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DEVELOPMENT AND PERFORMANCE EVALUATION OF A PULLING FLAX MACHINE

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ABSTRACT

The laboratory experiments were carried out through the successive agricultural seasons of (2008-2009) at the center laboratory of Agricultural Engineering Research Institute (AEnRI) Dokki – Giza. Field experiments were conducted at the experimental farms of Gemmaiza Research Station, Gharbia Governorate, during the harvesting season of (2009), to develop the lentil pulling machine to be suitable for pulling flax crop using available locally materials to construct, modify and develop flax pulling machine. The developed machine consists of two vertical conveyor belts and power transmission. The developed machine was evaluated by measuring pulling efficiency, harvester performance (actual field capacity and field efficiency), fuel consumption rate, energy requirement and criterion cost under the studied variables; machine forward speeds of 1.44, 2.16, 2.57 and 4.5 km/h, finger rotating speeds of 0.393, 0.524, 0.654 and 0.837 m/s and soil moisture contents of 15.75, 18.35, 21.96 and 29.24 % (w.b). The obtained results concluded that the developed machine can be worked at the optimum operating parameters of 2.16 km/h forward speed, 0.654 m/s finger rotating speed (kinematic ratio of 1.18) and 21.96 % soil moisture content to obtain the suitable performance in pulling efficiency of 98.30%, actual field capacity of 0.46 fed/h, field efficiency of 80.00%, fuel consumption of 5.60 l/h, energy requirements of 38.7 kW.h/fed and criterion cost of 163.70 L.E/fed.

1. INTRODUCTION

Flax is one of the most important fiber crops in the world today. It plays an important role in Egyptian national economy due to export as well as local industry. It is grown in Egypt and some other countries as a dual purpose for seeds and fibers.

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In Egypt, flax is cultivated in total area of about 12784 fed. (New land 453 fed. and Old land 12331 fed.), total productivity 55359 ton (new land 1662 ton and old land 53697 ton) (**Economic Affairs Sector 2009**). The Flax must be harvesting by pulling system to defend the crop economics. The shortage of hand labors in Egyptian agriculture has become a pressing problem in recent years. This shortage, has led to a continuous increase in the cost of agricultural production labors cost of 300 L.E and need of 8-10 labor. This problem has become an urgent one particularly in the pulling period of flax crop, which are presently pulling by hand. **Ibrahim (1983)** indicated that the pulling force required uprooting flax plant ranged from 8 to 34 N which is considered triple the pulling force value at Belarosia, the coefficient of friction ranged from 0.25 to 0.47 which was found less than its value at Belarosia. The force of uprooting (cutting), at the lowest third portion of the stalk ranged from 45 to 164 N. The minimum value of pressure on stalks at which mechanical damage may occur was found to be 120 kPa. **Klenin et al. (1985)** reported that the flax pullers may be in the form (a) Straight belt conveyor and rollers consist of two endless puller belts running over the driven pulleys, the driven pulleys and the rollers which keep the two belts passed together. The dividers feed the stalks to the puller rolls, which grip them at the point of contact of the two belts. The stalks are held over the zone where the belts are in close contact. (b) Curvilinear belt conveyor and rollers: Consists of a puller belt, puller disks, clamping rollers, and a guide plate. The stalks are passed between the belt and the disk. Simultaneous with the pulling operation, the stalks are conveyed to the left (in the direction of motion of the machine). Between the disks, the stalks are transported by the pressure exerted on them by the guide plate. **Hunt (1986)** stated that the forward speed is probably the most important factor in optimizing the performance of a machine harvester. Several investigations have determined that total losses increase rapidly as forward speed increase, because of over loading, rack losses, particularly, rise with an increase in speed. The increase in rack loss appears to be directly proportional to speed and can amounted by 4% of the total yield as speed increased from 3.2 to 5.6 km/h in heavy yielding grain. **Rodjief et al. (1986)** used the belt and disk puller (TLN) which was made in Russia for pulling flax plants an arranging the harvest stalks in windrows. The pulling device has to be mounted on the three points linkage of the tractor, which is a reversible motions tractor. Therefore, the puller acts as a front mounted machine. The pulling device inclination angle to the horizontal, which depends on the flax stalks length and ranges from 150 to 200 for long stalks 80 to 100 cm, and could be adjusted by changing the top link length. **Abdel-Wahab (1987)** designed a prototype of lentil walker puller to pull the lentil plants under manual and mechanical planting. Three types of cylindrical and conical shape for pulling fingers with clearance of 6.0, 20.6 and 22.8 mm were tested. **Hamad et al. (1991)** found that pulling efficiency reaches its maximum value of 92 % at speed ratio equal to 4.07 (between finger rotating speed and machine forward speed) and using the modified pulling flax machine, reduce the hourly operating costs for about 3.21 times compared with manual pulling. **Abdel-Wahab (1994)** reported that the pulling force increased by increasing the lentil stem diameter and decreasing moisture content of plant. The values of pulling forces were 68 and 42 N/plant, moisture content of 15 % and 32 %, respectively at lentil stem diameter of 6 mm. While the values were 15 and 7 N/plant at moisture content of 15 % and 32 % and stem diameter of 2 mm, respectively. **El-Sharabasy (2003)** developed and constructed a lentil pulling machine in (ATB), Germany. The developed machine tested in Egyptian fields to determine the suitable conditions for lentil pulling. He mentioned that, the minimum fuel and energy required were 0.84 L/fed and 1.65 kW.h/fed recorded under seed drilling planting method 22 cm spacing between rows at finger rotating speed of 0.654 m/s and machine forward speed of 3.5 km/h (kinematics parameter, 0.71) and seed moisture content of 20%. So, this research aimed to develop the pulling bar of lentil-harvesting machine to suite the pulling operation of flax with tractor, evaluate the developed machine performance and determine the optimum studied parameters.

2. MATERIALS AND METHOD

2.1. MATERIALS:

2.1.1. Flax plants:

Physical and mechanical properties of flax plants presented in Table 1.

Table 1. Physical and mechanical properties of flax plants.

Plants characteristics	Average value
Flax variety	Giza-4
Plant height	937.8 mm
Technical length (from the soil to the flowering zone)	761.4 mm
Flower zone length	202.3 mm
Stem diameter at 10 cm distance from ground surface	2.014 mm
Number of plants/m^2	1247
Mass of 1000 seed/gm	7.43 g
Biological yield (seed and straw yields)	4.60 Mg/fed
Straw yield/fed	3.92 Mg/fed
Average pulling force	60.64 N

2.1.2. Pulling machine:

(A): The pulling machine before development:

The lentil-pulling machine consists of four main parts follows: pulling device (pulling finger, steel case and dividers), crop reel, conveyor belt, power transmission and small engine with maximum power of 12 kW. Photo1.

