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Study the Effect of Adding a Rotary cultivator to a Moldboard Plow and Some Soil Physical Properties

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Abstract

Abstract*:* The experiment was conducted in Diyala Governorate, Al-Shamsiya area, in one of the fields belonging to the Baladrooz Agricultural Division (Plot 8, Sa'da and Namla) during the 2024–2025 agricultural season for cultivating yellow maize. A modified moldboard plow was used, and the experiment included three factors: tillage depth at two levels (10 cm and 15 cm), PTO rotational speed at two levels (540 rpm and 1000 rpm), and forward speed at three levels (2.625 km/h, 3.779 km/h, and 5.031 km/h). The parameters studied were fuel consumption, Power Requirements, and Draft Efficiency. The results showed that the lowest fuel consumption (4.32 L/ha) was recorded at a depth of 10 cm, PTO speed of 540 rpm, and a forward speed of 2.625 km/h, while the highest value (14.02 L/ha) was observed at 15 cm depth, 1000 rpm, and 5.031 km/h. Power requirements increased significantly with operating conditions, from 12.47 kW at 10 cm, 540 rpm, and 2.625 km/h, to a maximum of 44.35 kW at 15 cm, 1000 rpm, and 5.031 km/h. Draft efficiency values ranged between 63.30% and 68.55%, with no significant differences among treatments, indicating stability of this parameter under different tillage conditions.

Keywords: Combined implement, moldboard plow, germination percentage, wheel slip

I. Introduction

Agricultural machinery and equipment have long been fundamental to agriculture, playing a crucial role in advancing farming operations and increasing yield per unit area. With the global population rapidly growing and food demand rising, coupled with the expansion of cultivated land, it's essential to abandon traditional methods and embrace modern farming techniques. This shift involves manufacturing sophisticated, high-capacity, and faster machines, such as plows and other diverse implements. These innovations streamline seedbed preparation and offer greater control over factors influencing productivity, ultimately leading to higher output, improved crop quality, reduced costs, shorter seedbed preparation times, and expanded cultivated areas. Agricultural mechanization stands as a key indicator of this transition from conventional to modern farming practices ,Combined implements offer numerous advantages, including reduced working time, lower operating costs, decreased wheel slip, reduced fuel consumption, increased field efficiency, and less time for seedbed preparation **[3]**. Yellow corn (maize) ranks as the third most cultivated crop

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globally by area, following wheat and rice, with an average yield of 5.5 tons per hectare. Corn is a staple crop in many Asian and African countries, primarily serving as a key component in poultry and livestock feed **[16]**. Corn's versatility allows its cultivation across various agricultural environments. While many international organizations emphasize the need for increased production by 2050 due to population growth, Iraq's output falls short of expectations, with the spring season yield at merely 1.2 tons per hectare, according to the Iraqi Ministry of Agriculture, contrasting sharply with the global average of 5.5 tons per hectare **[1]**. The objectives of this study are:

1. To perform several agricultural operations in a single pass.

2. To reduce fuel consumption and save time

3. Minimize soil compaction damage resulting from repeated machinery passes. This study also investigates the effect of the developed plow on the germination percentage of yellow corn.

II. Material and Methods

Fuel Consumption: Fuel consumption was measured by completely filling the fuel tank. After performing the treatment, the consumed fuel was replenished using a graduated injector with a 50 ml capacity, and the refilled amount, representing the actual fuel consumption, was recorded. This was calculated using the following equation **[17]:**

$$Fc = \frac{Q}{D \times W} \text{ .... (1)}$$

Where:

Fc: Fuel consumed per hectare (L/ha).

Q: Quantity of fuel consumed during the treatment (mL).

D: Length of the tilling line in the treatment (m).

Wp: Actual tilling width (m).

