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RESEARCH ARTICLE
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Indication of the optimal utilization of the mouldboard plow with angular skimmer manufactured locally in different field conditions.

Adel Ahmed Abdullah Rajab[2] Rateeb Hussein Ali[1]

[1] *General Directorate of Education in Kirkuk Governorate, Ministry of Education, Kirkuk, IRAQ.*

[2] *Department of Agricultural Machinery and Machinery, College of Agriculture and Forestry, University of Mosul, Mosul, IRAQ.*

*Corresponding Author: rateeb.22agp99@student.uomosul.edu.iq.

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ABSTRACT

This study was conducted during the fall agricultural season of 2023 on the researcher's own farm, located at western of Al-Zab city – Al-Hawija district – Kirkuk governorate, to evaluate the performance of the mouldboard plow with and without locally manufactured angular skimmer. The study was implemented in two phases. In the first phase, the required dimensions and measurements for the angular skimmer were established, a suitable metal type was determined, and the angular skimmer was manufactured according to the dimensions and measurements. In the second phase, a field evaluation was conducted to assess the operational efficiency of the mouldboard plow with the locally manufactured angular skimmer and compare it with the mouldboard plow without skimmer (as a control). Therefore, the studied factors through a practical experiment used mouldboard plow at two levels (with and without attached the locally manufactured angular skimmer), at two levels of forward speeds 3.57, 6.30 km h-1. The impacts of these factors on soil volume disturbed, soil slice angle, lateral movement distance of furrow bottom, and tillage appearance (number of soil blocks with a diameter exceeding 10 cm per m2).

The forward speed 3.57 km h-1 significantly contributed to higher values for both tillage appearance and angle of soil slice deflection, while the forward speed 6.30 km h-1 significantly contributed to higher values for soil volume overturned and furrow bottom exposed area. Mouldboard plough with angular skimmer exhibited significantly higher values for both the angle of soil slice and the distributed soil volume. In comparison, the implement without the angular skimmer showed significantly higher values for both tillage appearance and lateral movement distance of furrow bottom. The mouldboard plough with the angular skimmer significantly contributed to higher values for both the angle of soil slice and the distributed soil volume at a forward speed of 6.30 km h-1. In comparison, the plow without the angular skimmer significantly contributed to higher values for tillage appearance and lateral movement distance of furrow bottom at a forward speed of 3.57 km h-1.

***Keywords*:** angular skimmer, soil volume raised, lie angle of soil slice, tillage appearance.

INTRODUCTION

The plowing process is considered one of the important and main processes for preparing the soil by breaking up the surface layer and forming small earth blocks that facilitate the movement of water and air into the soil, which in turn leads to improving the physical properties of the soil. The qualitative characteristics of plowing depend on the practical speed of the machine, the nature of the treated soil, and the optimal choice of tillage implement. In the case of inappropriate selection of this equipment, this leads to negative results in soil characteristics, which in turn reflects negatively on the processes of plant growth and crop production. Also, the use of the rotary plow leads to achieving most of the plowing goals of cutting, turning, and dismantling the soil, which was confirmed by [1]. The presence of brush in the soil is considered one of the factors that reduce the efficiency of the work of agricultural machinery and equipment, especially plows, whose effect is to reduce the disintegration of the soil and reduce the depth of the plow arms. The angular skimmer is considered one of the auxiliary parts of the plow body, and its function is to make a vertical cut in the soil for a distance of up to half a mile. The depth of plowing leads to reducing the lateral and vertical resistance of the soil to which the plow is exposed by a rate ranging between (10-15%) [2]. Its use also reduces the pressure on the surface of the plow bed, as well as scraping or cutting at a certain angle for part of the soil. The transported soil is placed on the surface of the tipping plate so that it falls before the parent section at the bottom of the previous furrow and fills the gap between adjacent plowing lines, giving a homogeneous appearance to the plowed soil with few undulations and a minimum number of dirt masses [3]. Studies have also shown a positive effect of using the angular skimmer. The harrow plough increases the burial of surface furrows, as well as bushes and plant residues [4]. The angular harrow is very similar to the shape of the harrow of the harrow plough, and using it in the appropriate position and choosing the appropriate forward speed, it is possible to achieve an increase in practical productivity while achieving a

satisfying quality of work. Thus, obtaining good performance of the inverter plow while working in different conditions, and maintaining better stability of the plow. This study came as a result of the lack of in-depth local studies on the locally manufactured angular plow, and because this auxiliary part attached to the inverter plow is important in improving some tillage indicators.

