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Integrated Hoeing Machine Suitable for Using Rice Straw

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ABSTRACT

This study was conducted to develop a mechanical hoeing machine with an improved shear containing a unit for adding straw pieces after the hoeing process to eliminate weeds and improve soil properties between the planting rows and a wheel for reformation of the inter-row. The machine hung to the tractor for experiments and taking measurements. The integrated hoeing machine was tested on the sugar beet crop for the 2023 planting season. After 10 days of planting the field experiments were conducted and measurements were taken, were conducted in Tanah village, Dakahlia Governorate. The hoeing machine was tested under four study parameters, as follows: three tractor speeds (3, 5, and 7 km/h), three straw cutting lengths (3, 5, and 7 cm), three wheel press weights (17.2, 33.2, and 49.2 kg), and three wings shear widths (50, 55, and 60 cm). To evaluate the hoeing machine performance, the following measurements were taken: weed removal efficiency (We%), weed growth efficiency (Wc%), plant damage percentage (Dp%), and row gap shape (Fp). The best results were achieved at an average tractor speed of 5 km/h, straw cutting lengths of 3 cm, average wheel weight of 33.2 kg and shear wings width of 55 cm, due to the results obtained in weed removal efficiency (We = 98%) and weed control efficiency (We = 96.4%) with the lowest percentage of plant damage (Dp = 0%) and the best regularity of line belly re-formation..

Keywords: hoeing weed control – Mechanical hoeing - sugar beet- Bottom inter- rows - Press metal wheel - hoeing shear

INTRODUCTION

There are many definitions of weeds, and scientists differ in naming weeds on plants according to their characteristics and places of growth. Beringe, (2019) defined weeds as all plants that grow in undesirable places and compete with the original plant for their nutrition. There are many weed control systems, including the integrated weed control system. Harker, (2013) explained that this system is based on the use of two types of control methods, namely pesticide and mechanical control, and it is considered one of the forms of development and integration between control systems. The top priority of these operations is to get rid of these weeds because they are risky to the original plant, as they compete with the plant and reduce its productivity. Kunz et al., (2015) defined hoeing as removing and getting rid of weeds or any unwanted plants that negatively impact the plant in terms of competition for food and reducing crop productivity. EL-Shabrawy, (2019) pointed out the importance of the hoeing process and its benefits. It helps reduce the soil, which enhances the plant's ventilation. Its main purpose is also to remove weeds to the maximum extent possible while modifying the shape of the line after completing the process. It also improves the drainage properties, increasing the soil quality. and developed a hoeing unit with shares that suit the process between vegetable crop rows. This study tested the machine regarding share angles and types in different conditions. The machine was equipped with a press wheel with three different depths. The best results of this experiment were at a shear tilt angle of 45 degrees. This angle and the immense depth of the press wheel, which is 4 cm, were achieved because it achieved an efficiency of removing weeds of 97% with the best line formation and the least damage to the plant. Blackshaw et al., (2007) explained

the negative effects of using pesticides, which led to a preference for research and development of mechanical methods for controlling weeds. One of these negative effects is that the continued and repeated use of pesticides for weeds, in the same way, causes the selection of new groups of weeds resistant to these pesticides, in addition to the side and negative effects that affect the soil, groundwater, and humans. Hayab, (2011) explained that the reason for farmers and researchers turning to mechanization again is the emergence of new varieties resistant to chemicals used in pesticides or pesticides such as glyphosate resistance from some harmful weeds. The rate of organic farming has increased in the last five years due to its benefits. Bryonsima, (2017) developed a weed-removal machine. It is a rotating piece that works by energy and is attached to three axes. Two blades in the shape of an L were added to it, all of which were mounted on a special column for the machine. The efficiency of this machine was 60% of the percentage of removing weeds from the field. Rathod et al., (2010) developed a rotary tiller to control weeds between rows of crops. Field tests were conducted at different speed levels with four L-shaped blades. The tiller was operated at a rotational speed of 257 rpm. This study provided good results in terms of the efficiency of eliminating and removing weeds, which was 86.34% and then 92.23% in succession. It noted that it saved time by up to 70% and costs by up to 68.7%. This study aims to develop an integrated hoeing unit consisting of a front shear to remove weeds from the bottom and sides of the planting rows, followed by a unit for falling rice straw pieces to cover the distance containing the remains of weeds that have been weeded between the rows with straw, followed by a press wheel that compresses and reformation and press, the furrow bottom to provide to ensure the best remove of weeds and reshaping the inter-row.

