Egypt. J. Agric. Res., 80 (3), 2002.

COMPARATIVE PERFORMANCE OF TWO MECHANICAL WHEAT HARVESTING COMBINES WITH TRADITIONAL SYSTEM

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(Manuscript received Feb. 2002)

Abstract

Field experiments were carried out at the experimental field of Rice Mechanization Center, Meet El-Deeba, Kafer El-Sheikh Governorate, Egypt. Two different types of Japanese combines harvesting machines, Yanmar model CA-385, cutting width 1400 mm, crawler travelling unit, adjusted pick tines and star wheels. Multi-purpose combine harvester Yanmar model CA-760, cutting width 2060 mm, crawler travelling unit, front reel, were tested at three different forward speeds of about (2.3, 3.2 and 4.5 km/h) three cylinder speeds (22.7, 28.1 and 32.1 m/s) and three moisture contents (16.3,13.6 and 10.9%) for wheat crop.

The lowest values of header losses, threshing losses and shoe losses were (0.27,0.37 and 0.20%) and (0.35,0.27 and 0.17%) recorded at grain moisture content of 13.6 %, cylinder speed of 28.1 m/s and forward speed of 2.3 km/h, for combines CA-760 and CA-385 respectively. Also the minimum values of total losses were (0.84 and 0.79 %) respectively obtained at forward speed of 2.3 km/h, cylinder speed of 28.1 m/s and grain moisture content of 13.6%, which are recommended for optimum harvesting wheat. At these conditions the criterion cost (109.3 and 94.3 L.E/Fed), for the combines CA-760 and CA-385, respectively compared with manual harvesting followed by mechanical threshing and winnowing (192.55 L.E/Fed).

INTRODUCTION

Wheat is among the most important cereal crops in Egypt as well as in many parts of the world. It is used for making bread and other food stuffs, animal feeding and other artificial purposes in most countries around the world. In Egypt, it occupies about 2.5 millions Feddans with a national average of about 2370 kg / Feddan, producing yearly about 5.72 million tons which is very far below the amounts needed for local consumption.

As known, cereal crops are too sensitive to harvesting operation due to the high percentages of grain losses affecting the total yield, there fore much care has to be taken to carry out the harvesting operation to minimize production losses and hence cost. Many projects and researches are running in the scope of grain losses resulted at different stages during harvesting operations using combine machines.

At constant feed rate for combining wheat, grain moisture content of about 15.5% and 3 mm belt concave clearance, the unthreshed grain decreased from 2.5 to 0.8% and the grain damage increased from 2.9to 3.5%. This was accomplished when threshing drum speed increased from 700 to 900 rpm (El-Shazely, 1991).Also, unthreshed grain increased from 2.5to 4.8%, when grain moisture content increased from 15.5 to 17.5 %.

Increasing forward speed tends to increase the actual field capacity and to decrease the field efficiency (Helmy, *et al.*1995). They also indicated that the actual field capacity increased by increasing straw moisture content.

To evaluate the operation of the developed harvester which mounted on the front of tractor for harvesting wheat, (El-Sahrigi, *et al.*1998) found that the total fabrication cost, calculated according to the price level of 1995, reached 19250 L. E. The operating cost was 34.1 L. E/h for the tractor and the developed harvester.

In China, India, Egypt and elsewhere, vertical reapers have been used for harvesting wheat and rice (El-Sahrigi and Khan 1990 and El-Sahrigi *et al.* 1992). However, the output of the reaper was low and considerable labor was still required for collection, threshing, cleaning and bagging seed from a combine. (Kepner *et al.*1982). Studied the losses from combine which are often identified as gathering, cylinder, straw-walker, and shoe losses.

Concerning the combine header losses,(Griffin,1976) stated that the irusual causes are: missed grain heads due to improper reel speed, grain shattering by too-fast reel speed, grain thrown over in front of the reel by too-low reel height and grain shattered by too-fast ground speed.

El-shal and Morad (1991) experimentally measured the header losses at different header and crop variables such as: reel speed index, horizontal distance between the reel axis and the cutter bar, the reel teeth angle to the vertical direction and crop moisture content, they determined the optimum values of the previous variables using results obtained during the harvesting operation of standing and lodging rice crop.

Using two different types of combine harvesting machines to harvest three rice variety (Kamel, 1999) proved that all kinds of losses (header, drum and shoe losses) increased with the increase of cutting height and harvesting speed for the two tested combines and the lowest value of total losses were obtained at harvesting speed of 0.3 m/s and cutting height of 7 cm.

Suraya *et al.* (1982) stated that moisture content and feed rate highly significant as the major influences on percent shoe loss. There was a reducing effect of cylinder speed on the unthreshed grain. Whilst, there was a positive effect on total grain damage, visible and invisible. Helmy (1988) added that there was apositive effect of the front speed of a combine on the cut straw length. The energy consumption also increased as the front speed increased.

El-Haddad *et al.* (1995) reported that wheat combine harvester give the lowest cost of about 229 L.E / Fed. in comparison with 283.4 L.E/fed. for mounted mower and 300 L.E/fed. for manual sickle.

