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PRFORMANCE EVALUATION OF A RICE MILLING MACHINE UNDER EGYPTIAN CONDITION

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ABSTRACT: The present work was carried out in a private rice milling center, Farskour, Damietta Governorate, Egypt. The objective of this study was to test the rice milling machine which is widely used in most Egyptian villages. The experimental studies were carried out to evaluate the performance of a rice milling machine. The performance of the milling machine was studied under the following parameters: feed rate, clearance of out let, and grain moisture content in terms of total grain losses, overall machine efficiency, machine productivity, specific energy, criterion costs. The experimental results revealed that the highest values of machine productivity and overall machine efficiency were 1.086 and 1.173 Mg/hr., and 86.75 and 93.00% for Giza-178 and Sakha-101 varieties, respectively, while the lowest values of required power and specific energy were 11.28 and 11.05 kW; and 14.23 and 13.29 kW.hr./Mg, respectively, for the same rice varieties, furthermore the lowest values of both operational and criterion costs were 42.95 and 41.30 LE/Mg; and 271.80 and 254.28 LE/Mg, respectively, for the same rice varieties. The optimum operating parameters of milling machine were found at 1.4 Mg/hr., feed rate with 7.5 mm clearance of out let at 12% grain moisture content for sakha 101 variaty while, for rice variety Giza 178 the optimum operating parameters of milling machine were found at 1.2 Mg/hr., feed rate with 5.0 mm clearance of out let at 14% grain moisture content.

Key words: Clearance of out let, moisture content, feed rate.

INTRODUCTION

Rice crop is considered one of the most important economical crops as it participates in the national income added to the local consumption in feeding and different aspects. Milling is a process of removing the hulls and bran from the harvested and dried rough rice to produce white rice with minimum percentage of broken grains and impurities. The broken grains cause a loss because they have lower market price. So, during rice milling process, controlling in factors affecting the quality of grain rice is attractive effort. The output of milled rice and its quality are highly affected by the milling degree to remove the outer layer of the rice. The type of rice mill and the method of operation affect the quality of milled rice, significantly. In Egypt, milling industry uses both imported and locally made machines of different types and designs. There are several types of small simple machines which are used for completing the milling process in one operation and now being used in great deal for the milling industry.These machines are composed of two horizontal tangential rubbers of rollers, which revolving in opposite directions and different speeds to hulling rice and the brown rice is milled into white rice by a milling roller and hexagonal screen. Therefore, the operational characteristics of such machine must be well established and understood to minimize milling losses. Abdelmotaleb (1998) carried out a study on the effect of harvesting dates and methods on yield and milling quality for rice crop. He showed that the optimum moisture content for harvesting rice crop by combine

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harvester ranged between 19-23% (wb). The percentage of milled rice (whole and broken kernels) was not significantly affected by delayed harvesting. However, the percentage of head rice (whole kernels of milled rice) was greatly affected by delay harvesting. Shi-gang (2006) studied the relationship between the different moisture content of brown rice and the energy consumption, the broken rice rate, the crack rate and the head rice yield. It could be concluded that the head rice yield increased at first falls and then decreased along with the raise of moisture content and it could reach the maximum value (70.78%) when moisture content was 15.5%. The energy consumption of rice milling decreased along with the increase of moisture contents. The broken rice rate fell at first and then increased along with the raise of moisture contents and it could reach the minimum value (4.28%) when the moisture content was 15.5%. In the early study of milling conditions and breakage. Soltanabadi and Hemmat (2007) showed that excessive rotation of rice, when the grains revolve inside the milling chamber, increase breakage. Ease of grain movement in the milling chamber could minimize this problem by utilizing screw conveyor at the first part of rotor. In this study, the rotor of a conventional milling was equipped with a screw conveyor. The effects of two rotor types (modified and conventional rotors), three output rates of 412, 654 and 915 kg/hr., and three blade distances from the agitator 11, 12 and 13 mm were examined on indices of rice quality. Results showed that only the effect of blade distance on percentage of breakage was significant and the effect of feed rate on all measured parameters was also significant. In addition, the interaction effects of rotor type and blade distance, rotor type and feed rate on percentage of whole white rice and breakage were significant, respectively. The milling performance index showed that the best conditions for both rotors can be obtained at output rate of 412 kg/hr., and 11 or 12 mm blade distance from the agitator. For this adjustment the average of percentage of breakage in the modified and conventional rotors were 20.5 and 23, respectively. Varnamkhasti *et al.* (2007) stated that one of the methods in reducing the rice losses is to modify and optimize the current machines in the line of milling process. A rotor equipped with a screw conveyor was used. Factors were the rotor speed and the output flow rate for two common rice varieties. Results showed that the most effective factor on the quality of rice is the output flow rate in such a way that with its increase, an increase in the breakage percentage and a decrease in degree of milling was observed. The highest breakage percentage for both varieties occurred at 800 rpm and output flow rate of 600 kg/hr. Also, it was found that the Sazandegi variety showed higher breakage percentage and degree of milling in compare to those of Sorkheh variety. The highest and the lowest breakage percentages for both varieties occurred in the range of 400 to 600 kg/hr. At last, for Sorkheh variety, a rotor speed of 600 rpm with an output flow rate of 400 to 500 kg/hr., and for the Sazandegi variety, a rotor speed of 700 rpm and an output flow rate of 400 kg/hr., were considered as the best combinations. Firouzi *et al.* (2010) studied the effects of two engineering factors on the performance of Engleberg rice whitener as the most common machine for rice milling. Three levels of the size of perforated screen (No. 22, 24 and 26) and three levels of the blade-rotor clearance (8, 10 and 12 mm) were considered for the experiment. It was concluded that as the size of perforated screen increased, amount of rice breakage and whiteness decreased at first and then did not change significantly. Amount of rice breakage and whiteness decreased with increasing the blade-rotor clearance. The output rate increased significantly with increasing blade-rotor clearance but the effect of the size of perforated screen was insignificant on the output rate. A clearance of 10 mm and perforated screen No. 26 was the best combination for milling of Hashemi variety using Engleberg rice whitener. Appiah *et al.* (2011) estimated post harvest losses of rice from harvesting to milling to provide basic information important regarding the losses. They found that SB30 milling machine was more efficient and produced 67.3% head grains compared to SB10 (50%) and the locally manufactured machine 47.3%.

It showed that long grain varieties required lesser energy than short grain varieties .This slight difference in amount of consumption of energy may have come due to variation in grain thickness, hardness and shape of the kernels. The main objectives of this research are as follows:

1. Optimize some operating parameters (feed rate, clearance of out let and grain moisture content) affecting the performance of the rice milling machine.
2. Evaluate the milling machine performance from the economic point of view.

MATERIALS AND METHODS

This study was carried out through the year of 2016 at private rice milling center, Farskour, Damietta Governorate, Egypt. To evaluate the performance of a rice milling machine.

Materials

The used crop

Two different rice varieties of (Giza -178 and Sakha-101) were used. Some characteristics of rice grains were determined before milling operation such as: length, width, thickness, mass of 1000 grains, percent of sphericity and hardness.

The milling machine

The milling machine (HBN 130 SR) was used to study the effect of some operating parameters on rice milling yield. The used milling machine carry out two operations at the same time (husking and whitening) so as to save time and cost.

The milling machine consists mainly of power source, transmission system, frame, milling unit (husking and whitening) as shown in Fig. 1.

