Effect of Soil Moisture and Tillage Depth on Some Mechanical Properties for Tillage Machines Type (Moldboard Plow)

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Abstract

The effect of soil moisture and tillage depth was studied based on some mechanical properties for type tillage machine (moldboard plow) and soil physical characteristics wene tested two soil moisture levels of 10-12%and 12-14% and three levels tillage depth of 14,16 and 18 cm .The experiments were conducted in a factorial experiment under randomized complete block design with three replications. The results showed that the soil moisture 10-12 % was significantly better than the soil moisture 12-14% as while tillage depth at range 14cm was significantly superior to the other two levels 16 and 18 cm in all studied conditions. The results showed fuel consumption of 11.348 and 10.777 L.ha-1 , slippage percentage of 9.291 and 9.111 % power losses due to slippage of 2.689 and 2.414 Kw, field efficiency of 68.358 and 68.967 %, drawbar power 12.226 and 12.001kw and specific resistance 9.045 and 8.553 $N.^{cm-2}$ for soil moisture 10-12% and tillage depth 14 cm , respectively.

تأثير رطوبة التربة وعمق الحراثة على بعض الصفات الميكانيكية لنوع الة الحراثة (المحراث المطرحي)

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الخلاصة

نفذت تجربة لدراسة تأثير رطوبة التربة وعمق الحراثة على بعض الصفات الميكانيكية والفيزيائية للتربة تحت مستويين من رطوبة التربة ١٠ – ١٢% و وثلاثة مستويات للأعماق ١٤، ١٦، ١٨ سم باستعمال RCBD المحراث المطرحي. نفذت التجربة وفق التجارب العاملية تحت تصميم القطاعات العشوائية الكاملة بثلاثة مكررات. اشارت النتائج الى تفوق المستوى الرطوبي ١٠ – ١٢% معنويا على المستوى الرطوبي ١٢ – ١٤%، بينما تفوق عمق الحراثة ١٤ سم معنويا على المستويين ١٦ و ١٨ سم في جميع الصفات المدروسة. كانت النتائج المسجلة، استهلاك الوقود ١١.٣٤٨ و ١٠.٧٧ لتر.هكتار$^{-١}$، نسبة النزلاق ٩.٢٩١ و٩.١١١% ، القدرة المفقودة بالانزلاق ٢.٦٨٩ و ٢.٤١٤ كيلو واط، الكفاءة الحقلية ٦٨.٩٦٧ و ٦٨.٣٥٨% ، القدرة على ذراع السحب ١٢.٢٢٦ و١٢.٠٠١ كليو واط، والمقاومة النوعية ٨.٥٥٣ و ٩.٠٤٥ نيوتن.سم$^{-٢}$ على التوالي عند المستوى الرطوبي ١٠ – ١٢% وعمق حراثة ١٤ سم.

الكلمات الدالة: الصفات التربة الفيزيائية، الصفات الميكانيكية، رطوبة التربة، عمق الحراثة، المحراث المطرحي.

1.Introduction

A tractor is an engineering vehicle specifically designed to deliver at a high tractive effort or torque at deferent speeds, for the purposes of the machinery used in agriculture such as plows and planters etc. And all agricultural implements may be towed behind or mounted on the tractor, and the tractor may also provide a more of tasks . Tractors are used for many different tasks. Because the tractor is a versatile machine .Soil tillage is the quality that enables a soil to provide the proper nutrients, in the proper amounts and in the proper balance, for the growth of specified plants when other growth factors such as light, temperature, moisture and the soil physical condition . High fertility soil tillage depend on plow type and this further implies an increase in the range of crops that can be grown [2].

