Maximizing wheat crop yield using a mobile thresher at small holdings

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Abstract: This study was carried out at a private farm in Owlad Sakr District, Sharkia governorate Egypt during 2015 summer season. It aimed to maximize wheat crop yield by modifying a stationary thresher. The modification involved tractor mounting the thresher to move among the field and the thresher was attached with a feeding device and a straw container. The experiment was established and designed statistically as a factorial experiment in complete randomized blocks with three replications. The tested treatments were wheat plant feeding rate levels of 500, 700,900 and 1100 kg/h and wheat plant moisture content levels of 16%, 18% and 20% (w.b.). The obtained results showed that the modified thresher decreased the total grain losses with 45.24%, increased the threshing efficiency with 1.35%, increased the cleaning efficiency with 8.16% and decreased the threshing criterion costs with 38.24%, with the stationary thresher. So, it is recommended to apply wheat threshing using the mobile thresher.

Keywords: develop, experiment, threshing efficiency, mobile thresher

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1 Introduction

In Egypt, wheat is considered as a strategic and cashed crop. Whereas, the production is used in local consumption of feed and different aspects. The Egyptian annual wheat cultivated area is about 2.985 million feddans, producing 8.089 million Mg grains approximately with an average of 2.710 Mg grains/fed (Ministry of Agriculture and Land Reclamation, 2012). Despite the introduction of improved varieties of wheat, better chemical and hydrological inputs, the production is still insufficient to face the population feeding requirements due to some factors. One of these factors is wheat grain losses during harvest and post harvest.

As cited by El-Hadded (2010) 52%, 11.10%, 10.03% and 26.87% of the total arable area is divided into holdings area of less than 5, 5-10, 10-20 and more than 20 feddans, respectively. The holding area affects to great extent the technique of the used farm machinery, especially harvest and threshing techniques that have considerable impact on wheat grain losses. At medium and large holdings, wheat is harvested and threshed using the combine harvester which is considered as an efficient, economical, and lower labours required machine. It minimizes wheat grain losses to be 1.20%-2.92% of the total yield. The yielded straw is collected using a up baler, then, the bales are transported using a drawn trailer for straw chopping, resulting in 5.20% straw losses of the total straw yield (Taherzadeeh and Hojjat, 2013 Abo-El-Naga, 2009 Mirasi et al., 2013). While, at small holdings, wheat harvest is carried out manually using a sickle that breaks down plant stems, resulting in fallen ear heads, loss of panicles and grain shattering on the soil surface. Then, wheat stems remained on soil surface until reaching the proper plant moisture content for threshing, leading to grain losses due to birds, rodents and weather conditions. Consequently, wheat plants are manually bundled together and transported using drawn wooden

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carts or drawn trailer outside the field to open threshing yards, losing a portion of grains. Then, wheat plants are threshed using a manual feeding stationary thresher which increases the grain losses due to the irregular feeding So, wheat grain losses during conventional harvest, bundling, transporting, threshing, winnowing and cleaning are 3.67%, 3.98%, 0.24%, 1.18%, 2.46% and 4.53%, respectively. In addition, the traditional harvest and threshing techniques achieve 15% straw losses of the total straw yield (Agha et al., 2004 Pawar et al., 2008; Akhyani et al., 2009).

So, it is essential to minimize the harvest grain losses to be 2.09% -2.27% using rear tractor mounted reciprocating mower, self-propelled mower and reaper. Also, using the binder minimizes the bundling losses to be 0.86% (Imara et al., 2003; Pawar et al., 2008; Abo El-Naga, 2009 Muhammad et al.,2015). In addition, attaching a feeding device with the stationary thresher lowered total grain losses by 34.85%, consequently, threshing efficiency and cleaning efficiency increased by 0.62% and 3.00%, respectively (Ali et al., 2007; Mahmoud et al., 2007).

Study aimed to modify a stationary thresher to maximize wheat crop yield as follows:

(1). Tractor mounting the thresher to be mobile among the field during the threshing operation to the transport grain losses.

(2). Attaching a feeding device with the thresher to keep the uniformity of the fed and lower the threshing losses.

(3). Attaching a straw container with the thresher which collects the chopped straw to minimize the straw losses.

2 Material and methods

To fulfill the study objective, a field experiment of 70 × 60 m area was carried out at a private farm in Owlad Sakr District, Sharkia governorate Egypt during 2015 summer season.

Wheat Misr 1 variety of 1.06 m height, 400 plants/m^2, 9% wheat straw moisture content (w.b.) and 15% plant moisture content (w.b.) was harvested using a self propelled reciprocating mower of 1.20 m working width, cutting height 0.10-0.30 m and engine cycle, air-cooled and 2.55 kW power.

2.1 Stationary thresher

The used stationary thresher is specified in Table 1 and lined in Figure 1. It is manually feeding. It is operated using a 2 WD tractor of 48.5 kW power. It requires seven labors for crop feeding, threshing and grain handling.

