Tikrit Journal for Agricultural Sciences
ISSN:1813-1646 (Print); 2664-0597 (Online)
Journal Homepage: http://www.tjas.org
E-mail: tjas@tu.edu.iq
DOI: https://doi.org/10.25130/tjas.25.4.3

TJAS
Tikrit Journal for Agricultural Sciences

Investigation of tillage appearance and some performance indicators for two types of plows under different plowing speeds

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KEY WORDS:
tillage, plowing speed, plowing depth, energy consumption, moldboard

Received: 27/03/2025
Revision: 12/06/2025
Proofreading: 25/10/2025
Accepted: 26/06/2025
Available online: 31/12/2025

ABSTRACT

This research examined the effects of plow type and speed on performance indicators during the 2022 harvest. A Massey Ferguson tractor was used to study a moldboard plow and a disc plow at three speeds (3.8 km/h, 5.756 km/h, and 7.584 km/h) in a split-plot design with three replications.

The disc plow achieved a better working width exploitation coefficient (85.824%) than the moldboard plow (79.033%). Speed significantly influenced this coefficient, with 7.584 km/h giving the highest value (88.775%). The combination of the disc plow and 7.584 km/h yielded the maximum coefficient (92.528%). For depth stability, the disc plow was superior (91.433%) to the moldboard plow (85.924%). Speed was also a major factor, with 3.8 km/h producing the highest depth stability coefficient (94.858%).

Lateral deviation was lowest for the moldboard plow at slower speeds (1.688%). Vertical deviation increased with speed, peaking with the disc plow at 7.584 km/h (7.865%). Field productivity was highest for the disc plow (0.493 hectares/hour versus 0.418 hectares/hour). Draft requirement was highest at the top speed (29.434 kW). Energy consumption was lowest for the disc plow (42.506 kWh/ha) and highest for the moldboard plow (49.486 kWh/ha). The study concludes that both plow type and operating speed significantly impact tillage performance and efficiency.

دراسة مظهر عملية الحراثة وبعض مؤشرات الأداء لنوعين من المحاريث تحت سرعات حراثة مختلفة

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الخلاصة
بحثت هذه الدراسة تأثير نوع المحراث وسرعته على مؤشرات الأداء خلال موسم الحصاد لعام 2022. استُخدم جرار ماسي فوركسون لدراسة محراث مطرحي قلاب ومحراث قرصي بثلاث سرعات (3.8 كم/ساعة، 5.756 كم/ساعة، و7.584 كم/ساعة) ضمن تصميم تجريبي القطع المنشقة بثلاثة تكرارات.
حقق المحراث القرصي معامل استغلال عرض العمل أفضل (85.824%) من المحراث المطرحي القلاب (79.033%). أثرت السرعة بشكل ملحوظ على هذا المعامل، حيث سجلت سرعة 7.584 كم/ساعة أعلى قيمة (88.775%). أما الجمع بين المحراث القرصي وسرعة 7.584 كم/ساعة فقد حقق أعلى معامل (92.528%). وفيما يتعلق بثبات العمق، تفوق المحراث القرصي (91.433%) على المحراث المطرحي القلاب (85.924%). كانت السرعة عاملاً رئيسياً أيضاً، حيث حققت سرعة 3.8 كم/ساعة أعلى معامل ثبات للعمق (94.858%).
وكان الانحراف الجانبي أقل ما يمكن للمحراث المطرحي القلاب عند السرعات المنخفضة (1.688%). وازداد الانحراف الرأسي مع السرعة، وبلغ ذروته مع المحراث القرصي عند سرعة 7.584 كم/ساعة (7.865%). وكانت إنتاجية الحقل أعلى ما يمكن للمحراث القرصي (0.493 هكتار/ساعة مقابل 0.418 هكتار/ساعة). وكانت متطلبات السحب أعلى ما يمكن عند السرعة القصوى (29.434 كيلوواط). وكان استهلاك الطاقة أقل ما يمكن للمحراث القرصي (42.506 كيلوواط ساعة/هكتار) وأعلى ما يمكن للمحراث المطرحي القلاب (49.486 كيلوواط ساعة/هكتار). وتخلص الدراسة إلى أن نوع المحراث وسرعة التشغيل يؤثران بشكل كبير على أداء وكفاءة عمليات الحراثة.
الكلمات المفتاحية: حراثة , سرع الحراثة ، أعماق الحراثة ، استهلاك الوقود ، المطرحي.

