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The effect of tractor- implement passes on the soil moisture content of plowed silty clay soil

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Abstract. The research was conducted to study the effect of soil compaction on the moisture content of silty clay soil at two levels of moisture contents namely 16.1% and 24.5%. The soil was plowed by moldboard plow at depths of 10, 15 and 25cm. The soil compacted by passing the tractor-moldboard plow combination on the soil surface of plowed soil once, twice, three, four and five times on the same lane. The moisture content was measured for plowed, plowed and compacted soils and for depths of 0-5, 5-10, 10-15, 15-20 and 20-25cm. The total weight of the tractor and the moldboard plow is 31.78kN. The inflation pressure of the rear and front wheels is 2.5bar and 1.0bar respectively. The results showed that the MC increased from 14.70% to 19.29% (31%) and from 23.1 to 26.78% (16%) when the soil depth increased from 0-5 to 20-25cm for the unplowed soils of MC of 16.1% and 24.5% respectively. When the soil was plowed MC for both levels decreased but the reduction was higher in the surface layer compacted with deep layer. For MC level of 16.1% it became 13.71% and 19.05% while for Mc level of 24.5% it became 22.56% and 25.49% for same depths respectively. When the plowed soil was compacted by passing the tractor on the soil surface the moisture content decreased but the reduction depended on the number of the passes and on the moisture content level of the soil. For the soil of MC of 16.1%, the moisture content decreased from 15.61% to 12.90 (17.40%) and to 10.29% (34%), while for the soil of MC of 24.5% it decreased from 24.43% to 23.34% (4.70%) and to 20.81% (15.80%) when the soils were compacted once and five times respectively. Soil compaction decreased the moisture content most at depth of 5-10cm while the surface depth 0-5cm became second for both MC levels. For the remaining depths the reduction in MC decreased as the depth increased in soil of MC of 16.1% for all the number of passing. But for wetter soil (24.5%) MC increased for the lower depths for one and two passes but decreased for three, four and five passes. The reduction in the moisture content of the soil due to compaction was slightly higher for the shallow plowing depth compared with the deeper plowing depth but it was higher for soil of lower MC (16.1%) compared with the soil of higher MC (24.5%). It decreased from 15.51 to 10.11% (35%) and from 16.87% to 11.43% (32%) for plowing depths of 10 to 25cm in soil of MC of 16.1% respectively. But it decreased from 23.91% to 20.29% (15%) and from 25.04% to 22.31% (11%) for same plowing depth respectively. The lowest moisture content recorded for five passes and shallow plowing depths for both MC levels. The moisture contents are 8.98% and 18.36% for MC levels 16.1% and 24.5% respectively. The soil of lower MC lost greater amount of moisture content than the soil of higher MC due to compaction for all the number of passes and plowing depths.

Keywords: Moisture content, soil compaction and number of passes

Introduction

The moisture content of the soil is the source of the plants water. The amount of the moisture content in a soil depends upon the soil porosity and the size of the pores as the pores become smaller as the ability of the soil to hold the water increases. However, the water movement and the ability of the soil to supply the water to plants decrease (4, 6, 8).

The reduction in the water movement especially the downward movement could lead to soil water logging when the soil is heavily irrigated or heavy rain fallen (10, 11,

The Massey Ferguson 285S

Massey Ferguson 285S was used to carried out the experiments. The tractor is two wheels drive tractor produced by UZEL Company 1995. The engine power is 56.6 kW. The total tractor weight is 30kN. The rear and front wheels weights are 17.37 kN and 12.63 kN respectively. The rear tires size is 18.4/15-30. The rear tires diameter and width are 1.70m and 0.381m respectively. The size of the front tires 16-7.5. The diameter and the width of the front tires 0.91 and 0.19m respectively. The rear tire grousers height, width and inclination angle are 4cm, 4cm and 45^0 respectively. The inflation pressure of the rear and front tires are 1 bar (100 kN/ m^2) and 2.5 bar (250 kN/ m^2) respectively.

Moldboard plow

Deeper digger moldboard plow was used to conduct the experiments. The plow consists of three bodies. The plow is provided with pin point penetrator to increase the ability of the plow to penetrate the soil to the required depth.

The field experiments

The experiments were conducted in silty clay soil. The local of the experiments field is agriculture college, Garmit Ali. The field was divided into three areas. The dimensions of each area are 30 and 10m. The three areas were plowed using the moldboard plow. The operating depths were 10, 15 and 25cm for the three areas respectively. The operating depth was conducted randomly. Each area was divided to halves. The tractor and the implement combination passed on the surface of the plowed area to compact the soil once, twice, three, four and five times (figure 1). The passes for more than once were repeated on the same tire lane. The same passes were repeated on the second half.