Materials and Methods

This study was carried out in the agricultural season (2023) in one of the agricultural fields in the Al-Zab district – Kirkuk Governorate. The area of the exploited field was (1) hectares and characterized by a flat topography. The soil texture was clay after it was transformed, as the percentage of clay reached (480 g/kg), the silt percentage is (327 g/kg), and the sand percentage is (193 g/kg). The land was planted with wheat crop for the season preceding the experiment. A Turkish-made Massey Forexen puller (MF 285 S) with horsepower (75 hp) was used. The puller was used to pull and carry the plow and measuring all performance indicators (a source of power). An Iraqi-made inverter plow (Alexandria) was also used, with a mass of 360 kg, a working shaft of 87 cm, and several bodies of three. The type of weapon was chisel and the type of the plow was cylindrical. The angular plow was manufactured by the researcher at the Al-Tassahal Factory for the Manufacture of Agricultural Machinery and Equipment – Kirkuk. A test was also conducted of the metal from which the angular skimmer was made in the laboratories of the Mechanical Engineering Department/College of Engineering – University of Mosul. Table (1) show and Figure (1) the mechanical properties and chemical composition of the metal from which the angle grinder is made, and the design map of the angular skimmer, respectively. The experimental field was divided according to the Randomized complete block design (RCBD) method and the split plot design method was used [5]. For the purpose of implementing the experiment, the main plots were allocated (Main Plot) for the forward speed of plowing, and each section A main board and two secondary boards (sub plot), which in turn are designated for the plow. Thus, the experiment consists of two factors, the first of which is the forward speed of the plow with two levels (3.57, 6.30) km/hour. The second factor is the plow with two levels (the plow with the angular skimmer, the plow without the angular skimmer), and the length of one treatment in the replicate is (30) meters. Statistical analysis of the data and analysis of variance were conducted with Duncan's multiple range test for means to find significant differences under the probability level (0.05) and (0.01) to compare the means of the different treatments. After planning the experiment according to the established design, the experimental field was irrigated using irrigation. The extent of change in moisture content was monitored using a device to measure soil moisture percentage.

662.**Tillage appearance (represents the number of dirt blocks whose diameter exceeds (10) cm/m^2):**

To measure this characteristic, a wooden frame with dimensions of (50) cm x (50) cm was used, meaning that the area of this frame is (0.25) square metres. This frame was thrown randomly with (9) samples for one replicate, and then the number of dirt blocks whose diameter increased about (10) cm/square meter, then sum it and divide it by the number of samples, find the average, and then multiply the number obtained by (4) to get the number of dirt blocks in an area per square meter [13].

2. Lie angle of the soil slice:

It is the angle at which the soil slice tilts away from the tillage line. This angle is measured using an L-shaped ruler, a protractor, and a graduated ruler with a length of (50) cm. The graduated ruler is placed horizontally at the ground's surface and vertically on the tillage line and the furrow wall. The protractor is inserted parallel to the L-shaped ruler. After that, the solid ruler with a length of (50) cm is placed in a position parallel to the inclination of the plowed soil, and the value of the angle is acute in relation to the L-shaped ruler and the graduated protractor. Thus, the short ruler is placed in a position parallel to the values of the existing angles (fixed) on the protractor, meaning it is the angle that corresponds to the ruler. It is the value of the angle of inclination (lie) of the soil slice [13].

3. The transverse distance of the bottom of the cheek (to the bottom of the groove):

The transverse distance to the bottom of the groove is measured by using two rulers with a length of (30) cm. The two rulers are placed from the bottom of the groove to the top of the surface of the groove, parallel to the wall of the groove. Then the distance is calculated between the intersection points of these two rulers with the solid ruler with a length of (150) cm, which is placed in a horizontal with the soil surface and perpendicular to the plowing line, with (3) random readings for each replicate. The average (average) of those readings is found, after which the actual width (bottom) of the furrow is determined [13].

