Zagazig J. Agric. Res., Vol. 37 No. (3) 2010

RESPONSE OF SOME RICE VARIETIES TO MECHANICAL HARVESTING BY COMBINE HARVESTERS

Amira M. N. Ibrahim*, M. K Abdel-Wahab, M. A. I. Arnaout and M. M. A. El-Sharabasy

Agric. Eng. Dept., Fac. Agric., Zagazig Univ., Egypt.

ABSTRACT

Field experiments were carried out during the agricultural seasons of 2007 and 2008 at Kafr El-Hamam farm, Sharkia governorate to investigate the response of two rice varieties (Sakha-101 and Giza-178) to mechanical harvesting using two combine harvesters (Yanmar and Claas) at four average forward speeds of 0.5, 1.2 , 1.9 and 3.1 km/h and four average grain moisture contents of 15, 18, 21 and 25%. The results obtained reveal that, the minimum total grain losses were 2.70 and 3.9%; 2.76 and 3.0% at average grain moisture content of 15% and forward speed of about 1.2 km/h, using Yanmar and Claas combines to harvest rice crop (Sakha-101 and Giza-178) varieties respectively. The maximum field capacity values were 0.97and 2.72 fed/h ; 0.94 and 2.60 fed/h at average grain moisture content of 15% and forward speed of about 3.1 km/h, using Yanmar and Claas combines to harvest rice crop (Sakha-101 and Giza-178) varieties, respectively. The maximum cutting efficiencies (%) and the minimum specific energy consumed values (kW.h/fed) were (92.7 and 93.7 % ; 91.6 and 90.5 %) and (14.62 and 8.45 kW.h/fed ; 21.26 and 9.38 kW.h/fed) at average grain moisture content of 15% and forward speed of about 0.5 km/h, using Yanmar and Claas combines to harvest rice crop (Sakha-101 and Giza-178) varieties, respectively. The minimum criterion cost values for harvesting both rice crop varieties (Sakha-101 and Giza-178) were 263.00 and 331.60 L.E/fed ; 236.6 and 251.8 L.E/fed at average grain moisture content of 15% and forward speed of about 0.5 km/h, using Yanmar and Claas combines to harvest rice crop (Sakha-101 and Giza-178) varieties, respectively.

Keywords: Harvesting, field capacity, field efficiency, power required, specific energy consumed, harvesting cost.

***Corresponding author:** Amira M. N. Ibrahim, Tel.: +20120074741
E-mail address: amira_nabih2010@yahoo.com

INTRODUCTION

Rice is one of the most important crops in the world which affected on the national and international income and feeding people. The cultivated area is 1.5 million feddans yearly producing 6.2 million ton. The average yield was 4.09 ton/fed. In Sharkia governorate the cultivated area is 0.288 million feddans yearly producing 1.135 million ton. (according to ministry of Agriculture 2003). Resulted to increasing rice varieties in this time such as Giza-178 and Sakha-101 and their different characteristics. However, the variable characteristics are considered critical factors affecting the performance of mechanical harvesting by combine harvesters since rice crop is sensitive to the high percentage of grain losses which affecting on the total grain yield. So, several investigations are required to evaluate the response of rice varieties to mechanical harvesting. Harvesting agricultural crops is one of the labor consuming operations. The labor shortage during harvesting period is a big problem in Egypt. Mechanized harvesting, particularly in the labor deficit area is very important in minimizing avoidable losses well for timely harvesting of rice crop. Fouad et al. (1990) compared the performance of two types of combines for harvesting rice crop in Egypt. The two combines were operated at three forward speeds of 0.9, 2.3 and 2.8 km/h for rice combine and 0.8, 2.1 and 2.9 km/h for the conventional combine. There was a highly significant decrease in total harvesting costs with an increase in operation speed from 0.9 and 0.8 km/h to 2.3 and 2.2 km/h for the rice and conventional combines, respectively. Hassan et al. (1994) mentioned that increasing forward speed from 1.6 to 2.6 km/h at cutter-bar speed of 1.2 m/s and constant grain moisture content of 22.3% increased total losses from 0.8 to 1.25%, using Yanmar combine for rice crop. EL-Shazly and Morad (1994) mentioned that to optimize the energy required to reap and thresh wheat crop. The following condition could be taken:-

- The lowest amount of energy (1138.49MJ/fed) and least value of relative energy consumption (0.632 MJ/kg) were recorded in the case of using combine (yanmar) and heighest ones (3606.2MJ/fed and 1.935) with (Ferrari) method.
- The energy consumption can be optimized when the forward speed

of 2.5 km/h and length to width ratio (L/W) of 2.0 are considered.

- The use of power sources of small tractor (18.4 kW), electrical engine of (7.46 Kw) and diesel engine of (48.5kW) to operate threshing machine saved the energy consumption with percentages of 51.11, 70.31 and 73.5 respectively.

-The traditional reaping and threshing method, using electrical or diesel engine is more economical to use in comparison with other methods not only for the lowest consumed energy but also for less grain losses.

Helmey *et al*., (1995) found that the actual field capacity decreased by increasing straw moisture content. However, there is a direct proportion with straw moisture content and clogging time. They added that, forward speed of rice combine from 0.85 to 2.27 km/h tends to decrease harvesting cost from 82.46 to 59.93 L.E./ton for rice variety Giza-171 and from 57.69 to 37.61 L.E./ton, for rice variety Giza-175. El-Sharabasy (1997) mentioned that, by increasing combine forward speed the field capacity is greatly increased, and inversely decreased field efficiency. Increased forward speed from 1.5 to 2.7 km/hr at average grain moisture content of 22.45% and constant L/W ratio of 2/1 the field capacity rabidly increased from 0.36 to 0.60 fed/hr consequently, the field efficiency decreased from 74.41 to 68.62% at the same previous factors. Kamel (1999) used two different types of Japanese combines for rice harvesting to harvest three rice varieties of Giza-178, Sakha-101 and Sakha-102 at three cutting heights of 7.12 and 18 cm under three harvesting speeds of 0.3, 0.5 and 0.8 km/h. He added that all kinds of losses for the two combines under investigation increased with the increase of harvesting speed and cutting height for the three selected rice varieties. The lowest values of total losses obtained at harvesting speed of about 0.3 km/h with cutting height of about 7 cm recording 3.25, 2.4 and 2.4% for rice varieties Giza-178, Sakha-101 and Sakha-102, respectively for combine harvester CA-385 (hold in) system compared with 3.9, 3.15 and 3.0% for combine harvester CA-760 (through in) system under the same previous conditions. The highest value of total grain losses for both combine types did not exceed 5.80 % compared with 25 %. when utilizing traditional harvesting system. Ghonimey and Rostom

(2002) mentioned that the average values of the cutting height for the different combines CA-32, CA-385 EG, RI-40 and PRO-48 were 25.0, 15.4 and 12.8 cm, respectively. It's clear that the maximum value of cutting efficiency was 87.15 % for the PRO-48 combine and the minimum value of cutting efficiency was 74.90 % for CA-32 combine. Results also showed that the cutting efficiency of the PRO-48 combine increased by 12.25 compared with CA-32 combine this increase represents a difference of cutting height about 12-20 cm of straw. El-Khateeb (2005) recommended that using multi-purpose combine harvester (Yanmar model CA-760 with cutting width of about 2m) to harvest rice crop variety sakha-102 was the most efficient and economic system (89.7 L.E/fed) compared with manual harvesting followed by thresher (181.6L.E./fed). It is very important to operate the combine harvester at the optimum conditions to obtain minimum grain losses and maximum grain yield according to the rice variety. Therefore, this study aimed to evaluate two combine harvesters for harvesting and threshing two rice crop varieties and their response to mechanical harvesting.

