment, College of Agriculture, University of Basrah. The following treatments were used in this research:

1-Three levels of manure (0, 20 and 40 ton ha^{-1}), which was determined by ma-chine forward speeds, size of manure feeding openers and manure feeding ro-tational speed.

2-Three depths of manure application (0, 20 and 30 cm). The depths were determined (controlled) using tractor hydraulic system.

3-Two application methods of manure (mixing and subsoil laying) were used. The manure was mixed with soil using three mixing blades (tines).

Manure (cattle residues) was collected from field beyond station of Agricul-tural research, College of Agriculture, Garmat Ali then composted in a hall of 2×3×0.5 m diameters for three months at 60% moisture content. The compost dump was manually stirred every 14 days. Then compost air-dried and used in the experiment. A sample of composted manure was dried at 50°C and analyzed for routine analysis as described by Page *et al*. (1982) and presented in table (2).

The field was plowed perpendicularly at 30 cm depth and, divided to three main blocks (levels of manure). Each main block was divided into two sub-main blocks (application methods of manure), while the depth of manure application was carried out as rows of 10 m length within the sub-main blocks. The different treatments were arranged in RCBD with split-split plot design with three replications. The experiment was conducted using drip irrigation system. Spanish hybrid variety (Cadiz) of maize (*Zea mays* L.) was banded on manure rows. All plots received urea (46 % N) at level of 200 kg N ha^{-1}, triple super phosphate (20.21 % P) at level of 130 kg P ha^{-1} and potassium sulfate (43 % K) at level of 100 kg K ha^{-1}. The normal agricultural processes of maize were practiced as usually followed in the commercial production of Al-Hartha region.

Table (1): Basic soil characteristics prior to the experiment.

Property	Unite	Value
pH		8.13
EC	dS m^{-1}	7.61
Organic matter	g kg^{-1}	6.11
$CaCO_3$	g kg^{-1}	335.10
Available - N	mg kg^{-1}	18.72
Available - P	mg kg^{-1}	16.12
Available - K	mg kg^{-1}	95.34
CEC	Cmol kg^{-1}	25.25
Ca^{++}	mmole L^{-1}	11.13
Mg^{++}	mmole L^{-1}	10.90
Na^{+}	mmole L^{-1}	21.32
K^{+}	mmole L^{-1}	10.60
CO_3^{--}	mmole L^{-1}	0.00
HCO_3^{-}	mmole L^{-1}	9.34
Cl^{-}	mmole L^{-1}	30.15
SO_4^{--}	mmole L^{-1}	19.23
Bulk density	Mg m^{-3}	1.31
Sand	g kg^{-1}	188.87
Silt	g kg^{-1}	590.46
Clay	g kg^{-1}	220.67

Table (2): Some chemical properties of manure used.

Property	Unite	Value
pH		6.42
EC	dS m^{-1}	13.25
Nitrogen	g kg^{-1}	17.37
Phosphorus	g kg^{-1}	7.16
Potassium	g kg^{-1}	10.44
Organic matter	g kg^{-1}	363.22
Organic carbon	g kg^{-1}	210.69
Bulk density	Mg m^{-3}	0.59
C/N Ratio		12.13
C/P Ratio		29.43

At the end of growing season (Oct. 10, 2015), sample (0-30 cm) for each experimental unite was collected by core sampler to determine bulk density, or by Oger to determine soil moisture according to Black (1965). All the obtained data were subjected to analysis of variance (ANOVA) using Genstat program. Means were compared using Least Significance Difference (LSD) at 5% level of probability (Al-Rawi and Khalaf-Allah, 1980).

Results and discussion

1-Bulk density

The application of manure at various levels had significant effect ($P \leq 0.05$) on soil bulk density at the end of growing season of corn plant (Fig. 1). Increasing the manure levels from 0 to 20 and 40 ton ha^{-1} decreased the bulk density from 1.26 to 1.22 and 1.17 Mg m^{-3}, respectively. This result was in agreement with some previous reports (Shirani *et al*., 2002; Brye *et al*., 2004 and Mosaddeghi *et al*., 2009). The organic materials have low bulk density and higher porosity when it was added to the soil caused significant decrease in bulk density. Organic mate-rials influence microbial activity since, they provide the soil with carbon and nutrients essential for growth which bon-ding soil particles by hyphens and differ-rent exudates result in increased porosity and decreased bulk density (Al-Mohammedi, 2009). Al-Delfi (2013) found that organic manure decreased bulk density as a result of increasing the mean weight diameter of the soil aggregates.

Fig. 2 showed that the depth of the manure had significant effect on the bulk density ($P \leq 0.05$). The lowest soil bulk density (1.20 Mg m^{-3}) was observed for 30 cm depth, while the bulk density were 1.23 and 1.22 Mg m^{-3} for 10 and 20 cm depths, respectively. This result may attribute to higher root biomass and higher soil moisture in the deeper soil layers resulting in lower bulk density. The changing of the soil bulk density with different application of manure depth was reported by Guo *et al*. (2016).

