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TEST AND EVALUATION OF THE FACTORS AFFECTING ON THE FRESHLY HARVESTED PEANUT THRESHING MACHINE PERFORMANCE

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ABSTRACT

Peanut is an important produce in the global food chain because of their high-quality oil and protein content. Due to the significant value of its production in Iran, a threshing machine was developed for high-quality harvesting, to reduce harvesting costs and labor effort. In the course of a number of field experiments to evaluate the performance of the machine, the rotational speed of the thresher was adopted at three levels of 150, 200, and 300 rpm. Other experimental factors included the distance of the concave from the thresher (2, 6, and 8 cm) and the product feeding rate of 750, 850, and 950 kg·h^{-1}. Regarding the measurements, the threshing efficiency, the separation rate, and the percentage of the crushed product were calculated and evaluated. The results revealed that as the rotational speed of the thresher, the increment feeding rate of the product and the distance between the thresher and the concave grate increased, the thresher efficiency decreased. The maximum threshing efficiency of 95% was obtained at a rotational speed of 150 rpm and a distance of 2 cm. Also, with increasing the rotational speed of 300 rpm and a distance of 8 cm, the threshing efficiency decreased to 75%. The separation rate decreased intensely as the distance between the thresher and the concave increased. In addition, the separation rate decreases with increasing rotational speed of the thresher. At a rotational speed of 150 rpm and a distance of 2 cm, the separation rate was 96%, but the separation rate decreased to 76% as rotational speed increased to 300 rpm and distance increased to 8 cm. With increasing rotational speed and feeding rate, the percentage of crushed pods increased. The maximum of 16% was obtained at a rotational speed of 300 rpm, a feeding rate of 950 kg·h^{-1} and a distance of 2 cm.

Nomenclature

V	Linear velocity ($m \cdot s^{-1}$)	E_t	Threshing efficiency (%)
R	Radius (m)	w_l	Weight of pods collected from all outlets per time unit ($kg \cdot h^{-1}$)
ω	Angular velocity ($rad \cdot s^{-1}$)	w_0	Weight of remaining crops per time unit ($kg \cdot h^{-1}$)
η_h	Separation rate (%)	B_p	Percentage of broken pods (%)
w_p	Weight of harvested crops per area ($kg \cdot m^{-2}$)	w_b	Weight of the crushed pods collected from the main threshing output per time unit ($kg \cdot h^{-1}$)
w_s	Weight of leftover crops per area ($kg \cdot m^{-2}$)	W_1	Weight of total pods per time ($kg \cdot h^{-1}$)
		abbreviation	
		PTO	Power Take-Off

Introduction

Seed loss and physical damage, including cracking and crushing seeds at harvest, are significantly affected by threshing performance. Therefore, in recent decades, different research has been conducted on different threshing methods and the design and development of different threshing machines (Fu et al., 2018). However, because the maintenance of yield and the reduction of damaged seeds play an important role in sustainable development, research on threshers continues. The loss rate is the key parameter in evaluating the threshing process (Karlen et al., 2014). According to reports, the main sources of seeds loss include environmental conditions, harvesting, collection, threshing, and separation (Abdi and Jalali, 2013). Although control of natural factors is largely beyond human control, decreasing mechanical losses in the threshing process is a good option to enhance seed yield (Pishgar-Komleh et al., 2013).

Peanut (*Arachis hypogaea* L.) is an annual legume that is cultivated in 109 countries due to the high quality of its oil and protein content in the seed. The cultivation area of this crop in Iran is approximately 3000 hectares, and the average yield is 4 tons per hectare. Peanut is specific to tropical and subtropical regions. The seeds of this valuable plant have a 44-55% oil content, which makes peanut the third oilseed plant in the world after soybean and rape (Dobreva et al., 2021). Peanut pods containing seeds and shells grow in the ground, while the plant blooms and is fertilized above the ground. Therefore, when harvesting this crop, its edible part is contaminated with soil, and the optimal separation of soil from the pod and the subsequent removal of seeds from the pod is of great importance to maintain its yield (Anco et al., 2020).

