ROTARY MOWER PERFORMANCE IN COTTON-STALK CHOPPING

AND DESTRUCTION OF THE PINK BOLLWORM

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Abstract

Seven evaluation parameters were studied in the present work to evaluate chopping operation of cotton stalks (variety Giza 86). Experiments were carried out at the experimental farm, Sakha Agric. Res. Station, Kafr EL-Sheikh Governorate . In general rotary mowers functioned satisfactorily in cotton stalk chopping. The results revealed that the highest value of actual field capacity was 1.50 fed /h. at forward speed 5.0 km/h and P.T.O. rotating speed of 540 r.p.m . At these speeds the machine had the lowest cutting energy of 16.5   kw.h/fed.   Also, the highest value of cutting efficiency of 95.0 %, chopping efficiency of 94.9 % and degree of destruction of the pink bollworm of 83.3 % were obtained at forward speed of 1.6 km/h and P.T.O. rotating speed of 540 r.p.m. The lowest fixed and variable costs of 8.35 L.E/fed were estimated at these speeds .

INTRODUCTION

Cotton stalk removal is one of the most urgent field operations to be mechanized, because of the timeliness importance for clearing land . Cotton stalk is considered to have an economical value, since it can be used as fuel, pressed board manufacture, or roughage for nontraditional animal feed. Cotton is considered one of the most important fiber crops in the world. The yearly cultivated area in Egypt reached about 770.000 feddans. At Kafr EL-Sheikh Governorate the planted area is about 115,000 feddans. The quantity of stalks left behind is estimated between 1 to 2 tons per feddan depending upon the planted variety of cotton.

The objective of the present work is to study the effect of operating parameters on the following factors: cutting efficiency, chopping efficiency, degree of the destruction of bollworms , power requirements , field efficiency and the combined cost of the tractor and chopping machine .

REVIEW OF LITERATURE

The cutting force is greatly affected by the diameter of the plant stem. Three types of plants were studied by El-Sahar (1988). The plants were cotton, wheat and lawn. A force of 625 N was needed to cut 9 mm cotton stalk diameter at 6.5% moisture content, while only 40.8 N force was needed to cut 4 mm wheat stem diameter at 35.4 % moisture content , and only 35 N force was needed to cut 2.5 mm lawn stem diameter at 65.5 % moisture content .

The properties of different cotton stalks affect energy requirements for cutting . The cutting energy was 7.6 Joule for 8 mm stalks diameter compared with 30.0 Joule for 18 mm stalk diameter. (EL Danasory, 1990) .

The energy requirements for the cutting operation of different crops namely : rice, wheat, cotton and alfalfa at different moisture contents, different velocities and different forward speeds, were studied by (Mourad, 1981) who found that the harvesting operation at high moisture content is requiring high energy for cutting.

The energy requirements for cutting the sesame plants ranged from 4.32 - 27.02 Joule / stem while the cutting force ranged from 432.14-1351.31 N/stem depending on the moisture content of the stems.(Imbabi, 1992) .

The number of pink bollworms at the rest stage in harvested cotton fields were about 100,000 per feddan , while it were originally about 200,000 per feddan. These estimations were averaged in villages distributed in the Nile delta . (Bishara , 1974).

Taib (1982), found that the cost of cotton stalks removal using tractor mounted mower, self propelled mower, cotton shredder, hand hoe and ensilage combine were 5.03, 7.26,10.44, 13.7 and27.23 L.E /fed, respectively.

The horsepower needed for cotton cutting operation increases with the increase of forward speed (Gomaa, 1982), as well as the fuel consumption in cotton stalk cutting operation increases with the increase of engine rotary speed .

The performance of cotton stalk cutting machine operating at a low speed of 1.65 km / h gave clean cut with short stubbles of about 8.1 cm height. A high speed of 6.3 km/ h gave a ruptured cut with longer stubbles of about 18.7 cm height . (EL - Nakib,1985) .

The performance of a machine used in cutting cotton stalk at a low speed of 0.75 km / h gave a clean cut with short stubbles of 3.6 cm height at a high cutting efficiency of 93.3 % . (Awady,et.al, 1986) .