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MATERIALS AND METHODS

This study aims to develop and manufacture an integrated machine for hoe weeds between vegetable planting rows, add straw pieces between the planted lines and reshape the bottom of the line, then press the straw layer with a rear wheel to fix and compress a straw layer that acts as an insulating cover that prevents the passage of sunlight so that there is no chance for weeds to grow again during the plant growth period, this reduces the number of times weed hoeing occurs and increases the efficiency of removing weeds. The machine was manufactured in a local workshop in Tanah village, Dakahlia Governorate.in a clay loam soil. Its performance was evaluated on agricultural land planted with vegetable crops, such as sugar beets. The experiments were conducted Starting from the germination stage of the plant with two leaves in August 2023 and harvesting in February 2024.The mechanical properties of the testing soil are summarized in table (1).

Table 1.The mechanical analysis of the soil

Soil Texture	Particles size distribution (%)			
	Clay	Silt	Fine sand	Coarse sand
Clay loam	49.2	40.6	8.9	1.3

The developed a hoeing unit:-

The developed hoeing machine with modified parts was constructed and fabricated at the local workshop in Mansoura city, it's manufactured as a proto-type one unit suitable for one inter-row hoeing process and consists of many parts. The developed hoeing design was made for the machine with dimensions that fit the previously presented planting rows in terms of the distances between the rows. It must be taken into account that it allows the machine to pass without harming the plant and the height of the plants dealt with in the study so that they are not harmed when passing over them during the hoeing weed process. Based on these dimensions, the machine was designed with the dimensions as shown in figure (2A, B and C)