The power source

The machine was powered by an electric motor 22 kW (30 hp) at a rated speed of 850 rpm.

The transmission system

The machine is operated by means of pulley (30 cm diameter) and belt powered from the electric motor pulley (20 cm diameter). The power is transmitted from the machine pulley to the other moving parts by means of pulleys and belts with different speed ratios.

The frame

The frame is made of rectangular iron sheet steel. It includes elements to fix the motor, the transmission system, the husking and whitening units.

The milling unit

The milling unit consists of a drum and concave with holes. Specifications of the milling unit were as follow: type of milling is abrasive type, milling drum length 27 cm, milling drum diameter 15 cm, number of drum slices 6, concave length 30 cm, concave cells shape is rectangular having dimensions of (15 – 2 mm).

The rice grains fall in the milling unit to be husked and milled. A suction air stream is supplied by a centrifugal blower. The air sucked by the blower entrains brains from milled rice to be passed through the concave holes.

Outside the machine. Another horizontal air stream is supplied by a fan to push milled rice to be delivered from the milled rice outlet.

The main dimensions of the machine were as follow: Overall length 2000 mm, overall width 1200 mm, overall height 1500 mm, totals mass 500 kg.

Measuring instruments

Drying oven

Samples of grain were taken for moisture content determination. The oven method was used to dry samples for one hour at 130°C.

Balances

a- An electronic balance was used to weight the bundles. The balance had a range between (0 to 40 kg). (Sensitive to 5 grams).

b- An electronic balance was used to weight the grain losses and samples. The balance had a range between (0 to 5 kg). (Sensitive to 1.0 micro gram).

Methods

The samples were taken after harvesting by the combine at grain moisture content of about 20.5%. Then, they dried using natural drying method under shade with in layers, to get the different levels of grain moisture content in order to study their effect on total grain losses and overall machine efficiency at different operating parameters of milling machine.

Fig. 1. The rice milling machine

Physical and engineering properties of rice varieties

In recent years, there has been a general recognition of the need to determine the physical and engineering characteristics of grains. This characteristics are used to develop and design different machines or in the analysis of the behavior of the product in handling of material.

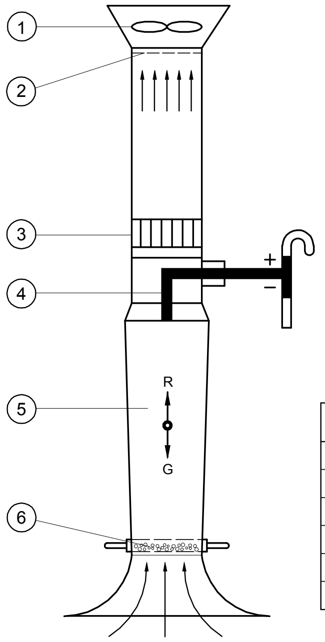
In this study some physical and engineering properties of rice crop were either measured or calculated.

Physical properties

A random sample of about 500 grains was taken from rice crop to obtain data on some physical properties such; as length, width, thickness, mass of 1000 grains, volume, arithmetic diameter, geometric diameter, frontal area, transverse area, and percent of sphericity.

Engineering properties

Some engineering properties (aerodynamic and mechanical properties) Such as: terminal velocity, repose angle, and friction angle were considered. A quantity of grains was used to determine repose angle. The grains were poured under gravity from a suitable height to form a cone surface and the horizontal plan was recorded to represent response angle of grains using the meter of repose angle. Grain friction angle was measured on metal sheet surface at grain moisture content of 14 to 20 % using a digital friction angle device. The terminal velocity is determined by measuring the air velocity required to suspend a seed in a vertical air stream by aerodynamic tube (Fig. 2).



No.	Part name
1	Fan
2	Flow sraighteners
3	Collector
4	Measuring tube
5	Suction tube
6	Screen

Fig. 2. Critical velocity apparatus

Experimental conditions

The performance of the machine was experimentally measured under the following parameters: Two rice varieties of Giza -168 and Sakha - 101; four different feed rates of 1.0, 1.2,1.4 and 1.6 Mg/hr., four different clearance of out let 2.5, 5.0, 7.5 and 10.0 mm and four different grain moisture contents of 10, 12, 14 and 16% in average.

Measurements and determinations

Evaluation of the performance of the rice milling machine was based on the following indicators:

Total grains losses

Total grains losses includes both broken grains and unshelled grains. The percentage of total losses was calculated by using the following equation:

$$\text{Total grain losses} = \text{broken grains} + \text{unshelled grains} \quad (1)$$

The percentage of broken grains (Bg)

$$Bg = \frac{\text{Mass of broken rice grains in the sample}}{\text{Total mass of the sample}} \times 100 \quad (2)$$

The percentage of unshelled grains ($unsh_g$)

$$unsh_g = \frac{\text{Mass of unshulled rice grains in the sample}}{\text{Total mass of the sample}} \times 100 \quad (3)$$

Machine productivity

Machine productivity was determined by the following equation:

$$Mp = \frac{Ms}{t}, \text{ kg/hr.} \quad (4)$$

Where:

Mp = machine productivity, kg/hr.

Ms = mass of milled rice, kg

t =the time consumed in the milling operation, hr.

Overall machine efficiency:

Overall machine efficiency (Me) was calculated by using the following equation:

$$Me = \frac{\text{Mass of output grains from milling operation in the sample}}{\text{Total mass of the sample}} \times 100 \quad (5)$$

Specific energy

Specific energy for the threshing and cleaning operation can be calculated as follows:

$$\text{Specific energy} = \frac{\text{Required power}}{\text{Machine productivity}}, \text{kW.h/kg} \quad (7)$$

Criterion cost

The criterion cost required for the threshing and cleaning operation was estimated using the following equation (Awady *et al.*, 1982):

$$\text{Criterion cost} = \text{operating cost} + \text{seed losses cost, LE/Mg} \quad (8)$$

$$\text{Operating cost} = \frac{\text{Machine cost}}{\text{Machine productivity}}, \text{LE/Mg} \quad (9)$$

Machine hourly cost was determined using the following equation (Awady, 1978):

$$C = \frac{p}{h}\left(\frac{1}{a} + \frac{i}{2} + t + r\right) + (W.e) + \frac{m}{192} \quad (10)$$

C = machine cost, LE/hr.,

p = price of machine, LE

h = yearly working hours, hr./year

a = life expectancy of the machine, hr.

I = interest rate/year

t = t axes, over heads ratio

r = repairs and maintenance ratio

W = power of motor in, kW

e = hourly LE/kW.hr.,

m = the monthly average labour wage, LE

192 = reasonable estimation of monthly working hours.

RESULTS AND DISCUSSION

The obtained results will be discussed under the following items:

Table 1 shows some physical properties of the rice grains while Table 2 shows some engineering properties of the same grains.

Table 1. Some physical properties of rice grains

Rice crop	Physical properties									
	Length (mm)	Width (mm)	Thickness (mm)	Mass of 1000 grains (g)	Volume (mm^3)	Arithmetic diameter (mm)	Geometric diameter (mm)	Frontal area (mm^2)	Transverse area (mm^2)	Percentage of sphericity (%)
Giza- 178	8.17	3.97	2.47	16.97	41.93	4.87	4.31	25.46	55.85	52.77
Sakha-101	7.93	3.24	2.09	23.80	28.10	4.42	3.77	20.17	46.01	47.58

Table 2. Some engineering properties of the used rice varieties.