Photo 1. The lentil pulling machine before development.

(B): The pulling machine after development:

The lentil-pulling machine was developed to be suitable for pulling flax crop. The developed pulling machine (Figs.1, 2 and Photo2) consists of the following four main parts:

1. Pulling device: The pulling device consists of 20 pulling fingers (10 pulling units). Each finger is conical in shape and its diameter was 54.5 mm at the rear end and 18 mm at the front end. The finger length was 200 mm. (**El-sharabasy, 2003**).

No.	Part Name	No. of parts	No.	Part Name	No. of parts
1	Flax pulling machine	1	4	Tractor PTO	1
2	Hitching point	2	5	Front wheel	2
3	Tractor engine	1	6	Rear wheel	2

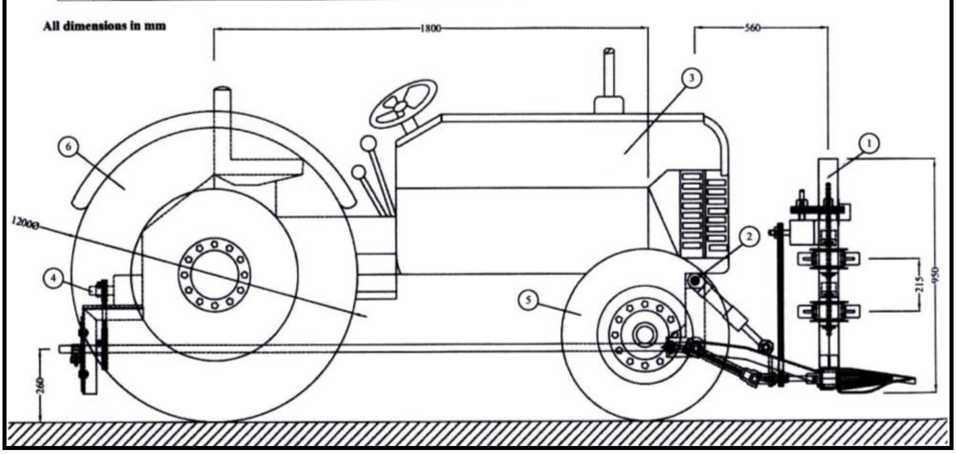


Fig. 1. The front view of the developed flax pulling machine.

No.	Part Name	No. of parts	No.	Part Name	No. of parts
1	Front wheels	2	4	Rear wheels	2
2	Tractor engine	1	5	Flax pulling machine	1
3	Tractor PTO	1	6	Hitching point	2

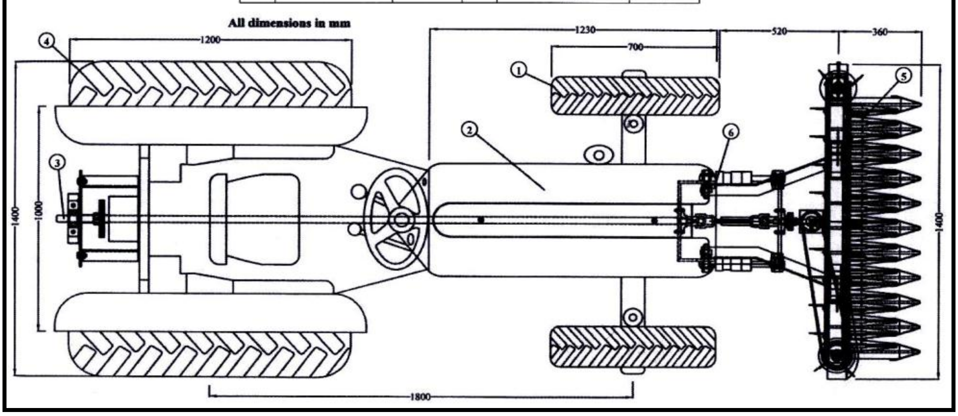


Fig. 2. The top view of the developed flax pulling machine.

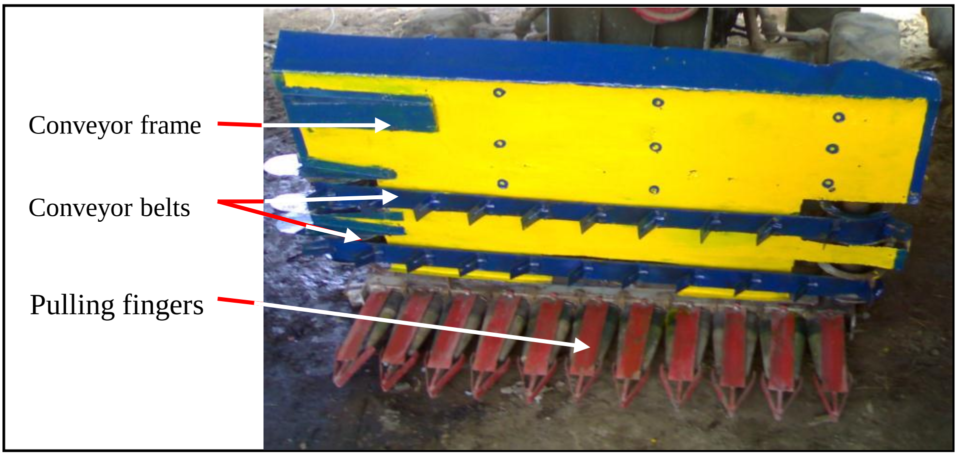
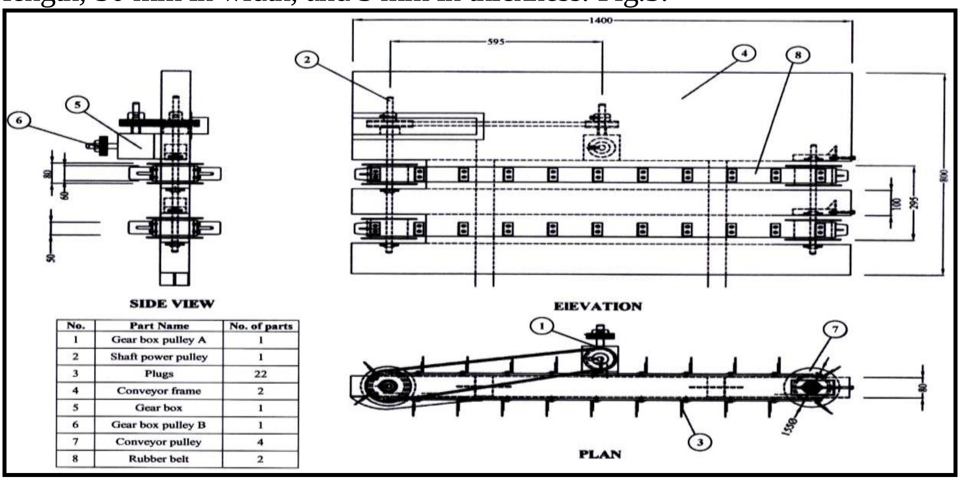


Photo 2. The developed flax pulling bar.

