The effect of adding weights and the forward speed of the agricultural tractor on some mechanical properties using the moldboard plow

Thnoon Youns Hussein Alsheekh Ali [1]
thanoontop21@gmail.com

Saad Abduljabbar Alrijabo [2]
saad21955mech@gmail.com

[1] Agricultural Research Department Ninavah, Agricultural Research office, Ministry of Agricultural, Iraq

[2] Department of Agricultural Machinery and Equipment, College of Agriculture and Forestry, University of Mosul , Ninavah , Iraq

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Abstract

The study was conducted during the agricultural season (2017-2018) and the size distribution of soil particles was (10.5% sand, 51.7 clay, 38.25 silt) so soil texture is clay soil to find out the effect of adding weights on the wheels of the agricultural tractor using the moldboard plow by measuring some indicators, including the drawbar power, soil resistance penetration, tillage depth achieved, and the soil disturbed volume and 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 addition of weights on the wheels of the tractor (310) kg recorded the lowest value for drawbar power and highest value for the tillage depth achieved, and the soil disturbed volume, while not adding weights (0) recorded the lowest value for the soil resistance penetration. The forward speed (3.3) km.h^{-1} excelled in recording the lowest value of the drawbar power and highest value of tillage depth achieved, while the third speed (7.7) km.h^{-1} excelled in recording the highest value of the soil disturbed volume and the lowest value of soil resistance penetration. The interaction between adding weights on the wheels of the tractor (310) kg and the forward speed (3.3) km.h^{-1} registry the less value the drawbar power and the highest value for soil resistance penetration and tillage depth achieved, while the addition of weights on the wheels tractor (310) kg and the forward speed (7.7) km.h^{-1} registry the highest value of the soil disturbed volume.

Key words: Moldboard plow, Adding weights, Forward speed, Drawbar power, Tillage depth achieved

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Correspondence Author: Thnoon Youns Hussein Alsheekh Ali - thanoontop21@gmail.com

Introduction

Agricultural tractors are the backbone of any productive agricultural process, and they have received a lot of attention, study, and scientific research in developed countries, not only because they reduce costs of agricultural operations, also they perform these operations with minimal muscular effort [1]. [2] found that when adding weight to the drive wheels of the tractor, the power loss decreased from (18 to 9 kilowatts) when adding (450) Kg to the rear wheels compared to not adding weight (0) Kg to the driving wheels of the tractor .[3] Explained that when increasing the speed using the moldboard plow from (4,248 to 6,932) $km.h^{-1}$, led to an increase in the drawbar power from (12,317 to 27,846)hp. In their study, [4] found the effect of speed, wheel weight, and number of passes on soil compaction, the decrease in speed from (3.6 to 2.7) $km.h^{-1}$ and (2.7 to 1.81) $km.h^{-1}$ led to an increase in soil resistance to penetration by (11.1%) and (13.2%) respectively. [5] found that adding weight, whether in the form of adding water to the inside of the tires of agricultural tractor wheels, or in the form of iron discs installed on the rear wheels; leads to achieving the maximum tillage depth, and also showed a decrease in the value of the maximum tillage depth when choosing higher gear ratios (increasing the speed) significantly, as the speed increased from (4.2 to 6.5 and then to 8) $km.h^{-1}$, tillage depth decreased from (25.53 to 24.25 and then to 23.62) cm, with decrease rates of (5.01%) and (2.59%) respectively.[6] indicated that there is a significant effect of the practical speed on the soil disturbed volume. When the speed increased from (2.72 to 4.34 and 6.23) $km.h^{-1}$, increased the soil disturbed volume from (322.76 to 437.57 and then to 599.07) $m^3.h^{-1}$ respectively.