4. Volume of soil raised:

This expression can be defined as the amount of soil volume raised by the plow during the plowing period. It depends on the machine's actual (practical) productivity and the plowing depth. The volume of soil raised is calculated using the following equation [7].

S.D. V= EFC* DP * 100 …… (1)

S.D. V= Stirred soil volume (cubic meters/hour)

EFC = Actual field productivity (ha/hour)

DP = actual plowing depth (cm).

.Table (1) The mechanical properties and chemical composition of the metal chosen to manufacture the angle grinder

Mechanical properties	Chemical composition	Metal type

Angular skimmer parts	Tensile strength (N/mm^2)(Mpa)	(HRC) Hardness	Yield stress (Mpa)(N/mm^2)	Elongation ratio (%)	Carbon (c%)	Manganese (Mn%)	Chromium (Cr%)	Copper (Co%)	Sulfur(S%)	Phosphorous (P%)	AISI
Cutting blade	700	40	430	10	0.7	0.85	0.003	0.003	0.01	0.01	1070
Without the skimmer	700	20	430	10	0.7	0.85	0.003	0.003	0.01	0.01	

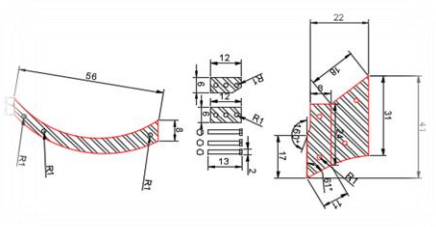

Figure 1: the design of the manufactured angular skimmer.

Picture (1) of the angular planer with the rotary plow.

Results and discussion

1- Tillage appearance: (number of dirt clods with a diameter greater than 10 cm/m^2).

Table (2) indicates that there are significant differences in the effect of the studied factors on the appearance of tillage, as the forward speed was (3.57) km/h, recording the highest value for the number of dirt blocks per unit area, which amounted to (11.58) blocks/m^2. In contrast, the forward speed was recorded (6.30). km/hour. The lowest value for the number of dirt blocks per unit area was (9.38) blocks/m^2. The reason for this is that the greater the forward speed of plowing, the smaller the number of dirt blocks per unit area, due to the increase in throwing and hitting the dirt blocks, as well as the increase in the force of their collision with each other, which leads to the crushing and disintegration of the dirt blocks, and this is consistent with [8] and [9] and [10] and [11]. The effect of the plow used also showed significant differences in the appearance of the tillage, as the plow with the angular skimmer recorded the lowest value for the number of dirt blocks (9.44) blocks/m^2, while the plow without the angular skimmer recorded the highest value for the number of dirt blocks (11.52). Mass/m^2, and the reason for this is that the angular skimmer and its operation in front of the harrow penetrated it to half the depth of plowing. The passage of the harrow over plowed (treated) soil, which increased the process of dismantling the earthen blocks. That the inclination of the body of the angular skimmer also led to an increase in the dismantling of the earthen masses as a result Streamlined soil movement on the skimmer body. The bilateral interactions between the studied factors also showed significant differences in the appearance of tillage, as the table shows that the bilateral interaction between the forward speed of plowing and the plow also showed a considerable difference, as the highest value was recorded for the number of dirt masses of (12.44) blocks/m2 when using the plow without the angular skimmer with the forward speed. (3.57) km/hour, while the plow with the angular skimmer recorded the lowest value for the number of dirt masses, amounting to (8.16) blocks/m2, with the forward speed of the plowing (6.30) km/hour. The reason for this is that the greater the forward speed, the presence of the skimmer leads to a decrease in the number of dirt blocks due to the force of throwing and colliding the dirt blocks with each other, in addition to the process of dismantling the soil slice, including the dirt blocks.