The experiments were conduct at moisture content of 24.5% and were

12). The water evaporation from the soil surface increases as the air temperature increases and that occurred due to the soil capillary. To reduce the risk of soil water logging and water evaporation the soil should be plowed. The plowing operation loosening the soil which resulted in greater pores sizes and that improves the soil water infiltration and its ability to leach the salinity downward. But on other hand the soil water holding capacity decreases and therefore the total water available to the plants reduced as well as the water evaporation from the top layer increases (9, 13, 14, 15).

To improve the soil water holding capacity it should be compacted to some extent by the soil compacting implements (2, 13, 16, 17). However the sever compaction giving contrary result such as reducing the soil porosity and therefore lowering the water infiltration and some time smear the soil surface by smashing soil structure and that reduces the seeds emergency (1, 2, 5). The sever soil compaction also effect the moisture content of the soil. The extent of effect and the changes of the moisture content with number of passes and within the soil layer will be studied in this research.

A soil of silty clay texture was plowed at three depths, namely 10, 15 and 25 cm. The plowed soil was compacted by passing a tractor-implement combination on the surface once, twice, three, four and five times on the same lane. The soil samples to measure the moisture content were collected for the soil depths 0-5, 5-10, 10-15, 15-20 and 20-25 cm for the plowed and unplowed soils to compare the changes in the moisture content within these depths and between the plowed and unplowed soils. The changes in the moisture content between the plowing depths due to the compaction were also studied.

Materials and Methods

were moisture content, bulk density, cone penetration index and porosity. The measurements were repeated three times randomly.

Soil physical properties measurement

Soil texture

The soil texture was measured by pipette method as it is mentioned in (1). The results are shown in table (1).

repeated at moisture content of 15%. The soil physical properties were measured for unplowed, plowed and compacted soils and for both moisture contents. The measurements were taken for depths of 0-5, 5-10, 15-20 and 20-25 cm. The measurements for the compacted lanes were taken across the compacted zone as shown in figure (2). The soil physical properties measured

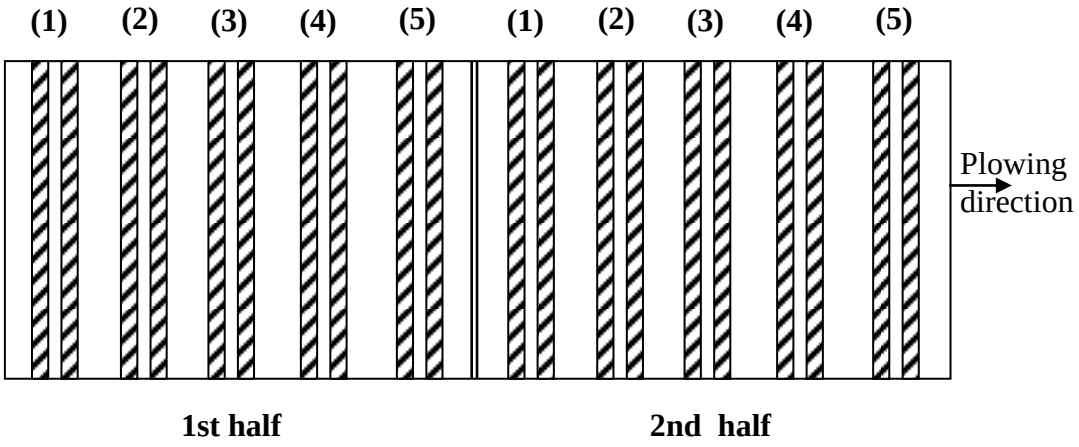

Fig. (1): The numbers of passes are cross to the plowing operation for soil compaction.

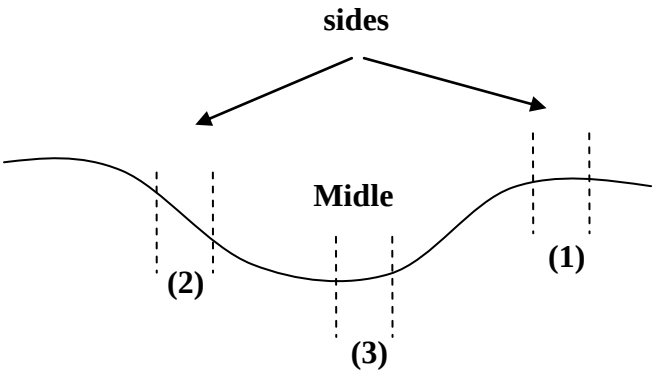

Fig. (2): The soil physical measurements across the tire compacted lane.

