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FIELD PERFORMANCE OF COMBINES IN HARVESTING SUNFLOWER CROP

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ABSTRACT

This study has been conducted to investigate the feasibility of using the general combine harvester in harvesting and threshing the sunflower crop. A comparative study between the traditional method and combine harvester in threshing sunflower crop was carried out through evaluation of several parameters concerning the performance of combine harvester such as the drum (cylinder) speed (400, 500 and 600 rpm), forward speed (2.8, 3.5 and 4.2 km/h), length of feeding material (60, 120 and 170 cm), concave clearance (1.5 , 2 , 2.2 cm) , moisture content of crop (12, 16 and 23.5 %)

The obtained results indicated that the optimum forward speed for harvesting sunflower plant was 3.5 km/h. It gave the least total losses and the maximum level of cleaning efficiency. Moisture content of 16 % (w.b) gave the lowest level of total losses and seed damage and achieved the highest level of cleaning and threshing efficiencies. While the optimum cylinder speed and concave clearance were 500 rpm and 2.2 cm, respectively. The study also indicated that increased length of stalks decreased total losses .

INTRODUCTION

Sunflower (Helianths. annnuus. L.) has become the second oil seed crop in the whole world. It is surpassed only by soybeans (Glycine, max (L) mere). Sunflower oil has good chemical and physical qualities more than soybean oil, and also it is preferred more than all other oil plants because it has no poisonous elements. The conventional methods of harvest and post harvest of sunflower have many disadvantages such as the high cost, and intensive labor accompanied by high crop losses.

Kepner, *et al.* (1982) stated that, the seed losses from a combine can occur in connection with any of the four basic operations which are often identified as gathering, cylinder, walker and shoe which cause major losses. The sum of cylinder, walker and shoe losses constitute the processing losses. In addition to the losses due to, the heads, pods, or ears and free seeds lost during the cutting and conveying operations.

Lamp, *et al.* (1961) showed that the average losses of soybean production ranged from 8 to 10 percent of the soybean crop during the harvesting operation. Over 80 percent of this loss is caused by the combine header. Choice of variety, row width, plant population, cultural practices of proper harvest conditions, combine efficiency and operator skill are some of the factors that influence the header loss. Quick (1973) stated that, about 85

% of the combine losses were found to be at the header, primarily due to the action of reciprocating cutter bar.

Allen, *et al.* (1978) showed that, total losses ranged from 2.6 to 4 %. Largest losses occurred after plants passed optimum dryness, while largest part of the losses, 70 to 80 %, was at the header

Nyborg, *et al.* (1969) stated that, a decrease in grain straw ratio should result in an increase in loss if feed rate and other crop variables are held constant. Results indicated that a decrease in grain to straw ratio led to an increase in percent loss in most cereal crops such as : wheat, rye, oats and barley. They added that ,when grain/straw variations were considered, the results gave equally good correlation fittings. These results were based on loss characteristics of nine combines, each tested in five crop conditions during one season and four consecutive years of results using a standard general combine.

Allen, *et al.* (1978) showed that, the taller plants (more than 1.8 m), which are common in irrigated sunflower, caused excessive amounts of stalk to be fed into the separator. The extra stalk and leaf material were broken up by the cylinder, placed more load on the chauffeur which might add to seed carry over and seed trash. With tall plants, the large reel flipped few stalks with heads out of the header which were lost.

Abdel-Mageed, *et al.* (1994) studied the effect of cylinder speed, seed moisture content, length of stalks and concave drum clearance on total seed losses of sunflower by using the IRRI-PAK thresher. They found a direct relationship between length of stalk and loss at all moisture contents. Higher values of moisture content increase the effect of stalks length on loss. The obtained results indicated that ,the levels of parameters at which the least loss value had been obtained.

Fairbanks, *et al.* (1979) stated that, combine harvesting tests were run at three cylinder speeds, approximately 650, 775 and 900 rpm corresponding to peripheral speed of 16.63, 19.83 and 23.03 m/s respectively and three cylinder concave clearances 6.35, 11.11 and 15.88 mm in all possible combinations for each moisture content. They indicated that, cylinder at 30.4 percent grain moisture losses were lower with greater cylinder - concave clearance and high cylinder speed than with close clearance and slow cylinder speed. Lien, *et al.* (1976) explained that, cylinder loss was found to be a function of cylinders concave clearance. Lowa - 12 popcorn variety was harvested with minimum losses with cylinder - concave clearance of 2.54 to 5.49 cm for the front and 1.59 cm for the rear.

Sharma and Devanani (1979) indicated that ,by increasing concave clearance, grain output and germination percentage are increased, threshing efficiency and visible grain damage decreased and energy consumption remained constant. All threshing parameters were highly correlated with the concave clearance and were significant at 0.01 level of probability. Recommended concave clearance for sunflower and mustard crop were 12 mm and 4 mm for oil extraction and 12 mm fcr seed purposes.

Nath, *et al.* (1982) observed that, the level of machine loss is lowest in the lowest range of moisture content and highest in the highest range of moisture content of sunflower. Of one designates 2 percent machine loss as a tolerant target loss, it may exist somewhere in the moisture content range of 12 to 14 percent. From 31 to 25 percent moisture content, the corresponding machine loss increased from 2 to 6.8 percent. Thus low ranges of moisture content results in low machine losses.

The present work aims to study the feasibility of using the general purpose combines to thresh and clean the sunflower crop in one track in order to reduce the cost and total losses of harvest and to determine the optimum working conditions required to obtain the best performance.

MATERIAL AND METHODS

Case combine harvester:

A case model 1620 combine with standard 6 bar reel was used in this study. The combine header has a flexible cutter bar, working width 4.57 m. The header height is adjusted and controlled by hydraulic power. The feeder width and length were 92.7 and 119.4 cm. The threshing rotor diameter was 51 cm with a length 274.3 cm. The rotor has two-speed gears low range (from 269 - 705 rpm) and high range (from 583 rpm) while concave area was 0.631 m^2.