The total lost time differs from a combine to another and this was reflected on the field efficiency (El-Berry and Ahmed, 1989). The differences were not only attributed to the machine but mainly to the operator experience.

It is clear that improving the performance of combine devices during the harvesting operation of wheat crop is of great importance to minimize both grain losses and operational costs. So, the objective of this study is to investigate grain losses due to the different functional parts and to determine the possible optimum operating conditions for the harvesting operation of wheat crop.

MATERIALS AND METHODS

Field experimental was carried out at experimental field of Rice Mechanization Center, Meet El-Deeba, Kafer El-Sheikh Governorate. Using two different types of combine harvesting machines, namely, combine Yanmar model CA-385 and Multi-purpose combine Yanmar model CA-760, were used to harvest wheat crop (Sakha 69). Table (1) summarizes the technical specifications of the utilized combines.

The two combines were tested at three different forward speeds of about (2.3, 3.2 and 4.5 km/h), three cylinder speed of about (22.7, 28.1 and 32.1 m/s) and three grain moisture content (16.3, 13.6 and 10.9%). The specifications of wheat crop variety are shown in Table (2). The average wheat plants population in the study were 300 plants per square meter.

Table 1. Technical specifications of the two combines harvesters.

Specifications	Combine harvester Yanmar CA-385	Multi-purpose combine Yanmar CA-760
Overall length (mm)	4063	5600
Overall width (mm)	1904	2430
Overall height (mm)	2160	2650
Cutting width (mm)	1400	2060
Cuttin height (mm)	Hyraulically adjusted	Hydraulically adjusted
Engine type	Diesel, 3 cylinders, 4 strokes water cooled	Diesel, 4 cylinders 4 strokes water cooled
Out-put ps/rpm	38/2800	76/2600
Threshing unit type	shaking sieves and fans	Screw rotor
Threshing dram length (mm)	710	2170
Threshing dram diameter (mm)	420	650
Traveling unit	Crawler	Crawler

Table 2. Some physical properties of wheat variety (Sakha 69).

No. of sample	Plant length, cm	Weight of 1000 seed, g	Weight of sample, g	Weight of straw in sample, g	Weight of grain in sample, g	Grain/stra W ratio
1	88.0	4.4	250	150.0	100.0	1:1.50
2	85.0	4.0	250	149.5	100.5	1:1.49
3	84.5	4.0	250	145.5	1104.5	1:1.39
4	95.0	4.1	250	152.0	98.0	1:1.55
5	90.0	4.4	250	154.2	95.8	1:1.61
6	92.0	4.5	250	155.0	95.0	1:1.63
7	92.0	4.3	250	156.0	94.0	1:1.66
8	93.0	4.1	250	148.5	101.5	1:1.46
9	97.0	4.3	250	153.6	96.4	1:1.59
10	96.0	4.2	250	151.7	98.3	1:1.54
Mean	91.5	4.20	250	151.5	98.5	1:1.55

Test procedure of harvesting losses:

i) Pre-harvest losses measurement:

Pre-harvest losses were determined by using a wooden frame (1m x 1m square) repeatedly in the unharvested area and the grain losses in the frame were counted. The percentage of pre-harvest losses was calculated using the following equation:

$$\text{Pre-harvest losses \%} = \frac{\text{Pre-harvest losses /fed}}{\text{Total yield / fed}} \times 100$$

ii) Header loss measurement:

Header loss obtained by locating the wooden frame 1 m^2 randomly in the harvesting test area where the throughput of the combine was previously collected on the canvas sheet. The grain losses in the frame represent pre-harvest and header loss together. Then to get only the header loss, the pre-harvest losses must be sub tracted. The percentage of header loss was calculated using the following equation:

$$\text{Header losses \%} = \frac{\text{Header losses / fed}}{\text{Total yield / fed}}$$

iii) Threshing loss measurement:

Drum or cylinder losses were collected by using canvas sheet to collect straw and unthreshed panicles at the rear of the combine. The percentage of threshing losses was calculated by using the following equation.

$$\text{Threshing losses \%} = \frac{\text{Threshing losses / fed}}{\text{Total yield / fed}}$$

iv) Cleaning shoe losses measurement:

To determine shoe losses, a canvas sheet was placed below the rear of the shoe so that material discharged from the cleaning show is dropped on the canvas sheet, while the combine moves at a certain distance, then the grains on the sheet, which represent shoe losses were weighed. The percentage of shoe losses was calculated using the following equation.

$$\text{Cleaning (Shoe) losses \%} = \frac{\text{Shoe (Cleaning losses) / fed}}{\text{Total yield / fed}}$$

Combine performance efficiency:

$$\text{Performance efficiency \%} = \frac{\text{Output / fed}}{\text{(Output + Total losses) / fed}} \times 100$$

The machine output is the amount of grain collected in the bin of harvester. Total losses of combine (header, threshing and shoe loss)

Machine performance:

a) Calculation of the effective field capacity:

The effective field capacity was calculated as follow:

$$E.F.C. = \frac{1}{\text{Effective total time in hours required per feddan}}, \text{ fed / h}$$

b) Field efficiency:

The field efficiency was calculated using the following formula:

$$\eta_f = \frac{E.F.C.}{T.F.C.} \times 100, \%$$

Visible grain damage measurement:

Visible grain damage was determined by separating the damaged grain by hand from a mass of 50 grams sample was taken at a random. The percentage of grain damaged was calculated based on the original weight of sample.