INTRODUCTION

The process of Tillage is considered to be a significant prerequisite of cultivating an adequate seedbed and it is accomplished by the usage of sophisticated mechanization equipment (Isaak *et al*., 2024). This is done to enhance field technical indicators and to increase the properties of soils so that the growth of the seed is done under the best conditions. The forces around the world have conducted recent research on moldboard plows, which has also done extensively regarding dimensions of the plow type, speed, and type of soil and how they affect the performance of the plows. The results have shown that raising productivity and performance of such plows is possible through widening of operating machine or enhancement of speed of operation depending on different conditions in the farms Abdullah and Hilal (2014). A combination of the appropriate plow and an ideal plowing speed are the significant factors contributing to the increase in soil physical characteristics and the level of productivity of a field Isaak and Ahmed, (2009). In their study by using the rotating disc plow, Kassar *et al*., (2018) found out that when the plowing depth and forward speed increased, the forces on the plow (horizontal and vertical) also increased in proportion. The horizontal force however increased more than the vertical force.

The research has indicated that the plowing depth was more significant than forward plowing speed. The maximum horizontals (14.01 kN) and vertical forces (2.25 kN) occurred at a depth of 25 cm whereas the minimum values of both horizontals (9.53 kN) and vertical forces (1.87 kN) arose at a depth of 15 cm. The researchers explained this phenomenon by the fact that the cross-sectional area of the soil is increasing and its resistance increases with increased depths in soil that require a larger force to shear and overturn the soil. In addition to this, a speed of 6.3km/h produced the largest horizontal and vertical forces and the lowest values of both were obtained at 3.9km/h Abdullah and Ghazwan (2014); Tahir, (2010). The authors of Swain *et al*., (2022) studied the effect of three different speeds (2.65, 4.20 and 6.05 km/h) on two different plows the moldboard plow and disc plow using various important performance parameters of the equipment. Their results showed that the actual productivity associated with actual speed of the moldboard plow was at a speed of 6.05km/h. In his research Al-Jarrah, (2011) that used the reversible moldboard plow, it was noted that plowing depth had strong bearing on the drawbar power. The minimum drawbar power (8.053 kW) was noted at the depth of 15-20 cm as compared to 8.841 kW at the depth of 20-25 cm. He explained this variation by the fact that more force was needed to pull as the plowing depth was greater and thus the drawbar force was increased. The paper also identified that the working speed was also a major factor concerning the drawbar power whereby the power developed with the increase in the velocity. The drawbar powers at the work speeds of 2.22, 3.22 and 5.85 km/h, were found to be 4.344, 6.896 and 14.101 kW, respectively. The researcher explained this demand by the fact that with the higher speeds, there was more energy used meaning that speed is an ingredient in calculating power hence resulting in an increment in the demanded power Abdul-Kreem, (2017); Aday *et al*., (2001). In their research, using the reversible disc plow, Al-Jarrah *et al*., (2023) commented that the forward speed played a significant role in energy consumption. The lowest value of the energy usage involved in the first speed (2.29 km/h) of 118.21 megajoules per hectare, and the maximum energy consumption at 126.19 megajoules per hectare was noticed in the second speed (5.85 km/h). They explained this increment by the fact that the augmented pulling force needed at increased speeds necessitated similar increment in energy expenditure Azawi *et al*., (2024).

Based on the above, the importance of tillage equipment and processes becomes evident in enhancing field conditions, agricultural machinery, and, consequently, agricultural productivity. This study focuses on examining the tillage appearance and several performance indicators of two types of plows under different plowing speeds.

MATERIAL AND METHODS

This experiment was conducted to study the effects of plow type and plow speed on tillage appearance and several performance indicators during the 2022 farming season. The first elements of the two types of plows include:

Moldboard plow

Use a three-botom moldboard plow, Turkey. The individual share has a design width of 35 cm, while the total design width is 105 cm. The plow itself weighs 293 kg.

