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Studying the Effect of Implement of Two Plowing Depths and Manure Mixing with Soil on the Soil Moisture Content

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Abstract: A field experiment was carried out in silty clay soil at Agricultural Research Station of Garmat Ali in order to study the effect of the plowing depths and manure application on soil moisture content at different soil depths (0-10 (d_1), 10-20 (d_2), 20-30 (d_3), 30-40 (d_4), 40-50 (d_5) and 50-60 cm (d_6)) and two periods (after plowing and after harvesting the sunflower crop). The experiment was conducted using an implement of plowing and manure mixing with soil, which consists of two main parts (two moldboard plows and two subsoilers).The implement was designed and manufactured in the Agriculture machines and Equipment Department in 2015. The treatments used in the study were included two levels of manure application (0 and 45.5 ton ha^{-1}) and two plowing depths of moldboard plow (M) with three plowing depths of subsoiler (S). They were 20 cm of moldboard plow with 20, 30 and 40 cm of subsoiler ($M_{20}S_{20}$, $M_{20}S_{30}$ and $M_{20}S_{40}$), and 30 cm of moldboard plow with 10, 20 and 30 cm of subsoiler ($M_{30}S_{10}$, $M_{30}S_{20}$ and $M_{30}S_{30}$). The results showed that the soil moisture content (MC) was significantly decreased with increasing the plowing depths by the moldboard plows and subsoilers especially after soil plowing. While, the MC significantly increased with increasing the soil depth after the plowing and after harvesting the crop. In contrast, mixing the manure with soil at level 45.5 ton ha^{-1} by the manufactured implement increased the soil moisture content by 10.73% after the plowing and by 2.33% after the harvesting the sunflower crop compared with untreated soil with manure.

Key words: Soil moisture content, Manure, Plowing Depth, Soil depth, Subsoiler, Moldboard plow.

Introduction

Soil moisture content is an important factor and has great effects on the biological processes in the soil, some soil physical properties and available nutrients of plant (Jianhua, 1996 and Jassim, 2015). In addition, the moisture content of soil was affected by tillage methods, plowing depth and manure application (Khurshid *et al.*, 2006 and Sornpoon and Jayasutiya, 2013).

The tillage of soil was considered to be one of the important processes affecting on soil physical properties (Keshavarzpour and Rashidi, 2008). Many studies indicated that the plowed soil by different plows had a low moisture content compared with unplowed soil (Licht and Al-Kaisi, 2005 and Alvarez and Steinbach, 2009). Pervaiz *et al*. (2009) reported that the deep plowing by subsoiler increased the soil moisture content by 6% compared with conventional plowing, and by 11.54% when the soil depth increased from 0-15 to 30-60 cm. As well as, their results indicated that the moisture content of soil decreased after the end growth season of plant compared with the soil at the beginning of growth season especially at soil depth of 0-15 cm. Mahdy (2010) found that the soil moisture content was significantly increased by 34.28% in the plowed soil by moldboard plow alone compared with moldboard plow followed subsoiler.

Application of organic manure was a common strategy to improve physical properties of soil such as soil moisture and porosity (Koenig and Johuson, 1999). Haynas and Naidu (1998) reported that addition of manure in to soil resulted in higher moisture content of soil due to increases the soil organic matter, which improved the water holding capacity. This was confirmed by Aday *et al*. (2017), where the authors found that mixing the cattle manure with soil down to the depth of 30 cm amount of 40 ton ha^{-1} increased the soil moisture content by 36.19% compared with untreated soil (without manure).

The objective of this study was to determine the effect of plowing depth with and without manure application on soil moisture content using an implement of plowing and manure mixing with soil, which designed and manufactured in the Agriculture machines and Equipment Department in 2015.

Material and methods

The experiment was carried out in silty clay soil of Agricultural Research Station College of Agriculture field of Garmat Ali in 2015.The initial physical and chemical properties of soil depths 0-10 (d_1), 10-20 (d_2), 20-30 (d_3), 30-40 (d_4), 40-50 (d_5) and 50-60 cm (d_6) were analyzed according to Richads (1954), Black *et al.* (1965) and Page *et al.* (1982). The results are presented in the table (1).

