J. Agric. Sci. Mansoura Univ., 32 (1): 475 - 489, 2007

DEVELOPMENT OF A LOCAL SUNFLOWER THRESHING MACHINE SUITABLE FOR SMALL HOLDINGS

El-Sheikha, M. A.*; H. El. Abb-Alla *; A. L. Lotfy and M. A. El-Rajhi****

*** Dept. of Agric. Eng., Faculty of Agric., Mansoura University.**

**** Agric. Eng. at Agric. Eng. Res. Institute, ARC.**

ABSTRACT

A threshing machine was fabricated and tested to suit the shape and proprieties of sunflower crop. It consisted of a threshing, power drive and power transmission units. Three levels of drum speeds (٨.٣ ، ١٠.٩ ، 14.7 m/s), three levels of cylinder concave clearance (2, 3, 4cm), three positions of threshing drum [(2 Rows 8 teeth), (3 Rows 12 teeth) and (6 Rows 24 teeth)] and three levels of sunflower moisture contents (10, 14, 19 %) were studied. Test results indicated that the best operating conditions were at a speed of 14.7 m/s, clearance of 4 cm and seeds moisture of 10% (d.b).

INTRODUCTION

Sunflower is considered one of the most important oil seed crops in Egypt. It ranks the second largest world source of vegetable oil after soybeans with respect to oil production (FAO, 1990), it is cultivated in small areas in Egypt during the last decades in spite of the great shortage in oils. This was due to the strong competition for the limited land area between sunflower and other strategic crops such as cotton, corn and rice. FAO (2005) mentioned that, sunflower seed area harvested (ha) in the world in 2004 season equal to 21, 394, 044 but in Egypt it equal 15,650 ha (37, 262 feddan); sunflower seed yield (Hg/Ha)* in the world in 2004 season equal to12,250 but in Egypt it reaches 22, 588 Hg/Ha (9,487 Hg/feddan); and sunflower seed production (Mt) in the world in 2004 season reached 25,208,114 Mt but in Egypt it was about 35, 350 Mt.

Jadhav *and* Deshpande (1990) Development a pedal-operated sunflower thresher. The manually-operated hold-on sunflower thresher consisted principally of threshing, cleaning and power transmission units. The output capacity, threshing efficiency and cleaning efficiency were about 40 kg (seed)/h, 100%and 96 to 98% respectively. Rizvi *et al.* (1993) compared the performance of different threshing drums for sunflower threshing. the study showed that the peg type cylinder with a speed range of 400 to 500 rpm and a concave clearance range from 2,54 to 3.00 cm can be used for a sunflower threshing unit. Naravani and Panwar (1994) studied the effects of the impact mode of threshing on the threshability of a sunflower crop. The results showed that threshing efficiency increased as the impact energy increased at seed moisture contents ranging from 5.76 to 13.56% (w.b.). The

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*Hg= 10^5 gram   Mt = 10^6 ton

Tg = 10^{12} gram   Ha = 2.39 feddan threshing efficiency of 71% with 9.7% (w.b.) seed moisture content at an energy level of 20.6 N.m were observed. Bansal *et al.* (1994) evaluated different sunflower threshers. Sunflower threshers based on axial flow designs were mostly used. It was concluded that sunflower should be threshed at a cylinder speed of 6.5 m/s with a feed rate of 1,500 to 2,000 kg/h at a grain moisture content of 30% (w.b.). Bhutta *et al.* (1997) compared the performance of a locally made sunflower thresher and a combine harvester. The power operated sunflower thresher had an output capacity of 447 kg/h with a threshing efficiency of 97.3% and a breakage of 4.87%. The combine harvester threshing drum consisted of 8 rasp bars of 104 cm in length and 60 cm in diameter. The combine harvester had an output capacity of 1,000 kg/h with a threshing efficiency of 98.7% and breakage of 0.26%. Anil *et al.* (1998) designed a prototype threshing machine for sunflower seeds. Using the basic principles adopted for cereal threshers. Test resuls indicated that the optimal threshing performance was achieved at 9 to 13 % moisture content, 180 kg/h feed rate and 500 rpm cylinder speed. Sudajan *et al.* (2001) determined some of the physical properties of both sunflower seed and head at various moisture levels for use in the design of a prototype sunflower thresher. Commonly used sunflower varieties in Thailand, Hysun-33, Pioneer Jumbo and Cargill-3322 were used by them. Many studies were carried out to evaluate cylinder-concave type, cylinder concave-clearance, peripheral speed of cylinder, feed rate, moisture content and type of crops as cited by Bainer et al. (1978). But very rare studies were conducted on threshing sunflower crop neither in Egypt or other countries in the world. The conventional methods of harvest and post harvest of sunflower have many disadvantages such as seeds damage and un-threshed seeds that lead to decrease threshing efficiency and seeds quality. But there is not enough researches to solve this problem. So a mechanical thresher for sunflower threshing was developed and adapted.

Therefore, the objectives of the present study were to determine the following:

(a) To develop a threshing machine suits the shape and proprieties of sunflower crop and to evaluate the performance of the threshing machine concerning capacity, threshing efficiency, and grain damage.

(b) To study and recommend the best combination of operating parameters for the developed sunflower thresher that maximizing the threshing efficiency and threshing capacity, minimizing damage seeds, un-threshed heads and energy use. For the importance of sunflower as oilseed crop, the mechanical harvesting with low cost and less seed damage should be carried out for increasing sunflower production.