Disc plow

The disc plow consists of three discs, each with a diameter of 66 cm. The concavity of the disc’s measures 10 cm, while the inclination angle is 25 degrees and the disc angle is 50 degrees. The overall design width of the plow is 120 cm, and it weighs 340 kg. With the second variable, emphasis was made on the tractor forward speed and three tractor plowing speeds were chosen, that is, 3.8km/h, 5.7km/h and 7.5km/h. The tractor that was used was a Massey Ferguson tractor, which had a horsepower of 150, and the tractor was used at the field with these three speed repetitions and followed these three speeds three times. The time taken to cover 50 meters at each speed was measured to calculus the relative speed corresponding to each speed which was theoretically calculated. The study was a split-plot experiment using the Randomized Complete Block Design (RCBD) having three replications. The size of each experimental unit was 24 m², with a length of 20 meters and a width of 1.2 meters.

The measurements and computations were performed in the following method:

1. Coefficient of working width exploitation: The coefficient of working width exploitation was calculated according to the following equation Abdullah and Ghazwan (2012):

B (%) = (B_P / B_C) * 100

B = Coefficient of working width exploitation, %; B_P = Actual working width, cm; B_C = Theoretical working width, cm.

2. The depth stability coefficient of plowing: It is the ratio between the achieved depth and the fixed depth of the plow Abdullah and Hilal (2014).
3. Lateral deviation of plowing: The actual plowing width was measured at each treatment using a measuring tape and four replicates, and an average was taken to determine the actual width, as well as to find the lateral deviation ratio from the following equations Abdullah and Ghazwan (2014):

$$b_{sr} = \sum bp/np$$

b_{sr} = Average width, m.

b_p = Measured width, m.

n_p = Replications

$$\Delta b = \sqrt{\sum \frac{(bp - b_{sr})^2}{np}}$$

Δb = Average deviation of width, m.

$$\delta b = \left(\frac{\Delta b}{b_{sr}}\right) * 100$$

δb = Lateral deviation ratio, %.

4. Vertical deviation of plowing: The actual plowing depth was measured at each treatment using a measuring tape and four replicates, and an average was taken to determine the actual depth, as well as to find the vertical deviation ratio from the following equations Tahir, (2010):

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

a_{sr} = Average depth, m.

a_p = Measured depth, m.

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

Δa = Average deviation of depth, m.

$$\delta a = \left(\frac{\Delta a}{a_{sr}}\right) * 100$$

δa = Vertical deviation ratio, %.

5. Effective field capacity: It is calculated using the following equation Isaak and Ahmed, (2009):

$$EFc = \frac{Va * Bp * Tp * 1000}{10000}$$

EFc = Effective field capacity, ha/h.

Va = actual speed, km/h.

Bp = actual working width, m.

Tp = Time exploitation coefficient, %.

6. Tractive capacity: It is calculated using the following equation Abdullah and Layth (2013):

$$Tc = \frac{F * Va}{3.6}$$

Tc = Tractive capacity, kW.

F = Tractive force, N.

7. Consumed energy: It is calculated using the following equation Tahir and Jarad (2017):

$$Ce = \frac{Tc}{FEc}$$

Ce = Consumed energy, kW.h /ha

RESULTS AND DISCUSSION

Table 1 demonstrates a significant superiority of the disc plow in providing the highest value for the exploitation coefficient of the working width, which reached 85.824% compared to the moldboard plow, which recorded 79.033%. The reason behind this is that the disc plow has a larger designed working width compared to the moldboard plow, which is reflected in a larger actual working width when using the disc plow. Consequently, the disc plow achieved a higher exploitation coefficient of the working width compared to the moldboard plow.

Moreover, it is revealed that there is an important influence of the plowing speed on the coefficient of exploitation of the working width. The maximum exploitation coefficient of working width was achieved due to the high speed of the tractor at 7.584 kph, with 88.775 as the values of the coefficient, which is low in comparison to the other two speeds at 5.756 kph and 3.835 kph whose values were 81.814 and 76.697 respectively. The reason for this is that increasing the speed leads to an increase in the actual plowing width due to increased soil disturbance caused by the momentum obtained from the increased speed Abdullah and Ghazwan (2012).

Additionally, from Table 1, it is evident that the interaction between tillage systems and forward speed has a significant effect on the exploitation coefficient of the working width after plowing. The interaction between the disc plow and the speed of 7.584 km/h provided the highest value for the exploitation coefficient of the working width, 92.528%. This can be attributed to the superior performance of these factors in providing the best values for the exploitation coefficient of the working width. On the other hand, the interaction between the moldboard plow and the speed of 3.835 km/h resulted in the lowest value for the exploitation coefficient of the working width, which was 74.838%.