The cleaning fan consists of 6 blades, with 58.9 cm diameter and 61.7 cm wide, its speed was fixed at 450 rpm. The combine has 4.4 m^3. grain tank to collect yield.

Header modification:

As a result of flipping the reel to some stalks with their heads out at the header, a modification was done to improve the performance of the header.

The header was modified by adding a comb, which consists of 28 teeth with length of 40 cm each as shown, in Fig. (1A). These teeth can be fixed to a bar as a one unit while the bar can be fixed on the header or the teeth can be fixed directly on the header under the cutter bar.

Experimental procedure:

The experimental work was carried out at Gemmiza Agricultural Farm Research Station, Gharbia Governorate during 1993 - 1994 seasons.

MAJAK variety of sunflower was used in this study. The average of physical properties and characteristics of Majak variety are summarized as follows:

Plant height cm	head dia. cm	* stem dia cm	seed yield g/plant	weight of 1000 seed g	seed length cm	seed width cm
185.7	18	2.5	39	50	0.97	0.48

*** at the cutting height.**

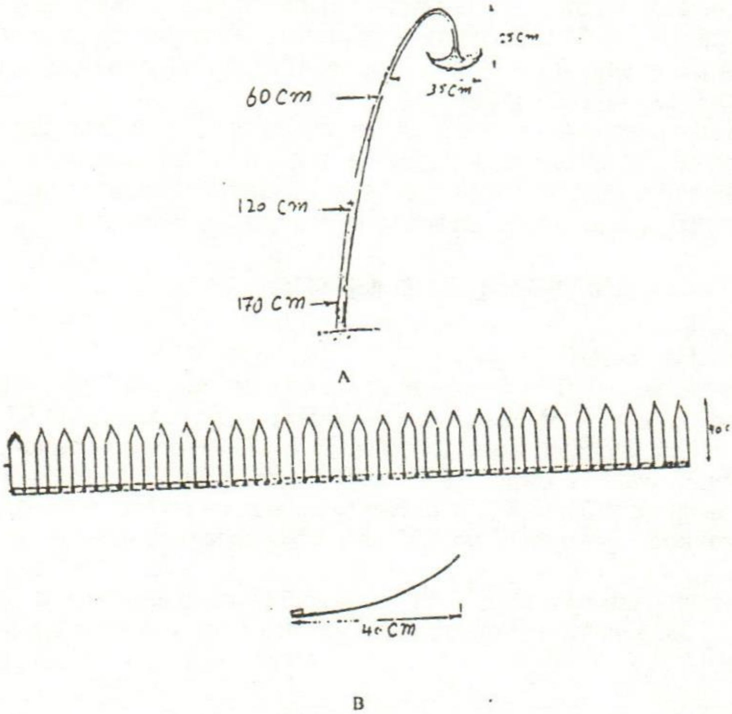

Fig. (1): Header modification and nature of sunflower plant growth.

Measurements:

To evaluate the header losses (H loss) the complete harvest was collected and weighed (W_h). Blowing loss (B_l%) was obtained by hanging a bag bellow the straw spreader to collect all seeds which came out with straw ashes and weighed (W_l). Each loss could be related to the total seed weight (Ws) as follows:

Total losses (T_{loss} %) is the sum of header loss and blowing loss.

$$T_{loss} = \frac{W_h + W_l}{W_s} \times 100$$

$$H_l = \frac{W_h}{W_s} \times 100$$

$$B_l = \frac{W_l}{W_s} \times 100$$

Seed damage (S_d%) was determined by taking 50 g samples and separating the damaged seed (W_d) and relating it to the weight (Ws).

$$S_d = \frac{W_d}{W_s} x\ 100$$

Threshing efficiency (E_{th} %) was evaluated by collecting the seed attached to the unthreshed parts of heads in blown materials in specific area, separated by hand and weighed (W_{th}) then related to the total seed weight.

$$E_{th}\ \% = \frac{W_s - W_{th}}{W_s} x\ 100$$

Cleaning efficiency (E_c) was assessed by separating the foreign materials (W_f) from 100 gm sample as related to the sample weight (Ws).

$$E_c = \frac{W_s - W_f}{W_s} x\ 100$$

RESULTS AND DISCUSSION

The obtained data represent the average of the two seasons 1993 and 1994.

1- Effect of different parameters on header loss:

Figures (2 and 3) show the effect of length of cut on header losses at different forward speeds, different cylinder speeds and different levels of moisture contents. The length of stalks was found to be inversely proportional to header loss which form a major part of the total losses (about 90 % of total losses). The lowest level of header loss was obtained at 170 cm length of stalks. However, at 170 and 120 cm length of stalks there existed the problem of blocking the reel and dropping its chain out of the gears. This resulted in a reduction in field operation efficiency. On the other hand with 60 cm length of stalks, the blocking disappeared but the header loss increased to its highest level because of the nature of sunflower growth. When the plant reached maturity, the heads tends to bend to any direction and go down, at the same time the stalk of plant bends to the same direction of heads (Fig. 1). So during harvest the reel flips some of the stalks with their heads causing an increase in header losses. This necessitated the improvement in design by using the modified header with the comb attached to it. The comb was used only with the 60 cm length of stalks which had reduced header loss from 14.89 to 2.1%.

Figures (2 and 3) show the effect of forward speed and moisture content on header loss. It is observed that at 23.5% moisture content an increase in forward speed increases header loss approximately linearly. Whereas at 16 and 12 percent moisture content the effect of forward speed on header loss is changeable. Increasing forward speed from 2.8 to 3.5 km/h decrease the header loss after that more increase in forward speed from 3.5 to 4.2 km/h increases header loss slightly.

