Agricultural engineering programs as related to employment requirements: 430 - 440

AN AUGER TINE INTER FURROW CROP CULTIVATOR.

H. A. Abdel Mawla[1], A. M. El-Lithy[2], E. M. Arif[3] and N. S. M. Ali[4]

ABSTRACT

The main aim of this research was to develop and test an implement for inter furrow cultivation. The unit is supposed to uproot and kill weeds at the early stage of the crop growth along the furrow sides and avoid crop seedlings damage. The unit also should open furrows to facilitate easy irrigation. The cultivator was fabricated and tested in the Faculty of Agriculture, Al-Azhar University, Assiut. The preliminary experiments show that the prototype of the cultivator was heavy and required high power to move. The unit was modified to improve power transmission. The main power shaft was developed to a telescopic shaft to permit adjusting the machine cultivation width according to furrow width. The ratio of the auger tine tip linear speed to the forward speed (λ) is considered one of the important parameters of testing the unit. The value of λ_2 = 4.14 showed the most efficient adjustment. The most efficient results also were achieved at cultivation depth 6 cm. the performance of the prototype equipped with ridger was improved because the ridger opens the furrow better for irrigation. The well fabricated prototype may cultivate 0.15 to 0.22 fed/h at 75 % cultivator efficiency.

INTRDODUCTION

Mechanical weed control is the main operation used for weed control. The operation reduces the drudgery involved with manual hoeing. Mechanical method requires both accurate transverse and longitudinal positional control to avoid crop damage. So far, commercial automated mechanical methods are not spread 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

[1] **Prof. and head of Ag. Eng. Dep., Fac. of Ag., AL-Azhar U. Assiut.**
[2] **Assoc. Prof., Ag. Eng. Dep., Fac. of Ag., AL-Azhar U. Assiut.**
[3] **Prof., Ag. Eng., Ag. Res. Cen., Ag. Eng. Res. Institute.**
[4] **Demonstrator, Ag. Eng. Dep., Fac. of Ag., AL-Azhar U. Assiut.**

(Awady, 1986; 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 have still good weeding efficiency but not recommended to be used because of their 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, solve 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. He indicated that the big power and 4- rotor arrangement are suitable for orchard cultivation, while the small power and 2- rotor arrangement are 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)** indicated that mechanical weed control may be widely used in the near future, in spite of some serious disadvantages. One of the most serious disadvantages 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 driving, leading to a cycloid tine trajectory covering both the intra- and inter-row areas. **Melander et al. (2005)** indicated that the selective intra-row weeding operation by hoeing requires both accurate transverse and longitudinal positional control to avoid crop damage. **Abdel-Maksoud (2008)** developed a self propelled harvesting machine to be used as tiller inter-rows in maize field, determine the optimum parameters affecting on the performance of the developed machine, and compare the developed machine with the traditional weeding methods.

MATERIAL AND METHODS

Cultivator description.

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

Cultivator components.

The detailed descriptions of the essential parts of the cultivator are shown in Figure (1). The main components of the cultivator include:

1. Frame.

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 was 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.

2. Power unit.

The cultivator was powered by 5.5 horsepower gasoline engine at 3600 rpm. A gearbox reduces the speed by 1/33 was used to transmit power to the ground wheel of the unit.

3. Power transmission.

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

4. Cultivation auger tine size.

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

Small size D_1 = 3 cm tine width, mid size D_2 = 4 cm tine width and large size D_3 = 6 cm tine width. Figure (2) shows the auger tine size.

