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Effect of Added Weights on Tractor Rear Tires and Soil Moisture Content on Some Indicators of Mechanical Unit Performance During Moldboard Plowing

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Abstract

The study was conducted to find out the effect of adding weights on the wheels of the agricultural tractor and soil moisture content using the moldboard plow by measuring some mechanical properties, including the drawbar power,fuel consumption, soil bulk density , irregularity index of tillage depth as a percentage and the soil disturbed volume in the cultivation season (2017-2018)in one of the agricultural fields with soil of clay texture which is located in the northeast of Mosul city. and the texture of the soil was clay the field was divided according to a split plot arrangement under Randomized Complete Block Design with three replications. The results of the study showed that the soil moisture content (14-16)% achieved fewer values for drawbar power, fuel consumption, irregularity index of tillage depth as a percentage and soil bulk density and the higher values for soil disturbed volume, while, the adding weights on tractor wheels of (310)kg gave the less values for drawbar power, fuel consumption, soil bulk density and Irregularity index of tillage depth as a percentage and higher values for treated soil volume, also the interaction between the soil moisture content (14-16)% with adding weights on tractor wheels (310)kg achieved the less values for each drawbar power, fuel consumption, soil bulk density and Irregularity index of tillage depth as a percentage, and the higher values for soil disturbed volume .

Key words: Moldboard plow, Adding weights, Soil moisture content, Drawbar power, Irregularity index of tillage depth
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Introduction

The field of mechanization of agricultural work above all is concerned with development of man and of his society, a comprehensive and integrated development, with what it provides of intellectual, technical, social and economic means and methods for the development of his life and the advancement of his society, as well as interest in this field in the training and preparation of human cadres technically and administratively to operate and manage agricultural equipment with technical and economic efficiency. This is why countries are encouraged to expand the use of agricultural mechanization units, in order to be able to provide human labor and raise the quality of agricultural products [1]. The addition of weights to the tires of the tractor is considered one of the basic and important matters used in determining the efficiency of the performance of the machine and the tractor, as the percentage of slippage decreases due to the improvement of the cohesion between the tires and the soil, also the addition of weights to the tires of the tractor increases the practical productivity with less fuel consumption [2]. Also mentioned [3] the adding weights to the rear wheel helps reduce drawbar power. Soil moisture is one of the most influential factors in the tillage process, as it directly affects the degree of soil fragmentation and the energy requirements to prepare a suitable bed for the soil, where [4] indicated that the best moisture conditions suitable for plowing are in the fragile state of the soil, in which the percentage of soil moisture content ranges from (14 to 18)% and that the soil moisture content affects the energy require ments and the draft force, because the increase in the soil moisture content of the soil leads to raisein the draft force as a result of the excess in soil adhesion in the plow arms with an increase in slippage and fuel consumption, and this was confirmed by [5] and [6]. The aim of the study is to identify the effect of moisture content and add appropriate weights on the rear wheels and record their best indicators in terms of performance of the mechanical unit in addition to finding the best combination among them.

Materials and methods

The study was conducted in one of the fields located northeast of Mosul, where the area of the field was actually exploited (6) dunums, and the field was planted with potatoes in the season that preceded the executing the experiment, noting that the experimental field was irrigated and the soil texture was clay. moldboard plow of Turkish origin was used, and two Massey Ferguson 285s tractors were used when carrying out the experiment due to the lack of a device for measuring the direct draft force on the suspension arms, where by a dynometer was used to calculate the draft force. The design of the complete random sectors was followed, and the method of split plots was used to conduct the experiment, where the main plots were allocated for the soil moisture content in two levels (14-16)% and (18-20)% and each main plots was divided into two secondary plots, were allocated for the weight added to the drive wheels as iron discs used on the tractor wheels in two levels without adding (0) kg and adding a weight of (310) kg, and thus the experiment was (2 * 2), meaning that it contained (4) treatment and with three replications, so that the number of experimental units became (12) units with an area of (90) m² for the experimental unit, with a length of (30) m, a width of (3) m, and the plowing depth was fixed at (18) cm. Duncan's multiple range test was used at the probability level of 0.05 to test the significance of the differences between the means of the different treatments. The following indicators were studied:

