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RESEARCH ARTICLE

Impact Statement of Metal Type Plow Weapons on the Variation in Rear Push Angle Value under Different Soil Textures Conditions

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ABSTRACT

This study was conducted during the agricultural season of 2023-2024 in one of the agricultural fields in Kirkuk Governorate - Hawija District - Zab Suburb in the southeast of Nineveh Governorate, to study the performance of locally manufactured plow weapons, including a study of the type of metal of the plow weapons at two levels (traditional - manufactured) and two levels of soil texture type (mixed - clayey) cm/h and the impact of that on some studied characteristics including stress, weapon wear, change in rear push angle value, and change in plowing depth. The experiment was conducted according to a completely randomized design (RCBD) with a split-split plot system and three replications. The results showed that traditional plow weapons recorded the highest values for both maximum stress, principal stress, and deviation. Also, the clayey soil type significantly outperformed in giving higher values for both weapon wear and change in rear push angle value and the occurring change in plowing depth. As for the type of plow weapons, the manufactured plow weapons significantly excelled in recording higher values for the change in rear push angle value, while the traditional plow weapons excelled significantly in recording higher values for both weapon wear and the occurring change in plowing depth.

INTRODUCTION

The subsoiler plow is considered one of the plows that help achieve the desired purpose of plowing and improve the physical and biological properties of the plowed soil. Therefore, these plows are very popular among farmers and have started to be widely used across Iraq because they are considered less resistant to stress and have a low burden on energy sources. This has allowed for vertical and horizontal expansion in development by achieving greater plowing depths compared to reversible plows using the same energy source, in addition to increasing their working width and speed significantly (Al-Banna, 1990). However, despite this, most plows used in the agricultural sector were foreign-made and met some of the needs of local farmers and some needs of government research stations and institutions. Most of these plows yielded results contrary to what is required and expected during operation. Therefore, it was necessary to manufacture plows locally, which helped reduce the flow of agricultural machinery, especially plows, including locally produced subsoiler plows according to local needs (Rajab, 2005).

There is a variety of machinery and equipment used for land preparation for agriculture, with different designs and manufacturing companies, reflecting the diversity of usage conditions for these machines and equipment and the diversity of crops grown and their requirements (Upadhyaya, 2009). In a study on the impact of three types of soil texture (sandy, light clayey, and heavy clayey) on subsoiler plow weapons, the results indicated a significant effect of sandy soil texture in recording the highest wear percentage (Napiórkowski, 2010).

It is suggested that subsoiler plow weapons be made from different types of metal depending on the terrains they encounter, for example, cast iron for sandy and yellow lands, and high-carbon steel for clayey lands and other types of metals. The chisel plow is a type of weapon with pointed tips, where the shape and type of the weapon depend on the type of work it is tasked with. If one tip breaks, the other tip can still be used. This type of weapon is suitable for working on weed-free land and with increased plowing depth. The duck foot plow is used to remove plant root residues from the soil (Jassim, 2018).

Calculating theoretical stresses using the finite element method has led to the necessity of improving and designing plow weapons to reduce the pressure they are subjected to, thus achieving better performance as the lower the stresses on the weapon, the better its performance (Mandal et al., 2015). The operational life of plowing equipment primarily depends on the resistance of materials to corrosion and their strength. The process of plowing mixed soil using the subsoiler plow indicated that the wear rate depends on the plowing speed and the components of the soil texture and their impact on the plow's properties, as confirmed by Ziemelis, Verdins (2017).

In a theoretical study using finite elements to measure theoretical stresses, it was found that the soil reaction affects the structure of the machine used in the study (Vajda et al., 2019). Modern studies have shown a close relationship between the design and improvement of agricultural machinery and their performance by improving soil handling tools using the discrete element method (D.E.M) (Aikins, 2023). In a study conducted to ensure the stability of plowing depth for the subsoiler plow in soil using wheels attached to the plow, this led to an increase in plowing depth and a decrease in the average deviation of the depth due to the stability provided by the plow wheels during work (Tukhtakuziev and Rasuljonov, 2020).