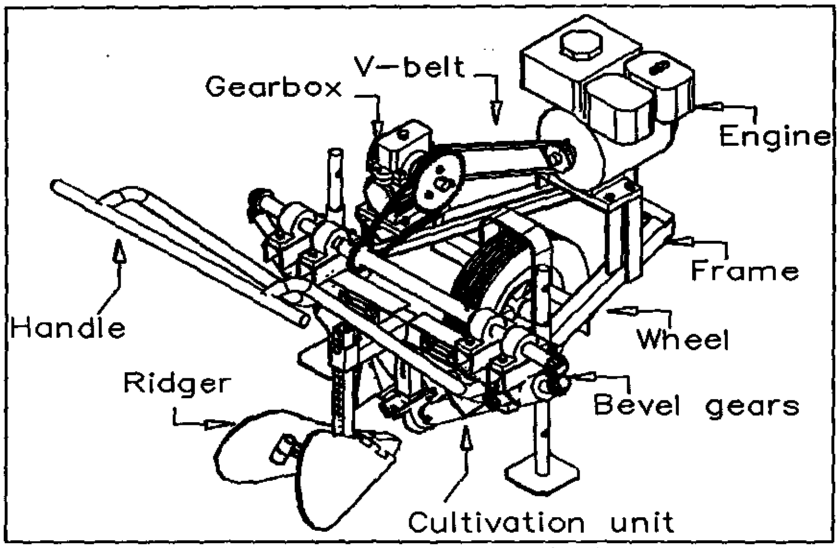

Fig. (1) Isometric of the designed cultivator.

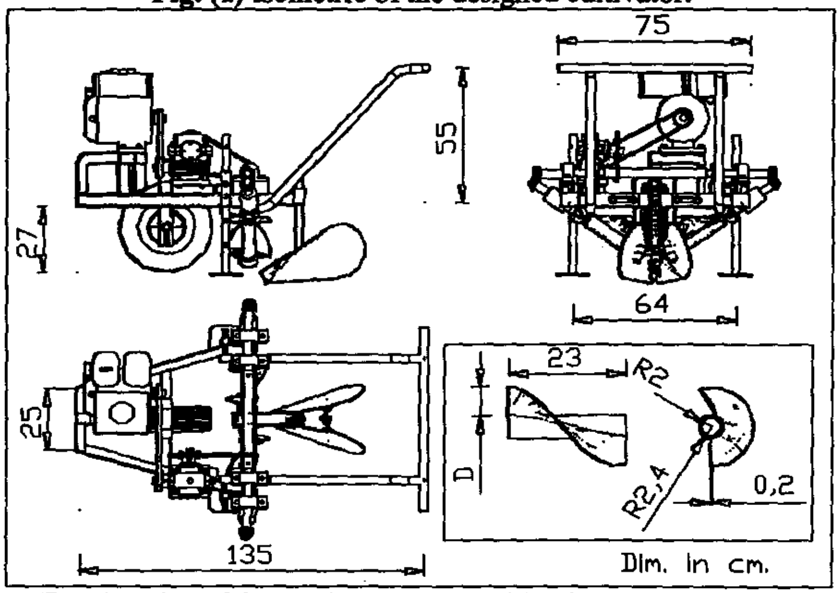

Fig. (2) The cultivator drawing and cultivation auger tine size.

6. Ridger.

The two wings of the ridger were attached to the beam with hinges at the front ends of each wing. The backsides of the furrow opener wings were attached to each other with a horizontally adjustable beam to allow adjusting the width of ridge operation.

7. Wheel and frame support axle.

One pneumatic wheel was positioned in the middle of the cultivator to carry the frame and other parts of the cultivator. The size of wheel is 4.00 - 8.

Methods.

Testes were run to evaluate the performance of the cultivation unit with and without the furrow opener. The performance of the cultivator was tested in the field at the existing soil moisture content. The soil moisture content was determined and recorded. The cultivator was tested under three speed ratio values 5.95, 4.14 and 2.97.

$$\text{Speed ratio } (\lambda) = \frac{Auger\ tine\ tip\ linear\ speed\ m/s}{Forword\ speed\ m/s}$$

(1) Soil collapse.

Standard sieves were used for mechanical analysis of soil after cultivation to determine soil agitation. Samples were collected after cultivation at surface levels of soil (cultivation zones).

(2) Weed removal efficiency.

Figure (3) shows the way to record the weeds density before and after cultivation, and to facilitate determine weed removal efficiency. The furrow was divided to samples each of 1 m along the furrow. The weed numbers were recorded on the field notes counted and classified according to variety. The same job was repeated after cultivation and weed removal efficiency was computed: initial

$$\text{W.R.E.} = \frac{Weed\ \ removed}{Initial\ \ weed\ \ found}$$

(3) Injured plants percentage.

Injured plants percentage was counted from some rows for certain distance immediately after cultivation by using the following equation:

$$D = \frac{J_1 - J_2}{J_1} \times 100$$ where: initial found before cultivation

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 within the same adjustment.