The cutting force is affected by an increase in diameter of stalk. Increasing the cotton stalk diameter from 8 to 9 and 10 mm at a moisture content of 60.5 % increases the required cutting force from 620.8 to 625 and 729.2 N, respectively. The cutting force decreased from 625 to 256.7 N. by increasing the moisture content of stalks from 6.5 to 55 % respectively for 9 mm diameter stalk . (Awady, *et al.* 1988) .

MATERIALS AND METHODS

Chopping of cotton stalks was carried out using a rotary type mower mounted on the three point linkage "category II", locally manufactured. During operation it was supported on slide rails. Driven from a tractor (P.T.O.), cutting width 1800mm. max. working speed 8 km/h, power take off shaft speed 540 r.p.m., rotary mower speed 1000 r.p.m., - number of knives: two.

Field experiments were carried out at Sakha Agricultural Research Station, Kafr EL-Sheikh Governorate, during the 2003 season to study technical and economic aspects when using a rotary mower. The cotton plant was the Egyptian cotton variety (Giza-86) in an area of about two feddans.

The following parameters were studied in the present work :

Cutting efficiency (η_c)

Cutting efficiency (η_c) was calculated from the following formula (EL-Nakib, 1985):

$$\eta_c = A\text{-}B/A \times 100$$

Where:

A = The weight of cotton stalks just above the soil surface before cutting , in kgs for one meter squared area.

B = The weight of cotton stalks left above the soil after cutting , in kgs for one meter squared area .

Chopping efficiency (E_c)

Chopping efficiency (E_c) was calculated by using the following formula (Cravcenico, *et al.* 1976):

E_c $= w_a\text{-}w_b/w_a \times 100$

W_a = weight of stalk in area of one m^2 before the chopping operation (Kg),

W_b = weight of stalk pieces which has length greater than 20 cm in an area of one m^2 and after one pass of the chopping machine (Kg).

Degree of destruction of the pink bollworm

The number of attacted bolls was counted before and immediately after mechanical treatments in an area of one m^2. The degree of destruction was calculated as follows (Hanna, *et al.* 1985):

Degree of destruction = F-L/F x 100

Where:

F = The number of the worms in the infested bolls before treatment in an area of one m^2.

L = The number of the worms in the infested bolls after treatment in an area of one m^2.

Cutting resistance force

The cutting resistance was determined for different diameters of cotton stalks and different moisture contents chosen at random using the cutting resistance measuring unit.

Calculation of the field efficiency (η_f)

The field efficiency (η_f) = (Actual field capacity/ Theoretical field capacity)x 100 .

Actual field capacity = (1/ Actual total time in hours required per feddan) Fed/h .

Power requirement per unit area

Required power = F_c (l/h) X 3.16 .... Kw (Suliman *et al.* 1993).

Miscellaneous equipment

The following equipment were used during the experimental work:

Measuring tape of 30 m long, stop watch, weighing balance, electronic oven, speedometer, square frame one meter side, and cutting resistance measuring unit.

RESULTS AND DISCUSSION

Crop characteristics

Preliminary experiments and measurements were carried out on the cotton stalk to indicate some of the main characteristics.

The following results were obtained for cotton stalk variety (Giza 86) :

Average length of plant, (cm)	125
Average diameter of cotton stalk, (cm)	1.2
Average number of plants, per (m^2) area	15.0
Average weight of plants, (g/m^2) area	830
Average stalk moisture content, (%)	36.0
Average number of branches of cotton stalks/ plant, (branch/stalk)in an area of m^2	21.0

Field experiments were conducted in a clay loam soil and the results of the effect of forward speed and P. T. O. rotating speed on the following operating parameters were recorded:

Field capacity and efficiency (η_f)

Fig. 1 and fig 6 show the actual field capacity and efficiency as affected by P. T. 0. Rotating speed and forward speed. It can be noticed that the actual field capacity increased from (0.32 to O. 71 fed/h), (0.50 to 1.15 fed /h) and (0.74 to 1.5 fed/h) when the forward speed is increased from (1.6 to 5 km/h) for the rotary mower at 320, 420 and 540 r.p.m. P.T.O. rotating speed, respectively. Also, the field efficiency decreased from (65 to 53 %), (75 to 60 %) and (83.2 to 66 %) by increasing the forward speed of the rotary mower at rotating speed of the P.T.O. 320, 420 and 540 r.p.m., respectively.

Cutting efficiency (η_c)

Fig. 2 indicates the effect of forward speed on the cutting efficiency at three different values of P. T. O. rotating speeds.

