Prospects of Modern Technology in Agricultural Engineering and Management of Environmental Problems: 43 - 58

STUDY ON THE MECHANIZATION OF CARAWAY CROP PRODUCTION UNDER EGYPTIAN CONDITIONS

Ali, M. M. A. * **, M. A. Tawfik** ** **, N. I. Bendary** ***

ABSTRACT

Field experiments were carried out to investigate some different mechanization systems for producing caraway crop under Egyptian conditions. Seed bed preparation was investigated using chisel plow, moldboard plow, rotary plow and land leveler. Planting was investigated using two types of seed drills (Colorado and Tye) machines comparing with the manual method. Threshing operation was investigated using threshing machine at different drum speeds, and different seed moisture contents. The obtained data revealed that, selecting the proper method of seed bed preparation (chisel plow one pass +land leveler) gave the best soil properties. Mechanical planting by seed drill (Colorado) comparing with seed drill (Tye) and manual method is considered the proper system for producing caraway crop under Egyptian conditions as it recorded the highest productivity (865 kg/fed). On the other hand seed drill (TYE) required minimum cost(103.75 L.E/Mg) .Drum speed of 12.56 m/s (600 r.p.m) and seed moisture content of (7.72%)are considered the proper values for threshing caraway crop as they recorded maximum efficiency and minimum energy.

INTRODUCTION

Agricultural policy depends on the successful technology through mechanizing the agricultural processes of strategical crops. In Egypt the medicinal and aromatic crops have an important export value. And also come in the fifth order after cotton, rice, and potato. Caraway is considered to be one of the most important medicinal and aromatic crops in Egypt as they participate in the local consumption added to export value and different aspects. Increasing the quantity and quality of any crop depends on improving the soil and plant conditions. Seed bed preparation, planting and threshing method, improving that.

* Assist. Prof. of Agric. Eng. Dept., Fac. of Agric., Zagazig Univ., Egypt.
** Lecturer of Agric. Eng. Dept., Fac. of Agric., Zagazig Univ., Egypt.
*** Graduate Student of Agric. Eng. Dept., Fac. of Agric., Zagazig Univ., Egypt.

Mechanization of these operations is of great importance to reduce time, labor and cost. **Habib *et al.* (1991)** mentioned that increasing of soil bulk density lead to increase the soil compaction. On the other hand soil bulk density decreases with increasing percentage of soil porosity. Soil bulk density is between (1.0 -1.6 gm/cm^3) for plowing layers with clay, loamy and silt soil but it is between (1.2 -1.8 gm/cm^3) with sandy soil. They also mentioned that soil bulk density increase with increasing working depth. Soil bulk is major factor to indicate soil properties. **Morad and El-Shazly (1994)** studied the effect of some operating parameters (moisture content and operating depth) on soil penetration resistance of rotary plow. They found that increasing soil moisture content significantly decreased soil penetration resistance. They also found that increasing soil moisture content from (13 to 24%) measured at various operating depths of 10, 15and 20 cm, decreased soil penetration resistance by 9,16and 20%. They added that the moisture content of 21% is considered the proper moisture content for plowing in the experimental soil. **Abd El-Maksoud *et al.* (1994)** indicated that, the seed-bed preparation by using the chisel plow (two times) followed by rotary tiller and mechanical leveling can be considered the suitable recommended method to obtain the best soil physical properties. Some times it is not preferable to use heavy implements in some soils due to their undesirable effect on its physical properties .**Abd-El-Aal (1998)** found that the soil bulk density was decreased after tillage operation. The reduction was more when the plowing depth was (25cm) and less reduction at (20cm) at forward speeds (2.4, 2.08 and 1.25cm/h) produced the maximum increase in soil porosity. **Abo El-Ees (1985)** showed that method of seed drilling is very effective due to its effect on uniformity of depth and spacing it is well known that mechanical seed drilling leads to more uniform spacing and sowing depth resulting in higher yield than the traditional hand method of sowing. **Dickey and Jasa (1989)** stated that it is necessary in case of automatic seed drills to calibrate them before sowing to know the exact seed rate it will drop. The seed drills are to be calibrated for each type of crop separately because of differences in shape, size and weight of different seeds. Proper care has to be taken in choosing the soil working part such as the tine. **Ibrahim** ***et al.*** **(2008)** developed seed drill feeding device to be suitable for black seed planting. They also optimized some operating parameters affecting the performance of the developed machine. **Tsujimoto** ***et al.*** **(2006)** indicated that result of the earlier performance test of the Turkish thresher showed that more than 90% of the straw was cut into small pieces of less that 10cm and was therefore of no value for feed. However, the results of the improved screw type threshing drum showed a rate of straw loss of only 9.0% for "Merchouch" wheat and 10.3% for "Beldi" barley of straw for feed. The objective of their study was to develop and evaluate .The performance of the local thresher to be suitable for caraway crop threshing. **Radwan** ***et al.*** **(2009)** developed local cereal threshing machine for threshing caraway crop and tested at different operating conditions, at rotor speeds of (500, 560, 630 and 700 r.p.m), moisture contents of caraway straw of (10.36 , 11.84 and 13.72%). Air speeds on sieves of (4.8, 5.7 and 6.8 m/s) were also tested some of factors were fixed such as, hole diameter of sieves was (3 mm) , feed rate was (540 kg/h) and concave clearance was (15 mm) seed moisture content of(11.84 %), drum speed of (500 r.p.m) and air speed of (4.8 m/s) resulting seed losses of (2.2%) threshing efficiency of 73.7% and criterion energy consumed 29.04 kW.h/ton. The objective of this woke are:

- Selecting the proper seed bed preparation and methods of planting for producing maximum productivity of caraway crop.
- Optimizing both seed moisture contents and drum speed for threshing caraway to maximize threshing efficiency.

MATEIRALS AND METHODS

The main experiments were carried out during the agricultural season of 2009/2010 at Kafer Awald Wafy, Sharkia Governorate to investigate some different mechanization systems for producing caraway (Egyptian variety) under Egyptian conditions.

The experimental area was about (1.5) feddans divided into (27) equal plots having dimensions of (66.6 x 3.5 m) per each. Mechanical analysis of the experimental soil was classified as clay soil (48.71% clay).

Materials:

The following equipments were used to accomplish the present research:

- ***Tractors:***

1. New-Holland "Fait" of 75 hp (55.93 k.W) engine power.
2. Kubota "L 285" of 30 hp (22.37 k.W) engine power.
3. Nasr "M 34 / T " of 60 hp(44.1 k.W)engine power.
4. Lamborjuni "Italy" of 85 hp (62.5 k.W) engine power.

- ***Seed bed preparation equipments:***

1- Chisel plow 9 tines, with working width of 225 cm.
2- Mould-board plow 3 boards, with working width of 125 cm.
3- Rotary plow with 125 cm working width, and 42 rotating cutters.
4- Land leveler, with working width of 305 cm.

- ***Planting machines:***

1. Seed drill 21 rows, model Colorado with working width 240 cm.
2. Seed drill 20 rows, model Tye with working width 300 cm.

-Harvesting:

The harvesting operation was carried out using the conventional method.

- ***Turkish Thresher:***

The machine consists of two components; threshing and winnowing units. The threshing drum is 120 cm length, 73 cm diameter and number of finger is 40. The winnowing unit consists of a fan, vibrating screen and air.

Methods:

The experimental treatments:

Nine treatments, namely A, B, C, D, E, F, G, H and I were carried out and replicated three times in a completely randomized block design.

A: Chisel plow one pass + land leveler + manual planting + threshing by threshing machine.

B: Chisel plow one pass + land leveler + seed drill (Colorado) + threshing by threshing machine.

C: Chisel plow one pass + land leveler + seed drill (Tye) + threshing by threshing machine.

D: Chisel plow two passes + land leveler + manual planting + threshing by threshing machine.

E: Chisel plow two passes + land leveler + seed drill (Colorado) + threshing by threshing machine.