Table 1. Effect of tillage systems and plowing speed in coefficient of working width exploitation

Implement	Speed working, km/h			
	3.835	5.756	7.584	
Moldboard plough	74.838 c	77.238 bc	85.022 ab	79.033 b
Disc plough	78.555 bc	86.389 ab	92.528 a	85.824 a
	76.697 b	81.814 b	88.775 a	

In Table 2, we find that the depth stability coefficient of plowing was not significantly affected by tillage systems. However, the reversible disc plow showed a non-significant superiority in providing the highest value for the depth stability coefficient, reaching 91.433%. This can be attributed to the rotational and dynamic action of this plow with the soil, which allows it to closely approach the theoretical plowing depth and consequently achieve a higher value for the depth stability coefficient. On the other hand, the moldboard plow recorded the lowest value for the depth stability coefficient, which was 85.924%, as it belongs to the crawling plows in which achieving depth is difficult due to the reaction of plowed soil masses on the plow body, lifting it upward and resulting in lower values for depth stability.

As for the effect of forward speed, it was statistically significant on the depth stability coefficient of plowing. The forward speed of the tractor at 3.835 km/h recorded the highest value for the depth stability coefficient, which was 94.858%, compared to the remaining speeds of 5.756 km/h and 7.584 km/h, which yielded depth stability coefficients of 90.208% and 80.970%, respectively. The reason for the superiority of the slower speed in providing the highest value for the depth stability coefficient is that increasing the speed leads to an increase in the momentum of the plowed soil layers on the plow and an increase in resistance on the machine. Also, the thrusting powers of the soil are escalated at a high speed and leave the plow soaring up. Consequently, the aggregate outcome of such resistances is the decrease of the plow stability and the reduction of the depth stability coefficient meaning the inverse correlation between plowing speed and the depth stability coefficient. This is similar to other past researches Abdullah and Hilal (2014); Abdullah and Layth (2013).

From Table 2, it is evident that the interaction between tillage systems and forward speed has a significant effect on the depth stability coefficient of plowing. The interaction between the reversible disc plow and a speed of 3.835 km/h provided the highest value for the depth stability coefficient, which was 98.330%. This can be attributed to the superior performance of these factors in providing the best values for the depth stability coefficient. On the other hand, the interaction between the moldboard plow and a speed of 7.584 km/h resulted in the lowest value for the depth stability coefficient, which was 80.277%.

Table 2. Effect of tillage systems and plowing speed on the depth stability coefficient of plowing

Implement	Speed working, km/h			
	3.835	5.756	7.584	
Moldboard plough	91.387 ab	86.110 bc	80.277 c	85.924 a
Disc plough	98.330 a	94.305 a	81.663 c	91.433 a
	94.858 a	90.208 a	80.970 b	

From Table (3), it is evident that the plowing system has a non-significant effect on the lateral deviation ratio. The reversible moldboard plow recorded the lowest value of the lateral deviation ratio, which was 2.513%. On the other hand, the reversible disc plow recorded the highest value of the lateral deviation ratio, which was 3.153%. This can be attributed to the fact that the reversible moldboard plow had a narrower actual plowing width and it is a crawler plow, resulting in a lower lateral deviation ratio. On the contrary, the lateral deviation ratios were higher when using the reversible disc plow due to its rotational nature and larger working width compared to the reversible moldboard plow.

The plowing speed had a significant impact on the lateral deviation ratio. As the speed increased, the lateral deviation ratio increased. The speeds (3.835, 5.756, 7.584) km/h recorded lateral deviation ratio values of (2.093, 2.945, 3.461) %, respectively. This is because an increase in speed increases the longitudinal resistance forces on the soil during plowing, resulting in a higher lateral deviation ratio. In other words, lower speeds resulted in a lower lateral deviation ratio, which aligns with the findings of the study Abdullah and Ghazwan (2014).

The interaction between the plowing system and field speed also had a significant effect on the lateral deviation ratio. The lowest value of the lateral deviation ratio, 1.688%, was observed when the reversible moldboard plow was combined with a speed of 3.835 km/h. On the other hand, the highest value of the lateral deviation ratio, 3.905%, was recorded when the reversible disc plow was combined with the highest field speed of 7.584 km/h. As mentioned earlier, this can be attributed to the fact that the reversible moldboard plow and lower ground speed resulted in the lowest values of the lateral deviation ratio, indicating a positive interaction and the recording of the lowest lateral deviation ratio values.