2. Dividers: The dividers were fixed in the front of pulling fingers to separate and guide the flax stalks into the pulling unit. The numbers of dividers were 11, each one have a specifically shaped and tapered front section. (**El-sharabasy, 2003**).

3. Conveyor belt: Two vertical conveyor belts were fixed on a special frame directly over the steel case to carry and move the pulled flax plants slightly aside the machine. The conveyor belt consists of twins vertical rubber belt which has dimensions of 1315mm for length, 60 mm for width and 10 mm for thickness. Each belt contains 22 L-shape plugs, each one has 60 mm in length, 50 mm in width, and 3 mm in thickness. Fig.3.

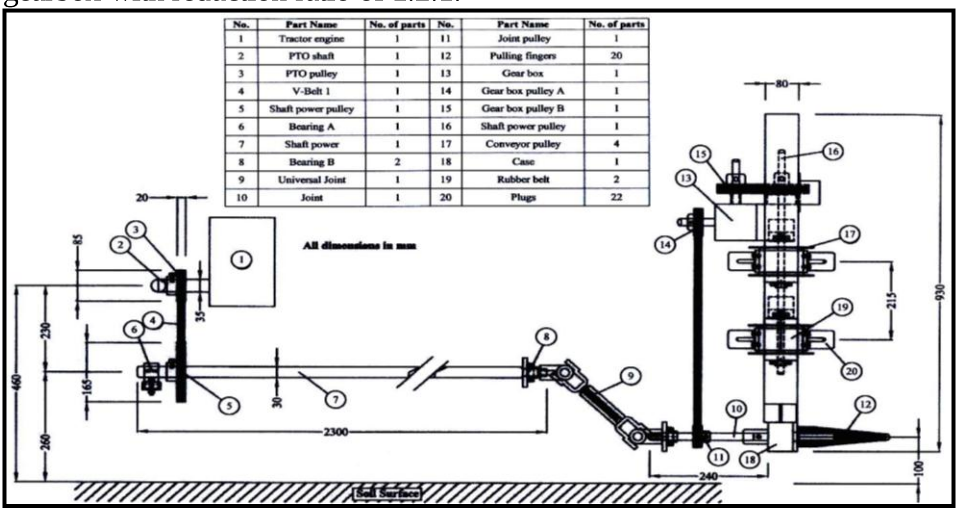


No.	Part Name	No. of parts
1	Gear box pulley A	1
2	Shaft power pulley	1
3	Plugs	22
4	Conveyor frame	2
5	Gear box	1
6	Gear box pulley B	1
7	Conveyor pulley	4
8	Rubber belt	2

Fig. 3. The elevation, side view and plan of the conveyor belt.

The conveyor belt is powered by means of two pulleys. The first pulley has diameter of 90 mm at rotation speed of 232 rpm fixed on the gearbox, and the second pulley with diameter of 130 mm was fixed on the main shaft. These two pulleys keep constant ratio between drive shaft rotating speed and finger rotating speed of (1:1.73) to give constant ratio between conveyor belt and machine forward speed of (1:1.4). (**Bosoi et al. 1991**).

4. Power transmission: The power is transmitted from the tractor PTO shaft to the pulling fingers through pulleys, gear box, universal joint and power shaft as shown in Fig.4. A 540 rpm at PTO pulley which has diameter of 85 mm can be transmitted to a pulley with diameter of 165 mm using V-belt between the two pulleys to be equal 278 rpm, with reduction ratio of 1.94:1. The rotating speed transported from the previous pulley to the power shaft with length of 2300 mm. The rotating speed transported from the power shaft to the case shaft through universal joint with length of 250 mm. Another advantage of universal joint, making easy the pulling device up during machine transport from field to another, and down during pulling operation in the field. The rotating speed of power shaft of 278 rpm at case shaft pulley with diameter of 75 mm can be transmitted to gear box pulley with diameter of 75 mm using V-belt between the two pulleys without reduction ratio. The rotating speed of gearbox pulley of 278 rpm reduced to 232 rpm in the gearbox with reduction ratio of 1.2:1.



No.	Part Name	No. of parts	No.	Part Name	No. of parts
1	Tractor engine	1	11	Joint pulley	1
2	PTO shaft	1	12	Pulling fingers	20
3	PTO pulley	1	13	Gear box	1
4	V-Belt 1	1	14	Gear box pulley A	1
5	Shaft power pulley	1	15	Gear box pulley B	1
6	Bearing A	1	16	Shaft power pulley	1
7	Shaft power	1	17	Conveyor pulley	4
8	Bearing B	2	18	Case	1
9	Universal Joint	1	19	Rubber belt	2
10	Joint	1	20	Plugs	22

Fig.4. Power transmission from PTO to pulling fingers and conveyor belts.

2.2. METHOD:

2.2.1. Planting method: The flax crop was planted using seed drilling machine at row spacing of 11 cm between rows at average depth of about 3 cm and the machine forward speed was adjusted at 3 km/h. The seed drilling required about 40 kg/fed of flax seeds to reach at the suitable plant density. Other processes such as irrigation, fertilizing and weed control were carried out according to Agriculture Ministry recommendations.

2.2.2. Pulling method: The mechanical pulling using the developed pulling machine was carried out under four different machine forward speeds of (1.44, 2.16, 2.63 and 4.50 km/h), four different finger rotating speeds of (150, 200, 250 and 320 rpm or 0.393, 0.524, 0.654 and 0.837 m/s) and four different soil moisture contents of 15.75, 18.35, 21.96 and 29.24 % (w.b) to evaluate the flax pulling machine performance during pulling operation.

2.2.3. MEASUREMENTS:

1. Pulling efficiency: is calculated by using the following equation:

$$Pe = \frac{N_P}{N_T} \times 100 \qquad (1)$$

Where: Pe = Pulling efficiency, %.

N_p = Number pf pulled plants/m^2.

N_T = Number of plants/m^2.

2. Field capacity: was the actual average time consumed during pulling operation (lost time + effective time). It can be determined from the following equation, **(Kepner et al. 1982):**

$$(2)\ F.C_{act} = \frac{60}{Tu + Tl}\ ,\ \text{fed/h}$$

Where: $F.C_{act}$ = Actual field capacity of the planter.