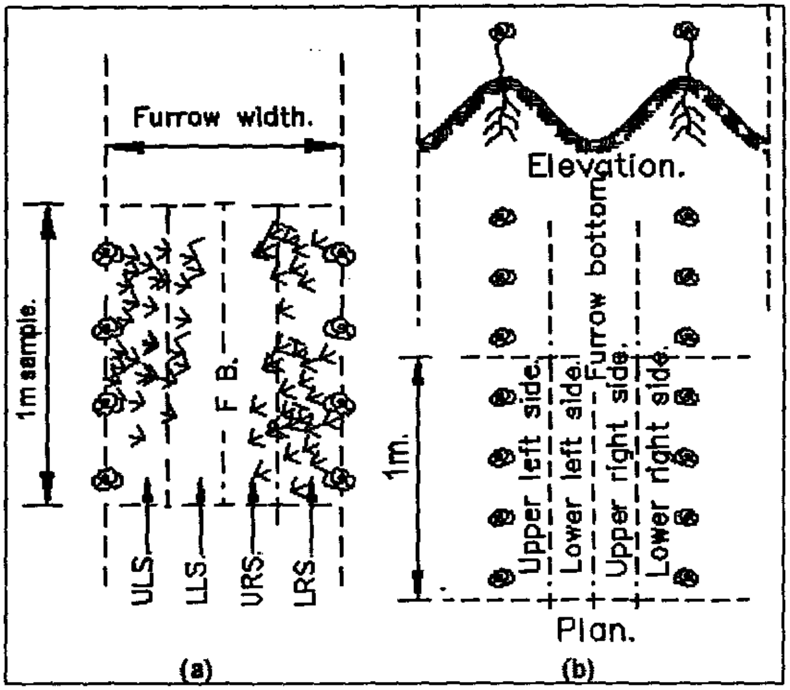

Fig. (3) Method of determining weed removal efficiency.
(a) Weed density distribution before cultivation.
(b) Furrow profile and cultivation zones.

(4) Cultivator productivity.

Cultivator performance was estimated in terms of weed removal efficiency, injured seedlings percentage, soil collapse, machine productivity and costs were compared to labor methods.

RESULTS AND DISCUSSION

(1) Soil agitation.

Preliminary experiments conducted to test the machine included 3 auger tines of three sizes. The length and pitch of the auger tine was fixed while the auger lip height was variable. Auger tines of lip height 3, 4 and 6 cm were tested. Actually, the cultivation depth was close to the lip height. Observation of the cultivated furrows showed that, in case of the 3 cm auger tine, the cultivation depth was shallow and many weeds were left without uprooting. The performance of the 4 cm lip tine was not considerably improved compared to the previous one.

Accordingly, it was decided to use larger auger tine. The 6 cm lip height auger tine slowed more improved performance of the cultivator from the point of view of soil agitation as well as weed uprooting. The rest of the experiments were completed using the 6 cm lip height auger tine.
Figure (4) shows the soil mechanical analysis of the cultivated soil which was done directly after cultivation. About 30% by weight of the soil sample was of cloud sizes little more than 2.5 mm and over 60% of the soil sample weight was of clod sizes less than 1.25 mm.