The study of the interaction between subsoiler plow weapons and soil texture, where the corrosion resistance of the plow weapons depends on the type of soil texture, leading to a reduction in corrosion in the plow weapons, as concluded by Dzhabborov et al. (2021). The wear rate of plowing equipment increases with the increase in sand particle size in the soil, and the working part of the plow is affected by the quality of the soil texture. Therefore, the coated part of the working surface of the plow can reduce soil friction with the plow, thus reducing wear resulting from the working surface of the plow with the soil, as affirmed by Malvajerdi (2023). Based on this, the objective of the study is to demonstrate the extent of the impact of the type of metal of subsoiler plow weapons on the variation in the rear push angle value when working under different conditions.

MATERIALS AND METHODS:

This study was conducted during the agricultural season of 2023-2024 in one of the agricultural fields in Kirkuk Governorate - Hawija District - Zab Suburb in the southeast of

Nineveh Governorate. The actual area of the field utilized was 10 dunums, and the land topography was flat with clay soil. I used a four-wheel drive Massey Forex ITM 285 G tractor with a horsepower of 75. Additionally, a three-row subsoiler plow with 11 tines and a working width of 216 cm was used. The plow weapons were manufactured by the researcher in the Industrial District - Kirkuk. At this stage, appropriate dimensions for the tines were determined, and their basic dimensions were adjusted to fit the dimensions of traditional tines previously used in the subsoiler plow, thereby determining the required shape and type for manufacturing. The necessary tine shapes were practically determined to ensure their success, with Figure 1 showing the design map of the locally manufactured tine. A metal test was conducted in the Mechanical Engineering Department laboratories at the College of Engineering, University of Mosul. Table 1 shows the chemical composition, while Table 2 shows the mechanical properties of the metal used to manufacture the subsoiler plow weapons. Maximum stress values, principal stress, and deflection were determined using the Inventor software, which is based on the finite element method under conditions similar to field conditions.

The experimental field was divided according to a Randomized Complete Block Design (RCBD) system and a Split-Plot Design method was employed for the experiment (Dawod and Elias, 1990). For the experiment to be factorial with two factors: soil texture type with two levels (silty, clayey), and the type of metal for the subsoiler plow weapons with two levels (traditional plow weapons , manufactured plow weapons), each treatment length in the replicates was 30 meters. Statistical analysis of the data was performed, and variance analysis was conducted using the Duncan's Multiple Range Test.

After implementing the experiment according to the designated design, the experimental field was irrigated using surface irrigation, and the moisture content changes were monitored using a soil moisture measuring device. The following characteristics were studied: stresses, tine wear, changes in the rear tilt angle, and changes in plowing depth.

1. Stresses: Stresses were calculated for both traditional and manufactured subsoiler plow weapons after applying forces to each of the mentioned parts under conditions similar to or close to the real field conditions using the Inventor program. This program specializes in mechanical designs and stress analysis by computer using the Finite Element Method (FEM). Maximum stress, principal stress, and deflection occurring due to forces on those parts during operation were determined.

2. Tine Wear: Wear index was determined after implementation for each replicate and for each type of tine, representing the difference in tine wear degree between them (Al-Khazarji and Al-Sharif, 1988).

3. Changes in Rear Tilt Angle: The changes in the rear tilt angle after plowing were measured for each factor and each replicate using a protractor to show the extent of change occurring in the rear tilt angle of the tine based on the degree and rate of wear (Al-Banna, 1990).

4. Changes in Plowing Depth: The achieved depth was calculated using a protractor, knowing that the theoretical depth regulated by the plow was 20 cm. It was calculated by subtracting the predetermined theoretical depth from the actual depth obtained in the field and the plowing steps for both types of tines. The resulting deviation in depth can be found by dividing the actual depth obtained by the predetermined theoretical depth (Rajab, 2005).