The tillage operation requires the most energy and power spent on farms. Therefore, draft and power requirements are important in order to determine the size of the tractor that could be used for a specific implement. The draft required for a given implement will also be affected by the soil conditions and the geometry of the tillage implement [14]. Power requirements are important parameters for measuring and evaluating performance of tillage implements. Many studies have been conducted to measure draft and power requirements of tillage implements under various soil conditions [16] .The coefficient of pull was about 16.6% of the draft force was directed towards cutting the soil and 83.4% was consumed in pulverization of soil particles. For all plowing depths and forward speeds .The plowing depth had more pronounced effect on the draft, unit draft, specific draft and coefficient of pull than the forward speed. The optimum forward speed was 1.75 m sec−1 [5] . Tillage is defined as mechanical manipulation of soil to provide a favorable environment for good germination of seeds and crop growth, to control the weeds, maintain infiltration capacity and soil aeration. A well planned tillage practice provides a favorable environment, suitable for better seed germination and effective plant growth. In addition, it also protects and maintains a strong soil structure to reduce soil erosion [8] . Fuel is the source of capacity for the machine as well as there are many parameters in tillage process that affect the fuel consumption of a machine, such as soil texture, soil moisture , machine type and size . Therefore, tractor fuel consumption is not constant and varies from one to another situation . According for the factors mentioned above [4]. The effect of forward speed and tillage depth on the draft for three primary tillage (moldboard plow ,chisel plow ,Disk plow) . Fuel consumption for tractor at various working depths of moldboard plough. Their results showed a linear relationship between fuel consumption and working depth of the moldboard plow. [7] . Study the effect based tillage depth on soil physical properties. The results revealed that all the soil physical properties i.e., soil moisture content, bulk density, porosity, penetration resistance, mean weight diameter, hydraulic conductivity and rate of infiltration were significantly improved with tillage consisting [15].

The field tests showed that soil conditions were in good working range for tillage operations. A significant increase in draft was observed for all the three tillage implements with an increase in forward speed and tillage depth . The moldboard plow showed greater draft requirement than the disk plow at the same depth and speed [10].

Tillage operation with the same implement over several years may lead to compacted layer in field soil. Plowing at the same depth year after year reinforce the plow pan development, so use of different tillage implement may be the only solution to breakup this pan and physical soil properties improve such as soil density, soil resistance to penetration and total porosity of soil [1].

The main goal of this research is to study the effect of soil moisture and tillage depth on some mechanical properties for moldboard plow.

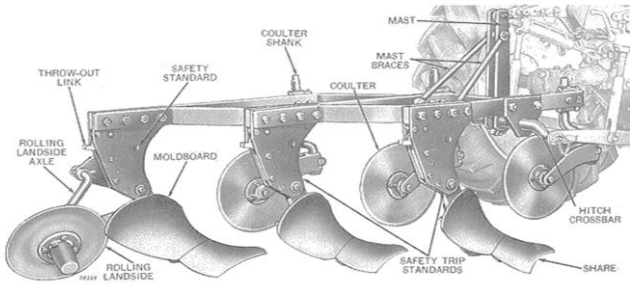
2.Materials and methods

This study was conducted in 2017 , to evaluate for two types machines (MF -250 and MF- 440 Extra) were used for experiment with moldboard plow table1 , the experiments were done at two levels of moisture soil 10-12% , 12-14% ,and three tillage depth 14, 16 and 18 cm , The moldboard plow was selected for the experiments of the plow organized on certain 18cm depth by hydraulic device for tractor and set at 18 cm depth and soil moisture 12-14% using the pipette methods.

Table 1. Tractor specifications

		
Parameters	**Machine type**	**Machine type**
	Massy Ferguson , Mf 285 s	Massy Ferguson , Mf 440 Extra
Engine Power	75 Hp	82 Hp
Engine speed (rpm)	2000	2200
Engine type	Perkins (diesel)	1104c.44
Cylinders number	4-cylinders	4-cylinders
	Firing order 1-3-4-2	Firing order 1-3-4-2
	starter volts 12	
PTO rpm	540	540
Weight	3470 Kg	3430 Kg

Table 2. moldboard plow specifications



Parameters	Moldboard plow
Working width	120cm
Length	3010mm
Height	1130mm
Weight	320 kg
Weapon width	40cm

2.1. Mechanical characteristics

2.1. 1. Fuel consumption

Fuel consumption is measured by the fuel consumption device in mL for treatment length (50 m) was calculated using Eq 1 [3] .

$$Q_F = \frac{Q_D \times 10000}{W_P \times D \times 1000} \quad (1)$$

Where: Q_F fuel consumed amount L\ ha , Q_D fuel consumed amount for treatment length (50 m), W_P machine width (m) , D treatment length (50 m).