Methods of manure application significantly affected the soil bulk density (Fig. 3). The lower value (1.20 Mg m^{-3}) was observed for mixing method as compared with subsoil layer method (1.23 Mg m^{-3}). This finding confirmed that mixing manure with full bulk of soil is expected to ensure improvement and stabilize soil structure, while presence of a manure-free layer beneath the surface, at the subsoil layer method, may reduce the benefit effect of organic matter on development of porosity, which resulted in higher bulk density. Al-Shamy (2013) observed that mixing organic manure with soil reduced bulk density as a result of increasing root biomass and soil moisture. However, a higher bulk density was observed for no treated underlying soil strata than that of treated soil, which may be due to the rearrangement of soil pores among particles resulting in low soil volume and high bulk density.

Fig. 4 showed that soil bulk density decreased with increasing manure levels for mixing and subsoil layer methods, with domination for mixing method. Highest value of 1.26 Mg m^{-3} was obtained for the control treatment (no manure added). The lowest value of 1.14 Mg m^{-3} was obtained for treatment of mixing manure at rate of 40 ton ha^{-1}, with reduction percent of 9.52% as compared with control treatment. The application of manure at level of 40 ton ha^{-1} as a subsoil layer gave the same value (1.20 Mg m^{-3}) of bulk density as that for mixing application of manure at level of 20 ton ha^{-1}. This findings clearly support that using the best useful method for distributing manure would provide economic benefits, improve the economic condition of farmers and preserve natural resources through reduction of the manure amounts used.

The interaction between manure levels and depth of manure application also showed a significant effect on soil bulk density (Fig. 5). At the same application rate, when the depth of application increased, the bulk density decreased with the trend being 10 > 20 > 30 cm. The effect of each two factors (application level and application depth) on soil bulk density would control the results which attributed to improve soil porosity, water content, soil structure, thereby decreased bulk density (Fig. 5). Highest value (1.26 Mg m^{-3}) was obtained in untreated soil, while the lowest value (1.14 Mg m^{-3}) was obtained in soil treated with 40 ton manure ha^{-1} at depth of 30 cm. The results also revealed that the bulk density in plot treated with 20 ton manure ha^{-1} at 30 cm depth had no significant difference with that in plot treated with 40 ton manure ha^{-1} at 10 cm depth , there values were 1.20 and 1.21 Mg m^{-3}, respectively. This means that the addition of less manure amount (20 ton ha^{-1}) at deeper depth can give the same results of greater amount of manure (40 ton ha^{-1}) shallow depth. This finding may provide a good potential to reduce the amount of added manure by 50% as a result to adding the manure in the deeper layers.

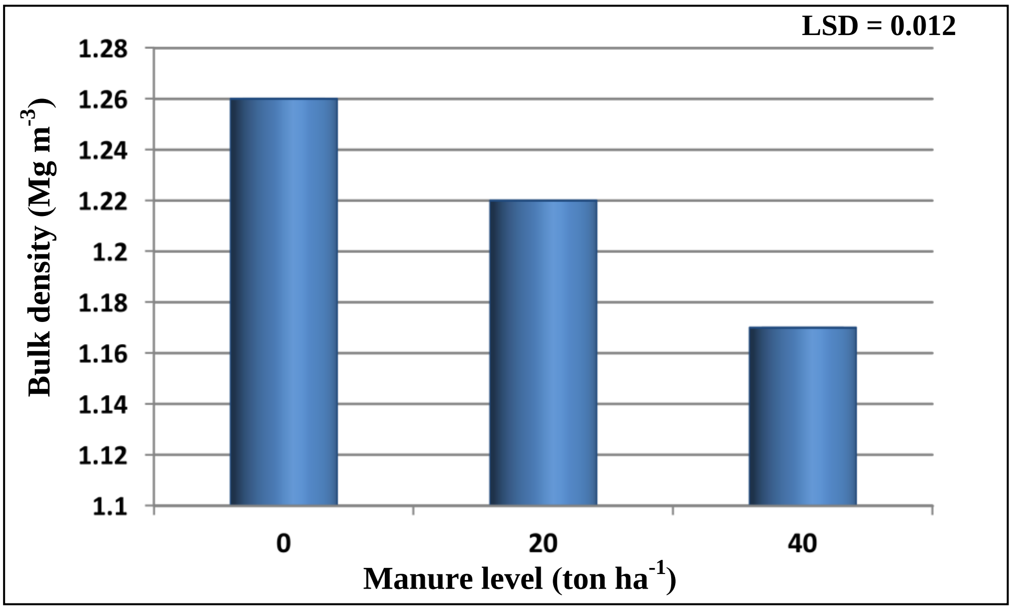

Fig. (1): Influence of manure levels on soil bulk density.