Rice crop	Engineering properties			
	Aerodynamic properties		Mechanical properties	
	Critical velocity of grains (m/sec.)	Impurities critical velocity (m/sec.)	Repose angle (deg.)	Friction angle (deg.)
Giza- 178	7.87 – 7.93	2.78 – 2.82	35-39	40-44
Sakha-101	7.70-7.76	2.64-2.72	30-33	35-38

Effect of Some Operating Parameters on Total Grain Losses for the Two Rice Varieties

Representative values of total grain losses versus feed rate, clearance of out let and grain moisture content at two different rice varieties are given in Fig. 3.

Concerning to the effect of feed rate on the total grain losses for sakha-101 variety, results showed that, increasing feed rate from 1.0 to 1.4 Mg/hr., under constant grains moisture content of 12% and various clearance of out let of 2.5, 5, 7.5 and 10 mm decreased total grain losses from 6.38 to 6.10; 6.28 to 5.65; 6.10 to 5.50 and 6.50 to 6.20%, respectively. Any further increase in feed rate more than 1.4 up to 1.6 Mg/hr., measured at the same previous clearances of out let, increased total grain losses from 6.10 to 6.60; 5.65 to 6.45; 5.50 to 6.30 and 6.20 to 6.70, respectively. While, for the other rice variety of Giza- 178, increasing feed rate from 1.0 to 1.2 Mg/hr., under constant grains moisture content of 14% and various clearance of out let of 2.5, 5, 7.5 and 10 mm decreased total grain losses from 7.00 to 6.60; 6.83 to 6.38; 7.16 to 6.85 and 7.33 to 6.95%, respectively. Any further increase in feed rate more than 1.2 up to 1.6 Mg/hr., measured at the same previous clearance of out let, increased total grain losses from 6.60 to 7.49; 6.38 to 7.35; 6.85 to 7.60 and 6.95 to 7.67, respectively. Increasing feed rate led to increase unshelled grains due the excessive grains in the milling unit, consequently the material leave the device without adequate milling that tends to increase unshelled grains. So, the total grain losses including both broken grains and unshelled grains are essential to establish optimum working conditions.

With respect to the effect of clearance of out let on the total grain losses for sakha-101 variety, results showed that increasing clearance of out let from 2.5 to 7.5 mm under constant feed rate of 1.40 Mg/hr., and various grains moisture content of 10, 12, 14 and 16% decreased total grain losses from 6.22 to 5.80; 6.10 to 5.50; 6.30 to 6.00 and from 6.80 to 6.65%, respectively. Any further increase in clearance of out let more than 7.5 up to 10 mm measured at the same previous grain moisture contents increased total grain losses from 5.80 to 6.35; 5.50 to 6.20 and 6.00 to 6.50 and from 6.65 to 6.95%, respectively. While, for the other rice variety of Giza- 178, increasing clearance of out let from 2.5 to 5 mm under constant feed rate of 1.20 Mg/hr., and various grains moisture content of 10 12, 14 and 16 % decreased total grain losses from 7.25 to 7.13; 7.00 to 6.80; 6.60 to 6.38 and from 7.55 to 7.25%, respectively. Any further increase in clearance of out let more than 5 up to 10 mm measured at the same previous grain moisture contents increased total grain losses from 7.13 to 7.55 ; 6.80 to 7.30 ; 6.38 to 6.95 and from 7.25 to 7.78%, respectively.

The decrease in broken grains by increasing clearance of out let is due to the increase of milled material thickness on the concave surface. While, the increase in unshelled grains by increasing clearance of out let is attributed to the low stripping and impacting forces applied to the rice grains.

Relating to the effect of grain moisture content on the broken grain losses for sakha-101 variety, results showed that, increasing grains moisture content from 10 to 12% under constant clearance of out let of 7.5 mm and various feed rates of 1.0, 1.2, 1.4 and 1.6 Mg/hr., decreased total grain losses from 6.25 to 6.10; 6.00 to 5.80; 5.80 to 5.50 and from 6.39 to 6.30%, respectively. Any further increase in grain moisture content more than 12 up to 16% measured at the same previous feed rates increased total grain losses from 6.10 to 6.90; 5.80 to 6.81; 5.50 to 6.65 and from 6.61 to 7.10%, respectively. While, for the other rice variety of Giza-178, increasing grains moisture content from 10 to 14% under constant clearance of out let of 5 mm and various feed rates of 1.0; 1.2; 1.4 and 1.6 Mg/hr., decreased total grain losses from 7.35 to 6.83; 7.13 to 6.38; 7.55 to 7.15 and 7.85 to 7.35%, respectively. Any further increase in grain moisture content more than 14 up to 16% measured at the same previous feed rates increased total grain losses from 6.83 to 7.55; 6.38 to 7.25; 7.15 to 7.68 and from 7.35 to 8.05%, respectively.

The decrease in the broken grain losses by increasing grain moisture content due to the elastic conditions of high moisture content of grains resulting in a little impacting force on the rice materials. Higher values of grain moisture content more than the optimum value tend to increase total grain losses because of the increase in unshelled grains by increasing grain moisture content. On the other side, the lower values of grain moisture content less than the optimum value tend to increase total grain losses due to the increase in broken grains by decreasing grain moisture content.