Table (1): Some physical and chemical properties of the soil at the depths (0-10), (10-20), (20-30), (30 - 40), (40 - 50), (50 - 60) cm and irrigation water salinity.

Properties	Units	Soil depths (cm)					
		(0-10)	(10-20)	(20-30)	(30-40)	(40-50)	(50-60)
sand	g kg^{-1}	200.51	139.15	173.74	151.89	162.61	67.69
silt		599.97	612.74	610.87	653.17	600.45	628.18
clay		199.52	248.11	215.39	194.94	236.94	304.13
Texture		Silty loam	Silty loam	Silty loam	Silty loam	Silty loam	Silty clay loam
Real density	Mg m^{-3}	2.61	2.61	2.62	2.65	2.65	2.65
Bulk density	Mg m^{-3}	1.26	1.27	1.28	1.29	1.30	1.30
Total porosity	%	51.34	50.95	51.14	51.32	50.94	50.94
Penetration resistance	kN m^{-2}	1300	1480	1640	1744	1900	1966
ECe	dS m^{-1}	7.69	12.50	13.89	18.67	18.72	20.17
Total carbonate	g kg^{-1}	339.12	338.41	316.51	300.35	290.45	280.11
Organic mater	g kg^{-1}	11.46	10.15	10.01	3.33	1.42	1.03
pH		7.23	7.63	7.79	7.80	7.80	7.80
CEC	cmolc kg^{-1}	29.21	30.12	29.11	28.32	27.50	27.11
Ec of water	dS m^{-1}	2.06					

The study was carried out using an implement of double depth soil plowing and mixed the manure with soil, which consists of manure tank, machine of manure feeding, three shallow tines for mixing the manure with soil, two moldboard plows and two subsoilers. The implement was designed and manufactured in the Department of Agricultural Machines and equipment, College of Agriculture, University of Basrah in 2015. The treatments used in the study concluded two levels of manure application 0 (OM_0) and 45.5 ton ha^{-1} (OM_1) and two depths of moldboard plows (M) with three depths of subsoilers (S), and were 20 cm (M_{20}) of moldboard plows with 20 (S_{20}), 30 (S_{30}) and 40 cm (S_{40}) of subsoilers, and 30 cm (M_{30}) of moldboard plows with 10 (S_{10}), 20 (S_{20}) and 30 (S_{30}) of subsoilers (table 2).

Table (2): The depth of plowing and the symbols of the treatments used in the experiment (M=moladboard plow, S = subsoiler, sh = shallow tines)**.**

Samples	Depths of plowing (cm) (implement)	Depths of subsoiler (cm)	Depths of moldboard (cm)	Treatments
M_{20}	20	----	20	Implement Part (moldboard plow)
M_{30}	30	----	30	
$M_{20}S_{20}$sh	40	20	20	all Implement parts (moldboard + subsoiler+ shallow tines)
$M_{20}S_{30}$sh	50	30	20	
$M_{20}S_{40}$sh	60	40	20	
$M_{30}S_{10}$sh	40	10	30	
$M_{30}S_{20}$sh	50	20	30	
$M_{30}S_{30}$sh	60	30	30	

After conducting the experiment treatments by the manufactured implement. . All the experimental plots received urea (46%N) at level of 160 kg ha^{-1}, triple super phosphate (47%p_2o_2) and potassium sulfate (52% K_2O) at level of 80kg ha^{-1} for each (FAO,1984). The sunflower seeds variety (confection) were planted in 15/9/2015 with four seeds per hole spaced 70 cm × 25 cm using drip irrigation system. After two weeks of sowing the plants were thinned to one plant per hole, and after 90 days of planting, the crop was harvested. The amount of water added to irrigate the crop was determined using the evaporation pan class A.

The moisture content (MC) was measured for two periods, after plowing by the implement manufactured and at the end of the growing season after harvest of the sunflower crop. MC was measured for depths of 0-10 (d_1), 10-20 (d_2), 20-30 (d_3), 30-40 (d_4), 40-50 (d_5) and 50-60 cm (d_6) according to Richards (1954) method.