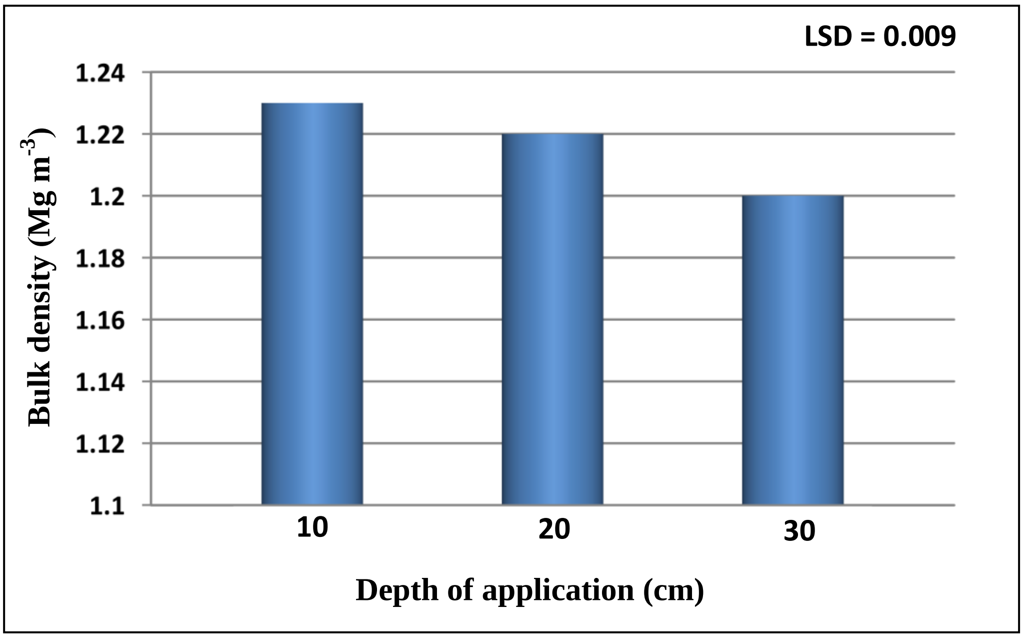

Fig. (2): Influence of depth of manure application on soil bulk density.

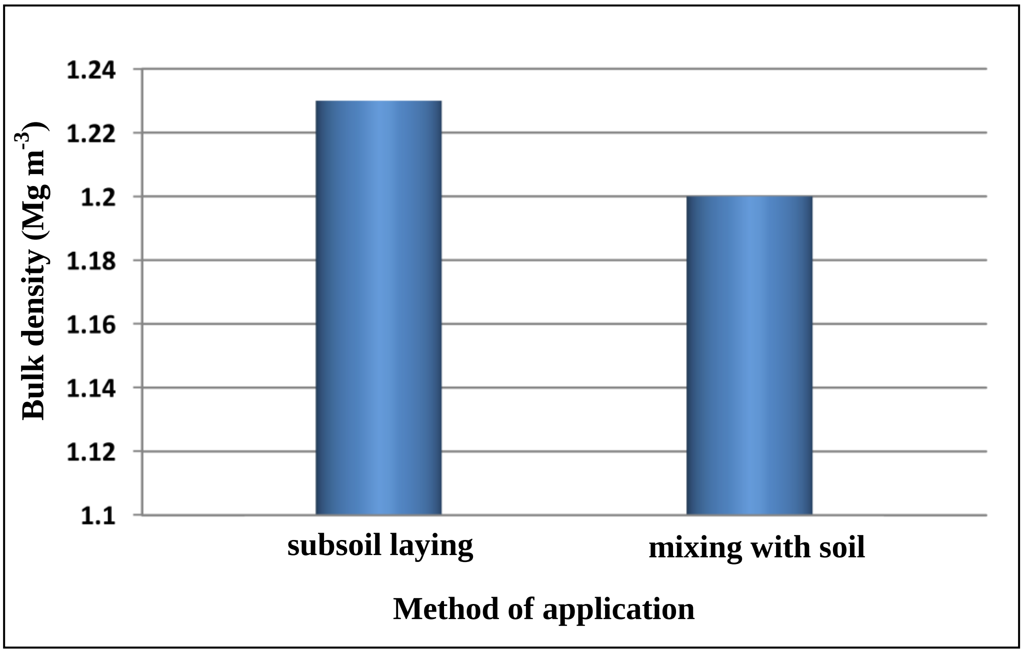

Fig. (3): Influence of method of manure application on soil bulk density.