The forward speed of 2.8 km/h is considered to be slow, so it gives the heads a chance to drop on the field causing more loss. The forward speed of 4.2 km/h also cause more loss by pushing the stalks far from the header and shake them causing the seed to separate from heads during cutting. While the middle forward speed of about 3.5 km/h gave a balance between forward speed and reel rotation permitting the heads to be picked before dropping on the land. So it could be concluded that around 3.5 km/h forward speed gave the lowest header loss. Figures (2and 3) show that 16 % moisture content gave the lowest level of header loss whereas 23.5 and 12 % moisture content gave high levels of header loss, this may be explained as : at 23.5 % the stalks are elastic and bend in the direction of machine, and when cutting they drop on the field. At 12 % moisture content, seeds can be separated easily from the outside periphery of head when the stalks were subjected to impact.

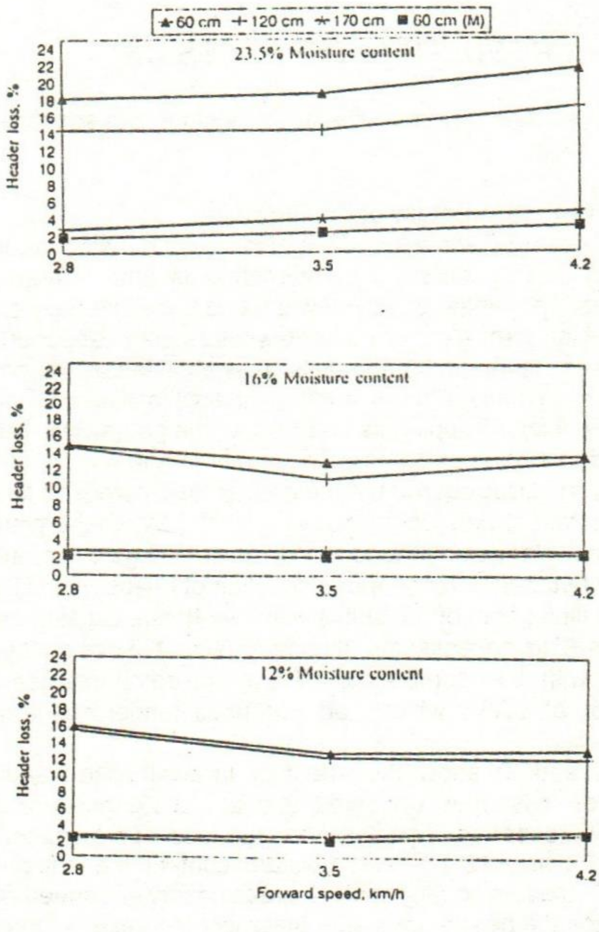

Fig. (2): Effect of forward speed on header losses at different length of stalks.
M= modification.

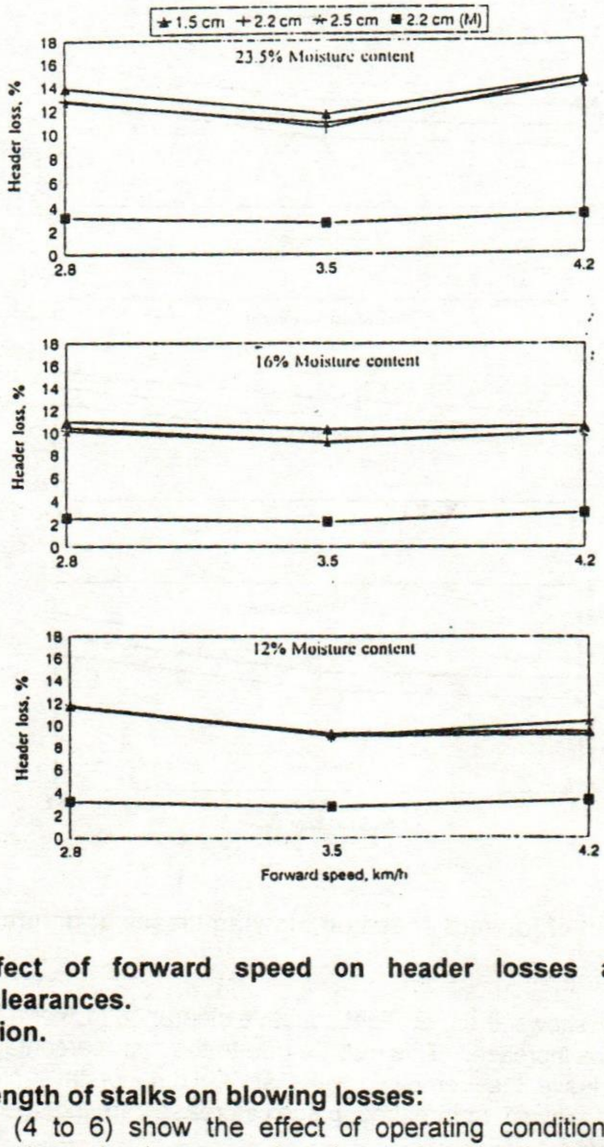

Fig. (3): Effect of forward speed on header losses at different clearances.
M= modification.

2- Effect of length of stalks on blowing losses:

Figures (4 to 6) show the effect of operating conditions on blowing losses. It may be clearly seen that, increasing length of stalks increase blowing losses at different levels of operating parameters. So, 60 cm length of stalks gave the lowest level of blowing loss, because this gives the lowest value of ashes with seeds. It can also be noticed (Figure 4) that an increase in forward speed increases blowing losses at almost a constant rate.

It is easily noted that, an increase in cylinder rotational speed from 400 to 500 rpm decreases blowing losses. Beyond that, further increase in cylinder rotational speed to 600 rpm resulted in an increase in blowing losses.