The results indicate that the increase in the forward speed from 1.6 to 5 k_m /h tends to decrease the cutting efficiency, from (86.6 to 69.5%), (93.3 to 84.8 %) and (95 to 86.1 %) at 320, 420 and 540 r.p.m speed , respectively. It can be noticed that increasing the P.T.O. rotating speed from 320 to 420 to 540 r.p.m. tends to increase the cutting efficiency to 78.7, 89.3 and 91 %, respectively. These results are in agreement with those obtained by EL - Nakib, (1985) .

Chopping efficiency (E_c).

Fig. 3 shows the effect of forward speed on chopping efficiency at three different values of P. T. O. rotating speeds. It is evident that increasing the forward speed from 1.6 to 5 $k_m$lh tends to decrease the chopping efficiency: from (85.5 to 69.8), (90.8 to 80.8 %) and (94.9 to 86.2 %) at 320,420 and 540 r.p.m speeds, respectively. The results indicate that increasing the P.T.O. rotating speed from 320 to 420 to 540 r.p.m. tends to increase the chopping efficiency, to 79.1, 85.9 and 90.7 %, respectively. These results agree with those obtained by EL-Khateeb, (1990).
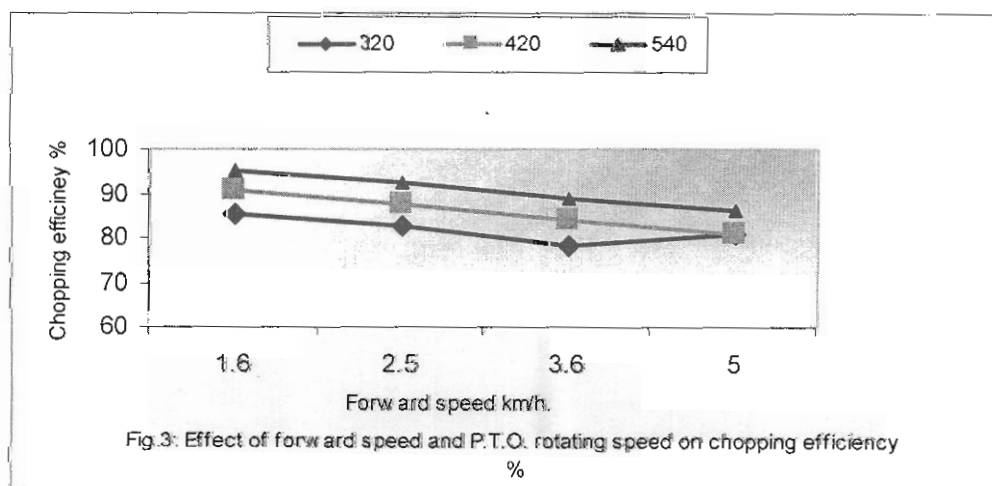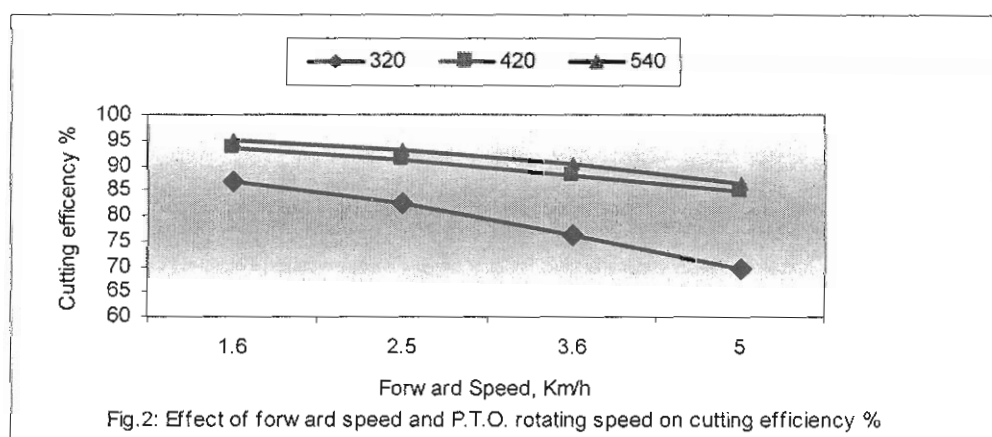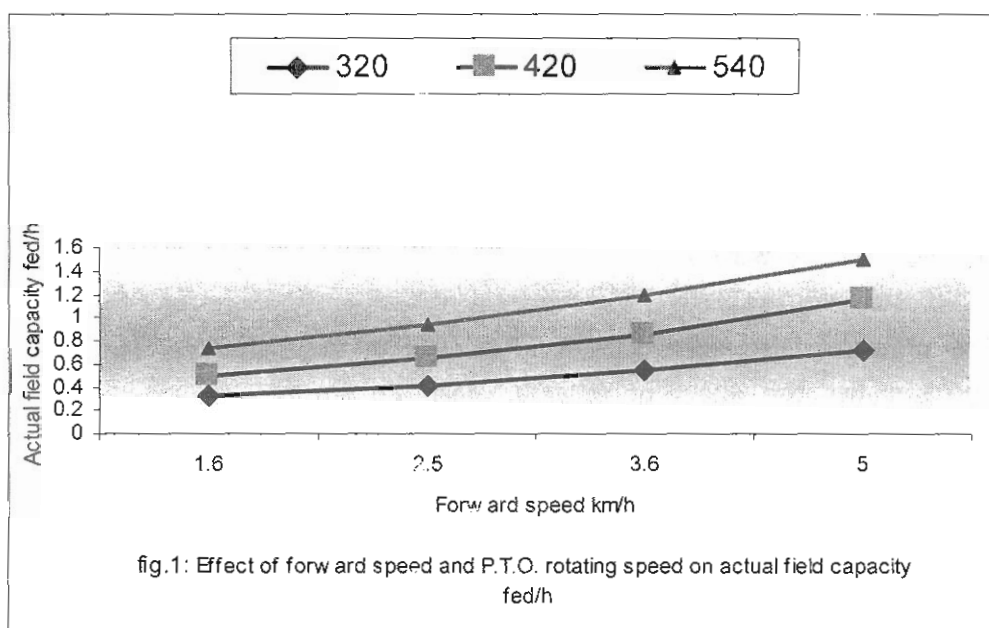
Degree of destruction

