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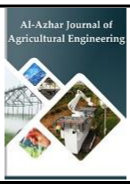

Full length article

Weeds control and crops furrow reconfiguration machine

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ABSTRACT

The main aim of this research was to fabricate a weed control machine and crops furrow reconfiguration. The machine was tested inter cabbage crop, to control weeds at the early stage of the crop growth, uproots and kill weeds along the furrow sides to avoid crop seedlings damage, with more plant support and facilitate irrigation along the furrow. The cultivator was fabricated and tested in the Faculty of Agricultural Engineering, Al-Azhar University, Assiut. The main results were the prototype of the cultivator was heavy and was consumed more power for transmutation to move, the research work improved the power transmutation and parts size and position it. The development included the main power shaft also, which changed from fixed length to variable length (A telescopic connection) to suit the crop. The optimum kinematic index (λ_2) and/or the 6 cm auger depth improved weeding efficiency. Using two augers with a ridger is more efficient than using two augers alone. The theoretical field capacity was 0.291 fed/h, actual field capacity was 0.22 fed/h and 75 % cultivator efficiency cabbage crop.

1. Introduction

Mechanical weed control is the most important method used in controlling weeds where it helps reduce the drudgery involved in manual hoeing but selective inter-row weeding operation by mechanical method requires both accurate transverse and longitudinal positional control to avoid crop damage. So far, commercial automated mechanical methods have not been developed for operation in the inter-row area (Melander et al., 2005). A few research projects, however, have identified prospective technologies that would allow highly selective mechanical weed control within crop rows (Wisserodt et al., 1999; Åstrand and Baerveldt, 2002; Blasco et al., 2002; O'Dogherty et al., 2007; Tillett et al., 2008).

Traditional weed control methods such as hand hoes and donkey pulled cultivators still have good weeding efficiency but are not recommended to be used because of it is high cost, more labor-consuming and more human effort done. So, the developed cultivator must have many advantages such as being suitable for the small-scale farmers, solving the problems of common cultivators, suitable for weeding operation in most types of crops, and in addition to simple construction. Awady (1986) designed and tested a power rotary cultivator. And he indicated that the big power and 4-rotor arrangement are suitable for orchard cultivation, while the small power and 2- rotor arrangement is suitable for inter-row cultivation. The forward speed decreases with depth. The forward speed varied between 0.65 and 0.31 km/h for depths between 5 and 13 cm. The specific time consumption per feddan ranged between 13 to 26 h/fed depending on the depth of cultivation. Hofmann (1993) said that mechanical weed control may be widely used in the near future, in spite of some serious disadvantages. One of the most serious is the low driving speed required for good steering along the plant rows. Simmone and Maguire (2004) indicated that the term 'cycloid hoe' refers to the combination of the circular movement of eight vertically directed tines and the linear movement of the implement in the direction of

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driving, leading to a cycloid tine trajectory covering both the intra- and inter-row areas. Melander et al. (2005) said that the selective intra-row weeding operation by hoeing requires both accurate transverse and longitudinal positional control to avoid crop damage. So far, commercial automated mechanical methods have not been developed for operation in the intra-row area. Abdel-Maksoud Y.S.A. (2008) developed a self-propelled harvesting machine to be used as tiller inter-rows in the maize field, determine the optimum parameters affecting the performance of the developed machine, and compare the developed machine with the traditional weeding methods.

2. Materials and methods

The machine was tested inter cabbage crop, to control weeds at the early stage of the crop growth, uproots and kill weeds along the furrow sides to avoid crop seedlings damage, with more plant support and facilitate irrigation along the furrow. Mechanical weeds control for vegetable crops especially can avoid the use of pesticides harmful to humans and the environment. The cultivator was fabricated and tested in the Fac. of Ag., Al-Azhar U., Assiut.

2.1. Cultivator Specifications

The hand steering cultivator frame is provided with a single rubber wheel. The soil working tines are represented in the two augers attached to the back of the frame. The auger tines suspended to the frame are inclined in the position of both sides of the frame. The soil agitation mechanism was powered by a 5.5 horsepower gasoline engine. A worm-type gearbox was used to provide an output speed reduction ratio of 1:33. An adjustable-height furrow opener is bolted at the end of the frame to reform the furrow after agitation. The engineering drawing is shown in Figs. 1 and 2.