Mechanical damage is usually caused by the seed hitting the rigid surface of the thresher unit, the short distance between the thresher and the concave, the feeding rate, and the inadequate thresher speed (Ali et al., 2021). The process of threshing peanuts is largely done manually, usually at 175 to 200 hours of labor per hectare required for seed-pod separation

(Reddy et al., 2012). To remedy this, Singh and Verma (1972) developed an experimental peanut thresher. During the evaluation, it was found, i.e., that the crop moisture content reduces damage to the seeds. In another study Singh and Verma (1972) reported that the optimal threshing speed was at 5·7 $m \cdot s^{-1}$. According to research on seed produce such as cereals and legumes, the factors of the rotational speed, the distance between the thresher and the concave, the feeding rate, and the shape of the thresher teeth are the most important factors in the performance and quality of the seeds (Singh and Verma, 1972). Sudajan et al. (2002) investigated the effect of threshing speed, the thresher-concave distance, and feeding rate on wheat threshing yield. Increasing the rotational speed and decreasing the distance between the thresher and the concave increased the percentage of damaged seeds, however, the mass of the threshed product increased per unit of time. Additionally, with increased feeding rate, the percentage of broken seeds increased (Sudajan et al., 2002).

Vejasit and Salokhe (2004) investigated the effect of threshing speed and concave distance and feeding rate on soybean threshing performance. According to the results, increasing the rotational speed of the thresher and reducing the thresher-concave distance increased the percentage of seed damage (Vejasit and Salokhe, 2004). The effects of threshing speed, thresher-concave distance, and feeding rate on the performance of sunflower thresher were investigated (Goel et al., 2015). It was found that increasing the rotational speed of the thresher and reducing the thresher-concave distance enhance the percentage of seeds damage. Vennela et al. (2018) compared the performance of a stationary thresher working with the tractor's power take off (PTO) shaft with a manual pedal thresher. The results showed that increasing the threshing speed causes a higher threshing efficiency. The working capacity of the PTO power thresher was also found to be 4 times higher than that of the manual pedal thresher (Vennela et al., 2018). Aboegela and Mourad (2021) tested an experimental thresher to separate peanut seeds from pods using rasp, spike teeth, and knife threshers. It was found that efficiency of the process increased as the threshing rotational speed increased and the feeding rate decreased. Additionally, the highest efficiency was obtained with the knife-type thresher (Aboegela and Mourad, 2021). The effect of the rotation speed of the thresher, the material of the thresher blade, and the number of thresher rasp bars were investigated in another study. The material of the thresher plates was selected from metal, rubber, and plastic, and the number of bars was 6, 9, and 12. The results of this study showed that increasing the rotational speed and the number of rasp bars increased the threshing efficiency, but also increased the number of damaged seeds. Metal plates increased the threshing efficiency, while rubber plates reduced the number of damaged seeds. By increasing the number of rubber rasp bars and the average speed, it is possible to have high threshing efficiency and low damaged seeds at the same time (Senthilkumar et al., 2017). El-Awady et al. (2009) evaluated the effect of the angle of the sieve and suction velocity on sieve cleaning efficiency of the sieve. They found that as the angle of the sieve and suction velocity increased, so did the machine’s working capacity of the machine (mass per unit time), but the cleaning efficiency and seed loss rate increased intensively (El-Awady et al., 2009).

Some modification was made to the wheat thresher in Turkey to turn it into an axial thresher to increase threshing performance; the threshing capacity of this thresher has been reported in wheat and rice 390 and 634 $kg \cdot h^{-1}$, respectively. In addition, 1.5 and 1.2% were achieved in threshing wheat and rice, respectively (Khan and Chaudhry, 1990).

Considering the literature review on the peanut threshing machine was limited and there are practically no manufacturers of this product on the world markets, the purpose of this study is to investigate the factors affecting the quality of threshing and the separation of peanuts. In addition, the effect of the working parameters of an experimental peanut thresher on the performance of the thresher unit was investigated.

Materials and Methods

The experiments were performed in Ardabil province, Parsabad Moghan region, Iran (39º.65´ N, 47º.91´ E) using the peanut cultivar NC2, grown in the Agricultural Research Center of Ardabil and Gilan provinces. A peanut threshing machine was used to separate seeds from peanut pods (Figure 1). The following operational parameters were taken into consideration in assessing the performance of the machine, including the thresher rotational speed, the thresher-concave distance and the feeding rate. The average seed weight per kilogram of peanut was 300-400 grams. The moisture content of the seeds in the tested cultivar was 45%. The samples were dried at 130ºC for 18 hours in a convective dryer. The weight reduction of samples due to moisture loss was recorded and crop and seed moisture was determined in percentage. To use the threshing machine, the plant must first be harvested and piled, and then fed into the machine through a feeder.