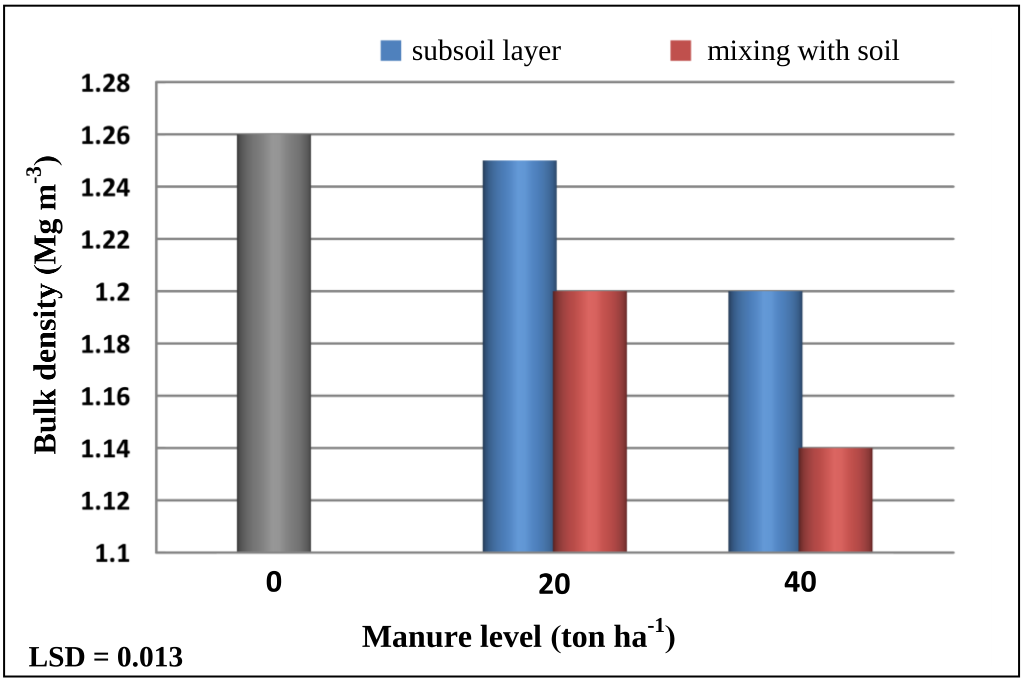

Fig. (4): Influence of manure levels on soil bulk density at different application methods.

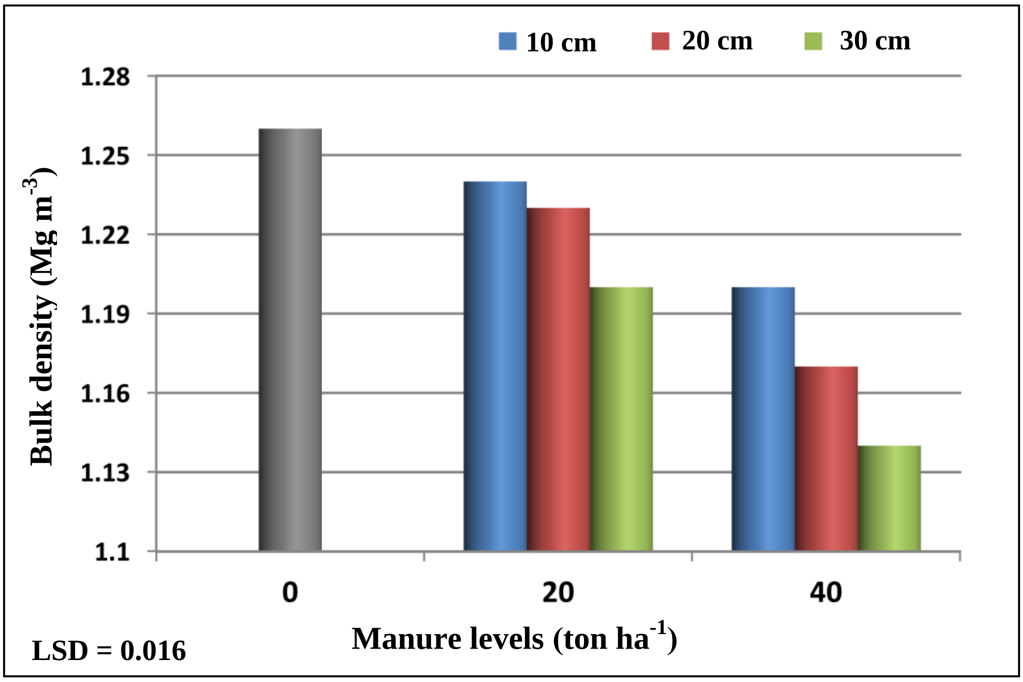

Fig. (5): Influence of manure levels on soil bulk density at different depth of application.

Statistical analysis of the experiment showed that neither the interaction of depth × method nor the interaction of level × depth × method had any signify-cant effect on soil bulk density.

