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EVALUATION OF LOCALLY THRESHING MACHINE PERFORMANCE FOR THRESHING LENTIL CROP.

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ABSTRACT

The main objectives of this research are to study the feasibility of cereal threshing machine for dry lentil seed threshing and select the optimum conditions for operating it. Threshing machine performance was investigated as a function of change in drum speeds of 7.85, 9.82, 11.78, 13.74, and 15.71 m / sec, feed rates of 10.00, 11.67, 13.13, 15.00, and 16.67 kg /min, and seed moisture contents of 10.31, 12.30, and 14.12 %. The experiments were carried out at the experimental farm of Tag EL-Ezz Research station, Dakahliea Governorate during season 2004 on lentil crop at three different times after hand harvest operation to drying the field. All experiments were conducted using locally thresher machine The obtained results show that, the local threshing machine can be successfully used for threshing lentil crop under the following conditions: feeding rate of 11.67 kg/min and drum speed of 11.78 m / sec at seed moisture content of 10.31 %, resulting in seed damage of 0.62 %, unthreshed seed of 0.15 %, total seed losses of 0.77 %, seed output of 302.1 kg/h, threshing efficiency of 99.79 %, consumed energy of 0.116 kW. h /kg, and criterion cost of 85.83 L.E/ton.

INTRODUCTION

Lentil is one of the important leguminous crops in the world. In Egypt lentil is cultivated in total area of about 25 thousand feddans, producing about 14 thousand metric tons, where the major planting area is in Upper Egypt. Lentil is used as a rich source of protein feed which are very nutritious, lentil plants provide high quality straw for animals feeding and increase soil fertility. Up till now, the manual threshing of lentil crop is still the common practice followed by the majority of the farmers in Egypt. **Sharma and Devnanl (1980)** reported that the threshing efficiency increased with the increase of cylinder speed but decreased with the increase of feeding rate and concave clearance. Energy consumption was directly proportional to cylinder speed, feed rate, and remained constant at selected concave clearance. At higher speeds, the visible grain damage was 5% and the germination percentage was low. **Huynh et al. (1982)** stated that the seed separation from the stalks and passage of seed through the concave gate is a function of some variables such as crop feed rate, threshing speed, concave length and cylinder diameter and concave clearance. These variables also related to the threshing losses and seed separation efficiency. **Helmy (1988)** indicated that the unthreshed grain of wheat loss and the total

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grain damage are affected by cylinder speed, feed rate and moisture content as in these forms:

$$U.G = a + b (s) + c (f) + d (zs)$$

$$G.D = a + b \exp .01 (s) + c \exp. (f) + d (zg)$$

Where:

U.G = unthreshed grain, %
G.D = total grain damage, %
A, b, c and d = coefficient of equations.
S = cylinder speed, m/s
f =feed rate, kg/s
Zs = straw moisture content, %
Zg = grain moisture content, %

Sharma and Devnanl (1984) studied the threshing of soybean and cowpea. Threshing efficiency increased with the increase of cylinder speed but decreased with the increase of feed rate and concave clearance. Energy consumption was directly proportional to cylinder speed and feed rate, and remained constant at selected concave clearance. **Gane et al. (1984)** and **Gane (1985)** reported the utmost importance to harvest green pea seeds carefully, making sure that drum speed is low and seeds are harvested at right time. **Anwar** and **Gopta (1990)** reported that, the percentage of grain damage increased with on increase in cylinder speed for all feed rates and concave clearance combinations. The mean grain damage decreased with increasing concave clearance and feed rate. The percentage of total machine losses increased with as cylinder speed ranged from 480 to530 rpm. **Abo El-Khair (1991)** reported that, the unthreshed seed losses decreased with an increase in cylinder speed and with a decrease in cylinder-concave clearance for two levels of moisture. In addition, the unthreshed –seed loses increased with an increase in seed moisture level of seed at all parameters of both cylinder speed and cylinder-concave clearance. **Ajayi (1991)** indicated that, the material capacity of a thresher influenced by his speed of the threshing beater drum, the feed rate and the moisture contents of the material. At lower speeds of 300 and 500rpm of the beater drum ,the material at 13.3% moisture gave slightly decrease in capacity as the speed increased to 500 rpm. Mohamed (1994) found that, the machine power was directly proportional with drum speed, feed rate, and moisture content and grain damage. The machine power was reversibly proportional with the unthreshed grain. Total losses were significantly affected by application power. **El-Behery (1995)**concluded that, the optimum cylinder rpm for threshing soybean was determined as 300- 400 rpm and the clearance between cylinder and concave was 18 mm. **Omar (1995)**concluded that, the unthreshed grains decreased while the damage grain and cleaning efficiency increased with increasing drum speed from 400 to 600 rpm. The optimum threshing dry pea can be obtained at 600 rpm. **El-Behery et al. (1997)** reported that, the grain out, grain damage, and grain losses are highly affected by the drum speed, while the unthresed grains decreased linearly under all type of machines. Too, the grain out, grain losses and feeding rate increased with decreasing moisture content. **Baiomy et al. (1999)** reported that, the best performance of AMRI thresher for threshing soybean crop was found at drum speed of 14 m/s that gave machine capacity of 900.11 kg/h, cleaning efficiency of 93.8% seed damage of 1.12 %and total losses of 1.22 %. But the best performance of Gabr thresher was found at drum speed of 12 m/s that gave machine capacity of 826.02 kg/h, cleaning efficiency of 92.79 % and damage of 2.14 **Baiomy (2002)** concluded that, the best performance of the machine was achieved at 22 m/s drum speed, threshing capacity was 1840 kg/h at the previous drum speed, total losses and damaged grains were 1.1 % and cleaning percentage was 98.67 %.