MATERIALS AND METHODS

The main experiments were carried out through two successful agricultural seasons of 2007/08 and 2008/09 at Kafr El-Hamam farm, Sharkia governorate to evaluate the performance of two combine harvesters during the harvesting operation and the response of two rice varieties to mechanical harvesting.

Materials

Rice crop

Two rice varieties (Sakha-101 and Giza-178) were taken under all test runs. Table1 show some physical properties of rice crops.

Methods

The main experiments were carried out in total harvesting area of about 33 feddans divided into two equal main plots of 16.5 feddans planted with rice crop (Sakha-101 and Giza-178) varieties. Each main plot was divided into two equal sub main plots of 8.25 feddans for each for harvesting rice crop with two different combines (Yanmar and Claas). Each sub main plot was divided into four equal small plots having dimensions of (55 × 50 m^2) for operating combine harvester under four different grain moisture

Zagazig J. Agric. Res., Vol. 37 No. (3) 2010

Table 1. The physical properties of two rice varieties.

Physical properties	Sakha-101	Giza-178
Plant height, cm	87.4	85
No. of grains per panicle	110	100
No. of panicles/m^2	440	490
No. of panicles/hill	17.3	19.6
Weight of grains/ 10 panicle, g	23.5	18.2
Yield, Mg/fed	4.1	3.2

Combine harvesters

A Japanese combine (Yanmar) and German combine (Claas) were operated to harvest rice crops. The specifications of combine harvesters are as following:

Table 2. The specifications of combine harvesters.

Specifications	Yanmar combine	Claas combine
Model	CA-385 EG Japan	GS 130 – 2CN
Type	4 or 5 row combine	AR 120
Output power (kW/rpm)	28/2800	136/2500
Overall length (mm)	4063	6000
Overall width (mm)	1450	4500
Overall height (mm)	2160	4000
Weight (kg)	1927	7200

contents of 15, 18, 21 and 25 % in average and four different combine forward speeds of 0.5, 1.2, 1.9 and 3.1 km/h. Each treatment was replicated three times to calculate the means. The other processes such as irrigation, fertilization and weed control were the same in the whole treatments according to the Egyptian experience and technical recommendations. Grain moisture content was determined on dry basis with the oven method at 105^{o}C for 24 hours in laboratory of faculty of agriculture, Zagazig University.

According to ASAE (2003).

Field Capacity and Field Efficiency

Theoretical field capacity was determined by the following equation:

F. C_{th} = **Error!** …..………3.1

Where:

C_{th} = Theoretical field capacity, (fed/h).

W = Theoretical width, m.

V = Harvesting speed, km/h.

Actual field capacity was the actual average rate of field average by the amount of actual time (lost + productive time) consumed in the operation. It can be determined from the following equation.

F. $C_{act.}$ = **Error!** …………3.2

Where:

C_{act} = The actual capacity of the machine, (fed./h)

Tu = The utilization time per feddan in minutes.

Ti = The summation of lost time per feddan in minutes.

Field efficiency is calculated by using the following equation:

$$E_f = \frac{F.C._{act.}}{F.C._{th.}} \times 100 \quad \% \text{ ....3.3}$$

Where:

E_F = The field efficiency of the machine (%).

Cutting Efficiency

Cutting efficiency is calculated using the following equation:

Cutting efficiency (E_{act}) =

$$\frac{H_a}{H_a + H_b} \times 100 \text{ ……….3.4}$$

Where:-

E_{act} = Cutting efficiency, (%).

H_a= Height of the removal crop, (cm).

H_b = Height of the remaining straw, (cm).

Total Grain Losses

The percentage of total grain losses was calculated by using the following equation:

Total grain losses = (Pre-harvesting + Operating) losses, (%)… (3.5)

Pre-harvesting grain losses

Zagazig J. Agric. Res., Vol. 37 No. (3) 2010

Pre-harvested losses was determined by locating a frame of a square meter in the un-harvested area and the grain losses in the frame were counted and weighted. The percentage of pre-harvested losses was calculated by using the following equation:

Pre-harvested losses, (%) =

$$\frac{\text{Pre} - \text{harvested losses/fed}}{\text{Total yield/fed}} \times 100 \quad ...3.6$$

Operating grain losses

Header losses

Header losses were obtained by locating a frame of a square meter on the ground in front of the combine. During the harvesting operation, the combine was stopped at a point where the cutter-bar had passed over the frame, but the drive wheels had not. The combine was backed to access the sample. The grain losses in the frame represent pre-harvest and header losses (cutting losses) together, then, for indicating the header losses only, the pre-harvest losses must be subtracted. The percentage of header losses was calculated using the following equation.

Header losses (%) = **Error!** × 100……3.7

Threshing and cleaning losses

Threshing and cleaning losses were obtained by locating a frame of square meter on the ground after the combine machine had passed over the crop. The grain losses in the frame represent (pre-harvest, header, threshing and cleaning) losses. Then, for indicating the threshing and cleaning losses only the pre-harvest and header losses must be subtracted. The percentage of threshing and cleaning losses

were calculated by using the following equation:

Threshing & cleaning. Losses =

$$\frac{\text{Threshing \& cleaning losses/fed}}{\text{Total yield/fed}} \times 100 ...3.8$$

Un-cutting losses:

Un-cutting losses were obtained by cutting un-harvesting crop using hand sickle for each plot area. The total sample was collected and threshed manually, then the cleaning grains were weighted. The percentage of un-cutting losses were calculated by using the following equation: Un-cutting losses (%) =

$$\frac{\text{Un} - \text{cutting looses/fed}}{\text{Total yield/fed}} \quad ....3.10$$

Specific Energy Consumed

To estimate the engine power during harvesting process, the decrease in fuel level accurately measuring immediately after each treatment. The following formula was used to estimate the engine power. Hunt (1983).

$$EP = \begin{bmatrix} f.c\left(1/3600\right)PE\times \\ L.C.V\times 427\times\eta_{thb}\times \\ \eta_m \times 1/75\times 1/1.36 \end{bmatrix}, \; kW ...3.11$$

Solving equation (2), the consumed energy can be calculated as following:

$$Engine\,power\,(Diesel) = 3.16\ f.c.\ \ , kW\ \ ...3.12$$

Where:-

f.c = The fuel consumption, (*l*/h).