Invisible grain damage measurement:

A germination test was carried out to determine the invisible damaged in grains. The germination test was carried out using three petri dishes on a paper filter covered with water and incubated at 20°C for 24 hours. The germinated seeds were collected in each dish and expressed as a percentage of the original number of grains.

Criterion cost:

The criterion cost of the harvesting operation was estimated by using the following equation (El-Awady *et al.*,1982).

Criterion cost /fed. = operating cost/fed ÷ grain loss/ fed.

$$\text{Operating cost / fed.} = \frac{\text{Machine cost (L.E/h)}}{\text{Actual field capacity (fed./h)}}$$

Measuring instruments:

Electrical drying oven, Balance, Stop watch, Tachometer, Ruler and measure tape (30 meter long), different sizes of frames and sheets and Calibrated cylinder

The mentioned equipment was used to measure: number of tillers /m^2, plant height cm, Number of panicles /m^2, Grain index, weight of panicle g, grain moisture content and measurements of grain harvesting losses at different functional parts of both combines.

RESULTS AND DISCUSSION

Effect of forward speed and grain moisture content on header losses using two combines. Table 3 shows that increasing the forward speed tends to increase header losses. The same trend has been reported by Fouad *et al.*, (1990) and Kassem, (1995). The obtained values of header losses were (0.37, 0.27 and 0.65%), (0.40, 0.35 and 0.69%) at the following grain moisture contents 16.3, 13.6 and 10.9% for combines CA-760 and CA-385 respectively. This trend may be due to the excessive load of plants on the cutter-bar, results show that, decreasing moisture content from 16.3to 10.9% at forward speed of 2.3 km / h increased header losses from (0.37 to 0.65%) and (0.4 to 0.69%) for combines CA-760 and CA-385 respectively. The lowest header losses value was recorded at a moisture content 13.6% and forward speed 2.3km/h, for combine CA-760.

Table (4) indicates the effect of cylinder speed and grain moisture content on the threshing for the two combines at different forward speed. It is obvious that increasing the cylinder speed from 22.7to 32.1 m/s tends to decrease, threshing losses from (1.00, 0.41and 0.60%) for combine CA-760 and (0.90, 0.40 and 0.50%) for combine CA-385 at constant forward speed of 2.3 km/h, and grain moisture content of 16.3%. It is apparent that increasing grain moisture content tends to increase threshing losses at all forward speeds and cylinder speeds due to the less dense wheat crop layer between the rotor and the concave per unit time. The lowest threshing loss was recorded at moisture content 13.6% and cylinder speed 28.1 m/s .

Table (5) demonstrates the effect of forward speed, cylinder speed and grain moisture content on shoe losses using the two combines. Increasing forward speed tends to increase shoe losses due to the excessive load of materials on the sieves. The forward speed of 2.3, 3.2 and 4.5 km/h gave shoe losses of about (0.25, 0.29 and 0.37%) and (0.21, 0.24 and 0.32%) for combines CA-760 and CA-385 respectively, at constant cylinder speed of 22.7 m/s and grain moisture content of 16.3%. The other cylinder speeds and grain moisture content had the same trend. The reason for that, increasing the cylinder speed increases the broken straw on the sieve, which tends to increase the shoe losses. Similar results were reported by Kepner *et al.*, 1982. It is also apparent that the shoe losses increased by decreasing grain moisture content at all forward speeds and cylinder speeds. The minimum shoe losses were noticed at grain moisture content of 16.3% and cylinder speed of 28.1 m/s.

Table (6) illustrates the effect of cylinder speed and grain moisture content on the total losses at different forward speed. The obtained values of total losses were (1.06, 1.30 and 1.73%) and (1.06,1.19 and 1.75%) for combines CA-760 and CA-385 respectively, at forward speeds of 2.3, 3.2 and 4.5 km/h at cylinder speed of 28.1 m/s and grain moisture content of 16.3%. The other grain moisture contents had the same trend. Increasing forward speed tends to increase the total losses at all cylinder speed and grain moisture contents. The least value of total losses was obtained at cylinder speed of 28.1 m/s.

Generally, it is clear that the least value of total losses was obtained at a forward speed of 2.3 km/h and grain moisture content of 13.6%.