Tu = Utilization time per feddan in minutes.

Tl = Summation of lost time per feddan in minutes.

3. Field efficiency: is calculated by using the values of the theoretical field capacity and effective field capacity rates as, **(Kepner et al. 1982):**

$$\eta_f = \frac{F.C_{act}}{F.C_{th}} \times 100,\ \% \qquad (3)$$

Where: η_f = Field efficiency, %. $F.C_{th.}$ = Theoretical field capacity.

4. Energy requirements: To estimate the engine power during pulling process, the decrease in fuel level in fuel tank accurately measuring immediately after each treatment. The following formula was used to estimate the engine power (**Hunt, 1983**):

$$EP = \left[F.C\left(1/3600\right)\rho E \times L.C.V \times 427 \times \eta_{thb} \times \eta_m \times 1/75 \times 1/1.36\right], kW \quad (4)$$

Where: F.c = Fuel consumption, (l/h).

ρE = Density of fuel, (kg/l), (for Gas oil = 0.85).

L.C.V = Calorific value of fuel, (11.000 k.cal/kg).

427 = Thermo-mechanical equivalent, (kg.m/k.cal).

η_{thb} = Thermal efficiency of the engine, (35 % for Diesel engine).

η_m = Mechanical efficiency of the engine, (80 % for Diesel engines).

So, the energy can be calculated as following:

$$\text{Energy requirements} = \frac{\text{Engine power,(kW)}}{\text{Actual field capacity,(fed/h)}}, \text{ kW.h/fed} \quad (5)$$

5. Pullting cost: was estimated using the following equation:

$$\text{Pulling cost} = \frac{\text{Machine cost (L.E/h)}}{\text{Actual field capacity (fed/h)}}, \text{ L.E/fed} \quad (6)$$

Machine cost was determined by using the following equation **(Awady 1978)**:

$$C = \frac{P}{h}\left(\frac{1}{a} + \frac{i}{2} + t + r\right) + \left(0.9\,W.S.F\right) + \frac{m}{144}, \text{ L.E/h} \quad (7)$$

Where:

C = Hourly cost, L.E/h. P = Price of machine, L.E.

h = Yearly working hours, h/year. A = Life expectancy of the machine, y.

i = Interest rate/year. F = Fuel price, L.E/l.

t = Taxes, over heads ratio. R = Repairs and maintenance ratio.

m = Monthly average wage, L.E 0.9 = Factor accounting for lubrications.

W = Engine power, hp. S = Specific fuel consumption, l/hp.h.

144 = Reasonable estimation of monthly working hours.

6. Criterion cost: was estimated using the following formula:

$$\text{Criterion cost} = [\text{Pulling cost} + (\text{Stalks} + \text{Seeds})\text{ losses}], \quad (\text{L.E/fed}) \quad (8)$$

3. RESULTS AND DISCUSSION

The obtained results from all treatments during pulling operation of flax crop using the developed pulling machine will discuss under the following headlines as follows:

3.1. Pulling efficiency:

Fig. (5-C) show that the machine forward speed of 2.16 km/h recorded the maximum pulling efficiency of 88.24, 90.21, 93.30 and 82.56 % at different soil moisture contents of 15.75, 18.35, 21.96 and 29.24 % at finger rotating speed of 0.654 m/s, (kinematic parameter of 1.18).

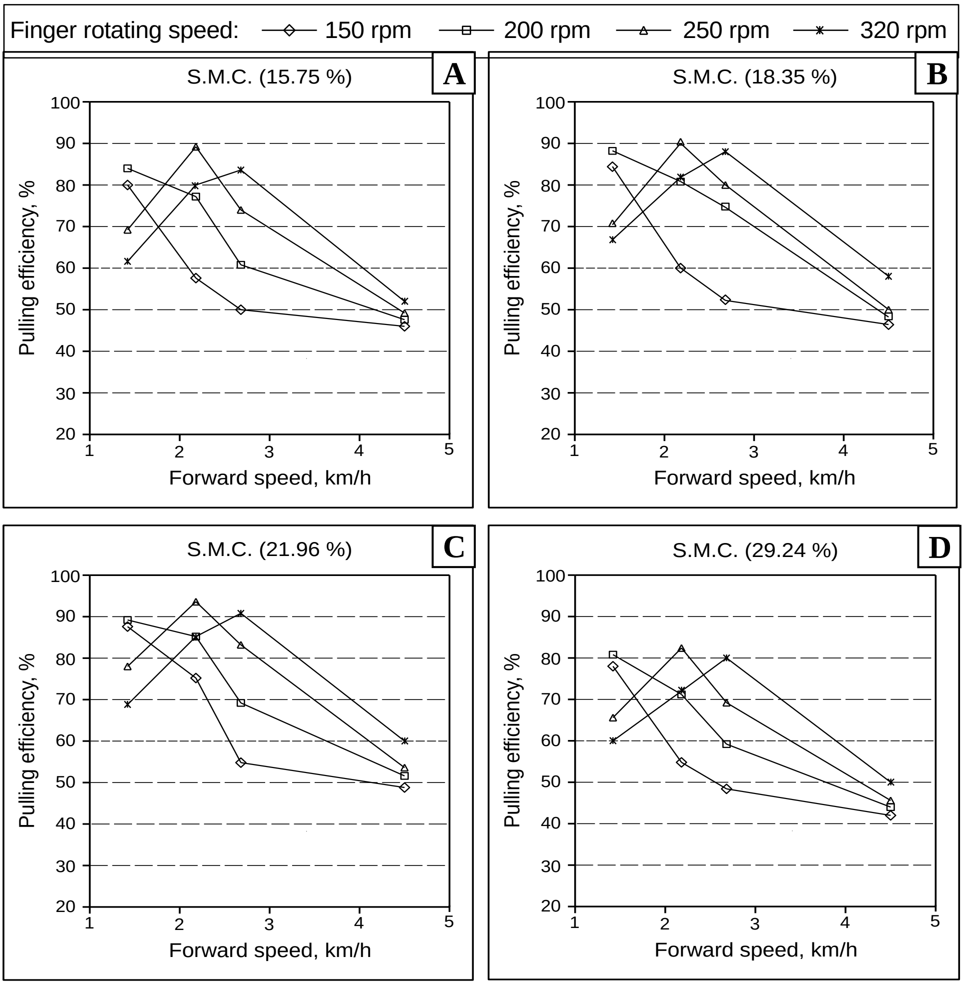


Fig. 5. Effect of machine forward speed on pulling efficiency at different finger rotating speeds and different soil moisture contents.