The fuel amount consumed was measured using graduated cylinder placed in the fuel duct between the tank and the fuel injection pump , After the cylinder dictated with fuel it will be closed duct fuel from the tank by a tap . Fig 1. The fuel is used from the cylinder when the treatment access ,length 50m. When it completed the treatment (length 50 m). Fills the cylinder with fuel and another treatment is started in three replication.

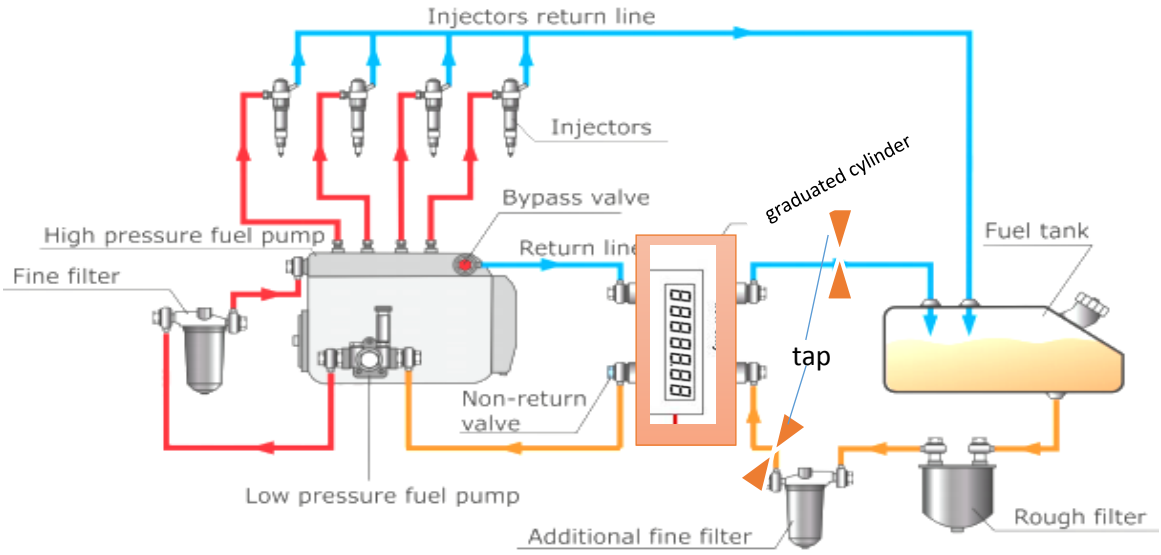


Fig .1. Fuel consumption measurement device by graduated cylinder

2.1.2. Slippage percentage

Measured by the practical and theoretical speed [2] Practical speed :After tillage depth determination in the experiment the plow hacked in the soil with practical speed 3km .hr^{-1}, within treatment length (50 m) for both soil moisture and tillage depth in three replication. The Eq (2) was used for calculation of the practical speed .

$$V_P = \frac{3.6 \times D}{T_P} \qquad (2)$$

Where : V_P practical speed Km.hr^{-1} , T_P practical time (hr) .

Theoretical speed :Without plowing the soil , only the weapon touches the soil, with speed 3km.hr within treatment length (50 m) for both soil moisture and tillage depth in three replication. The Eq (3) was used for calculation of theoretical speed

$$V_T = \frac{3.6 \times D}{T_t} \qquad (3)$$

Where : V_T theoretical speed Km.hr^{-1} , T_t theoretical time (hr) .

The Eq (4) was used for calculation of the slippage percentage using two speeds the practical and theoretical .

$$S = \frac{V_t \times V_p}{V_t} \times 100 \qquad (4)$$

Losing power due to slippage was calculated of the Fig .6. [2]

$$P_S = \frac{F(V_t \times V_p)}{270} \qquad (5)$$

Where : P_S : Power losses due to slippage (kw)

2.1.3. Field efficiency:

Field efficiency is the ratio of effective field capacity to theoretical field capacity, and it can be affected by time lost in the field and full width of the machine. The Eq (6) was used for calculation of the field efficiency [12]

$$F_E = \frac{E_{FC}}{T_{FC}} \times 100 \quad (6)$$

2.1.4. Force of drag:

The drag force was calculated by dynamometer tied between the tractor Massey -Ferguson -440 Extra and the tractor Massey -Ferguson -265s pregnant for the moldboard plow with use a flexible cord. The tractor Massey -Ferguson -440 Extra which drag the tractor Massey -Ferguson -265s pregnant for the moldboard plow without soil penetrates and the measured number subtraction from the measured number new in dynamometer screen when working the moldboard plow inside the soil . for both soil moisture and tillage depth. Eq (7) was used for calculation of drag force [11] .

$$F = T_{DP\ with\ load - T_{DP}\ withou\ load} \quad (7)$$

F : drag force (KN) , $TDP\ with\ load$;The total drag power for the tractor when plow loading , $T_{DP}\ withou\ load$:The total drag power for the tractor when plowing without loading .