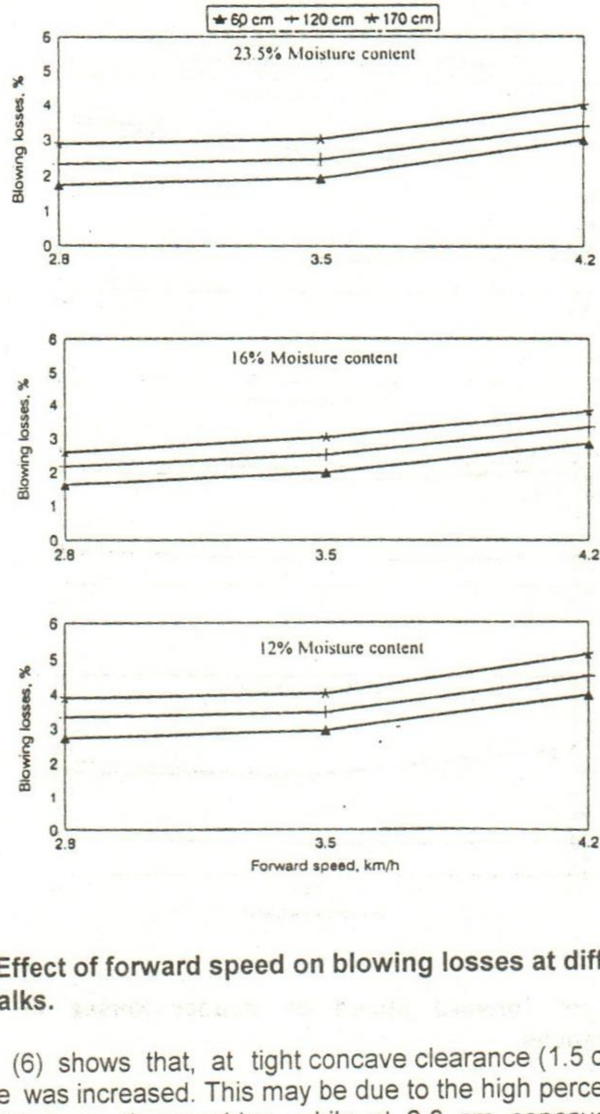

Fig. (4): Effect of forward speed on blowing losses at different length of stalks.

Fig. (6) shows that, at tight concave clearance (1.5 cm) broken seed percentage was increased. This may be due to the high percentage of broken seeds which leave the combine, while at 2.9 cm concave clearance the percentage of blowed unthreshed pieces increase carrying seeds with them leaving the combine.

It may be noted that, decreasing seed moisture content from 23.5 to 16 % decreases blowing losses while further decrease to 12 % increases blowing losses. This may be explained that at 23.5 % seed moisture content, seeds can be separated easily from heads and while at 12 % seed moisture content, the amount of broken seeds increase in the blown materials. In general one can say that the presence of unthreshed parts or broken seeds in the blown material would mean high blowing losses.

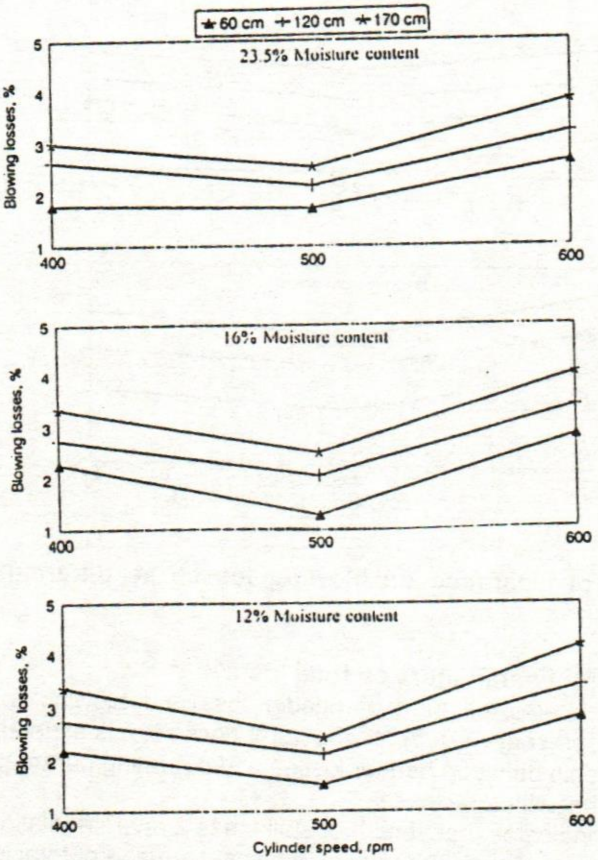

Fig. (5): Effect of forward speed on blowing losses at different length of stalks.

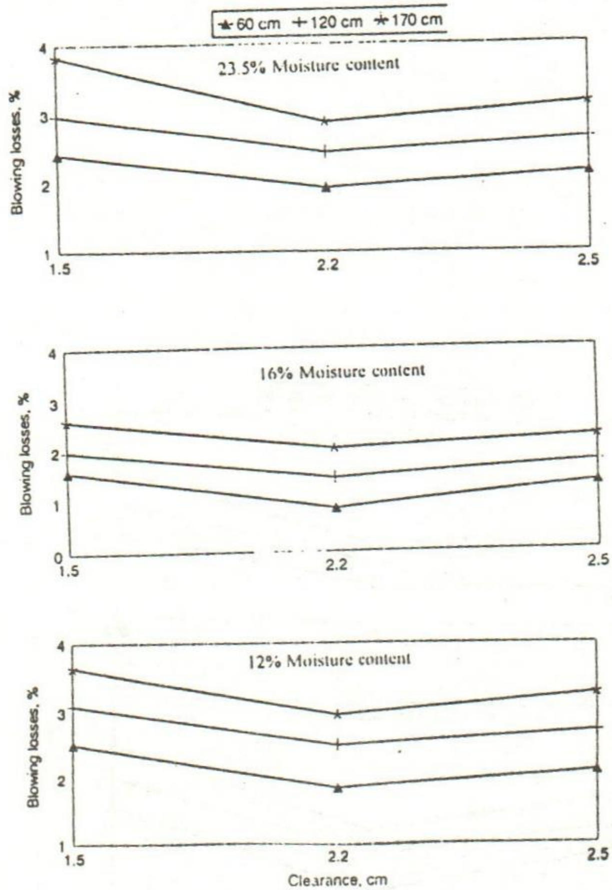

Fig. (6): Effect of clearance on blowing losses at different length of stalks.