Table 2: Effect of the studied factors and their interactions on the appearance of tillage (the number of dirt clods with a diameter greater than 10 cm/m^2)

	The forward speed of the tiller, km/h	Plow		Effect of forward speed of plowing, km/h
		With skimmer	Without skimmer	
Overlap The forward speed of the tiller and the plow	3.57	10.72B	12.44 A	11.58 A
	6.30	8.16 C	10.60 B	9.38 B
Plow effect		9.44 B	11.52 A	

- The lower value is better.

The angle of lie of the soil slice (degrees):

Table (3) shows the effect of the studied factors and their interactions on the character of the lie-back angle of the soil slice. Where there are clear significant differences in the effect of the forward speed of plowing on the character of the lie-back angle of the soil slice, as the lowest value of the lie-back angle of the soil slice (46.82) degrees was recorded at the forward speed of plowing (6.30 km/h, while the highest value of the soil slice lie angle (53.77) degrees was recorded at the forward speed of plowing (3.57) km/h. The reason for this is that as the forward speed of plowing increases, it leads to a decrease in the average depth achieved for the slice. At the same time, it leads to an increase in the pushing force and throwing the soil aside, which ultimately leads to a decrease in the value of the lie angle of the soil slice, and this is consistent with what was mentioned by both [12] and [13]. The table also shows that there are significant differences in the effect of the plow used on the lying angle of the soil slice, where the plow with the angular skimmer recorded the highest value for the lying angle of the soil slice (55.24) degrees. In contrast, the plow without the angular skimmer recorded the lowest value for the lying angle of the soil slice (45.35) degrees. The reason is due to the presence of the angular skimmer with the plow helps the plow to increase its penetration into the soil, which leads to an increase in the achieved depth of the stirred soil slice and thus an increase in the value of the lien angle of the soil slice. On the contrary, in the absence of the angular skimmer with the plow, the table also shows that there are significant differences in the bilateral interaction between the forward speed of the plow in terms of the soil slice lie angle, as the highest value for the soil slice lie angle (59.99) degrees was recorded when using the plow with an angular skimmer and the forward speed. For plowing (3.57) km/h, while the plow without the angular skimmer recorded the lowest lying angle of the soil slice (43.16) degrees with the forward speed of plowing (6.30) km/h. That might be due to the high speed and the absence of the angular skimmer, which achieve the lowest depth and stirs up the soil, and this is reflected in the angle of lying of the soil slice, which decrease

Table 3: Effect of the studied factors and their interactions on the characteristic of the soil slice's lie angle (degrees)

	The forward speed of the tiller, km/h	Plow		Effect of forward speed of plowing, km/h
		With skimmer	Without skimmer	
Overlap The forward speed of the tiller and the plow	3.57	59.99 A	47.55 C	53.77 A
	6.30	50.49 B	43.16 D	46.82 B
Plow effect		55.24 A	45.35 B	

- A value around 50 degrees is the best.

The transverse distance of the bottom (meters):

Table (4) shows that there are significant effects of the forward speed of plowing on the characteristic of the transverse distance to the bottom, as the highest value of the transverse distance to the bottom was (0.827) metres, at the forward speed of plowing (6.30) km/hour, while the lowest value of the transverse distance to the bottom was (0.821). meters, at the forward speed of plowing (3.57) km/h. The reason for this is that increasing the forward speed of plowing leads to reduction in the achieved depth and thus increasing the transverse distance to the bottom, and this result is consistent with what was found by [14]. The increase in forward speed increases the transverse distance to the bottom. The table also shows that there are significant differences in the effect of the plow on the characteristic of the transverse distance to the bottom, as the highest value of the transverse distance to the bottom was recorded when the plow without the angle skimmer (0.829) meters, while the lowest transverse distance to the bottom was recorded when the plow with the angle skimmer (0.818) metres, and that was might be due to the presence of the angular skimmer with the plow leading to an increase in the depth achieved (the greater the depth, the smaller the transverse distance to the bottom). The table also shows that there are significant differences in the bilateral interaction of the forward speed of the plow and the plow, where the lowest value for the transverse distance to the bottom is (0.814) meters. It was recorded at the plow with the angular skimmer with the forward speed of (3.57) km/h, while the highest value of the transverse distance of (0.831) meters was recorded at the plow without the angular skimmer with the forward speed of the tiller (6.30) km/h.