Table 1 Stationary thresher specifications

Machine overall dimensions: 3.05 × 2.25 × 2.10 m. Feeding gate area: 0.46 m^2. Threshing unit dimensions: 1.45×2.20 ×1.75 m. Threshing drum: Type: spike tooth. Diameter: 0.675 m. Length: 1.180 m. Speed: 450-850 . Knives: 44 knives of 0.29 m nesslength and 0.008 m thickness. Knife rows: rows.	Concave: Type: perforated sheet metal of 3 mm thickness with 15 mm diameter circular holes. Concave perforation: 15 mm diameter circular holes for wheat, barley and soybean. Sieves: Number of holes/cm^2: 125. Hole diameter: 6 mm. Fan: Type: centrifugal Number of blades: 5. Straw gate out area: 0.18 m^2.

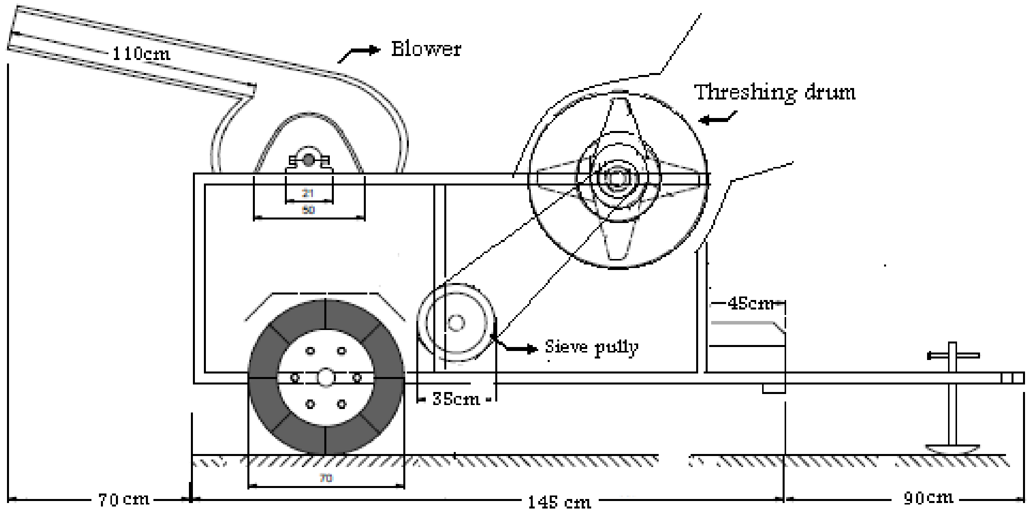


Figure 1 Schematic diagram of the stationary thresher

2.1.1 Thresher modification:

As indicated in Figure 2, Figure 3 and Figure 4, the used stationary thresher was modified as follows:

(1). Hitching system: A point hitching system was manufactured from steel bar of 0.05 and 0.01 m width and thickness, respectively. It was fastened with the thresher to be rear tractor mounted.

(2). Feeding device: A feeding device is attached with the thresher. As shown in Figure 3 the feeding device consists of the following parts:

a. Frame: An oblique shaped frame was manufactured from the galvanized steel of 1.50, 0.90 and 0.50 m in length, width and height, respectively. At the frame commencing point, the tilt angle was 0° with the vertical level, then, the frame was tilted vertically with a rate of 60 °/m.

b. Feeding hopper: It was manufactured from steel sheet of 0.50, 1.00 and 0.60 m in length, width and height, respectively. At the hopper middle, a feeding shaft having two feathers was fastened to deliver the fed material to the hopper middle where nine fingers were secured at the external shaft periphery.

c. Conveyor belt: A flat rubber belt of 3.00, 0.90 and 0.005 m in length, width and thickness, respectively was fixed with a moving chain which was driven using three gears. Eight sheet steel angle bars of 0.075 and 0.090 m in height and width, respectively were fixed with the belt to control the uniformity of the fed material.

d. Transmission system: As indicated in Figure 4 the motion was transmitted from tractor PTO to the main drive shaft, which transmitted the motion to pulley 1), pulley 2) and pulley 4) by v belt so, the motion was arrived to threshing shaft by pulley 3). Gear 5) distributed the motion to [sieve shaft, section fan straw by gear box 8) and gear 9). Gear (9) transmitted the motion to the feeding shaft through gears 6) and 7) by chains.

(3). Straw container: A parallelogram shaped container was manufactured from the galvanized steel of 1.61, 2.20 and 2.30 m in length, width and height, respectively. It was fastened around the straw gate out. The container capacity is 750 kg straw.