The main objective of this research work is to study the feasibility of cereal threshing machine for dry lentil seed threshing. The thresher was tested for optimum feeding rate, threshing efficiency and drum speed, minimum seed damage and cost analysis.

MATERIALS AND METHODS

The experiments were carried out at the experimental farm of Tag EL-Ezz Research station, Dakahliea Governorate during season 2004 on lentil crop at three different times after hand harvest operation to drying the field. All experiments were conducted using locally threshing machine (Mabrouk thresher) as shown in Fig.(1), and 75 horsepower tractor .The specifications of these machines are shown as the following:

*** Threshing machine specifications:**

General:

Type: Axial flow thresher. **Manufacturer:** Mabrouk workshop, Tanta.

Overall dimensions:

Length: 320 cm. without hitch, 415 cm. with hitch. **Width:** 127 cm.
Height: 198 cm. **Source of power:** P.T.O. shaft.

Threshing drum:

Type: beater type with flat knives bolted on a 25.4 cm. diameter central tube. **Dimensions:** drum diameter with knives 75cm, length 118cm.

Drum knives: Total of 120 knives, 24cm. long, 3cm. wide and 0.6 cm. flat bolted to the central tube

Feed opening: 20x50cm. for paddy and 20x118cm. for wheat and other crops.

Concave:

No. of concave holes: 5holes per (10x10cm.) **Holes diameter:** 30mm.
Concave clearance: 3cm.

Grain winnowing unit:

Eccentric stroke of the screen: 3.5cm.
Hole of vibration screen diameter: 10mm.
No. of holes: 33 holes per (10x10cm.).
Screen slope: 5 degrees with horizontal.
Screen dimension: 245 x 110cm. long and width respectively.
Fan size dia.: 87cm-width 56.5 cm.
Fan Blades: 6 blades, radially mounted.

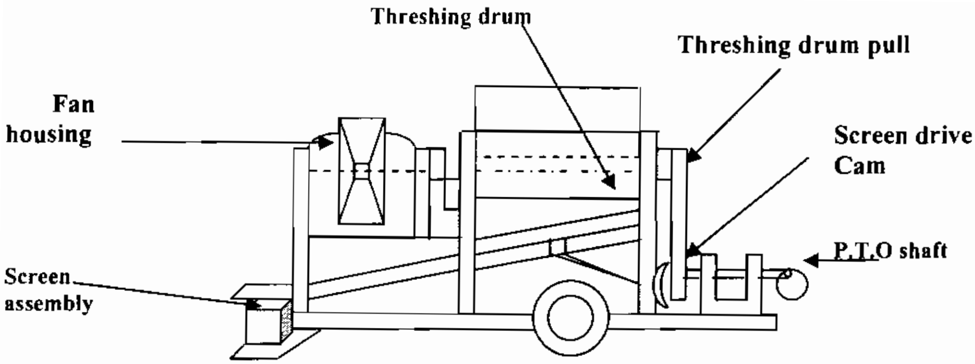


Fig (1): Prototype of locally manufactured threshing machine.

Tractor specifications:

Type: Universal 650-M **Engine type:** Four-stroke diesel injection.
Power: 75 hp (55.93 kW) **Rated speed:** 1440 rpm. **Made:** Romania.

The threshing machine performance was studied under the following parameters:

- Five different feeding rates (10.0, 11.67,13.33,15.00 and 16.67 kg/min)
- Five different peripheral drum speeds (7.85, 9.82, 11.78, 13.74and15.71 m/sec.).
- Three different moisture contents (10.31, 12.34and 14.12% ± 0.5 %
- (d.b)) at the optimum maturity of dry lentil plant. Table (1) indicates the physical properties of lentil seed crop used in all experimental tests.