PE = The density of fuel, (kg/*l*), (for Gasoline = 0.85).

L.C.V = The lower calorific value of fuel, (11.000 k.cal/kg).

η_{thb} = Thermal efficiency of the engine (35 % for Diesel engines).

427 = Thermo-mechanical equivalent, (kg.m/k.cal).

η_m = Mechanical efficiency of the engine (80 % for Diesel engines).

Hence, the specific energy consumed can be calculated as follows

$$Spesific\,energy\,concumed\ = \frac{Engine\,power,(kW)}{Field\ capacity,(\ fed\ /\ h)},\ kW.h/\ fed......3.13$$

Harvesting Cost

The total cost of harvesting operation was estimated using the following equation.

$$Operating\,cost = \frac{Machine\ cost\ (L.E\ /\ h)}{Actual\ \ field\ capacity(\ fed\ /\ h)},\ (L.E\ /\ \ fed)........3.14$$

Machine cost was determined by using the following equation (Awady *et al*., 1978):

$$C = \frac{P}{h}\left(\frac{1}{a}+\frac{i}{2}+t+r\right)+\left(0.9W.S.F\right)+\frac{m}{144}..................3.15$$

Where:-

C = Hourly cost, L.E/h.	*P* = Price of machine, L.E.
h = Yearly working hours, h/year.	*a* = Life expectancy of the machine, h.
i = Interest rate/year.	*F* = Fuel price, L.E/*l*.
t = Taxes, over heads ratio.	*R* = Repairs and maintenance ratio.
m = Monthly average wage, L.E	*0.9* = Factor accounting for lubrications.
W = Engine power, hp.	*S* = Specific fuel consumption, *l*/hp.h.
144 = Reasonable estimation of monthly working hours.	

Zagazig J. Agric. Res., Vol. 37 No. (3) 2010

RESULTS AND DISCUSSION

In this study, the discussions will cover the effect of harvesting system, machines forward speeds and grain moisture contents on total grain losses, field capacity and efficiency, energy consumed and total cost requirements for harvesting and threshing rice crop.

Effect of Crop Variety and Combine Forward Speed on Field Capacity

Fig. 1 Show the effect of rice variety on field capacity. The field capacity during harvesting rice crop (Sakha-101) with Yanmar combine harvester were 0.97, 0.92, 0.86 and 0.79 fed/h under different grain moisture contents of about 15, 18, 21 and 25% and constant forward speed of 3.1 km/h. While the field capacity was 0.94, 0.92, 0.78 and 0.75 fed/h, at the same previous condition, during harvesting rice crop (Giza 178). These results show that there is no high difference in field capacities between the rice varieties using Yanmar combine because the physical properties for these varieties are much the same. While, increasing forward speed from 0.5 to 3.1 km/h increased the field capacity from 0.14 to 0.97, 0.13 to 0.92, 0.11 to 0.86 and 0.10 to 0.79 fed/h; 0.42 to 1.72, 0.38 to 2.60, 0.34 to 2.30 and 0.32 to 2.14 fed/h under different grain moisture contents of 15, 18, 21 and 25%, during harvesting rice crop (Sakha-101) using Yanmar and Claas combine harvesters, respectively. The increase of field capacity with the increase of combine forward speed was affected by harvesting time consumed and the field capacity is a function of the machine effective width and forward speed.

Effect of Combine Harvester Type and Grain Moisture Content on Field Efficiency

Concerning the effect of combine harvester type on combine field efficiency, results obtained in fig. 1 show that during harvesting rice crop (Giza-101), field efficiency decreased from 81.10 to 74.59, 77.10 to 74.20, 67.40 to 63.20, and from 62.20 to 57.10 %, at different combine forward speeds of 0.5, 1.2, 1.9 and 3.1 km/h and constant grain moisture content of about 15% using Yanmar and Claas combine harvesters, respectively.

While relating to the effect of grain moisture content on combine field efficiency, results obtained in fig. 1 show also that during harvesting rice crop (Sakha-101), increasing grain moisture content from 15 to 25% decreased filed efficiency rabidly from 85.20 to 78.50, 79.60 to 74.50, 73.20 to 71.50 and 69.10 to 63.70% under different forward speeds of 0.5, 1.2, 1.9 and 3.1 km/h, using Yanmar combine harvesters. The decrease in field efficiency of Claas combine compared with the Yanmar one and also with the increase in grain moisture content may attributed to the more lost time during harvesting operation consequential from overcrowding rice crop in threshing chamber due to unsuitable threshing conditions resulting from high percentage of moist crop.

Effect of Combine Harvester Type and Its Forward Speed on Cutting Efficiency

As to the effect of combine harvester type on cutting efficiency, results in fig. 2 show that during harvesting rice crop (Sakha-101) Claas combine harvester recorded the higher cutting efficiencies of 93.7, 90.2, 87.9 and 84.3% compared with the Yanmar one which recorded the lower cutting efficiencies of 92.7, 89.1, 85.6 and 82.4% at different forward speeds of 0.5, 1.2, 1.9 and 3.1 km/h and constant grain moisture content of about 15%, respectively. This result may attribute to the more stability of Claas combine during cutting operation due to its heavy weight compared with the Yanmar combine. Concerning the effect of combine forward speed on cutting efficiency, results obtained in fig. 2 show that increasing combine forward speed from 0.5 to 3.1 km/h decreased cutting efficiency from 92.7 to 82.4, 91.8 to 81.3, 91.1 to 80.4 and 90.5 to 78.1% and from 93.7 to 84.3, 93.4 to 82.5, 92.8 to 79.9 and 91.4 to 76.9%, at different grain moisture contents of about 15, 18, 21 and 25%, using Yanmar and Claas combines to harvest rice crop (Sakha-101) variety, respectively. Decreasing cutting efficiency with the increase in combine forward speed was due to decrease kinematic parameter (relation between cutter bar velocity and machine forward speed) causing uneven conditions for cutting operation resulting less cutting efficiency.

Effect of Crop Variety and Grain Moisture Content on Cutting Efficiency

Fig. 2 show the effect of rice variety on cutting efficiency. The cutting efficiencies during harvesting rice crop (Sakha-101) with Yanmar combine harvester