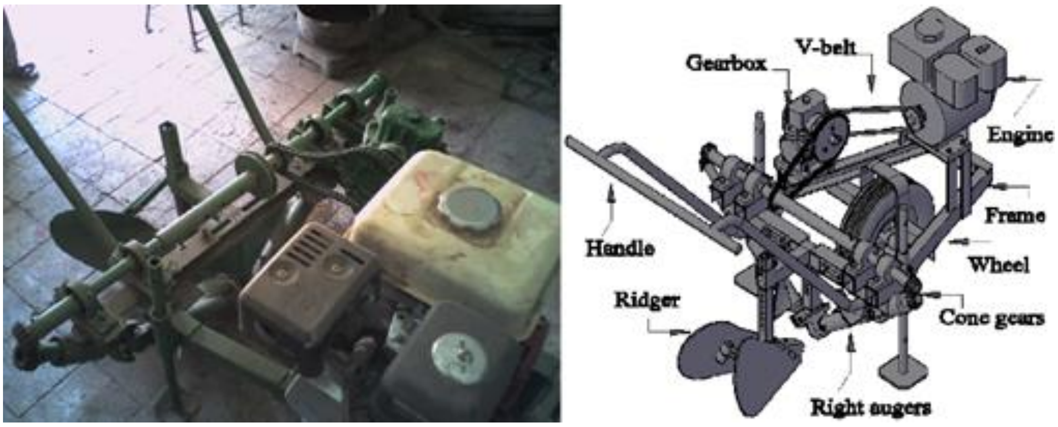

Fig. 1. Isometric of the designed cultivator

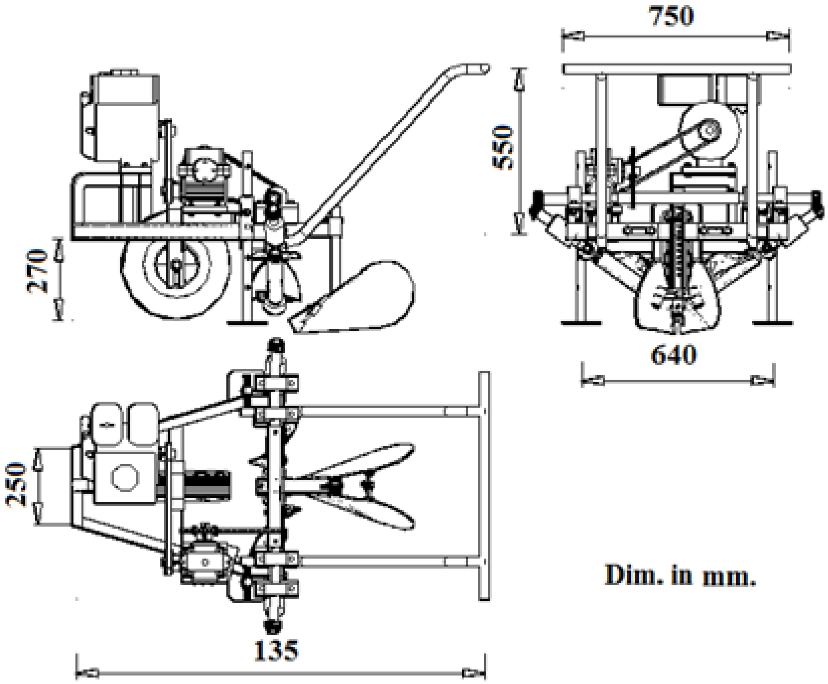

Fig. 2. The engineering drawing of the cultivator.