Field performance characteristic of combine harvester:

1. Effective field capacity:

Fig. (1) indicates that the effective field capacity increased by increasing the forward speed. The obtained values were 0.97, 1.20 and 1.6 fed/h at forward speeds of about 2.3, 3.2 and 4.5 km/h respectively, with grain moisture content at an average of 10.9% for combine CA-760. The other grain moisture content had the same trend. Values of effective field capacity were 0.67, 0.90 and 1.20 fed/h at same forward speed and grain moisture content for combine CA-385. The grain moisture content of about 16.3,13.6 and 10.9% gave the following values of the effective field capacity (1.30, 1.50 and 1.60 fed/h), (0.95, 1.00 and 1.20 fed/h) for combines CA-760 and CA-385 respectively at forward speed of about 4.5 km/h. The other forward speeds had the same trend. It is evident that decreasing grain moisture content tends to increase the effective field capacity. This result agreed well with that reported by Fouad *et al.*, 1990 and Helmy *et al.*,1995.

2. Field efficiency:

Fig. (1) shows the effect of forward speed and grain moisture content on the field efficiency. It is noticed that increasing forward speed tends to decrease field efficiency for all moisture contents.

The forward speed of about 2.3, 3.2 and 4.5 km/h gave field efficiency of about (85.2, 75.0 and 71.4%), (86.3, 84.1 and 80.0%) for combines CA-760 and CA-385, respectively at grain moisture content of an average of 10.9%. The other grain moisture contents had the same trend. The grain moisture content of about 16.3, 13.6 and 10.9%gave the following values of field efficiency (70.6, 75.1 and 85.2), (75.9, 84 and 86.3%) for combines CA-760 and CA-385 respectively at forward speed of about 2.3 km/h. The other forward speeds had the same trend. Its clear that decreasing grain moisture content tends to increase field efficiency for combines. Similar trend has been obtained by Fouad *et al.* (1990).

3. Fuel consumption:

Fig. (2) demonstrates the effect of forward speed, cylinder speed and grain moisture content on the rate of fuel consumption for the two combines. The forward speeds of 2.3, 3.2 and 4.5 km/h gave the following values of fuel consumption rate (9.0, 9.8 and 10.4 l/h), (4.1, 4.4 and 4.91/h) for combines CA-760 and CA-385 respectively at cylinder speed about 22.7 m/s and grain moisture content at an average of 10.9%. The other cylinder speed and grain moisture contents had the same trend. It is apparent that the increasing forward speed tends to increase the rate of fuel consumption at all cylinder speeds and grain moisture contents for the two combines. The lowest cylinder speed of 22.7m/s gave the smallest values of fuel consumption rate at all forward speeds and grain moisture contents. It can be noticed that decreasing the grain moisture content trend to decrease fuel consumption rate at all forward speeds. The fuel consumption rate of about (12.6 and 10.4), and about (5.7 and 4.9 l/h) for combines CA-760 and CA-385, respectively at forward speed of 4.5 km/h and cylinder speed of about 22.7 m/s when the moisture content decreased from (16.3 to 10.9 %). The other forward speeds and cylinder speeds had the same trend.

4. Combine performance efficiency:

Fig. 3 shows the effect of forward speed, cylinder speed and grain moisture content on the combine performance efficiency. It is clear that the performance efficiency decreased by increasing the forward speed at all grain moisture contents. The forward speeds of about 2.3, 3.2 and 4.5 km/h gave values of combine performance efficiency of about (98.7, 98.0 and 97.0 %), (98.8, 98.3 and 97.6 %) for combines CA-760 and CA-385, respectively at cylinder speed of about 28.1m/s and grain moisture content of about 16.3 %. Therefore, grain moisture content of about 13.6 %, forward speed of about 2.3Km/h and cylinder speed of about 28.1 m/s are recommended for harvesting wheat crop.

Machine criterion cost

Table (7) indicates the effect of the combine forward speed, cylinder speed and grain moisture content on the criterion cost of the harvesting operation. The forward

Table 3. Effect of forward speed and grain moisture content on header loss, % for the two combines.

Forward speed, km/h	Header Losses, %					
	Combine CA - 760			Combine CA - 385		
	Moisture content, %			Moisture content, %		
	10.9 %	13.6	16.3 %	10.9	13.6	16.3 %
2.3	0.65	0.27	0.37	0.69	0.35	0.40
3.2	0.67	0.34	0.41	0.71	0.39	0.46
4.5	0.91	0.53	0.62	0.99	0.57	0.66

Table 4. Effect of forward speed, cylinder speed and grain moisture content on threshing loss, % using the two combines.