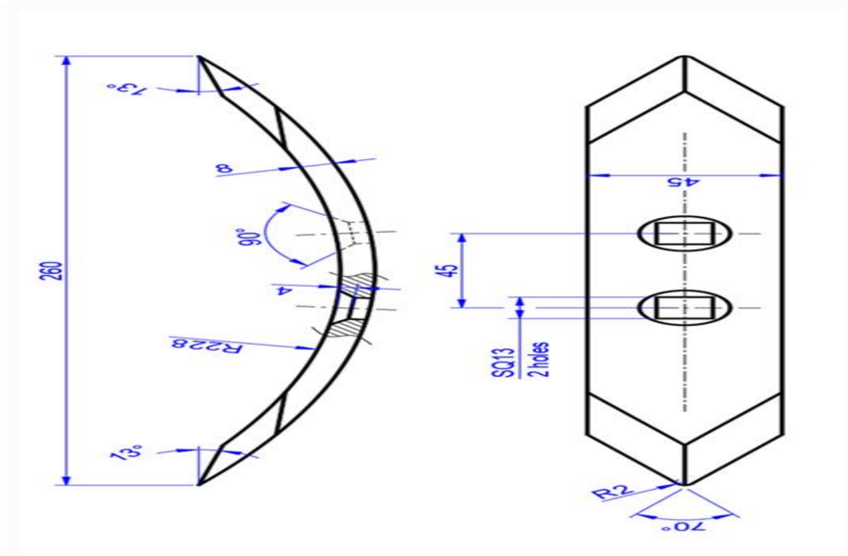

Figure (1): Design map of the locally manufactured weapon (mm).

Table (1): The chemical composition of the Elements

Elements / Metal type	C	Mn	S	P	Cr	Cu	Fe
Manufactured	0.35	0.92	0.05	0.04	0.002	0.003	Rem
Traditional	0.26	0.65	0.04	0.03	0.003	0.003	Rem

Table (2): The mechanical properties of the metal

Parameters / Metal type	Hardness (HRB)	Elongation Ratio (%)	Tensile Strength (N/mm^2)(MPa)	Yield Stress (N/mm^2)(MPa)
Manufactured	88	20	350	950
Traditional	72	25	280	440

RESULTS AND DISCUSSION

1- Stresses: The main stress, maximum stress, and deflection of traditional and locally manufactured plow weapons were determined using the (Inventor) program based on the Finite Element Method (FEM). The aim was to determine the ability of plowshare arms to withstand the stresses applied to them and how they can be distributed over the working surfaces under conditions similar to field conditions. Table (3), supported by Figures (2) and (5), shows the maximum stress for traditional and locally manufactured plow weapons .

Traditional plow weapons recorded higher maximum stress values of 0.4441 MPa, while locally manufactured plow weapons recorded lower maximum stress values of 0.4386 MPa. Figures (3) and (6) show the principal stress, where traditional plow weapons recorded the highest principal stress value of 0.3424 MPa, while locally manufactured plow weapons recorded the lowest principal stress value of 0.3402 MPa.

Figures (4) and (7) show the deflection that occurs for traditional and locally manufactured plow weapons during operation. Traditional plow weapons recorded the highest deflection value of 0.001269 mm, while locally manufactured plow weapons recorded the lowest deflection value of 0.001237 mm. This is because as the forward plowing speed increases, soil resistance increases, leading to an increase in the applied momentum exerted by the working parts during soil tillage. This contributed to a greater increase in stress in traditional plow weapons compared to locally manufactured plow weapons . This is because the working parts of traditional plow weapons were at different levels, which in turn reduced the ability of these parts to withstand this increase, including stress, which resulted in higher values for it. In addition, the mechanical properties of the metal of the manufactured plow weapons were better, as shown in the table of their properties, and this also helped to reduce stress values compared to traditional plow weapons .

Table (3): Results of stress analysis using the (Inventor) program for traditional and locally manufactured plow weapons.

Stresses / Metal type	Maximum Stress (Mpa)	Main Stress (Mpa)	Deflection (mm)
Manufactured	0.4441	0.3424	0.001269
Traditional	0.4386	0.3402	0.001237