The experiment was carried out in an experiment using full randomized complete block design (RCBD) with three replications. All the obtained data were subjected to analysis of variance using the Gen stat software. The mean treatments were compared using (R LSD) at a probability level of 0.05. The mean of the coefficients at the beginning and the end of the planting season were compared using the t-test at the probability level (0.05).

The aim of the study was to demonstrate the effect of use the implement of two plowing depths and manure mixing with soil on the soil moisture content.

Results and discussion

The manure application had a significantly affect due to increase soil moisture content (MC) after soil plowing and after harvesting plant by 10.73 and 2.33% for the manure application (45.5 ton ha^{-1}) compared unapplied manure (0 ton ha^{-1}) table (3) and figure (1A and 1B). The reason for this increase is related to the manure ability in keeping the water due to its surface area as well as improves the soil physical properties, which improved its MC retention (Koenig and Johnson, 1999; Magdoff and weil, 2004 and Aday *et al*., 2017).

Table (3): Statistical analysis of the test (F) of the values of moisture content (MC) (OM=organic manure levels, Ms = deep machine components, D = soil depths, ** = significant differences at level 0.01, * = significant differences at level 0.05, ns = no significant differences).

Source	df	After plowing	After harvesting
		MC	MC
OM	1	785.640**	74.510**
MS	5	62.940**	1.510^{ns}
d	5	13160.580**	164.720**
OM× MS	5	0.650^{ns}	0.280^{ns}
OM× d	5	247.560**	5.580**
MS×d	25	24.560**	0.930^{ns}
OM× MS×d	25	0.630^{ns}	0.540^{ns}

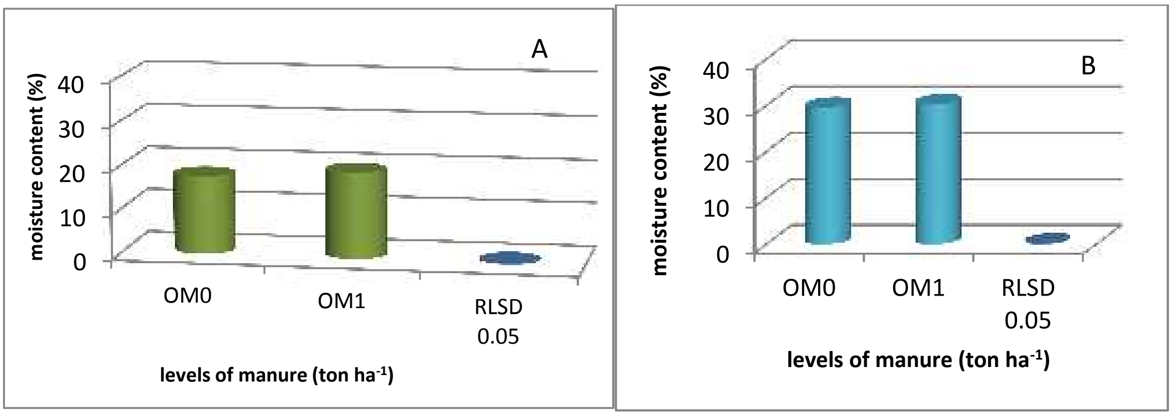

Fig. (1): Effect levels of manure on moisture content (%) for soil A after plowing B after harvesting.

The result in figure (2) showed that the moisture content of soil after the plowing significantly decreased (table 3) with increasing the implement depths (implement parts depths, moldboard plow and subsoiler), while there was no significant effect on MC after the harvesting of plant. The MC was significantly decreased by 7.65% when increasing the implement depth from 40 to 60 cm. Also when the plowing depth of moldboard plow was fixed at 20 cm (M_{20}), the MC decreased by 3.62 and 7.08% with increasing the subsoiler depth (S) from 20 (S_{20}) to 30 (S_{30}) and 40 cm (S_{40}), respectively. While increasing the depth of moldboard plow from 20 (M_{20}) to 30 cm (M_{30}), the MC decreased by 3.21 and 7.96% with increasing the subsoiler depth from 10 (S_{10}) to 20 (S_{20}) and 30 cm (S_{30}), respectively. This can be related to increase the volume of plowed soil by the moldboard plow which over turned the soil and this lead to increase the area of plowed soil exposed to the weather condition and thus reduced the moisture by the