F: Chisel plow two passes + land leveler + seed drill (Tye) + threshing by threshing machine.

G: Mould board plow + rotary plow + land leveler + manual planting + threshing by threshing machine.

H: Mould board plow + rotary plow + land leveler + seed drill (Colorado) + threshing by threshing machine.

I: Mould board plow + rotary plow + land leveler + seed drill (Tye) + threshing machine.

Manual harvesting was carried out for all treatments during the experiment. The depth of the tillage was (20 cm). For both manual and mechanical planting methods, the row spacing is (45 cm) and the spacing between two seeds in the same row was (30 cm). Manual planting was required about (5 kg/fed) of seeds while seed drill was required about (3 kg/fed) of seeds. Plant depth was adjusted (2 cm) at forward speed (5 km/h) for two seed drills. Fertilizing, irrigation and weed control were the same in all treatments according to the technical recommendations. The threshing operation was conducted under three different drum speeds of (550, 600 and 650 r.p.m (11.51, 12.56 and 13.60 m/s) at four moisture contents of (9.73, 8.54, 7.72 and 6.85%).

Measurements:

Soil bulk density and some plant characteristics as well as crop yield were measured as indicators for the planting operation. Unthreshed seeds, mechanical seed damage, threshing losses threshing efficiency and cleaning efficiency were calculated as an indicators for the threshing operation.

- ***Soil Bulk density:***

The bulk density was calculated by using the following equation:

$$Pb = m_b / v_b \text{ , ...(1)}$$

Where:

Pb = Soil bulk density, gm/cm^3.

m_b = Dry weight of the soil in the container, gm.

v_b = Volume container, cm^3.

• *Field capacity:*

Actual field capacity was the actual average time consumed during the operation (lost time + productive time). It can be determined from the following equation:

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

Where:

$F.C_{act}$ = Actual field capacity of the cutting machine.

T_u = Utilization time per feddan in minutes.

T_l = Summation of lost time per feddan in minutes.

• *Field efficiency:*

Field efficiency is calculated by using the values of the theoretical field capacity and effective field capacity rates as:

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

Where:

η_f = Field efficiency, %.

• *Energy consumed:*

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

$$EP = \left[f.c.(1/3600)PE \times L.C.V. \times 427 \times \eta_{thb} \times \eta_m \times 1/75 \times 1/1.36\right] kW \ldots(4)$$

Where:-

$f.c.$ = Fuel consumption, (l/h).

PE = Density of fuel, (kg/l), (for gas oil = 0.85 and benzene = 0.72).

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

η_{thb} = Thermal efficiency of the engine (35 and 25%) for Diesel and Otto).

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

η_m = Mechanical efficiency of the engine (83 % for diesel).

Hence, the specific energy consumed can be calculated as follows:-

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

• ***cost analysis:***

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

$$C = \frac{P}{h}\left(\frac{1}{a} + \frac{i}{2} + t + r\right) + (0.9\,W.S.F) + \frac{m}{144} \quad ...(6)$$

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, h.
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.

RESULTS AND DISCUSSION

Results and discussion will present under the following items:

Field capacity and field efficiency for different seed bed preparation systems:

Fig. (1) show that the field capacity values were 1.697, 2.196, 0.888, 0.897 and 2.277 fed/h for chiseling 1st, chiseling 2nd, mould board plow, rotary plow and land leveler ,respectively. And the field efficiency values were 79.29, 82.22, 74.62, 75.37 and 78.51% under the same machine, respectively.

Field capacity and field efficiency of different planting systems:

Fig. (2) show that field Capacity of manual planting was 0.0501 fed/h while it reached to 1.86 and 2.604 fed/h at mechanical planting(seed drill(Colorado)and seed drill (Tye), respectively and field efficiency values were 58.93, 81.57% and 91.05% under the same previous conditions.