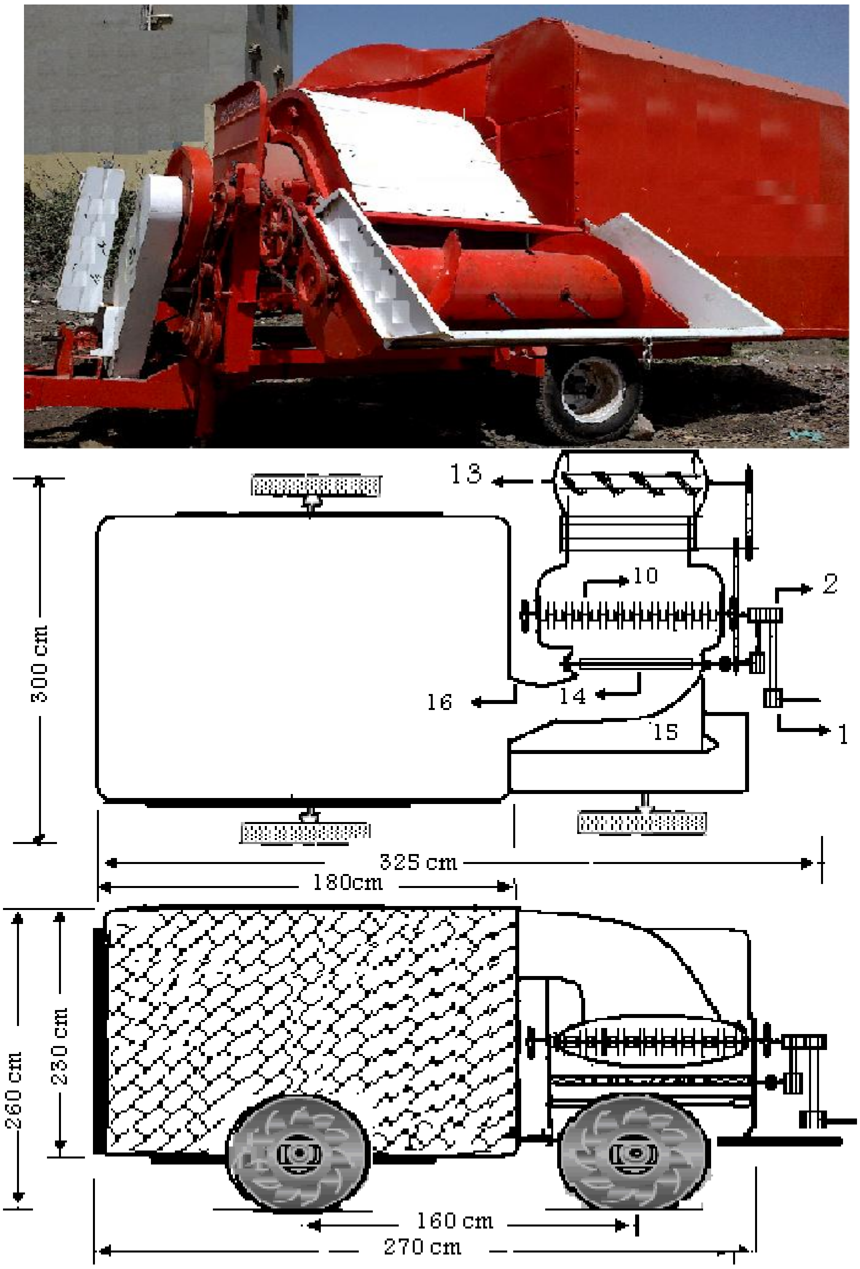


Figure 2 Schematic diagram and photo of the modified thresher

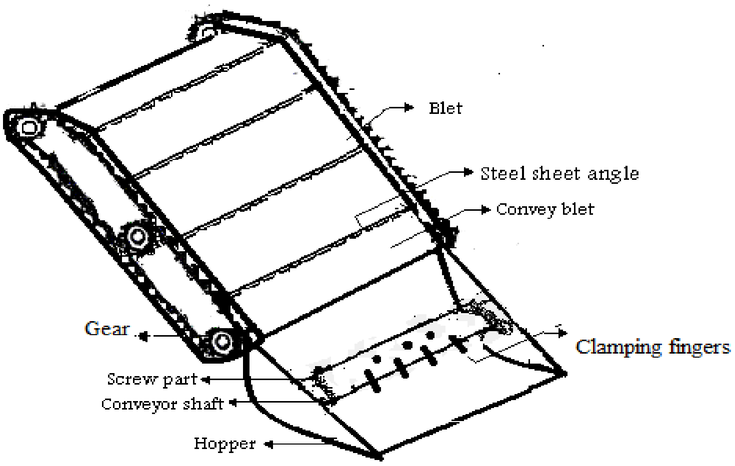
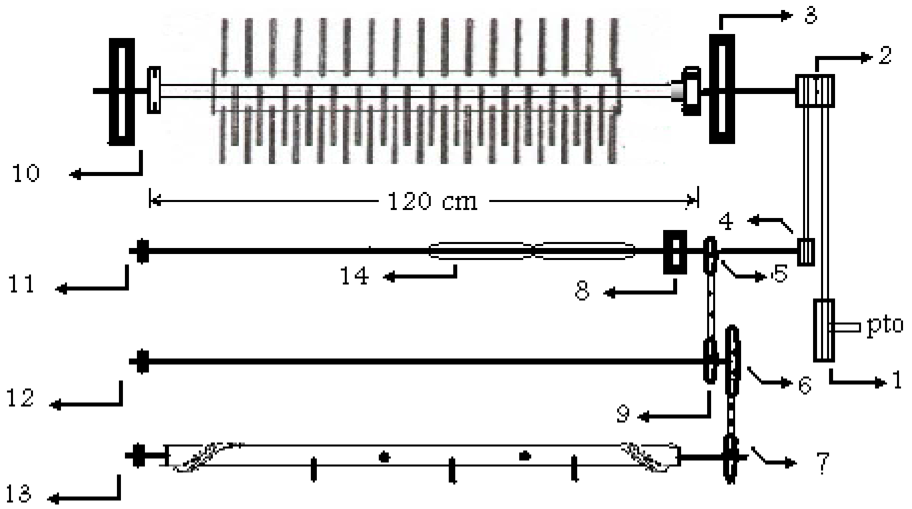