Table (1): The texture of the soil of the field of the experiment

Sand ($g.kg^{-1}$)	Clay ($g.kg^{-1}$)	Silt ($g.kg^{-1}$)	Soil texture
15.40	45.50	39.10	Slity clay

10-15, 15-2- and 20-25cm for both soils moisture contents 15 and 24.5%. The results are shown in table (2)

Soil moisture content

The soil moisture content was measured by core method using dry weight for depths 0-5, 5-10,

Table (2). The moisture content of the soil at two moisture content levels for different depths

Moisture content 24.5%					**Moisture content 16.1%**			
Unplowed soil			Plowed soil		Unplowed soil		Plowed soil	
Depth (cm)	Moisture Content %	Bulk density t/m^3	Moisture Content %	Bulk density t/m^3	Moisture Content %	Bulk density t/m^3	Moisture Content %	Bulk density t/m^3
0-5	23.21	1.11	22.56	1.010	14.70	1.22	13.71	1.016
5-10	24.60	1.16	23.14	1.015	16.32	1,27	15.44	1.036
10-15	24.91	1.20	23.44	1.019	17.97	1.32	16.20	1.057
15-20	25.70	1.25	24.82	1.024	18.33	1.35	17.35	1.067
20-25	26.78	1.30	25.49	1.031	19.29	1.42	19.05	1.150

Table (3). Soil bulk density of unplowed and plowed soils and for the number of passes.

Moisture content 16.1%	Bulk density (Mg/m^3)	**Unplowed soil**	**plowed soil**	**Number of passes**				
				1	2	3	4	5
		1.29	1.09	1.32	1.35	1.37	1.40	1.45
Moisture content 24.5%	Bulk density (Mg/m^3)	1.20	1.02	1.12	1.15	1.17	1.21	1.23

the moisture evaporation by increasing the amount of air passing through the soil section.

The effect of number of passes of the tractor- implement on the moisture content of the soil

When the tractor- implement combination passes on the soil surface can cause compaction which impeding the soil particles and therefore reducing the size and number of the pores in the soil which reduces the ability of soil to hold the water (fig.4). The water of the compacted soil moves sideways to the zones of lower compaction.

When the soil of MC of 16.1% was passed on once by the tractor-implement compaction the moisture content reduced from 16.35% to 12.90% (8.8%), but for five passes it reduced to 10.29% (21%). This clear reduction in the moisture content is related to the reduction in pores sizes and number which can be seen from the increase in the bulk density which increased from 1.09 for the plowed soil to 1.32 (21%) and 1.45Mg/m^3 (33%) for one and five passes. For the remaining passes the results are medium between the mentioned passes.

For the soil of MC of 24.5%, one pass reduced the moisture content from 23.16% to 22.96 (0.8%) while five passes reduced it to 19.37% (16.4%). The lower reduction in the moisture content of this soil was because the formation of the big clods when plowed which withstand the pressure underneath the tractor tire and that reduced the compaction which can be seen from limited increase in the bulk density (table 3). The greater amount of water in the soil would improve the soil ability to withstand the pressure which causing the compaction. The result showed that the soil loss appreciable amount of its moisture content when it is compacted and this means the compaction should be at lower scale to

Results and Discussion

The effect of the depth of the soil on the moisture content

The moisture content of the soil for both MC levels increased as the depth increased (fig. 3) but the difference between the top layer and the deep layer was greater in the lower MC level (16.1%) than in the higher MC level (24.5). It increased from 14.70% to 19.29% (31%) for the soil of lower MC level (16.1%) while it increased from 23.1% to 26.78% (16%) for the soil of higher MC of 24.5% for depths of 0-5 and 20-25cm respectively. This was because the water moves from the top layers to the lower layers due to the gravitational force and the surface layer loss moisture by evaporation due to the effect of the air movement and the sun light. However, the lower difference between the top layers and the lower layers in the soil of MC of 24.5% was because the
losses in the moisture content from soil surface by evaporation was lower because the air condition was cooler.

On average the first soil had lower MC value than the second. This was because the bulk density of the first soil of MC of 16.1% was greater than the second soil (24.5%) and this means on other hand the first soil is more compacted which reduced the soil ability to hold more water in its layer (table 2). The higher bulk density of the soil of MC of 16.1% properly due to that its water films were thinner which let the soil particles to come closer and that contrary to the soil of higher MC (24.5%) where the water files were thicker which pushed the soil particles away from each other.

When the soil was plowed the moisture content for all the layers decreased slightly and the reduction was greater in the top layers than in the lower layers for both soil MC levels. The plowing operation increased the size of the soil pores which encouraged

(16.40%) compared with the plowed soil. The lower losses in MC in this level of MC were due to the resistance of the soil to the compaction. This means the MC losses decreased as MC increased.

The highest reduction in MC was recorded to depth 5-10cm while the second for depth 0-5cm but for the other depths it decreased with depth (the lost to depth of 20-25cm). The reason of high reduction in MC from depth of 5-10cm was because this depth suffered the highest compaction and that was due to the penetration of the lugs of the tires of the tractor down to this depth while depth of 0-5cm became second in compaction. For the rest of depths the compaction penetration decreased with depth.