Effect of seedbed preparation treatments on soil bulk density:

Soil bulk density generally decreased due to tillage and other treatments considered. Fig. (3) show that the reduction for soil bulk density, (%). can be arranged in descending order as follows: F, C, E, I, B, D, H, A and G. It is clear that the treatment (F): (Chisel plow two passes + land leveler + seed drill (Tye) + threshing by threshing machine) recorded the highest value of reduction in soil bulk density (17.78 %) this can be explained by the fact that the density decreased by increasing the number of tillage passes or tillage procedures involved in the treatment., while treatment(G): (Mould board plow + rotary plow + land leveler + manual planting + threshing by threshing machine) recorded the lowest value of reduction in soil bulk density (11.02 %) due to eliminating mould board plow, rotary plow and land leveler.

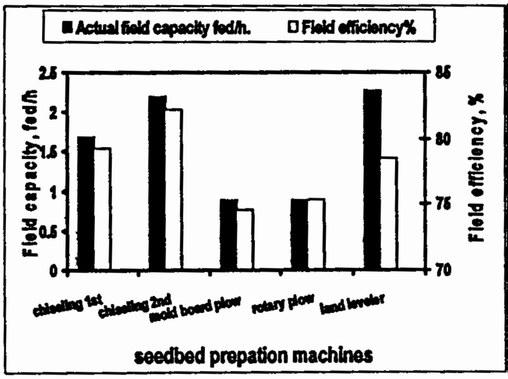

Fig. (1): The actual field capacity and field efficiency for seedbed preparation machines.

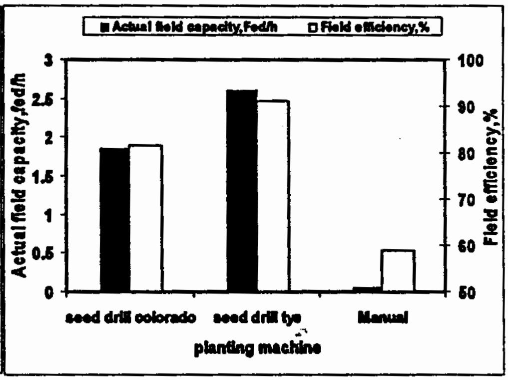

Fig. (2): The actual field capacity and field efficiency for planting methods.

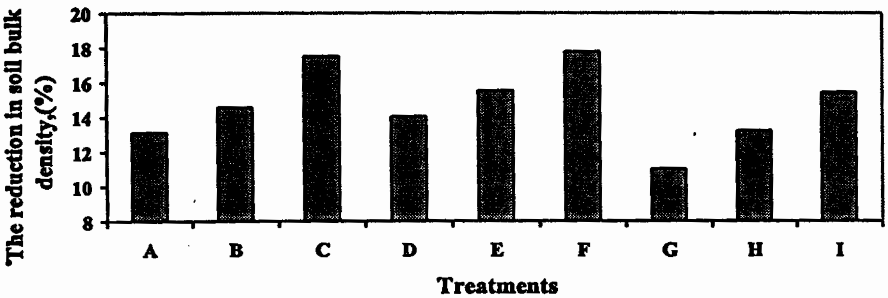

Fig (3) Effect of seedbed preparation treatments on soil bulk density

Effect of different planting methods on some plant characteristics and crop yield:

Results in Table (1) shows that the complete emergence of plants was noticed after 10 days using seed drill (Colorado) and after 12 days using seed drill (Tye), while the period increased to 14 days using manual planting. This is due to the fact that the depth of planting could not be thoroughly adjusted. Table (1) shows that the maximum germination ratio of 96% was remarked under the manual method. The germination ratio decreased to 94%, 93% under seed drill (Colorado and Tye), respectively. That is due to the feeder under seed drill machine resulting in cracked seeds. Table (1) shows that uniformity of distribution values were 21.9, 15.8 and 17.2 % using manual planting and mechanical planting, respectively. That is due to the control in the seeds spacing under mechanical planting comparing with manual. Table (1) shows that the highest plant population of 18.6 plant/m^2 was noticed under manual planting. While it decreased to 15.8, 14.5 plant/m^2 under seed drill (Colorado and Tye), respectively. This is due to the high germination ratio of manual planting comparing with mechanical planting. It was observed from table (1) that the maximum stem length of 145 cm was noticed under manual planting lead to increase plant length. While it decreased to 120, 115 cm under seed drill (Colorado and Tye), respectively. Table (1) shows that the average weight of 1000 grains were 16.67, 16.80 and16.53 gm under manual planting and seed drill (Colorado and Tye), respectively. Also table (1) shows that the average values of yield obtained were 0.822, 0.865 and 0.841 Mg/fed under manual planting and seed drill (Colorado and Tye), respectively. So, mechanical planting using seed drill (Colorado) type is the advisable method for planting caraway crop because of its high resulting caraway crop because of its high resulting yield comparing the other type seed drill (TYE).