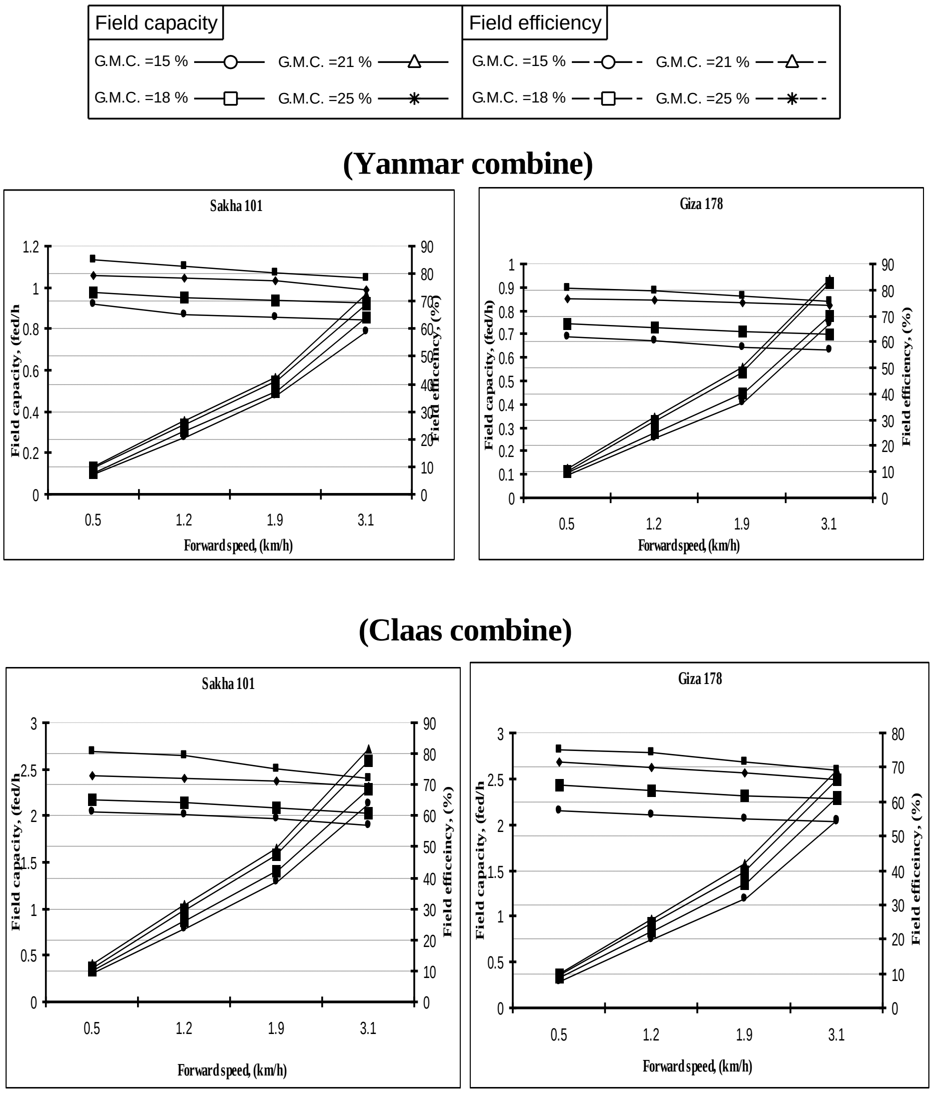
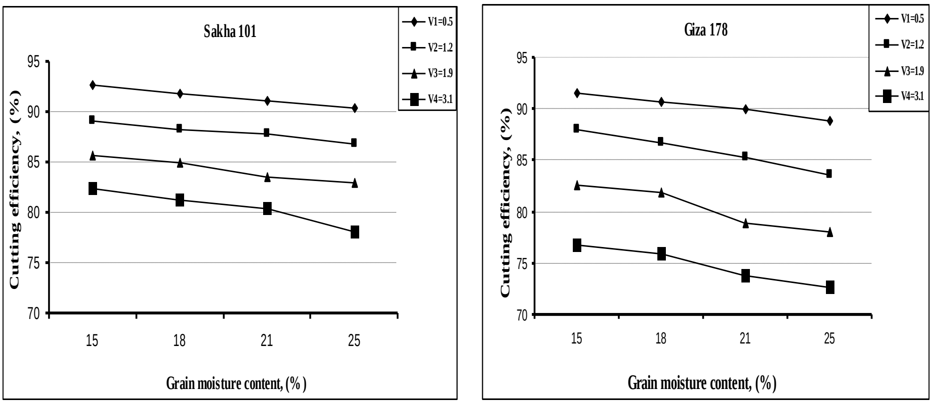


Fig. 1. Effect of combine forward speed on field capacity and efficiency at different grain moisture contents during harvesting two rice varieties.

(Yanmar)



(Claas)

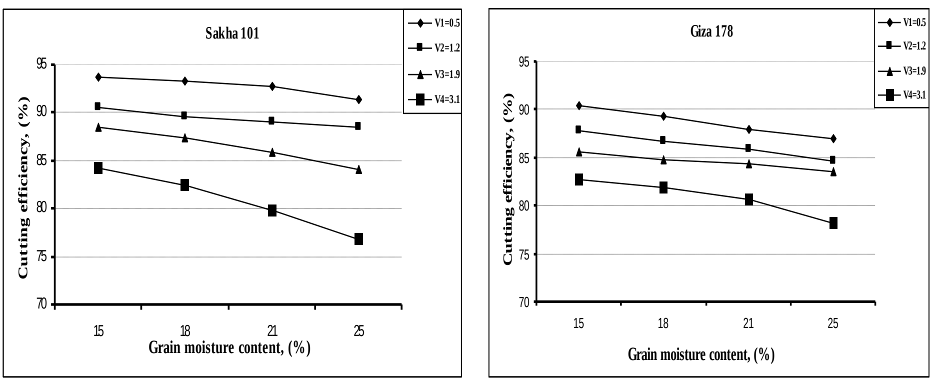


Fig. 2. Effect of grain moisture content on cutting efficiency at different combine forward speeds during harvesting two rice varieties.

Zagazig J. Agric. Res., Vol. 37 No. (3) 2010

Were 92.7, 91.8, 91.1 and 90.5%, under different grain moisture contents of about 15, 18, 21and 25% and constant forward speed of 0.5 km/h. While the cutting efficiencies were 91.6, 90.7, 90.0 and 88.9%, at the same previous conditions, during harvesting rice crop (Giza-178). Decreasing cutting efficiency during harvesting rice crop (Giza-178) compared with (Sakha-101) may attribute to more branches in the plant which affected on cutter bar stability during cutting operation.

Relating to the effect of grain moisture content on cutting efficiency, results in fig. 2 show that increasing grain moisture content from 15 to 25% decreased cutting efficiencies slightly from 92.7 to 90.1, 89.1 to 86.8, 85.6 to 80.3 and 82.4 to 78.1%, under different forward speeds of 0.5, 1.2, 1.9 and 3.1 km/h, using Yanmar combine harvesters in rice crop (Sakha-101) field. Decreasing cutting efficiency with increasing grain moisture content may attribute to more uneven conditions during cutting operation such as lodging plants.