Table 3. Effect of tillage systems and plowing speed in lateral deviation of plowing

Implement	Speed working, km/h			
	3.835	5.756	7.584	
Moldboard plough	1.688 b	2.835 ab	3.016 ab	2.513 a
Disc plough	2.499 ab	3.054 ab	3.905 a	3.153 a
	2.093 b	2.945 ab	3.461 a	

Based on the data presented in Table (4), we observe the non-significant effect of the plowing system factor on the quality of the vertical deviation ratio. The moldboard plow yielded the lowest value for the vertical deviation ratio, measuring 4.462%. This can be attributed to the shallow actual plowing depth achieved by the moldboard plow, resulting in less vertical deviation due to the limited amount of tilled soil mass. Conversely, the disc plow had the highest recording of vertical deviation ratio of 6.087 because it plowed into a deeper depth and therefore, had greater vertical deviation since the tilled soil masses had high resistance.

Table (4) shows that the effect of speed on the vertical deviation ratio is significant. There was a direct correlation between the speed and the ratio of vertical deviation. The ratio of vertical deviation rose to 6.589 percent as the velocity rose to 7.584 km/h as compared to 4.011 percent at a speed of 3.835 km/h. The reason being that the higher speed is accompanied with high intensity of resistance forces of soil plowing and high friction forces resulting in higher plow rising and high proportion of vertical deviation. The outcomes are consistent with the results of the two Abdullah and Ghazwan (2014).

The relationship between the type of plowing system and the speed exhibited was very influential to the vertical ratio of deviation as was evident on Table (4). The lowest value of the vertical deviation ratio was obtained to be 3.733% when the speed of the moldboard plow realized its lowest at 3.835 km/h. The latter can be credited to the fact that both factors affect an individual less. The greatest value of the vertical deviation ratio on the other hand was observed in the case of interaction between disc plow and speed of 7.584 km/h with a value of 7.865.

Table 4. Effect of tillage systems and speed in vertical deviation of plowing

Implement	Speed working, km/h			
	3.835	5.756	7.584	
Moldboard plough	3.733 b	4.340 b	5.312 ab	4.462 a
Disc plough	4.288 b	6.108 ab	7.865 a	6.087 a
	4.011 b	5.244 ab	6.589 a	

Using Table (5), it can be seen that, by interaction of the tillage systems and the ground speed, the systems had a great influence on the field productivity. The reversible disc plow with a forward facing moldboard was more productive in the fields and there was a notable variance between the productivity of the disc plow, which was 0.493 and 0.418 hectares/hour respectively. The increased productivity of the disc plow with reversible moldboard can be explained by the fact that the working width and size were more extended, which led to increased field productivity. The reason is that the working width is directly correlated with the field productivity as it was argued in the previous studies Isaak and Ahmed, (2009).

Ground speed was also discovered to have a significant influence in productivity within the field as a relationship existed between ground speed and field productivity; it is inversely related. Maximum field productivity was 7.584km/hour, equivalent to 0.618hectares/hour, but where the ground speed was high, 7.584km/hour, the productivity was greatest, being 0.618 hectares/hour. Field productivity was greatest when the ground speed was 7.584km/hour, equivalent to 0.618 hectares/hour, and the field productivity was less when the ground speed was 5.756km/hour and 3.83. These findings are in line with the past research results Isaak and Ahmed, (2009); Abdullah and Ghazwan (2012); Abdullah and Layth (2013); Tahir and Jarad (2017).

Furthermore, the interaction between tillage systems and ground speed was found to have a significant effect, with the highest field productivity of 0.660 hectares/hour observed with the disc plow and a ground speed of 7.584 km/hour. On the other hand, the dump plow with a ground speed of 3.835 km/hour recorded the lowest field productivity of 0.270 hectares/hour.

Table 5. Effect of tillage systems and speed in effective field capacity

Implement	Speed working, km/h			
	3.835	5.756	7.584	
Moldboard plough	0.270 e	0.409 cd	0.575 ab	0.418 b
Disc plough	0.322 de	0.497 bc	0.660 a	0.493 a
	0.296 c	0.453 b	0.618 a	

The effect of tillage systems was found to be statistically insignificant on the attribute of pulling capacity, as shown in Table (6). However, the dump plow recorded the lowest pulling capacity of 20.846 kilowatts compared to the disc plow, which had a pulling capacity of 21.293 kilowatts. This can be attributed to the narrower working width of the dump plow compared to the disc plow, resulting in lower pulling force for the dump plow and consequently lower pulling capacity. This finding is consistent with the results of studies Abdul-Kreem, (2017); Aday *et al*., (2001).