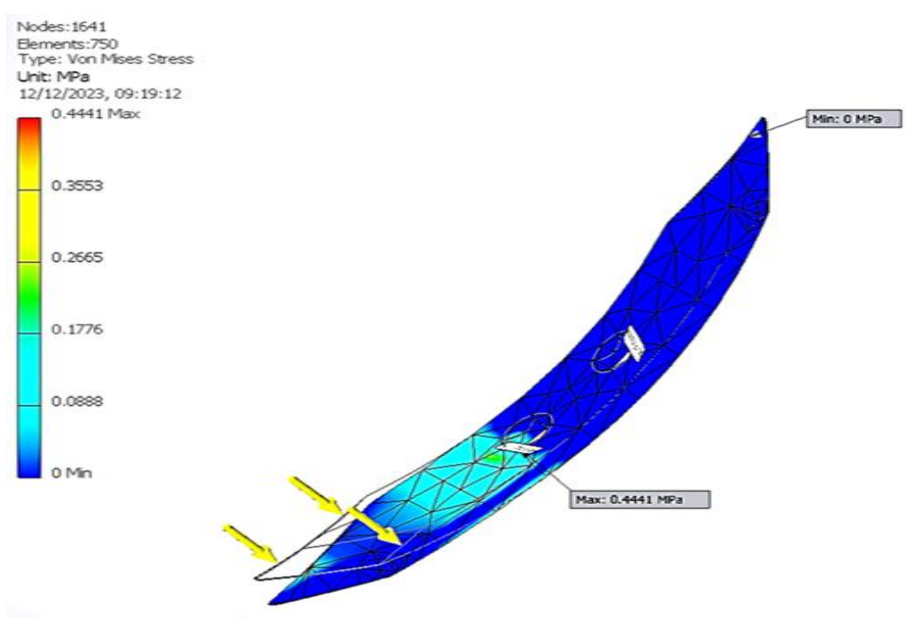

Figure (2): The distribution of maximum stress for traditional plowshare arms.

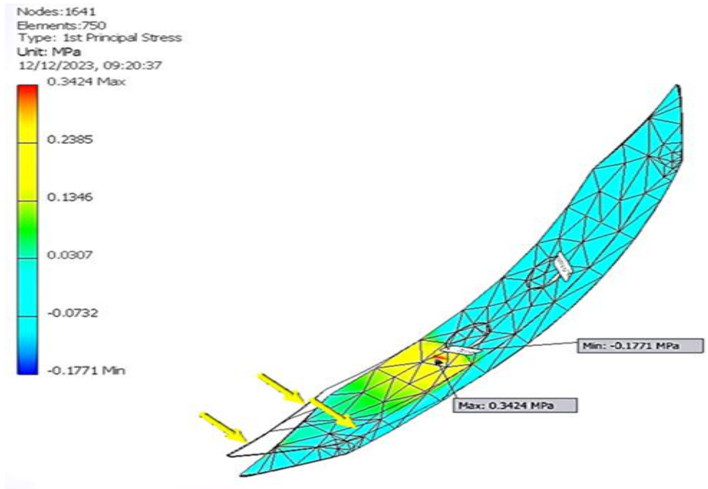

Figure (3): The distribution of principal stress for traditional plowshare arms.

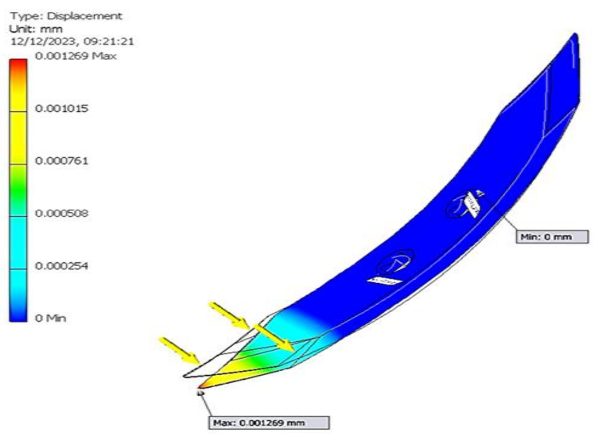

Figure (4): The deflection of traditional plowshare arms.

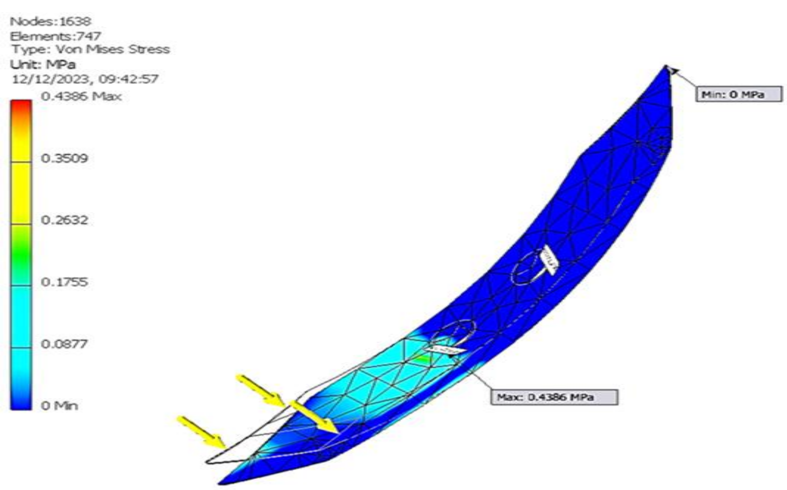

Figure (5): The distribution of maximum stress for locally manufactured plowshare arms.