2.1.5. Drawbar power

Drawbar power was determined by Eq (8) [2]

$$C_D = F \times V_b \quad (8)$$

Where : C_D capacity of drag (Kw) , F force of drag (KN) , V_p practical speed (Km.hr-^{1})

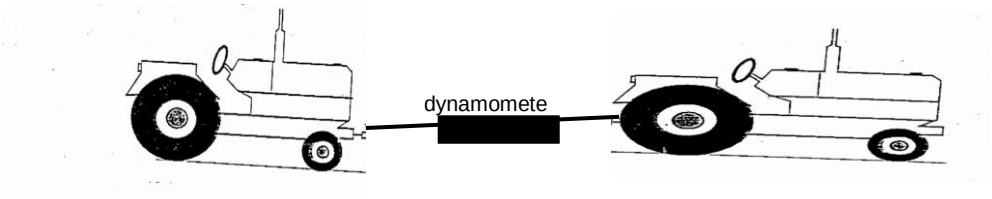


Fig .1. dynamometer connecting between two machines (MF-440 Exrta and MF-265s)

2 .1.6 . Specific resistance

The Eq (9) was used for calculation of the Specific resistance [4]

$$S_{.R} = \frac{F}{A} \quad (9)$$

Where : S_R specific resisance (KN M^{-2}) , F force of drag (KN) , A disassembled distance (M^2) .

2.2. Physical properties:

Physical properties of the soils determined ,were taken soil samples for six site randomly selected from the field and for three tillage depths determined in the experiment were 14,16 and 18 cm by the hydraulic device for tractor according to the method used by [7] were taken of the soil samples for different depths , and drying it in the oven

until it reaches the required level 12-14% . And then the first part was executed from experiment. When obtain on level 10-12% and implementation the second part of experiment [3] . each running test .

2.2.1 Soil moisture:

Samples were taken to measure soil moisture in the surface layer, 10 cm ,12 cm and 14cm . Samples were weighted before and after 105˚C . The moisture content of soil samples after one month ,two months and the ending of agricultural season , was calculated by using Eq (10) [6].

$$W_{=\frac{W_w}{W_s}\times 100} \quad (10)$$

Where : W :Is soil moisture percentage , W_w : Is weight wet soil , W_s : Is weight dry soil .

2.2.2.Soil bulk density

For measuring bulk density, three soil samples from different parts of the land were collected using the pipette method. The collected samples were immediately put in plastic bags to conserve moisture during transferring to the laboratory and weighed it, then dried at 105 ˚C for 48 hr. Mass of dried soils was weighted, Soil bulk density was determined by Eq (11) [6]

$$P_{b=\frac{M_S}{V_T}} \quad (11)$$

Where : P_b : Dry bulk density (mg. m^{-3}) , M_S :weight of the dried soil sample (mg) , V_T: total volume of the soil sample (m^3) .

2.2.3. Total soil porosity

The total porosity of soil samples collected for each treatment was calculated using following equation , an assumed particle density of 2.65 $mg.m^{-3}$. The Eq (12) was used for calculation of the total porosity of soil [9]

$$T_{SP=}\left(1-\frac{P_b}{P_S}\right)\times 100 \quad (12)$$

Where : T_{SP} : total soil porosity (%) , P_b : dry bulk density ($mg.m^{-3}$) , P_S : partial density ($mg.m^{-3}$) , and shown in the table below.