(c) The cost of sunflower threshing preparation system with new machine.

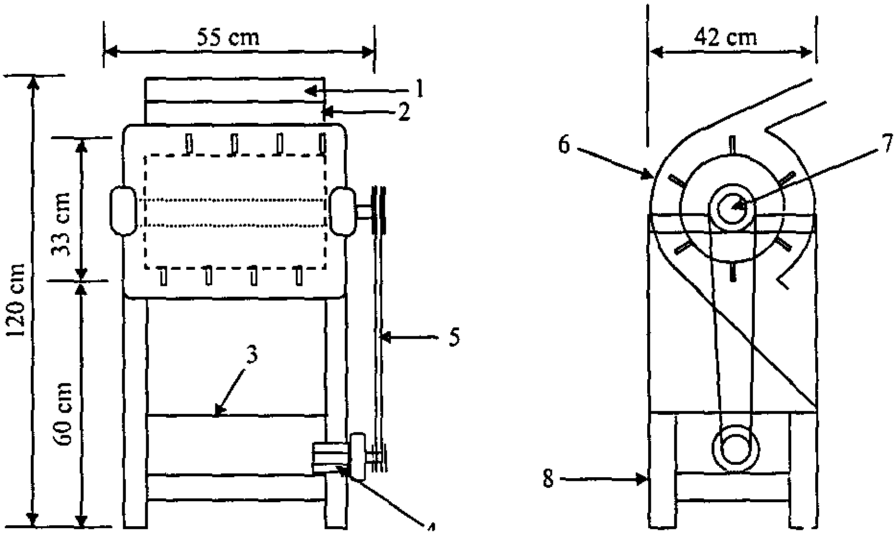
(d) Propagation to use conventional threshing tools which made from a cheap and simple raw.

MATERIALS AND METHODS

Materials:

The used machine in this study is illustrated in figure (1).It consisted of a threshing unit separates seeds from sunflower heads. For proceeding all treatments, and replicates an electric motor provided with over load protection was used. Its specifications are shown in table 1.

At the end of drum shaft there is three different diameter pulleys and V-belt were used to transmit power to the threshing unit.



1 - Input , 2- Feed hopper, 3 – Output, 4 – Power unit, 5 - V. belt,
6 – Housing, 7 - Drum shaft, 8- Frame

Fig. 1: Elevation and side view of the developed thresher

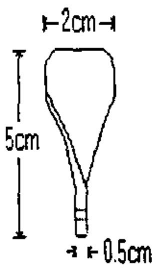


Fig. 2: Schematic diagram of a tooth

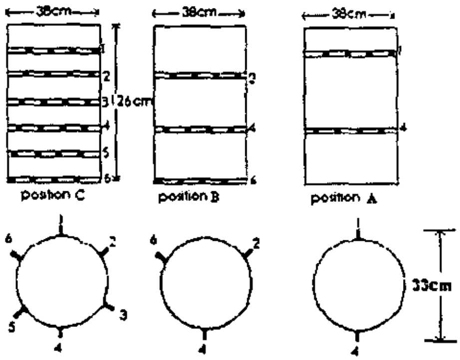


Fig. 3: Distribution of teeth on the cylinder

A General Electric A. C Motor 0.56 KW 190- 380 Voltage rotates with a speed of 1400 rpm. was used to drive the machine.

Table 1: The physical properties of the Pioneer sunflower crop.

Crop conditions	Value	Average
Size of head-mean (S.D. of 10 heads)		
- Diameter, mm	100 - 300	196
- Height of head, mm	40 - 48	44.9
Size of grain-mean (S.D. of 100 grains)		
- Length, mm	9 -11	10.25
- Width, mm	6 - 8	7.38
- Thickness, mm	4 - 6	5.13
- Mass of one seed, g	0.05 - 0.071	0.0605
- Mass of 1000- seeds, g	40 – 75	52

Methods:-

Preparing the machine for operation:-

A) Cylinder -concave clearance:-

The drum has to be adjusted at 2, 3 and 4 cm clearances by using a thickness fillers (2, 3 and 4 cm steel plates). After loosing the two bearing of the cylinder and moving the cylinder axe horizontally to get the suitable clearance.

B) Thresher speed:-

The electric motor has to be moved up and down to be able to match the different pulleys diameter (20.5, 15.5 and 11.5cm) on drum shaft and consequently change the drum speed (8.3, 10.9 and 14.7m/s) respectively.

Experimental design:-

All experiments were carried out at El Serw Agricultural Research station Damietta Governorate. The experiments were carried out on one variety of sunflower namely pioneer. It was planted during seasons 2005 and 2006 as mentioned before. The tests were carried out at the period from 5-30 October to study the effect of the modified threshing machine upon the threshing capacity, seed damage and un-threshed seeds as affected by different cylinder speeds (8.3, 10.9 and 14.7 m/s) named S_1, S_2 and S_3 respectively. Three readings (replicates) were taken and all values were scheduled.

The average moisture content of seeds were [19, 14 and 10 % d.b[(1)]] named M_1, M_2 and M_3 respectively.

Feeding sunflower heads was started manually by feeding heads one by one into the hopper. The seeds separated during heads movement along the drum circumference. Threshed material were collected after running each experiment. Then the samples were taken for determining the

(1) - d.b. = dry base.

factors under study. The samples were sieved with a 3 mm sieve holes diameter to separate the seeds from trash materials and then weighted.