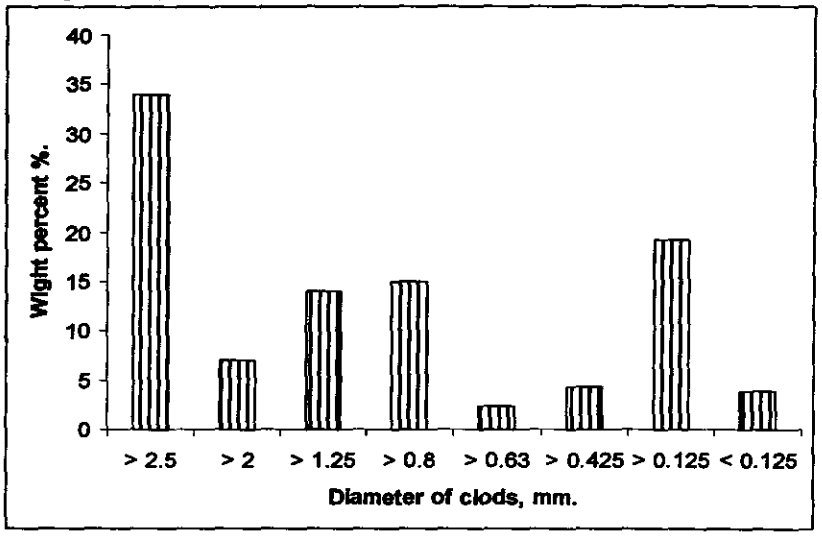

Fig. (4) Soil mechanical analysis of the cultivated soil.

(2) Weed removal efficiency.

Table (1) shows the weed removal efficiency data as recorded when operating the machine to cultivate corn crop at the experimental farm of the university. The machine, provided with a 6 cm lip auger tine, was operated at 160 rpm and 0.34 m/s. The data of five trails were calculated and recorded in the Table (2). The initial number and type of weeds were counted and recorded before cultivation. A distribution map was drown to permit estimation of the cultivation tine behavior and capability of weed removing. After cultivation, the weeds left behind without uprooting or killing was also counted and their positions were localized. Weed control efficiency was then computed according to the equation mentioned methods.
As shown in the table, weeds were not uniformly grown on the furrow. Some samples of 1m long included as much as199 weeds of different

varieties. Some other samples of 1m long also included only 62 weeds. Where after cultivation, 60 weeds were left in the high weed density sample (199) with weed removal efficiency about 68%. In case of the weed sample 62 weed/m before cultivation only 11 weed were still not uprooted after cultivation, which represented 83% weeding efficiency. Weeding efficiency seems to depend more on the type of the weed itself. The deep root weeds and these of hard thin stalks largely resist uprooting. It was observed that *Premade grass* and *Half grass* resist uprooting because of the deep root and the high tensile strength of the stem.

(3) Percentage injured seedlings.

The criteria of the cultivator design were to determine the dimension the auger tine to cover the area on both sides of the furrow. The auger tine length, diameter and auger inclination were precisely measured and adjusted to minimize crop seedling damage and to maximize the cultivated area. Due to the 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 a well trained labor operated the machine. It was also observed that when increasing the speed relation of the auger tine the percent damage may slightly be increased due to the more exhaust of the labor and may have less control on the cultivator steering. Percentage injured also may vary according to the crop variety where some crop seedlings may be more fragile than the other. Percentage injured was always less than 1.2% for Corn seedlings and may rarely exceed 1.0% in case of Cabbage seedlings.

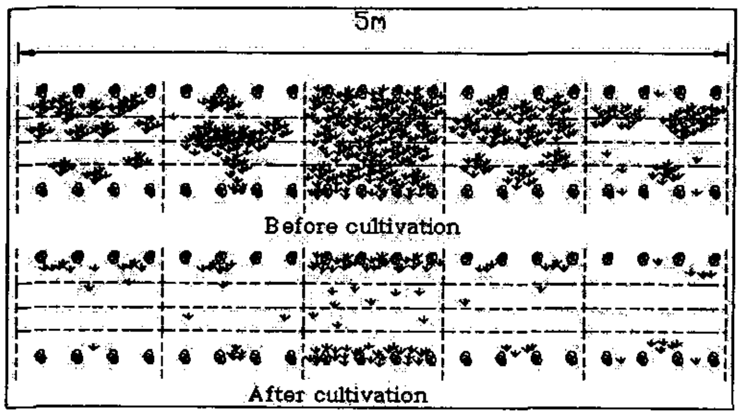

Fig. (5) Weeds density distribution after and before cultivation.

Table (1) Number of weeds and weed removal efficiency at cultivation zones.

Cultivation Zones.	Furrow portion rank										Average		W.R.E (%)
	1		2		3		4		5				
	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	
Upper right side	33	10	12	7	53	27	28	7	22	4	30	11	63.3
Lower right side	27	2	32	1	49	5	34	2	25	0	33	2	94
Furrow bottom	0	0	6	0	8	1	5	0	0	0	4	0	100
Lower left side	5	0	35	2	38	3	14	0	3	0	19	1	95
Upper left side	13	1	9	5	51	26	16	4	12	7	20	9	55
Total	78	13	94	15	199	60	97	13	62	11	106	23	78.3

Table (2) Number and variety of weeds not removed after cultivation.