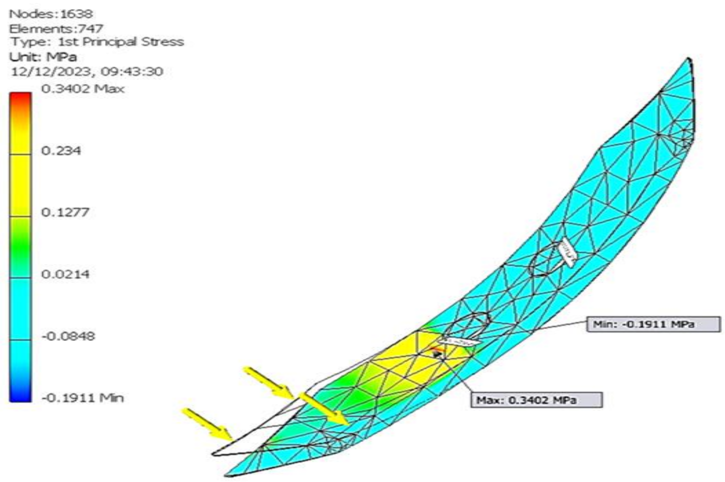

Figure (6): The distribution of principal stress for locally manufactured plowshare arms.

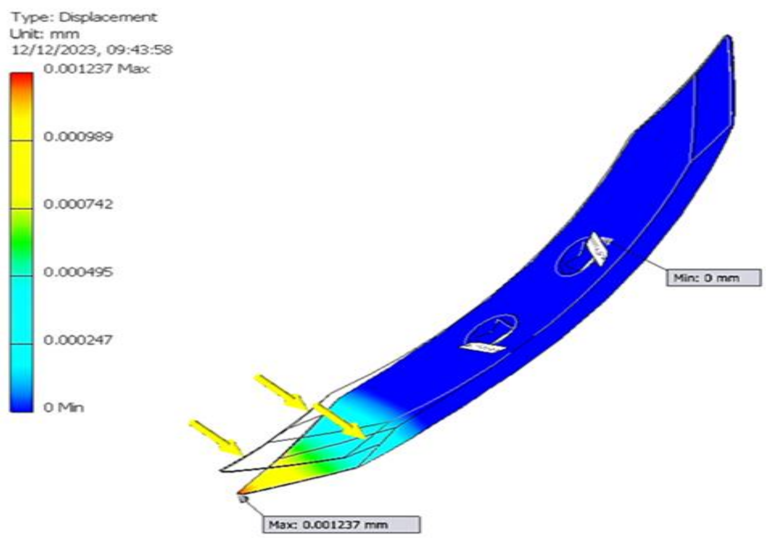

Figure (7): The deflection of locally manufactured plowshare arms.

2- Wear of the plow weapons (g): Table (4) shows clear significant differences in the effect of the studied factors on the wear characteristic of the plow weapons , as the clay soil achieved the highest value for the wear characteristic of the plow weapons 559.24 g, while the mixed soil recorded the lowest value for the wear characteristic of the plow weapons 550.25 g. The reason for this is that the soil texture has a direct effect on wear, as the more clayey the soil, the more difficult it is for the plowshare to penetrate it, which in turn requires high forces and effort from the plow and therefore high friction, which is reflected in increased wear.

The table also shows that the type of metal for the used digger plow weapons had significant differences, as the manufactured plowshare achieved the lowest wear value 537.52 g, while the traditional plowshare recorded the highest wear value 571.97 g. This is attributed to the fact that the higher the hardness of the metal of the plowshare, the lower the wear rate of the plowshare. This is consistent with what Bayhan (2006) stated, that the hardness of the plowshare has a positive effect in reducing the wear rate.

The table also shows that there are no significant interactions between the type of soil texture and the type of plowshare in the wear characteristic.

Table (4): The effect of the studied factors and their interactions on the wear characteristic of the plow weapons (g).