The small un-threshed heads and the parts of large un-threshed heads which reset in the sieve were threshed manually by scratching them. The summation of the threshed and un-threshed seeds represents overall seeds weight.

In all experiments the sample components were weighed to get the percentage of the un-threshed seeds, seed damage and moisture content.

Split–split plot design was used to evaluate the effect of the dependent and the independent variables and their interaction on the machine performance.

Feed rate:-

The material was fed into threshing unit through the feed hopper manually until reaching the threshing capacity. The material was fed in all treatments with a constant rate. Feed rate and thresher capacity was run as follows:-

1- Sunflower heads were positioned on an inclined wooden board. They were gently pushed steadily to the hopper in certain seen time.

In order to get certain machine capacity the next procedure was followed:-

1- The machine was operated at the optimum steady speed.
2- Two operators were ready to feed the heads of the sunflower and a third one (timekeeper) adjusted the time.
3- Sunflower heads were placed on the inclined board ready for steady feeding (10 kg upon each plate / minute) to avoid speed reduction.
4- Fluent operator must stop as the timekeeper declared stopping.
5- Feeding rate must not exceed the average rate speed reduction.

Measurements:-

To determine the optimum conditions for the sunflower thresher under study, the following calibration criteria were studied: Threshing efficiency, %., Threshing capacity, kg/min. and Seeds damage, %.

RESULTS AND DISCUSSION

1-Influence of cylinder speed:-

Threshing efficiency:

Figure (4) showed the effect of increasing cylinder speed on threshing efficiency(%). It could be observed that high cylinder speed used on the modified thresher reduced un-threshed seeds and tended to increase threshing efficiency. Consequently, increasing cylinder speed increased the maximum threshing efficiency from 92.7 to 96.9 % at, concave clearance (2 cm), position (C) of 24 teeth and moisture content (10%).The minimum value was achieved at moisture content (19%).

It increased from 90.2 to 94.5% at concave clearance (2cm) and position (C) of 24 teeth. It was remarked that threshing efficiency increased with increasing cylinder speeds, according to the following descending order S3>S2>S1.

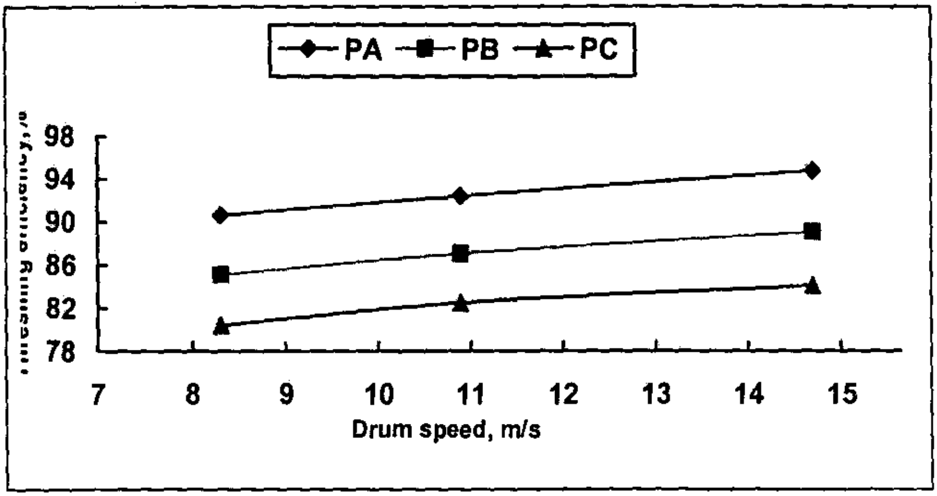


Fig. 4 Effect of drum speed (S) on threshing efficiency,% at different levels of spikes number(p).

Seeds quality:

Figure (5) showed the effect of increasing cylinder speed on seeds quality (%).

Data showed the relation between cylinder speed and seeds quality under different cylinder speeds. There was positive effect of cylinder speed on seed damage due to the increase of impact forces that was shifted to the sunflower heads by the drum with the increase of drum speed during threshing process. Increasing cylinder speed from 8.3 to 14.7 m/s increased the minimum value of seeds damage from 0.07 to 0.13 % at concave clearance (4 cm), position (A) of 8 teeth and moisture content (19%). Maximum value was achieved at moisture content (10%). It increased from 1.87 to 3.32 % at concave clearance (2 cm) and position (C) of 24 teeth. Cylinder speeds were arranged according to the following descending order: S1 >S2 >S3.

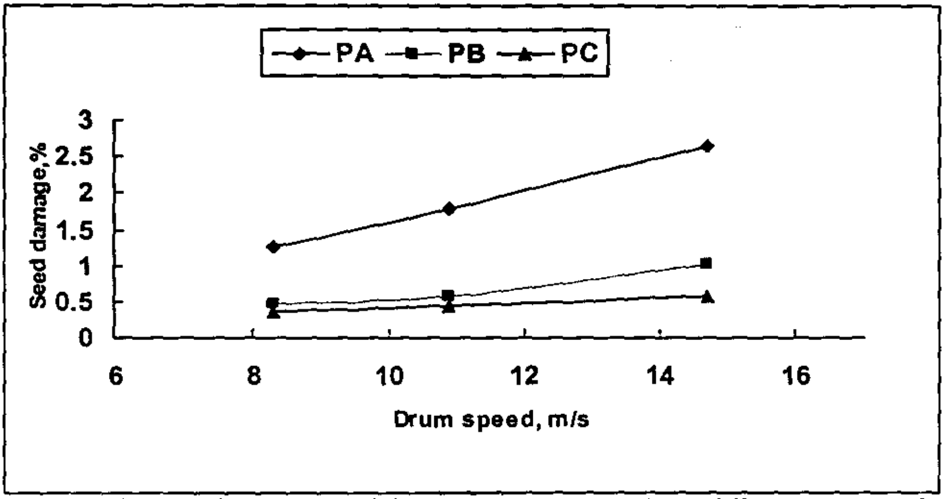


Fig. 5 Effect of drum speed (S) on seed damage, % at different levels of spikes number (p).