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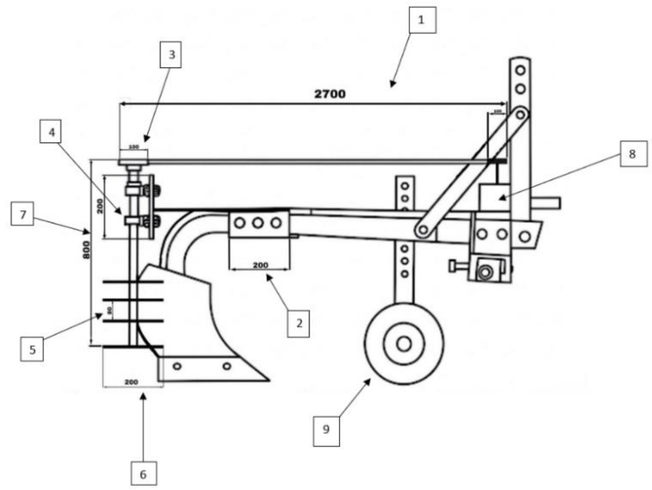

Fig. 1. diagram of the Moldboard Plow (1) Movement drive belt (2) Hitch area to plow frame (3) Bearing diameter (4) Mounting of the tool shaft to the frame (5) Spacing between blades (6) Tool length (7) Tool support shaft) 8) Power transmission unit (9) Depth control wheel

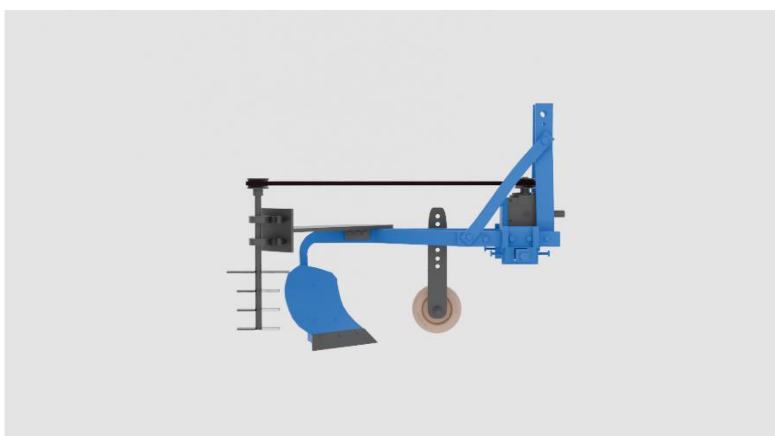

Fig. 2. isometric diagram of the Moldboard Plow.

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Power Requirements: - [18] confirmed that agricultural tractors consume about 20% of the total energy required for the farm. Therefore, improving the performance of agricultural tractors can reduce energy losses. To calculate the power required for any agricultural operation, we must estimate the amount of energy needed to operate machines or agricultural tractors while performing specific tasks. The required power is calculated using the following equation mentioned by[19]: -

$$R.E.P = \left(Fc * \frac{1}{3600}\right) * \rho f * L.C.V * 427 * \eta th * \eta m * \frac{1}{75} * \frac{1}{1.36} . (2)$$

Where: - R.E.P: - power required from the engine from fuel consumption (KW)

FC: - fuel consumption rate (L/h)

ρf: - fuel density (KG/L) the density of diesel fuel is (0.85 kg/L)

L.C.V: - lower calorific value of fuel (Kcal/KG) the average value for diesel is (104Kcal/KG) this is the amount of thermal energy released from the combustion of one kilogram of fuel. This value represents the chemical energy stored in the fuel

427: - the mechanical thermal equivalent is a conversion factor used to convert energy from thermal units (Kcal/KG) to mechanical work units (Kg m/Kcal). Thermal efficiency of the engine (assumed = 40%)m: Mechanical efficiency of the engine (assumed = 80%)

(1.36) (75) Unit conversion factors where (hp = 0.735 kW) and (kW = 1.36 hp)