Figure 3 Schematic diagram of the feeding device



No	Part name	No	Part name	No	Part name	No	Part name
1	Pulley φ, 0.60 m	5	Gear φ, 0.10 m	9	Gear φ, 0.15 m	13	Screw shaft.
2	Pulley φ, 0.35 m	6	Gear φ, 0.35 m.	10	Threshing shaft.	14	Suction fan straw.
3	Flywheel φ, 0.90 m	7	Gear φ, 0.15 m.	11	Sieve shaft.		
4	Pulley φ, 10 m.	8	Gear	12	Feeding shaft		

Figure 4 Schematic diagram of the transmission system

2.2 Treatments and statistical design

During the experiment the following treatments were tested:

(1). Wheat plant feeding rate levels of 500, 700,900 and 1100 kg/h.

(2). Wheat plant moisture content levels of 16%, 18% and 20% (w. b.).

The experiment was established and designed statistically as a factorial experiment in complete randomized blocks with three replications.

2.3 Measurements

As recommended at operator manual, the thresher before and after modification was operated at threshing drum speed of 17.35 m/s and slope of sieves 3 °horizontal. The mobile thresher is evaluated at tractor forward speed levels of 0.30, 0.37, 0.51 and 0.61 km/h which are achieved by selecting appropriate gears, adjusting tractor engine throttle at the maximum position at adjusting the engine speed around 80%.

Wheat crop yield losses

According to Shamabadi (2012) the following items are determined:

$$Total\ \text{grain losses} = \frac{W_d + W_u}{W_t} \times 100,\ \% \quad \ldots\ldots\ldots\ldots \quad (1)$$

$$Threshing\ efficiency = \frac{W_t - W_u}{W_t} \times 100,\% \ \ldots\ldots(2)$$

$$Cleaning\ efficiency = \frac{Wc}{W_t} \times 100,\ \%\ldots\ldots\ldots(3)$$

$$Straw\ \text{losses} = \frac{W_{st} - W_{sy}}{W_{st}} \times 100,\%\ldots\ldots\ldots\ldots\ (4)$$

Where

W_d is mass of damaged grains, ton/h

W_u is mass of un-threshed grains, ton/h

W_t is mass of total input grains, ton/h

W_c is mass of clean grains, ton/h

W_{st} is mass of total input straw, ton/h

W_{sy} is mass of yielded straw, ton/h.

Thresher performance

The following items are determined as cited by Srivastava et al. (2006):

Actual field capacity (*AFC*):

$$AFC = \frac{1}{ATT},\ \text{kg/h} \ \ldots\ldots\ldots\ldots \quad (5)$$

Where:

ATT is actual total time required for threshing one ton of wheat t plants, hrs.

Thresher productivity:

$$Thresher\ \text{productivity} = \frac{W_c}{ATT},\ \text{kg grains/h} \ \ldots\ (6)$$

$$Thresher\ \text{productivity} = \frac{\text{Ws}}{ATT}$$, kg straw/h …. (7)

Field efficiency

$$\eta_f = \frac{\text{AFC}}{\text{TFC}} \text{x} 100$$ ………….(8)

Where:

TFC is theoretical field capacity, fed/h.

Specific energy requirements:

1). Specific threshing energy requirements:

The thresher torque is measured using torque transducer and data acquisition system. The expended power is determined as follows:

Expended threshing power = 0.001 × torque (N*m) × angular velocity (rad\s), kW ……..……(9)

Then, the net threshing power (*Pth*) is estimated as follows:

Pth = 3.61 (PL – PuL), MJ …………(10)

Where:

PL is machine power with load, kW;

PuL is machine power without load, kW;

3.61 is coefficient of changing from kW.h to MJ;

2). Specific traction energy requirements:

The thresher is mounted using a tractor of 48.5 kW power. The auxiliary tractor of 82.8 kW power pulled the whole combination. The draught force (*D*) is measured as the horizontal component of the force between the driving tractor and the tractor-thresher combination using a spring dynamometer. The average dynamometer readings (*D*) are determined when the auxiliary tractor and the tractor-thresher combination are moving in sequence on the soil surface. The traction force (TF) required for the thresher is estimated as the between the dynamometer reading and the rolling resistance (*RR*) of the 48.5 kW tractor which is estimated by pulling the tractor alone on the soil surface. Then, the power required for operating the thresher alone is calculated as follows:

Po= TF × *S*, kW …………...(11)

Where:

Po is power requirements, kW;

TF is traction force, kN;

S is actual tractor forward speed, m/s.