Threshing capacity:

Figure (6) showed the effect of increasing cylinder speed on threshing capacity (kg/min).

By increasing the cylinder speed from 8.3 to 14.7 m/s, the threshing capacity increased. This is due to increasing speed of sunflower heads in the threshing chamber. The cylinder speeds were arranged according to the higher capacity as: S3>S2>S1.

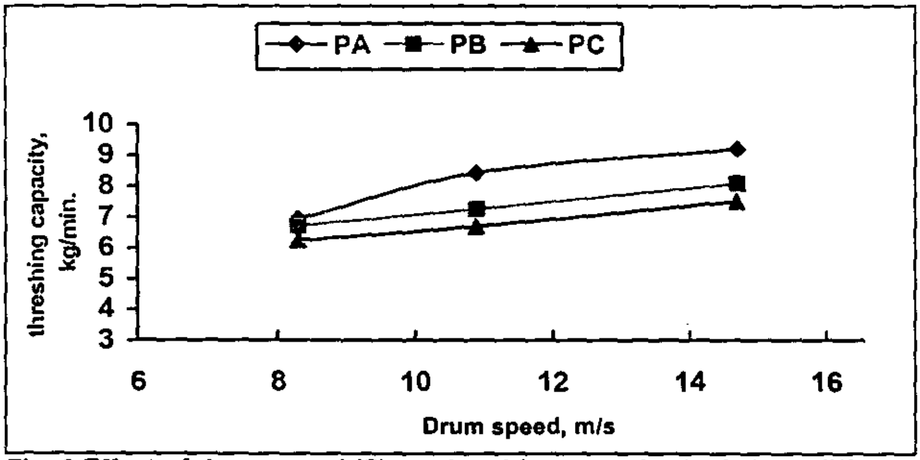


Fig. 6 Effect of drum speed (S) on threshing capacity, kg /min at different levels of spikes number (p).

2-Influence of cylinder- concave clearance:-

Threshing efficiency:

Figure (7) showed the effect of cylinder- concave clearance on threshing efficiency(%).

By reducing the cylinder- concave clearance from 4 to 2 cm the minimum value of threshing efficiency increased from 91% to 92.7% at drum speed (8.3 m/s), at position (C) of 24 teeth and moisture content (10 %). The maximum value of threshing efficiency was achieved at drum speed (14.7 m/s) increased from 95.1% at concave clearance (4 cm) to 96.9% at (2 cm) at drum speed (14.7 m/s), position (C) of 24 teeth and moisture content (10 %). For high threshing efficiency the concave clearance values could be arranged according to the following descending order C2 >C3 >C4.

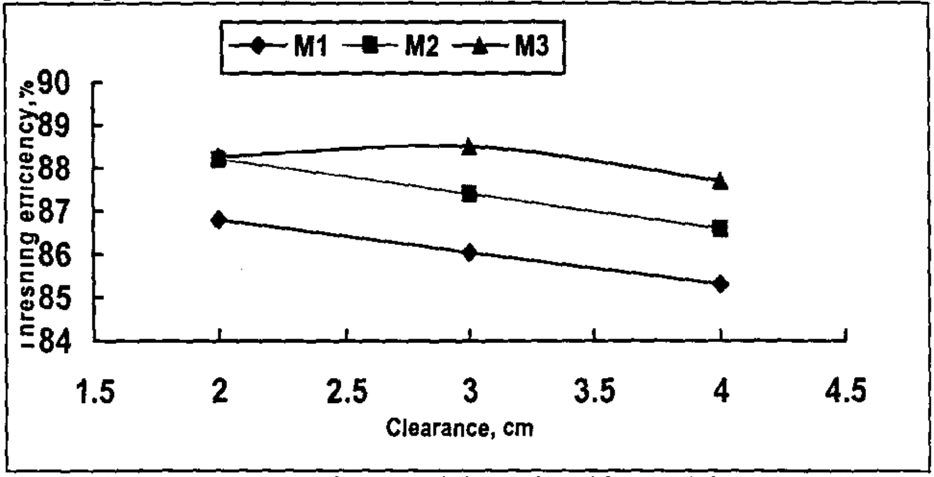


Fig. 7 Effect of concave clearance(C) on threshing efficiency at different levels of moisture contents (M).

Seeds quality:

Figure (8) showed the effect of cylinder- concave clearance on seeds quality (%).

Seeds quality increased with increasing cylinder-concave clearance. As it was discussed before. With increasing clearance from 2 to 4 cm, the minimum value of seed damage decreased from.0.43 to 0.07 % at drum speed (S1), position (A) of 8 teeth and moisture content (19 %).The maximum value of seed damage was achieved when drum speed (14.7 m/s), was decreased from 0.62 % at clearance (2 cm) to 0.13% at 4 cm, position (A) of 8 teeth and moisture content (19%).Form obtained results, it was found that, seeds quality increased with increasing clearance under different cylinder speeds and degree of moisture content.