Figure 1. A panut threshing machine

According to initial experiments, it was found that at the rotational speed less than 50 rpm the tresher does not have a high ability to separate the seeds from the pod, although the percent of damaged seeds is low. According to previous studies, at a rotational speed greater than 100 rpm, threshers have a high ability to separate seeds from the pod, however the number of damaged seeds has also increased with increasing threshing speed (Aboegela and Mourad, 2021; Senthilkumar et al., 2017; Srinivasan et al., 2021; Vennela et al., 2018). Therefore, in this experiment, the thresher rotational speed was selected between 100 and 300 rpm to determine the optimal value of the thresher speed in combination with the feeding rate and the thresher-concave distance (Table 1).

Table 1.
Independent parameters of the thresher section

Parameter	Level 1	Level 2	Level 3
Rotational speed of thresher (rpm)	150	200	300
Feeding rate ($kg \cdot h^{-1}$)	750	850	950
Thresher-concave distance (cm)	2	6	8

The factorial experimental design, i.e. a fully randomized design was used to analyze the main effects and relations between independent factors. Also, Duncan's multiple domain test at a 5% probability level was used to compare the means.

To measure the rotational speed of the thresher shaft and other actuator shafts, the Mar menix MTC 442 contact Tachometer was used.

Mechanical components of the peanut threshing machine

Feeding unit

The feeding unit consists of a 2 mm metal sheet chamber (120 cm×80 cm×20 cm). A chain with 4 cm flaps feeds peanuts into the machine. Its rotational torque of which is powered by a pulley and a conveyor attached to it. The mechanism is connected to the actuator of the machine (Fig. 2). The conveyor pulley or chain speed is increased or decreased by changing the pulley diameter. By changing the size of the pulley diameter to 12, 14, and 16 cm, the rotational speed of the conveyor pulley was 50, 70, and 100 rpm, respectively. In this section, first, the peanut plant weighed in 1 to 100 kg clusters and also entered through feeder, experimentally. After the experiment, it was concluded that the minimum amount of peanut fed into the machine is 20 kg, and the maximum is 70 kg. The retention time of the peanut in this section was 2 to 6 seconds, which was achieved by changing the size of the pulleys.

Figure 2. Product feeder to the thresher unit

The thresher unit

With a helix 2 meters long, the unit is considered an axial current thresher (Fig. 3). The rotational speed changes with the diameter of the pulley diameter (20, 22, 25 cm). By changing the pulley and the rotational speed of the tractor, it was concluded that it is not possible to separate the pods and cocoons of peanuts from the plants at speeds of less than 100 rpm. Therefore, with the change of pulleys and the PTO rotational speed, the threshing speed should be above 100 rpm. At a speed greater than 100 rpm, the peanut plants were completely removed from the threshing machine and their pods were completely separated from the straw.

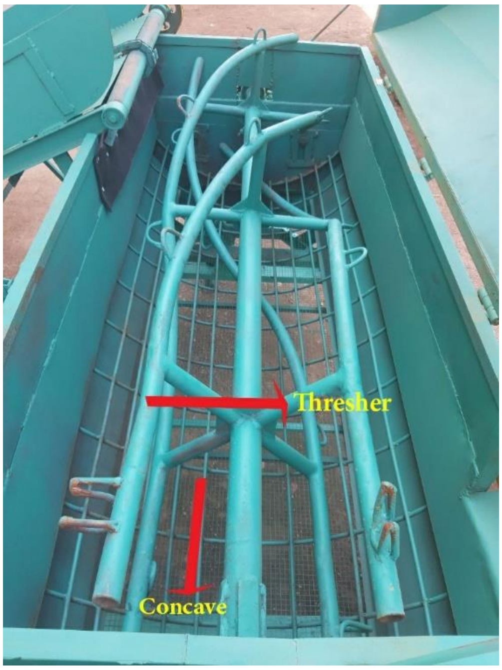

Figure 3. Thresher and concave system

The concave

The concave grate is a metal structure made of round rods, which houses metal rods, 10 cm in diameter. This grate has rectangular holes with area of 15 cm^2, which provide an easy passage of peanut pods. The concave performs threshing of peanuts and metal roads are responsible for removing the pods from the roots. The thresher is fixed, but the thresher-concave distance is adjustable with a bolt. The distance variation range was between 2-8 cm. It was determined that to separate the peanut pod from the roots and straw with less damage to straw, stalks and pods, the distance should be more than 2 cm.