Cylinder speed, m/s	Threshing loss, % at forward speed of 2.3 km / h					
	Combine CA - 760			Combine CA - 385		
	Moisture content, %			Moisture content, %		
	10.9 %	13.6	16.3 %	10.9	13.6	16.3 %
22.7	0.70	0.43	1.00	0.60	0.40	0.90
28.1	0.38	0.37	0.41	0.35	0.27	0.40
32.1	0.53	0.33	0.60	0.45	0.33	0.50
Cylinder speed, m/s	Threshing loss, % at forward speed of 3.2 km / h					
	Combine CA - 760			Combine CA - 385		
	Moisture content, %			Moisture content, %		
	10.9 %	13.6	16.3 %	10.9	13.6	16.3 %
22.7	0.80	0.52	1.10	0.70	0.55	1.00
28.1	0.50	0.41	0.60	0.53	0.38	0.45
32.1	0.72	0.45	0.80	0.61	0.49	0.70
Cylinder speed, m/s	Threshing loss, % at forward speed of 4.5 km / h					
	Combine CA - 760			Combine CA - 385		
	Moisture content, %			Moisture content, %		
	10.9 %	13.6	16.3 %	10.9	13.6	16.3 %
22.7	0.87	0.61	1.30	0.73	0.64	1.10
28.1	0.62	0.49	0.80	0.51	0.40	0.78
32.1	0.81	0.52	1.00	0.62	0.51	0.92

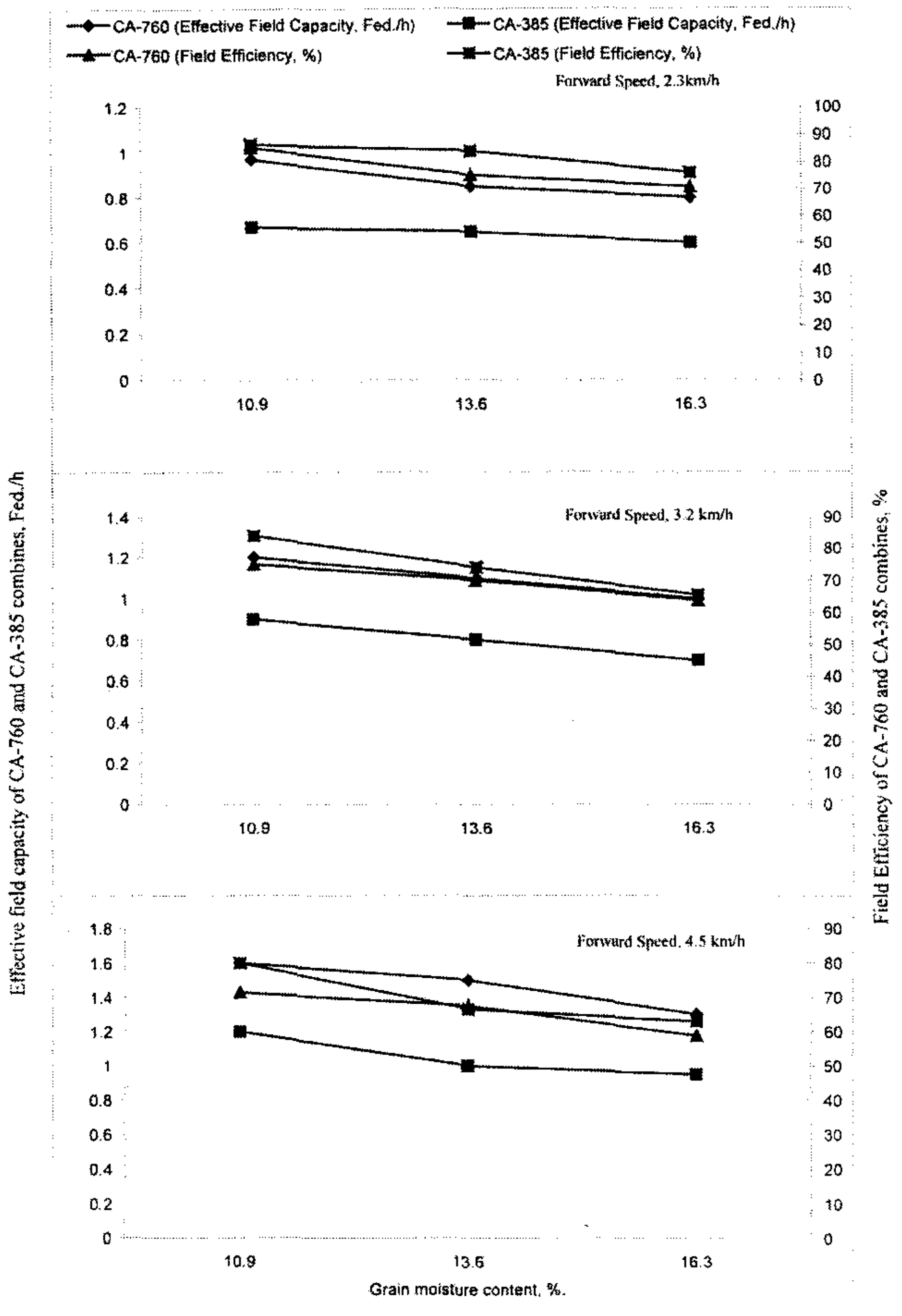

Fig. 1. Effect of forward speed and grain moisture content on the effective field capacity and efficiency using two combines at different forward speeds.

Table 5. Effect of forward speed, cylinder speed and grain moisture content on shoe loss, % for the two combines.