Variety weeds	Furrow portion rank				
	1	2	3	4	5
Rough cyperus	2	0	12	0	0
Halfa grass	1	2	4	1	0
Purslane	5	5	25	5	3
Lasser bind weed	0	0	4	0	0
Bermuda grass	4	6	18	7	8

(3) Cultivator productivity and costs.

The cultivator tested within this research is an experimental unit fabricated to prove the success of the idea and to prove that single wheel hand steering cultivator to cultivate the furrow planted crop.

The cultivator was modified to secure continuous operation with reasonable exhaust of the labor. Actually, the machine showed productivity higher than a single laborer. The unit is considered promising for modification to duplicate the unit productivity and to reduce the labor exhaust. Further research work is required to modify the unit for higher productivity and reliability. The machine performance may be largely improved with minimum effort and modifications.

CONCLUSION

A compact size single wheel cultivator was designed and tested to be capable of cultivating between the crops planted on furrows. The most important goal was to make the unit move inside the furrow and cultivate both furrow sides, which means agitating soil to suitable depth and kill weeds. The unit was provided with two auger tines mounted parallel to the furrow sides. Preliminary experiments were run to determine the possible front speed of the unit and the ratio of auger tine linear speed to front speed to achieve maximum soil agitation and weed removal.

The test results of soil mechanical analysis shows that about 60% of the soil sample (by weight) clod size was less than 1.25 mm diameter. Weed removal efficiency ranged from 70% to 83% depending on the type of weeds. Damage to crop seedlings ranged from 0.5 to 1.5%. A further study to modify the unit for higher weed removal efficiency and lower labor exhaust is required.

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<u>الملخص العربي</u>

عزاقة بين خطوط المحاصيل ذات أسلحة بريمية.

ا.د/ حسن عبد الرازق عبد المولي[١] ، د/ أحمد ماهر الليثي[٢]
ا.د/ الأمين محمد عارف[٣] ، م/نبيل شعبان محمود علي[٤]

صنعت وجربت وحدة للعزيق داخل المحاصيل المزروعة علي خطوط بهدف إيجاد وسيلة ميكانيكية ناجحة تؤدي في النهاية لتصنيع آلة يمكن عن طريقها الاستغناء عن الفأس. وقد وضعت بعض المعايير المهمة لتصميم تلك الآلة وكان من أهمها أن تكون منضغطة الحجم بحيث تتحرك داخل خط واحد. وأن تستمد الأسلحة قدرتها من محرك بترولي صغير لضمان الحصول علي قدرة كافية لإثارة التربة وإزالة الحشائش. أيضا تكون متزنة بالرغم من حملها علي عجلة وحيدة. وكذلك تكون أسلحتها مائلة ميلا" يوازي جانبي الخط وإمكانية ضبطها وأيضا تكون موجه بالعامل وسهلة الحركة علي طول الخط لتتميز بالقدرة علي المناورة في نهاية الخط والدوران من خط للمجاور له دون الإضرار بالنباتات. وقد تمت تجربة الآلة في محصولي الذرة والكرنب. وأظهرت النتائج أن الأسلحة البريمية قامت بإثارة التربة بدرجة جيدة حيث كانت ٦٠% من حجم القلاقيل الناتجة أقل من ١,٢٥ سم. كما بينت النتائج أن كفاءة إزالة الحشائش تراوحت من ٧٠% إلي ٨٣% حسب نوع الحشائش. وتراوحت نسبة الضرر لنباتات المحصول من ٠,٥% إلي ١,٥% حسب ظروف التجربة.

١- استاذ ورئيس قسم الهندسة الزراعية – كلية الزراعة جامعة الأزهر فرع اسيوط.
٢- استاذ مساعد الهندسة الزراعية – كلية الزراعة جامعة الأزهر فرع اسيوط
٣- استاذ الهندسة الزراعية _ معهد بحوث الهندسة الزراعية _ مصر.
٤- معيد بقسم قسم الهندسة الزراعية – كلية الزراعة جامعة الأزهر فرع اسيوط.