The effect of the tractor passes on the moisture content of the soil for different plowing depths

Plowing operation reduced the soil moisture content slightly. The reduction depends on the plowing depth, it decreased as the plowing depth increased in the soil of lower moisture content (16.1%) but remained almost the same for wetter soil (24.5%), table (4). The reduction in moisture content of the soil when plowed is related to big soil pores which improved the soil aeration and then the evaporation. Also the over turn of the soil by the plow exposed the wetter soil at depth to the air and the sun which increased the evaporation. The reduction in the moisture content losses as the plowing depth increased in soil of lower moisture content (15%) was because the soil overturn decreased as the plowing depth increased and that reduced the losses of deeper layers. In the soil of higher moisture content (24.5%) the formation of big wet clods protect the moisture within the clods while the losses were from their surfaces.

The greater reduction in soil of the lower moisture content compared with keep as much as moisture in the soil to reduce the irrigation requirement.

The effect of the number of passes on the soil compaction distribution in the plowed soil profile.

The plowing operation reduced in MC of the soil slightly for Mc levels 16.1% and 24.5%, the reduction was 3.2% and 5.1% respectively. The plowing operation improved soil porosity and therefore encourage air movement within the soil profile and that increased water evaporation and that reduced the MC of the soil (fig. 5,6, 7, 8and 9).

The compaction operation reduced the MC of the soil but the reduction depends on the amount of MC of the soil during the compaction operation and on the number of the passes on the soil surface by the tractor-implement combination. Passing once on the plowed soil of lower MC (16.1%) MC decreased from 15.61% to 12.02% (23%) but compared with the unplowed soil of MC of 16.1%, it decreased by 25.4%. For the plowed soil of MC of 24.5%, it decreased by 25.4%. For the plowed soil of MC of 24.5%, it decreased from 23.16% to 22.96% (0.8%) and by 6.02% compared with unplowed soil. The bigger reduction in MC in the lower MC soil was because the soil strength was lower and that caused crashing to the soil clods which it forced the water to move sideways to the around soil. This is not so in the soil of higher MC because its higher cohesion produced greater clods which resisted the compaction so the soil kept great part of it pores and therefore retained great deal of its MC. Also its surface was smeared and formed layer reduced the water evaporation.

For five passes, MC in the soil of lower MC decreased to 9.48% (39%) compared with plowed soil and this regarded big reduction and that would effect the crops growth if the soil were planted. In the higher soil MC, the moisture content decreased to 19.37%

on the soil surface and on the moisture content level before the plowing operation. For soil of MC of 15% the MC decreased by small amount of 0.94%, 0.54% and 0.07% (percentage of reduction 6.1%, 3.3% and 0.4%) for plowing depths of 10, 15 and 25cm respectively. The plowing operation increased the water evaporation. For the soil of greater MC (24.5%), the moisture content decreased by 1.21%, 1.29% and 1.21% (percentage of reduction of 5.1%, 5.3% and 4.8%) for the same plowing depths respectively. This was because the soil of higher MC lost greater amount of MC because its surface was wetter and that caused higher water evaporation.

When the soil of lower moisture content was compacted once, its moisture content decreased by 3.12%, 3.74% and 3.9% (21.4%, 24% and 23%) for plowing depths 10, 15 and 25cm respectively. However, when the soil was compacted five times, it's MC decreased by 5.59%, 6.08% and 6.7% (38%, 39.4% and 40%) for the same plowing depths respectively. The effect of the number of passes was almost same for the three plowing depths and that was properly the pressure underneath the tractor tires approached the deeper depths but in fewer amounts compared with shallow depth.

For the soil of higher MC the moisture content values decreased by 0.61%, 0.51% and 0.49% for one pass of the tractor-implement combination for depths of 10, 15 and 25cm respectively. When the soil compacted five times MC decreased by 4.34%, 4% and 3.02% for the same depths respectively. The reduction in MC due to compaction is low in this high MC level and that was because the soil clods were big which kept the moisture within their bodies. As well as the strength of the big colds were high which render them to withstand the pressure created by the tractor tires as it that of higher moisture content was because the first soil well pulverized than the second soil and that increased the number of pores which encouraged the water evaporation.

When the soils were compacted by passing the tractor-implement combination on their surfaces the moisture content decreased from 14.57% to 10.11% (30.6%) and from 22.70% to 20.29% (10.6%) for the shallow plowing depth (10cm) for soils of MC of 15%and 24.5% respectively. For deeper plowing depth it decreased from 16.87% to 11.43% (31.9%) and from 23.83% to 22.31% (6.3%) for the same soils moisture contents respectively.

The reduction in the moisture content with soil compaction is related to soil particles and clods impeding which reduces the pores sizes and hence squeeze the water out of them as well as the water films around the soil particles would be decreased due to the compaction. The greater reduction in the soil of lower moisture content than the soil of higher moisture content was due to the weaker strength of the first soil clods which render it more vulnerable to compaction and its smaller clods were easier to be broken down by the tire and that can be seen clearly from the bulk density (table 2). This caused soil compaction and therefore losing great amount of their moisture content by scabbing to near by soil. For wetter soil the reduction in the moisture content was lower because the soil clods were stronger and more resistible to compaction so that its bulk density is lower.