1-Drawbar Power (hp) :

It is the power measured at the end of the towing arm or the hydraulic lifting arms. It also represents the available power to pull the agricultural equipment. It is the rate of work done per unit time, and it is the product of multiplying force by speed [7]. It can be calculated from the following equation: [8]

$$DP = FT * Vp/270 \quad (hp)$$

Since:

DP = Drawbar Power (hp)

FT = drag force (kg)

Vp = practical speed ($km.h^{-1}$)

2- Fuel Consumption ($L.ha^{-1}$) :

Fuel consumption was measured, where a graduated cylinder was used to add fuel to the fuel tank of the tractor after completing each transaction line, and it was calculated according to the following equation [9] :

$$FC = Fca \times 10 / Wp * Dp \quad (L.ha^{-1})$$

Since:
FC = amount of fuel consumed per unit area (L/ha).
Fca = measured amount of spent fuel (ml).
Wp = Actual tillage width (m).
Dp = actual tillage depth (m).

3- Soil Bulk Density ($g.cm^{-3}$) :

It represents the relationship between the weight of the solid particles in the soil to the total volume of the soil, and therefore its value will always be less than the value of the true density. Density cylinder was used to estimate the apparent volume by the gravimetric method, as stated in [10], and is calculated according to the following equation:

$$Pb = Ms/Vt \quad (g.cm^{-3})$$

Since:
Pb = Soil Bulk Density ($g.cm^{-3}$).
Ms = mass of soil solid particles (g).
Vt = total volume of soil (cm3).

4- Irregularity index of tillage depth (%) :

The tillage depth achieved was calculated using two rulers, the first with a length of (30) cm and the second with a length of (1) meter. The irregularity index for the tillage depth was also calculated as a percentage (%), which represents the percentage in which the plow deviates from the tillage depth that was previously determined. The deviation is important in determining the suitability of the plow, and it is calculated by the following equation: [11]

$$a_{sr} = \sum ap / np$$

As that
a_{sr} = average depth (cm).
ap = Measured Depth (cm).
np = the number of repetitions

$$\Delta a = \sqrt{\sum (ap - a_{sr})^2 / np}$$

Δa = mean deviation of depth (cm).

$$\delta a = (\Delta a / a_{sr}) * 100$$

δa =Irregularity index of tillage depth.(%)

5-Soil Disturbed Volume (m3.h-1) :

It is stirred by the plow during the plowing period, and depends on the practical productivity of the machine and the actual depth of Tillage. The volume of soil stirred up can be calculated according to the following equation: [12]

$$S.D.V = DP * Efc * 100 \quad (m3.h-1)$$

Since:
S.D.V = soil volume stirred up (m3.h-1)
EFc = actual field productivity (ha. h-1)
DP = actual plowing depth (cm).

Results and discussion

1- Drawbar Power(hp) :

Table No. (1) shows that there was no statistically significant effect of the soil moisture content on the characteristic of the drawbar power, but numerically, the soil moisture content (18-20%) registry the largest drawbar power amounting to (12.352) hp, compared with the soil moisture content (14-16%), which registry the less value of the drawbar power (11,493) hp. The reason for this is that increasing the soil moisture content leads to an increase in the draft force, and since the draft force is one of the components of the drawbar power, the drawbar power increases, and this is consistent with [13]. The added weight on tractor wheels gave clear significant differences, as the addition of weights (310) kg achieved the least significant value for the drawbar power and amounted to (10.724) hp, compared with not adding weights (0) kg, which registry the highest significant value for the drawbar power (13.121) hp, the reason returns adding weights increases the ability of the tractor to transfer the power available at the tires into a drawbar power, and this is consistent with what was mentioned by [14]. The interaction between the soil moisture content and the added weight on the wheels of the tow showed significant differences. The soil moisture content (14-

16%) with the addition of weights on the tractor wheels (310) kg was significantly superior in registry the less value of the drawbar power and amounted to (9.643) hp, compared with the same content and without adding weights on the tractor wheels (0) kg that It achieved the highest significant value of (13,343) hp.