Draft Efficiency: - To measure the draft efficiency of any agricultural tool or machine, the relationship between draft force and the energy or force applied to achieve the required work is used [17], as shown in the following equation : -

$$DE = \left(\frac{Output\ power}{INput\ Power}\right) \times 100 \dots\dots\dots\dots\dots\dots (3)$$

Where: - DE: Draft Efficiency (%)

III. Results and Discussion

Fuel Consumption(L/ha): The results presented in Table (1) showed a significant increase ($p<0.05$) in fuel consumption as forward speed increased. The average fuel consumption rose from 4.32 L/ha at 2.625 km/h to 7.23 L/ha at 3.779 km/h, and then to 11.49 L/ha at 5.031 km/h, with an LSD value of 0.691. This is because higher speeds lead to increased soil resistance and wheel slippage, demanding more power from the tractor and thus greater fuel consumption, which is consistent with the findings of **[20]** that higher productivity per unit of time requires more energy. The results also revealed a significant effect of PTO shaft speed on fuel consumption, which increased from 6.81 L/ha at 540 rpm to 8.55 L/ha at 1000 rpm (LSD = 0.564), as a faster rotational speed requires more energy to break up the soil. Similarly, increasing the tillage depth from 10 cm to 15 cm led to a significant increase in average

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consumption from 7.30 L/ha to 8.06 L/ha (LSD = 0.564), reflecting the need for more power to overcome the greater soil resistance at deeper depths.

TABLE (1): Effect of Tillage Depth, PTO Rotational Speed, Forward Speed (S), and Their Interactions on Fuel Consumption (liters/hectare)

Depth mean	P mean	forward speed			PTO	Depth
		3: 5.031 km/h	2: 3.779 km/h	1: 2.625 km/h		
7.30	6.81	10.21	6.22	4.03	540 RPM	10 cm
		11.93	7.20	4.23	1000 RPM	
8.06	8.55	9.81	6.43	4.16	540 RPM	15 cm
		14.02	9.09	4.85	1000 RPM	
LSD: D=0.564*	LSD: P =0.564*					
		11.49	7.23	4.32	Speed Mean	
		LSD: S =0.691*			Value LSD	

Power Requirements(kw):-The results presented in Table (2) showed a significant increase ($p<0.05$) in power requirements with an increase in forward speed. The average required power increased from 13.66 kW at 2.625 km/h to 22.98 kW at 3.779 km/h, and then to 36.36 kW at 5.031 km/h. The LSD value for this was 2.186, indicating that higher speeds raise the required draft force due to increased soil resistance and friction.

Depth also had a clear significant effect (LSD = 1.785), as power requirements increased from an average of 23.11 kW at a depth of 10 cm to 25.51 kW at 15 cm. This is because a greater depth increases the soil resistance that must be overcome, requiring more power from the tractor, which is consistent with engineering principles that confirm power increases directly with both speed and soil resistance.

Furthermore, the PTO shaft rotational speed significantly affected power requirements (LSD = 1.785), with the average required power rising from 21.55 kW at 540 rpm to 27.06 kW at 1000 rpm. This is because increasing the rotational speed requires more energy to break up the soil more quickly, thereby increasing the overall power requirements.

TABLE (2): Effect of Tillage Depth, PTO Rotational Speed, Forward Speed (S), and Their Interactions on

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Power Requirements(kw)

Depth mean	P mean	forward speed			PTO	Depth
		3: 5.031 km/h	2: 3.779 km/h	1: 2.625 km/h		
23.11	21.55	32.30	19.69	12.47	540 RPM	10 cm
		37.75	22.77	13.38	1000 RPM	
25.51	27.06	31.05	20.34	13.17	540 RPM	15 cm
		44.35	28.77	15.35	1000 RPM	
LSD: D=1.785*	LSD: P =1.785*					
		36.36	22.98	13.66	Speed Mean	
		LSD: S =2.186*			Value LSD	

Draft Efficiency(%): The results in Table (3) showed that draft efficiency was significantly affected by forward speed ($p<0.05$). The average efficiency increased from 64.80% at a speed of 2.625 km/h to 66.08% at 3.779 km/h, and then to 67.32% at 5.031 km/h. The LSD value for this factor was 2.265. This improvement in draft efficiency with increasing speed is attributed to the fact that higher speeds reduce the time required for operations and minimize time-related losses. There is also a relative improvement in wheel traction at medium to high speeds, which leads to a greater utilization of the applied power during tillage operations.