Forward speed, km/h	Shoe loss, % at cylinder speed of 22.7 m/s					
	Combine CA - 760			Combine CA - 385		
	Moisture content, %			Moisture content, %		
	10.9 %	13.6	16.3 %	10.9	13.6	16.3 %
2.3	0.36	0.24	0.25	0.29	0.20	0.21
3.2	0.39	0.27	0.29	0.32	0.22	0.24
4.5	0.44	0.29	0.37	0.39	0.23	0.32
Forward speed, km/h	Shoe loss, % at cylinder speed of 28.1 m/s					
	Combine CA - 760			Combine CA - 385		
	Moisture content, %			Moisture content, %		
	10.9 %	13.6	16.3 %	10.9	13.6	16.3 %
2.3	0.29	0.20	0.28	0.27	0.17	0.26
3.2	0.31	0.23	0.29	0.28	0.19	0.28
4.5	0.33	0.29	0.31	0.33	0.23	0.31
Forward speed, km/h	Shoe loss, % at cylinder speed of 32.1 m/s					
	Combine CA - 760			Combine CA - 385		
	Moisture content, %			Moisture content, %		
	10.9 %	13.6	16.3 %	10.9	13.6	16.3 %
2.3	0.31	0.27	0.30	0.29	0.21	0.28
3.2	0.34	0.30	0.34	0.35	0.25	0.30
4.5	0.36	0.33	0.36	0.36	0.28	0.34

Table 6. Effect of forward speed, cylinder speed and grain moisture content on total loss, % for the two combines.

Cylinder speed, m/s	Shoe loss, % at forward speed of 2.3 km/h					
	Combine CA - 760			Combine CA - 385		
	Moisture content, %			Moisture content, %		
	10.9 %	13.6	16.3 %	10.9	13.6	16.3 %
22.7	1.71	0.87	1.62	1.58	0.87	1.51
28.1	1.32	0.84	1.06	1.31	0.79	1.06
32.1	1.49	0.85	1.27	1.43	0.84	1.18
Cylinder speed, m/s	Shoe loss, % at forward speed of 2.3 km/h					
	Combine CA - 760			Combine CA - 385		
	Moisture content, %			Moisture content, %		
	10.9 %	13.7	16.3 %	10.10	13.7	16.3 %
22.7	1.86	1.09	1.80	1.73	1.13	1.70
28.1	1.48	1.02	1.30	1.52	0.99	1.19
32.1	1.73	1.09	1.55	1.67	1.13	1.46
Cylinder speed, m/s	Shoe loss, % at forward speed of 2.3 km/h					
	Combine CA - 760			Combine CA - 385		
	Moisture content, %			Moisture content, %		
	10.9 %	13.8	16.3 %	10.11	13.8	16.3 %
22.7	2.22	1.43	2.29	2.11	1.44	2.08
28.1	1.86	1.31	1.73	1.83	1.20	1.75
32.1	2.08	1.38	1.98	1.97	1.36	1.92

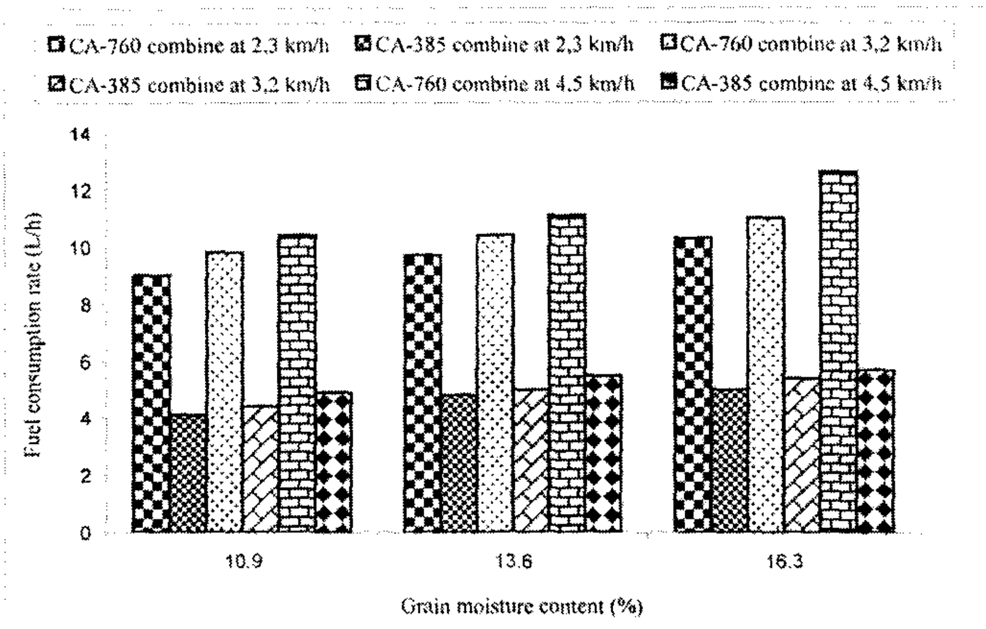

Fig. 2. Effect of forward speed and grain moisture content on fuel consumption rate in using two combines.