3- Effect of different parameters on total loss:

Total losses are, the sum of header loss and blowing loss. As the header losses represents 90 % of the total loss so, it is expected that the trend of relationship between header losses and operating parameters would be very close to that with total losses.

Figure (7) indicates that, length of stalks has a reverse relationship with total loss, as header losses represent high percentage of total losses, it is reasonable to note that, using header comb reduces total loss in general at different conditions.

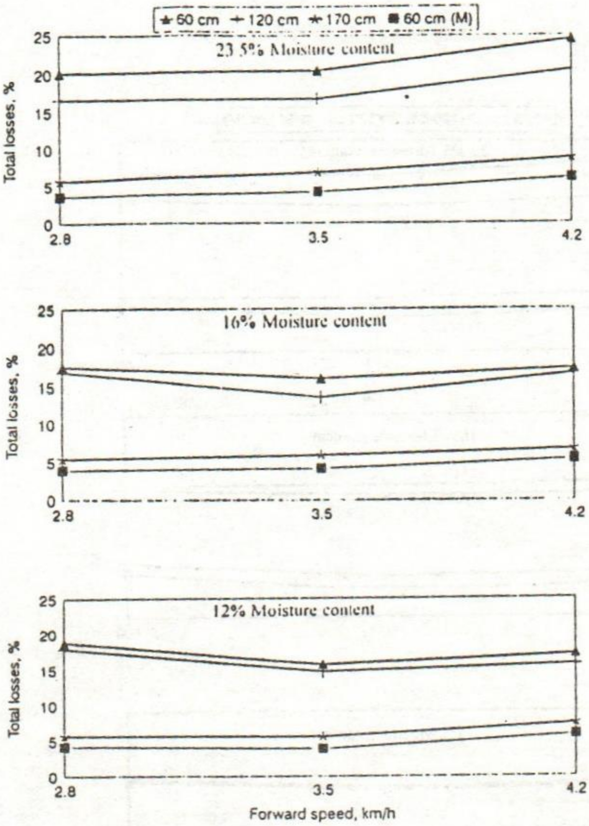

Fig. (7): Effect of forward speed on total losses at different length of stalks.
M= modification.

Figure (7) explains that there is a direct relationship between forward speed and total losses at 23.5 percent of moisture content whereas, at 16 and 12 percent of moisture content the effect of forward speed on total losses is not uniform. This may be because of the strcng effect of header losses on the total losses. The header comb in average reduced the total losses from 12.72 % to 3.67 % .This means that header comb would reduce about 71% of total losses.

The minimum total loss occurred at 500 rpm cylinder rotational speed. Lower or higher speeds cause more total losses. The reason could be quoted to the header losses results as mentioned befcre.

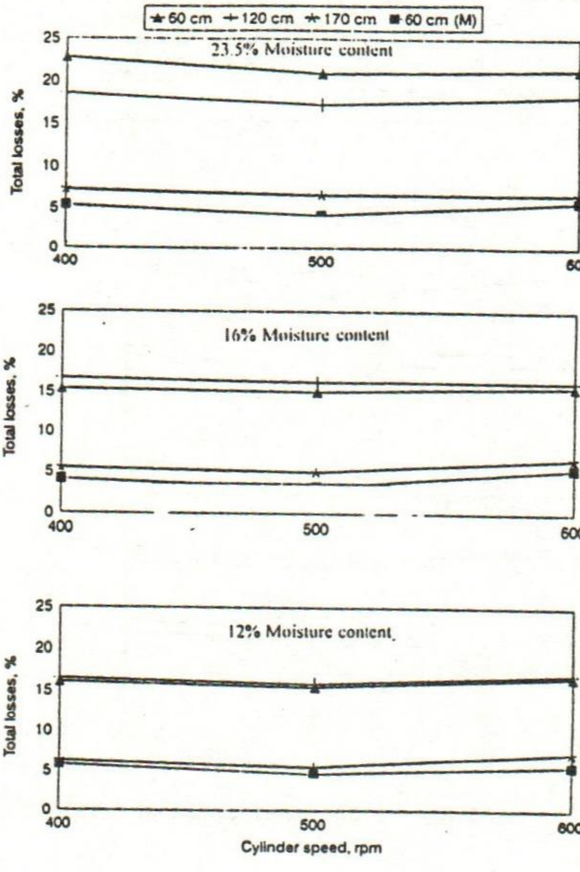

Fig. (8): Effect of cylinder speed on total losses at different length of stalks.
M= modification.

Figure (9) indicate that, total losses decrease as the concave clearance increase from 1.5 to 2.2 cm, beyond that, further increase in concave clearance to 2.9 cm increases total losses for the 16% and 12% moisture content . The lowest loss was found at 2.2 cm concave clearance.

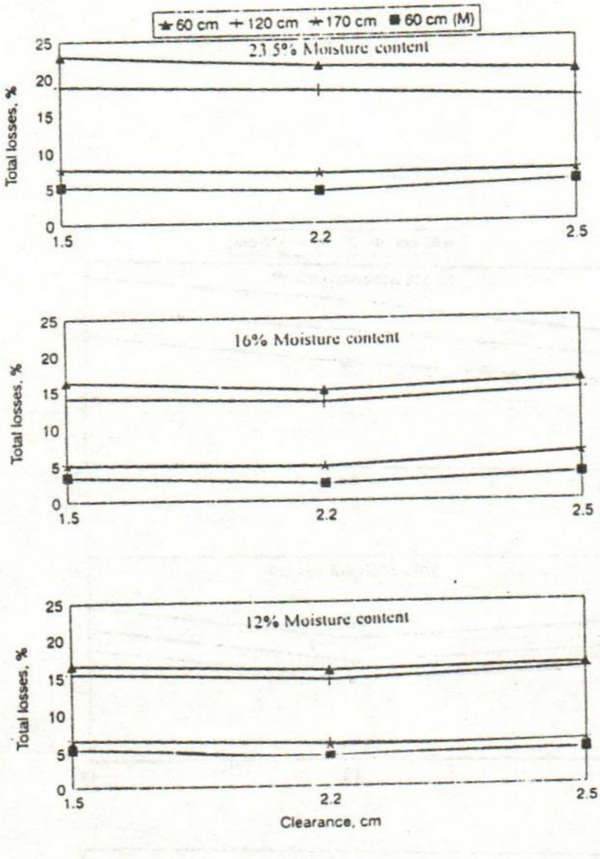

Fig. (9): Effect of clearance on total losses at different length of stalks. M= modification.