2.2. Mechanical cultivation of tomato crop using a single row cultivator

2.2.1. Cultivator components

The main components of the cultivator include:

- ***Frame***

The frame was formed from welded steel channels section 50 mm width × 35 mm height × 3 mm thickness. The trapezoidal-shaped frame of dimensions 600 mm width base, 250 mm narrow base and 700 mm width fabricated to fit the requirements of fixing the engine, attaching the ground wheel and bolting the bearings on which the drive system is positioned. The frame design considered the suitable size of the machine in relation to the power unit used, the hand steering by the labor and maneuvers insides one furrow.

- ***The power unit***

The soil agitation mechanism was powered by a 5.5 horsepower gasoline engine.

Gearbox

The gearbox reduces the speed by 1/33.

- ***Power transmission***

The power is transmitted from the engine to the gearbox through a v-belt and from the gearbox to the main power transmission shaft through pair of sprockets. There are pair of bevel gears are connected with the main power transmission shaft. These two bevel gears transmute the motion to the auger by universal joints with a different angle.

- ***Cultivation unit***

The cultivation unit is shown in Fig. 3. To facilitate increasing the capability of the machine for cultivating crops of a wide range of furrow widths and depths, the cultivation mechanism is connected to the main power transmission shaft with a smart connection. A telescopic connection was provided that overlapped with the transmission shaft and still connected to the cultivation auger tine with the bevel gear so that the width of cultivation could be easily changed.

- ***Ridger***

The ridger is shown in Fig. 4. The beam was fabricated from rectangular cross-section steel 30 × 30 mm. Holes were drilled on the beam to allow furrow depth adjustments. The two wings of the ridger are attached to the beam with hinges at the front ends of each wing. The backsides of the furrow opener wings are attached with a horizontally adjustable beam as shown in the figure to allow adjusting the width of ridge operation.

- ***Wheel and frame support axle***

One pneumatic wheel is positioned in the middle of the cultivator to carry the frame and other parts of the cultivator. The diameter of the wheel is 360 mm and the width is 100 mm.

2.3. Experimental variables

The performance of the cultivator was tested in the field at the existing soil moisture content (26.75 %) unit with and without the furrow opener.

2.3.1. Cultivation depth

The performance of the cultivator was tested under three different sizes of cultivation auger tines that were fabricated and tested:

1) Small size D1 = 3 cm tine width,
2) Midsize D2 = 4 cm tine width and
3) Large size D3 = 6 cm tine width.

2.3.2. Kinematic index (λ)

$$\lambda = \frac{N}{V} \qquad [1]$$

where:
λ = Kinematic index,
N = Auger linear speed (m/s), and
V = Forward speed (m/s).

N = 2πrn where: n: auger's different rotation speeds (rpm), N: auger linear speed (m/s) and r: radius of auger's rotation (m). The cultivator was tested under three kinematic index values as shown in Table 1 at three auger's different rotation speeds 230 rpm, 160 rpm and 115 rpm.

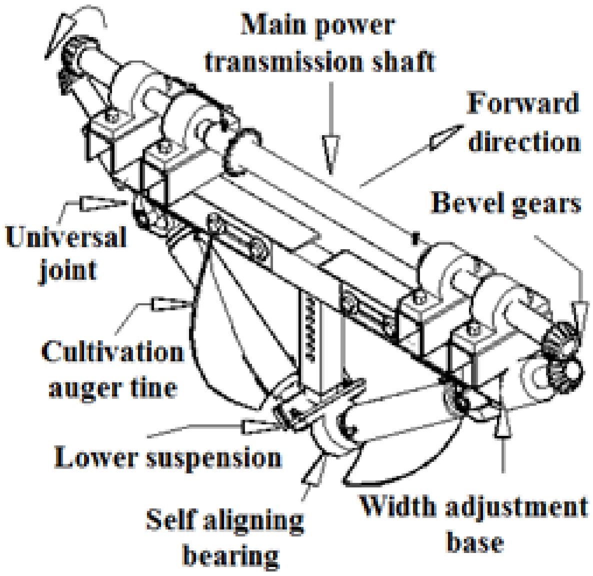

Fig. 3. The cultivation unit.