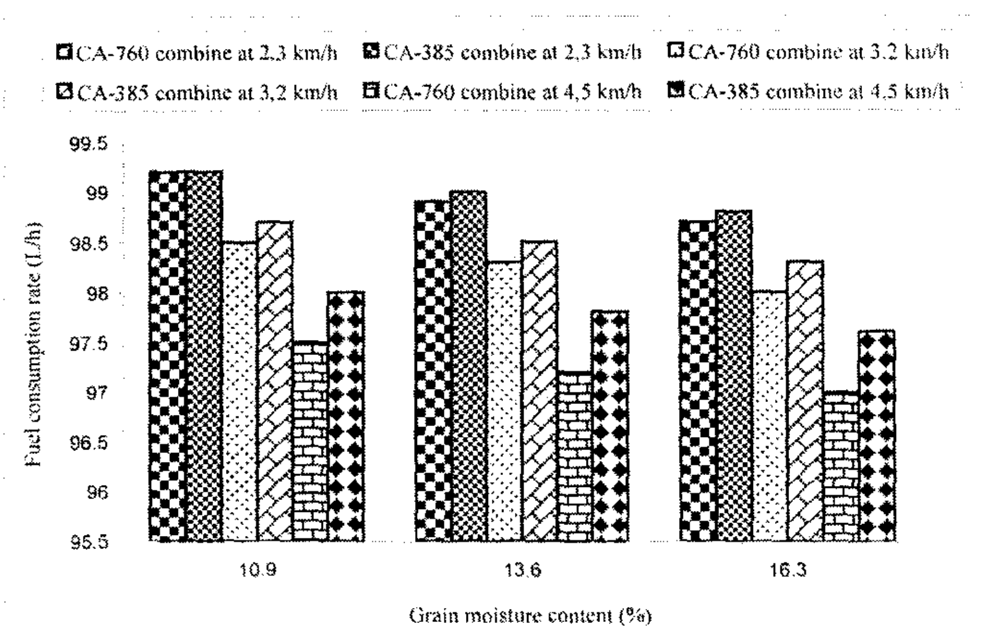

Fig. 3. Effect of forward speed and grain moisture content on combine performance efficiency using two combines.

speeds of about 2.3,3.2 and 4.5 km/h gave the following values of (109.3,105.2 and 103.5 L.E/fed) and (94.3, 90.4 and 89.2 L.E/fed) for combines CA-760 and CA-385, respectively, at cylinder speeds of 28.1m/s and grain moisture content at an average of 10.9 %. The other grain moisture contents and cylinder speed had the same trend. It is clear that increasing forward speed tends to decrease the criterion cost of the harvesting operation. This trend is due to increasing effective field capacity as the forward speed increased.

From Table (7) the criterion costs were about (110.1, 109.3 and 112.2 L.E/fed.) and (98.5,94.3 and 96.0 L.E/fed) for combines CA-760 and CA-385, at cylinder speeds of 22.7,28.1 and 32.1 m/s, respectively, at the forward speed of 2.3 km/h and grain moisture content at an average of 10.9 %.

Table 7. Effect of forward speed, cylinder speed and grain moisture content on the criterion cost using the two combines

Forward speed, km/h	cylinder speed, m/s	Mean values of criterion cost L.E/fed. Grain moisture content, %					
		16.3		13.6		10.9	
		CA-760	CA-385	CA-760	CA-385	CA-760	CA-385
2.3	22.7	115.0	100.3	112.9	99.0	110.1	98.5
	28.1	113.9	98.2	110.7	97.3	109.3	94.3
	32.1	114.0	99.6	110.9	97.9	112.2	96.0
3.2	22.7	113.2	98.3	110.6	97.0	109.1	95.2
	28.1	112.3	96.5	108.5	94.0	105.2	90.4
	32.1	112.6	96.8	108.0	94.5	110.3	92.3
4.5	22.7	111.3	97.5	109.0	95.2	105.3	92.5
	28.1	110.0	97.0	104.0	90.7	103.5	89.2
	32.1	105.4	96.8	104.3	93.2	103.0	90.8

Manual cost analysis:

The criterion cost was estimated at the following optimum operating conditions, grain moisture content of about 13.6%, feed rate of about 0.5 kg/s and cylinder speed of about 28.1m/s. The criterion cost of harvesting and threshing operations was estimated by using the following equation (ElAwady *et al.*, 1982).

Criterion cost / fed. = operating cost/fed + grain loss cost /fed

The thresher fabrication costed about 6000 L.E., The cost of operation per hour was calculated considering five years effective life of the thresher where the thresher can work 400 hours every year. The cost of operating the thresher for one operating hour is 8.58 L.E in addition to 4 L.E/h cost of four labors required for feeding and handling the crop. The tractor cost is about 13.16 L.E/h The threshing cost is then 25.74 L.E/h.

The thresher capacity is 682 kg/h and the average time to thresh the crop of one feddan is 2.5 hours. The cost of threshing the crop of one feddan of wheat is then 64.35 L.E/Fed.