The degree of destruction may be considered as a qualitative and quantitative parameter to evaluate the effect of the rotary mower on the control of pink bollworms.
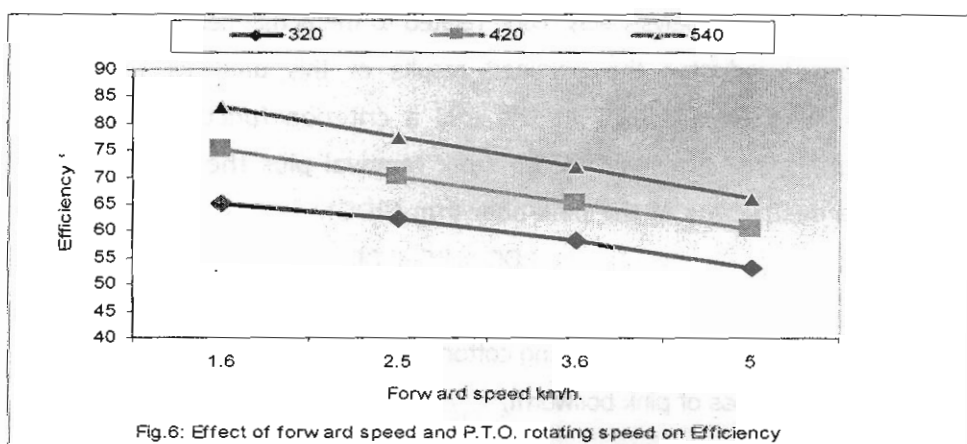
Fig. 4 illustrates the effect of forward speed on degree of destruction at three different values of P. T. O. rotating speeds. The results indicate that the increase in the forward speed from 1.6 to 5k_m/h, tends to decrease the degree of destruction from (48.6 to 33.5 %), (66.2 to 56.8%) and (83.3 to 63.5 %) at 320, 420 and 540 r . p. m speed , respectively. It can be noticed that increasing the P.T.O. rotating speed from 320 to 420 to 540 r.p.m. tends to increase the degree of destruction to 42.2, 61.6 and 73.7 %, respectively.

The results show that , the P. T.O. rotating speed of 540 r.p.m destroy the highest number of worms in the infested bolls . These results agree with those obtained by (Taieb, 1982).