Table (1): Some physical properties of the dry lentil plant.

Characteristics	Average value
Stem length, cm.	35.95
Stem diameter, mm	3.27
Number of branches /pl.	5.19
Number of pods /pl.	38.33

Evaluation of the threshing machine performance was done taking into consideration the following indicators:

1-Machine productivity:

- Machine productivity (P_{th}) was calculated by the following formula:

$$P_{th} = P_w / t, \text{ ---------- ton/h}$$

Where:

P_w = the mass of total seeds, ----------- ton

t = the time consumed in threshing operation, --------- h

2- **Seed losses, seed damage and threshing efficiency:**

Seed losses (S_L), seed damage (S_d) and threshing efficiency ($\acute{\eta}_{th}$) were calculated by the following formulas:

$$\text{Seed losses } (S_L)\,\% = \frac{\text{Mass of seed losses with the straw}}{\text{Total mass of seeds}} \times 100$$

$$\text{Seed damage } (S_d)\ \% = \frac{\text{Mass of seed damage}}{\text{Mass of threshing seeds (seed output)}} \times 100$$

$$\text{Threshing efficiency } (\eta_{th})\ \% = \frac{\text{Mass of threshing seeds (seed output)}}{\text{Total mass of seeds}} \times 100$$

3- Total losses:

The total losses calculated by using the following formula:

Total losses = Unthreshed seeds + seed losses from straw outlet + damaged seeds.

- Moisture contents estimated by using air oven method.
- Drum speed was determined by using speedometer.
- The cracked and damaged seeds were determined by hand collected and weighting from one kg of output seeds.

4- Power and energy requirements:

It calculated according to the following formula:

$P = H \times M / 3600$, ---------- kW (Georing 1992)

$M = Q \times \rho$

Where:

P = fuel equivalent power, -------------- kW

H = gross heating value of fuel, -------kJ / kg = (45434 kJ / kg).

M = fuel consumption rate, -----------kg/h.

Q = fuel consumption rate, ------------ L/h.

P = fuel density, --------------------- kg/L (0.823 kg/L)

Specific energy requirements (kW.h / ton):

It was calculated by multiplying the consumed power (kW) by the time (h) and then dividing by the machine productivity (ton).

5-Threshing hourly cost:

It was calculated by using fixed and variable cost method.

-The production cost: it was calculated according to the following formula;

Production cost (L.E/ton) =Threshing operation cost (L.E/h)/ Seed output (ton/h)

-The Criterion cost was calculated by using the following formula:

Criterion cost = Production cost (L.E/ ton) + losses cost (L.E/ton)

RESULTS AND DISCUSSION

Effect of threshing parameters on seed damage and unthreshed seeds:

Regarding to fig. (2), Increasing the peripheral drum speed from 7.85 to 15.71 m / s, increases the seed damage by (68.00, 90.00, 106.25, 163.64 and 185.71 %) , (48.78, 54.29, 72.72, 114.28 and 122.22 %) and (48.21, 53.06, 60.98, 64.71 and 75.86 %) at feeding rates of 10.00, 11.67, 13.33, 15.00 and 16.67 kg/min and seed moisture contents of 14.12,12.30 and 10.31 % respectively. The vice versa was noticed with the unthreshed seeds which decreased by (76.36, 71.67, 64.29, 58.14 and 58.97 %), (74.36, 65.12, 60.42, 57.89 and 47.06 %) and (96.00, 92.86, 75.68, 72.72 and 50.00 %)

respectively under the same pervious conditions. The obtained results revealed that seed moisture content affects deeply on the percentage of unthreshed seed. In addition, increasing of drum speed as affected on seed damage percentage due to break fast of seed capsule.

Effect of threshing parameters on total seed losses:

Viewing to fig (3), Increasing the peripheral drum speed from 7.85 to 11.78 m / s, reduced the total seed losses by (37.31, 38.73, 37.82, 30.29 and 33.33 %),(26.96, 27.50, 24.80, 24.29, and 23.87 %) and (15.69, 25.92, 21.93, 21.95 and 25.93 %) at feeding rates of 10.00, 11.67, 13.33, 15.00 and 16.67 kg/min and seed moisture contents of 14.12,12.30 and 10.31 % respectively. While, increasing the peripheral drum speed from 11.78 to 15.71 m/s, increased the total seed losses by (14.28, 14.94, 13.40, 13.11 and 2.85%), (10.70, 10.34, 8.50, 1.89 and 5.08 %) and13.95, 18.75, 11.24, 4.17 and 15.00 %) respectively, under the same previous conditions. It is clear from data and figures that, increasing the drum speed increased the seed damage decreased the unthreshed seed and total seed losses. In addition, increasing the feed rate decreased the seed damage and increased the unthreshed seed and total seed losses while, increasing the seed moisture content decreased the seed damage, and increased the unthreshed seed and consequently the total seed losses. It observed that at low drum speeds, fan and crank mechanism to obtain shaking action for screen the same seed moisture content. Therefore, the optimum conditions to minimize the total losses were found at seed moisture content of 10.31%, peripheral drum speed of 11.78 m / s and feed rate of 11.67 kg / min.