Effect of Combine Harvester Type and Its Forward Speed on Specific Energy Consumed

As to the effect of combine harvester type on specific energy consumed, results in fig. 3 show that during harvesting rice crop (Sakha-101) Yanmar combine harvester recorded the higher specific energy consumed of 71.36, 30.97, 22.42 and 14.62 kW.h/fed, compared with the Claas one which recorded the lower specific energy consumed of 31.52, 14.83, 12.04 and 8.45 kW.h/fed, at different combine forward speeds of 0.5, 1.2, 1.9 and 3.1 km/h and constant grain moisture content of about 15%, respectively. Because of the specific energy consumed is a function on power requirements and actual combine field capacity. So, this result attribute to the less field capacity of Yanmar combine due to its small cutting width of about 1.45 m compared with Claas one which has cutting width of about 4.50 m. Concerning the effect of combine forward speed on specific energy consumed, results obtained in fig. (3) show that increasing combine forward speed from 0.5 to 3.1 km/h decreased specific energy consumed rabidly from 71.36 to 14.62, 78.62 to 15.65, 95.09 to 17.29 and 106.90 to 19.11 kW.h/fed and from 31.52 to 8.45, 42.18 to 10.37, 55.35 to 13.33 and 70.44 to 16.40 kW.h/fed, at different grain moisture contents of about 15, 18, 21 and 25%, using Yanmar and Claas combines to harvest rice crop (Sakha-101) variety, respectively. This result was due to increasing the actual combine field capacity with the increase in combine forward speed led to less specific consumed energy according to the specific energy consumed equation (3.13).

Effect of Crop Variety and Grain Moisture Content on Specific Energy Consumed

Fig. 4 show the effect of rice variety on specific energy consumed. The specific energy consumed during harvesting rice crop (Sakha-101) using Yammer combine harvester were 71.36, 78.62, 95.09 and 106.90 kW.h/fed, under different grain moisture contents of about 15, 18, 21 and 25% and constant forward speed of 0.50 km/h. While during harvesting rice crop (Giza-178) the specific energy consumed were higher than (Sakha-101) which were 91.15, 102.76, 120.36 and 139.40 kW.h/fed, at the same previous condition. Also the same trend was observed using Claas combine harvester in both (Sakha-101) and (Giza-178) rice varieties. This result was due to more branches in the same plant required more cutting force during cutting operation which consumed more energy.

Effect of Combine Harvester Type and Its Forward Speed on Total Grain Losses

The type of combine harvester is highly affected on the total grain losses under the same rice crop variety and moisture content. Fig. 4 show that during harvesting rice crop (Sakha-101), the total grain losses increased from 4.5, 4.0, 4.2 and 5.5% to 7.0, 6.4, 6.7 and 9.5%, at different combine forward speeds of 0.5, 1.2, 1.9 and 3.1 km/h and constant grain moisture content of about 25%, using Yanmar and Class combine harvesters, respectively. While during harvesting rice crop (Giza-178), the total grain losses increased from 4.1, 3.8, 4.1 and 5.8% to 7.1, 6.2, 6.8 and 9.2%, at the same previous conditions. Results obtained show that Class combine harvester recorded higher grain losses compared with Yanmar combine under the same previous conditions during all test runs. This result was attributed to the different technique in harvesting operation. While the Yanmar combine cutting the plants and threshing the kernels only, the Class combine cutting and threshing the whole plants, causing more materials in threshing chamber resulting more grain losses with out threshing come out with chaff materials. Relating to the effect of combine forward speed on total grain losses, results in fig. 4 show that the minimum grain losses were recorded at the lower forward speed for both Yanmar

Zagazig J. Agric. Res., Vol. 37 No. (3) 2010

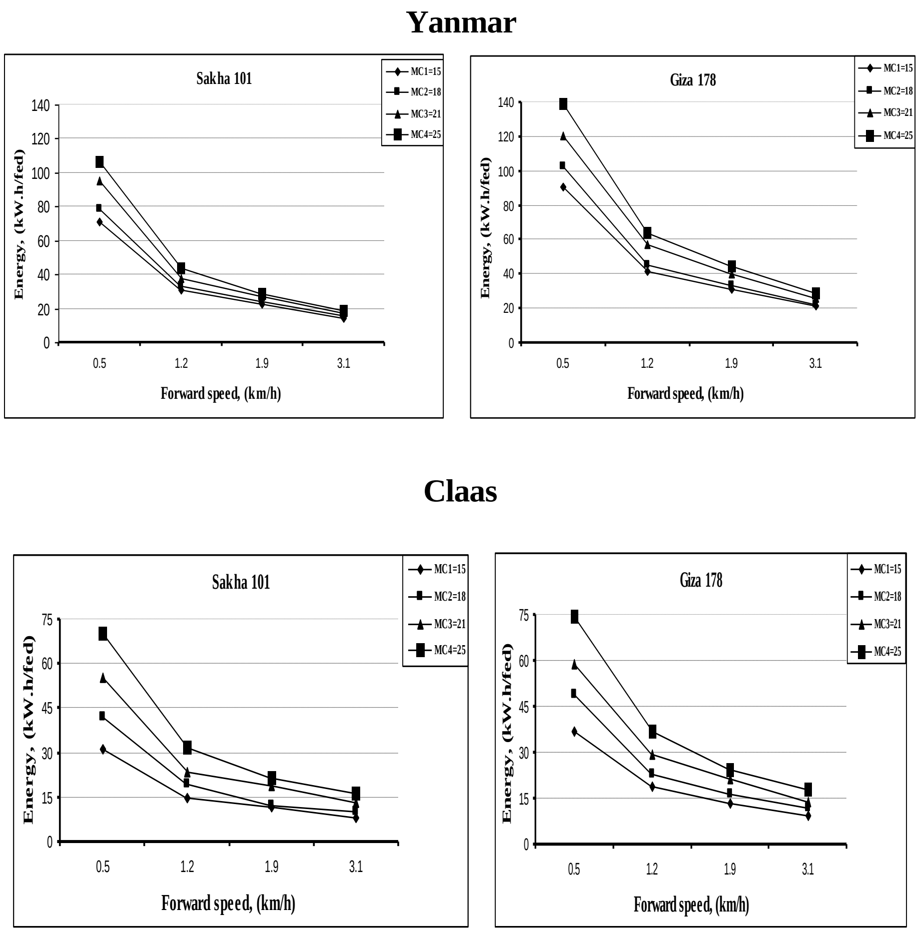


Fig. 3. Effect of combine forward speed on specific energy consumed at different grain moisture contents during harvesting two rice varieties.

and Class combine harvesters. Increasing combine forward speed from 0.5 to 3.1 km/h increased the total grain losses rabidly form 2.9 to 4.2, 3.4 to 4.8, 4.0 to 5.2 and 4.5 to 5.5% and form 4.7 to 6.3, 5.4 to 7.5, 6.1 to 8.9 and 7.0 to 9.5 %, at different grain moisture contents of about 15, 18, 21 and 25 %, using Yanmar and Class combines to harvest rice crop (Sakha-101) variety, respectively.