Fig. 2A. Hoeing unit during field experiments

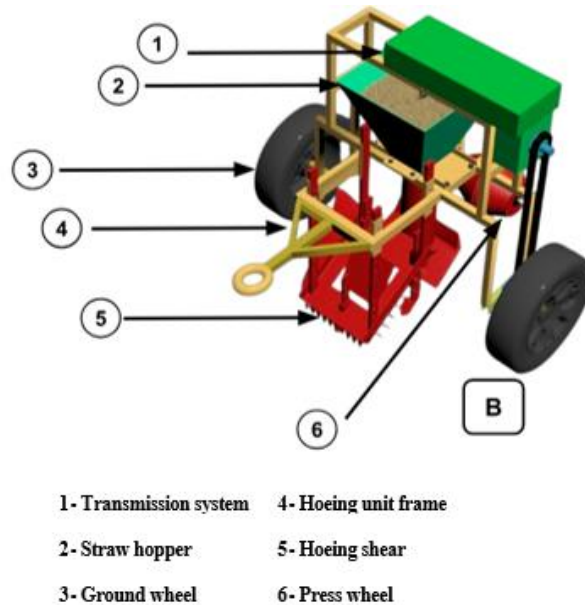


Fig. 2B. A developed hoeing unit with developed parts

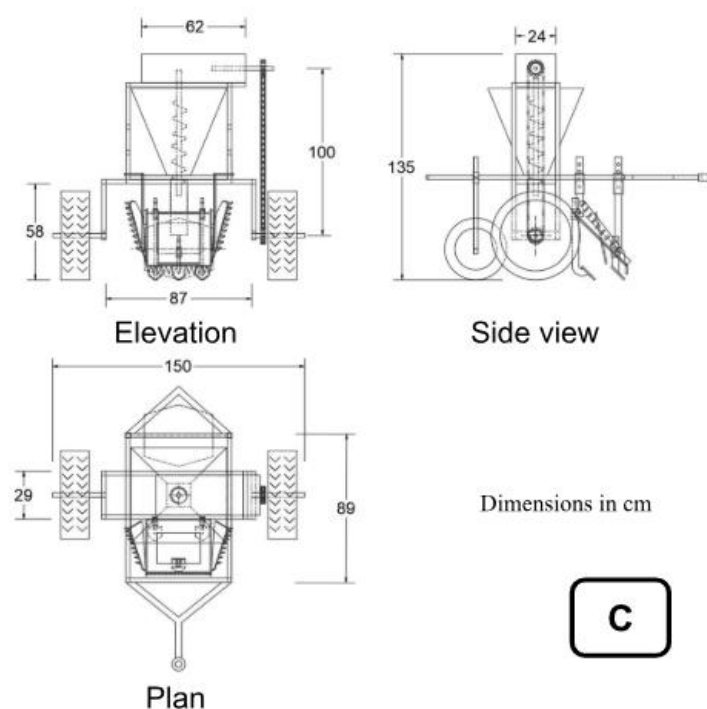


Fig. 2C. A schematic diagram for the developed hoeing unit with dimensions

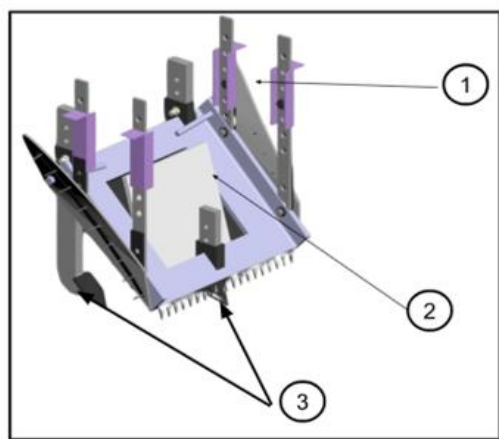
From figure (2 A and 2B) the hoeing machine consists of four main parts as follow:

Hoeing unit frame :

The frame, on which all the machine's components were fixed, is made of steel with a tractor-mounted suspension unit.

Modified hoeing shear:

The machine has a hoeing weed shear at the front, with adjustable side wings. It consists of the following parts, as shown in figure (3)



1- Hoeing wings 2- Sliding knife blank 3- Subsurface share

Fig. 3. Modified share parts

(1) Hoeing shear wings:

To collect and conform the soil on both sides of the planting rows.

(2) Subsurface hoeing shares:

It operates to a depth of 5 cm below the soil to ensure the removal of weed residues, and soil disintegration, improve aeration and improve the drainage properties of irrigation water.

(3) Sliding knife:

An open slice at a 33-degree angle from the shear body, with dimensions of (26 * 31) cm, works to turn the soil slice passing from the front cutting edge of the shear to ensure complete cutting of the weed roots.

Straw hopper:

It is a metal hopper in which straw pieces are placed. These were lowered through a cylinder at the bottom of the hopper, and a piece of sheet metal with a width equal to the distance between two rows distributed the straw parts throughout the bottom of the rows.

Transmission system:

It is a system consisting of gears and a chain to transmit motion, which takes its motion from the progressive motion of the tractor. The system is connected to a screw shaft inside the straw hopper that operates to lower the straw pieces.

press wheel:

The wheel is made of solid iron and has a gate that allows it to be increased in weight by filling it with sand. It is designed to reformation the row bottom and compress the straw pieces. It is located at the rear of the machine behind the hoeing tool and the thatch unit.

The studied factors used in this study:

1- Three tractor speeds (V) ($V_1 = 3$ km/h & $V_2 = 5$ km/h & $V_3 = 7$ km/h).

2- Three straw cutting lengths (L) ($L_1 = 3$ cm & $L_2 = 5$ cm & $L_3 = 7$ cm).

3- Three press wheel weights were used: (W) ($W_1 = 17.2$ kg & $W_2 = 33.2$ kg & and $W_3 = 49.2$ kg).