The sieve

In this section, peanuts are sifted and cleaned. This unit includes a chassis and a galvanized net with 1 cm^2 holes (Fig. 4). When the pods move forward on the sieve, they are cleaned from mud. The sieve normal inclination angle was 15º and can be increased up to 30º. The connecting rod arm is 14 cm long, and has a reciprocating motion which shakes sieve at predetermined frequency and amplitude. The amplitude of sieve was varied through three off-center points embedded on the crank. The linear speed of this unit is adjusted by the pulley connected to the gearbox. In addition, the pulley diameter can be changed to 12, 14, and 16 cm. The linear velocity is also calculated according to equation (1):

$$V=R\cdot\omega \quad (1)$$

where:

V – is the linear velocity, $m\cdot s^{-1}$

R – is radius, m

ω – is the angular velocity, $rad\cdot s^{-1}$

Figure 4. Sieve in the separation section

The blower

The blower was mounted to create a velocity slightly lower than terminal velocity of peanut pods for separation of stripped plants, straw and other foreign materials (Fig. 5). The rotation speed of important parameters such as blower suction velocity is adjustable. The flow velocity is regulated based on separation performance.

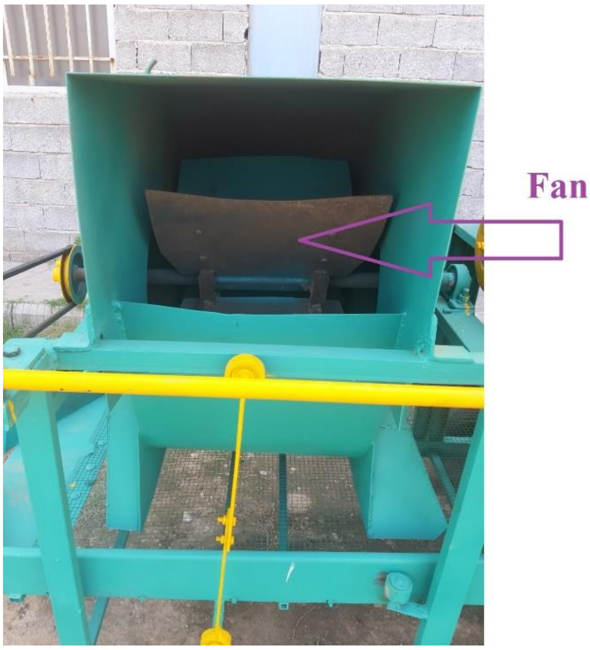

Figure 5. Suction fan that was used to separate foreign materials from peanut pods.

Evaluation of peanut threshing machine

Separation rate

Separation rate is the percentage of peanut pods that were separated from roots and stems. This comparison is relative to the peanut separation with labors and other non-mechanized methods. The separation rate was calculated using the Eq. (2):

$$\eta_h = \frac{w_p}{(w_p+w_s)} \cdot 100 \qquad (2)$$

where:

η_h – is the separation rate, (%)

w_p – is the weight of collected seeds per area, (kg·m^{-2})

w_s – is the weight of remaining seeds on the field per area, (kg·m^{-2})

Threshing efficiency

The threshing efficiency is the ratio of weight of pods collected from all outputs per time unit and weight of input pods per time (Eq. 3).

$$E_t = \frac{w_l}{w_0} \cdot 100 \tag{3}$$

where:

E_t – is the threshing efficiency, (%)

w_l – is the weight of pods collected from all outlets per time, (kg·h^{-1})

w_0 – is the weight of input pods per time, (kg·h^{-1})

Broken pods

The percentage of broken pods is calculated using the following the equation (4):

$$B_p = \frac{w_b}{w_1} \cdot 100 \tag{4}$$

where:

B_p – is the percentage of broken pods, (%)

w_b – is the weight of the broken pods collected from the main outlet per time, (kg·h^{-1})

w_1 – is the weight of total input pods per time, (kg·h^{-1})

Results and Discussion

The results of variance of variables analysis on threshing criteria were presented in Table (2).