Materials and Methods

The study was conducted in one of the fields located northeast of Mosul on the road to waterfalls, where the area of the field was exploited (1.5) ha, and the field was planted with potatoes in the season that preceded the season of executing the experiment, noting that the experimental field was irrigated and the soil texture was clay. Moldboard plow Turkish origin was used, and two Massey Ferguson 285s tractors were used when carrying out the experimenting due to the lack of a device for measuring the direct draft force on the suspension arms, whereby a dynamometer was used to calculate the pulling force. The design of the sectors Randomized Complete Block Design was followed, and the method of split plots was used to conduct the experiment, where the main plots were allocated for the weight added to the drive wheels, where the iron discs were used as an additional weight on the tractor wheels in two levels without adding (0) kg and adding a weight of (310) kg, and each main plots was divided in three secondary plots that were allocated to the forward speed at three levels (3.3, 5.6, 7.7) $km.h^{-1}$, and thus the experiment was (2 * 3), meaning that it contained (6) treatment with three replications, so that the number of experimental units became (18) treatment with an area of (90) m^2 for the experimental unit, Each treatment has 30 m of length and 3m of width. 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]

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

Since:

DP = Drawbar Power (hp)

FT = drag force (kg.f)

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

2-Soil Resistance Penetration ($KN.m^{-2}$) :

It was calculated using a Penetrometer, before working on the surface of the soil and

for each treatment, and after working in the center of the impact of the rear tire for all treatments, as the measurement was done by placing the device vertically on the ground, and applying constant pressure on the handle at the top of the device, so that the cone penetrates the soil layer to be measured, its resistance to penetration, then record the reading, take nine readings for each repeater, then calculate its average, then apply the following equation [9].

Conintex = F/A (KN.m^{-2})

Since:

Conintex= Soil Resistance Penetration (KN.m^{-2})

F = force (kN) = reading of the device (kg.f) x constant / 1000

A = Area of the base of the cone (m²) = (Diameter)² x Ratio/4

3-Tillage Depth Achieved (cm) :

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 previously determined tillage depth. The deviation is important in determining the suitability of the plow, and it is calculated by the following equation: [10]

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

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.(%)

4-Soil Disturbed Volume (m^3.h^{-1}) :

Is stirred by the plow during the plowing period, and depends on the practical produ ctivity of the machine and the actual depth of tillage. The volume of soil stirred up can be calculated according to the following equation: [11]

S.D.V=DP*Efc*100 (m³/h)

Since:

S.D.V = soil volume stirred up (m3.h^{-1}).

EFc = actual field productivity (ha/h).

DP = actual plowing depth (cm).

Results and Discussion

1- Drawbar Power(hp) :

Table No. (1) showed that the addition of weights (310 kg) recorded the lowest significant value for the drawbar power, which amounted to (10.724) hp, compared with not adding weights (0) kg, which recorded the highest significant value for the drawbar power (13.121) hp. the reason for this may be that the use of weights has led to a decrease in the percentage of slippage as a result of the increased soil shear stress, which reduces the draft force, and since the draft force is one of the components of the drawbar power, as the relationship between them is direct, the drawbar power decreases, and this is consistent with what mentioned by [2] , [9]. It was also found that the increase in the forward speed had a significant effect on the drawbar power, as it was found that the first forward speed (3.3) km.h-1 was significantly superior to the second and third speeds (5.6 and 7.7) km.h-1 in recording the least significant value of the drawbar power at a rate of (5.776).) hp, compared with the second and third gears, which recorded the highest significant value (12.219 and 17.773) hp respectively. the reason for this is that the increase in speed leads to an increase in the acceleration of the soil compounds, an increase in the kinetic energy given to the soil, an increase in the resistance of the soil to movement, an increase in slip, and an increase in the draft force, and thus an increase in drawbar power, in addition to that the drawbar power depends on both the forward speed and the draft force. Both of them mean an increase in the drawbar power , as the relationship between them is direct, and these results are consistent with what was stated by **[12]** , [13]. The interaction between the weight added on the tractor wheels and the forward speed on the characteristic of the drawbar power showed significant differences, as the addition of weights (310) kg on the tractor wheels with the first forward speed (3.3) km.h^{-1} recorded the less significant

value of the drawbar power , which amounted to (4.916) hp. compared with not adding weights (0) kg and the third forward speed (7.7) km.h^{-1}, which recorded the highest significant value of the drawbar power and amounted to (18.931) hp.