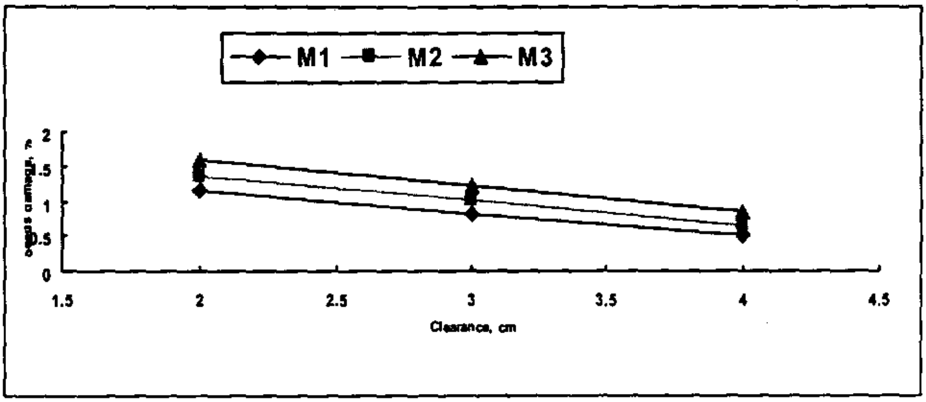


Fig. 8 Effect of concave clearance(C) on seed damage,% at different levels of moisture contents(M).

Generally, it can be decided that the clearance had very little effect on seeds damage. The cylinder – concave clearances were arranged according to the following descending order: C4 >C3>C2.

Threshing capacity:

Figure (9) showed the effect of cylinder- concave clearance on threshing capacity (kg/min).

With increasing the clearance between cylinder and concave from 2 cm to 4 cm the threshing capacity increased. Threshing capacity at drum speed (14.7m/s) resulted in maximum value. The threshing capacity increased from 11 to12.25 kg/min. at position (C) of 24 teeth and moisture content (M3). Threshing capacity increased from 9.25 to10.75 kg/min. at position (C) of 24 teeth and moisture content (10%). For high threshing capacity cylinder concave clearances were arranged according to the following descending order: C4> C3 > C2.

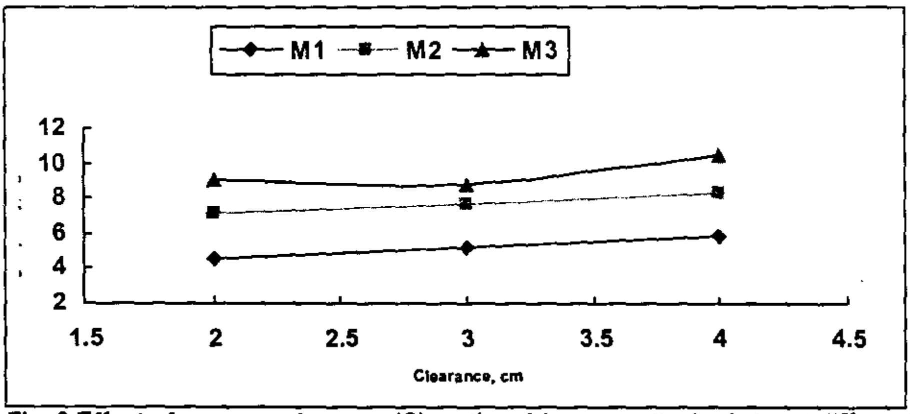


Fig. 9 Effect of concave clearance(C) on threshing capacity, kg /min. at different levels of moisture contents(M).

3- Influence of Spike Teeth Position and Number on:-

Threshing efficiency:-

Figure (10) showed the effect of adding different numbers of spike teeth rows on threshing efficiency (%).

1- For the spike teeth arranged in two rows on the cylinder. Teeth numbers were 8. Its effect was proportional to the number of passes to a certain limit. In this case the percentage of threshing efficiency, increased to maximum value, it was 86.1 % at drum speed (14.7 m/s), concave clearance (2 cm) and moisture content (10 %). The minimum value of threshing efficiency was 78.8 % at drum speed (8.3 m/s), concave clearance (4 cm) and moisture content (19 %). The minimum threshing efficiency was very low because of the lower speed, high moisture content and the very wide clearance which made heads elastic and easy to escape from threshing unit.
2- At the second case, the teeth were arranged in three rows on the cylinder. Teeth numbers were 12. In this case the threshed material will exposed to more teeth resulted in better threshing. In this case the percentage of threshing efficiency increased about 5 % than case A. The threshing efficiency was 91.1 % at drum speed (14.7 m/s), concave clearance (2 cm) and moisture content (10 %). The minimum value of threshing efficiency was 83.1 % at drum speed (8.3 %), concave clearance (4 cm) and moisture content (19 %).
3- At the third case, the teeth were arranged in six rows on the cylinder. Teeth number were 24. This was the optimum number of the used teeth. This arrangement gives the relative best results considering the numbers of teeth. It gave the maximum percentage of threshing efficiency 96.9 at drum speed (14.7 %), concave clearance (2 cm) and moisture content (10 %).The minimum value was 88.4 % at drum speed (8.3 %), concave clearance (4 cm) and moisture content (19 %). For high threshing efficiency the teeth positions could be arranged according to the following descending order C>B>A.