Sakha 101 variety **Giza 178 variety**

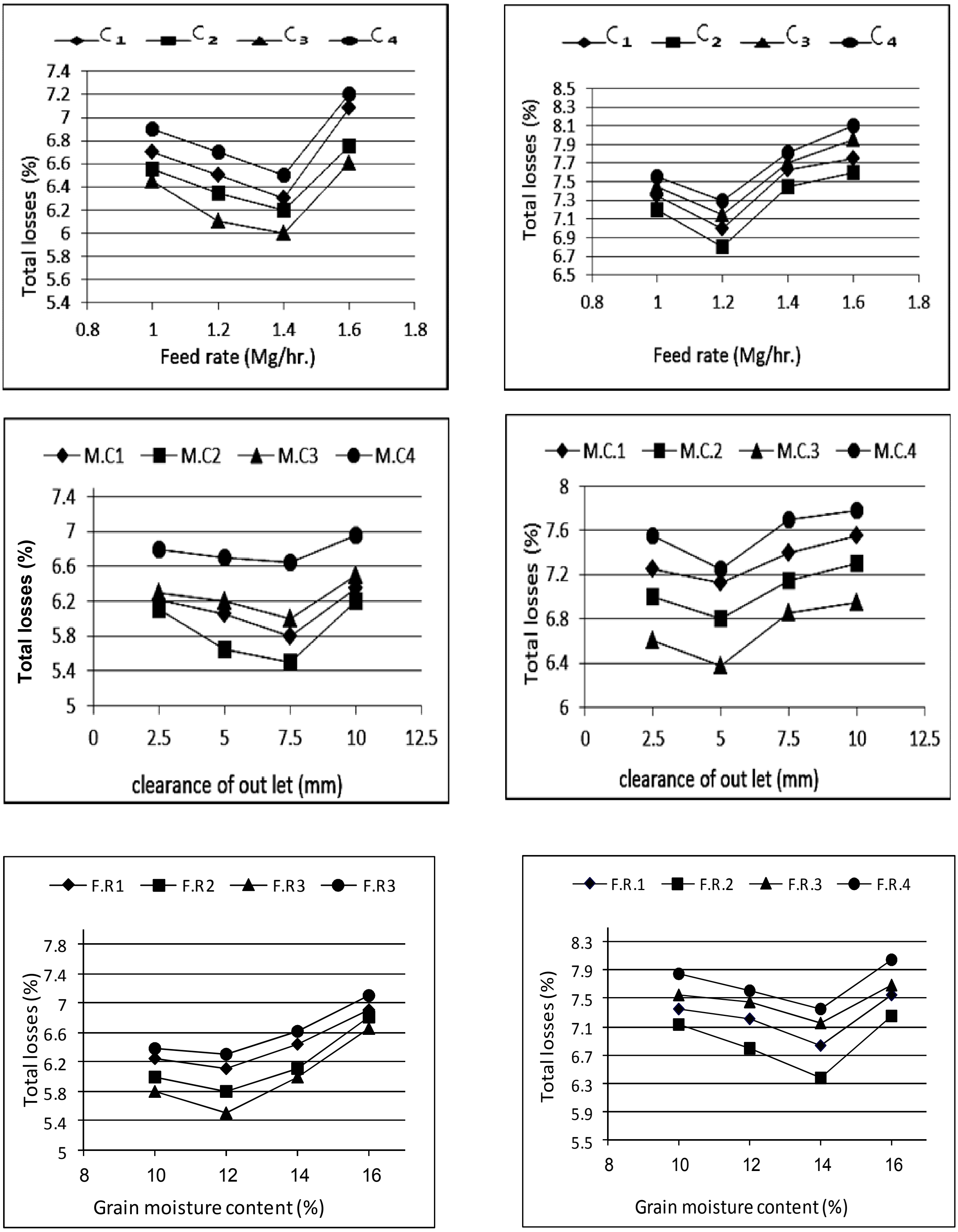


Fig. 3. Effect of feed rate, clearance of out let and grain moisture content on total grain losses for sakha 101 and Giza 178 varieties

Effect of Some Operating Parameters on Overall Machine Efficiency for the Two Rice Varieties

Representative values of overall machine efficiency versus feed rate, clearance of out let and grain moisture content of two different rice varieties are given in Fig. 4.

Concerning to the effect of feed rate on the machine efficiency for sakha-101 variety, results showed that increasing feed rate from 1.0 to 1.4 Mg/hr., under constant grains moisture content of 12% and various clearances of out let of 2.5, 5.5; 7.5 and 10 mm increased machine efficiency from 86.30 to 91.60; 87.50 to 91.90; 90.90 to 93.00 and from 84.88 to 90.65%, respectively. Any further increase in feed rate more than 1.4 up to 1.6 Mg/hr., measured at the same previous clearances of out let, decreased machine efficiency from 91.60 to 84.50; 91.90 to 86.50; 93.00 to 89.20 and from 90.65 to 83.45%, respectively. While, for the other rice variety Giza-178, increasing feed rate from 1.0 to 1.2 Mg/hr., under constant grains moisture content of 14% and various clearances of out let of 2.5, 5.0; 7.5 and 10 mm increased machine efficiency from 86.00 to 87.15; 86.85 to 87.93; 85.23 to 86.60 and from 83.13 to 84.85%, respectively. Any further increase in feed rate more than 1.2 up to 1.6 Mg/hr., measured at the same previous clearances of out let, decreased machine efficiency from 87.15 to 82.63; 87.93 to 84.05; 86.60 to 81.50 and from 84.85 to 80.23, respectively.

With respect to the effect of clearance of out let on the machine efficiency for sakha-101 variety, results showed that increasing clearance of out let from 2.5 to 7.5 mm under constant feed rate of 1.40 Mg/hr., and various grains moisture content of 10, 12, 14 and 16% increased machine efficiency from 90.00 to 91.58; 91.60 to 93.00; 88.90 to 90.90 and from 84.8 to 87.10%, respectively. Any further increase in clearance of out let more than 7.5 up to 10 mm measured at the same previous grain moisture contents decreased machine efficiency from 91.58 to 89.30; 93.00 to 90.65; 90.90 to 87.85 and from 87.10 to 83.40%, respectively. While, for rice variety Giza-178, increasing clearance of out let from 2.5 to 5 mm under constant feed rate of 1.20 Mg/hr., and various grains moisture content of 10, 12, 14 and 16% increased machine efficiency from 84.00 to 85.67; 85.45 to 86.75; 87.15 to 87.93 and from 82.30 to 83.8 5%, respectively. Any further increase in clearance of out let more than 5 up to 10 mm measured at the same previous grain moisture contents decreased machine efficiency from 85.67 to 82.20; 86.75 to 83.25; 87.93 to 80.85 and from 83.85 to 80.25%, respectively.

The increase in overall machine efficiency is attributed to the decrease in total grains losses, that tended to improve milling operation.

Relating to the effect of grain moisture content on the machine efficiency for sakha-101 variety, results showed that increasing grains moisture content from 10 to 12% under constant clearance of out let of 7.5 mm and various feed rates of 1.0, 1.2, 1.4 and 1.6 Mg/hr., increased machine efficiency from 89.53 to 90.90; 90.40 to 91.50; 91.58 to 93.00 and from 87.55 to 89.20%, respectively. Any further increase in grain moisture content more than 12 up to 16 % measured at the same previous feed rates decreased machine efficiency from 90.90 to 83.43; 91.50 to 84.83; 93.00 to 87.10 and from 89.20 to 81.65%, respectively. While, for rice variety Giza-178, increasing grains moisture content from 10 to 14% under constant clearance of out let of 5 mm and various feed rates of 1.0, 1.2, 1.4 and 1.6 Mg/hr., increased machine efficiency from 84.05 to 86.85; 85.67 to 87.93; 82.63 to 85.70 and from 81.00 to 84.05%, respectively. Any further increase in grain moisture content more than 14 up to 16% measured at the same previous feed rates decreased machine efficiency from 86.45 to 82.50; 87.23 to 83.85; 85.70 to 80.85 and from 84.05 to 79.35%, respectively.

Values of grain moisture content more than or less to the optimum value tend to decrease machine efficiency because of increasing the total grain losses.

Effect of Some Operating Parameters on Machine Productivity for the Two Rice Varieties

Representative values of machine productivity versus feed rate, clearance of out let and grain moisture content at two different rice varieties are given in Fig. 5.