4 Three shear wings width: (Ww) ($Ww_1 = 50$ cm & $Ww_2 = 55$ cm & $Ww_3 = 60$ cm).

Experimental measurements:

There were four measurements were calculated:

1- Weed removal efficiency (We %) :

Hoeing weed efficiency refers to the number of weeds removed in a known longitudinal distance (10 meters) and is calculated immediately after the hoeing weed process.

$$We \% = (1 - R1/R) * 100$$

Where:

R1 = Number of stay weeds directly after hoeing.

R = Total number of weeds between the rows.

2- Weed control efficiency (Wc %) :

It is achieved 10 days after hoeing weed. It is defined as the number of weeds actually removed within a known length (10 meters) of the rows.

$$Wc \% = (1 - R2/R) * 100$$

Where:

R2 = Number of weeds that already stay after 10 days from hoeing process and irrigation in 10 m longitudinal distance between the rows.

3- Percentage of damaged plants (Dp %) :

It is defined as the number of plants of the main crop damaged by the hoeing weed unit during its operation and is calculated using the following equation:

$$Dp \% = (1 - Nd/Np) * 100$$

Where:

Nd = Number of plants that were not damaged after the hoeing weed unit passed through.

Np = Total number of plants before the hoeing weed unit passes through.

4- Furrow profiles (Fp) :

The shape of the line sections was bottom and defined after the improved hoeing weed unit passed between the lines and completed the hoeing weed unit process each time using the section marker tool, as shown in figure (4).

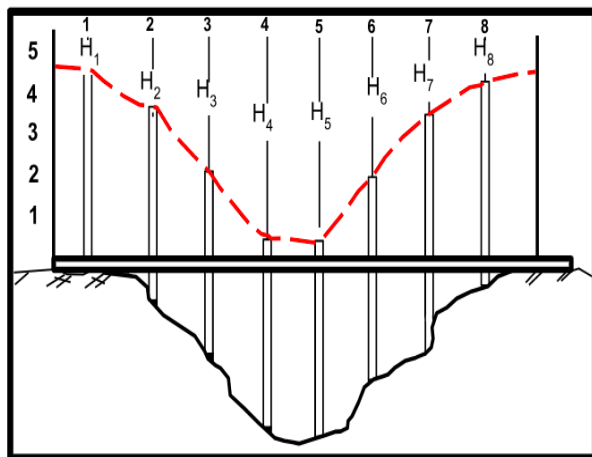


Fig. 4. The profile of the inter-row planting edge

RESULTS AND DISCUSSION

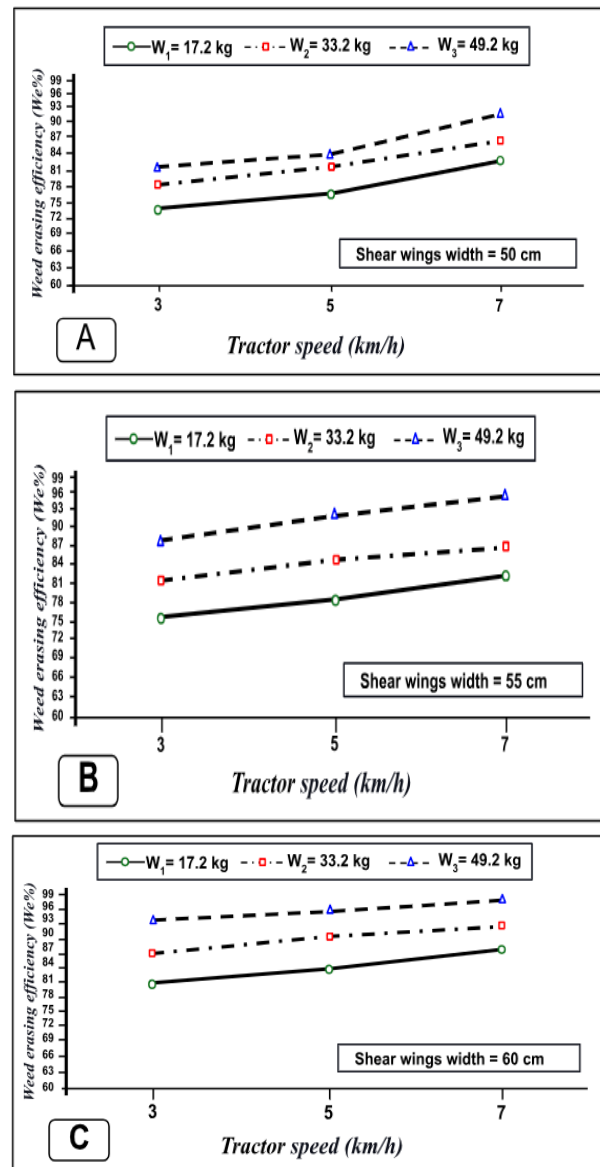
1- Weed removal efficiency (We %)