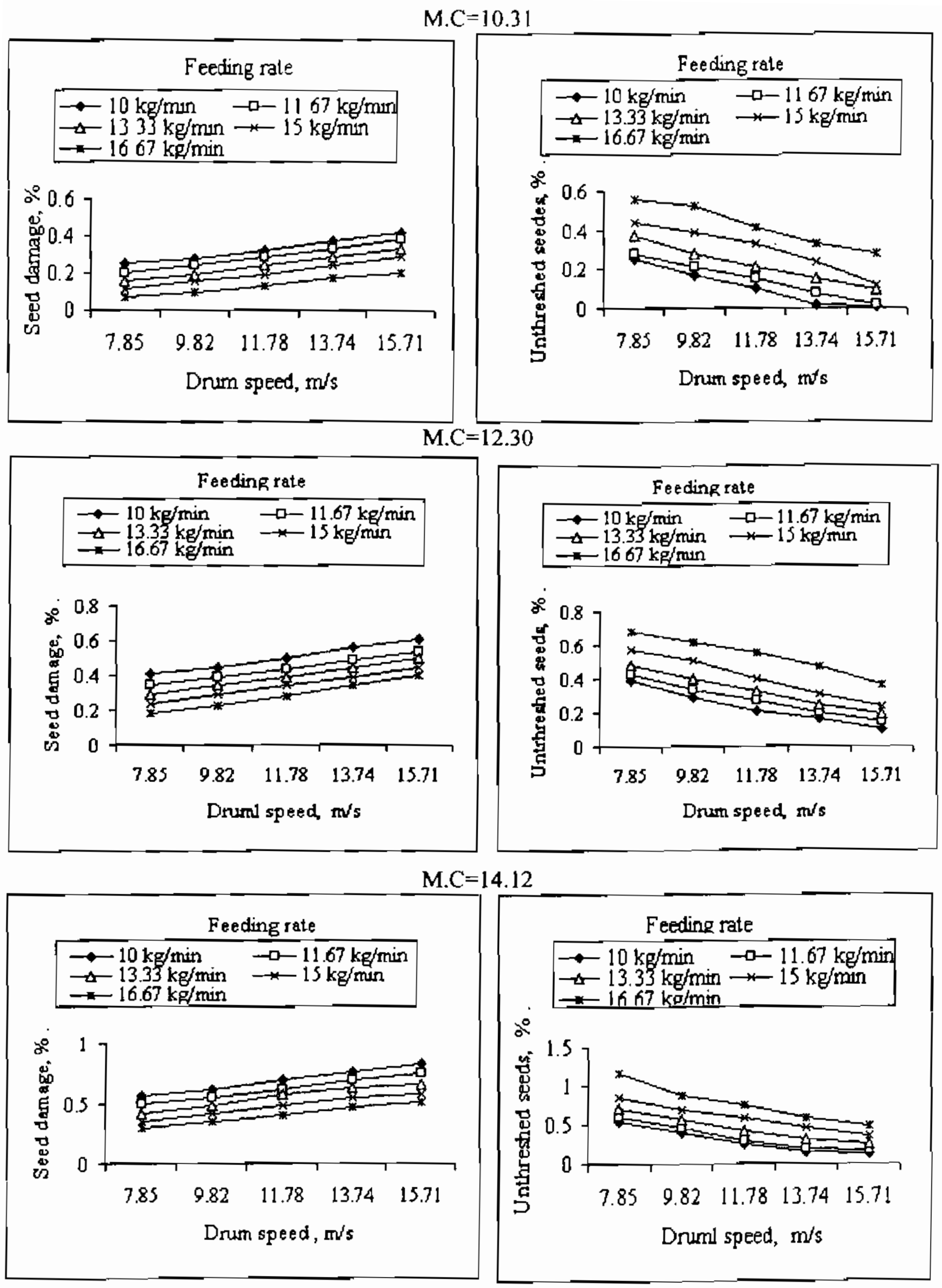
Effect of threshing parameters on threshing efficiency:

From fig. (3), it is clear that increasing the drum speed from 7.85 to 11.78 m / s increased threshing efficiency by (0.65, 0.68, 0.66, 0.62 and 0.92 %) , (0.42, 0.44, 0.45, 0.54 and 0.54 %) and (0.34, 0.38, 0.41, 0.46 and 0.39 %)at feeding rates of 10.00, 11.67, 13.33, 15.00 and 16.67 kg/min and seed moisture contents of 14.12,12.30 and 10.31 % respectively.