Tractor-thresher required power = 3.61 (dynamometer readings × S), MJ ………………(12)

3). Specific laborer energy requirements:

Laborer energy requirements=3.6× 0.075 x AFC^h × *Nl*, MJ ………………………… (13)

Where:

0.075 is power of an agricultural laborer, kW/fed.

Nl is number of laborers.

AFC^h is manual field capacity, ton/h.

$$Input\ energy\ requirements = \frac{total\ \text{energy requirements}}{AFC_h}$$, MJ/ton ……………………………………(14)

$$Ouput\ energy\ requirements = \frac{total\ \text{energy requirements}}{thresher\ \text{productivity}}$$, MJ/ton (15)

Threshing costs:

As cited by Begum et al.(2012), threshing costs, L.E./h are calculated by employing the conventional method of estimating both fixed and variable costs.

$$\text{Threshing criterion costs} = \frac{operational\ \text{costs (LE/h)}}{thresher\ \text{productivity}} + \text{lossed grains price}$$, LE/ton ……………………...(16)

Statistical

SPSS (Version 20.0) computer software package is used to employ the analysis of variance test and the L.S.D. tests for thresher productivity data.

3 Results and discussion

Wheat crop losses

Table 2 realized that there is no crop transporting losses using the mobile thresher due to accomplishing the threshing operation inside the field. While, using the stationary thresher achieved 0.35% straw losses.

Figure 5 shows the direct proportional of unthreshed grains to the wheat plants feeding rate. As the feeding rate increased from 500 to 1100 kg/h under plant moisture content levels of 16%, 18% and 20%, the unthreshed grains increased with 29.33%, 37.18% and

42.22%, respectively using the stationary thresher. Meanwhile, in case of using the modified thresher the corresponding values of unthreshed grains were 25.72%, 32.00% and 35.73% with the same respect. This results may be explained that at higher feeding rate, the threshed material resides lower time in the threshing chamber, lowering the knife strikes per unit time against the threshed material. Also, the positive relation between plant moisture content and unthreshed grains is due to the positive effect of plant moisture content on grain elasticity which allows the easily motion of threshed material at lower moisture content in threshing chamber without completing the threshing operation.

As demonstrated in Figure 5, there is a reversible relation between feeding rate and damaged grains. As feeding rate raised from 500 to 1100 kg/h under plant moisture content levels of 16%, 18% and 20%, the damaged grains decreased with 18.34%, 15.66%, and 13.49% using the stationary thresher and with 16.35%, 12.17%, and 10.28% using the modified thresher, respectively. This finding may be explained that the higher feeding rate lifts the thickness of the threshed material layer, resulting in decreasing the impact action between knives against grains. In addition, at lower moisture content levels, the grain has lower strength against impact force, leading to higher values of damaged grains.

Data showed that the modified thresher achieved lower values of un-threshed and damaged grains. It is due to the uniform distribution of wheat plants along the modified feeding device, which enable plants to enter the threshing chamber from the panicles direction. Thus, the uniform impact is expected, resulting in lower values of unthreshed and damaged grains.

Figure 5 showed that feeding rate of 900 kg/h and plant moisture content of 16% recorded the lower total grain losses values of 7.78% and 4.26%, respectively using the thresher before and after modification. The modified thresher decreased the percentage of total grain losses by 45.24%, comparing with the stationary thresher.

Data presented in 2 reveal that the mobile thresher did not lose wheat straw due to collecting straw in the container. Meanwhile, the stationary thresher 14.55% of the yielded straw.

Table 2 Crop transporting and straw losses

Losses	TRANSPORTING, %	Straw, %
Stationary thresher	0.35	14.55
Mobile thresher	-	-

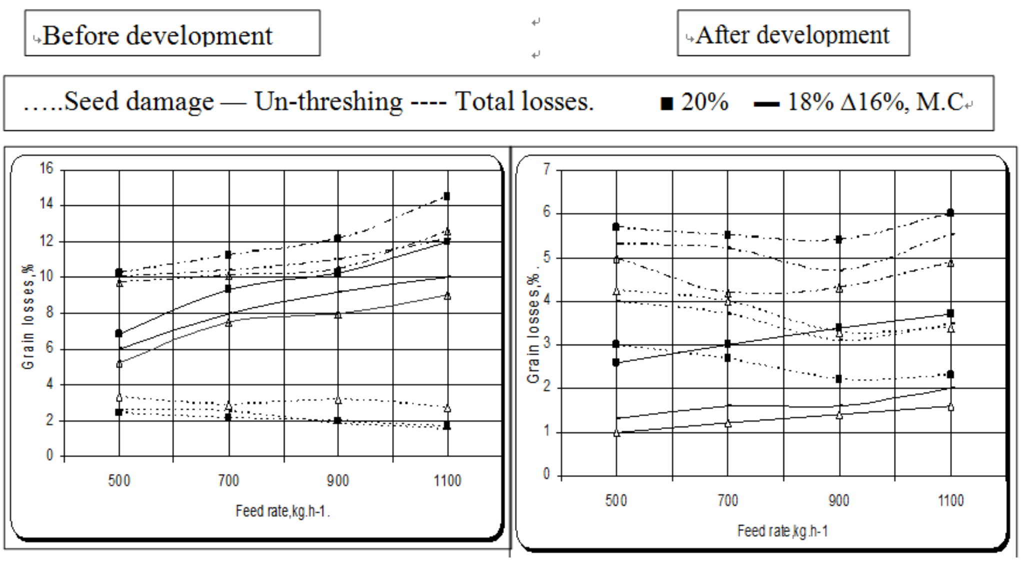


Figure 5 Effect of crop feeding rate on threshing losses under different plant moisture content levels.