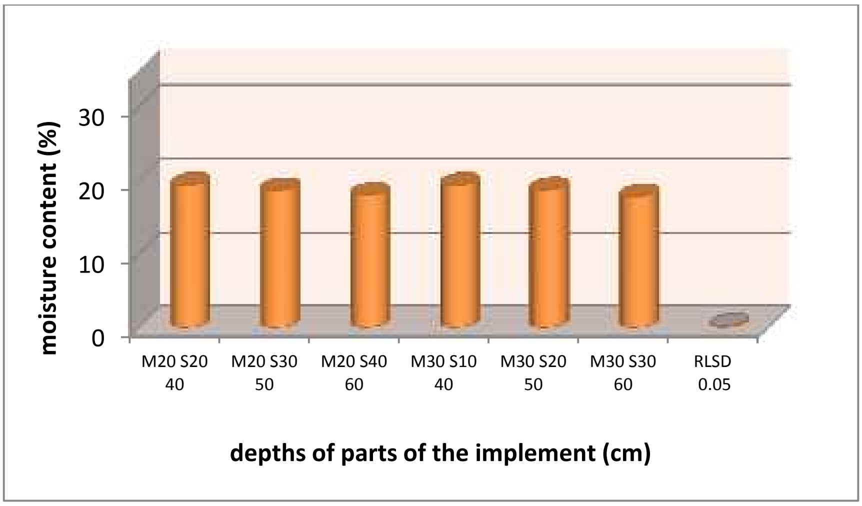

Fig. (2): Effect of implement parts on the moisture content of the soil (%) after plowing operation.

evaporation from soil surface. However, after sunflower crop harvest the depths of M and S (parts of the implement) did not significantly affect the soil MC.

The results showed that MC increased significantly as the depth increased (table 3). Depths d_6 (50-60) and d_5 (40-50) surpassed the remaining depths in MC after plowing operation and crop harvesting (figure3A and 3B). After plowing operation, MC of depths d6 and d5 was higher than for depth of d1 by 266.82 and 246.12%, respectively (Fig. 3A). This was because the soil moisture at deeper depths was away from the weather conditions such as the hot air and sun shine in addition to that the plowing operation disturbed the soil water capillary which stopped the soil moisture rising to the soil surface. The depths d2, d3, and d4 recorded the higher percentage of MC than depth d1by 24.74, 85.11 and 91.33% respectively. After harvesting the sunflower crop the MC for d_2, d_3, d_4, d_5 and d_6 increased compared with that for d1 by 3.13, 5.80, 7.72, 9.14 and 12.56% respectively.

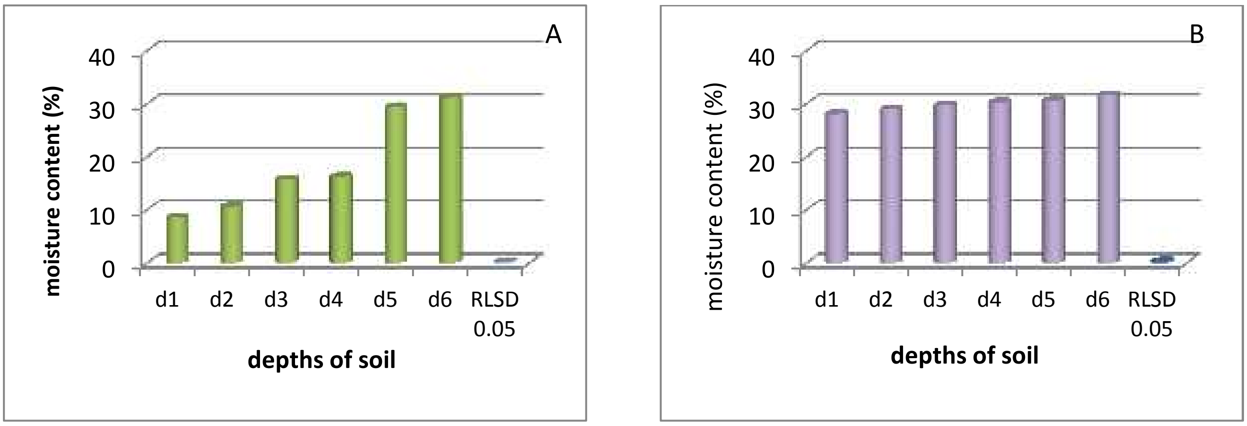

Fig. (3): Effect depths of soil on moisture content (%) for soil A after plowing B after harvesting.