Plow weapons / Soil type	Manufactured	Traditional	Mean of soil
Clay	541.88	576.60	559.24 A
Mixture	533.16	567.33	550.25 B
Mean of Plow weapons	537.52 B	571.97A	

3- Change in the value of the rear draft angle (°): The table shows clear significant differences in the effect of soil type on the change in the value of the rear draft angle. Clay soil achieved the highest value for the rear draft angle, which was 64.44°, while mixed soil recorded the lowest value for the rear draft angle, which was 58.11°. The reason for this is that there is a relationship between the type of soil texture and the value of the change in the rear draft angle of the plowshare. This relationship is what determines the amount of change in the value of this angle depending on several factors, including the change in the practical plowing depth achieved for the type of plowshare in the type of soil texture and the mechanical properties of the metal from which the plowshare is made.

The table also shows that there are significant differences between the type of plowshare in the change in the value of the rear draft angle, as the manufactured plowshare achieved the highest value for the angle, which was 62.44°, while the traditional plowshare recorded the lowest value for this angle, which was 60.11°. The reason for this is that the strength and hardness of the metal of the manufactured plow weapons , according to the table of mechanical properties, helped the plow weapons to resist wear and thus reduced the change in the value of the rear draft angle.

The table also shows that there are no significant interactions between soil type and plowshare type on the change in the value of the rear draft angle.

Table (5): The effect of the studied factors and their interactions on the change in the value of the rear draft angle (°).

Plow weapons / Soil type	Manufactured	Traditional	Mean of soil
Clay	65.83	63.50	64.44 A

Mixture	59.50	56.72	58.11 B
Mean of Plow weapons	62.44 A	60.11 B	

4- Change in plowing depth (cm): Table (6) shows the effect of the studied factors and their interactions on the change in depth. Soil type had a significant effect on the change in depth, as clay soil achieved the highest value, which was 0.32 cm, while mixed soil recorded the lowest value, which was 0.20 cm. The reason for this is the reaction of the soil to the plow, which causes the plow to lift up and thus reduces the depth of the plowshare in the soil.

The table also shows that there are significant differences between the type of traditional plowshare, as it achieved the highest value for the change in depth, which was 0.30 cm, while the manufactured plowshare achieved the lowest value, which was 0.22 cm. The reason for this is the strength and hardness of the metal of the manufactured plowshare, which increased the depth of the plowshare in the soil and overcame its resistance, and thus increased the achieved depth and reduced the change in depth because the relationship is inverse.

Table (6): The effect of the studied factors and their interactions on the change in plowing depth (cm).

Plow weapons / Soil type	Manufactured	Traditional	Mean of soil
Clay	0.27 B	0.37 A	0.32 A
Mixture	0.17 D	0.22 C	0.20 B
Mean of Plow weapons	0.22 B	0.30 A	

The table also shows that there are significant interactions between soil type and plowshare type on the change in depth, as clay soil with the metal of the traditional plowshare achieved the highest value 0.37 cm, while mixed soil with the type of metal of the manufactured plowshare recorded the lowest value 0.17 cm. The reason for this is that soil texture plays a major role in the change in depth with the properties and specifications of the used plowshare. The more the soil texture tends to be mixed, the better the penetration of the soil as a result of the low resistance of the soil and thus the stability of the plow's work is better, which is reflected in a decrease in the change in depth.

CONCLUSLON

Based on the findings of this study, it is now possible to confirm the following conclusions:

The traditional plowshare recorded the highest values for maximum stress, principal stress, deflection, wear rate, and depth change. Clay soil recorded the highest values for plowshare wear, rear draft angle change, and plowing depth change. The manufactured digger plowshare type recorded the highest value for the change in the value of the rear draft angle.

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REFRANCES

Aikins, K. A. (2023). Review of discrete element method simulations of soil tillage and furrow opening. Agriculture.

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

Al-Khazarji, Qahtan Khalaf Muhammad and Abdel-Jawad Muhammad Ahmed Al-Sharif (1988). Erosion: its causes, types, and methods of protection. Dar Al-Kutub for Printing and Publishing, Baghdad University, Ministry of Higher Education and Scientific Research.

Bayhan, Y. (2006). Reduction of wear via hardfacing of chisel ploughshare. Tribology international, 39(6), 570-574.