2-Soil water content

Contrary to the bulk density, the manure application rates increased the soil water content (Fig. 6). When the manure levels were increased from 0 to 20 and 40 ton ha^{-1} , the water content increased from 24.19 to 28.84 and 32.20 %, respectively. This result was in agreement with Dridi and Toumi (1999) and Al-Hasan (2008). Application of chemical fertilizers alone (0 ton manure ha^{-1}) decreased the moisture retention capacity (Guo *et al.*, 2016), however, manure application could improve the total porosity and water holding capacity of soils. This findings clearly support that the manure can well improve soil moisture condition,. A significant correlation being found between bulk density (x) and soil moisture content (y) as follow; $y = -86.598x + 133.87$ ($r = 0.9719^{**}$). Al-Fadlly (2011) found that the soil water content was increased after addition of organic residues and that can be attributed to the soil bulk density reduction and to the high organic matter input. The increasing of water holding capacity of soil treated with manures and reducing rates of evaporation from the soil surface can result in increasing soil moisture content (Jasim *et al.*, 2008).

The results presented in Fig. 7 showed that soil moisture values were 26.33, 28.67 and 30.23% for application depth of manure of 10, 20 and 30 cm, respectively. The difference was significant ($P \leq 0.05$) among the three depths. The highest soil moisture content was recoded for depth of 30 cm which may be related to higher accumulation of organic matter in this depth. A similar result was reported by Avnimelech and Kochva (1997) who found a significant correlation between organic carbon and soil water content in two layers 0-10 and 10-30 cm, suggesting that water holding capacity of the added organic carbon is 341 and 825% in the 0-10 and 10-30 cm layers, respectively, since the organic carbon in 0-10 cm layer is mostly made of the native organic matter, while organic carbon in the lower layer consists of mainly from the organic carbon that was leached down from the compost. Furthermore, the results showed that the highest value of soil moisture were associated with lowest values of bulk density in different working depths (Fig. 2) and significantly correlated as given by the following equation: $y = -101.05x + 151.43$ ($r = 0.9086^{**}$). Zhang *et al*. (2014) found a negative correlation between bulk density and water content at depths 0-10 and 10-20 cm of soil under farmyard manure application.

Soil water content significantly increased in soil mixing manure plot compared with subsoil laying manure plot. The mean values were 29.25 and 27.57%, respectively (Fig. 8). This results might be enhanced by the improvement in the soil structure and soil porosity and decreased in soil bulk density (Fig. 3), in addition to the improvement in the soil holding capacity.

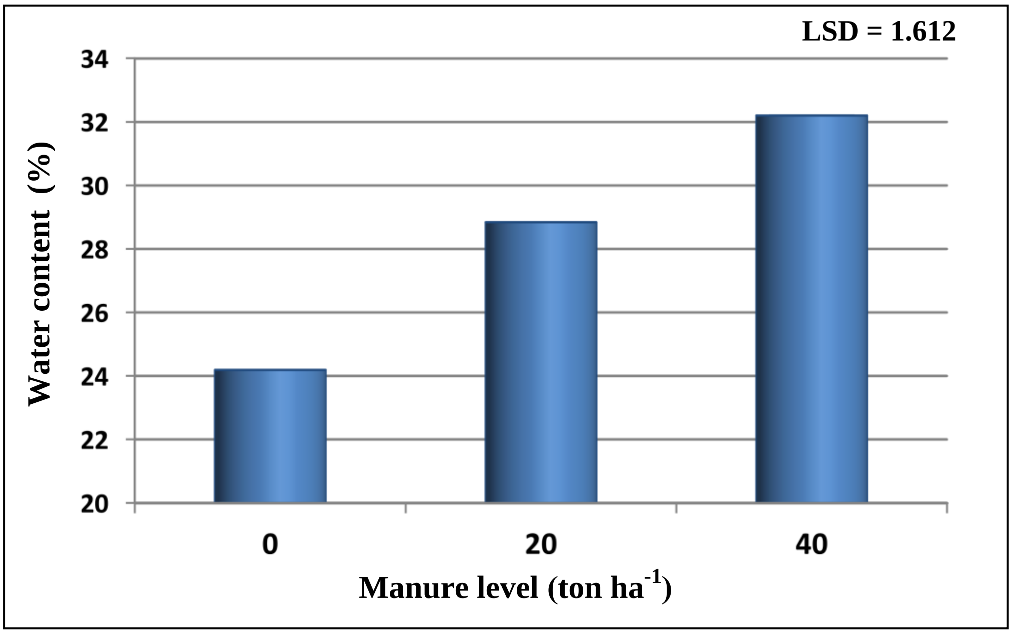

Fig. (6): Influence of manure levels on soil water content.