Table (1) Effect of added weight, soil moisture content and their interactions on drawbar power (hp)

Soil moisture content(%)	Added weight (Kg)	Interaction added weight and soil moisture content	Average soil moisture content (%)
14-16	0	13.343 a	11.493a
	310	9.643 b	
18-20	0	12.899 a	12.352a
	310	11.805 a	
Average Added weight (Kg)	0	13.121 a	
	310	10.724 b	

The different letters within the same column indicates that there is a significant difference between the treatments at the level of significance p>0.05, values were Mean ± standard error.

2- Fuel consumption (L.ha^{-1}) :

Table (2) shows that the effect of soil moisture content led to a significant difference on fuel consumption, as the soil moisture content (14-16%) recorded the least significant value for fuel consumption and amounted to (17.195)L.ha^{-1},compared with the soil moisture content (18-20%)) which recorded the highest significant value (26.855) L.ha^{-1}, where it was found that increasing the soil moisture content increases fuel consumption, and the reason for this may be due to the fact that increasing the soil moisture content led to an increase in soil adhesion to the surface of the working part of the plow, which in turn led to an increase in draft power, increased load on the tractor, and increased fuel consumption, and this is consistent with mentioned [5]. It is noted that the effect of the added weight on the wheels of the tractor was significant on the fuel consumption, as it was found that when adding the weights on the wheels of the tractor, it led to a decrease in fuel consumption. Adding weights(310) kg recorded the lowest significant value for fuel consumption, amounting to (17.764)L.ha^{-1}, compared to not adding weights (0) kg, which recorded the highest significant value for fuel consumption (26.286) L.ha^{-1}. The reason for this may be that the use of weights led to a reduction in slip and the dynamic stability of the tractor wheels, and thus the stability of the tractor's work in the field, and the reduction of the expended power, which led to a decrease in fuel consumption, and this agreed with what was mentioned by [15]and [16]. The interaction between the soil moisture content and the weight added on the tractor wheels resulted in significant differences , as the soil moisture content (14-16%) with the addition of weights on the tractor wheels (310) kg was significant in registry the lowest value of fuel consumption, which amounted to (15.219)L.ha^{-1},compared with the soil moisture content (18-20%) and without adding weights on the wheels of the tractor (0) kg, which achieved the highest significant value (33.400) L.ha^{-1}.

Table (2) Effect of added weight, soil moisture content and their interactions on Fuel consumption (L.ha^{-1})

Soil moisture content(%)	Added weight (Kg)	Interaction Added weight and soil moisture content	Average soil moisture content(%)
14-16	0 310	19.172 b 15.219 c	17.195 b
18-20	0 310	33.400 a 20.309 b	26.855 a
Average Added weight (Kg)	0 310	26.286 a 17.764 b	

The different letters within the same column indicates that there is a significant difference between the treatments at the level of significance p>0.05, values were Mean ± standard error.

3- Soil bulk density (g.cm^{-3}) :

Table No. (3) shows that the effect of soil moisture content was not significant on the soil bulk density characteristic statistically, but numerically, the soil moisture content (14-16%) recorded the lowest value for soil bulk density and amounted to (0.813) g.cm^{-3}, compared with soil moisture content (18-20%),which record the highest value (0.821) g.cm^{-3}. The reason for this is that the increase in soil moisture leads to an increase in the water layer envelopes around the soil particles, and when exposed to mechanical treatments, soil particles slide and roll over each other easily, and the convergence process leads to the expulsion of air and a reduction in the size of the pores in the soil body, thus increasing soil bulk density, and these results agreed with [17] and [18] .The addition of weights (310) kg recorded the lowest value for soil bulk density and amounted to (0.806) g.cm^{-3}, compared to not adding weights (0) kg, which recorded the highest value for soil bulk density (0.828) g.cm^{-3}. The reason for this may be that the addition of weights led to an increase in the stability of the work of the tractor and the plow, which led to the ease of cutting and turning the soil section during plowing without tamping, compared to not using weights, where the tractor and the plow are in a less stable state. the interaction between the soil moisture content and the weight added on the tractor wheels led to no significant differences in the soil bulk density, as the soil moisture content was recorded (14-16%) with the addition of weights on the wheels of the tractor (310) kg to obtain the lowest value for the soil bulk density, which amounted to (0.802) g.cm^{-3}, compared with the soil moisture content (18-20%) and without adding weights (0) kg, which achieved the highest value (0.832) g.cm^{3}.