4- Seed damage:

Seed damage was found to be directly proportional to cut length and cylinder rotational speed, whereas it was inversaly proportional to concave clearance and moisture content as shown in figures (10 to 12). However, the effect of forward speed on seed damage is changeable. Increasing forward speed from 2.8 to 3.5 km/h decreases seed damage. Whereas further increase in forward speed to 4.2 km/h an increment in seed damage was noted.

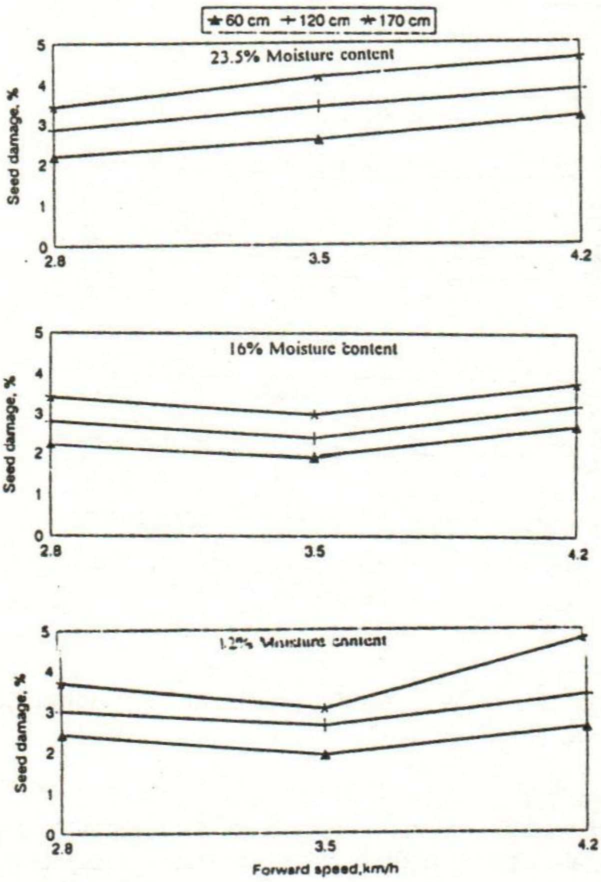

Fig. (10): Effect of forward speed on seed damage at different length of stalks.

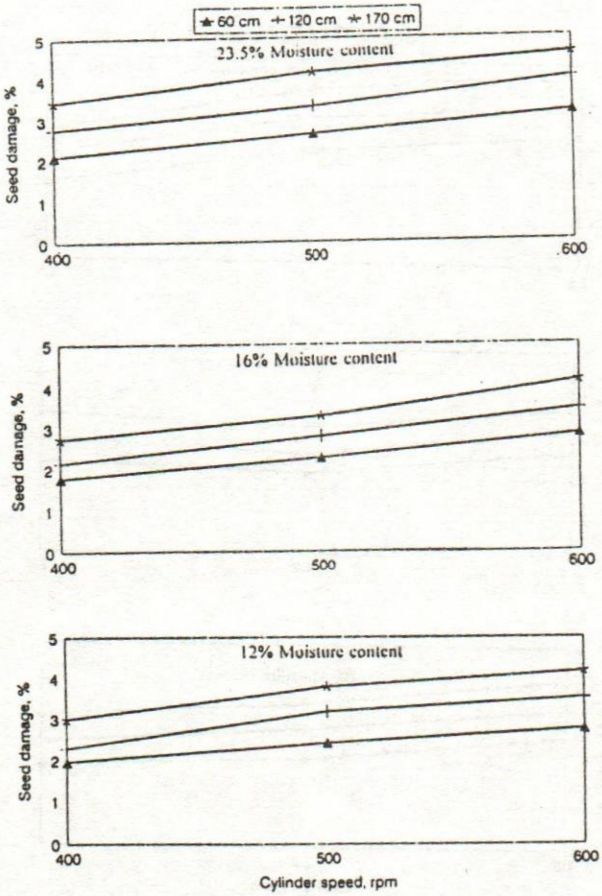

Fig. (11): Effect of cylinder speed on seed damage at different length of stalks.

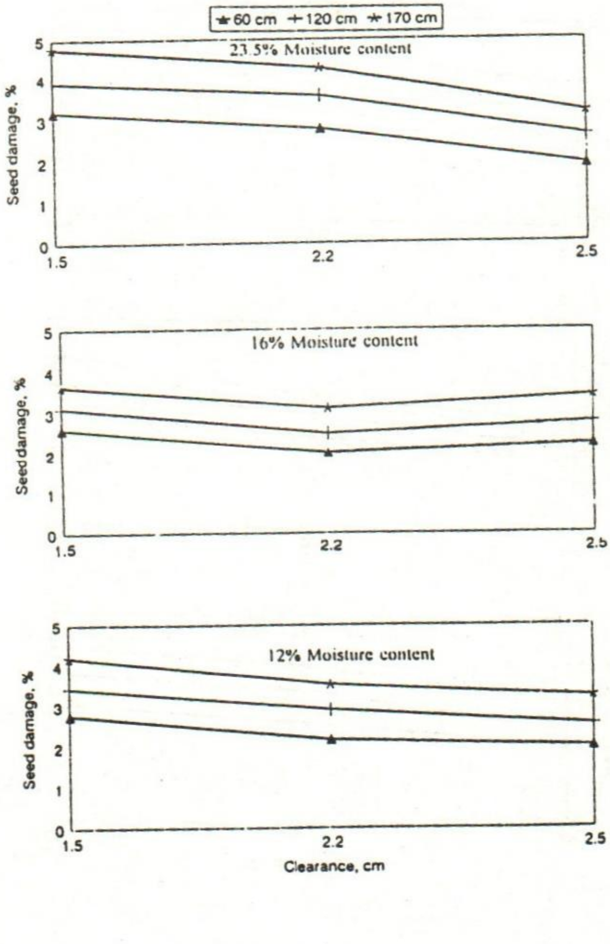

Fig. (12): Effect of clearance on seed damage at different length of stalks.