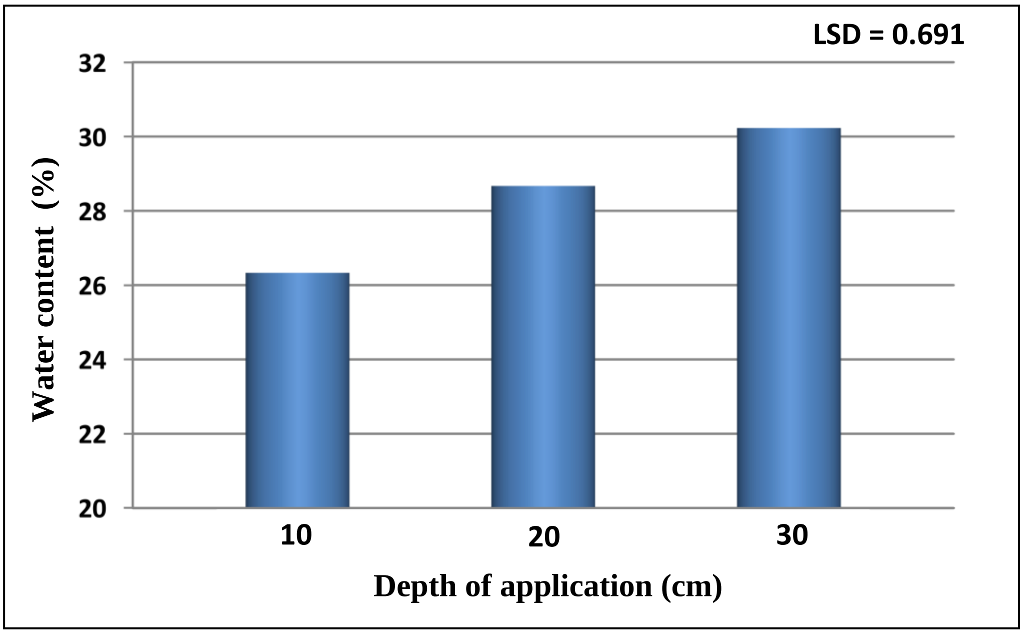

Fig. (7): Influence of depth of manure application on soil water content.

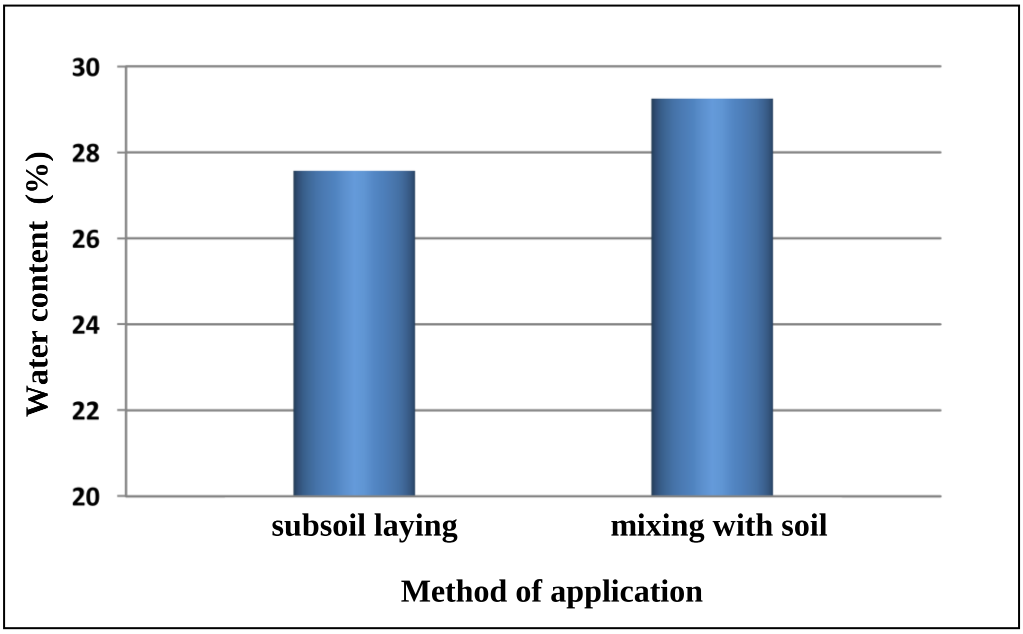

Fig. (8): Influence of method of manure application on soil water content.