Table 2.
Results of analysis of variance (ANOVA) to evaluate the variables of the thresher-concave distance, the feeding rate and the thresher rotational speed on threshing performance.

Source	Df	Mean Square		
		Threshing efficiency	Pod separation rate	Broken pods
D	2	570.215**	64.9557**	27.850**
F	2	84.813**	55.956**	48.536**
S	2	741.453**	45.2449**	42.7852**
D*F	4	5.466**	1.732^{ns}	2.860**
D*S	4	38.956**	25.974**	27.715**
F*S	4	8.289**	0.185^{ns}	0.009^{ns}
D*F*S	8	0.848^{ns}	0.764^{ns}	0.026^{ns}
Error	54	0.786	0.776	0.015
Total	80			

D: Thresher-concave distance , F: The feeding rate, S: Speed of the thresher

Relation of experimental factors on the efficiency of threshing

The relation between the thresher and the concave distance and the feeding rate on the threshing efficiency is shown in Figure 6. The maximum threshing efficiency of 90% was obtained at a short distance of 2 cm, and a feeding rate of 750 kg·h^{-1}. However, with increasing distance and feeding rate, the threshing efficiency decreased, so the efficiency was reached 77% at a maximum distance of 8 cm and a feeding rate of 950 kg·h^{-1}. As the distance between the thresher and the concave increases, the threshing efficiency decreases intensively. Also, as the feeding rate, the threshing efficiency decreased.

As a noteworthy point in Figure (6) is that at the thresher and concave distance of 2 cm compared to the other two distances of 4 and 8 cm was very sensitive to feeding rate change in terms of threshing efficiency decrement, since the reduction slope was sharp. Furthermore, the feeding rate of 750 kg·h^{-1} was more sensitive to changes in the distance between the thresher and the concave than the other two feeding rates, based on the reduction of threshing efficiency. Therefore, when the feeding rate is low, it is better to keep the distance between the thresher and the concave as small as possible, so that the product engagement should be desirable in terms of threshing.

Figure (6) shows the distance between the thresher and the concave is a more important factor in controlling the threshing efficiency because by adjusting the thresher-concave distance of 2 cm, the feeding rate did not significantly impact on reducing the efficiency. At a feeding rate of 950 kg·h^{-1} and a distance of 6 cm between the thresher and concave the threshing efficiency was higher than when the thresher and concave distance was 6 cm and the feeding rate was 750 kg·h^{-1}. Similar results have been reported in the research on a peanut harvester (Srinivasan et al., 2021).

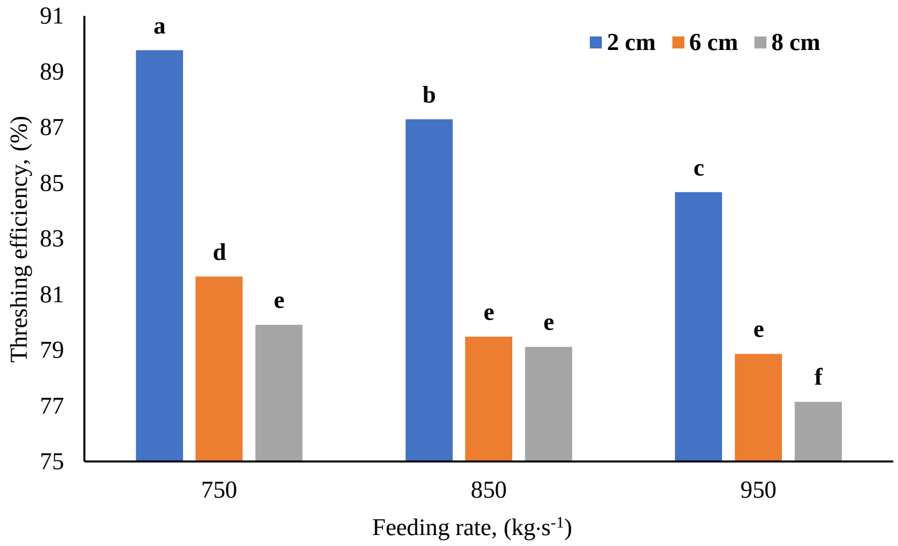

Figure 6. Effect of the relation between the thresher-concave distance and the feeding rate on threshing efficiency.