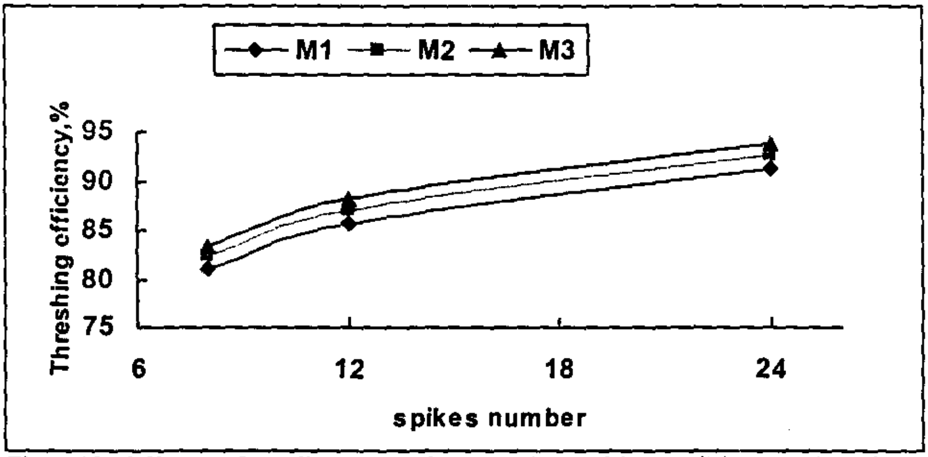


Fig. 10 Effect of spikes number and positions (P) on threshing efficiency at different levels of moisture contents (M).

Seeds quality:

Figure (11) showed the effect of adding different numbers of spike teeth rows on seeds quality (%).

Using impact method of threshing sunflower crop with low levels of Speeds made heads impact without severity, so little agitation happened, all of these conditions caused little seed damage. The effect of adding two rows (8 teeth), three rows (12 teeth) and six rows (24 teeth).It was observed that there was little differences in seeds damage between positions (A and B). Therefore, it can be recommended to use more teeth. This effect can be explained with quicker escaping of the material from threshing unit .It subsequently decreases remaining time in threshing chamber, decreasing probability of seeds damage. Higher percentage of seeds damage (3.32 %) was remarked under position (C) of 24 teeth number, drum speed (14.7m/s), concave clearance (2 cm) and moisture content (10 %). Lower seeds damage, 0.07 % was noticed under position (A) of 8 teeth, drum speed (8.3 m/s), concave clearance (4 cm) and moisture content (19 %). The cylinder speed affected greatly the seeds damage and subsequently affected the seed quality. Minimum percentage of visible seeds damage at concave clearance (4 cm), moisture content (19 %) and position (A) of 8 teeth were (0.07, 0.1 and 0.13%) at drum speeds (8.3, 10.9 and 14.7 m/s) respectively. These results occurred because of increasing drum speeds from (8.3 to 14.7) which increased the impact action on threshed material, this subsequently increased the chance to increase seed damage, thus decreasing rate of seeds quality. Drum speeds were arranged according to the following descending order: - S1 >S2 >S3. Enlarging cylinder concave clearance decreased seed damage percentage. These percentages occurred from a little difference between concave clearance (2, 3 and 4 cm). Minimum percentage of visible seeds damage at moisture content (19%), position (A) of 8 teeth and drum speed 8.3 m/s were (0.07, 0.2 and 0.43 %) at concave clearance (4, 3 and 2 cm) respectively. These results may be due to the opened concave end.

Reducing the moisture content from M1 (19 %) to M3 (10 %), the seed quality decreased. This was because it led to minimizing the seeds elasticity and consequently the resistance of seeds to the impact action. This effect increased seed damage and subsequently decreased seed quality. Seed resistance to be impacted increased with increasing moisture content, which were arranged according to the following descending order: M1 >M2 >M3.

Threshing capacity:

Figure (12) showed the effect of adding different numbers of spike teeth rows on threshing capacity(kg/min).

adding more spike teeth upon threshing capacity under the different studied factors. It was noticed that, adding more teeth upon the cylinder increased thresher capacity. That means, adding more teeth to the cylinder, affected heads with a great number of spikes with their centrifugal force. So that, the remaining time of the threshed material in the chamber decreased. For high threshing capacity the teeth position could be arranged according to the following descending order C>B>A. Increasing both the cylinder speeds from (8.3 to 14.7 m/s), cylinder concave clearance from (2 to 4 cm) and decreasing the moisture content from (19 to 10 %) increased threshing capacity under all teeth positions. The lower rate of threshing capacity was

3.5 kg/min at position (A) of 8 teeth, drum speed (8.3 m/s), concave clearance (2 cm) and moisture content (19 %).The maximum threshing capacity was 12.25 kg/min at position (C) of 24 teeth, drum speed 14.7 m/s, concave clearance 4 cm and moisture content 10 %. It was observed that, threshing capacity increased from 2 to 4 cm for. Concave clearances were arranged according to the following descending order: C4> C3>C2.