Table (1) Effect of the studied factors and their interactions on the characteristic of drawbar power (hp)

	Add weight (Kg)	Forward speed Km.h^{-1}			Average Add weight
		3.3	5.6	7.7	
Interaction weight add and forward speed	0	E 6.635	C 13.797	A 18.931	A 13.121
	310	F 4.916	D 10.642	B 16.614	B 10.724
Average forward speed		C 5.776	B 12.219	A 17.773	

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-**The Soil Resistance Penetration (KN.m^{-2}):**

The added weight on the tractor wheels recorded clear significant differences on the soil resistance to penetration as shown in Table (2), when adding the weights on the wheels of the tractor (310 kg) recorded the highest significant value for the soil resistance to penetration, which amounted to (905.1)KN.m^{-2}, compared to without adding weights (0) kg, which registry the less significant value of soil resistance penetration (818.2) KN.m^{-2}. The reason for this is that increasing the load on the tires increases soil compaction under the tractor tires, and these results are consistent with the findings of [14] , [15]. It was also found that the increase in the forward speed produced clear significant differences in the characteristic of soil resistance to penetration, as it was found that the first forward speed (3.3) km.h^{-1} had recorded the highest significant value of the soil resistance to penetration amounted to (943.9) KN.m^{-2}, compared with the second and third speeds. (5.6) and (7.7) km.h^{-1}, the second speed gave a lower significant value compared to the first amounted to (844.1) KN.m-2, while the third speed recorded the least significant values of soil resistance penetration was (797) KN.m^{-2}. The reason for that increase in speed leads to a reduction in the period of passage of the tractor over the soil surface, which reduces soil compaction under the tractor tires, and this is consistent with [4] and [16]. The interaction between the weight added on the tractor wheels and the forward speed on thecharacteristic of Soil Resistance To Penetration indicated that there aredifferences, as the non-adding of weights on the wheels of the tractor (0) kg with the third forward speed (7.7) km.h^{-1} the least significant value of Soil Resistance To Penetration (754.4)) KN.m^{-2}, compared with adding weights on the wheels of the puller (310)kg and the first forward speed (3.3) km.h^{-1}, which recorded the highest significant value of soil resistance penetration (977.0) KN.m^{-2}.

Table (2) Effect of factors and their interactions on Soil Resistance To Penetration (KN.m^{-2})

	Add weight (Kg)	Forward speed Km.h^{-1}			Average Add weight
		3.3	5.6	7.7	
Interaction weight add and forward speed	0	AB 910.8	DE 789.4	E 754.4	B 818.2
	310	A 977.0	BC 898.9	CD 839.5	A 905.1
Average forward speed		A 943.9	B 844.1	B797	

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-Tillage Depth Achieved (cm) :

It is noted in Table No. (3) that the addition of weights (310) kg achieved the highest significant value for the tillage depth achieved, which amounted to (16.332) cm, compared with not adding weights (0) kg, which recorded the lowest significant value for the tillage depth achieved (15.593) cm. 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 the slip rate, and thus the stability of the depth this agreed with [17], [5]. the first forward speed (3.3) km.h^{-1} was significantly superior to the second and third speeds (5.6) and (7.7) km.h^{-1} in obtaining the highest significant value for the tillage depth achieved, which amounted to (16.961) cm, while the second and third speeds gave the lowest tillage depth achieved. It reached (15.886 and 15.041) cm. the reason for this is that the increase in the rates of resistance in forward of the plow's shares due to the increase in speed leads in turn to an increase in the force of the soil pushing vertically to the resistance equation, which causes the plow to be raised slightly and this leads tillage depth achieved decreases, and this agrees with what was stated by [18], [13]. the interaction between the weight added on the tractor wheels and the forward speed on the characteristics of the tillage depth achieved showed significant differences. , compared with not adding weights on the wheels of the tractor (0) kg and the third forward speed (7.7) km.h^{-1}, which recorded the least significant value for the tillage depth achieved (14.763) cm.

Table (3) The effect of the studied factors and their interactions on the characteristic of the tillage depth achieved (cm)

	Add weight (Kg)	Forward speed Km.h^{-1}			Average Add weight
		3.3	5.6	7.7	
Interaction weight add and forward speed	0	AB 16.666	C 15.350	C 14.763	B 15.593
	310	A 17.255	B 16.422	C 15.319	A 16.332
Average forward speed		A 16.961	B 15.886	C 15.041	

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-Soil Disturbed Volume (m^3.h^{-1}) :