The decrease of forward speed less than 2.16 km/h or increase forward speed more than 2.16 km/h leads to decease pulling efficiency resulting from unsuitable speed ratio which gave less pulling efficiencies. On the other hand, the effect of finger rotating speed on pulling efficiency since the speed ratios were increased or decreased causing unsuitable conditions during pulling process at Fig.5. Referring to the soil moisture content, it has a great effect on pulling efficiency due to its affect on required pulling force, which increased with the decrease of soil moisture content resulting minimum pulling efficiencies. The suitable soil moisture content was 21.96 %, which recorded the maximum values of pulling efficiencies of 77.52, 93.30, 83.35 and 54.12% at different machine forward speed of 1.44, 2.16, 2.63 and 4.50 km/h and constant finger rotating speed of 0.654 m/s.

3.2. Actual field capacity:

Fig. (6-C) show that the maximum value of actual field capacity of 0.860 fed/h was obtained at forward speed of 4.50 km/h, finger rotating speed of 0.654 m/s and soil moisture content of 21.96 %. On the other hand, the minimum value of actual field capacity of 0.184 fed/h was obtained at forward speed of 1.44 km/h, finger rotating speed of 0.393 m/s and soil moisture content of 29.24 %.The actual field capacity is greatly affected by pulling time consumed. Therefore, increase actual field capacity by increasing in forward speed was attributed to the short time to pull the flax plants from the planting area.

As to the effect of finger rotating speed on actual field capacity, finger rotating speed of 0.654 m/s gave the best value of actual field capacities of 0.687, 0.736, 0.860 and 0.655 fed/h at constant machine forward speed of 4.50 km/h and different soil moisture contents of 15.75, 18.35, 21.96 and 29.24 %, respectively. Any further increase or decrease in finger rotating speed from 0.654 m/s resulting less actual field capacity since the speed ratios were increased or decreased causing unsuitable conditions during pulling process. Increasing speed ratio than 1.18 leads to increase pulling plants in the unit time causing more clogging plants in the pulling unit consumed more time to remove them. Also, decreasing speed ratio than 1.18 leads to decrease machine forward speed which directly decrease the machine field capacity. The highest value of actual field capacity of 0.860 fed/h was obtained at soil moisture content of 21.96 % at machine forward speed of 4.50 km/h and finger rotating speed of 0.654 m/s. On the other hand, decreasing soil moisture content to 15.75 % leads to decrease actual field capacity to 0.687 fed/h at the same previous conditions. The decrease of actual field capacity with the decrease of soil moisture content may attribute to increase the catching force for flax roots causing unsuitable conditions for pulling operation resulting less field capacity.

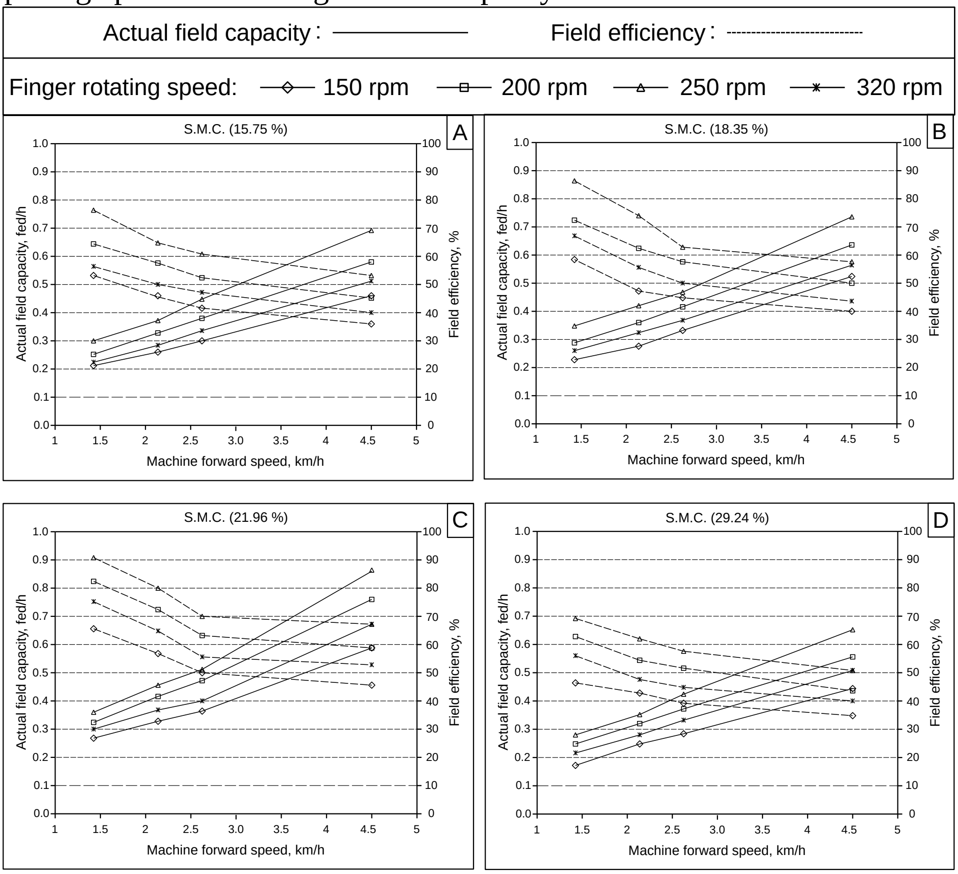


Fig.6. Effect of machine forward speed on actual field capacity and field efficiency at different finger rotating speeds and different soil moisture contents.

3.3. Field efficiency:

Fig.6. illustrated that field efficiency was gradually decreased by increasing machine forward speed from 1.44 to 4.50 km/h at all treatments. The machine forward speed of 1.44 km/h recorded the maximum field efficiencies of 76.14, 86.29, 90.32 and 69.53% at different soil moisture

contents of 15.75, 18.35, 21.96 and 29.24 % and constant finger rotating speed of 0.654 m/s (speed ratio of 1.71). On the other hand, the machine forward speed of 4.50 km/h recorded the minimum field efficiencies of 53.42, 57.23, 66.87 and 50.90 % at soil moisture contents of 15.75, 18.35, 21.96 and 29.24 % and constant finger rotating speed of 0.654 (speed ratio of 0.52). Increasing machine field efficiency with the decrease in machine forward speed may attribute to the reduction of lost time compared with the actual pulling time. While, increasing forward speed leads to decrease machine field efficiency since the lost time increased.