Table (6) indicates an inverse relationship between ground speed and pulling capacity. The effect of ground speed on pulling capacity was found to be statistically significant. At a lower ground speed of 3.835 km/hour, the pulling capacity was the lowest at 12.650 kilowatts, significantly lower than the other speeds. With the ground speed of 5.756km/hours being raised to 7.584km/hours, the pulling capacity rose as well, by changing 21.125 kilowatts to 29.434 kilowatts. This could be explained by the fact that the speed of the ground is one of the factors and components in determining pulling capacity. Also, the higher speed the higher the kinetic energy of the soil and the acceleration forces of mechanical soil implements that produces higher pulling capacity. These findings are consistent with the results of the research Al-Jarrah, (2011); Abdul-Kreem, (2017); Abdullah and Layth (2013).

Finally, from Table (6), it is evident that the interaction between tillage systems and ground speed also had a statistically significant effect on pulling capacity. The lowest values of pulling capacity were recorded at the first speed of 3.835 km/hour, with no significant difference between using the disc plow and the dump plow, yielding pulling capacities of 12.500 kilowatts and 12.800 kilowatts, respectively. This result is consistent with the individual effects of tillage systems and ground speed. The highest values of pulling capacity were observed at the higher ground speed of 7.584 km/hour for both the disc plow and the dump plow, with pulling capacities of 29.442 kilowatts and 29.425 kilowatts, respectively.

Table 6. Effect of tillage systems and speed in tractive capacity

Implement	Speed working, km/h			
	3.835	5.756	7.584	
Moldboard plough	12.800 c	20.312 b	29.425 a	20.846
Disc plough	12.500 c	21.937 b	29.442 a	21.293
	12.650 c	21.125 b	29.434 a	

The effect of tillage systems, ground speed, and their interactions on the attribute of energy consumption was found to be statistically significant, as shown in Table (7). The lowest energy consumption was recorded when using the disc plow, which registered 42.506 kilowatt-hours per hectare. This is due to the higher field productivity of the disc plow, which is inversely proportional to energy consumption. On the other hand, the dump plow recorded the highest energy consumption at 49.486 kilowatt-hours per hectare, attributed to its lower field productivity due to its narrower working width compared to the disc plow.

Table (7) also reveals that the variations in the ground speed had a significant influence on energy consumption, and it had an inverse characteristic with the consumption. The lowest figure in energy consumption was 43.131 kilowatt-hours per hectare, at the first speed of 3.835 km/hours and the highest value of energy consumption was noted at the highest ground speed per hour, that is 7.584 km/hours, with the value of 47.881 kilowatt-hours per hectare. This was not much different compared to the second speed of 5.756 km/hour that took a value of 46.977 kilowatt-hours per hectare as the value of energy consumption. In such a way the faster was the ground speed the higher was the energy consumed per unit area. This can be attributed to the fact that an increase in speed leads to an increase in both pulling capacity and field productivity, which are elements in calculating energy consumption. These results align with the findings of studies Al-Jarrah, (2011);Tahir and Jarad (2017).

The interaction between tillage systems and ground speed also had a statistically significant effect on energy consumption. The lowest energy consumption of 38.799 kilowatt-hours per hectare was observed when the disc plow and the first ground speed (3.835 km/hour) interacted. This is because the disc plow and the first ground speed individually recorded the lowest values of energy consumption. On the other hand, the dump plow, when operated at the highest ground speed of 7.584 km/hour, recorded the highest energy consumption per unit area at 51.191 kilowatt-hours per hectare. This is due to the fact that, this untamination of these factors singly led to the peak energy consumption, and that this dissimilarity was statistically significant.