Caraway Crop Threshing

Un threshed seeds

Fig. (4) show the relationship between un threshed seeds and different drum speeds at different seed moisture contents. The obtained results

Table (1): Effect of different planting methods on some plant characteristics and crop yield.

Planting methods	Emergence (Period/day)	Germination ratio (%)	Uniformity distribution. C.V. (%)	Plant population (plant/m^2)	Stem length (cm)	Weight of 1000 seeds per (gm)	Crop yield per (Mg/fed)
Manual	**14**	**96**	**21.9**	**18.6**	**145**	**16.67**	**0.822**
Seed drill (Colorado)	**10**	**94**	**15.8**	**15.8**	**120**	**16.80**	**0.865**
Seed drill (Tye)	**12**	**93**	**17.2**	**14.5**	**115**	**16.53**	**0.841**

Show that drum speed and seed moisture content affect deeply on the percentage of un threshed seeds. The highest value of un threshed seeds of 10.14%, was observed under the high level of seed moisture content of 9.73 %, and low drum speed of 550 r.p.m, while the lowest value of 0.78%, was observed under low seed moisture content of 6.85% and high drum speed of 650 r.p.m.

Mechanical seed damage

Fig. (5) show the relationship between damaged seeds and different seed moisture contents at different drum speeds. It is noticed that minimum value of mechanical seed damage was 0.94% recorded at low drum speed of 550 r.p.m and high seed moisture content of 9.73%.

Threshing losses

Fig. (6) show the relationship between total losses (including un threshed seeds and damaged seeds together) and different drum speeds at different seed moisture contents. It is noticed that minimum value of threshing losses was 5.80 % recorded at drum speed of 600 r.p.m and seed moisture content of 7.72 %.

Threshing efficiency

Threshing efficiency was affected by many variables such as drum speed and seed moisture content. Results obtained in Fig (7) indicated that the

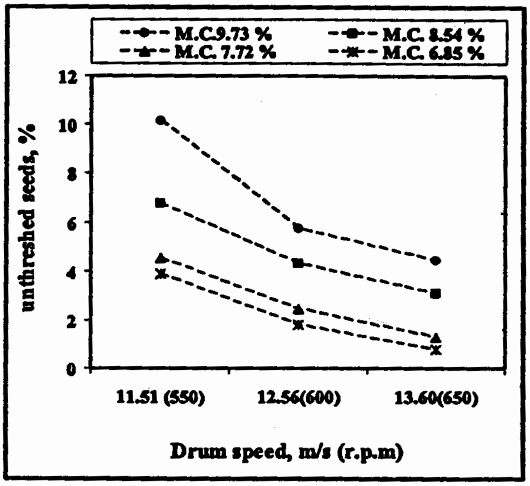

Fig. (4):Effect of drum speed under different seed moisture content on un threshed

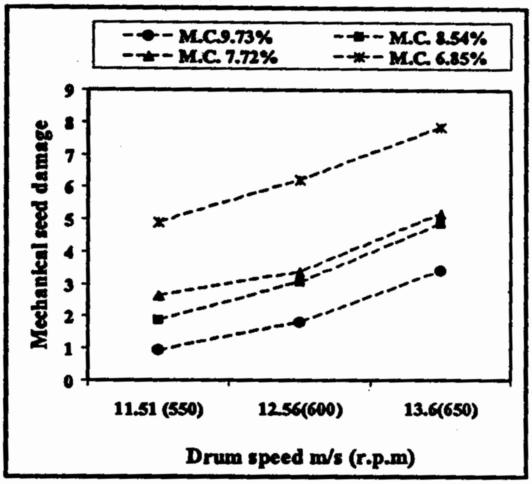

Fig. (5): Effect of drum speed and seed moisture content on mechanical seed damage.