Table 3. Experiment field properties

Soil moisture%	Depth tillage cm	Soil bulk density $Mg.m^{-3}$	Total soil porosity %
10-12%	14	1.22	53.96
	16	1.30	50.94
	18	1.41	46.79
12-14%	14	1.32	50.18
	16	1.36	48.67
	18	1.47	44.52

Table 4.Soil minutes volumes analysis in the experiment field

Soil moisture%	Tillage depth Cm	silt	Clay	sand	Soil tissue
	14	480	360	160	
10-12 %	16	470	400	130	
	18	460	370	170	
Av		470	376.67	153.33	Silt Clay loam
12-14%	14	470	390	150	
	16	480	360	160	
	18	460	370	150	
Av		476.67	370	153.33	Silt Clay loam

The same method was used to test Moldboard plow at soil moisture in the range 12-14% and tillage depth of 14cm and 16cm in three replications. The results were analyzed statistically by using the randomized complete block design RCBD and the difference among treatments for each factor was tested according to the least significant differnce L.S.D test [13].

3.Results and discussion

3.1. Fuel consumption

The influence of tillage depth on fuel consumption $L.ha^{-1}$ was shown in Table. **I** The tillage depth of 18cm has the highest fuel consumption which required of 12.860 $L.ha^{-1}$, the lowest fuel consumption and 1:1by depth of 14 cm has riquired of 10.777 $L.ha^{-1}$. Because of the high pressure on moldboard plow during tillage process leads to fuel consumption increased . These findings are consistent with the findings of [14]. It is indicated that the fuel consumption of the level 10-12% soil moisture was significantly better than level 12-14% soil moisture. The results were 11.348 and12.126 $L.ha^{-1}$ respectively .Because of high soil resistance of the plow movement and increase the force of the clouds and thus increasing fuel consumption. These results are consistent with the results of [3]. The level of the fuel consumption at different conditions is shown in Fig**. 2** for tillage depth and soil moisture.

I. The effect of soil moisture and tillage depth on fuel consumption. $L.ha^{-1}$

Soil moisture %	Tillage depth cm			Means of soil moisture %
	14	16	18	
10-12%	**10.612**	**11.122**	**12.311**	**11.348**
12-14%	**10.941**	**12.031**	**13.408**	**12.126**
LSD=0.05				**0.408**
Means of tillage depth	**10.777**	**11.576**	**12.860**	
LSD=0.05		**0.621**		

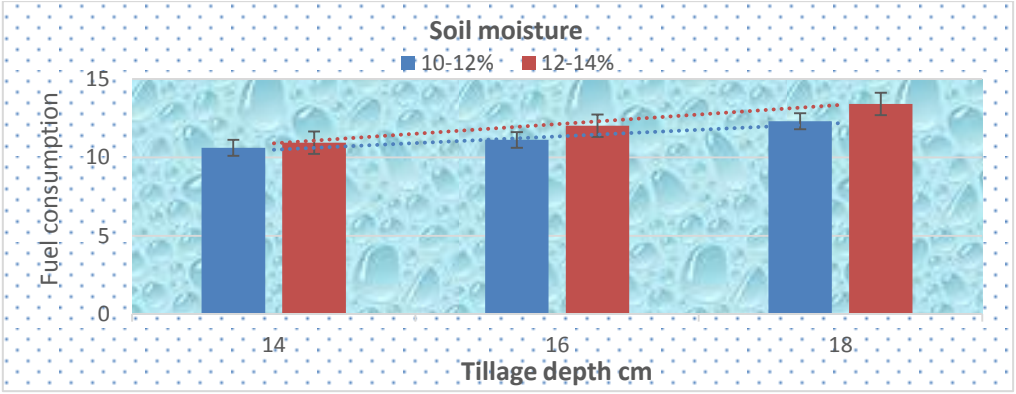


Fig 2. The effect of soil moisture and tillage depth on the fuel consumption L.ha^{-1}

3.2. Slippage percentage

The influence of tillage depth soil moisture on the slippage percentage % was shown in Table **II** . At tillage depth of 14cm has the lowest slippage percentage of 9.111%, and tillage depth of 18 cm has the highest slippage percentage which required of 10.729%. This is due to the increased drag force when increase tillage depth led to increase hence slippage ratio increased. These results are consistent with the results of [2]. It is indicated that the slippage percentage of the soil moisture 10-12% was significantly better than soil moisture 12-14%.the results were 9.291% and 10.303 % respectively These results are consistent with the results of [10]. The slippage percentage required is shown in Fig.3 at different conditions for soil moisture and tillage depth .