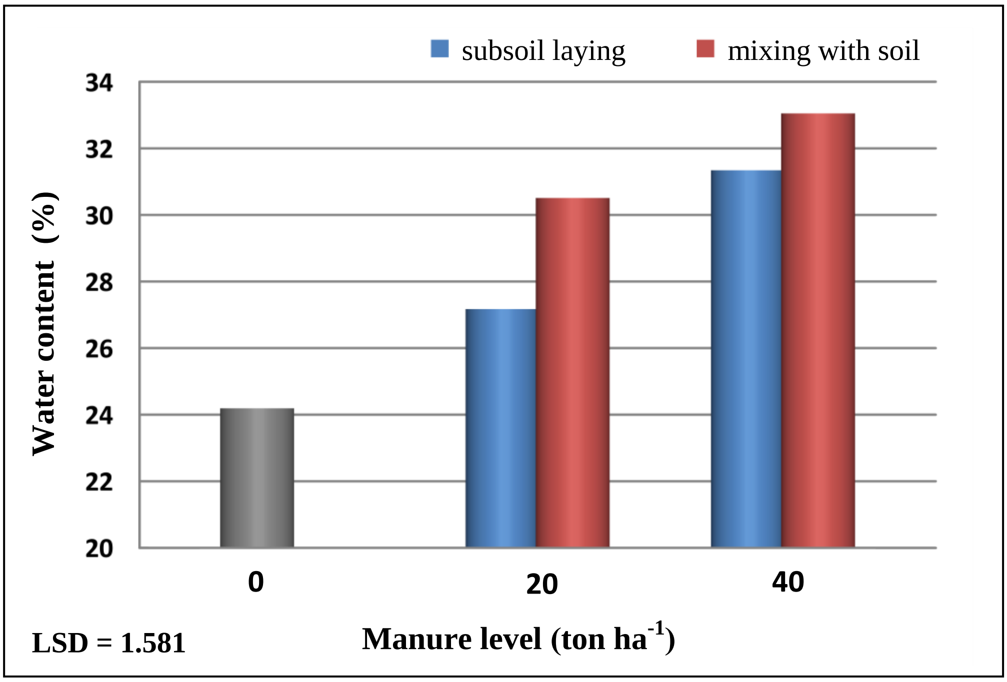

Fig. (9): Influence of manure levels on soil water content at different application methods.

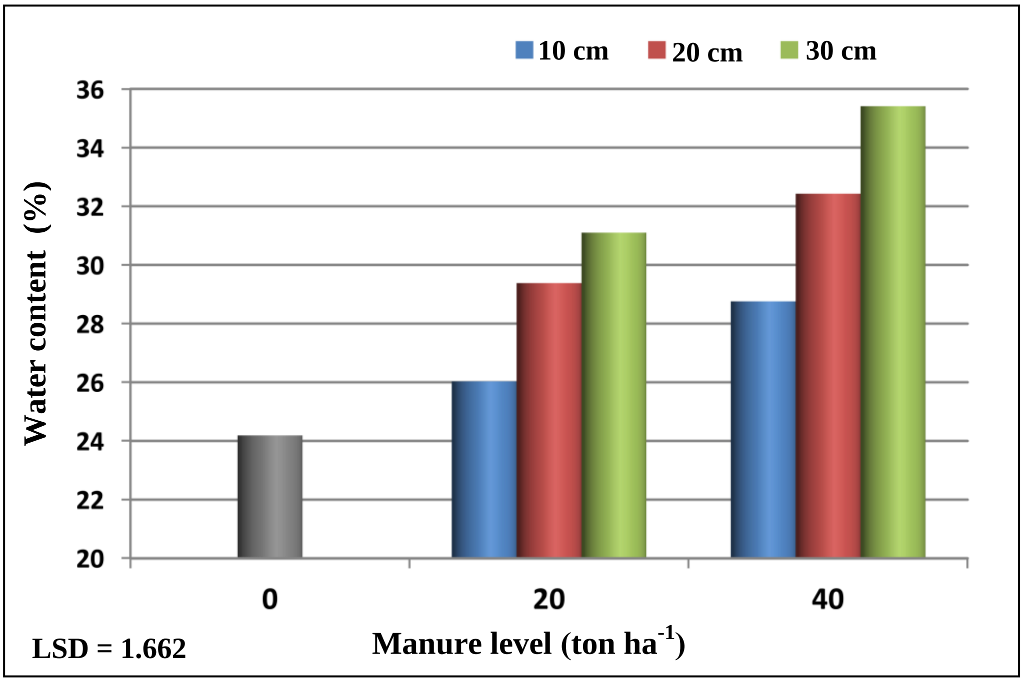

Fig. (10): Influence of manure levels on soil water content at different depth of application.