Dawod, Khalid Muhammad and Zaki Abdul-Elias (1990). Statistical methods for agricultural research. Dar Al-Kutub for Printing and Publishing, Mosul University, Ministry of Higher Education and Scientific Research.

Dzhabborov, N. I., Dobrinov, A. V; and Jabborov, P. N. (2021, March). Research and modeling of the wear process of parts of the soil tillage working implements. In *IOP Conference Series: Earth and Environmental Science* (Vol. 699, No. 1, p. 012038). IOP Publishing.

Jassim, Abdulrazzaq Abdul Latif (2018). Agricultural machinery and tillage and soil smoothing equipment, Dar Al-Jamia for Printing, Publishing and Translation, Baghdad University, Ministry of Higher Education and Scientific Research.

Malvajerdi, A. S. (2023). Wear and coating of tillage tools: A review. *Heliyon*.

Mandal, S. K., Bhattacharyya, B., Mukherjee, S., & Maity, A. (2015). Rotary Tiller's Blade Design using Finite Element Analysis (FEA). Int. J. of Modern Studies in Mech. Engineering, 1(1).

Napiórkowski, J. (2010). Abrasive soil pulp properties analysis in wear impact aspect. *QUARTERLY TRIBOLOGIA*, *233*(5), 53-62.

Rajab, Adel Ahmed Abdullah (2005). Development of locally manufactured digger plow. PhD thesis, Department of Agricultural Mechanization, College of Agriculture and Forestry, Mosul University.

Tukhtakuziev, A., & Rasuljonov, A. R. (2020, December). Ensuring the stability of the processing depth of suspended soil mounted machines. In *IOP Conference Series: Earth and Environmental Science* (Vol. 614, No. 1, p. 012156). IOP Publishing.

Upadhyaya, S.K .(2009) Soil Dynamics. American Society of Agricultural and Biological Engineers, Vol.3 Chapter 3, Part I and II , 273-359.

Vajda, M. Z., Oláh, Z., & Orosz, Á. (2019). Evaluating The Stress Field On Sweep During Tillage Process Applying Coupled Finite-Discrete Element Method. In ECMS (pp. 358-363).

Ziemelis, M., & Verdins, G. (2017). Plough parts wear resistance depending on their material composition and processing technology. *Engineering for Rural Development*, *16*, 455-460.

بيان تأثير أسلحة نوع معدن أسلحة المحراث الحفار على التغير في قيمة زاوية الدفع الخلفية لها عند ظروف نسجات تربة مختلفة

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الخلاصة

أجريت هذه الدراسة في الموسم الزراعي عام 2023 - 2024 في احدى الحقول الزراعية في محافظة كركوك – قضاء الحويجة – ناحية الزاب في الجنوب الشرقي من محافظة نينوى، لدراسة أداء أسلحة المحراث الحفار المصنعة محلياً، وتضمن البحث دراسة نوع معدن أسلحة المحراث الحفار بمستويين (تقليدي – مصنع) ومستويين لنوع نسجة التربة (المزيجية– الطينية)كم/ساعة وتأثير ذلك على بعض الصفات المدروسة منها الاجهاد ، تأكل الأسلحة ، التغير في قيمة زاوية الدفع الخلفية ، التغير الحاصل في عمق الحرث. نفذت التجربة وفق تصميم القطاعات العشوائية الكاملة (RCBD) بنظام الالواح المنشقة - منشقة وبثلاث مكررات. واظهرت النتائج ان أسلحة المحراث التقليدي سجلت اعلى قيمة لكل من الاجهاد الأعظم والاجهاد الرئيسي والانحراف ، كما تفوقت نوع التربة (الطينية) معنويا في إعطاء قيم أعلى لكل من تأكل الاسلحة والتغير في قيمة زاوية الدفع الخلفية والتغير الحاصل في عمق الحرث. اما بالنسبة لنوع أسلحة المحراث فقد تفوقت أسلحة المحراث المصنع معنويا في تسجيل قيم أعلى للتغير في قيمة زاوية الدفع الخلفية، في حين تفوقت أسلحة المحراث التقليدي معنويا بتسجيل قيم أعلى لكل من تأكل الأسلحة والتغير الحاصل في عمق الحرث.

الكلمات الافتتاحية: الاجهادات، تأكل الاسلحة، التغير في قيمة زاوية الدفع الخلفية ، التغير الحاصل في عمق الحرث ، المحراث الحفار.