While, increasing the peripheral drum speed from 11.78 to 15.71 m/s threshing efficiency decreased by (0.06, 0.07, 0.05, 0.07 and 0.09 %), (0.10, 0.09, 0.08, 0.08 and 0.06 %) and (0.08, 0.09, 0.07, 0.08 and 0.10 %) respectively under the same previous conditions. From the previous explained data, it can be demonstrate the optimum conditions for threshing lentil crop at seed moisture content of 10.31%, feed rate of 11.67 kg / min, and peripheral drum speed of 11.78 m / s to achieve threshing efficiency of 99.79 %. In all cases, threshing efficiency increased by increasing drum speed and decreased by increasing seed moisture content.

Effect of threshing parameters on the operating and losses cost:

Criterion cost is considered the best method to determine the optimum conditions of operation. That is included the operating cost and losses cost.



Feg. (2): Effect of drum speed and feeding rate on seed damage and unthreshed seeds under different moisture contents.

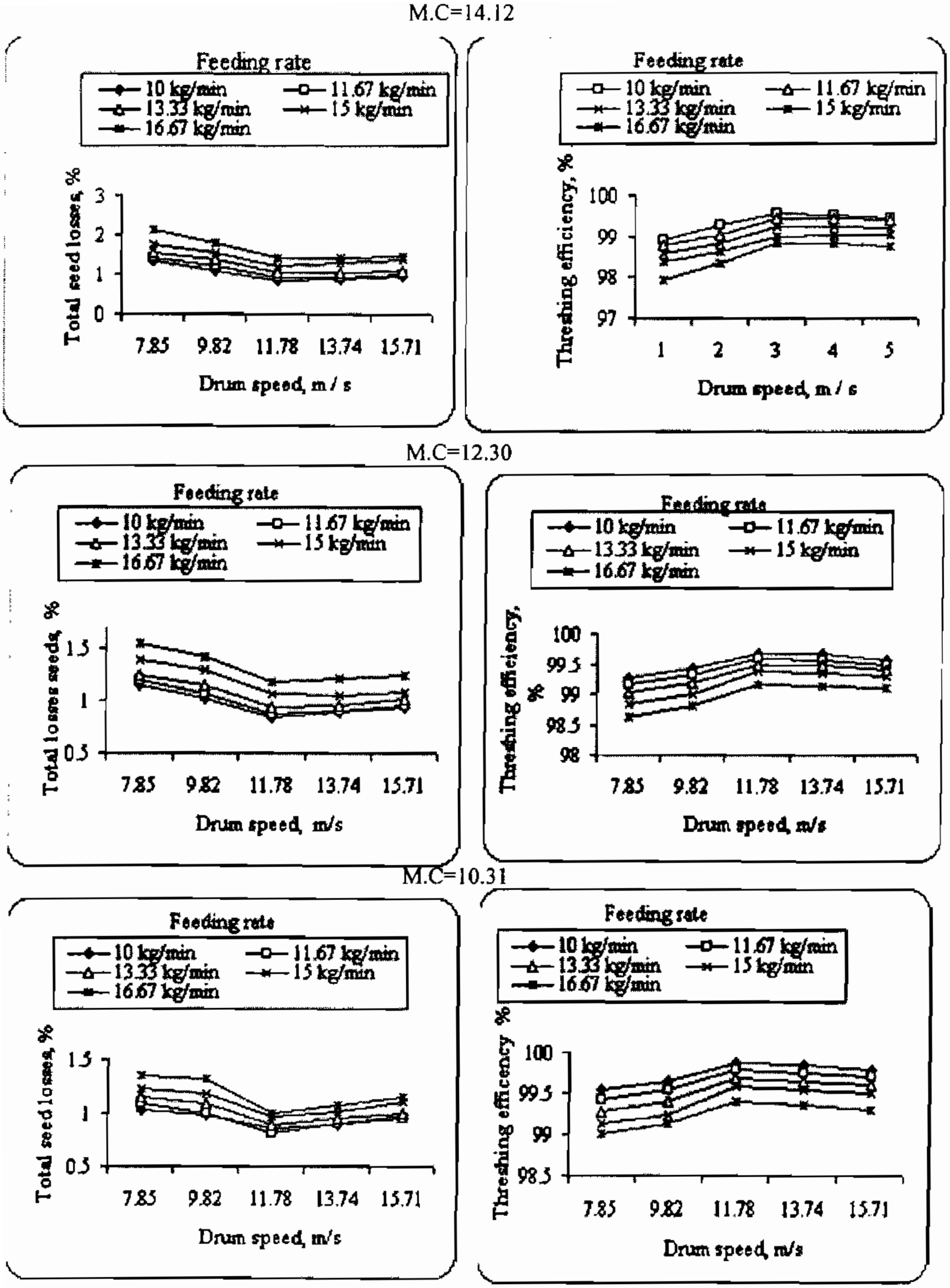


Fig.(3): Effect of speed and feeding rate on total seed losses and threshing efficiency under different moisture contents.