Threshing efficiency

Figure 6 reveals that as feeding rate increased from 500 to 1100 kg/h under plant moisture content levels of 16%, 18% and 20%, the threshing efficiency decreased with 2.16%, 3.00% and 4.30% and with 2.85%, 3.58% and 4.97 % using the stationary thresher and the modified thresher, respectively.

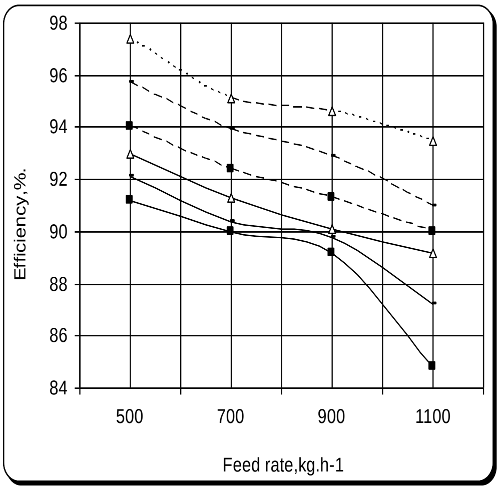


Figure 6 Effect of crop feeding rate on threshing efficiency under different plant moisture content levels

Cleaning efficiency

As shown in Figure 7, as feeding rate increased from 500 to 1100 kg/h under plant moisture content levels of 16%, 18% and 20%, the cleaning efficiency decreased with 4.11%, 4.85% and 6.54% and with 4.45%, 5.18% and 7.11% using the stationary thresher and the modified thresher respectively. This finding is attributed to the higher amount of inert material which mixed with the threshed grains using the stationary thresher.

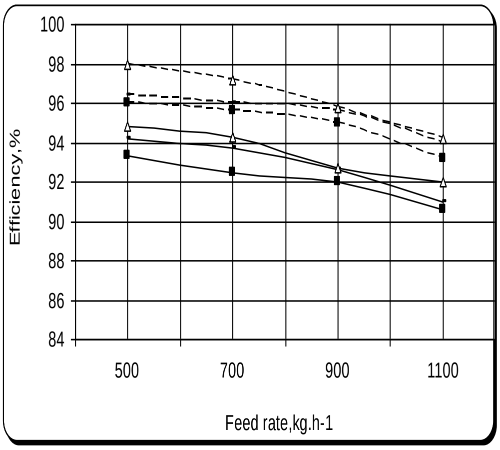


Figure 7 Effect of crop feeding rate on cleaning efficiency under different plant moisture content levels

Thresher performance

Thresher field capacity, productivity and field efficiency:

Table 3 shows that the thresher field capacity and productivity are positively proportional with the plant feeding rate. They are negatively proportional with the plant moisture content. The higher stationary thresher field capacity value of 0.103 ton/h and the higher productivity values of 0.470 ton grains/h and 0.560 ton straw/h were achieved using 1100 kg/h plant feeding rate and 16% plant moisture content. While, the mobile thresher achieved the higher field capacity value of 0.1051 ton /h and the higher productivity values of 0.487ton grains/h and 0.575 ton straw/h at same operational conditions.

These findings may be explained that as the plant feeding rate increased, more amount of the plant is threshed per unit time, resulting in higher values of thresher field capacity and productivity. While, at lower plant moisture content levels, the threshed material elasticity decreases, consequently, the friction resistance between the threshed material and threshing chamber decreases, causing easy motion in threshing chamber, resulting in higher values of thresher field capacity and productivity.

Table 3 clarifies the reversible relation between the plant feeding rate and the thresher field efficiency. It is attributed to the higher time loss during the frequent stoppage due to the clogging of the stationary thresher. While, at the higher levels of plant feeding rate, the mobile thresher expends more loss time for emptying the straw container.

The analysis of variance indicates that there is a highly significant difference in the thresher productivity due to the plant feeding rate, the plant moisture contents and the interaction between these treatments. The L.S.D. test shows that 1100 kg/h plant feeding rate and 16% plant moisture content achieved the highest thresher productivity among the other treatments.