Sakha 101 variety **Giza 178 variety**

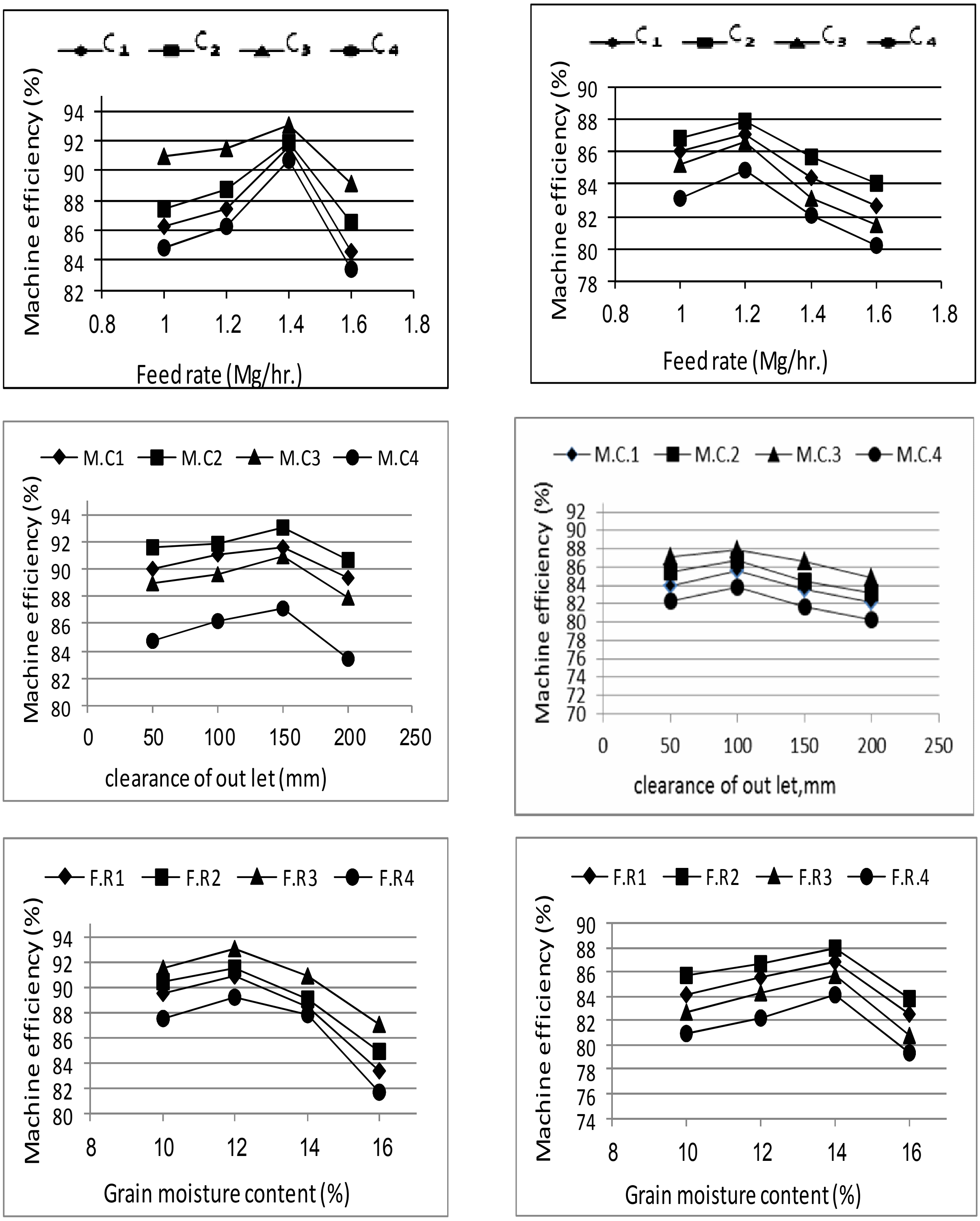


Fig. 4. Effect of feed rate, clearance of out let and grain moisture content on machine efficiency for sakha 101 and Giza 178 varieties

Sakha 101 variety **Giza 178 variety**

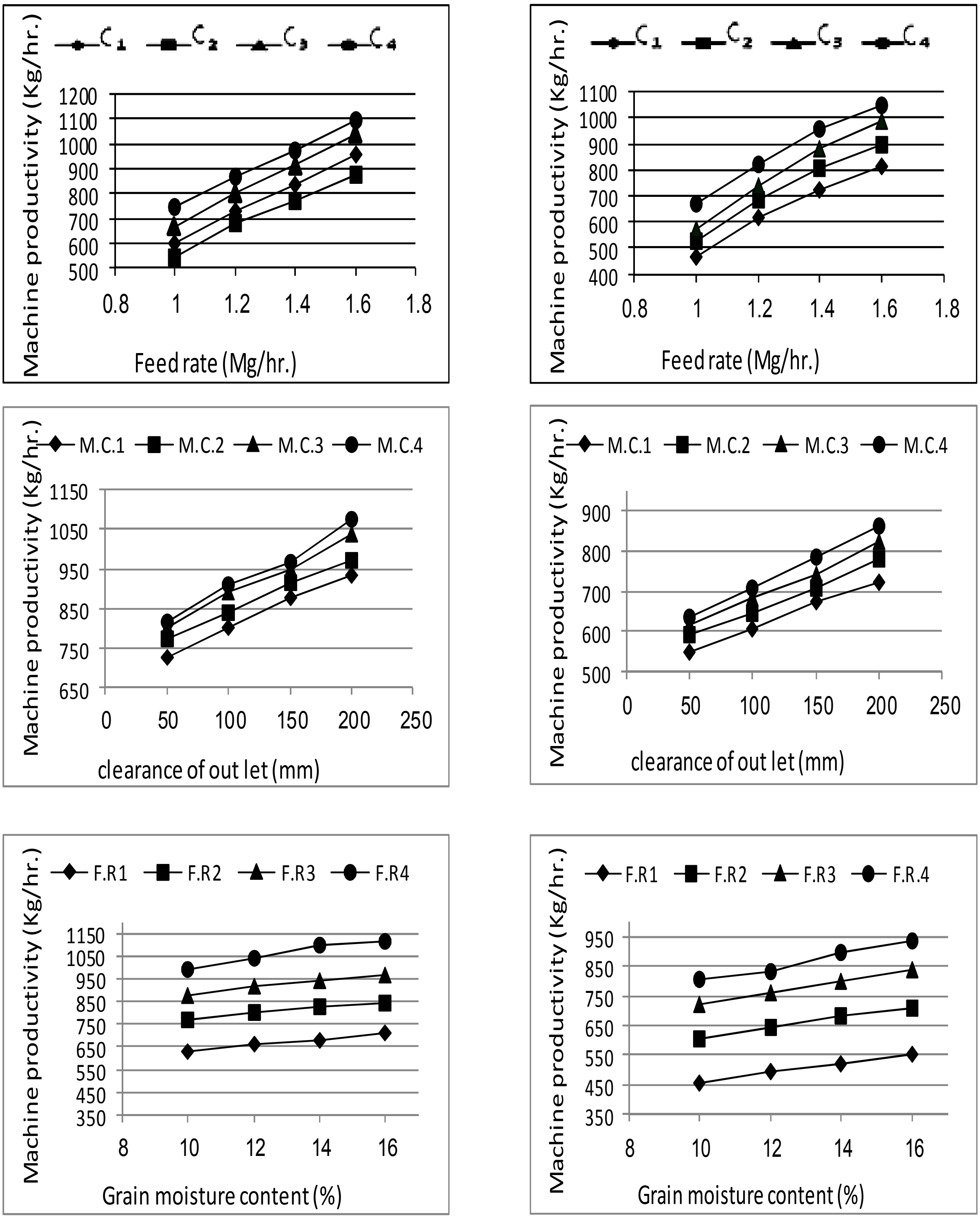


Fig. 5. Effect of feed rate, clearance of out let and grain moisture content on machine productivity for sakha 101and Giza 178 varieties

Concerning to the effect of feed rate on the machine productivity for sakha-101 variety, results showed that, increasing feed rate from 1.0 to 1.6 Mg/hr., under constant grains moisture content of 12% and various clearances of out let of 2.5, 5.0; 7.5 and 10 mm increased machine productivity from 546.39 to 874.75; 597.03 to 953.44; 661.52 to 1036.92 and from 743.01 to 1097.33%, respectively. While, for rice variety Giza 178, increasing feed rate from 1.0 to 1.6 Mg/hr., under constant grains moisture content of 14% and various clearance of out let of 2.5, 5.0; 7.5 and 10 mm increased machine productivity from 462.24 to 816.00; 522.32 to 900.00; 573.86 to 983.68 and from 666.85 to 1048.42%, respectively.