5- Cleaning efficiency:

Figures (13 and 14) indicate that increasing forward speed increases cleaning efficiency in the first stage. Further increase in forward speed decreases cleaning efficiency. The same trend was noted with concave clearance . Furthermore, decreasing moisture content from 23.5 to 16 % increases cleaning efficiency, while more decrease in moisture content to 12 % decreases cleaning efficiency. It seems that increase of both forward speed and concave clearance will accelerate the separation process of chaff till reaching a certain optimum(3.5 km/h and 2.2 cm clearance for all moisture contents) after which minimum or no chaff is available to be separated.

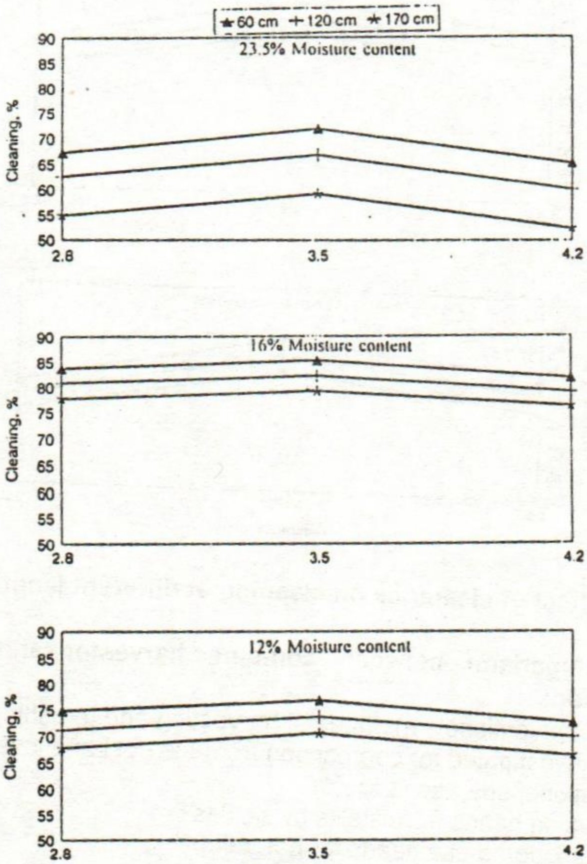

Fig. (13): Effect of forward speed on cleaning at different length of stalks.

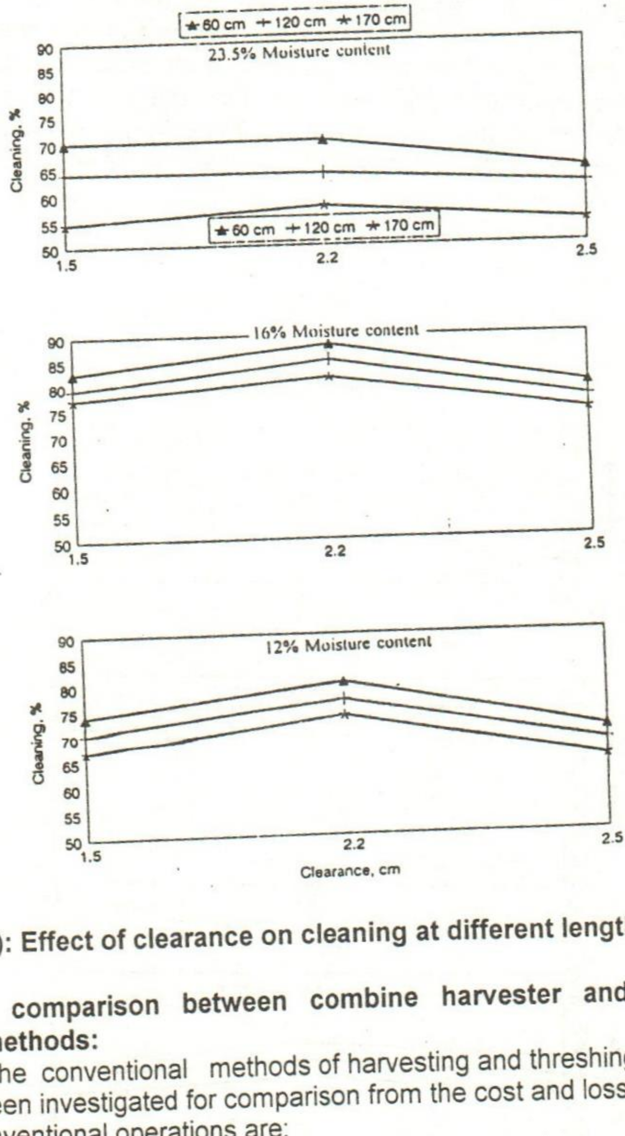

Fig. (14): Effect of clearance on cleaning at different length of stalks.

6- A comparison between combine harvester and conventional methods:

The conventional methods of harvesting and threshing sunflower crop have been investigated for comparison from the cost and losses point of view. The conventional operations are:

1- Cutting heads from stalks by sickles.
2- Transport these heads for natural drying.
3- Leaving heads from 7 to 15 days.
4- Threshing heads: this operation is done by two methods.
   a- Labors hand.
   b- Threshing machines.
5- Blowing seeds resulted from threshing by screening them using hand operated screens.