Figure 7 shows the relation between the thresher-concave distance and the rotational speed of the thresher on the thresher efficiency. The maximum threshing efficiency was 95%

at a rotational speed of 150 rpm and a distance of 2 cm. With increasing the thresher rotational speed and thresher-concave distance, the threshing efficiency decreased, and at a rotational speed of 300 rpm and a distance of 8 cm, the threshing efficiency was 75%.

Please note that in Figure (7) setting a 2 cm distance between the thresher and the concave is very sensitive to changes in the rotational speed of the thresher compared to the other two distances. Its efficiency decreases more sharply as speed increases. Also, the rotational speed of 150 rpm is more sensitive to changes in distance between the thresher and concave than the other two rotational speeds, and its efficiency decreases with a greater slope as distance increases. Therefore, at a low rotational speed, it is better to keep the distance between the thresher and the concave as small as possible, so that the impact on the product between the thresher and the concave increases, hence the threshing process is performed precisely.

Also, the thresher-concave distance at a rotational speed of 150 and 200 rpm is a more important factor in controlling the threshing efficiency, and its variations have a more important role in controlling the threshing efficiency than the rotational speed. Therefore, to obtain a higher threshing efficiency, it is recommended to change the distance between the thresher and the concave instead of reducing the rotational speed. Researchers in many studies have pointed out that the reduction of rotational speed due to reduced working capacity is not economically justified and used distance as a variation in the thresher control the impact efficiency on the product (Bello et al., 2019).

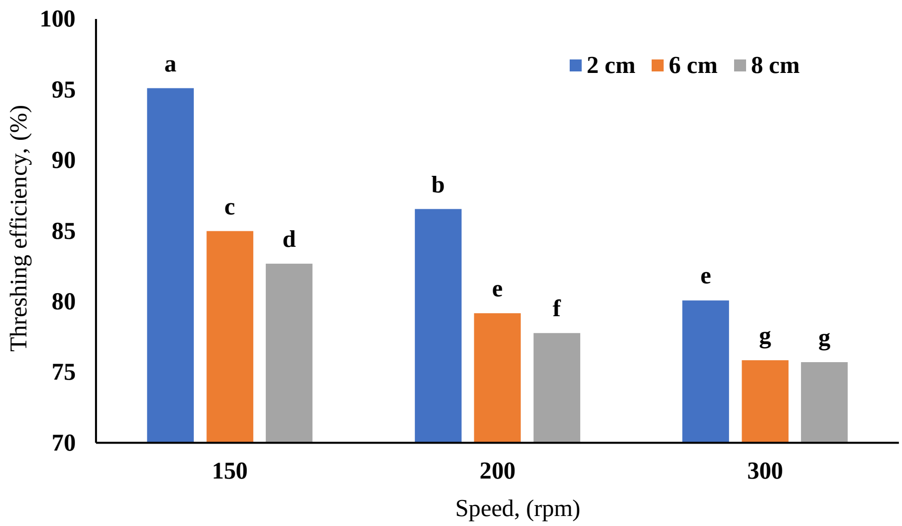

Figure 7. Relation between the thresher-concave distance and rotational speed on the threshing efficiency

Figure 8 shows the relation between the feeding rate and the rotational speed of the thresher on the threshing efficiency. It was found that the threshing efficiency decreased with increasing rotational speed and feeding rate. Threshing efficiency decreased from a maximum of 90% at 150 rpm and a feeding rate of 750 kg·h^{-1} to 77% at a rotational speed of 300 rpm and a feeding rate of 950 kg·h^{-1}. The feeding rate of 750 kg·h^{-1} was more sensitive to the rotational speed of the thresher than other feeding rates, so with the increase of the thresher speed, its threshing efficiency decreased more sharply. Please note that in Figure (8) changes in rotational speed were more effective on controlling the threshing efficiency than the feeding rate. It is obvious that at a rotational speed of 300 rpm, changing the feeding rate showed little effect on increasing the threshing efficiency. However, changing the rotational speed to 200 rpm at all feeding rates, the threshing efficiency was higher than the threshing efficiency at 300 rpm.