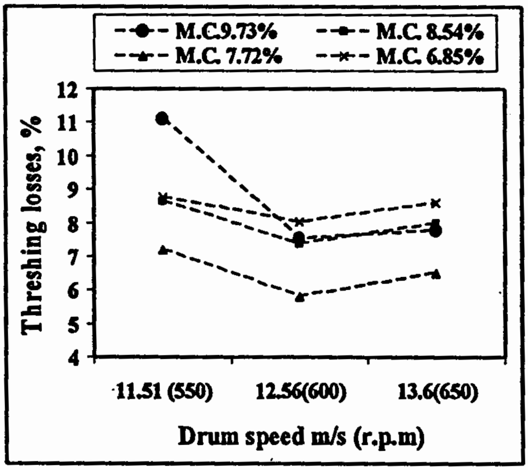

Fig. (6): Effect of drum speed and seed moisture content on threshing losses.

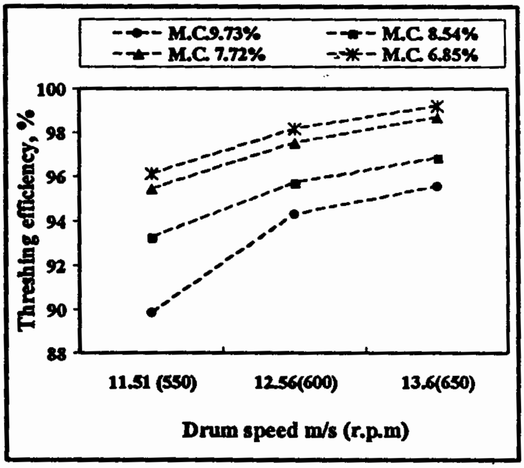

Fig. (7): Effect of drum speed and seed moisture content on threshing efficiency.

threshing efficiency increased with the increase in drum speed. On the other hand, threshing efficiency decreased by increasing seed moisture content, where the seeds can not be separated easily and as a result, the percentage of un threshed grains increased.

Cleaning efficiency

Fig (8) show that the relation between cleaning efficiency and different drum speeds at different seeds moisture contents. The cleaning efficiency increased from 90.1 to 93.50, from 91.90 to 95.00 from 94.00 to 96.45 and from 95.60 to 97.80% at different seed moisture contents of 9.73, 8.54, 7.72 and 6.85%, respectively by increasing drum speed from 550 to 650 r.p.m.

From the above data of the threshing process, it can be concluded that: the seed moisture content of 7.72 % and drum speed of 600 r.p.m are considered the optimum conditions through which losses percentage is minimum.

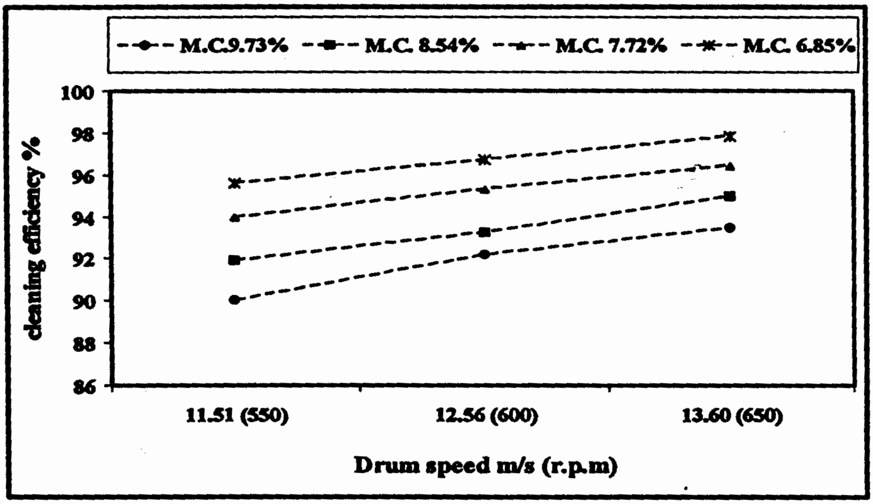

Fig. (8): Effect of drum speed and seed moisture content on cleaning efficiency.