While, during harvesting rice crop (Giza-178) variety, increasing combine forward speed from 0.5 to 3.1 km/h, the total grain losses increased rabidly from 3.3 to 4.4, 3.5 to 4.8, 3.9 to 5.0 and 4.1 to 5.8% and form 3.6 to 5.5, 5.6 to 8.1, 6.5 to 8.6 and 7.1 to 9.2%, at different grain moisture contents of about 15, 18, 21 and 25%, using Yanmar and Class combine harvesters, respectively. The increase of total grain losses with the increase of combine forward speed was attributed to the higher impact of cutter bar with rice plants causing more shattering losses, and also the unsuitable conditions of threshing process resulting from excessive materials passed into threshing chamber

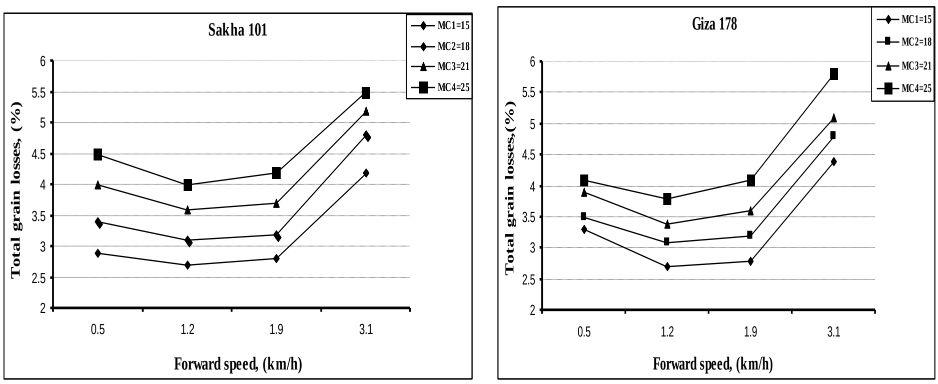
Effect of Crop Variety and Grain Moisture Content on Total Grain Losses

Fig. 4 show the effect of rice variety on total grain losses. The total grain losses during harvesting rice crop (Sakha-101) with Yanmar combine harvester were 4.2, 4.8, 5.2 and 5.5%, under different grain moisture contents of about 15, 18, 21and 25% and constant forward speed of 3.1 km/h. While the total grain losses were 4.4, 4.8, 5.0 and 5.8%, at the same previous conditions, during harvesting rice crop (Giza-178). The results reveal that the rice variety (Giza-178) recorded more grain losses due to the height of plants causing more lodging plants resulting more shattering losses during cutting operation, and also more un-threshing plants due to clogging in the threshing chamber.

As to the effect of grain moisture content on total grain losses data in fig. 4 show that the minimum grain losses were recorded at the lower grain moisture content for both Yanmar and Class combine harvesters. During harvesting rice crop (Sakha-101), increasing grain moisture contents from about 15 to 25% increased the total grain losses rabidly from 2.9 to 4.5, 2.7 to 4.0, 2.8 to 4.2 and 4.2 to 5.5% and from 4.7 to 7.0, 3.9 to 6.4, 4.1 to 6.7 and 6.3 to 9.5%, under different forward speeds of 0.5, 1.2, 1.9 and 3.1 km/h using Yanmar and Class combine

Zagazig J. Agric. Res., Vol. 37 No. (3) 2010

Yammer



Claas

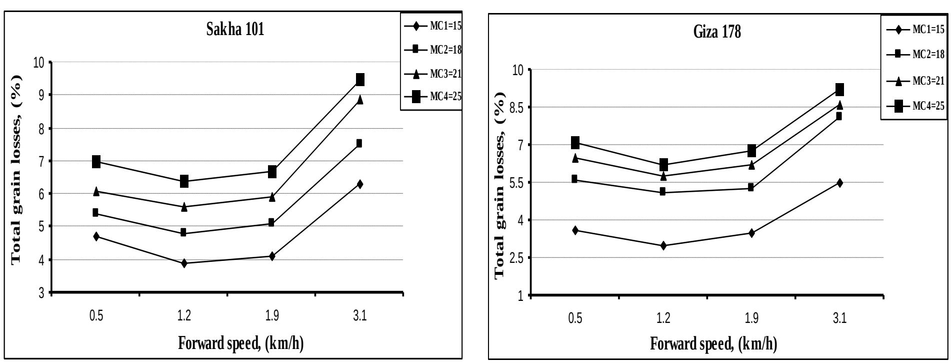


Fig. 4. Effect of combine forward speed on total grain losses at different grain moisture contents during harvesting two rice varieties.

harvesters, respectively. While during harvesting rice crop (Giza-178), increasing grain moisture content from 15 to 25% increased the total grain losses rabidly from 3.3 to 4.1, 2.7 to 3.8, 2.8 to 4.1 and 4.4 to 5.8% and from 3.6 to 7.1, 3.0 to 6.2, 3.5 to 6.8 and 5.5 to 9.2%, at the same previous conditions.

Effect of Combine Harvester Type and Crop Variety on Operating Cost

The type of combine harvester is highly affected on the operating cost under the same rice crop variety and moisture content. Fig. 5 show that during harvesting rice crop (Sakha-101), the operating cost decreased from 630.2, 245.1, 154.8 and 91.0 L.E/fed to 450.7, 180.3, 114.0 and 69.6 L.E/fed, at different combine forward speeds of 0.5, 1.2, 1.9 and 3.1 km/h and constant grain moisture content of about 15%, using Yammer and Class combine harvesters, respectively. While during harvesting rice crop (Giza-178), operating cost decreased from 678.7, 252.1, 157.6 and 93.9 L.E/fed to 485.4, 193.2, 119.8 and 72.8 L.E/fed, at the same previous conditions. The previous results show that Yammer combine harvester recorded higher operating cost compared with Class combine under the same conditions during all test runs. This result was attributed to the lower actual field capacity of Yanmar combine due to its small cutting width causing high operating cost according to equation (3.14).

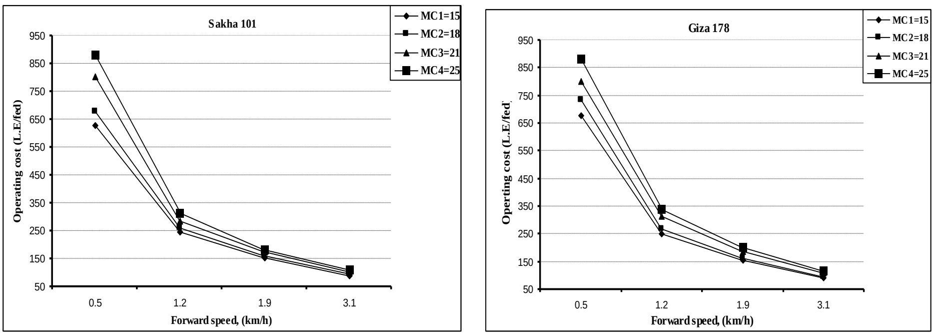
Relating to the effect of crop variety on the operating cost results in fig. 5 show that the operating cost during harvesting rice crop (Sakha-101) with Yanmar combine harvester were 154.8, 160.4, 176.5and 183.8 L.E/fed, under different grain moisture contents of about 15, 18, 21and 25% and constant forward speed of 1.9 km/h. While the operating cost were 157.6, 163.4, 187.7 and 200.5 L.E/fed at the same previous conditions, during harvesting rice crop (Giza-178). Increasing operating cost during harvesting rice crop (Giza-178) compared with (Sakha-101) may attribute to decrease combine field capacity resulting from uneven cutting and threshing conditions.