With respect to the effect of clearance of out let on the machine productivity for sakha-101 variety, results showed that, increasing clearance of out let from 50 to 200 mm^3 under constant feed rate of 1.4 Mg/hr., and various grains moisture content of 10, 12, 14 and 16% increased machine productivity from 727.20 to 935.46; 773.12 to 973.64; 800.88 to 1038.60 and from 816.50 to 1076.10%, respectively. While, for rice variety Giza 178, increasing clearance of out let from 2.5 to 10 mm under constant feed rate of 1.2 Mg/hr., and various grains moisture content of 10, 12, 14 and 16% increased machine productivity from 550.59 to 724.44; 592.70 to 778.68; 616.13 to 823.94 and from 634.10 to 864.56%, respectively.

The increase in machine productivity by increasing clearance of out let due to the increase of seeds flow through the concave openings at the same time unit.

Relating to the effect of grain moisture content on the machine productivity for sakha-101 variety, results showed that, increasing grains moisture content from 10 to16% under constant clearance of out let of 7.5 mm and various feed rate of 1.0, 1.2, 1.4 and 1.6 Mg/hr., increased machine productivity from 630.74 to 707.04; 770.67 to 839.92; 875.59 to 964.69 and from 987.10 to 1113.50%, respectively. While, for rice variety Giza 178, increasing grains moisture content from 10 to 16% under constant clearance of out let of 5 mm and various feed rate of 1.0, 1.2; 1.4 and 1.6 Mg/hr., increased machine productivity from 456.29 to 551.76; 606.32 to 707.11; 723.51 to 837.82 and from 804.42 to 939.10%, respectively. With respect to the machine productivity increased by increasing grain moisture content due to the increase in weight of grains.

Effect of Some Operating Parameters on Specific Energy For the Two Rice Varieties

Values of specific energy versus feed rate, clearance of out let and grain moisture content at two different rice varieties are given in Fig. 6.

Concerning to the effect of feed rate on the specific energy for sakha-101 variety, results showed that, increasing feed rate from 1.0 to 1.6 Mg/hr., under constant grains moisture content of 12% and various clearance of out let of 2.5, 5, 7.5 and 10 mm decreased specific energy from 25.31 to 17.92; 22.38 to 16.19; 19.49 to 14.67 and from 16.74 to 13.43%, respectively. While, for rice variety Giza 178, increasing feed rate from 1.0 to 1.6 Mg/hr., under constant grains moisture content of 14% and various clearance of out let of 2.5, 5.0; 7.5 and 10 mm decreased specific energy from 33.97 to 21.60; 28.73 to 19.37; 25.37 to 16.61 and from 21.16 to 15.31%, respectively.

With respect to the effect of clearance of out let on the specific energy for sakha-101 variety, results showed that, increasing clearance of out let from 50 to 200 mm^3 under constant feed rate of 1.4 Mg/hr., and various grains moisture content of 10, 12, 14 and 16% decreased specific energy from 18.69 to 13.80; 19.10 to 14.44; 20.45 to 15.10 and from 21.46 to 15.63%, respectively. While, other rice variety Giza 178, increasing clearance of out let from 50 to 200 mm^3 under constant feed rate of 1.2 Mg/hr., and various grains moisture content of 10, 12, 14 and 16% decreased specific energy from 24.29 to 16.86; 25.29 to 17.76; 26.84 to 18.60 and from 27.62 to 18.94%, respectively. The decrease in energy by increasing clearance of out let is attributed to the smoothly seeds flow on the concave surface that reduces energy.

Relating to the effect of grain moisture content on the specific energy for sakha-101 variety, results showed that, increasing grains moisture content from 10 to 16% under constant clearance of out let of 7.5 mm and various feed rate of 1.0, 1.2, 1.4 and 1.6 Mg/hr., increased

Sakha 101 variety **Giza 178 variety**

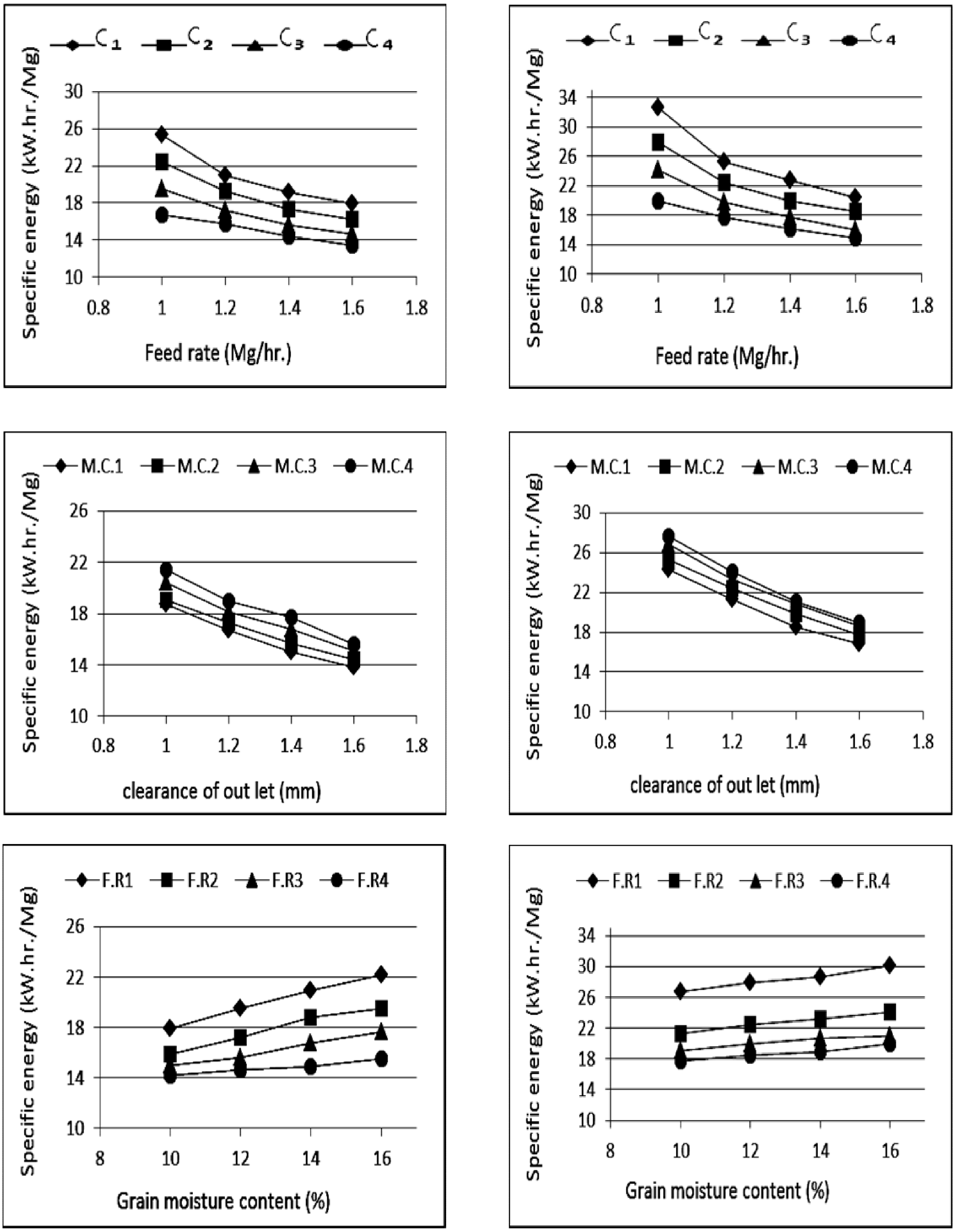


Fig. 6. Effect of feed rate, clearance of out let and grain moisture content on specific energy for Sakha 101 and Giza 178 varieties