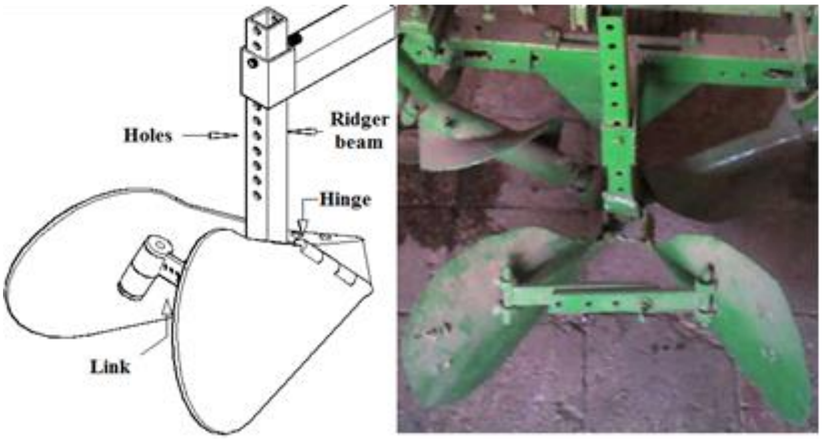

Fig. 4. The ridger to crops furrow reconfiguration.

Table 1.
Kinematic index (λ) at the radius of auger's rotation.

Kinematic index (λ)	The different auger's linear speeds (N) (m/s)	Averages of the wheel's linear speeds (v). (m/s)	Speed ratio
λ_1	2.0232	0.34	5.95
λ_2	1.4074		4.14
λ_3	1.0116		2.97

2.4. Measurements

2.4.1. Weeding efficiency

A wooden frame (1m × 1m) was used to determine the number of standing weeds in grams before and after the cultivation. The dry weight of weeds was determined by electric oven drying at 60° c for 18 hours according to **Jackson, (1967)**. The efficiency of weed control was calculated using the following formula according to **Abdel-Latief, (1992)**:

$$\eta_w = \frac{D_{wb} - D_{wa}}{D_{wb}} \times 100 \qquad [2]$$

where

η_w = The weeding efficiency (%).
D_{wb} = The dry weight of weeds (g/m²) collected before cultivation.
D_{wa} = The dry weight of weeds (g/m²) collected after cultivation and 5 days later.

2.4.2. Injured plants percentage

Injured plants percentage was counted from some rows for a certain distance immediately after cultivation and 5 days later to determine the number of injured plants according to **Hemeda and Ismail, (1992)** by using the following equation:

$$D = \frac{J_1 - J_2}{J_1} \times 100 \qquad [3]$$

where

D = The percentage of injured plants (%).
J_1 = The total number of plants within an adjusted distance before cultivation operation.
J_2 =The total number of injured plants immediately after cultivation operation and five days later within the same adjust

2.4.3. Furrow profile

The furrow profile was drawn before and after cultivation. The cross-section was drawn by using a straight wood piece marked every 5cm and a water level was used to adjust the longitudinal line at the furrow bottom. Average readings were computed to draw a furrow profile. Furrow profile replicates were taken ten times for each experiment.

2.4.4. Theoretical field capacity

The theoretical field capacity was determined using the following equation:

$$\mathrm{T.F.C.} = \frac{W \times S}{4.2} \qquad [4]$$

where

T.F.C. = The theoretical field capacity (fed/h).
W = The theoretical width (m).
S = Average forward speed (km/h).

2.4.5. Actual field capacity

The actual field capacity was determined using the following equation:

$$\mathrm{A.F.C.} = 1/T \qquad [5]$$

where

A.F.C. = The actual field capacity (fed/h).
T = Actual time (min).

2.4.6. Field efficiency

The Field efficiency was determined using the following equation:

$$\eta_f = \frac{\mathrm{A.F.C.}}{\mathrm{T.F.C.}} \times 100 \qquad [6]$$

where

A.F.C. = The actual field capacity (fed/h).
T.F.C. = The theoretical field capacity (fed/h).