Effect of Combine Forward Speed and Grain Moisture Content on Criterion Cost

Relating to the effect of combine forward speed on criterion cost, results in fig. 6 show that the minimum criterion cost were recorded at the higher forward speed of 3.1 km/h for Yanmar

Zagazig J. Agric. Res., Vol. 37 No. (3) 2010

Yanmar



Claas

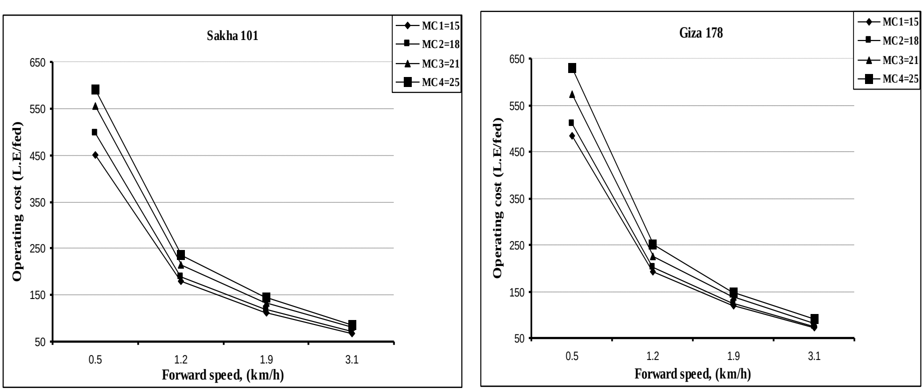


Fig. 5. Effect of combine forward speed on operating cost at different grain moisture contents during harvesting two rice varieties.

combine and 1.9 km/h for Class combine harvester. Increasing combine forward speed from 0.5 to 3.1 km/h decreased the criterion cost rabidly form 752.2 to 263.0, 819.7 to 292.9, 968.1 to 319.6 and 1069.3 to 340.7 L.E/fed and form 781.8 to 236.6, 844.4 to 249.9, 927.3 to 271.9 and 1015.5 to 304.2 L.E/fed, at different grain moisture contents of about 15, 18, 21 and 25 %, using Yanmar combine to harvest rice crop (Sakha-101) and (Giza-178) varieties, respectively.

While, Increasing combine forward speed from 0.5 to 1.9 km/h decreased the criterion cost rabidly form 646.7 to 282.1, 720.2 to 331.8, 810.8 to 376.3 and 879.6 to 420.6 L.E/fed and form 602.4 to 232.8, 691.6 to 298.2, 784.7 to 339.2 and 861.0 to 369.5 L.E/fed at different grain moisture contents of about 15, 18, 21 and 25 %, using Claas combine to harvest rice crop (Sakha-101) and (Giza-178) varieties, respectively. Any further increase in combine forward speed leads to increase criterion cost due to increase grain losses.

As to the effect of grain moisture content on criterion cost, results in fig.(6) show that decreasing grain moisture content led to decrease criterion cost using both Yanmar and Claas combine harvesters in both (Sakha-101) and (Giza-178) rice crop varieties. This result was due to the suitable conditions for cutting and threshing rice crop at 15% grain moisture content.

CONCLUSION

Two combine harvesters (Yanmar and Claas) were operated to harvest two rice varieties (Sakha-101 and Giza-178) at four different forward speeds of 0.5, 1.2, 1.9 and 3.1 km/h and four different grain moisture contents of 15, 18, 21 and 25 % to determine the suitable combine harvester and its forward speed and also suitable grain moisture content during harvesting and threshing operation in rice fields. Data from this study led to the following conclusions:-

The maximum field capacity was 0.97and 2.72 fed/h ; 0.94 and 2.60 fed/h at average grain moisture content of 15% and forward speed of about 3.1 km/h, using Yanmar and Claas combines to harvest rice crop (Sakha-101 and Giza-178) varieties, respectively. The maximum cutting efficiency (%) and the minimum specific energy consumed (kW.h/fed) were (92.7 and 93.7 % ; 91.6 and 90.5 %) and (14.62 and 8.45 kW.h/fed ; 21.26 and 9.38 kW.h/fed) at average grain moisture content of 15% and forward speed of about 0.5 km/h, using Yanmar and Claas combines to harvest rice crop (Sakha-101 and

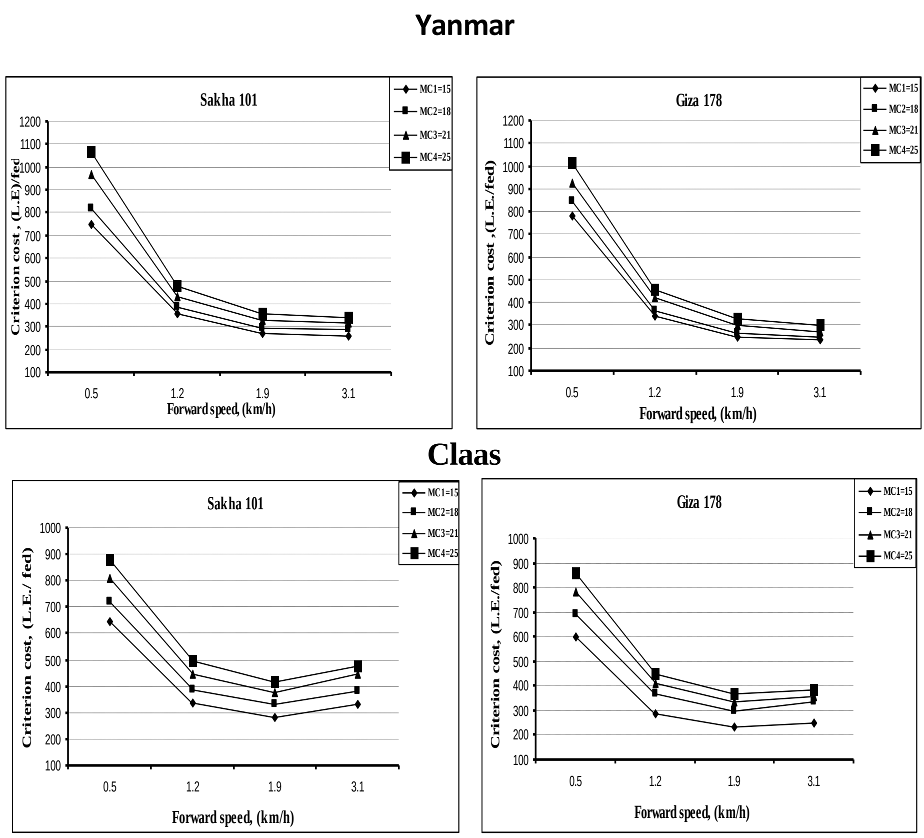


Fig. 6. Effect of combine forward speed on criterion cost at different grain moisture contents during harvesting two rice varieties.

Giza-178) varieties, respectively.