The interaction effect of the number of passes and the plowing depth on the soil moisture content

The reduction in the soil moisture content occurred due to the plowing operation and soil compaction (table 5). The amount of reduction depended on the plowing depth, the number of passes

which made them easer to be crashed by the tractor tires. This lead to compact the soil severely as it can be seen from the bulk density value which approached 1.45Mg/m^3 (table 3) and that squeezed the water out from the soil pores and lead to water escaping to the around areas of compaction.

can be seen from the bulk density value 1.23Mg/m^3 (table 3) which remained low and that an indicator to the soil resistance to compaction .The resistance of the clods to sever crashing reduced expelling the water of the clods out.

In contrast the clods of the soil of lower MC were smaller and weaker

Table (4): Soil moisture content for unplowed, plowed and compacted soils for three plowing depths and two moisture content levels.

Moisture content (%)			Operating depths (cm)		
			10	15	25
	15	Unplowed soil	15.51	15.99	16.87
		Plowed soil	14.57	15.45	16.80
		Compacted soil	10.11	10.46	11.43
	24.5	Unplowed soil	23.91	24.24	25.04
		Plowed soil	22.70	22.95	23.83
		Compacted soil	20.29	20.96	22.31

Table (5): The moisture content for unplowed soil, plowed soil and compacted soil for five tractor-implement passes, three plowing depths and two moisture content levels

Moisture content %		Unplowed soil				Plowed		
	15%	10	15	25		10	15	25
		15.51	15.99	16.87		14.57	15.45	16.80
		Compacted soil		No. of passes	1	11.45	11.71	12.90
					2	10.75	11.17	12.21
					3	10.03	10.34	11.25
					4	9.36	9.73	10.71
					5	8.98	9.37	10.10
	24.5%	Unplowed soil				plowed		
		10	15	25		10	15	25
		23.91	24.24	25.04		22.70	22.95	23.83
		Compacted soil		No. of passes	1	22.09	22.55	23.34
					2	21.79	22.44	23.28
					3	20.19	21.15	22.65
					4	19.02	19.70	21.48
					5	18.36	18.95	20.81

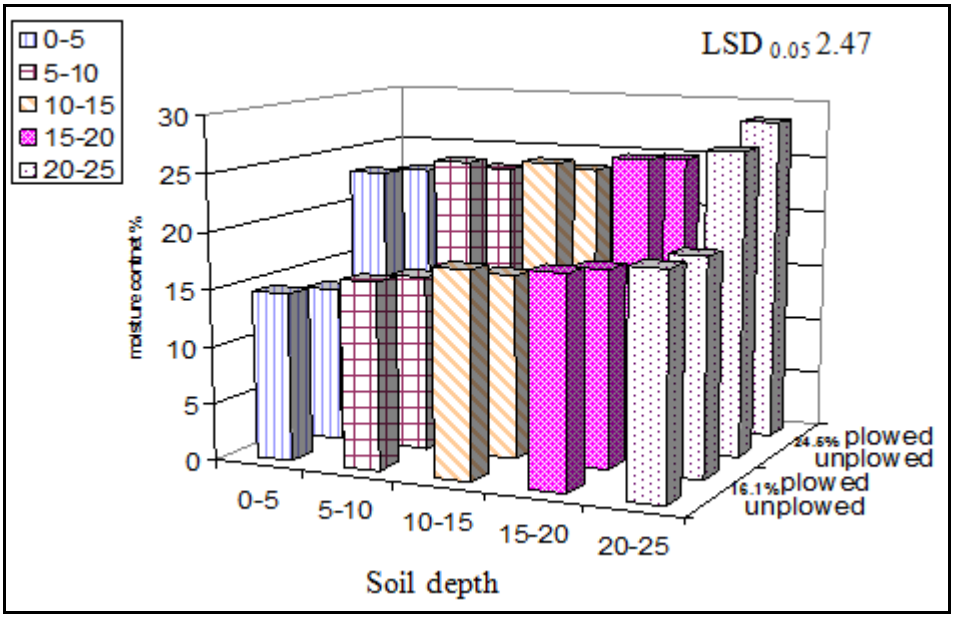

Fig. (3): Moisture content versus soil depth for plowed and unplowed soils for moisture contents of 16.1% and 24.5%.