Table 3 Effect of plant feeding rate and plant moisture content on thresher field capacity, productivity and field efficiency

Plant feeding rate, kg/h	Plant moisture content, %	Stationary thresher				Mobile thresher			
		Field capacity, ton /h	Productivity, ton /h		Field efficiency, %	Field capacity, ton/h	Productivity, ton /h		Field efficiency, %
			Grains	Straw			Grains	Straw	
500	16	0.495	0.212	0.280	98.81	0.498	0.214	0.282	99.55
	18	0.489	0.209	0.277	97.01	0.494	0.207	0.279	98.46
	20	0.484	0.207	0.273	96.91	0.489	209.14	0.275	97.76
700	16	0.666	0.290	0.371	95.23	0.677	0.294	0.376	96.56
	18	0.658	0.287	0.368	94.37	0.671	0.293	0.375	95.46
	20	0.650	0.284	0.364	93.46	0.665	0.291	0.371	94.36
900	16	0.845	0.365	0.445	93.44	0.846	0.366	0.446	94.59
	18	0.834	0.360	0.439	92.14	0.837	0.363	0.443	93.01
	20	0.823	0.354	0.434	91.54	0.826	0.361	0.440	91.57
1100	16	0.103	0.470	0.560	91.25	0.105	0.487	0.575	90.00
	18	0.102	0.466	0.555	90.00	0.103	0.475	0.578	92.62
	20	0.101	0.461	0.550.	89.34	0.102	0.471	0.563	99.63

Specific energy requirements:

Data presented in Table 4 showed that the lower input and output specific energy requirements values of 48.25 and 95.00 MJ/ton for threshing and cleaning wheat plants using the stationary thresher. While, the corresponding values of input and specific energy using the mobile thresher were 37.00 and 76.45 MJ/ton with the same respect. The specific energy requirements are directly proportional with plant feeding rate and plant moisture content. feeding rate from 500 to 1100 kg/h under grain moisture content levels of 16%, 18% and 20% raised the energy requirements with 7.72%, 9.15% and 10.95%, respectively using the stationary thresher. Whilst, the corresponding values of the energy requirements were 8.94%, 10.12% and 11.82% with the same respect using the modified thresher. This finding may be illustrated that the higher feeding rate accompanied with excessive wheat plants in the threshing chamber which raised the friction between the plant bulk and thresher components, resulting in the increased load on the threshing drum consuming more energy. In addition, the grains of higher moisture content required higher energy to be completely threshed due to the higher grain elasticity degree. Despite the modified thresher required lower labors number, it consumed more threshing energy compare with the stationary thresher. This observation is due to the attachment of feeding device with the modified thresher which required more energy for operating the feeding device and moving the thresher among the field.

From Table4, there is an obvious drop in specific energy requirements with the thresher forward speed. As the thresher forward speed increased from 0.30 to 0.61 km/h, the specific energy requirements decreased from 4.05 to be 1.02 MJ/fed. This trend is attributed to the reversible relation between the machine forward speed and the rolling resistance which is required to move the tractor and the thresher. So, at the lower forward speed, there is an increase in the required force to deflect tractor wheels to push the disturbed soil and to overcome wheel and axle bearing friction, resulting in higher draft, consuming more fuel.

Table 4 Effect of plant feeding rate and plant moisture content on thresher specific energy requirements

Plant feeding rate, kg/h	Plant moisture content, %	Stationary thresher		Mobile thresher							
		Input specific energy, MJ/ton	Output specific energy, MJ/ton	Input specific energy, MJ/ton				Output specific energy, MJ/ton			
			Output specific energy, MJ/ton	0.30 km/h	0.37 km/h	0.51 km/h	0.61 km/h	0.30 km/h	0.37 km/h	0.51 km/h	0.61 km/h
	16	39.65	76.10	41.85	40.15	38.85	37.00	80.45	78.90	77.89	76.45
500	18	40.46	78.95	43.00	42.55	41.80	40.05	81.11	89.25	78.85	77.00
	20	41.83	80.50	44.80	43.60	42.20	38.95	82.86	80.90	79.00	77.95
	16	40.89	81.00	42.60	41.54	40.00	38.90	85.80	83.80	82.86	81.05
700	18	41.90	82.01	43.88	41.55	40.00	38.95	86.25	84.85	83.55	82.45
	20	42,50	83.80	45.28	43.60	42.70	41.75	87.00	86.00	84.90	82.80
	16	43.78	87.91	45.00	44.15	40.20	38.85	89.80	87.95	86.15	85.15
84.00	18	44.00	88.95	46.85	45.10	43.70	41.55	90.55	89.50	88.20	87.50
	20	45.80	90.01	47.20	46.10	44.80	4265	90.00	89.55	88.24	87.00
	16	46.85	93.54	48.55	46.55	44.80	43.80	95.35	93.90	92.56	91.00
1100	18	47.55	94.00	49.24	47.55	45.00	43.85	96.462	9.500	94.25	93.60
	20	48.25	95.00	50.50	48.05	46.80	46.55	98.04	97.55	96.55	95;00

Threshing costs:

Figure 8 shows that the increased plant feeding rate from 500 to 1100 kg/h decreased threshing costs of stationary thresher and modified thresher with 10.87% and 11.58%, respectively. While, the decrement of plant moisture content with 2% the threshing costs with 6.65% and 12.58% using the stationary thresher and the modified thresher, respectively. In addition, operating the stationary thresher and the modified thresher at plant feeding rate of 900 kg/h and plant moisture content of 16% recorded the lower threshing costs of 126.5 and 208.00 L.E./ton, respectively.