Harvesting one feddan requires 8 labors, wage of each 8 L.E/day. The cost of harvesting one feddan is 64.0 L.E. The cost of gathering the crop in one feddan is 15.0 L.E. The cost of harvesting one feddan by sickle, manual gathering and mechanical threshing is therefore 143.35 L.E.

The cost of grain losses for one feddan is 49.20 L.E. It should be noticed that the price of one kg of wheat grain = 65 L.E, and price of one kg of broken wheat grain = 0.20 L.E. Hence, the criterion cost = 143.35 + 49.20 = 192.55 L.E/fed.

CONCLUSIONS

In conclusions the following may be summarized:

1. The lowest header losses were recorded at grain moisture content of 13.6% and forward speed of 2.3 km/h .
2. The lowest threshing losses were recorded at cylinder speed 32.1 m/ s and grain moisture content of 13.6 %.
3. The lowest shoe loss were recorded at forward speed 2.3 km / h and grain moisture content of 13.6 %.
4. Generally, the least value of total losses was obtained at forward speed of 2.3 km/h, cylinder speed of 28.1m/s and grain moisture content of 13.6%.
5. The obtained values of the effective field capacity were (0.97, 1.20 and 1.60 fed,/h) at forward speed of about 2.3, 3.2 and 4.5km/h, respectively. Also, values of field efficiency were (85.2, 75 and 71.4%) at same forward speed for combine CA-760. Also, values of the effective field capacity and field efficiency were (0.67, 0.9 and 1.2 fed/h), (86.3, 84.1 and 80%) for combine CA-385 at the same forward speed.

6. The optimum values of combine performance efficiency were obtained at forward speed of 2.3km/h, cylinder speed of 28.1m/s and grain moisture content of 10.9% AT this condition the criterion costs (109.3 and 94.3 L.E /fed), for combines CA-760 and CA - 385, respectively compared with manual harvesting followed by mechanical threshing and winnowing (192.55 L. E /fed) .

RECOMMENDATIONS

1. The forward speed of about 2.3km/h, cylinder speed of 28.1m/s and grain moisture content of about 10.9% are considered the optimum operating conditions for mechanical harvesting of wheat crop.
2. Harvesting wheat crop by using combine harvester is an efficient and economic system compared with manual harvesting and gathering followed by mechanical thresher.

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الأداء المقارن لنوعين من الحاصدات الميكانيكية والحصاد التقليدى للقمح

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١- أقل فاقد لجهاز الصدر الأمامى الكومباين سجلت عند محتوى رطوبى ١٣,٦٪ وسرعة أمامية ٢,٣ كجم/ساعة.

٢- أقل فاقد دراس سجل عند سرعة دورانية لإسطوانة الدراس كانت ٢٢,١ م/ث ومحتوى رطوبى للحبوب ١٣,٦٪.

٣- أقل فاقد لجهاز الفصل والتنظيف سجلت عند سرعة أمامية ٢,٣ م/ث ومحتوى رطوبى ١٣,٦ ٪.

٤- أقل قيمة للفواقد الكلية حصل عليها عند سرعة أمامية ٢,٣ كم/ساعة وسرعة أسطوانة الدراس الدورانية ٢٨.١ م/ث ومحتوى رطوبى ١٣,٦٪.

٥- القيم المتحصل عليها للسعة الفعلية وهى (٠,٩٧ - ١,٢٠ - ١,٦ فدان/ساعة) عند سرعة أمامية (٢,٣ - ٣,٢ - ٤,٥ كم/ساعة) على التوالى. وأيضاً قيم الكفاءة الحقلية للكومباين كانت (٨٥,٢ - ٧٥,٠ - ٧١,٤ ٪) عند نفس السرعات السابق ذكرها وذلك للكومباين (CA-670).

٦- أفضل قيم أداء للكومباين حصل عليها عند سرعة أمامية ٢,٣ كم/ساعة وسرعة دورانية لإسطوانة الدراس ٢٨,١ م/ث ومحتوى رطوبى ١٠,٩٪ عند هذه الظروف عند معيار تكاليف قيمته (١٠٩,٣ و٩٤,٣ جنيه / فدان) لنوعى الكومباين المستخدمين فى هذه الدراسة بالمقارنة بتكاليف الحصاد اليدوى والتى تبلغ (١٩٢,٥٥ جنيه / فدان).

التوصيات التطبيقية :

- استخدام النتائج التى وصل إليها البحث فى اختيار أنسب سرعة أمامية لآلة الحصاد حوالى (٢,٣ كم / ساعة) وسرعة إسطوانة الدراس حوالى (٢٨,١ م/ث) والتى تحقق أقل قيمة لفواقد الحصاد المختلفة عند المحتوى الرطوبى المناسب حوالى (١٠,٩ ٪).
- الاتجاه إلى استخدام الكومباينات الشاملة لحصاد القمح يعتبر نظام كفأ واقتصادى مقارنة بعملية الحصاد اليدوى ثم استخدام ماكينة الدراس والتذرية.