Table 4: Effect of the studied factors and their interactions on the characteristic of the transverse distance of the bottom (meters)

	Plow

	The forward speed of the tiller, km/h	With skimmer	Without skimmer	Effect of forward speed of plowing, km/h
Overlap The forward speed of the tiller and the plow	3.57	0.814 C	0.827 AB	0.821 B
	6.30	0.823 B	0.831 A	0.827 A
Plow effect		0.818 B	0.829 A	

- Higher value is better.

Volume of soil raised: (m^3/hour).

Table (5) shows the effect of the studied factors and their interactions on the character of the stirred soil volume, where there are clear significant differences, as the forward speed of plowing exceeded (3.57) km/hour, with the lowest value recorded for the stirred soil volume amounting to (536.32) m^3/hour, while it was recorded. The highest value of the volume of soil stirred up was (862.34) m^3/hour at the forward speed of tillage (6.30) km/hour. The reason for this is due to increasing the forward speed of tillage, which leads to an increase in the plowed area, which in turn leads to an increase in the volume of soil stirred up. Also, the practical speed is considered one of the factors involved in calculating the actual productivity is that by increasing it, the volume of soil raised increases, meaning that the plowed area is directly proportional to the forward speed of plowing, and this is consistent with what was found by [15], [16], and [17]. The table also shows that the plow used gave significant differences, as the plow with the angular skimmer recorded the highest value for the volume of soil stirred, which amounted to (735.80) m^3/hour. In contrast, the plow without the angular skimmer recorded the lowest value for the volume of soil stirred, which amounted to (662.78) m^3/hour.The presence of the angular skimmer with the plow leads to an increase in the depth of plowing achieved, so the plowed area is larger and thus leads to an increase in the size of the soil section raised, because the actual depth is considered one of the determinants of the size of the soil raised. Also, the presence of the angular skimmer reduces the lateral pressure on the plow, which leads to the plow maintaining its working width, which in turn leads to an increase in actual productivity. The table also shows that there are significant differences in the bilateral interaction between the forward speed of plowing and the plow, as the plow with the angular skimmer and the forward speed of plowing (6.30) km/hour recorded the highest value for the volume of soil raised, reaching (910.61) m^3/hour, while the plow without the angular skimmer speed of (3.57) km/hour, the value of the volume of soil stirred was lower, reaching (511.65) m^3/hour. This is due to the decrease in actual productivity and the lack of actual depth, and thus the decrease in the volume of soil stirred

Table 5: Effect of the studied factors and their interactions on the volume of soil raised (m^3/hour)

	The forward speed of the tiller, km/h	Plow		Effect of forward speed of plowing, km/h
		With skimmer	Without skimmer	
Overlap The forward speed of the tiller and the plow	3.57	506.99 C	511.65 D	536.32 B
	6.30	910.61 A	814.06 B	862.34 A
Plow effect		735.80 A	662.78 B	

- Higher value is better.

Conclusion

We conclude from the results obtained that the plow with the angular skimmer recorded the lowest values for both the appearance of the tillage (the number of dirt clods with a diameter greater than 10 cm/m2) and the transverse distance of the bottom, and the highest values for both the lying angle of the soil chip and the volume of soil raised. The forward speed (3.57) km/h recorded the highest value for both the tillage profile and the soil slice lie angle and recorded the lowest value for both the transverse distance to the bottom and the volume of soil raised. While the forward speed (6.30) km/h recorded the lowest value for the tillage profile and the soil slice lie angle, and the highest value for both the transverse distance to the bottom and the volume of soil raised. While the bilateral interaction between the plow without the angular scraper and the forward speed of plowing (3.57) km/h recorded the highest value for the appearance of the plowing. In contrast, the bilateral interaction between the plow with the angular scraper and the forward speed (3.57) km/h recorded the highest value for the lying angle of the soil slice. While the bilateral interaction between the plow without the angular scraper and the forward speed (6.30) km/h recorded the highest value for the transverse distance to the bottom. While the plow using the angular scraper with speed (6.30) km/h recorded the highest value for the volume of soil raised.