Generally, the modified thresher decreased the threshing costs with 38.24%, with the stationary thresher. It is due to the increased threshing efficiency, the lower total grain losses and the lower labors number.

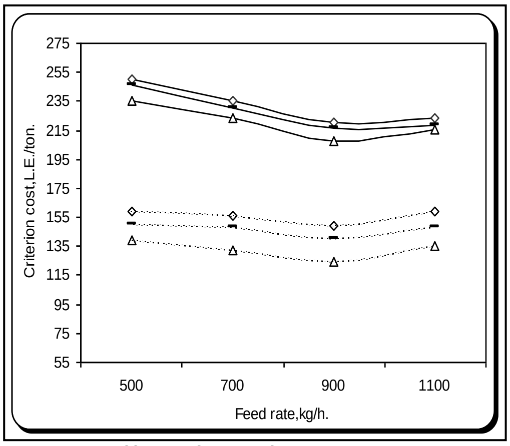


Figure 8 Effect of crop feeding rate on threshing costs under different grain moisture content levels

4 Conclusions

Results obtained from this study led to the following conclusions:

(1). Crop feeding rate of 900 kg/h and plant moisture content of 16% recorded the lower total grain losses.

(2). The modified thresher decreased the total grain losses with 45.24%, with the stationary thresher.

(3). The modified thresher increased the threshing and cleaning efficiency with 1.35 and 8.16%, respectively with the stationary thresher.

(4). The crop feeding rate of 900 kg/h and plant moisture content of 16% recorded the lower threshing costs of 208.00 and 124.5 L.E./ton using the stationary thresher and the modified thresher, respectively.

Finally, it is recommended to apply wheat threshing using the mobile thresher.

References

Abo El-Naga, M. H., H. A. El-Gendy, and G. G. Radwan. 2009. Determine of wheat harvest systems requirements. *J. Agric. Sci. Mansoura Univ.*, 34(5): 5823-5835.

Agha, S. K., F. C. Oad, and M. H. S. 2004. Grain losses of wheat as affected by threshing timings. *International Journal of Agriculture & Biology*, 6(6): 1170-1171.

Akhyani, A., A. Mohammadi, A. Barjasteh, and Z. Shamabadi. 2009. Technical instruction of the wheat and barely in Semnan province. Jihade Agric. Organization press of the Semnan province. Management of the extension and operation system. Extension Pub., No. 17.

Ali, M. M., M. M. El-Sharabasy, and M. A. Khattab. 2007. Development of feeding device in a turkish threshing machine. *Misr J. Agric. Eng.*, 24(2): 235-258.

Begum, E. A., M. I. Hossain, and E. Papanagiotou. 2012. Economic analysis of post-harvest losses in food grains for strengthening food security in northern regions of Bangladesh. *IJAR-BAE*, 1(3): 56-65.

El-Hadded, W. Z. 2010. Developing and maximizing the performance of local threshing machine for small holding to suit chopping and shredding crops residues. *Misr J. Agric. Eng.*, 27(4): 1588-1607

Imara, Z. M., Kh. A. Khadr, W. M. Mechail, and A. O. Arif. 2003. Effect of different planting and harvesting methods on wheat production. *Misr J. Agric. Eng.*, 20 (1): 115-128.

Mahmoud, M. A., M. A. El-Sharabasy, and Kh. A. Khattab. 2007. Development of feeding device in a Turkish threshing machine. *Misr J. Agric. Eng*., 24(2): 235-258.

Ministry of Agriculture and Land Reclamation. 2012. "Agricultural Statistics" Economic Issues sector, Cairo, Egypt: 78-115.

Mirasi, A., M. A. Asoodar, and A. Abdeshahi. 2013. The effects of combine type and wheat variety on losses harvesting in Chaharmahal and Bakhtiari Province (Iran). *International Journal of Agriculture and Crop Sciences* , 5(1): 63-68.

Muhammad, S., D. Mueen, A. Mushtaq, A. Liaqat, Q. Masood, A. Muhammad, and K. Laila. 2015. Grain losses of wheat as affected by different harvesting and threshing techniques. *International Journal of Research in Agricultural and Forestry*, 2(6): 20-26.

Omran, M. S. 2008. A comparative study of the most widely harvesting systems for wheat crop in Egypt. *Misr J. Agric. Eng*., 25(3): 804-823.

Pawar, C. S., N. A. Shirsat, and S. V. Pathak. 2008. Performance evaluation of combine harvester and combination of self propelled vertical conveyor reaper with thresher for wheat harvesting. *Ag. Update*, 3(1&2):123-126.

Shamabadi, Z. 2012. Measurement the wheat losses in harvesting stage. *International Journal of Agriculture and Crop Sciences*, 4(23): 1797-1802.

Srivastava, A. K., C. E. Goering, and R. P. Rohrbach. 2006. Engineering principles of agricultural machines. 2nd Ed. ASABE Pub. USA.

Taherzadeeh, A., and S. S. Hojjat. 2013. Study of post-harvest losses of wheat in North Eastern Iran. *International Research Journal of Applied and Basic Science*, 4 (6): 1502-1505.