Cutting energy (kw.h/Fed)

Studying the different parameters of fuel consumption and the total time of any field operation helps in calculating the power requirements.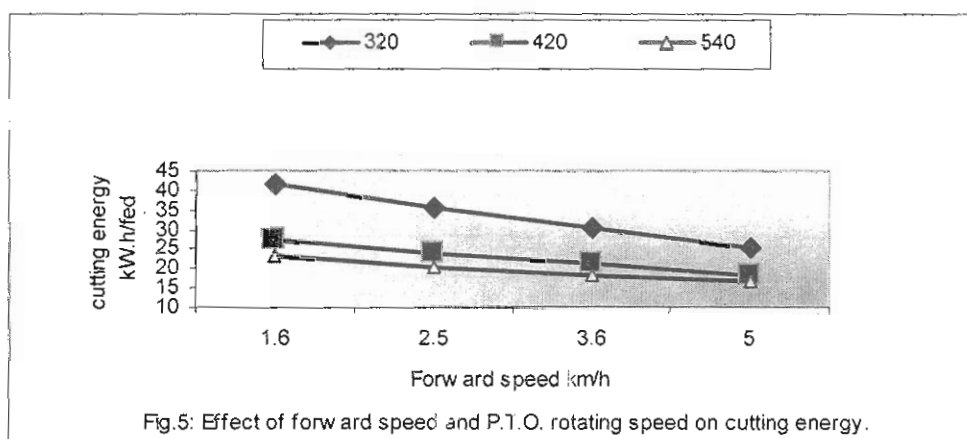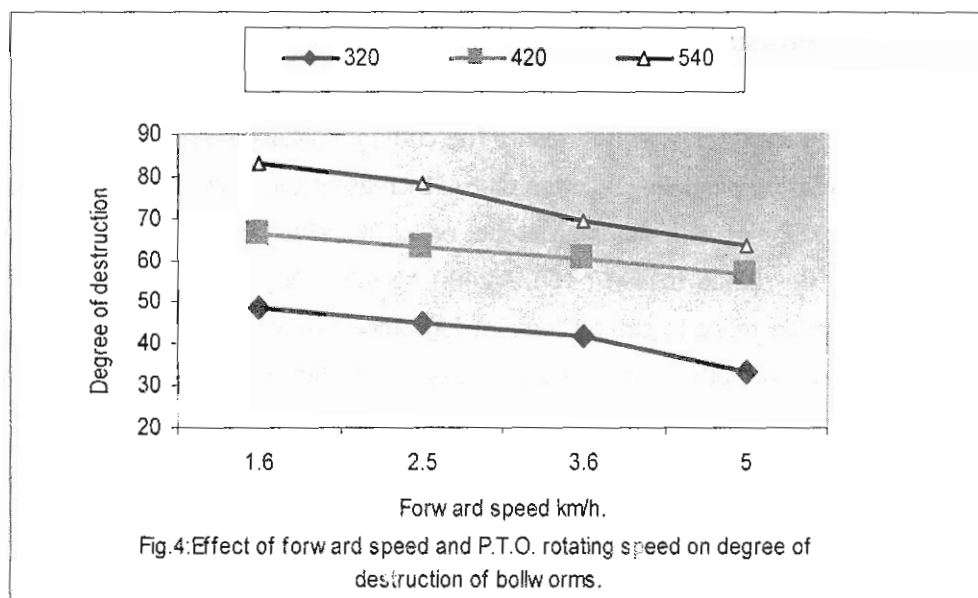 Fig. 5 shows the effect of forward speed on cutting energy at three different values of P. T. O. rotating speed. The results indicate that , increasing machine forward speed from 1.6 to 5k,,/h tends to decrease the cutting energy from (41.4 to 23.3), (27.5 to18.3) and (23.1 to 16.6 kw.h/fed) at 320 , 420 and 540 r.p.m speeds, respectively. These results agree with those obtained by Helmy *et al.* (1995) .

fig.1: Effect of forward speed and P.T.O. rotating speed on actual field capacity fed/h

Fig.2: Effect of forward speed and P.T.O. rotating speed on cutting efficiency %

Fig.3: Effect of forward speed and P.T.O. rotating speed on chopping efficiency %

Fig.4: Effect of forward speed and P.T.O. rotating speed on degree of destruction of bollworms.