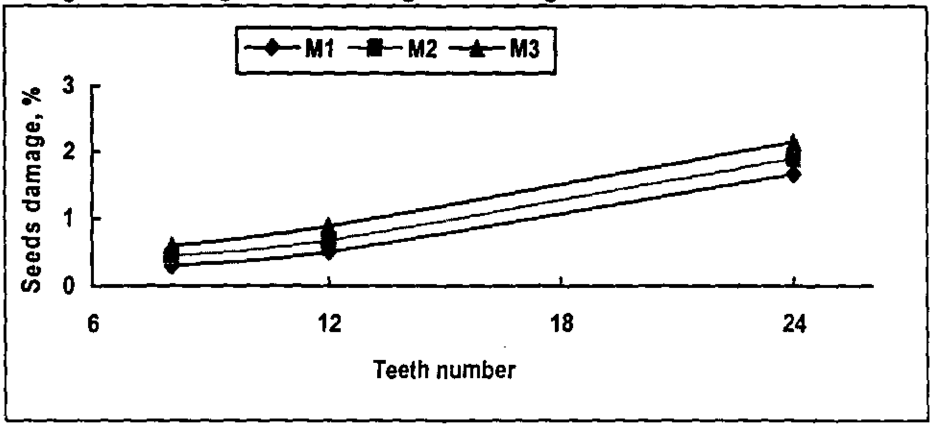


Fig. (11) Effect of spikes number and positions (P) on seed damage,% at different levels of moisture contents (M).

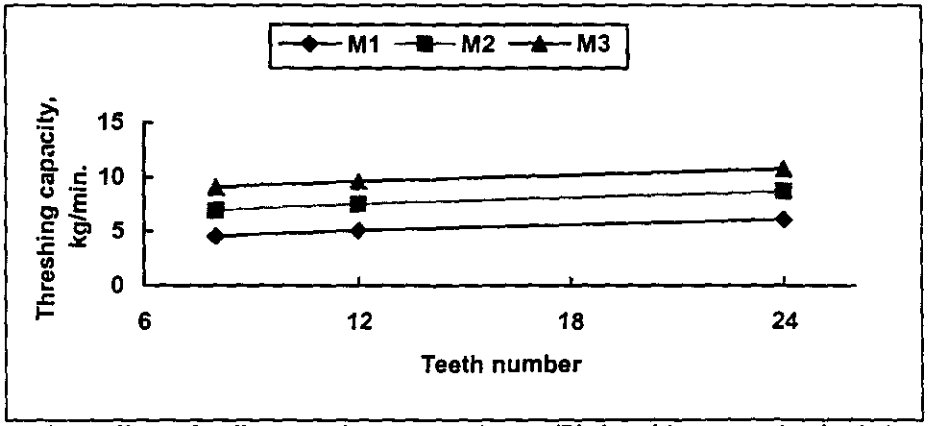


Fig. (12) Effect of spikes number and positions (P) threshing capacity, kg /min. at different levels of moisture contents (M).

4-Influence of moisture content:-

Figure (13) showed the effect of increasing heads moisture content on threshing efficiency(%).

Threshing efficiency:

Un-threshed seeds decreased with decreasing the head's moisture content, from 19% to 10% . This may be due to the increase of grain moisture content and sunflower heads, thus grains were not easily threshed and resulted in more threshing losses. This increased the threshing efficiency from 78.8 % at, drum speed (8.3 m/s), concave clearance (4cm), position (A) of 8 teeth and moisture content (19%) to 96.9

% at drum speed (14.7 m/s), position (C) of 24 teeth, concave clearance (2 cm) and moisture content (10%).The effect of moisture content was arranged according to the following descending order: M3>M 2>M1.

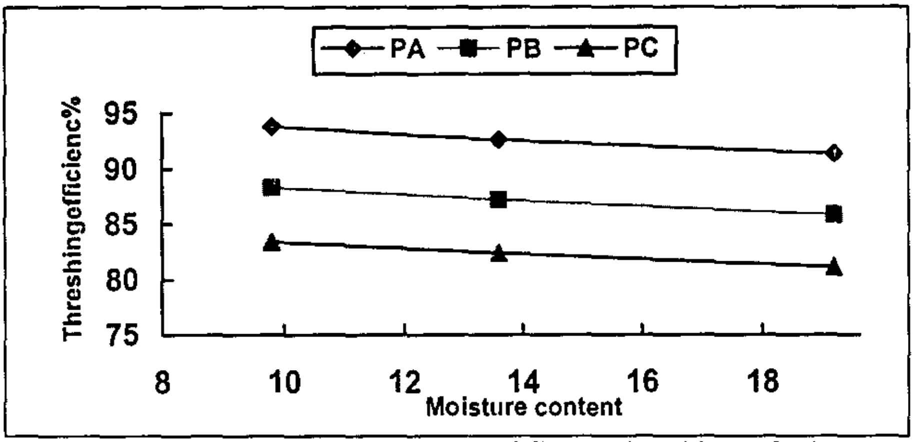


Fig. 13 Effect of moisture contents (M) on threshing efficiency at different levels of spikes number and position (P).

Seeds quality:

Figure (14) showed the effect of increasing heads moisture content on seeds quality(%).

Seed damage decreased with increasing moisture content. This may be due to the elasticity of seeds. It decreased from 3.32 % at, drum speed (14.7m/s), concave clearance (2 cm), position (C) of 24 teeth and moisture content (10%) to 0.07% at, drum speed (8.3 m/s), concave clearance (4 cm), position (A) of 8 teeth and moisture content (19 %). Moisture contents were arranged according to its effect upon seed damage as follows M1 >M2>M3.