specific energy from 17.90 to 22.15; 15.86 to 19.50; 15.00 to 17.69 and from 14.24 to 15.53%, respectively. While, for the other rice variety of Giza 178, increasing grains moisture content from 10 to 16% under constant clearance of out let of 5 mm and various feed rate of 1.0, 1.2, 1.4 and 1.6 Mg/hr., increased specific energy from 26.78 to 30.11 ; 21.29 to 24.12; 19.11 to 20.92 and from 17.76 to 19.93%, respectively.

Effect of Some Operating Parameters on Criterion Costs For the Two Rice Varieties

Representative values of criterion cost versus feed rate, clearance of out let and grain moisture content at different rice varieties are given in Fig. 7.

Concerning to the effect of feed rate on the criterion costs for sakha-101 variety, results showed that, increasing feed rate from 1.0 to 1.4 Mg/hr., under constant grains moisture content of 12% and various clearance of out let of 2.5, 5, 7.5 and 10 mm decreased criterion costs from 273.35 to 255.30; 268.65 to 247.95; 261.15 to 237.90 and from 277.00 to 261.30%, respectively. Any further increase in feed rate more than 1.4 up to 1.6 Mg/hr., measured at the same previous clearance of out let, increased criterion costs from 255.30 to 277.65; 247.95 to 272.30, and 237.90 to 264.60 and from 261.30 to 280.70, respectively. While, for rice variety Giza 178, results showed that, increasing feed rate from 1.0 to 1.2 Mg/hr., under constant grains moisture content of 14% and various clearances of out let of 2.5, 5, 7.5 and 10 mm decreased criterion costs from 293.65 to 281.30; 289.20 to 271.80; 299.55 to 286.90 and from 304.60 to 289.45%, respectively. Any further increase in feed rate more than 1.2 up to 1.6 Mg/hr., measured at the same previous clearances of out let, increased criterion costs from 281.30 to 308.05; 271.80 to 303.90 and 286.90 to 311.40 and from 289.45 to 315.80, respectively.

With respect to the effect of clearance of out let on the criterion costs for sakha-101 variety, results showed that, increasing clearance of out let from 2.5 to 7.5 mm under constant feed rate of 1.4 Mg/hr., and various grains moisture content of 10, 12, 14 and 16% decreased criterion costs from 266.55 to 249.20; 255.30 to 237.90; 270.00 to 254.3 and from 284.40 to 275.95%, respectively. Any further increase in clearance of out let more than 7.5 up to 10 mm measured at the same previous grain moisture contents increased criterion costs from 249.20 to 270.60; 237.90 to 261.30 and 254.30 to 273.60 and from 275.95 to 289.05%, respectively. While, for rice variety Giza 178, results show that, increasing clearance of out let from 2.5 to 7.5 mm under constant feed rate of 1.2 Mg/hr., and various grains moisture content of 10, 12, 14 and 16% decreased criterion costs from 305.50 to 300.00 ; 296.00 to 287.80 ; 281.30 to 271.80 and from 313.65 to 305.35%, respectively. Any further increase in clearance of out let more than 5 up to 10 mm measured at the same previous grain moisture contents increased criterion costs from 300.00 to 312.75 ; 287.80 to 302.90, and 271.80 to 289.45 and from 305.35 to 317.80%, respectively.

Relating to the effect of grain moisture content on the criterion costs for sakha-101 variety, results showed that, increasing grains moisture content from 10 to 12% under constant clearance of out let of 7.5 mm and various feed rate of 1.0, 1.2, 1.4 and 1.6 Mg/hr., decreased criterion costs from 267.05 to 261.15; 257.20 to 249.33; 249.20 to 237.90 and from 270.80 to 264.60%, respectively .Any further increase in grain moisture content more than 12 up to 16% measured at the same previous feed rates increased criterion costs from 261.15 to 287.45; 249.33 to 282.60; 237.90 to 275.95 and from 264.60 to 290.85%, respectively. While, for rice variety Giza 178, increasing grains moisture content from 10 to 12% under constant clearance of out let of 5 mm and various feed rate of 1.0, 1.2, 1.4 and 1.6 Mg/hr., decreased criterion costs from 308.90 to 289.20; 300.00 to 271.80; 313.55 to 297.95 and from 322.90 to 303.90%, respectively. Any further increase in grain moisture content more than 14 up to 16% measured at the same previous feed rates increased criterion costs from 289.20 to 313.60; 271.80 to 305.35 and 297.95 to 320.65 and from 303.90 to 327.10%, respectively.