Table No. (4) notes that the soil disturbed volume section has increased with the increase of the weight added on the wheels of the tractor, as the addition of weights on the wheels of the tractor (310) kg registry the highest significant value for the volume of the soil disturbed volume, which amounted to (500.33) m³/h^{-1}, compared with no addition Weights (0) kg, which registry the less significant value for the volume of the soil disturbed volume up (450.30) m³/h. 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 is a direct relationship, so with increasing productivity, the soil disturbed volume increases, and this agreed with both [19] , [20]. the increase in the forward speed of plowing gave clear significant differences in this characteristic, as the third forward speed (7.7) km.h^{-1} excelled in registry the highest soil disturbed volume section and amounted to (617.65) m3.h^{-1}, and the second speed registry (5.6) km.h^{-1} with a lower significant value compared to the third its registry (492.96) m3.h-1, while the first speed registry (3.3) km.h-1 the less significant value, amounting to 315.34 m3.h^{-1}. The reason for this may be due to the fact that the plowed area increases with the increase in the practical speed of plowing, which leads to an increase in the size of the soil disturbed volume and this agreed with [18) ,[6]. the interaction between the weight added on the tractor wheels and the forward speed had a significant effect on the soil disturbed volume , as the addition of weights on the wheels (310) kg and the third forward speed (7.7) km.h^{-1} registry the highest significant value for the soil disturbed volume ,which amounted to (647.48) m³/h, compared with not adding weights on the wheels (0) kg and the first forward speed

(3.3) km.h^{-1}, which registry the less significant value for the soil disturbed volume amounted (300.67) m³/h.

Table (4) Effect of the studied factors and their interactions on the characteristic of soil disturbed volume (m³/h)

	Add weight (Kg)	Forward speed Km.h^{-1}			Average Add weight
		3.3	5.6	7.7	
Interaction weight add and forward speed	0	F 300.67	D 462.41	B 587.83	B 450.30
	310	E 330.02	C 523.50	A 647.48	A 500.33
Average forward speed		C 315.34	B 492.96	A 617.65	

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

It is possible to work at a speed of up to 7.7 km .h^{-1} when the soil moisture is ideal, with the addition of weights on the tractor wheels, as it leads to an increase in the soil disturbed volume and a lower value of the soil resistance to penetration when the weights are removed. Also, additional weights should be used on the wheels of the tractor of the study because it leads to a decrease in the drawbar power, and an increase in the soil disturbed volume and the tillage depth achieved.

References

[1] Abod, M ; M; (1981), Tractors and their power units, Basra University Press, Republic of Iraq.

[2] Aday, S.H. and T. M. Al-Sahwan (2009). The effect of the tire inflation pressure and the added weight to the traction wheels on some of the tractor field performance parameters of 2wd (MF285S). *Basrah J.Aagric.Sci.22 (2):219-235.*

[3] Al-Sharifi, S ; K; Alwan (2009). The effect of two types of plows with different depths and speeds on the performance of the mechanical unit and some physical soil characteristics, *Babylon University Journal, Pure and Applied Sciences, 1 (17): 182-205.*

[4] Taghavifar , H. and A. Mardani (2014).Effect of velocity wheel load and multipass on soil compaction .*Journal of the Saudi society of agricultural sciences 13: 57-66.*

[5] Al-Adhadh, A; Y; Hanoun (2011). The effect of the type of weight added to the driving wheels of the tractor on the maximum plowing depth and bulk density, *Karbala University Scientific Journal, 9 (7): 310-313.*

[6] Amer, K ; Zimam (2017). The effect of different speeds of two types of plows on some performance indicators of the mechanical unit. *Iraqi Journal of Agricultural Sciences, 48 (4): 1141-1147.*

[7] Al-Banna, A; Ramo (1990). Soil preparation equipment. Directorate of Dar Al-Kutub for Printing and Publishing, University of Mosul, Ministry of Higher Education and Scientific Research.

[8] Mohammed Ali, L; Hussein and A ; S ; M ; Ezzat (1978). Field crop mechanization equipment. Directorate of Dar Al-Kutub for Printing and Publishing, University of Baghdad, Ministry of Higher Education and Scientific Research, Iraq.

[9] Aday, S ; H; (2016). Tractor Performance Mechanics. Part One. Al-Kafeel House for Printing, Publishing and Distribution. Basra University. Iraq.

[10] Bernacki, H.; J. Haman and C.Z. Kanafojski. (1972). Agricultural machines theory and construction. Vol. (1), Spring Field, 111: Nat, Technical Information Service.

[11] Bukhari, S, M. A. Bhutto and J. M. B. Mirani. (1988). Performance of selected tillage implements. Agric. Mech. In Asia, Africa and Latin America 19 (4): 9-14.