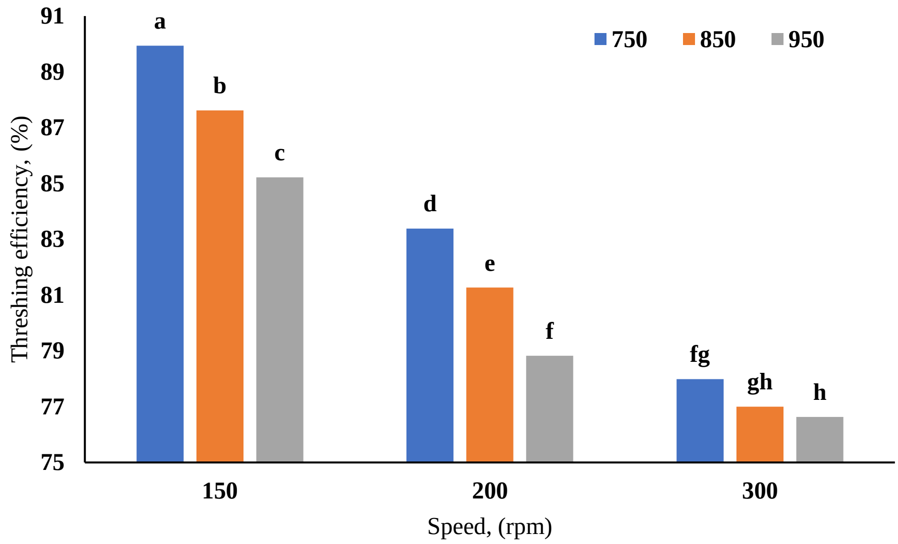

Figure 8. Relation between the feeding rate in rotational speed and the threshing efficiency

The statistical characteristics of the regression model that predict the impact efficiency based on the thresher-concave distance, feeding rate, and thresher rotational speed are presented in Table (3). According to the standard coefficients in this table, it can be concluded that the thresher concave distance was the most effective factor and the feeding rate and the rotational speed of the thresher were in second and third place. The final predictor equation is given below. The determined coefficient of 0.86 showed a good relationship between the threshing efficiency and the investigated parameters.

Table 3.
Statistical characteristics of stepwise regression model for predicting threshing efficiency based on thresher - concave distance, thresher rotational speed and feeding rate

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	107.10	1.17	91.84	0.000	
D	-1.476	0.101	-14.56	0.000	1.00
F	-0.04333	0.00766	-5.65	0.000	1.00
S	-0.002016	0.000123	-16.38	0.000	1.00

Threshing efficiency=107.10-1.476 D-0.04333 F - 0.002016 S, R^2=0.86

Investigation of the effect of experimental factors on the separation rate

The relation between the thresher-concave distance and the thresher's rotational speed of the thresher on the separation rate is shown in Figure 9. As the thresher-concave distance increased, the separation rate decreased sharply. Additionally, the separation rate decreased as the thresher rotational speed increased. At a rotational speed of 150 rpm and a distance of 2 cm, the separation rate was 96%; however, the separation rate decreased to 76% with increasing the rotational speed and distance to 300 rpm and 8 cm, respectively. It is noteworthy that setting the thresher-concave distance to 2 cm proved very sensitive to changes in the thresher rotational speed compared to the other two distances, and its separation rate declined more radically.

In addition, the 150 rpm rotational speed was more sensitive to changes in the thresher-concave distance than the other two rotational speeds, and the separation rate decreased with a greater slope. Therefore, when the thresher-concave distance is small, it is better to keep the rotational speed of the thresher as low as possible. Otherwise, due to the high speed and the short thresher-concave distance, many pods can be crushed and destroyed, or the pod may not be separated from the plant at all (Bello et al., 2019).

Therefore, the thresher-concave distance is a more important factor in controlling the separation rate. There is no need to change the thresher speed to achieve a higher separation rate at a constant speed because by adjusting the distance of 2 cm between the thresher and the concave, the separation rate increased. Finally, the separation speed can be improved by minimizing the thresher-concave distance and using the average speed.