Table (3) Effect of added weight, soil moisture content and their interactions on soil bulk density (g.cm^{-3})

soil moisture content(%)	Added weight (Kg)	Interaction added weight and soil moisture content	Average Soil moisture content(%)
14-16	0 310	0.825 0.802	0.813
18-20	0 310	0.832 0.810	0.821
Average Added weight (Kg)	0 310	0.828 0.806	

The different letters within the same column indicates that there is a significant difference between the treatments at the level of significance p>0.05, values were Mean ± standard error.

4- Irregularity index of tillage depth (%) :

It is noted from Table (4) that the soil moisture content did not have a significant effect on the Irregularity index of tillage depth statistically. The soil moisture content (14-16%) recorded the lowest value for the index of irregularity in tillage depth, which amounted to (2.412%), compared with the soil moisture content (18-20%), which recorded the highest value, which amounted to

(2.843)%. The reason for this may be due to the fact that soil resistance to penetration of plow shares decreases with increasing soil moisture before tillage as the action of deepening in the soil increased under the same tillage conditions, and this agreed with both [19] and [20].So that means the increase in soil moisture leads to an increase in the value of the Irregularity index of tillage depth, and the effect of the added weight on the tractor wheels was significant. The addition of weights (310) kg recorded the lowest significant value for the Irregularity index of tillage depth, amounting to (2.264)%, compared with not adding weights (0) kg, which recorded the highest significant value for the Irregularity index of tillage depth (2.992). The reason for this may be due to the increase in the dynamic stability coefficient of the tire, the increase in the tire contact area with the soil, and the decrease in the immersion value as a result of the increase in weight and its effect on the soil by reducing slip, and thus the stability of the depth (so adding weights led to a decrease in the Irregularity index of tillage depth) and this agreed with both [21] and [22].The interaction between the soil moisture content and the use of weight added on the tractor wheels result in significant differences, as the soil moisture content (14-16%) with the addition of weights on the tractor wheels (310) kg was significantly superior in registry the lowest value for the Irregularity index of tillage depth, which amounted to (2.106).) %, compared with the soil moisture content (18-20%) and not adding weights on the puller wheels (0) kg, which achieved the highest significant value for plowing depth (3.265)%.

Table (4) Effect of added weight, soil moisture content and their interactions on Irregularity index of tillage depth (%)

soil moisture content(%)	Added weight (Kg)	Interaction added weight and soil moisture content	Average soil moisture content(%)
14-16	0	2.718 ab	2.412 a
	310	2.106 b	
18-20	0	3.265 a	2.843 a
	310	2.420 ab	
Average added weight (Kg)	0	2.992 a	
	310	2.264 b	

The different letters within the same column indicates that there is a significant difference between the treatments at the level of significance p>0.05, values were Mean ± standard error.

5- soil disturbed volume ($m^3.h^{-1}$) :