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بيان الاستغلال الأمثل للمحراث المطرحي القلاب مع القاشط الزاوي المصنع محليا في ظروف عمل مختلفة.

رتيب حسين علي عبد الحليم[1] عادل أحمد عبدالله رجب[2]

[1] المديرية العامة للتربية في محافظة كركوك, وزارة التربية ،كركوك ، العراق .

[2] قسم المكائن وألالات الزراعية ، كلية الزراعة والغابات ،جامعة الموصل، الموصل ، العراق.

الخلاصة

أجريت هذه الدراسة بهدف تقييم عمل المحراث المطرحي القلاب من خلال إضافة القاشط الزاوي المصنع محليا، وتمت الدراسة بمرحلتين : المرحلة الأولى : شملت تثبيت الابعاد والقياسات المطلوبة للقاشط الزاوي المراد تصنيعه وتحديد نوع المعدن الملائم وتصنيع القاشط الزاوي على وفق الابعاد والقياسات ،المرحلة الثانية: تم فيها اجراء تقييم حقلي لكفاءة عمل المحراث المطرحي القلاب بالقاشط الزاوي المصنع محليا ومقارنة مع المحراث المطرحي من دون القاشط الزاوي ودراسة بعض مؤشرات الأداء الحقلي من خلال اجراء تجربة عملية اعتمدت فيها العوامل الاتية : العامل الأول استخدام السرعة الامامية للحراثة بمستويين (3.57 ،6.30) كم /ساعة، والعامل الثاني استخدام المحراث المطرحي القلاب بمستويين (المحراث بالقاشط الزاوي المصنع محليا، والمحراث بدون القاشط الزاوي). ودراسة مدى تأثير هذه العوامل على الصفات المدروسة والتي شملت : مظهر الحراثة (عدد الكتل الترابية التي يزيد قطرها على 10 سم/م2)، زاوية اضطجاع شريحة التربة، المسافة المستعرضة لقاع الاخدود ، حجم التربة المثار. تم تنفيذ التجربة في الموسم الزراعي (2023) في احدى الحقول الزراعية في ناحية الزاب – قضاء الحويجة – محافظة كركوك. تم استخدام تصميم القطاعات العشوائية الكاملة (*RCBD*) بنظام الالواح المنشقة – منشقة وبثلاث مكررات. وفيما يأتي اهم النتائج التي تم الحصول عليها عن طريق الدراسة : تفوقت السرعة الامامية للحراثة (3.57) كم/ساعة معنويا في إعطاء قيم أعلى لكل من مظهر الحراثة وزاوية اضطجاع شريحة التربة، في حين تفوقت السرعة الامامية (6.30)كم/ساعة معنويا في إعطاء قيم اعلى لكل من حجم التربة المثار والمسافة المستعرضة للقاع. اما بالنسبة للمحراث فقد تفوق المحراث بالقاشط الزاوي معنويا في تسجيل قيم أعلى لكل من زاوية إضطجاع شريحة التربة وحجم التربة المثار ، في حين تفوق المحراث بدون القاشط الزاوي معنويا بتسجيل قيم أعلى لكل من مظهر الحراثة والمسافة المستعرضة للقاع وبالنسبة للتداخل الثنائي بين السرعة الامامية للحراثة والمحراث فقد تفوق المحراث بالقاشط الزاوي مع السرعة الامامية (6.30) كم /ساعة معنويا في إعطاء قيم أعلى لكل من زاوية إضطجاع شريحة التربة وحجم التربة المثار في حين تفوق المحراث بدون القاشط الزاوي مع السرعة الامامية للحراثة (3.57) كم/ساعة معنويا في إعطاء قيم أعلى لمظهر الحراثة والمسافة المستعرضة للقاع.

الكلمات المفتاحية : القاشط الزاوي ، حجم التربة المثار، زاوية اضطجاع شريحة التربة ، مظهر الحراثة.