The minimum criterion cost values for harvesting both rice crop varieties (Sakha-101 and Giza-178) were 263.00 and 331.60 L.E/fed ; 236.6 and 251.8 L.E/fed at average grain moisture content of 15% and forward speed of about 0.5 km/h, using Yanmar and Claas combines to harvest rice crop (Sakha-101 and Giza-178) varieties, respectively.

REFERENCES

ASAE Standards. 2003. ASAE S358. Determination of Forage Moisture Content. ASAE Standards 2003, St. Joseph, MI: ASAE.

Awady, M. N. 1978. Tractor and farm machinery. Text book, Faculty of Agriculture, Ain-Shams University, 164-167.

El-Khateeb, H. A. 2005. A study on performance of axial flow combine harvester in rice crop harvesting. The 13th Annual conference of the Misr society of Agr. Eng., 14-15: 381-401.

El-Sharabasy, M. M. A. 1997. Selecting the proper system for mechanizing grain crops harvesting in the small holdings. M. Sc. Thesis, Agric. Eng. Dept., Faculty of Agric., Zagazig University, Egypt.

EL-Shazly M.A. and M.M. Morad. 1994. Optimizing the energy consumed in harvesting and threshing wheat crop. Misr society of Agr. Eng., 11(4): 1128-1138.

Fouad, H. A; S. A. Tayel, Z. El-Hadad and H. Abd el-Mawla. 1990. Performance of two different types of combines in harvesting rice crop in Egypt. AMA. 21 (3): 17-22.

Ghonimey, M. I. and M. N. Rostom 2002. Tech-Economical approach to combine harvesters evaluation. Misr J. Agr. Eng., 19 (1): 83-98. Hassan, M. A; M. M. Morad, M. A. El-Shazly and A. Farag .1994. Study on some operating parameters affecting the performance of combine devices with reference to grain losses. Misr J. Agr. Eng., 11 (3): 764-780.

Helmy, M. A; S. M. Gomaa, F. I. Hindy and R. R. Abu Shieshaa. 1995. Comparative study on two different rice combine harvester machines. Misr J. Agr. Eng., 12 (2): 479-495.

Hunt, D. 1983. Farm power and machinery management. 8th Ed. Iowa state Univ., Press Ames, USA. Ames, Iowa, USA: 364-368.

Zagazig J. Agric. Res., Vol. 37 No. (3) 2010

Kamel, O. 1999. Rice harvesting losses utilizing two different harvesting techniques of Japanese combine. Misr J. Agr. Eng., 16 (4): 237-251.

استجابة بعض أصناف الأرز للحصاد الآلي بآلة الحصاد الجامعة

أميرة محمد نبيه إبراهيم- محمد قدري عبد الوهاب - مراد على أرناؤوط
محب محمد أنيس الشرباصي
قسم الهندسة الزراعية – كلية الزراعة – جامعة الزقازيق – مصر.

تمت التجربة الحقليه خلال الموسم الزراعى ٢٠٠٧و٢٠٠٨ بمحطة البحوث بكفر الحمام محافظة الشرقية لتقدير استجابة صنفين من الأرز سخا ١٠١ و حيزة ١٧٨ للحصاد الآلى باستخدام نوعين من الكومابين يانمار وكلاس وتم تسجيل النتائج تحت عوامل تشغيل مختلفة هى أربع سرعات أمامية لكلا آلتى الحصاد الجامعة ٠,٥, ١,٢ , ١,٩ و ٣,١ كم / الساعة وأربع نسب لرطوبة الحبوب ١٥,١٨,٢١و٢٥% فى صنفى الأرز تحت الدراسة. كانت أقل قيمة للفواقد الكلية فى الحبوب لصنف الأرز (سخا-١٠١) هي ٣.٩ و٢.٧% عند سرعة أمامية ١.٢ كم/ الساعة ونسبة رطوبة للحبوب ١٥% باستخدام آلة الحصاد الجامعة (يانمار وكلاس) على الترتيب، بينما كانت أقل قيمة لصنف (جيزة-١٧٨) هي ٢.٧٦ و٣.١ % عند نفس المعاملات. كانت أعلى قيمة للسعة الحقلية لصنف الأرز (سخا-١٠١) هي ٠.٩٧ و٢.٧٣ فدان/ساعة عند سرعة أمامية ٣.١ كم/الساعة ونسبة رطوبة ١٥% باستخدام آلة الحصاد الجامعة (يانمار وكلاس) على الترتيب، بينما كانت أأعلى قيمة للصنف (جيزة-١٧٨) هي ٠.٩٤ و٢.٦ فدان/ساعة عند نفس المعاملات. بينما كانت أقصى قيمة للكفاءة الحقلية لصنف (سخا-١٠١) هي ٨٥.٢ و٨١.٠٢ % عند سرعة أمامية ٠.٥ كم/الساعة ونسبة رطوبة ١٥% باستخدام آلة الحصاد الجامعة (يانمار وكلاس) على الترتيب، بينما كانت أقصى قيمة لصنف (جيزة-١٧٨) هي ٨١.١ و٧٥,٣ % عند نفس المعاملات. وقد أوضحت النتائج أيضا أن أعلى قيمة لكفاءة القطع لصنف (سخا-١٠١) هي ٩٢.٧ و٩٣.٧ عند نسبة رطوبة ١٥% وسرعة أمامية ٠.٥ كم/الساعة باستخدام آلة الحصاد الجامعة (يانمار وكلاس) على الترتيب، بينما كانت أقل قيمة لصنف (جيزة-١٧٨) هي ٩١.٦ و٩٠,٥ % عند نفس المعاملات. اقل قيمة لمعدل استهلاك الوقود لصنف (سخا-١٠١) هي ٤.٣ و٥.٧ لتر/الساعة عند نسبة رطوبة ١٥% وسرعة أمامية ٠.٥ كم/الساعة باستخدام آلة الحصاد الجامعة (يانمار وكلاس) على الترتيب، بينما سجلت أقل قيمة للطاقة النوعية اللازمة لعملية الحصاد والدراس (لصنف سخا-١٠١) وهي ١٤.٦٢ و٨,٤٥ كيلووات.ساعة/الفدان عند نسبة رطوبة ١٥% وسرعة أمامية

١.٣كم/الساعة باستخدام آلـة الحصاد الجامعة (يانمـار وكلاس) على الترتيب. بينمـا كانـت أقل قيمة لصنف (جيزة-١٧٨) هي ٢١.٢٦ و٩,٣٨ كيلووات.ساعة/ الفدان، عند نفس المعاملات. وجد أن أقل قيمـة للتكـاليف الكليـة اللازمـة لعمليـة الحصـاد والـدراس لصنف (سخا-١٠١) هي ٢٧٢.٨ و٢٨٢,١ جنيـه/ فـدان عنـد نسـبة رطوبـة ١٥% وسـرعة أماميـة ١.٩كم/السـاعة باستخدام آلـة الحصاد الجامعة (يانمـار وكلاس)، علـى الترتيب. بينمـا كانـت أقل قيمـة للصنف (جيزة-١٧٨) هي ٢٤٩.٨ و٢٣٢.٨ جنيه/ فدان عند نفس المعاملات.