As indicated in Fig. (6-B) the higher field efficiency was occurred at the speed ratio of 1.71, which gave a suitable relation between finger rotating speed and machine forward speed. Finger rotating speed of 0.654 m/s gave the best value of field efficiencies of 76.14, 86.29, 90.32 and 69.53% at constant machine forward speed of 1.44 km/h and different soil moisture contents of 15.75, 18.35, 21.96 and 29.24%, respectively. Any further increase or decrease in finger rotating speed from 0.654 m/s resulting less machine efficiency since the speed ratios were increased or decreased causing unsuitable conditions during pulling process.

The same Fig. (6-B) illustrated that the soil moisture content of 21.96% was the suitable value which gave the maximum machine field efficiencies of 65.99, 82.32, 90.32 and 75.17 % at constant machine forward speed of 1.44 km/h and finger rotating speeds of 0.393, 0.524, 0.654 and 0.837 m/s, respectively. The decrease of soil moisture content less than 21.96% leads to decrease machine field efficiency to 53.34, 63.76, 76.14, and 56.82 % at the same previous conditions. This result may attribute to increasing catching force for plants causing more lost time during pulling operation. On the other hand, increasing soil moisture content more than 21.96% leads to decrease machine field efficiencies to 46.70, 63.20, 69.53 and 56.34% at the same previous conditions. This result may attribute to increase elastic conditions causing more clogging plants between fingers leads to increase lost time and then decrease field efficiency.

3.4. Energy requirements:

Fig.(7-C) indicated that increasing machine forward speed from 1.44 to 4.50 km/h led to decrease energy requirements from 67.7 to 15.7 kW.h/fed at soil moisture content of 21.96% and finger rotating speed of 0.393 m/s. The decrease in energy requirements by increasing the machine forward speed was attribute to the decrease in fuel consumption which depend on the time consumed to clear the flax plants area and also the short time of pulling finger passing over flax plants.

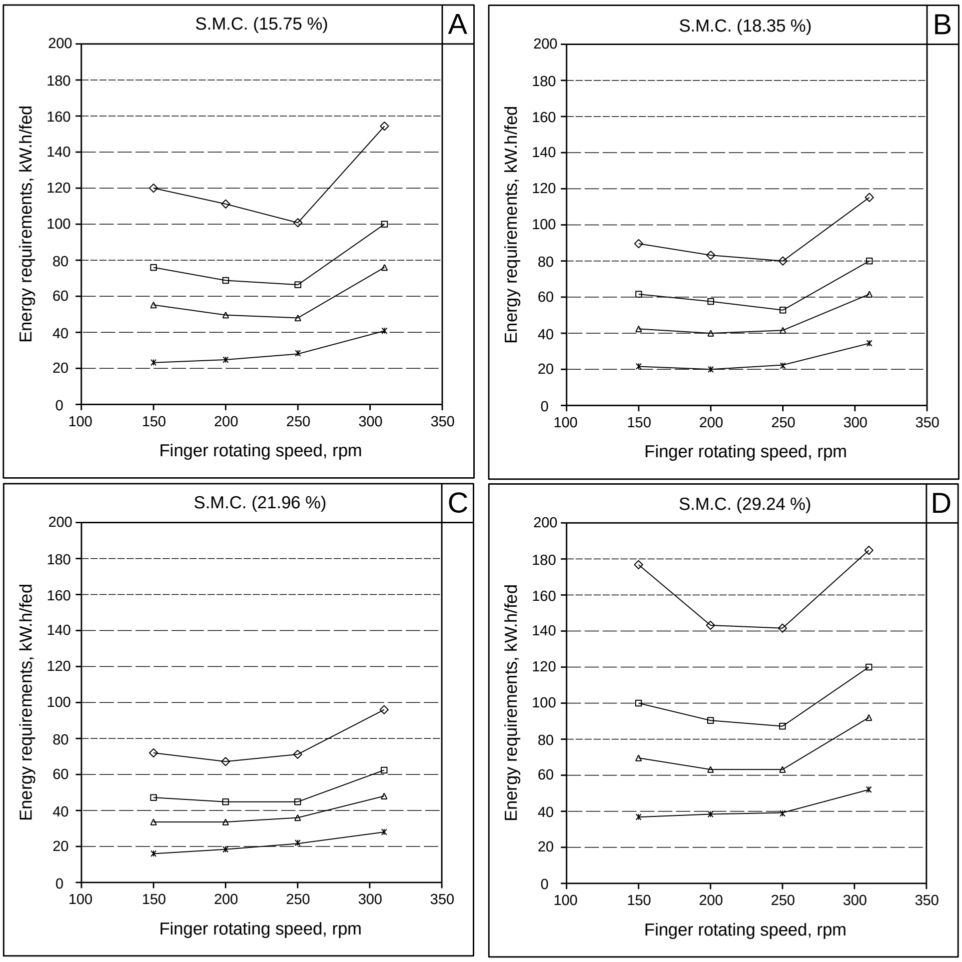


Fig. 7. Effect of finger rotating speed on energy requirements at different machine forward speeds and different soil moisture contents.

Fig. (7-D) indicate that the higher energy requirements of 186.8 kW.h/fed was occurred at the higher finger rotating speed of 0.837 m/s and lower machine forward speed of 1.44 km/h, which consumed more fuel at pulling operation. The energy requirements increased from 119.4 to153.6, 91.0 to

114.0, 72.9 to 93.9 and 175.3 to 186.8 kW.h/fed since the finger rotating speed increasing from 0.393 to 0.837 m/s at constant machine forward speed of 1.44 km/h and different soil moisture contents of 15.75, 18.35, 21.96 and 29.24%, respectively. Increasing energy requirements by increasing finger rotating speed was due to increase the revelation of tractor rpm consumed more fuel and energy. The results in Fig.(7-C) indicated that the lowest value of energy requirements was 14.0 kW.h/fed obtained at soil moisture content of 21.96%, finger rotating speed of 0.393 m/s and machine forward speed of 4.50 km/h. This result was due to the low revelation of tractor rpm consumed low fuel and energy. Any further increase in soil moisture content more than 21.96% leads to increase energy requirements to 100.0, 88.7, 86.8 and 121.4 kW.h/fed at constant machine forward speed of 2.16 km/h and finger rotating speeds of 0.393, 0.524, 0.654 and 0.837 m/s, respectively. This increase was due to more fuel consumed during high soil moisture content, since the slippage was in the maximum value. On the other side, any further decrease in soil moisture content less than 21.96% leads to increase energy requirements to 74.3, 67.5, 65.8 and100.9 kW.h/fed at the same previous conditions. This result may attribute to increase catching force for flax roots consumed more fuel and energy.