Fig.5: Effect of forward speed and P.T.O. rotating speed on cutting energy.

Fig.6: Effect of forward speed and P.T.O. rotating speed on Efficiency

Cutting Resistance Force

Table (1) Illustrates the cutting resistance force at different stalk diameters and different moisture contents of cotton plant. The cutting resistance force as measured is affected by increasing diameter of cotton stalk . Increasing the stalk diameter of cotton plant from 5 to 12 mm at moisture contents of 52 %, 45% and 35 % increased the cutting force from (220.6 to 580.7 N), (248.1 to 622.8 N) and (280.5 to740.5 N), respectively. The decrease in cutting force at high moisture level is due to the viability of the stalk tissues of cotton plant. These results are confirmed with those obtained by (Awady *et al.* 1988).

Table 1:Effect of stalk diameter of cotton plant on cutting resistance at different moisture contents.

Diameter of Cotton Stalk, (mm)	Cutting resistance, Newton for Diferent MC%		
	52%	45%	35%
5	220.6	248.1	280.5
6	225.4	270.1	309.1
7	250.9	300.2	400.2
8	260.2	370.4	470.8
9	290.4	401.5	530.2
10	340.1	500.3	605.9
11	500.9	580.7	700.6
12	580.7	622.8	740.7

Total cost

The economical aspects of cotton stalks removal can be evaluated through the specific cost of operation.

A complete cost analysis was made related to the actual field capacity of rotary mower. Table (2) indicates the obtained results of this analysis estimated as operation costs of one feddan. At the end a criterion function was taken as the sum of the specific cost of cotton stalk removal plus the residual loss due to incomplete destruction of the pink bollworm (RDC).

$$RDC = RC + DL$$

Where:

RC = the specific cost of removing cotton stalk,   L.E/Fed.

DL = residual loss of pink bollworm,   L.E/Fed.

$$DL = 10^{-2} (100-D)L. \qquad L.E/Fed.$$

Where:

D = degree of distruction, %

L = loss due to pink bollworm   (50 L.E/Fed.)

Data given in table (2) show that the criterion function costs for rotary mower which reached 8.35 L.E/Fed. at 540 r.p.m. and forward speed 1.6 km/h. Also, the results show that increasing the forward speed tends to decrease the criterion cost. The results indicate that increasing the P.T.O. rotating speed tends to increase the criterion cost L.E/Fed.

Table 2. Cost analysis and criterion function.

Forward speed km/h	P.T.O speed r.p.m	Total cost L.E/h	Actual field Capacity. Fed/h	Specific cost L.E/Fed	Degree of destruction %	Criterion Function cost LE/fed
1.60		7.01	0.32	21.91	48.6	25.7
2.50		7.01	0.41	17.09	45.0	27.5
3.60	320	7.01	0.55	12.75	41.7	2915
5.00		7.01	0.71	9.87	33.5	33.25
1.60		7.01	0.50	14.02	66.2	16.90
2.50	420	7.01	0.65	10.78	63.0	18.50
3.60		7.01	0.85	8.25	60.2	19.90
5.00		7.01	1.15	6.10	56.8	21.6
1.60		7.01	0.74	9.47	83.3	8.35
2.50	540	7.01	0.94	7.46	78.3	10.85
3.60		7.01	1.20	5.84	69.5	15.25
5.00		7.01	1.50	4.67	63.5	18.25

CONCLUSION

The study revealed the following main points:

- Increasing the forward speed from 1.60 to 5.00 km/h tends to decrease the cutting efficiency from 91.6 to 80.1 %. Also, increasing the P.T.O. rotating speed from 320 to 420 to 540 r.m.p tends to increase the cutting efficiency from 78.7 to 89.3 to 91.0 % respectively.

- The chopping efficiency decreased from 90.4 to 78.9 % by increasing the forward speed from 1.70 to 5.00 km/h., while the chopping efficiency increased from 79.1 to 85.9 to 90.7 % when the P.T.O. rotating speed increased from 320 to 420 to 540 r.p.m. respectively.

- The degree of destruction decreased from 66.1 to 51.3 % by increasing the forward speed 1.6 to 5.00 km/h., while the chopping efficiency increased from 42.2 to 61.6 to 73.7 % when the P.T.O. rotating speed increased from 320 to 420 to 540 r.p.m. respectively .