Table 7. Effect of tillage systems and speed in consumed energy

Implement	Speed working, km/h			
	3.835	5.756	7.584	
Moldboard plough	47.463 bc	49.804 ab	51.191 a	49.486 a
Disc plough	38.799 d	44.149 c	44.571 c	42.506 b
	43.131 b	46.977 a	47.881a	

CONCLUSION

Finally, this research confirms that plow type and plowing speed are important factors to affect the performance indicators of tillage, and the disc plow usually performs better than the moldboard plow in indicators of performance. Disc plow was also better in exploitation and stability of depth, field productivity and energy consumption. Speed was also an important factor with 7.584 km/h giving the best results in exploitation efficiency and pulling capacity though at the cost of increased vertical deviation and power. The interplay between the type and speed of the plow further reinforced the role of optimizing the two factors in order to get the best agricultural output. The results have beneficial implications regarding the efficiency of the tillage process, and it can inform farmers in the choice of the type of plow and operating speed that will allow to achieve more efficient and sustainable farming processes.

REFERENCES

Abdul-Kreem , Thaer T. (2017) Studying of some Mechanical Indictors for Different Mechanized Units of Tillage Systems under Gypsfreous Soil Conditions . *Tikrit University Journal of Agricultural Sciences*, Vol. 17 , No. 2 , 202-213.

Abdullah , Adel A. and Ghazwan A. Dham (2012) Study effect of moldboard plow shares shape design locally made on some performance parameter and soil physical properties . *Kirkuk University Journal of Agricultural Sciences*, Vol. 3 , No. 2 , 36-51.

Abdullah Adel A. and Layth M. Yahya (2013)Comparison study of shaped blades (T) designed and locally manufactured with conventional blades in performance of rotary plow . *Kirkuk University Journal of Agricultural Sciences*, Vol. 4 , No. 2 , 81-95.

Abdullah, A., & Hilal, Y. Y. (2014). Effect of the Distances And penetration Angles of Subsoiler Plow Tines Bilateral and the Tractor speed on Vibration , Some Field Indicators , Some Physical and Mechanical Properties. *The Jordanian Journal of Agricultural Sciences*, 10(3), 647–659.

Abdullah, A.A and Ghazwan A. Dahham (2014) studing locally made moldboard plow shares performance and it's effect on some power requirements and plowing criteria. *Mesopotamia Journal of Agriculture*, Vol. 42, No. 1 ,187 -201.

Aday , S . H. Hamid K. A. and Salman R. F. (2001). Energy requirement and energy utilization efficiency of two plow types for pulverization of heavy soil. *Iraqi J. Agri* . 6 (1) : 137-146.

Al-Jarrah, M. A. (2011). The effect of tire inflation pressure, plow depth, and forward speed on some field performance indicators of the tractor. *Journal of Dhi Qar Agriculture*, 39 (3),188-196.

Al-Jarrah, M. A. A. M. N., Aljuboori, H. A. H., & Al-Jawadi, R. A. M. (2023). Effect of Soil Moisture and Distance of Scraper in Field Performance of Disk Plow. *CURRENT APPLIED SCIENCE AND TECHNOLOGY*, 10-55003.

Azawi, A. , Turky, T. and Isaak, M. (2024). Sustainable Energy Use for Mechanized Wheat Production Systems in Iraq. *Tikrit Journal for Agricultural Sciences*, 24(2), 115-130. doi: 10.25130/tjas.24.2.10

Isaak, M., & Ahmed, M. A. (2009). Effect of two plow types and different plowing speed on some soil physical properties and some field technical indications. *Tikrit University Journal of Agricultural Sciences*, 9(1), 357–366.

Isaak, M., Azawi, A., & Turky, T. (2024). Influence of various tillage systems and tillage speed on some soil physical properties. *Progress in Agricultural Engineering Sciences*.47-37 ;(1) 20 .

Kassar, F. H., Szymanek, M., & Tanaś, W. (2018). Evaluation of the horizontal and vertical force of reversible moldboard plow in silty loam soil. *Mechanization in agriculture & Conserving of the resources*, 64(3), 76-77.

Swain, K. H., Amer, K. Z., & Muter, S. A. (2022). The effect of three different speeds of two types of plows on the performance indicaors of the mechanical unit. *International Journal of Agricultural & Statistical Sciences*, 18(1).

Tahir , H. Th. And A. H. Jarad (2017) study the effect of front speed and working width on some performance indicators, power requirement and economic costs for different sizes of agricultural tractors. *The Iraqi Journal of Agricultural Sciences,* Vol. 48, No. 6 , 1782 -1795.

Tahir, Hussein Th. (2010) Studying disc plow performance efficiency and its effect on tillage quality and wheat yield . *Kirkuk University Journal of Agricultural Sciences,* Vol. 1 , No. 1 , 90-101.