Figure 5 (A to C) shows that the greater the width of the shear wings, the higher the weed removal efficiency, especially with increasing speed.

The highest weed removal efficiency reached (We = 98%) at a tractor speed of (V₃ = 7 km/h), a shear wings width of (Ww₃ = 60 cm) between the rows, and a press wheel weight of (W₃ = 49.2 kg).

The higher the weed removal efficiency, the more the possible amount of weeds removed, which increases with advancing shear wings width and tractor speed due to the increased possibility for weed cutting.

The lowest weed removal efficiency was obtained (We = 74%), as shown in Figure 5 (A), at the lowest tractor speed (V₁ = 3 km/h), lowest shear wings width (Ww₃ = 50 cm), and lowest press wheel weight (W₃ = 17.2 kg). That means the least weed removal occurred at these treatments.

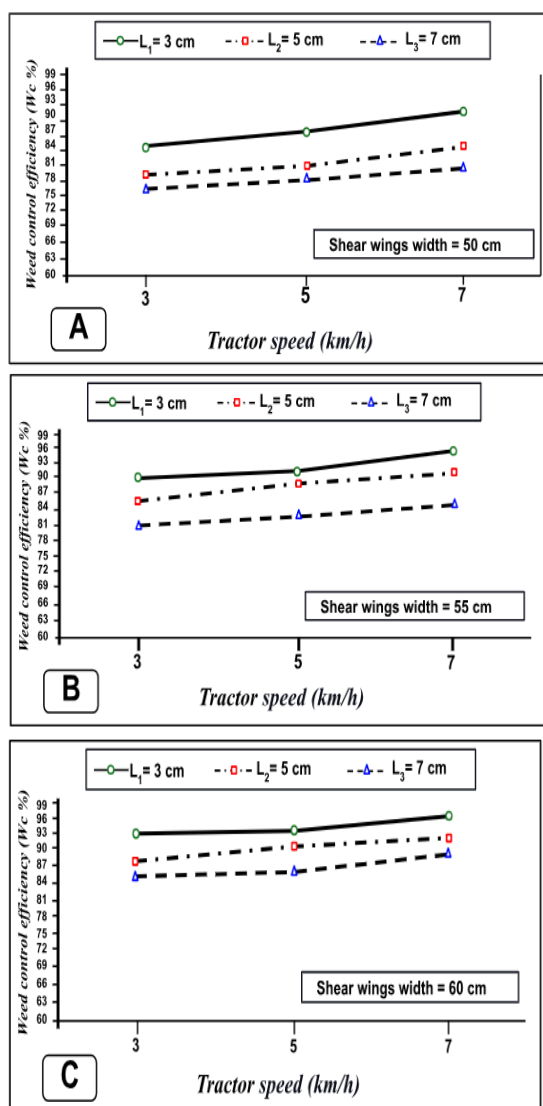


Figs. 5 (A to C). Weed removal efficiency (We%) at three levels of tractor speed (V) km/h, and width of shear wings (WW) cm with three levels of press wheel weights (W) kg

2- Weed control efficiency (Wc %) :

Weed control efficiency is measured 10 days after hoeing weed and irrigation. Figure 6 (A to C) shows that the highest weed control efficiency was (We = 96.4%) at the highest tread speed (V₃ = 7 km/h), the large edge wings width (Ww₃ = 60 cm), and the lowest straw lengths (L₁ = 3 cm). It is due to the quality of the straw pieces' overlapping, as the shorter their lengths. Make a more efficient cover. Overlap hinders weed growth. The high tractor speed and wide edge wings width also provide the best weed removal.