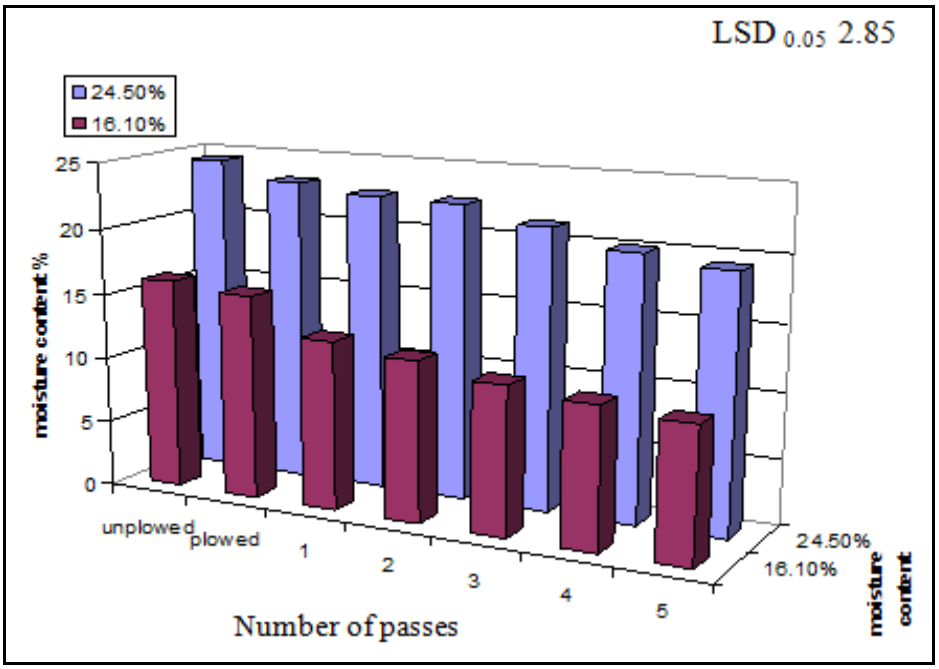

Fig. (4): Moisture content versus number of passes for moisture contents of 16.1% and 24.5%.

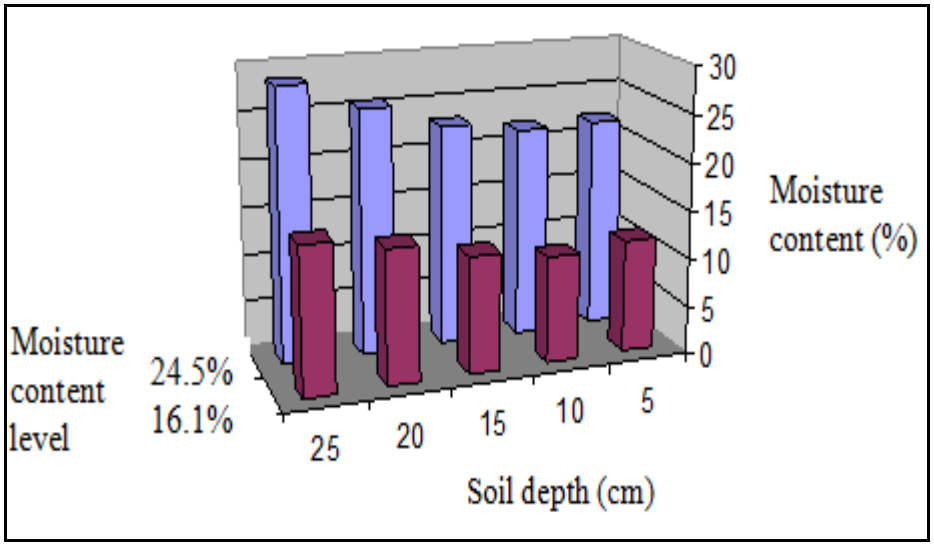

Fig. (5): The moisture content versus different depths for one pass on the soil surface for two moisture content levels.

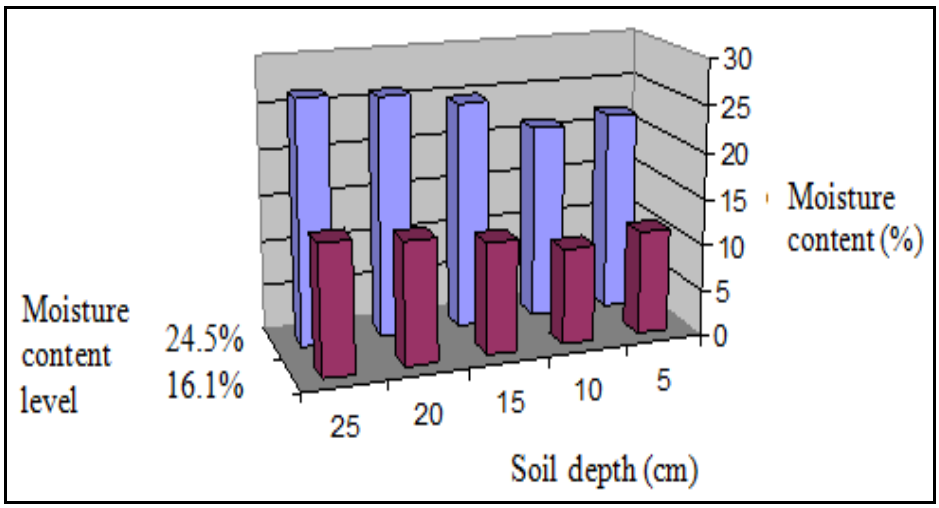

Fig. (6): The moisture content versus different depths for two passes on the soil surface for two moisture content levels.