Sakha 101 variety **Giza 178 variety**

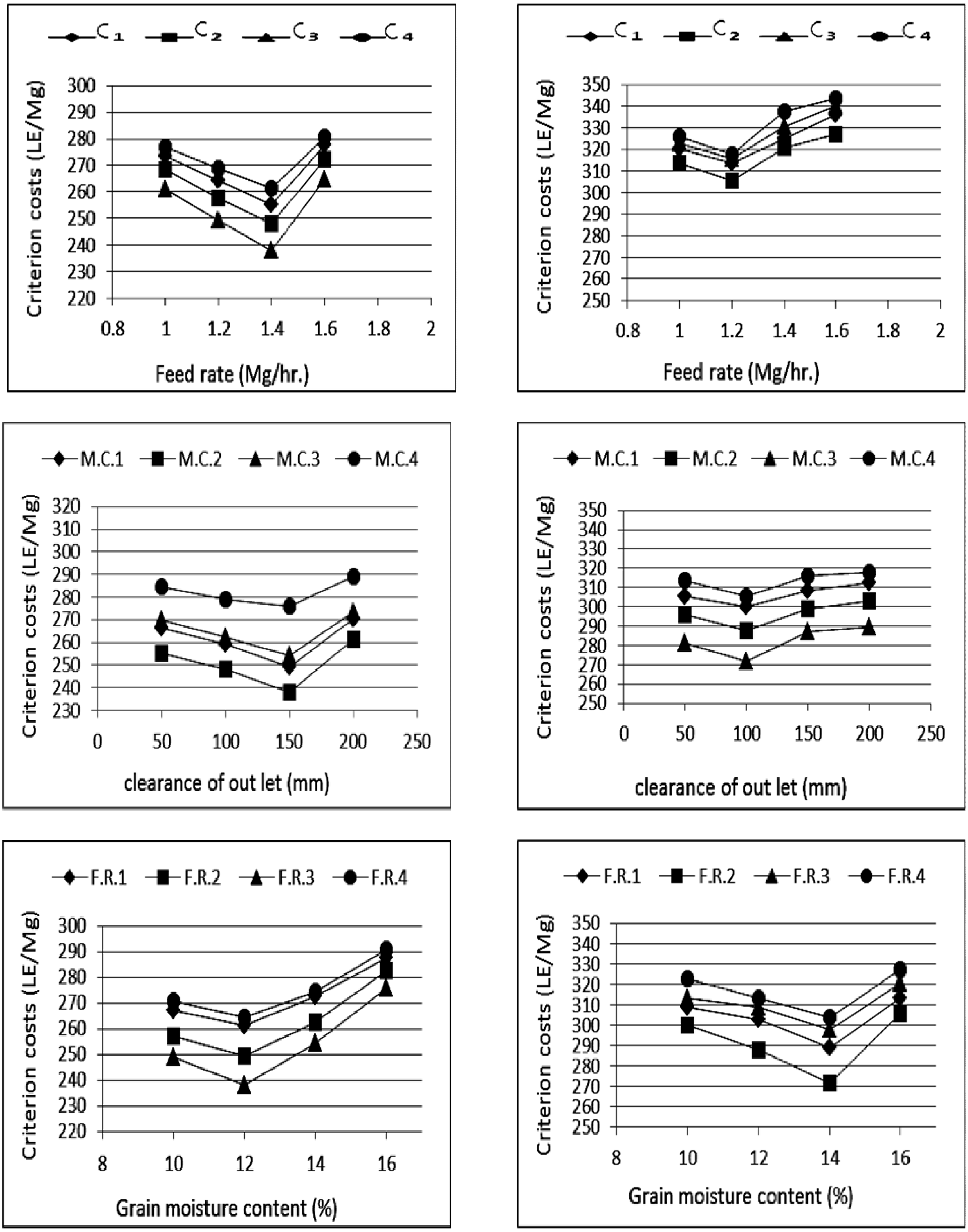


Fig. 7. Effect of feed rate, clearance of out let and grain moisture content on criterion cost for Sakha 101and Giza 178 varieties

Conclusion

The machine performance was evaluated using two rice varieties. From obtained results, the following conclusions can be taken:

- The highest value of machine productivity and overall machine efficiency was 1.086 Mg/hr., and 86.75%, the lowest value of specific energy and the criterion costs were 14.23 kW.hr./Mg and 271.80 LE/Mg for Giza-178 variety, respectively under clearance of out let of about 5 mm, feed rate of 1.20 Mg/hr., and grain moisture content of 14%.
- The highest value of machine productivity and overall machine efficiency was 1.173 Mg/hr., and 93.00%, the lowest value of specific energy and the criterion costs were 13.29 kW.hr./Mg and 254.28 LE/Mg for Sakha-101 variety, respectively under clearance of out let of about 7.5 mm, feed rate of 1.40 Mg/hr., and grain moisture content of 12%.
- The experimental results recommended the following main points when using milling machine:

• Adjust the milling machine at clearance of out let of about 5 mm for Giza 178 variaty and 7.5 mm for sakha 101 variaty.

• Operate the milling machine at a feed rate of 1.20 Mg/hr., (%) for Giza 178 variaty and 1.40 Mg/hr., for sakha 101 variaty.

• The best results were obtained at grain moisture content of 14% for Giza 178 variaty and 12% for sakha 101 variaty.

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تقييم أداء آلة لضرب الأرز تحت الظروف المصرية

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تم تنفيذ التجارب بمضرب خاص لضرب الأرز- فارسكور- محافظة دمياط لتقييم أداء آلة تقشير وتبييض الأرز لصنفي (سخا ١٠١ وجيزة ١٧٨)، وتم قياس الخصائص الطبيعية والهندسية لحبوب صنفي الأرز لما لها من تأثير معنوى على أداء الآلة موضع الدراسة، بالإضافة إلى الاستفادة بها عند تصميم وتطوير الآلات المختلفة فضلاً عن دراسة تحليل سلوك المنتج موضع الدراسة.لذلك تم قياس بعض الخصائص الطبيعية والهندسية لحبوب الأرز، وفيما يلى الأهداف الخاصة بهذه الدراسة: تحديد القيم المثلى لكل من معدل التلقيم وخلوص فتحة خروج الأرز ونسبة الرطوبة للحبوب لصنفين من الأرز تحت الدراسة، تقييم آلة ضرب الأرز فنيا واقتصاديا، ولتقييم أداء الآلة المطورة في تقشير وتبييض صنفي الأرز محل الدراسة تم أخذ بعض العوامل التالية: أربع معدلات تلقيم مختلفة لحبوب الأرز هي: ١,٠ ، ١,٢ ، ١,٤ و١,٦ ميجاجرام/ساعة وأربع خلوصات مختلفة لفتحة خروج الأرز (٢,٥ - ٥ - ٧,٥ - ١٠) مم عند أربع نسب رطوبة مختلفة للحبوب هي: ١٠ - ١٢ - ١٤ - ١٦%، تم قياس نسبة الفواقد الكلية لحبوب الأرز، حساب الكفاءة الكلية لآلة ضرب الأرز وانتاجيتها، تقدير القدرة اللازمة وكذا الطاقة النوعية والتكاليف الكلية لعملية التبييض، وقد أوضحت النتائج المتحصل عليها أن أفضل القيم المتحصل عليها أثناء التشغيل كانت كالتالي: أعلى إنتاجية للآلة في عملية تقشير وتبييض الأرز كانت ١,٠٨٦ ميجاجرام/ساعة، بينما كانت أعلى كفاءة ٨٦,٧٥% بينما أقل طاقة مستهلكة لعملية تقشير وتبييض الأرز باستخدام الآلة ١٤,٢٣ كيلوات.ساعة/ميجاجرام بينما أقل تكاليف حدية للآلة ٢٧١,٨٠ جنيه/ميجاجرام لصنف الأرز جيزة - ١٧٨وذلك تحت ظروف التشغيل التالية: خلوص فتحة خروج الأرز ٥ مم و معدل تلقيم ١,٢ ميجاجرام/ساعة عند نسبة رطوبة ١٤%، أعلى إنتاجية للآلة في عملية تقشير وتبييض الأرز كانت ١,١٧٣ ميجاجرام/ساعة، بينما كانت أعلى كفاءة ٩٣,٠٠% بينما أقل طاقة مستهلكة لعملية تقشير وتبييض الأرز باستخدام الآلة ١٣,٢٩ كيلوات.ساعة/ميجاجرام بينما أقل تكاليف حدية للآلة ٢٥٤,٢٨ جنيه/ميجاجرام لصنف الأرز سخا-١٠١ وذلك تحت ظروف التشغيل التالية: خلوص فتحة خروج الأرز ٧,٥ مم ومعدل تلقيم ١,٤ ميجاجرام/ساعة عند نسبة رطوبة ١٢%، ومما تقدم توصى الدراسة بما يلي: تشغيل الآلة عند نسبة رطوبة ١٤% لصنف الأرز جيزة-١٧٨ عند خلوص فتحة خروج الأرز ٥ مم ومعدل تلقيم ١,٢ ميجاجرام/ساعة، بينما يتم تشغيل الآلة عند نسبة رطوبة ١٢% لصنف الأرز سخا-١٠١ عند خلوص فتحة خروج الأرز ٧,٥ مم و معدل تلقيم ١,٤ ميجاجرام/ساعة.

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