The lowest weed control efficiency was (We = 76.4%), and this was achieved at the longest lengths of straw pieces (L₃ = 7 cm), the slowest tractor speed (V₃ = 7 km/h), and the smallest edge wing width (Ww₃ = 60 cm). This trend is due to the lower weed removal efficiency with these treatments. The longer edge length, the less overlap between the pieces, and the greater the chance of weed growth.



Figs. 6 (A to C). Weed control efficiency (Wc%) at three levels of tractor speed (V) km/h, and width of shear wings (WW) cm with three levels of straw cutting lengths (L) cm

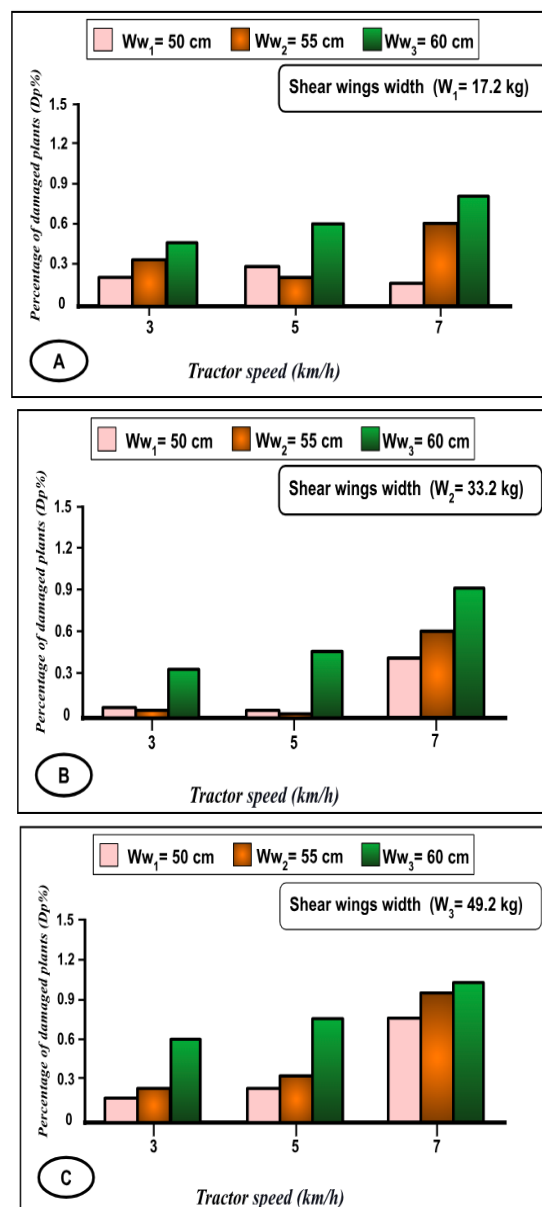
3- Percentage of damaged plants (Dp %)

Figure 7 (a-c) shows that the lowest plant damage rate was ($Dp = 0\%$) with a ($Ww_2 = 55$ cm) hoeing shear wings width, an average press wheel weight of ($W_2 = 33.2$ kg), and an average tractor speed of ($V_2 = 5$ km/h).

The highest plant damage rate was ($Dp = 1.05\%$) at a ($Ww_3 = 60$ cm) hoeing shear wings width, a tractor speed of ($V_3 = 7$ km/h), and a ($W_3 = 49.2$ kg) press wheel weight.

The experiment also induced a 0% rate with a lower hoeing shear wings width of ($Ww_2 = 50$ cm), a lower tractor speed of ($V_1 = 3$ km/h), and a lower wheel weight of ($W_3 = 17.2$ kg). Nevertheless, these results were not the best in terms of straw removal efficiency and the distance of the hoeing wings from the sides of the row. Consequently, removal efficiency was lower, and the control and resistance rates of weeds were lower.