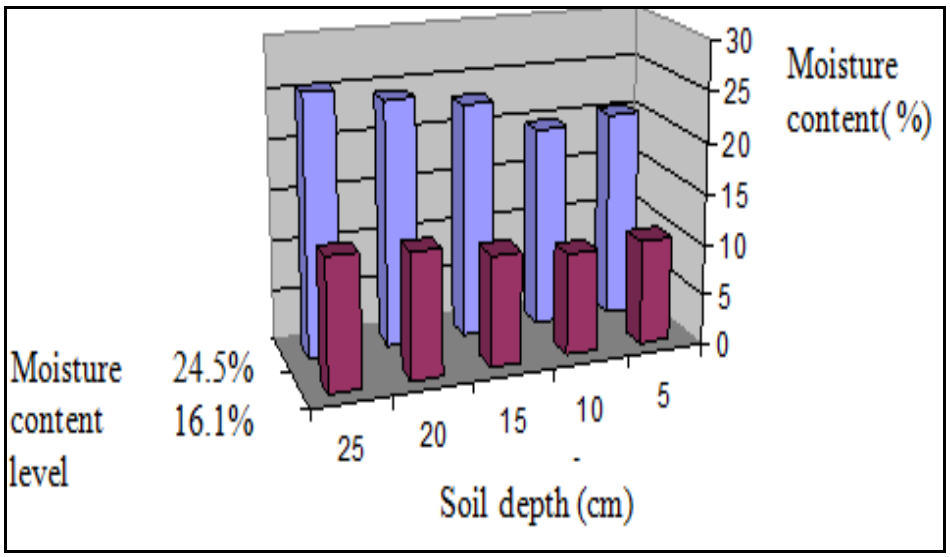

Fig. (7): The moisture content versus different depths for three passes on the soil surface for two moisture content levels.

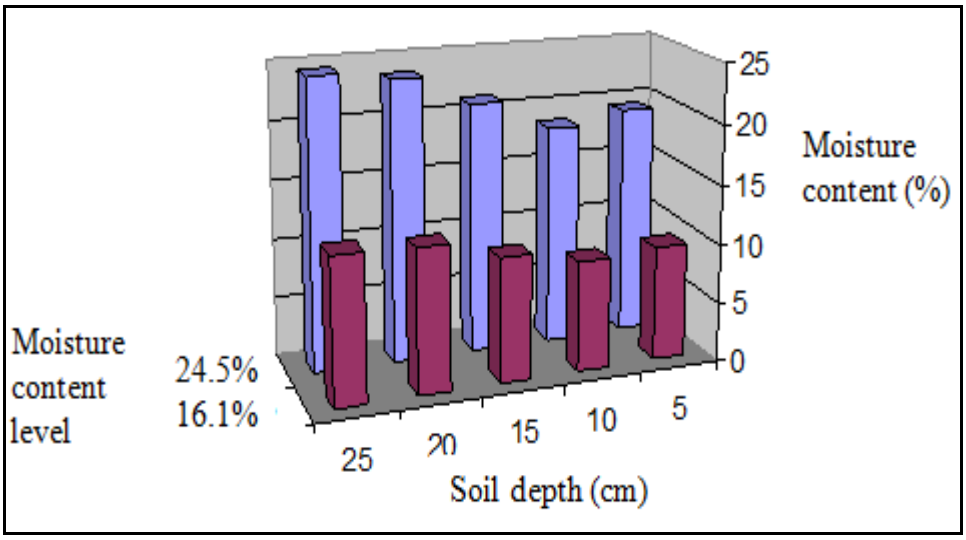

Fig. (8): The moisture content versus different depths for four passes on the soil surface for two moisture content levels.