The interaction between the implement parts depths and manure application levels did not have a significant effect on soil MC.

The interaction between the soil depth and manure application levels had a significant effect on the soil MC after soil plowing and crop harvesting (table 3). Figure (4-A) showed that MC increased with soil depth for OM_0 and OM_1, d_6 gave the highest value for OM_0 and OM_1 without significant differences. The values of MC are 31.14 and 31.21%, respectively. The second highest values were recorded for d_5. The values are 29.32 and 29.52% respectively. The lowest values were recorded for d_1 with significant differences between them. The values were 5.64 and 11.42% for OM_0 and OM_1, respectively. The other depths gave medium values.

OM_1 gave higher MC compared with the OM_0. The depths d_1, d_2 and d_3 gave higher MC compared with the same depths of OM_0; the values are higher by 5.87, 4.58 and 1.17% respectively. The values of MC for d_4, d_5 and d_6 for OM_1 did not significantly differ from that for OM_0. The reason for increasing in MC for d_1, d_2, and d_3 was because the manure improved the soil properties and retains the soil moisture (Nguyen, 2013 and Abdulkareem *et al*., 2018).

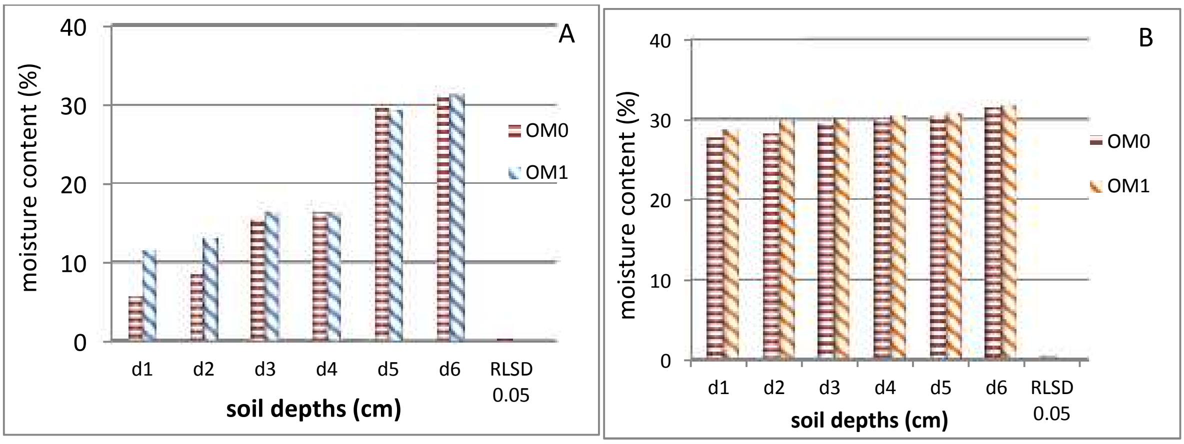

Fig. (4): effect of the interaction between manure levels and depths of soil on MC (%) for soil after plowing (A) after harvesting (B).

The interactions between the implement components depths and soil depths had a significant effect on soil MC after plowing (Table 3). Table (4) shows that MC increasing with the soil depth increasing and decreased when the depths of the components of the implement were decreased. The depth d_6 gave the highest values of MC while the lowest values for MC were recorded for d_1 and for all the depths of the implement components tested.