As for the effect of depth, draft efficiency increased from 65.44% at a depth of 10 cm to 66.70% at 15 cm. However, this difference was not significant (LSD = 1.849, NS), indicating that a change in depth within this range does not significantly affect draft efficiency. This is because the additional resistance caused by the increased depth was met with stable traction performance, especially with constant rotational speed and consistent field conditions. Regarding the effect of the Power Take-Off (PTO) shaft rotational speed, the average efficiency was 66.57% at a speed of 540 rpm compared to 65.57% at 1000 rpm. However, this difference was also not significant (LSD = 1.849, NS).

TABLE (3): Effect of Tillage Depth, PTO Rotational Speed, Forward Speed (S), and Their Interactions on

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https://iasj.rdd.edu.iq/journals/journal/issue/18682 *https://doi.org/10.54174/utjagr.v13i1.323*

Draft Efficiency(%)

Depth mean	P mean	forward speed			PTO	Depth
		3: 5.031 km/h	2: 3.779 km/h	1: 2.625 km/h		
65.44	66.57	67.99	66.89	64.63	540 RPM	10 cm
		64.42	65.41	63.30	1000 RPM	
66.70	65.57	68.32	65.47	66.11	540 RPM	15 cm
		68.55	66.57	65.15	1000 RPM	
LSD: D=1.849NS	LSD: P=1.849NS					
		67.32	66.08	64.80	Speed Mean	
		LSD: S =2.265*			Value LSD	

IV. REFERENCES

[1] AL-Ardhee, A. H. and Mahdi, N. T., (2022). Influence of Irrigation Systems and Covercrop on Water Productivity, and Maize Growth. Iraqi Journal of Agricultural Sciences, 53(6), pp. 1465-1475.

[2] Al-Azzawi, R... A. R. and Zeinalden, L.A.,(2023). Evaluating the Performance of Combined Equipment (RAU) and Field Tested. s.l., IOP Conf. Series: Earth and Environmental Science, pp. 1-9. https://ioppublishing.org/contacts/

[3] Aldaoseri,M.Jand Muhsin, S.J.(2022). Requirements and indicators of the Energy and Capacity for some Secondary Equipment to Prepare the soil and Franmentation index of Soil .IOP Conferences. Series: Earth and Environmental SCINCES. 1060(1). https://doi.org/10.1088/1755-1315/1060/1/012138

[4] Amer, K. Z., Azawi, A., Jebur, H. A., Al-shammary, A. A. G., et al. (2025). The Impact and Analysis of Mechanical Factors of the Mechanized Unit on the Production of "Vigna radiata L." Crop. Natural and Engineering Sciences, 10(1), 418-424. https://doi.org/10.28978/nesciences.1651195

[5] Jebur, H.A., & Alsayyah, Y.A. (2017). Study of the Soil Moisture Content and the Tractor Speed on the Performance Efficiency of the Machinery Unit. IOSR Journal of Agriculture and Veterinary Science, 10, 65-70. https://doi.org/10.5281/ZENODO.160856

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 323-331

https://iasj.rdd.edu.iq/journals/journal/issue/18682 *https://doi.org/10.54174/utjagr.v13i1.323*

[6] Aridhee, J. K. A., Abood, A. M., Kassar, F. H., Łysiak, G., & Dakhil, M. M. (2020). Influence of tractor slip on some physical properties of the soil and fuel consumption at varying tillage depths and speed. Plant Archives, 20(1), 141-145. Microsoft Word - 27.doc