3. Results and discussions

3.1. Effect of Kinematic index (λ) on weeding efficiency

Figs. 5 and 6 illustrate the effect of the relationship between the kinematic indexes (λ) and cultivation depths on weeding efficiency (%). The results explained that the improved quality of weeding efficiency with the kinematic index (λ_2) for any cultivation depths and the improved quality of weeding efficiency with increase depth of cultivation auger tines. This may be due to cultivator balancing during work at kinematic index (λ_2) than the kinematic index (λ_3), while at kinematic index (λ_1) the power is not enough to uproot the weeds from the soil. Moreover, observed that the wedding efficiency was higher at used two augers with ridger in comparison with used two augers alone at any given kinematic index (λ). This may be due to the performance of the furrow opener behind augers whereas its function cutting more weeds and cover it around the crop plants also, burial the weeds in the bottom and furrow sides behind augers.

The results observed that the weeding efficiency was increased by increasing the depth of cultivation auger tines. In addition, the weeding efficiency was slightly higher after cultivation by 5 days than that immediately after cultivation at any given cultivation depth. This may be due to the effect of cultivation depth on weed roots which were not completely uprooted and still grow after cultivation.

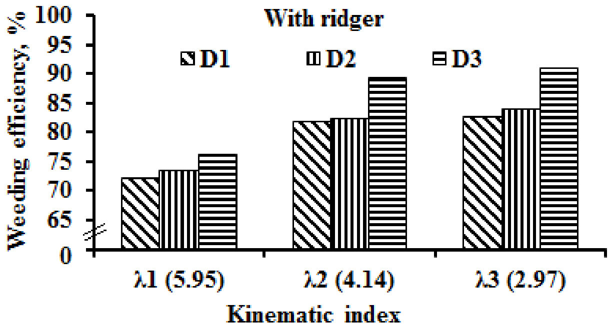

Fig. 5. Effect of (λ) on weeding efficiency (With ridger).

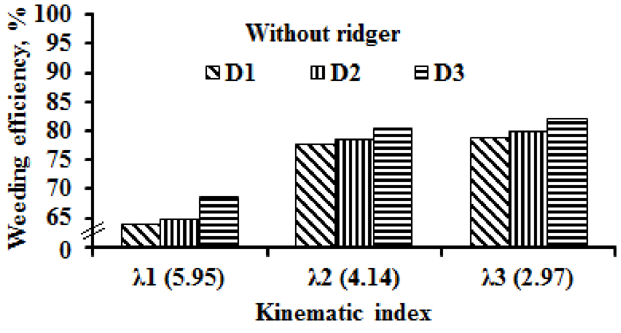

Fig. 6. Effect of (λ) on weeding efficiency (Without ridger).

3.2. Furrow profile

The shape of the furrow profile was drawn before and after cultivation to observe the effect of using a cultivation unit on the shape of the furrow profile at the existing soil moisture content of 28.75 % for the cabbage crop. Fig. 7 illustrates the effect of using the cultivation unit on the shape of the furrow profile.

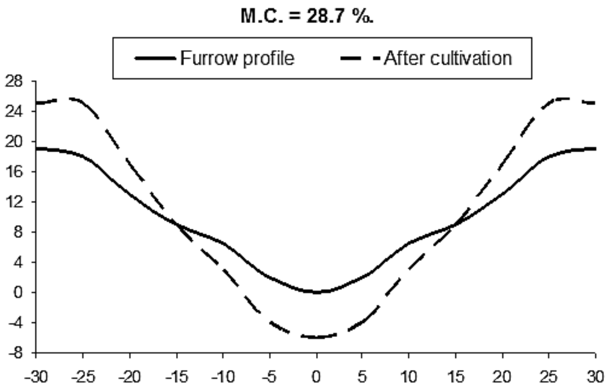

Fig. 7. Effect of using cultivation unit on furrow profile for cabbage crop.