3.5. Criterion cost:

Fig.(8-B) show that, the machine forward speed of 2.16 km/h recorded the minimum criterion cost of 251.2, 213.8, 163.7 and 336.6 L.E/fed at constant finger rotating speed of 250 rpm (kinematic parameter of 1.18) and different soil moisture contents of 15.75, 18.35, 21.96 and 29.24% , respectively. The decrease of forward speed less than 2.16 km/h or increase forward speed more than 2.16 km/h leads to increase criterion cost resulting from unsuitable speed ratio which gave less pulling efficiencies (more un-pulling plants) resulting high criterion cost. Finger rotating speed of 0.654 m/s gave the best values of criterion cost of 251.2, 213.8, 163.7 and 336.6 L.E/fed at different soil moisture contents of 15.75, 18.35, 21.96 and 29.24% and constant machine forward speed of 2.16 km/h, respectively. Any further increase or decrease in finger rotating speed from of 0.654 m/s resulting high criterion cost since the speed ratio were increased or decreased causing unsuitable conditions during pulling process.

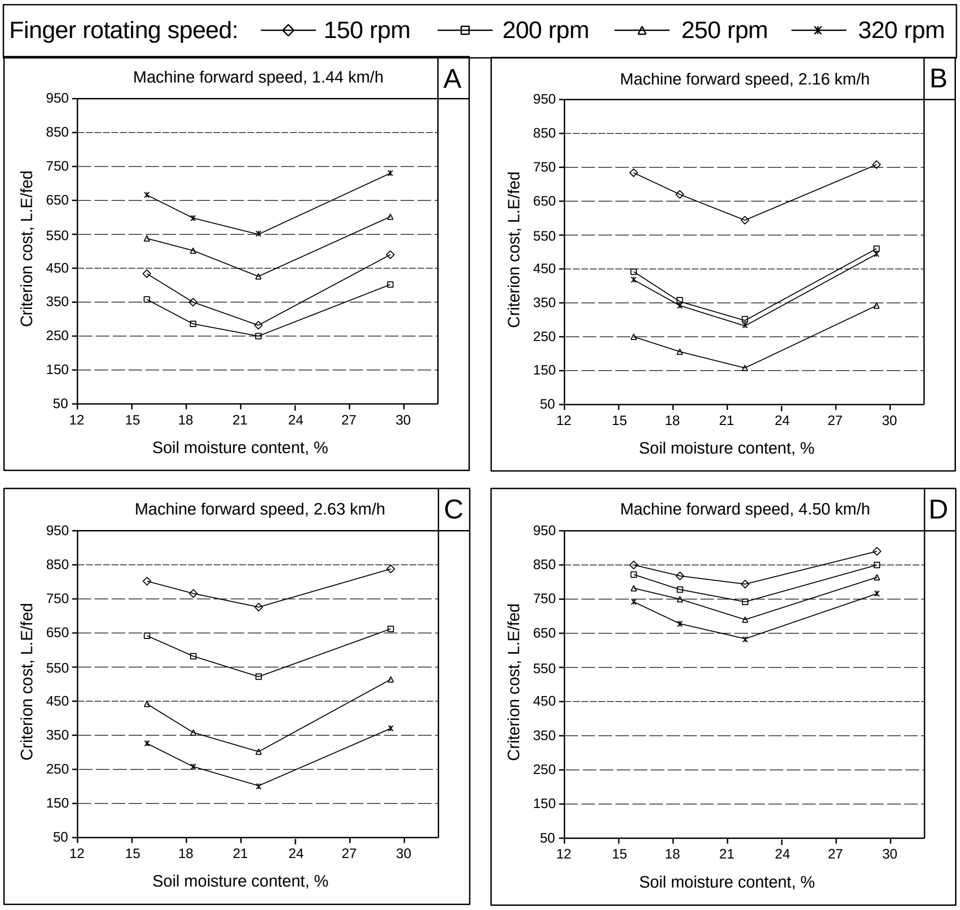


Fig. 8. Effect of machine forward speed on criterion cost at different finger rotating speeds and different soil moisture contents.

Referring to the effect of soil moisture content on criterion cost, the soil moisture content has a great effect on criterion cost due to its affect on required pulling force which increases with the decrease of soil moisture content resulting minimum pulling efficiencies. The suitable soil moisture content was 21.96 % which recorded the minimum values of criterion costs of 408.0, 163.7, 298.5 and 690.10 L.E/fed at different machine forward speeds of 1.44, 2.16, 2.63 and 4.50 km/h and constant finger rotating speed of 250 rpm, respectively. Increasing soil moisture content more than 21.96 % led to increase criterion costs to 603.8, 336.6, 514.5 and 815.7 L.E/fed at the same previous conditions and high soil moisture content of 29.24%. The increase in criterion cost with increasing in soil moisture content may attribute to decrease both pulling efficiency and machine field capacity. On the other side, decreasing soil moisture content less than 21.96% led to increase criterion cost to 542.2, 251.2, 437.4 and 783.3 L.E/fed at the same previous conditions and low soil moisture content of 15.75 %. The increase in criterion cost with decreasing in soil moisture content may attribute to decrease pulling efficiency and increase fuel consumed since the pulling force increased.

4. CONCLUSION

From the obtained results, it could be concluded that the developed machine for pulling flax crop can be used at the following operating parameters: (machine forward speed of 2.16 km/h, finger rotating speed of 0.654 m/s (1.18 kinematic ratio) and soil moisture content of 21.96 %) for maximum pulling efficiency of 93.30%, actual field capacity of 0.458 fed/h, field efficiency of 80.00%, fuel consumption rate of 5.60 L/h, energy requirements of 44.20 kW.h/fed and criterion cost of 163.70 L.E/fed.

5. REFERENCES

Abdel-Wahab, M. K. (1987): Prototype of a lentil walker puller harvester. Misr J. Agric. Eng., 4(4): 351-364.

Abdel-Wahab, M. K. (1994): Development of a lentil harvesting machine and its power requirement. Misr J. Agric. Eng., 11(2): 559-568.

Awady, M. N. (1978): Tractor and farm machinery. Text Book, Faculty of Agriculture, Ain-Shams University. pp. 164-167.

Bosoi, E. S; O. V. Verniaev, I. I. Smirnov and E. G. Sultan-Shakh (1991): Theory, construction and calculations of agricultural machines.

Volume two. Russian translations series 83. A. A. BALKEMAIROTT-ERDAM. 1991.

Economic Affairs Sector (2009): Bulletin of the agricultural statistics, Ministry of Agricultural and land reclamation, A.R.E. Vol.1:61.

El-Sharabasy, M. M. A. (2003): Development of a simplified machine suits for pulling process of lentil crop. Ph. D. Thesis, Agric. Eng. Dept., Faculty. of Agric., Zagazig Univ., Egypt.