[7] Hachim, I. T., & Jebur, H. A. (2022, July). A study some technical indicators of the local designed machine. In IOP Conference Series: Earth and Environmental Science **.** https://doi.org/10.1088/1755-1315/1060/1/012136

[8] Mankhi. Abbas A . and Hussein A. Jebur. 2022. A study Some Technical Indicators Under Impact Tillage Depth and Disk harrow Angle of the Compound Machine. IOP Conf. Series: Earth and Environmental Science IOP Conf. Series: Earth and Environmental Science 1060 (2022) 012137. https://doi.org/10.1088/1755-1315/1060/1/012137

[9] Kareem, A. M., & Jasim, A. R. A. (2023, December). The Effect of Tillage Depth on some Machinery Unit Performance Indicators, Soil Physical Properties and Germination Percentage using Combine Equipment. In IOP Conference Series: Earth and Environmental Science (Vol. 1262, No. 9, p. 092006). IOP Publishing. http://dx.doi.org/10.1088/1755-1315/1262/9/092006

[10] Almaliki, S. (2018). Simulation of draft force for three types of plow using response surface method under various field conditions. iraqi journal of agricultural sciences, 49(6). https://doi.org/10.36103/ijas.v49i6.151

[11] Ahmed. A.A. Hamid, & A. A. Alsabbagh.(2024). Field comparison of the performance of slatted and general purpose moldboard. iraqi journal of agricultural sciences, 55(3), 1178-1185. https://doi.org/10.36103/q0mpfw11

[12] Al-Rubaie, M. A., & Al-Ubaidi, M. O. G. (2018). Response of maize yield and yield components to tillage system and plant populations. The Iraqi Journal of Agricultural Science, 49(6), 944. https://doi.org/10.36103/ijas.v49i6.126

[13] Shaima S. Dawod, Alaa S. Ati, & Inas A. Abdujabbar. (2024). Management of using saline irrigation water and tillage systems on the soil mechanical and hydraulic . iraqi journal of agricultural sciences, 55(6), 2050-2059. https://doi.org/10.36103/5b2srn23

[14] Godwin, R. J., Misiewicz, P. A., White, D. R., Smith, E., Chamen, T., Galambošová, J., & Stobart, R. (2015). Results from recent traffic systems research and the implications for future work. Acta Technologica Agriculturae, 18(3), 57-63. https://doi.org/10.1051/bioconf/20201700177

[15] Aldaoseri, M. J., & Muhsin, S. J. (2022, July). Requirements and indicators of the Energy and Capacity for some Secondary Equipment to Prepare the soil and Fragmentation index of Soil. In IOP Conference Series: Earth and Environmental Science (Vol. 1060, No. 1, p. 012138). IOP Publishing. https://doi.org/10.1088/1755-1315/1060/1/012138

[16] Al-Janabi, L.K, Habib, N.S, and Farhan, M. K., (2023). Acomrative study between the Presence Orabsence of support for farmers of the Corn 54(2), pp.609-618. https://doi.org/10.36103/ijas.v54i2.1737

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 323-331

https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

[17] Jebur, H.A. (2013). Power weight tractor and Drawbar pull relationship during field operation. Ain Shams University.

[18] Alimardani, R., Abbaspour-Gilandeh, Y., Khalilian, A., Keyhani, A., & Sadati, S. H. (2007). Energy savings with variable-depth tillage" A precision farming practice. *American-Eurasian Journal of Agricultural & Environmental Sciences*, *2*(4), 442-447. 21.xps

[19] EI-Ashry, A., EI-Attar, M. A., & Mansour, N. E. (2003). Effect of some soil levelling and mechanical planting methods on soybean production. *journal of soil sciences and agricultural engineering*, *28*(12), 8397-8405. E,D/28-9//12- /J3E(12003.pdf

[20] Jebur, H. A. (2016). Determination and analysis of gross power losses for the farm tractor using prediction equations during field operations. elixir agriculture, 99(2016), 43208-43215. elixir journal