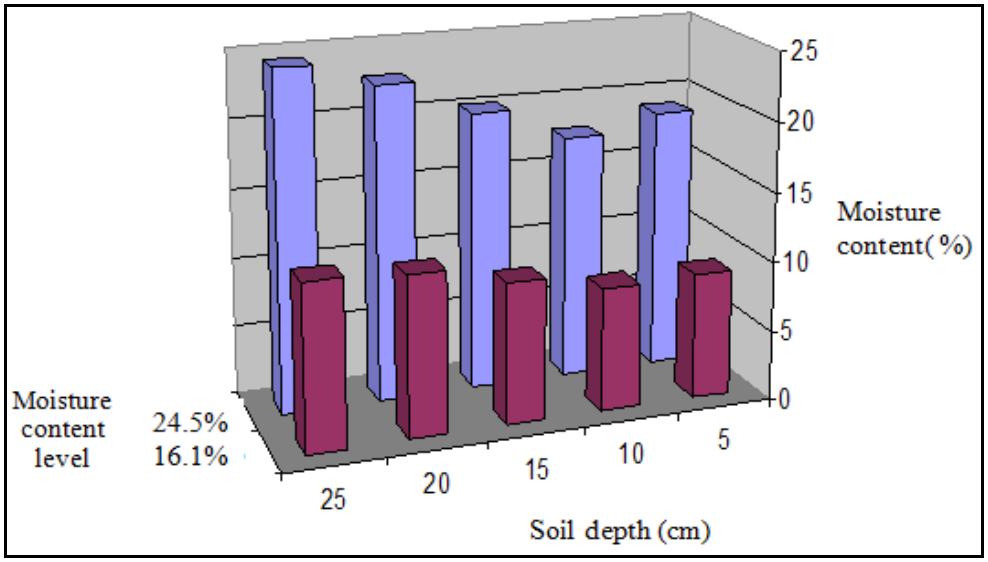

Fig. (9): The moisture content versus different depths for five passes on the soil surface for two moisture content levels.

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تاثير عدد مرات مرور الجرار والالة على المحتوى الرطوبي للتربة الغرينية الطينية المحروثة

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المستخلص. أجريت هذه التجربة لدراسة كبس التربة وعدد مرات مرور الجرار على المحتوى الطوبي للتربة الغرنية الطينية. حرثت التربة بمحراث مطرحي قلاب للاعماق 10 و15 و25 سم وكبست التربة بأمرار الجرار والمحراث المطرحي القلاب مربوط علية على سطح التربة مرة ومرتين وثلاث وأربع وخمس مرات. قيست الرطبة للتربة غير المحروثة والمحروثة والمكبوسة وللاعماق 5-0 و10-5 و15-10 و20-15 و-20 25 سم. الوزن الكلي للجرار والمحراث المطرحي القلاب 31.78kN وضغط هواء الاطارات الامامية والخلفية 2.5bar و1bar وعلى التوالي. أظهرت النتائج زيادة الطوبة من 14.70% الى 19.29% (31%) ومن 23.1% الى 26.78% (16%) عند زيادة العمق من 5-0 الى 25-20 سم للمستوين من الطوبة 16.1% و24.5% وعلى التوالي. عندما حرثت التربة أخفضت رطوبة التربة وكان الانخفاض عند السطح أكبر منة عند العمق ففى التربة التي رطوبتها 16.1% أصبحت الطوبة 13.70% و 19.29% أما في التربة التي رطوبتها 24.5% أصبحت الطوبة 22.56% و25.49% للعمقين 5-0 و25-20 cm وعلى التوالي. عندما كبست التربة أنخفضت الرطوبة ألا أن مقدار الانخفاض يعتمد على عدد مرات المرور وعلى المحتوى الرطوبي قبل الحراثة. ففى التربة ذات المحتوى الطوبي 16.1% أنخفضت الطوبة من 15.61% الى 12.90% (17.4%) والى 10.29% (34%) أما في التربة التي محتواها الرطوبي 24.5% أنخفضت الرطوبة من ة24.34% الى 23.34% (4.7%) والى 20.81% (15.80%) للمرور مرة واحدة ولخمس مرات وعلى التوالي. بينما للاعماق الاخرى وسط بين هذين العمقين. أدى كبس التربة الى خفض لجميع الاعماق وكان أعلى أنخفاض للعمق 10-5 cm وجاء العمق 5-0 سم ثانيا بينما للاعماق الاخرى فل الانخفاض مع زيادة العمق. أما بالنسبة للاعماق السفلي فى التربة التي محتواها الطوبي 24.5% فقد زادت الرطوبة للمرور مرة وأثنين ولكنها أنخفضت للمرور ثلاث مرات وأربع وخمس مرات. أدى كبس التربة الى خفض الرطوبة وكان الانخفاض أعلى ولو بمقدار محدود لعمق الحراثة الضحل مقارنة مع الاعماق الاكبر وكان الانخفاض أكبر في التربة الأقل رطوبة مقارنتا مع التربة الاعلى رطوبة. ففي التربة ذات المحتوى الرطوبي 16.1% أنخفضت الرطوبة من 15.51% الى 10.11% (35%) ومن 16.87% الى 11.43% (32%) اما في التربة ذات المحتوى الطوبي 24.5% أنخفضت الطوبة من 23.91% الى 20.29% ومن 25.04% الى 22.31% (11%) للعمقين 10و 25 سم وعلى التوالي. بينما كانت النتائج وسط للعمق 15 سم. تم تسجيل أكبر أنخفاض بالمحتوى الطوبي لخمس مرات مرور وللعمق الضحل ولكلا المستويين من الرطوبة للترب ذات المحتوى الرطوبي 16.1% الى 8.89% بينما للتربة ذات المحتوى الرطوبي 24.5% أنخفضت الى 18.36% كان الانخفاض اعلى في التربة الاقل مستوى رطوبي منها للتربة ذات المحتوى الرطوبي الاعلى لكون التربة الاقل محتوى رطوبي تنكبس بصورة أكبر من التربة ذات المحتوى الطوبي الاعلى.