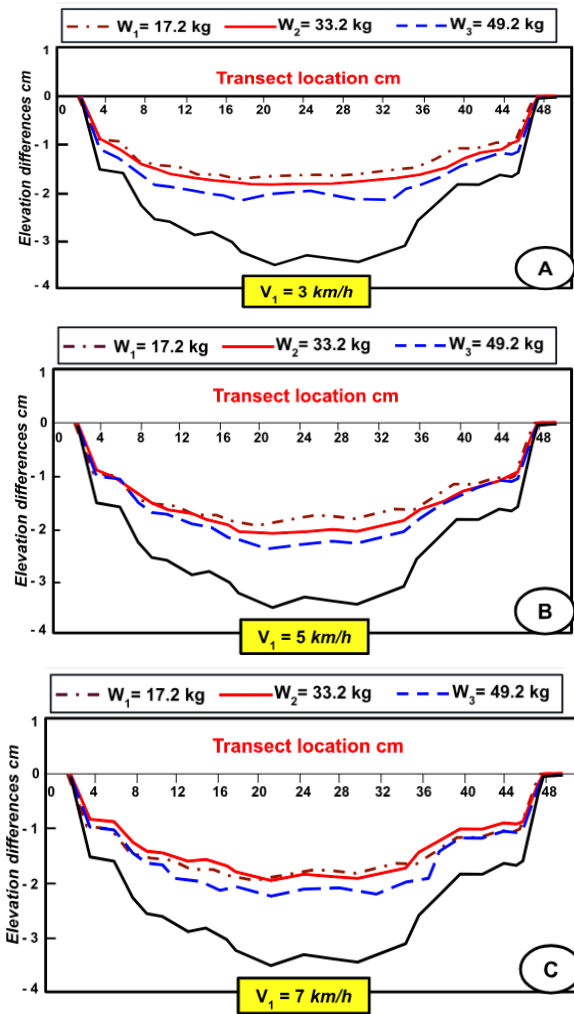
However, it is noted that the shear width of ($Ww_2 = 55$ cm) is the most appropriate due to its high effectiveness in eliminating weeds without harming the plant at an average speed. It is noted that adjusting the shear width to suit the width of the distance between the rows helps protect the plant without harming it.



Figs. 7 (A to C). Damaged plants percentage (Dp%) at three levels of tractor speed (V) km/h, and width of shear wings (WW) cm with three levels of press wheel weights (W) kg

4- Furrow profiles

Figure 8 (a to c) illustrates the effect of the weight of the press wheel on the regularity of the profile side row with the straw pieces. It is supposed that the greater the weight ($W_3 = 49.2$ kg) the more efficient the compression and levelling of the profile side row. However, the heavier wheel weight did not achieve the best shape due to crawling without the wheel rotating evenly. The best shape and regularity of the profile inter-row were achieved with the average weight of the press wheel ($W_2 = 33.2$ kg) at a low tractor speed ($V_1 = 3$ km/h). This occurred at straw pieces lengths of ($L_1 = 3$ cm), as this provided an advantage in overlapping the pieces and forming a more effective layer than larger pieces. It is prominent that increasing the speed increases the efficiency of cutting weed, but this negatively affects the regularity and shape of the profile inter-row. The results at a speed of ($V_3 = 7$ km/h) were irregular, mainly with the raised weight.



Figs. 8 (A to C). The furrow cross – section profiles at three levels of tractor speed (V) km/h, and three levels of press wheel weights (W) kg with straw cutting lengths ($L_1 = 3$ cm)