Table No. (5) showed that the soil moisture content (14-16%) was significantly superior to the soil moisture content (18-20%) in recording the highest significant value for the soil disturbed volume at a rate of (490.53) and (460.10) $m^3.h^{-1}$, respectively. The reason for this may be due to the fact that the increase in soil moisture content led to an increase in slippage, which reduced the process speed, and practical productivity, and since the practical productivity is one of the components of the volume of the soil disturbed volume included in its calculation; this also reduces the volume of soil disturbed volume, and these results agreed with [20]. And it is noticed the addition of weights on the wheels of the tractor (310) kg recorded the highest significant value for soil disturbed volume, which amounted to (500.33) $m^3.h^{-1}$, compared with not adding weights (0) kg, which recorded the least significant value for the soil disturbed volume(450.30) $m^3.h^{-1}$, the reason for this may be due to the fact that the presence of weights on the tires increases practical productivity, and since the relationship between productivity and the soil disturbed volume soil is a direct relationship, so with increasing productivity, the soil disturbed volume soil increases, and this agreed with both [23] and [3]. The interaction between the soil moisture content and the added weight on the tractor wheels show significant differences on soil disturbed volume as the soil moisture content (14-16%), with the addition of weights on the tractor wheels (310) kg, was significant in registry the highest volume of the soil disturbed volume , which amounted to (509.93) m³.h^{-1},compared with the soil moisture content (18-20%) and without adding weights on the wheels of the tractor (0) kg, which achieved the lowest soil disturbed volume and reached (429.46) m³.h^{-1}.

Table (5) Effect of added weight, soil moisture content and their interactions on soil disturbed volume (m³.h^{-1})

soil moisture content(%)	Added weight (Kg)	Interaction added weight and soil moisture content	Average soil moisture content(%)
14-16	0	471.14 b	490.53 a
	310	509.93 a	
18-20	0	429.46 d	460.10 b
	310	490.74 c	
Average added weight (Kg)	0	450.30 b	
	310	500.33 a	

The different letters within the same column indicates that there is a significant difference between the treatments at the level of significance p>0.05, values were Mean ± standard error.

Conclusion

Concluded do not use the moldboard plow when the soil moisture content is high and without adding weights to the agricultural tractor tires. Also it's recommended to work when the soil moisture content (14-16)% with adding weights on tractor wheels (310) kg lead to decrease drawbar power, fuel consumption, soil bulk density and Irregularity index tillage depth %, and increase soil disturbed volume. With these results, it is possible to work with agricultural tractors and the moldboard plow with the best field performance.

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مجلة جامعة كركوك للعلوم الزراعية

تاثير اضافة الاوزان على الاطارات الخلفية للساحبة ومحتوى رطوبة التربة على بعض مؤشرات أداء الوحدة الميكانيكية باستخدام المحراث المطرحي القلاب

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الملخص

أجريت الدراسة لمعرفة تأثير إضافة الاوزان على عجلات الجرار الزراعية والمحتوى الرطوبي باستخدام المحراث المطرحي القلاب في بعض الصفات المكننية ومنها (قدرة السحب واستهلاك الوقود ، الكثافة الظاهرية ، دليل عدم الانتظام لعمق الحراثة كنسبة مئوية وحجم مقطع التربة المثار) في الموسم الزراعي (2017–2018) في احد الحقول الزراعية الواقع في شمال شرق مدينة الموصل ونسجة التربة طينية. قسم الحقل وفق تصميم القطاعات العشوائية الكاملة (المنشقة) وبثلاث مكررات، وتبين من نتائج الدراسة أن المحتوى الرطوبي(14–16%) سجل اقل قيمة لكل من قدرة السحب واستهلاك الوقود والكثافة الظاهرية و دليل عدم الانتظام لعمق الحراثة كنسبة مئوية واعلى قيمة لحجم مقطع التربة المثار، كما سجلت إضافة الاوزان على عجلات الجرار (310) اقل قيمة لقدرة السحب و استهلاك الوقود والكثافة الظاهرية ودليل عدم الانتظام لعمق الحراثة كنسبة مئوية واعلى قيمة لحجم مقطع التربة المثار، حقق التدخل بين المحتوى الرطوبي (14–16)% مع إضافة الاوزان على عجلات الساحبة(310) كغم أقلّ قيمة لكلّ من قدرة السحب واستهلاك الوقود والكثافة الظاهرية و دليل عدم الانتظام لعمق الحراثة كنسبة مئوية وأعلى قيمة لحجم التربة المثار.

الكلمات المفتاحية: المحراث المطرحي القلاب، الوزن المضاف، محتوى رطوبة التربة، قدرة السحب، دليل عدم الانتظام لعمق الحراثة