From fig. (4) it is clear that increasing drum speed from 7.85 to 11.78 m / s decreased losses cost by (37.31, 38.28, 34.25, 32.95 and 32.30 %) . (26.96, 27.5, 24.81, 24.95 and 23.88 %) and (15.69, 20.40, 21.93, 21.90 and 25.94 %) at feeding rates of 10.00, 11.67, 13.33, 15.00 and 16.67 kg/min and seed moisture contents of 14.12,12.30 and 10.31 % respectively. While, increasing the peripheral drum speed from 11.78 to 15.71 m/sec increased losses cost by (14.29, 14.03, 6.56, 4.8 and 4.72 %), (10.95, 10.38, 8.51, 2.79 and 4.72 %) and (10.00, 10.47, 11.27, 5.10 and 15.03 %) respectively under the same previous conditions. Too, fig. (4) referred that, increasing the feeding rate from 10.00 to 16.67 kg / min, the operating cost decreased by (39.41, 39.27, 39.55, 39.58 and 39.62 %) , (39.62, 39.47, 39.67, 39.48 and 39.69 %) and (39.84, 39.62, 39.74, 39.71 and 39.75 %) at peripheral drum speeds of 7.85, 9.82, 11.78, 13.74 and 15.71 m / s and seed moisture content of 14.12,12.30 and 10.31 % respectively. While, in fig (5) the data showed that, increasing drum speed from 7.85 to 11.78 m / sec decreased criterion cost by (11.62, 13.67, 13.82, 15.36 and 13.67 %), (7.58, 8.82, 8.9, 10.31 and 11.07 %) and (4.35, 6.14, 7.48, 8.41 and 11.13 %) at feeding rates of 10.00, 11.67, 13.33, 15.00 and 16.67 kg/min and seed moisture content of 14.12, 12.30 and 10.31 % respectively. While, increasing the peripheral drum speed from 11.78 to 15.71 m/sec increased criterion cost by (3.06, 3.48, 1.71, 1.71 and 1.99 %), (2.32, 2.55, 2.43, 1.95 and 1.95 %) and (2.17, 2.54, 3.13, 1.58 and 5.27 %) respectively under the same previous conditions. However, the optimum conditions for threshing the lentil crop where recorded at seed moisture content of 10.31%, feed rate of 16.67 kg / min, and peripheral drum speed of 11.78 m / s to achieve criterion cost of 85.83 L.E / ton.

Effect of threshing parameters on energy requirement:

Power consumed in threshing operation estimated according to the fuel consumption. Data in fig. (5) Show that, increasing peripheral drum speed from 7.85 to 15.71 m / s increased the energy consumption by (13.18, 13.54, 15.36, 15.67 and 15.92 %), (13.72, 14.03, 15.84, 16.21 and 16.46%) and (14.30, 14.61, 16.55, 16.68 and 17.10 %) at feeding rates of 10.00, 11.67, 13.33, 15.00 and 16.67 kg/min and seed moisture contents of 14.12, 12.30 and 10.31 % respectively.