CONCLUSION

This study showed that the developed integrated hoeing weed unit performed highly efficient removing weeds and hindering their growth again, which led to reducing the number of hoeing weed times for the plant from three times to once during the plant period until harvest. This was done by forming a cover layer between the rows and compacting it to create a cover that hinders the growth of weeds again, as well as reducing irrigation operations by reducing water evaporation from the soil surface, which saves water quantities and rationalizes it. The results of the study showed that the best results were at an average tractor speed

of 5 km/h with the minimum length of straw pieces of 3 cm and an average press wheel weight of 33.2 kg, with the hoeing weed shear fixed at a 45-degree angle, where the efficiency of weed removal was ($We = 98\%$) while giving the best regular shape to the profile and the best compression and compaction of the straw layer without the presence of gaps to be as close as possible to an integrated cover that hinders the passage of the sun and reduces evaporation. The angle of the shear and the width of the shear wings are such that they fit on both sides of the two rows between which the shear passes, The best width of the shear wings was ($Ww_2 = 55$ cm). with the hoeing weed process being carried out at an early date when two leaves are on the plant. The plant damage rate was kept to a minimum ($Dp = 0\%$).

The tractor's excessive speed resulted in very efficient cutting and removing weeds, but with irregular profile shapes and scattered straw pieces, thus lowering the cover quality. On the other hand, large straw pieces had poor decomposition results, making them undesirable for use compared to smaller pieces. It was also observed that the heavier the compaction wheel, the less effective the compaction process was, with the wheel slipping or crawling occurring. Therefore, it is recommended to use a tractor speed of 5 km/h with straw pieces of 3 cm in length, an average compaction wheel weight of 33.2 kg and the shear wings width should be set to 55 cm to get the best results. It is also recommended that the number of machine units behind the tractor be repeated for many rows or more to achieve higher economic efficiency.

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آلة عزيق متكاملة تناسب استخدام قش الأرز

محمد نعيم الششتاوى على ، ماهر إبراهيم عبد العال ، طارق حسني الشبراوي المرسي و رباب عزت معنوق

قسم الهندسة الزراعية - كلية زراعة - جامعة المنصورة

المخلص

تمت هذه الدراسة لتطوير عذاقة ميكانيكية ذات سلاح عزيق مطور تحتوي على وحدة لإضافة قطع القش بعد عملية العزيق للتخلص من الحشائش وتحسين خواص التربة بين خطوط الزراعة وعجلة لتشكيل بطن الخط. تم تطبيق الآلة على الجرار لإجراء التجارب وأخذ القياسات وتم تجريب وحدة العزيق المتكاملة على محصول البنجر موسم زراعة ٢٠٢٣ تم إجراء التجارب الحقلية وأخذ القياسات بعد ١٠ يوم من الزراعة وتمت التجارب بقرية طنناح - محافظة الدقهلية. تم تجريب وحدة العزيق عند أربعة معاملات دراسية بينها كالتالي: ثلاثة سرعات للجرار (٣ - ٧) كم/ساعة - ثلاثة أطوال لقطع القش (٣ - ٧) سم - ثلاثة أوزان لعجلة الضغط (١٧,٢ - ٣٣,٢ - ٤٩,٢) كغ - وثلاثة أبعاد لعرض سلاح العزيق (٥٠ - ٥٥ - ٦٠) سم. ولتقييم أداء وحدة العزيق تم أخذ القياسات التالية: كفاءة إزالة الحشائش We % - كفاءة نمو الحشائش Wc % - نسبة الضرر في النباتات Dp % - شكل الفج بين خطوط الزراعة Fp . أظهرت هذه الدراسة أن وحدة العزيق المطورة قد حققت أعلى كفاءة في إزالة الحشائش وإعاقه نموها مجدداً، مما أدى إلى تقليل عدد مرات العزيق للنبات من ثلاث مرات إلى مرة واحدة خلال فترة نمو النبات وحتى الحصاد. وقد تحققت أفضل نتائج عند سرعة جرار متوسطة ٥ كم/ساعة وأطول قطع قش ٣ سم ووزن عجلة ضغط متوسط ٣٣,٢ كجم وعرض سلاح ٥٥ سم وذلك لما تم الحصول عليه من نتائج في كفاءة إزالة الحشائش ($We = 98\%$) وكفاءة مقاومة الحشائش ($Wc = 96,4\%$) مع أقل نسبة ضرر للنبات ($Dp = 0\%$) وأفضل شكل انتظامية لإعادة تشكيل بطن الخط.