II. The effect of soil moisture and tillage depth on slippage percentage %

Soil moisture %	Tillage depth cm			Means of soil moisture %
	14	16	18	
10-12%	8.441	9.102	10.331	9.291
12-14%	9.781	10.003	11.126	10.303
LSD=0.05				1.341
Means of tillage depth	9.111	9.553	10.729	
LSD=0.05		1.654		

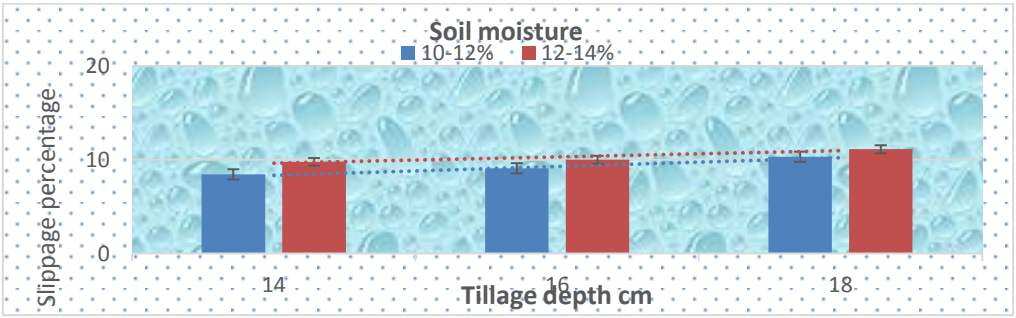


Fig 3. The effect of soil moisture and tillage depth on the slippage percentage %

3.3. Power losses due to slippage :

The influence of tillage depth soil moisture on the power losses due to slippage Kw . At the tillage depth of 14cm the result indicated the lowest power losses due to slippage of 2.414 Kw more over the tillage depth of 18 cm presented the highest power losses due to slippage of 3.299 Kw. Due to the increased drag force required for the moldboard plow led to increased power losses due to slippage . These results are consistent with the results of [11]. From Table **III**, it is indicated that the slippage percentage of the soil moisture 10-12% is significantly better than soil moisture 12-14%.The results were 2.689 Kw and 3.023Kw respectively These results are consistent with the results of [10] . The level of the losing power due to slippage at different conditions is show in Fig. 4 for soil moisture and tillage depth.

III. The effect of soil moisture and tillage depth on power losses due to slippage Kw.

Soil moisture %	Tillage depth cm			Means of soil moisture %
	14	16	18	
10-12%	2.214	2.682	3.171	2.689
12-14%	2.613	3.029	3.426	3.023
LSD=0.05				N.S
Means of tillage depth	2.414	2.856	3.299	
LSD=0.05		N.S		

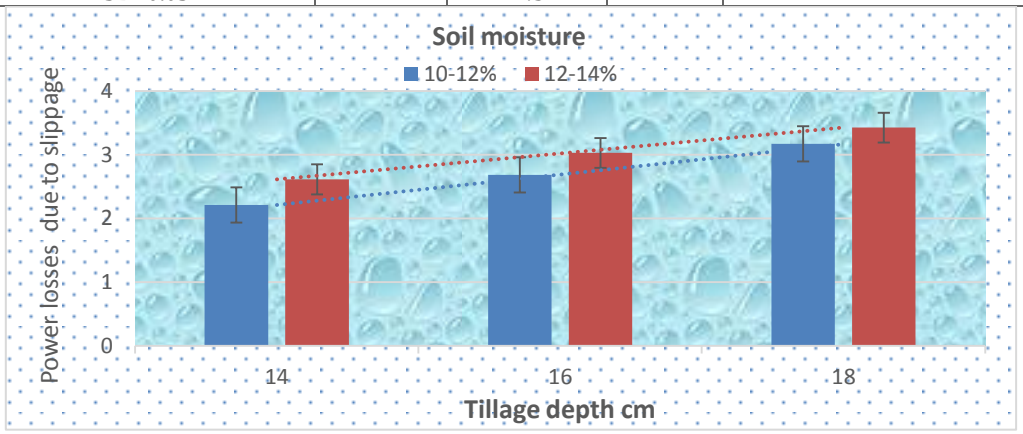


Fig 4. The effect of soil moisture and tillage depth on power losses due to slippage Kw.