6- Blowing all seeds which resulted from hand and/or mechanical threshing using traditional blowing machine.

Each step as previously explained has a contribution in the seed loss. Table (1) shows cost comparison between combine harvester and traditional methods. It indicates that the final loss and profit was in favor of combine harvester followed by conventional method with threshing machine, then the manual method .

Table (1): A comparison between combine harvester and conventional method.

Operation	Traditional method by hand		Traditional method by thresher machine		Combine harvester	
	Cost LE/Fed	Loss %	Cost LE/Fed	Loss %	Cost LE/Fed	Loss %
Handle harvest	40	3.0	40	3.0	--	--
Handle transport	40	3.0	40	3.0	--	--
Drying period	--	4.0	--	4.0	--	--
Handle thresh	48	6.0	--	--	--	--
Handle isolating	40	5.9	--	--	--	--
Thresher machine	--	--	50	5.8	--	--
Using combine	--	--	--	--	100	3.64
More bellowing	20	3.0	20	3	20	3.00
Total	188	24.9	150	18.8	120	6.64

Recommendations:

The combine harvester is recommended for use instead of conventional method in order to save cost, time, and increase yield.). To obtain the best combine performance, field capacity, lowest total losses and seed damage percentage, the machine should be adjusted to operate at optimum conditions of : 3.5 km/h forward speed, 500 rpm cylinder rotational speed, 2.2 cm concave clearance, 60 cm length of stalk at about 16 % moisture content, (this moisture content may be reached 100 - 105 day after planting .The combine cutter head may be provided with comb to obtain the minimum total losses.

REFERENCES

Abdel Mageed, H.N.; M.A. El-Saadany and A.S. Hamam (1994). The optimum working conditions of a locally designed machine in threshing sunflower crop. J. Agric Sci. Mansoura Univ., 19(10): 3421-3432.

Allen, R.R., Allen, F. Wiese, and E.B.H. Hudspeth (1978). Sunflower harvesting research. ASAE paper No. 78-1568 st. Joseph, MI. ASAE.

Fairbanks, G.E.; W.H. Johnson, M.D. Schrock, and Suryanath (1979) Grain sorghum harvesting loss study. Transaction of the ASAE, 22 (2): 246-250.

Kepner, R.A. Bainer, and E.L. Bargar (1982). Principle of farm machinery, third edition. The A VI publishing Co, West Port Connecticut, 392-428.

Lamp, B.J.; W.W. Jonson, and K.A. Harkness (1961). Soybean harvesting losses - approaches reduction, Transaction of the ASAE, 4(2): 203-205,

Lien, R.M.; C.G. Haugh; M.J. Silver, and R.B. Ashman (1976). Machine losses in field harvesting popcorn. Transaction of the ASAE, 19(5): 827-829.

Nath; W.H. Johnson, and G.A. Milliken (1982). Combine loss model and optimization of the machine system. ASAE paper No., 82-2502 Joseph, MI. ASAE.

Nyborg, E.O.; H.F. McColly, and R.T. Hinkle (1969). Grain - combine loss characteristics. Transaction of the ASAE, 12(6): 727-732.

Quick, G.R. (1973), Laboratory analysis of combine header. Transaction of the ASAE, 16(1): 5-12.

Sharama, K.D. and R.S. Devanani (1979). Threshing studies on sunflower and mustard. Agricultural Mechanization in ASIA (AMA) Spring, 69-72.

الأداء الحقلي لآلة الضم والدراس فى حصاد محصول عباد الشمس

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من أهم المشاكل التى تواجه إنتاج محصول عباد الشمس هى صعوبة إجراء عمليات الحصاد والدراس والتذرية بالطرق التقليدية لما تحتاجه من عمالة كثيرة ومجهود ووقت كبير. بالإضافة الى إرتفاع نسبة الفاقد من البذور مما جعل المزارعين يحجمون عن زراعته. ومن هنا جاءت أهمية هذا البحث لمحاولة حل هذه المشاكل وذلك بإجراء هذه العمليات مجتمعة باستخدام الكمباين.

ولأداء هذه العملية فقد لزم دراسة العوامل الآتية لتحديد أنسب الظروف والعوامل للتشغيل : المحتوى الرطوبى وطول ساق النبات والسرعة الأمامية للكمباين وسرعة الدرفيل والخلوص بين الاسطوانة والصدر. فقد أثبت البحث أن أفضل النتائج الخاصة بنسبة الفقد الكلى وكفاءة الدراس ونسبة النظافة كانت عند سرعة أمامية ٣,٥ كم/س، وعند نسبة رطوبة ١٦ % للبذور، وعند طول قطع ٦٠ سم، وعند خلوص ٢.٢ سم، وعند سرعة درفيل ٥٠٠ لفة/دقيقة، فكانت نسبة الفقد الكلى ٦,٦٤ % تحت هذه الظروف، فى حين كانت ٢٤,٩% عند إستخدام الطريقة التقليدية. وكانت التكلفة الكلية لهذه الطريقة الميكانيكية ١٢٠ جنيها للفدان بينما كانت ١٨٨ جنيهاً للفدان فى الطريقة التقليدية. وبتحليل النتائج إحصائيا للفقد الكلى إتضح أن السرعة الأمامية أثرت بنسبة ٢,١٩% بينما كان تأثير نسبة الرطوبة ١٢,٥٨% وتأثير طول القطع ٧٥,٢٥% وتأثير الخلوص ١,٨٩% وكان تأثير سرعة الاسطوانة غير معنوى حيث بلغ ٠,٢٦% وكانت نسبة الدراس ١٠٠% عند هذه المستويات. كما ثبت أن إستخدام التعديل الخاص بالصدر بإضافة مشط مسنن على عمود القطع قلل الفاقد الكلى وذلك بتقليل الفقد الأمامى بنسبة ٨٣% والذى كان يمثل ٩٠% من الفقد الكلى.