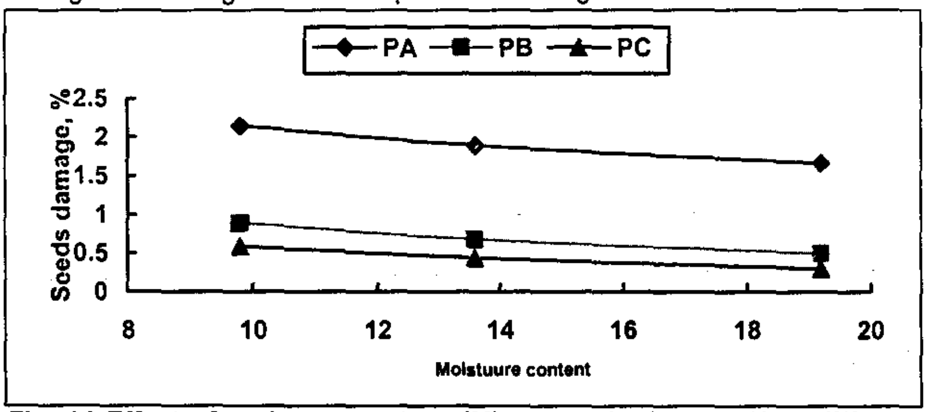


Fig. 14 Effect of moisture contents(M) on seeds damage,% at different levels of spikes number and position (P).

Threshing capacity:

Figure (15) showed the effect of increasing heads moisture content threshing capacity(kg/min).

Increasing moisture content from 10% to 19% decreased threshing capacity. This is due to less impact effect of the spikes on the threshed material as a result of higher elasticity of the material caused by higher moisture content. This phenomenon consequently needed more frequent impacts to reach the desirable results. The head's moisture were arranged according to its effect on threshing capacity as follows M3>M2>M1.

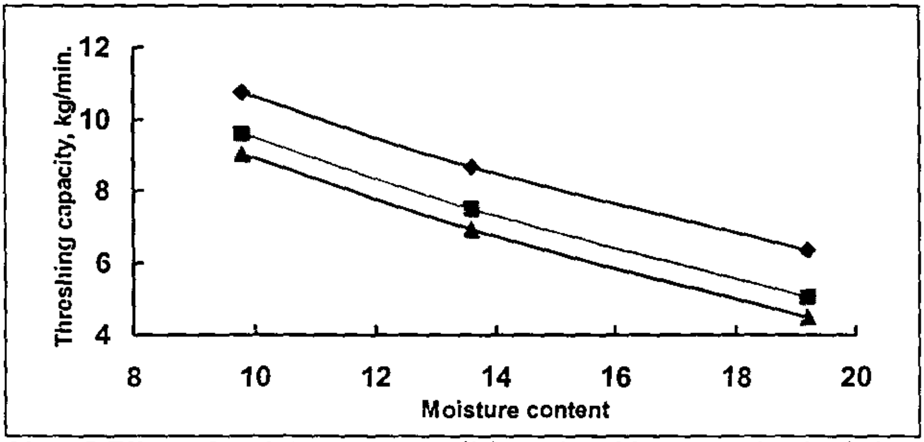


Fig. 15 Effect of moisture contents(M) on threshing capacity, kg /min.at different levels of spikes number and position (P).

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تطوير آله لدراس عباد الشمس محلية تناسب المزارع الصغيرة

محمد أحمد الشيخه* ، حسني الشبراوي المرسي* ،عبد المحسن لطفي و محمد علي إبراهيم الراجحي****

*** قسم الهندسة الزراعية كلية الزراعة- جامعة المنصورة**

**** معهد بحوث الهندسة الزراعية - مركزالبحوث الزراعية**

تعتبر عملية دراس محصول عباد الشمس من أهم العمليات الزراعية والتي تؤثر بشكل كبير علي إنتاجية المحصول والتي تتم عادة بالطريقة اليدوية حيث تقطع الأقراص وتنشر في الجرن لمدة (٣ - ٤) أيام بحيث يكون ظهر القرص لجهة الأرض والبذور لأعلي وفي طبقة واحدة ثم تدق لفصل البذور وتنظف البذور بغربلتها. وهذه العملية تتطلب عدد كبير من العمال وفترة زمنية طويلة لإنجازها بالإضافة إلي ما يواجهه المزارعون من فقد في المحصول وبالتالي يحجم المزارعون عن زراعته . لذا فالهدف من الدراسة هوالعمل علي تطوير آلة لدراس عباد الشمس صغيرة الحجم تناسب المزارع الصغيرة، تصنع من خامات محلية بسيطة لخفض التكاليف وجعلها في متناول المزارع البسيط. ولقد روعي في تصميم الآلة أن تناسب تكوين وشكل أقراص عباد الشمس وأن تكون ذا سعة دراس مناسبة للمساحة المنزرعة وكذلك تكون القدرة اللازمة لتشغيلها قليلة بقدر الإمكان وسهلة في التشغيل والتحكم وذات كفاءة دراس عالية بأقل قدر ممكن من الحبوب المكسورة.

أنسب ظروف التشغيل للآله المطورة هي :-

أ - تشغيل أكبر عدد من الأسنان الآلة والذي يمثله الوضع C (٢٤ سنه).

ب- أعلي سرعة للدرفيل ١٤,٧ م/ث (٨٥٠ لفه/الدقيقة).

جـ- أقل نسبة رطوبة للبذور (١٠ %).

د - أكبر خلوص بين الصدر ودرفيل الدراس (٤ سم).