3.4. Field efficiency

The influence of tillage depth on the field efficiency % . At the tillage depth of 14cm the result indicated the highest field efficiency of 68.967%, and tillage depth of 18 cm presented the lowest field efficiency of 66.552%. This is due to slippage percentage increased with soil moisture increasing .These results are consistent with the results of [12]. From Table **VI**, it is indicated that the field efficiency of the soil moisture 10-12% was significantly better than soil moisture 12-14%.the results were 68.358% and 67.024 % respectively . This due to lack of coherence between tractor wheels and soil with soil moisture increased led to slippage percentage increasing , hence field efficiency decreased. These results are consistent with the results of [2] . The level of the field efficiency at different conditions is show in Fig. 5 for soil moisture and tillage depth .

VI. The effect of soil moisture and tillage depth on field efficiency %

Soil moisture %	Tillage depth cm			Means of soil moisture %
	14	16	18	
10-12%	69.762	68.091	67.222	68.358
12-14%	68.173	67.015	65.883	67.024
LSD=0.05				1.129
Means of tillage depth	68.967	67.553	66.552	
LSD=0.05		1.566		

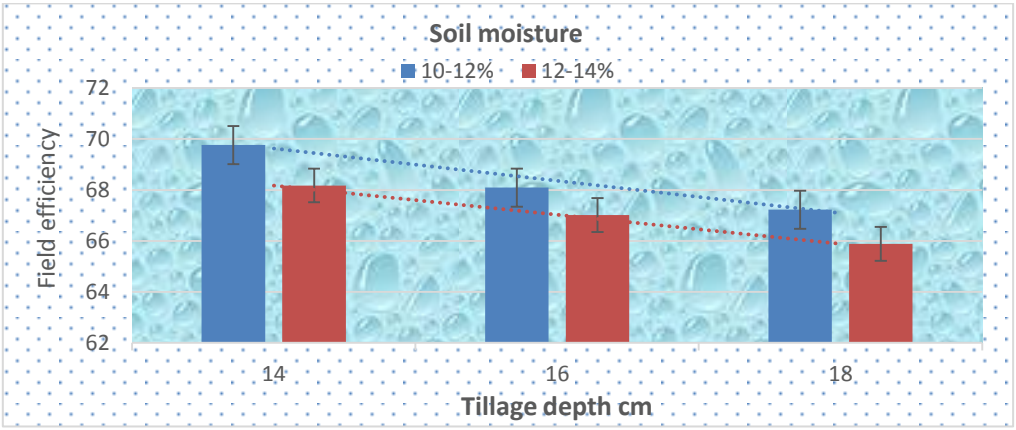


Fig 5. The effect of soil moisture and tillage depth on the field efficiency % .

3.5. Drawbar power

Table **VII** shows the influence of tillage depth , and the soil moisture on the drawbar power Kw. The results indicate that increasing the depth of tillage led to increase the drawbar power , and the results were 12.001, 12.653 and 14.017 Kw , respectively from different levels of tillage depth. Increased drag force with increased tillage depth when using moldboard plow leads to increasing drawbar power.These results are consistent with the results that gained by [14]. As for the decreasing the moisture led to decrease the drawbar power , and the results were 12.226 and 13.284 Kw, respectively . This is consistent with [16]. The levels of the drawbar power at different conditions is shown in fig **6** for soil moisture and tillage depth .

VII. The effect of soil moisture and tillage depth on drawbar power Kw.

Soil moisture %	Tillage depth cm			Means of soil moisture %
	14	**16**	**18**	
10-12%	**11.330**	**12.125**	**13.223**	**12.226**
12-14%	**12.671**	**13.181**	**14.811**	**13.284**
LSD=0.05				**1.091**
Means of tillage depth	**12.oo1**	**12.653**	**14.017**	
LSD=0.05		**1.105**		