- When the forward speed increased from 1.60 to 5.00 km/h the actual field capacity increased from 0.52 to 1.12 Fed/h., when the P.T.O rotating speed increased from 320 to 420 to 540 r.p.m. to increasing the actual field capacity from 0.50 to 0.80 to 1.10 Fed/h. respectively.

- Increasing the forward speed from 1.60 to 5.00 km/h tends to decrease the cutting energy from 30.7 to 20.0 kw.h/Fed., while the P.T.O. rotating speed increased from 320 to 420 to 540 r.p.m. tends to decrease the cutting energy from 33.1 to 22.17 to 19.5 kw.h/Fed. Respectively.

- From the economic point of view, changing the forward speed from 1.60 to 5.00 km/h, the specific cost varied from 21.91 to 9.87, and from 14.02 to 6.10 and from 9.47 to 4.67 L.E/Fed. at P.T.O. rotating speed from 320 to 420 to 540   r.p.m. respectively .

- The lowest value of criterion cost reached 8.35 L.E/Fed at a forward speed of 1.60 km/h and P.T.O. rotating speed reached 540 r.p.m.

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تقييم أداء محشة دورانية في تقطيع و فرم حطب القطن جيزه (٨٦) وتدمير ديدان اللوز

أسامة محمد كامل محمد

معهد بحوث الهندسة الزراعية – مركز البحوث الزراعية – الدقي

تعتبر عملية اخلاء الارض وتجهيزها للمحصول التالي من اهم العمليات الزراعية وانجاز عملية الأخلاء يزيد الفرصة للاعداد الامثل للتربة وحسب المساحة المنزرعة يعتبر القطن من اهم محاصيل الالياف في العالم وفي مصر ولذلك فان نزع حطب القطن يساعد في اضافة صناعات جديدة مثل الخشب المضغوط والعلف الحيواني والوقود الامن ومن ناحية اخري يساعد في مقاومة دودة لوز القطن. وعلي ذلك فقد اقترح هذا البحث تقييم اداء محشة دورانية في فرم حطب القطن...حيث اجريت التجارب في موسم ٢٠٠٣ في محطة البحوث الزراعية بسخا– كفر الشيخ علي مساحة ٢ فدان علي صنف القطن جيزة ٨٦.

الغرض من هذة الدراسة هو دراسة تاثير المتغيرات الاتية (سرعات التشغيل الامامية وسرعات عمود الادارة الخلفي للجرار) علي العوامل الاتية (كفاءة القطع–كفاءة الفرم–درجة تدمير ديدان اللوز– طاقة القطع–السعة الفعلية والكفاءة الحقلية–مؤشرات تكاليف استخدام الجرار والالة).

واسفرت نتائج الاختبارات أن اعلي انتاجية فعلية كانت ١,٥ فدان/ساعة تم الحصول عليها عند السرعة ٥كم/ساعة عند سرعة عمود الادارة الخلفي للجرار ٥٤٠ لفة/دقيقة وايضا حققت أعلي كفاءة قطع وكفاءة فرم ودرجة تدمير ديدان اللوز وكانت القيم ٩٥ %، ٩٤ % ٨٣ % علي الترتيب عند السرعة الاولي ١,٦ كم/ساعة وسرعة عمود الادارة الخلفي للجرار ٥٤٠ لفة/دقيقة. كما وجد ان الالة استهلكت اقل طاقة قطع وكانت قيمتها ١٦,٥ كيلو وات.ساعة/فدان عند السرعة ٥ كم/ساعة عند سرعة عمود الادارة الخلفي للجرار ٥٤٠ لفة/دقيقة.

وفقا لتحليل مؤشرات التكاليف الحقليه اظهرت النتائج فنيا واقتصاديا ان الآلة قد حققت تكاليف ٧,٠١ جنية/ساعة وتكلفة ٤,٦٧ جنية/فدان عند السرعة ٥ كم/ساعة وسرعة عمود الادارة الخلفي للجرار ٥٤٠ لفة/دقيقة....ومن ناحية اخري كانت اعلي كفاءة حقلية وصلت اليها الالة هـي ٨٣,٢ % عند السرعة ١,٦ كم/ساعة وسرعة عمود الادارة الخلفي للجرار ٥٤٠ لفة/دقيقة.