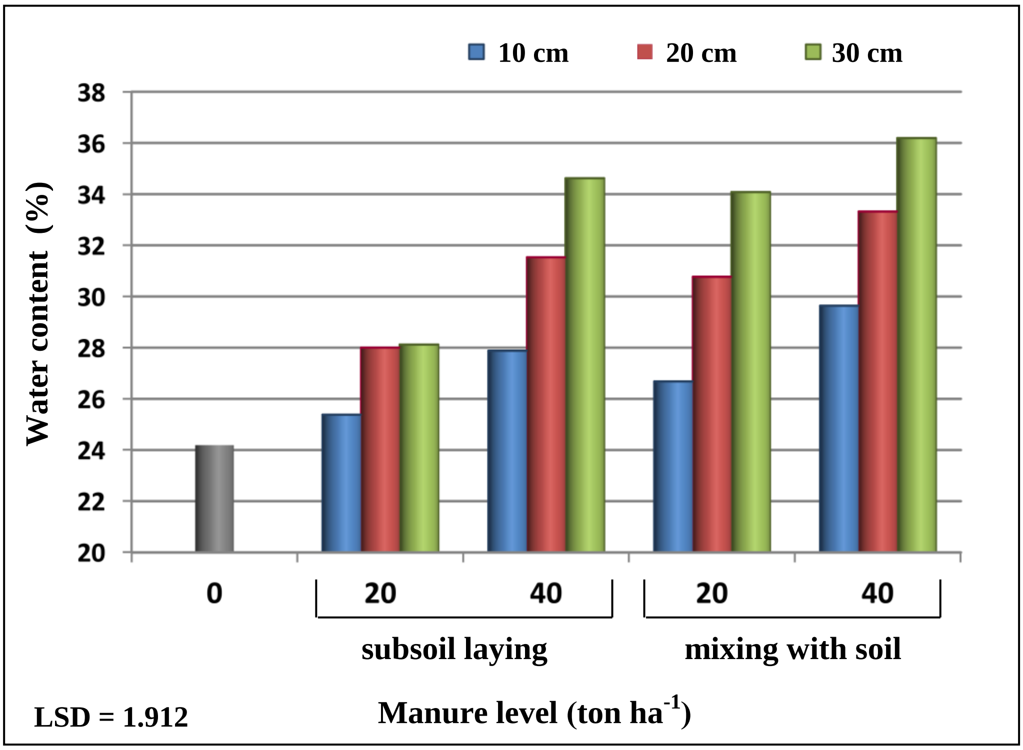

Fig. (11): Influence of manure level and method of application on soil water content at different depth of application.

The following equation clearly showed that the soil moisture content significantly correlated with bulk density but the formula was affected by method of manure application: y = -77.66x + 122.92 (r = 0.8919*). Baladia (2014) obtained high values of soil moisture content in the soil mixed with organic residues, and that attributed that to the best distribution of organic colloids in soil, which can hold water greater than the chemical colloids by10-100 times.

Manure levels had an obvious effect on soil water content in both methods of application (Fig. 9). Higher values were obtained for mixing method (30.50 and 33.05 % for 20 and 40 ton ha^{-1}, respectively) while the subsoil laying method values were 27.00 and 31.50 %, respectively. The lowest values of soil water content was recorded in plot receiving 0 ton ha^{-1} of manure (24.19%).

The results presented in Fig.10 showed that the combination effect of manure levels and depth of application was significant on soil water content ($P \leq 0.05$). Soil water content increased with depths of application (10 to 20 and 30 cm) for the two levels of application. The greatest water content was recorded for soil fertilized with 40 ton ha^{-1}. However, the water content in soil treated with 20 ton ha^{-1} at 30 cm depth was significantly higher than the water content in the soil treated with 40 ton ha^{-1} at 10 cm depth. The values of the former treatments were 31.10 and 28.70 %, respectively. This results clearly support the idea that the level of fertilization would not only con-trol soil properties and plant growth , but the placement and the method of fertilizer application would play an important role in fertilizer use efficiency. On the other hand, increasing manure level from 20 to 40 ton ha^{-1} increased water content which reached higher value of 35.41 % regard-less of application depth.

Statistical analysis of the experiment showed that the interaction between depth of manure application and method of application had no significant effect on soil water content.

The results presented in Fig. 11 indicated that combination of experimental factors (depth × level × method) caused a significant effect on soil water content ($P \leq 0.05$). Soil water content increased with the application depth and manure levels for the two methods of application. At all depths and manure levels, the highest values were obtained at mixing method as a compared with the subsoil layer meth-od. The highest water content (36.19 %) was recorded in soil mixed with 40 ton ha^{-1} of manure at 30 cm depth, which surpassed the other values by 5 and 50 %. In this study, using the active depth and the best method of application of the manure by using the machine improved physical properties of soil.

Conclusions

The manufactured machine works well in applying small and large quantities of organic fertilizer with high control and uniformity. The physical properties of soil were significantly improved. Soil bulk density and soil water content were significantly related to cattle manure in-put. The lowest bulk density and highest water content occurred in the plots fertilized with manure using the mixing method while the subsoil laying method was less on improving the soil physical properties. Mixing the manure with large volume of soil resulted in lower bulk density and higher water content.

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