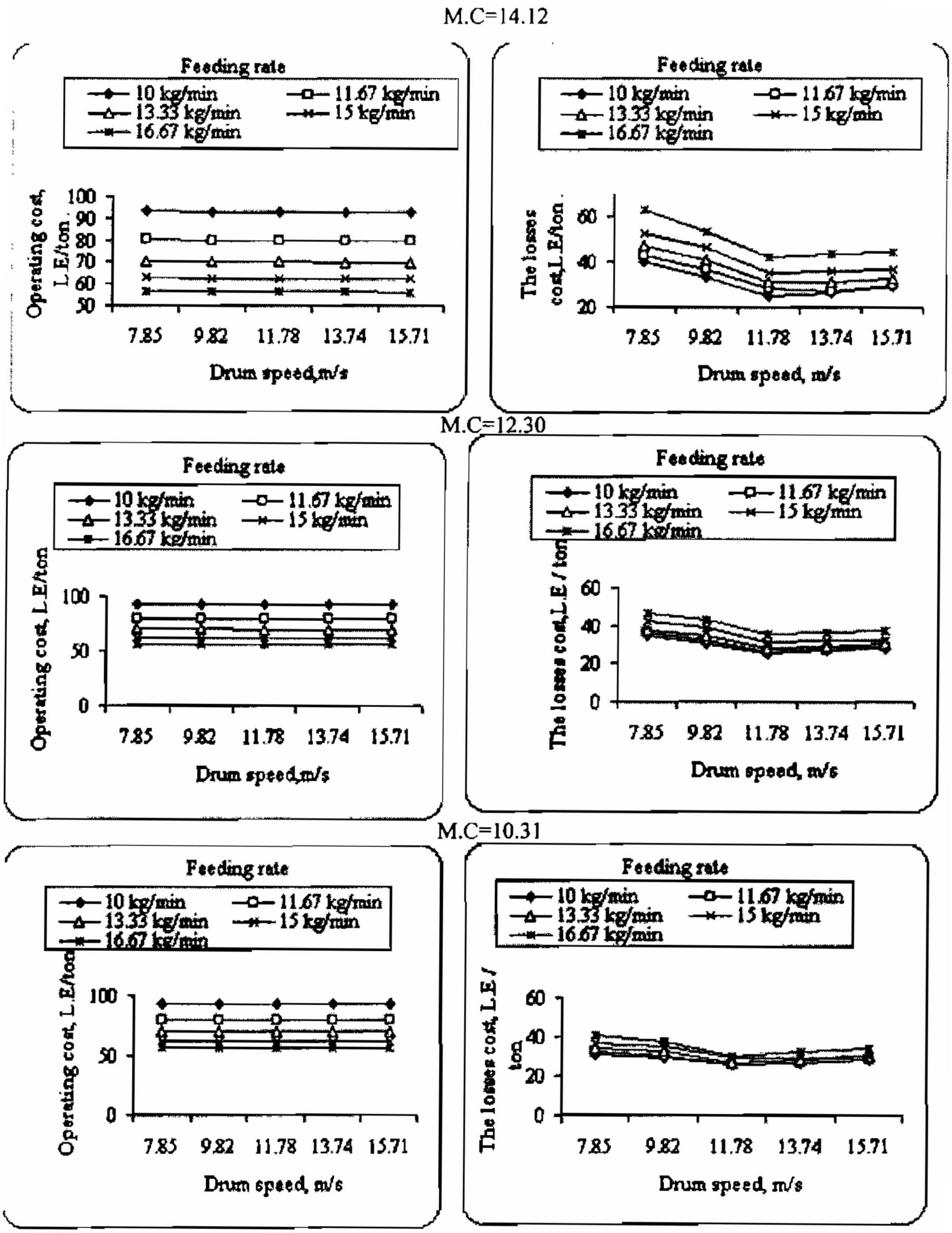


Fig (4):Effect of speed and feeding rate on operating and losses cost under different moisture contents.