Hamad, S. A; A. F. EI-Sahrigi, M. M. Ibrahim and A. S. Hamam (1991): Development of harvesting machine suitable for flax in Egypt, Misr J. Agric. Eng., 8(2): 142-153.

Hunt, D. R. (1983): Farm power and machinery management. 8th Ed. Iowa state Univ., Press Ames, USA. Ames, Iowa, USA: 364-368.

Hunt, D. R. (1986): Engineering methods for agricultural production. The AVT. Publ. Co., INC. Westport USA.

Ibrahim, M. M. (1983): Study of the different valuables found in flax harvesting device. Ph. D. Thesis, Agric. Eng. Insti. Minsk, USSR. (C.F. El-Sharabasy, 2003).

Kepner, R. A; R. Bainer and E. I. Barger (1982): Principles of Farm machinery. Third Edition, AVI publishing Company, INC. USA.

Klenin N. I; I. F. Popov and V. A. Sakun (1985): Agricultural machines, theory of operation, combination of controlling parameters and the conditions of operation. Amerid Publishing C., Pvt. Ltd., New Delhi, India.

Rodjief, F; B. Tokarief and B. Besakhoviedge (1986): The Agric. Reference. M1R publishers Moscow, USSR.

الملخـص العربــي

تطويـــــر وتقييـــــم أداء آلــــــة لتقليـــــع محصـــــول الكتـــــــــــان

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يعتبر الكتان واحد من أهم محاصيل الألياف والأكثر أهمية في العالم والتي يمكن زراعتها في مصر بتوسع، حيث يلعب الكتان دوراً هاماً في الاقتصاد القومي المصري وذلك بسبب التصدير فضلاً عن الصناعة المحلية. حالياً، إنتاج الكتان ليس بالقدر الكافي ليغطي الاحتياجات المحلية من الزيوت والألياف، لذا فنحن في أمس الحاجة لزيادة الإنتاج المحلي من الكتان وذلك لسد العجز وتحسين الوضع الاقتصادي وتوفير النقد الأجنبي.

زيادة إنتاجية الفدان من الكتان وتحسين جودته تعتمد علي عمليات الميكنة المختلفة وأهما هي عملية الحصاد التي غالباً ما تواجه مشكلة العمالة اليدوية لعدم توافر آلات تقليع الكتان المتخصصة. وللتغلب علي هذه المشكلة فقد تم تطوير آلة لتناسب تقليع محصول الكتان للتغلب علي مشاكل التقليع اليدوي بالنسبة لتقليل فواقد الكبسولات والسيقان وللتغلب علي المشاكل التي لوحظت بوضوح أثناء عملية الحصاد لمحصول الكتان باستخدام الطرق التقليدية للتقليع والتي تستهلك الكثير من الوقت وندرة العمالة اليدوية وبالتالي التكلفة العالية. تتكون الآلة المطورة من أربع أجزاء رئيسية هي: وحدة التقليع (أصابع التقليع) ، المجزءات ، سير النقل الراسي ليلائم نباتات الكتان وإزاحتها على جانب الآلة وجهاز نقل القدرة الذي ينقل الحركة من عمود (PTO) للجرار إلى الأمام ليناسب جهاز التقليع.

تم دراسة عدد من المتغيرات لتقييم هذه الآلة بعد التطوير والتي تشمل استخدام سرعات أمامية مختلفة للآلـــة وهـــي: ١.٤٤ ، ٢.١٦ ، ٢.٦٣ و ٤.٥٠ كـــم/س أو (٠.٤٠، ٠.٦٠ ، ٠.٧٣ و ١.٢٥ م/ث). سرعات دورانية مختلفة لأصابع التقليع وهي: ١٥٠، ٢٠٠، ٢٥٠ و ٣٢٠ لفة/دقيقة أو (٠.٤٢ ، ٠.٥٧، ٠.٧١ و ٠.٩١ م/ث) ، نسب مختلفة لرطوبة التربة وهي: ١٥.٧٥، ١٨.٣٥، ٢١.٩٦ و ٢٩.٢٤ % علي أساس جاف. وقد تم تقييم أداء هذه الآلة من خلال القياسات التالية: كفاءة التقليع ، أداء عملية الحصاد (السعة الحقلية الفعلية والكفاءة الحلقية ، معدل استهلاك الوقود ، الطاقة المستهلكة ، القدرة اللازمة لعملية التقليع ، تكاليف التشغيل لعملية التقليع والتكلفة الحدية لعملية التقليع.

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ويمكن تلخيص النتائج التي تم الحصول عليها علي النحو التالي:

تم الحصول علي أعلي قيمة لكفاءة التقليع وهي ٩٣.٣٠% وذلك عند نسبة رطوبة للتربة ٢١.٩٦ % وسرعة دورانية لأصابع التقليع ٢٥٠ لفة/دقيقة وسرعة أمامية للآلة ٢.١٦ كم /س. تم الحصول علي أعلي قيمة للسعه الحقلية الفعلية وهي ٠.٨٦ ف/س وذلك عند نسبة رطوبة للتربة ٢١.٩٦ % وسرعة أمامية للآلة ٤.٥٠ كم /س وسرعة دورانية لأصابع التقليع ٢٥٠ لفة/ دقيقة .من ناحية أخري فإنه عند استخدام سرعة أمامية للآلة ١.٤٤ كم /س وسرعة دورانية لأصابع التقليع ١٥٠ لفة/ دقيقة ، تم الحصول علي أقل قيمة للسعة الحقلية الفعلية وهي ٠.١٨ ف/س. أعلي قيمة للكفاءة الحقلية كانت ٩٠.٣٢ % وتم تسجيلها عند نسبة رطوبة للتربة ٢١.٩٦ % وسرعة أمامية للآلة ١.٤٤ كم /س وسرعة دورانية لأصابع التقليع ٢٥٠ لفة/ دقيقة وكانت أقل قيمة لمعدل استهلاك الوقود هو ٢.٦٢ لتر/س (٤.٤٣ لتر/ف) وأقل طاقة مستهلكة كانت ١٤.٠ (كيلووات.س/ف) وتم تسجيل هذه القيم عند سرعة أمامية للآلة ٤.٥٠ كم /س وسرعة دورانية لأصابع التقليع ١٥٠ لفة/ دقيقة ونسبة رطوبة للتربة ٢١.٩٦ %. أقل قيمة للتكاليف الحدية لتقليع محصول الكتان باستخدام الآلة المطورة كانت ١٦٣.٧٠ جنية/ف وسجلت عند سرعة أمامية للآلة ٢.١٦ كم /س وسرعة دورانية لأصابع التقليع ٢٥٠ لفة/ دقيقة ونسبة رطوبة التربة ٢١.٩٦ %.