Energy Requirements for Different Caraway Crop Mechanization Systems.

Fig (9)show that the total energy requirements to produce one Mg of caraway crop can be arranged in descending order as follows: H, I, G, B, C, E, F, A and D. It is clear that the treatment (H): (Mould board plow + rotary plow + land leveler + seed drill (Colorado) + threshing by threshing machine) required the highest value of energy (135.27 k.W.h/ Mg), while treatment (D): (Chisel plow two passes + land leveler + manual planting + threshing by threshing machine) required the lowest value of energy (62.26 k.W.h/ Mg),

Cost Analysis for Caraway Production

Fig. (10) show that the cost per unit of production for the different treatments. The cost of production per Mg of yield can be arranged in descending order of treatments as follows: G, D, H, I, A, E, F, B and C. It is clear that the treatment (G): (Mould board plow + rotary plow + land leveler + manual planting + threshing by threshing machine) required the highest value of energy (250.57 L. E. / Mg), while treatment (C): (Chisel plow one pass + land leveler + seed drill (Tye) + threshing by threshing machine) required the lowest value of energy (103.75 L. E. / Mg).

CONCLUSION

The field experiments aim to evaluate some different mechanization systems for producing caraway crop. Results showed that:

1. Treatment C: (Chisel plow one pass + land leveler + seed drill (Tye) + threshing by threshing machine) is recommended for caraway production under Egyptian conditions as it required minimum cost (103.75 L.E/Mg) comparing with the other treatments.
2. Drum speed of 12.56m/s (600 r.p.m) and seed moisture content of 7.72% are recommended for threshing caraway crop as it recorded both minimum losses and energy (5.80 % and 27.46 kw.h/fed), respectively.

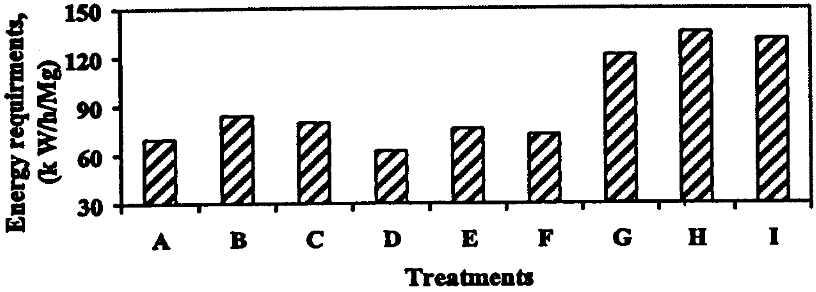

Fig. (9) Energy requirements to produce one Mg of caraway crop under different treatments.

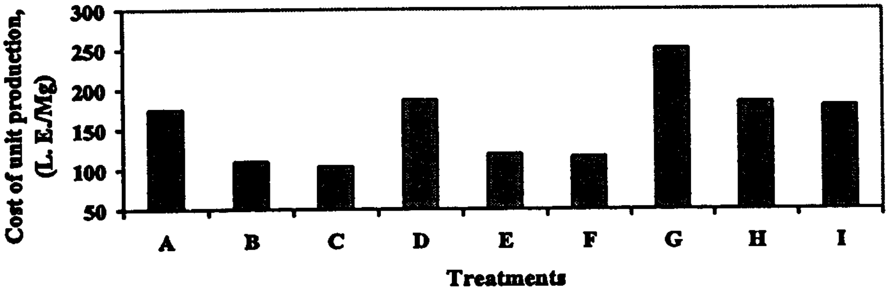

Fig. (10): Cost requirements to produce one Mg of caraway crop under different treatments.