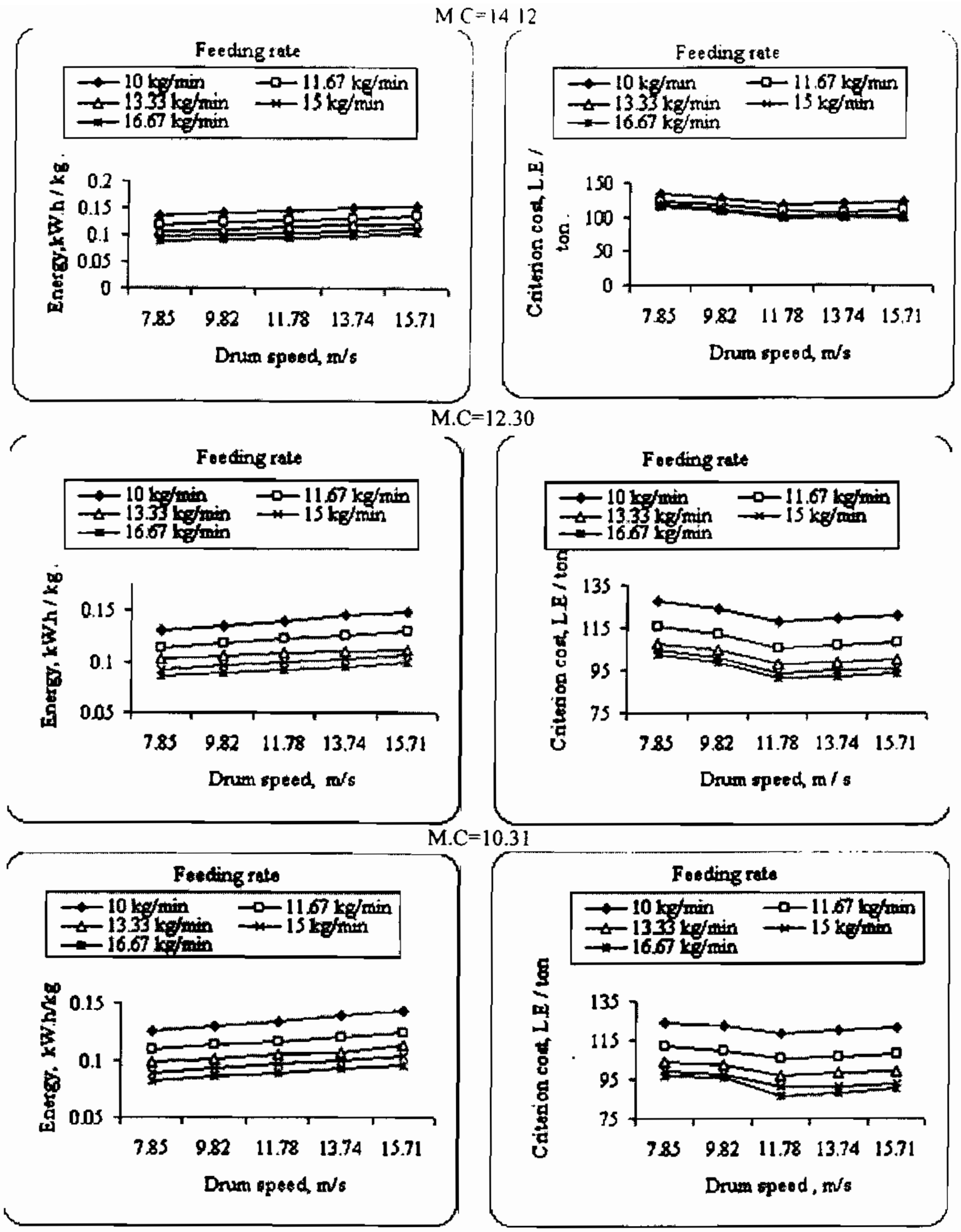


Fig (5):Effect of speeds and feeding rates on energy and criterion cost under different moisture contents.

SUMMARY AND CONCLUSIONS

The results showed the following;

1- Increasing drum speed increased seed damage, while decreased both unthreshed seed and total seed losses.
2- Increasing feed rate decreased seed damage, while increased both unthreshed seed and total seed losses.
3- Increasing seed moisture content decreased seed damage, while increased unthreshed seed and consequently total seed losses.
4- The optimum conditions for operating the threshing machine conducted at seed moisture content of 10.31%, peripheral drum speed of 11.78 m / s, and feed rate of 11.67 kg/min. resulting in seed damage of 0.62%, unthreshed seed of 0.15%, total seed losses of 0.77%, seed output of 302.1 kg/h, threshing efficiency of 99.79%, consumed energy 0.116 kW. h /kg, and criterion cost of 85.83 L.E/ton

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الملخص العربي

تقييم أداء آلة ا لدراس المحلية في دراس محصول العدس

محمد حمزة مخيمر أبو النجا* - هانى عبد العزيز الجندى* - إبتسام حسن موسى*

أجريت التجارب بالمزرعة البحثية بمحطة البحوث الزراعية بتاج العز بمحافظة الدقهلية. ،خلال الموسم الشتوى لعام 2004 على دراس محصول العدس ، بهدف دراسة إمكانية استخدام آلة دراس الحبوب المحلية الصنع في دراس محصول العدس تحت العوامل التالية :

1- السرعة المحيطية لدرفيل الدراس: 7.85 – 9.82 – 11.78 – 13.74- 15.71 م/ث.
2- معدل تغذية المحصول:10.00 – 11.67 – 13.33 – 15.00 - 16.67 كجم /دقيقة.
3- المحتوى الرطوبى للبذور :10.31 – 12.30 – 14.12 %.

وتم دراسة تأثير هذه المتغيرات على نسبة البذور المكسورة والغير المدروسة والفاقد الكلى وكمية البذور المنتجة من طن من المحصول وكفاءة الدراس وتكاليف التشغيل وتكاليف الفاقد.

أوضحت النتائج أن أفضل ظرف للتشغيل تحققت عند سرعة درفيل الدراس 11.78 م/ث ومعدل تغذية 11.67 كجم / دقيقة ومحتوى رطوبى للبذور 10.31 % حيث كانت نسبة البذور المكسورة 62، % والبذور الغير مدروسة 15، %، والفواقد الكلية للبذور77، %، والبذور الناتجة 302.1 كجم / ساعة، وكفاءة الدراس 99.79 % والطاقة المستهلكة 116، كيلووات . ساعة / كجم بذور وتكاليف التشغيل مضافا إليها تكلفة الفاقد 85.83 جنية / طن.

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