The interaction between the depths of the implement components and the soil depths significantly affected MC after soil plowing operation. MC increased with soil depth and decreased with implement components depth. d_6 gave the highest MC value whereas d_1 gave the lowest values. Changing the implements parts depths and remaining the soil depth constant also affected soil MC. At the depth of soil d_1 and fixing depth of M at 20 cm MC decreased by 6.07 and 7.87% when increasing the depths of S to 30 and 40 cm compared to a depth of 20 cm. Increasing the depth of M to 30 cm, MC values decreased by 1.49 and 2.76% when increasing the depths of S to 20 and 30 cm compared to the depth of 10 cm. Increasing the S depth and fixing M depth led to an increasing in the MC reduction. This difference in MC values may be due to the size of the soil plowing by Part M and soil teardown by Part S. The increase in the depths of the components of implement led to an increase in the size of the disturbed soil, which caused increasing in the soil area exposed to the weather conditions and thus reduced MC at the soil surface MC increased as soil depth increased due to the lower impact of external factors as well as the movement of water in the soil down due to ground attraction and low soil water capillary.

After the harvest, the results of the statistical analysis did not show any significant differences in MC values due to interference between the depth of the implement components and soil depths (Table 3).

Table (4): The interaction effect between depths of implement components on soil moisture content (%) after plowing.

Depths of implements / Component Depths of soil	$M_{20}S_{20}$	$M_{20}S_{30}$	$M_{20}S_{40}$	$M_{30}S_{10}$	$M_{30}S_{20}$	$M_{30}S_{30}$	Average of Soil depths
d_1	8.89	8.35	8.19	8.71	8.58	8.47	8.50
d_2	10.91	10.61	10.49	10.78	10.58	10.45	10.64
d_3	15.94	15.80	15.75	15.76	15.74	15.72	15.79
d_4	16.45	16.35	16.29	16.35	16.28	16.20	16.32
d_5	31.68	28.49	28.38	31.76	28.52	27.70	29.42
d_6	32.30	32.38	28.81	32.71	32.64	28.22	31.18
Average depths Of implement Components	19.36	18.66	17.99	19.35	18.72	17.79	18.64
RLSD 0.05	0.579						

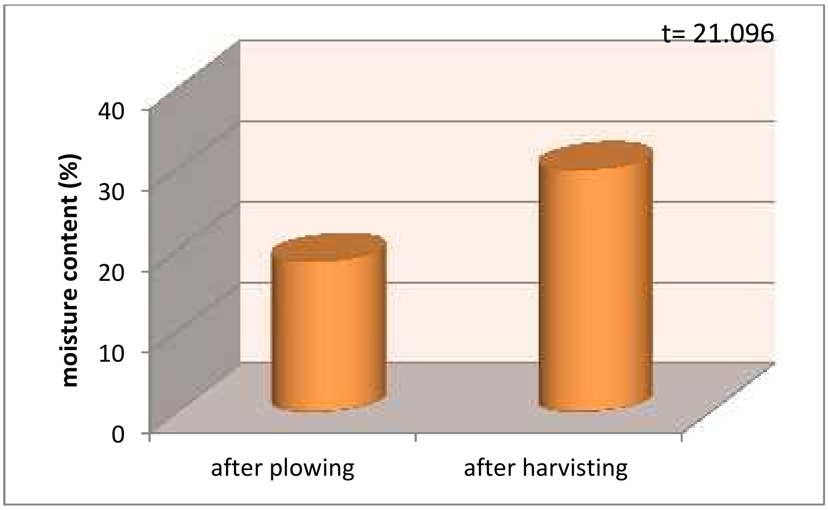

Fig. (5): Effect of the soil moisture content periods of measurement.

The results of t-test showed that there was a significant increase in MC of the soil after the harvest compared to its value after plowing. Figure (5) show that the MC increased by 60.46% after harvesting compared with the soil after plowing period. The reason may be due to the irrigation water, as well as the growth of the crop, which covered the soil surface, making the loss of moisture relatively low due to evaporation, on the other hand, the decline in MC after plowing may be due to the plowing operation increased the movement of water to the bottom as a result of increase in the soil porosity and low bulk density which pushed the MC away from the soil surface. Kumar and Chopra (2013) mentioned that the soil moisture was decreased after tillage because water movement downward.

Conclusions

The results were indicated that increasing the soil depths and manure application levels were capable to increase the moisture content of soil especially after harvesting of crop. Increasing the soil plowing depths by implement components (moldboard plow and subsoiler) decreased the soil moisture content especially after the plowing.

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