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الملخص العربي

دراسة عن ميكنة عمليات إنتاج محصول الكراوية تحت الظروف المصرية

د/ محمود مصطفى على على ، د/ محمد على توفيق م/ نهلة إبراهيم أحمد بندارى

أجريت تجربة لإعداد وزراعة ، ودراس محصول الكراوية تحت الظروف المصرية خلال موسم ٢٠٠٩/ ٢٠١٠ فى مساحة (١.٥) فدان فى أرض طينية بناحية كفر أولاد وفى – مركز الزقازيق – محافظة الشرقية.

وكانت أهداف الدراسة:

١- اختيار أنسب طرق إعداد مرقد البذرة، و الزراعة لمحصول الكراوية تحت الظروف المصرية التى تحقق أقل تكاليف.

٢- دراسة تأثير نسبة رطوبة النبات وسرعة درفيل الدراس على عملية الدراس.

* أستاذ مساعد – قسم الهندسة الزراعية – كلية الزراعة – جامعة الزقازيق – مصر.
** مدرس – قسم الهندسة الزراعية – كلية الزراعة – جامعة الزقازيق – مصر.
*** طالب دراسات عليا – قسم الهندسة الزراعية – كلية الزراعة – جامعة الزقازيق – مصر.

وقد أجريت التجربة باستخدام المعاملات الآتية:

(A) محراث حفار وجه واحد + تسوية + زراعة يدوى + دراس بالآلة الثابتة.

(B) محراث حفار وجه واحد + تسوية + زراعة بالسطارة (كلورادو) + دراس بالآلة الثابتة.

(C) محراث حفار وجه واحد + تسوية + زراعة بالسطارة (تاى) + دراس بالآلة الثابتة.

(D) محراث حفار وجهين + تسوية + زراعة يدوى + دراس بالآلة الثابتة.

(E) محراث حفار وجهين + تسوية + زراعة بالسطارة (كلورادو) + دراس بالآلة الثابتة.

(F) محراث حفار وجهين + تسوية + زراعة بالسطارة (تاى) + دراس بالآلة الثابتة.

(G) محراث قلاب مطرحى + محراث دورانى + تسوية + زراعة يدوى + دراس بالآلة الثابتة.

(H) محراث قلاب مطرحى + محراث دورانى + تسوية + زراعة تسطير (كلورادو) + دراس بالآلة الثابتة.

(I) محراث قلاب مطرحى + محراث دورانى + تسوية + زراعة تسطير (تاى) + دراس بالآلة الثابتة.

وقد تم تقييم المعاملات من حيث:

١- السعة والكفاءة الحقلية لطرق الإعداد المختلفة.

٢- تأثير طرق الإعداد على الكثافة الظاهرية.

٣- السعة والكفاءة الحقلية لطرق الزراعة المختلفة.

٤- تأثير طرق الزراعة على بعض صفات النبات.

٥- تأثير بعض العوامل على عملية الدراس (نسبة الرطوبة – سرعة الدرفيل).

٦- الطاقة المطلوبة لعمليات الميكنة المختلفة لمحصول الكراوية.

٧- التكاليف المطلوبة للعمليات الآلية المختلفة لمحصول الكراوية.

ومن خلال النتائج تم التوصل إلى التوصيات الآتية:

١- يوصى باستخدام المعاملة (C) محراث حفار وجه واحد + تسوية + زراعة بالسطارة (تاى) + دراس بالآلة الثابتة ، وذلك لإنتاج محصول الكراوية تحت الظروف المصرية حيث أنها سجلت أقل تكاليف (١٠٣.٧٥ جنيه/ ميجا جرام).

٢- يوصى بدراس محصول الكراوية عند نسبة رطوبة (٧.٧٢%) على أساس رطب وسرعة درفيل ٦٠٠ لفة/دقيقة (١٢.٥٦ م/ث) حيث أنها سجلت أقل قيمة لفواقد البذور.