3.3. Injured plants percentage

The percentage of injured plants due to operating the cultivator was calculated directly after cultivation and five days later as recommended by (Hemeda and Ismail 1992). The percentage of injured plants was determined at the existing soil moisture content of 28.75 %. Actually, the data shows that the percentage of injured plants did not change after five days from cultivation. The criteria of the cultivator design were to determine the dimension of the auger tine to cover the area on both sides of the furrow. The auger tine length, diameter and auger inclination were measured precisely and adjusted to minimize crop seedlings damage and to maximize the cultivated area. Due to variation of the crop seedlings' size, orientation and centralization upon the furrow top, some seedlings may obstruct the end of the shaft that provides the auger tine with power. Several accidents of seedling damage could be avoided if well-trained labor operated the machine. It was also observed that when increasing the speed ratio of the auger tine, the percent damage may slightly be increased due to more fatigues of the labor which may cause less control on the cultivator steering. The percentage injured was may rarely exceed 1.0 % in the case of cabbage seedlings. As a matter of fact, some crop seedlings may be scattered around the central line of the furrow top which may be one of the major reasons for the limited percent of damage recorded during the tests. In many cases, the first cultivation is done before the crop thinning, where the number of crop plants is much more than required. In these particular conditions, damage to some seedlings will not affect the crop density.

3.4. Field capacity and efficiency

Field capacity and efficiency of the cultivator measured under the average forwarding speed (V = 0.34 m/s), optimum kinematic index ($\lambda_2 = 4.14$), cultivation depth (D = 6 cm) and using the ridger that was mounted behind the augers cultivation for cabbage crop. It includes the effect of time lost in the field due to adjusting the width of the cultivation unit, the turns at the end of the furrow and refilling the fuel tank. The value of the theoretical field capacity calculated at the base of the width of the cultivation unit is 0.291 fed/h. The value of the actual field capacity measured in the field at the base of the actual time of cultivation operation desirable is 0.218 fed/h.

4. Conclusions

The obtained results can be concluded as follows:

1) The prototype of the cultivator was heavy and has required more power transmutation to move it, the research work improved the power transmutation and parts size and position it.
2) The development included the main power shaft also, which changed from fixed length to variable length (A telescopic connection) to suit the crop.
3) The optimum kinematic index λ_2 ($\lambda_2 = 4.14$ which was 160 rpm auger's rotation speeds on 0.34 m/s forward speed) improved the quality of weeding efficiency.
4) The optimum depth of cultivation auger tines (D = 6 cm) this depth achieves improved weeding efficiency.
5) Using the cultivation unit consisting of two augers with a ridger was superior to using the cultivation unit consisting of two augers alone.
6) Theoretical field capacity was 0.29 fed/h, the actual field capacity was 0.22 fed/h and the efficiency of the cultivator was 75 %.

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آلة مقاومة الحشائش وإعادة تشكيل خطوط المحاصيل

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الملخص العربي

الهدف الرئيسي من هذا البحث هو تصنيع آلة لمكافحة الحشائش وإعادة تشكيل الخط لتسهيل جريان مياه الري للمحاصيل المنزرعة على خطوط. تم اختبار الآلة للعزيق بين خطوط محصول الملفوف (الكرنب)، وإثارة التربة واقتلاع الحشائش على طول جوانب الخط لتجنب تلف الشتلات، ودفع التربة حول البادرات مع إعادة تشكيل الخط لتسهيل جريان مياه الري على طول الخط. تم تصنيع العزاقة واختبارها في كلية الهندسة الزراعية جامعة الأزهر بأسيوط. وقد كانت النتائج الرئيسية أن النموذج الأولي للآلة كان ثقيلًا ويحتاج مجهود للحركة والمناورة داخل الخط، وقد تميز التصميم بوجود عمود نقل القدرة الرئيسي التلسكوبي الذي يتيح امكانية تغيير عرض تشغيل الآلة. تحقق أفضل آداء للآلة مع الدليل الكينماتيكي للحركة (λ_2) وعمق ريشة بريمة العزيق التي تساوى ٦ سم، مع ضرورة وجود فجاج خلف أسلحة العزيق البريمية لزيادة كفاءة عملية العزيق. كما أظهرت النتائج أن السعة الحقلية النظرية كانت ٠,٢٩١ فدان/ساعة، وكانت السعة الحقلية الفعلية ٠,٢٢ فدان/ساعة مع كفاءة عزيق ٧٥٪.