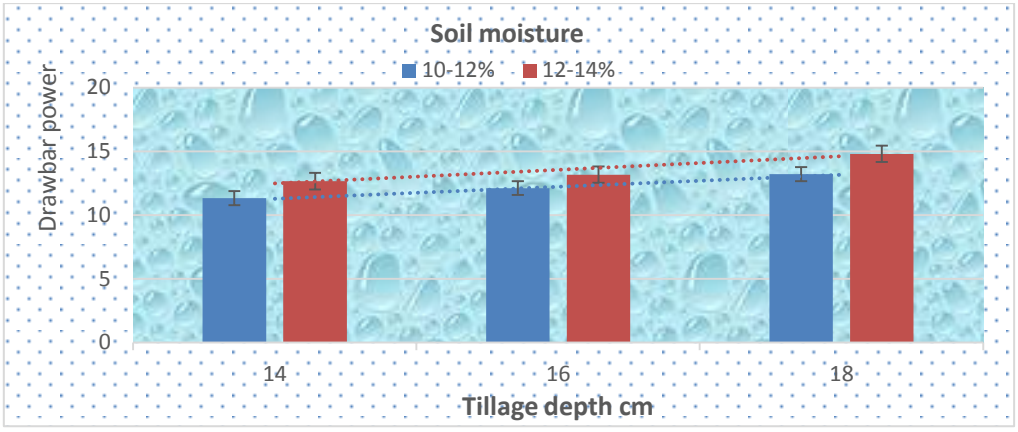


Fig 6. The effect of soil moisture and tillage depth on the drawbar power Kw .

3.7. Specific resistance

Table **VIII** shows the influence of tillage depth , and soil moisture on the specific resistance N.cm^{-2}. The results indicate that increasing the depth of tillage leads to increase the specific resistance , and the results were 8.553 , 9.671and 10.164N.cm^{-2} , respectively for defferent of tillage depth . Increased drag force with increased tillage depth when using moldboard plow leads to increasing specific resistance .These results are consistent with the results that gained by [10]. However, the soil moisture 10 -12% was significantly better than the soil moisture 12 – 14% and the results were 9.045 and 9.880 N.cm^{-2} , respectively. This is consistent with [1]. The levels of the specific resistance at different conditions is shown in fig **7** for soil moisture and tillage depth .

VIII. The effect of soil moisture and tillage depth on specific resistance N.cm^{-2}.

Soil moisture %	Tillage depth cm			Means of soil moisture %
	14	16	18	
10-12%	8.102	9.123	9.911	9.045
12-14%	9.004	10.219	10.416	9.880
LSD=0.05				0.021
Means of tillage depth	8.553	9.671	10.164	
LSD=0.05		0.143		

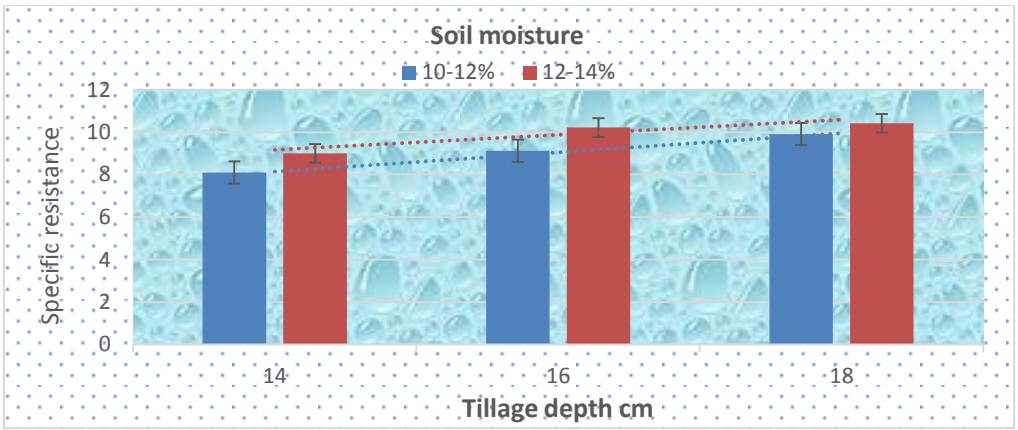


Fig 7. The effect of soil moisture and tillage depth on the specific resistance N.cm^{-2}.

4. Conclusions

The soil moisture 10-12%is significantly better than the soil moisture 12-14% in all studied condition , the tillage depth 14cm was significantly superior to other two levels 16 and 18cm in all studied properties. The best results were obtained by moldboard plow at soil moisture 10-12% and 14cm tillage depth.

5 Recommendations

The present recommends to carry out future studies using other of machinery types and conduct other organizations on machine and the moisture content to know their effect on the physical characteristics of soil and machine.

CONFLICT OF INTERESTS
There are no conflicts of interest.

6.References

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