[12] Zaidan, G; A; Daham (2012). Evaluation of the field performance of the locally manufactured moldboard plow rails, master's thesis, College of Agriculture and Forestry, University of Mosul.

[13] Al-Mafarji, A; H ; J; Abdullah (2016). The effect of working width and forward speed on productivity indicators and the economic evaluation of different capacities of agricultural tractors under conditions of different soil textures in Kirkuk Governorate, Master Thesis, College of Agriculture and Forestry, University of Mosul.

[14] Carman, K (2002).Compaction characteristics of towed wheels on clay load soil in a soil bin. Journal of Soil and Tillage Research 65(1):37-43.

[15] Way, Thomas R., T. kishimoto, H.A.Torbert ,E.C.Burt and A.C.Bailey(2009) .Tractor tire aspect ratio effects on soil bulk density and cone index. *J .Terramechanics.46(1):27-34.*

[16] Abdullah, A ; A ; and Y; Y ; Hilal (2014). The effect of distances and penetration angles of the two shares of the dual subsoil plow and the speed of the tractor on vibration and some field indicators and the physical and mechanical properties of the soil. *The Jordanian Journal of Agricultural Sciences, 10 (3) 647- 659.*

[17] Abdulrazzaq, F ; J ;(2006). The effect of adding water to the rear wheels of the tractor to increase the efficiency of the performance of the moldboard plow, *Iraqi Science Journal, 37 (5): 93-96.*

[18] Al-Taee, Y ; F ; M ; Mohammed (2013). Comparison of the performance of some types of plows in mechanical characteristics, Master Thesis, College of Agriculture and Forestry, University of Mosul

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تأثير الاوزان الإضافية والسرعة الامامية للساحبة الزراعية في بعض الصفات المكننية باستخدام المحراث المطرحي القلاب

ذنون يونس حسين الشيخ علي [1]
thanoontop21@gmail.com

سعد عبدالجبار الرجبو [2]
saad21955mech@gmail.com

[1] قسم البحوث الزراعية نينوى، دائرة البحوث الزراعية، وزارة الزراعة، العراق.
[2] قسم المكائن والالات الزراعية، كلية الزراعة، جامعة الموصل، نينوى، العراق.

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الملخص

أجريت الدراسة في الموسم الزراعي (2017–2018) في احد الحقول الزراعية وكان التوزيع الحجم لدقائق التربة (10.5% رمل، 51.7 طين ،38.25 غرين) وبذلك تكون نسجة التربة طينية لمعرفة تأثير إضافة الاوزان على عجلات الجرار الزراعية باستخدام المحراث المطرحي القلاب عن طريق قياس بعض الصفات المكننية، ومنها قدرة السحب ومقاومة التربة للاختراق وعمق الحراثة المتحقق وحجم مقطع التربة المثار. قسم الحقل وفق تصميم القطاعات العشوائية الكاملة (المنشقة) وبثلاث مكررات وتبين من نتائج الدراسة أن إضافة الاوزان على عجلات الجرار (310) كغم قد سجل اقل قيمة لقدرة السحب واعلى قيمة وعمق الحراثة المتحقق وحجم مقطع التربة المثار بينما سجل عدم إضافة الاوزان (0) اقل قيمة لمقاومة التربة للاختراق . تفوقت السرعة الامامية(3.3) كم/ساعة في تسجيل اقل قيمة لقدرة السحب واعلى قيمة لعمق الحراثة المتحقق ، في حين تفوقت السرعة الثالثة (7.7) كم/ساعة في تسجيل اعلى قيمة لحجم مقطع التربة المثار واقل قيمة لمقاومة التربة للاختراق . وحقق تداخل إضافة الاوزان على عجلات الجرار (310) كغم والسرعة الامامية (3.3) كم/ساعة اقل قيمة لقدرة السحب واعلى قيمة لكل من عمق الحراثة المتحقق و مقاومة التربة للاختراق. بينما سجل إضافة الاوزان على عجلات الجرار (310) كغم والسرعة الامامية (7.7) كم/ساعة اعلى قيمة لحجم التربة المثار.

الكلمات المفتاحية: المحراث المطرحي، الوزن المضاف، السرعة الامامية، قدرة السحب، عمق الحراثة المتحقق