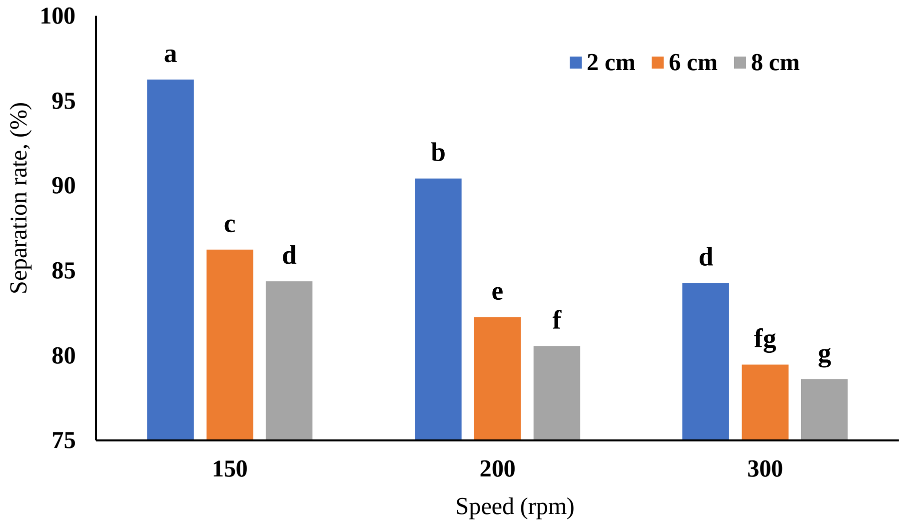

Figure 9. Interaction of the thresher-concave distance and rotational speed on the separation rate.

The effect of the feeding rate on the separation rate is presented in Figure (10). As can be seen, the separation rate reduced rapidly with increasing the feeding rate. At a feeding rate of 750 kg·h^{-1}, the separation rate was 86% and the separation rate was decreased to 83% with increasing the feeding rate to 950.

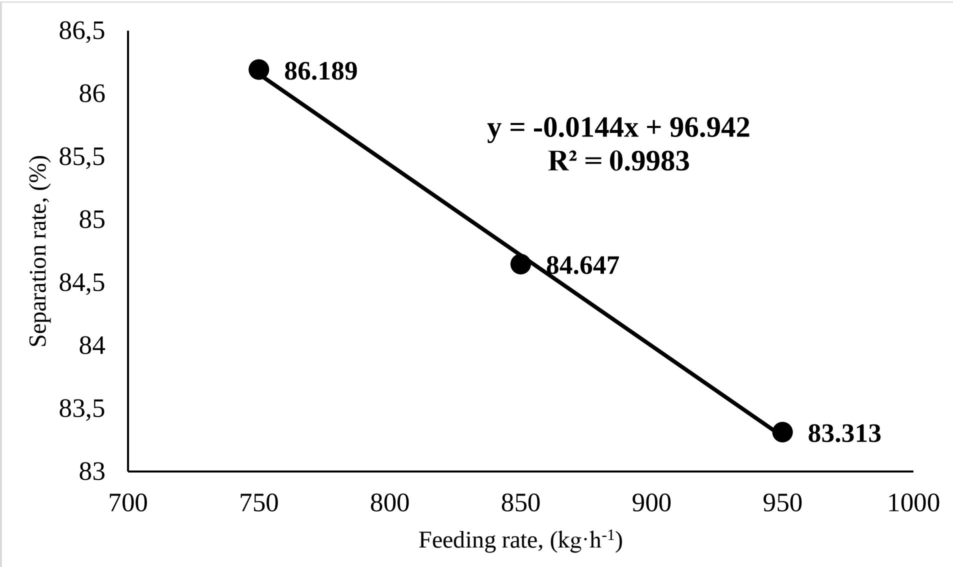

Figure 10. Impact of the feeding rate on the separation rate

The statistical characteristics of the regression model predicting the separation rate based on the variables of the thresher-concave distance, feeding rate, and thresher rotational speed are presented in Table (4). According to the standard coefficients, it can be concluded that the thresher-concave distance and the rotational speed have the greatest and least effect on the separation rate, respectively. The final predictor equation is given below with determination value of 0.91.

Table 3.
Statistical characteristics of stepwise regression model for predicting the separation rate based on thresher-concave distance, the thresher rotational speed and the feeding rate.

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	106.859	0.894	119.47	0.000	
D	-1.5789	0.0778	-20.30	0.000	1.00
F	-0.03501	0.00588	-5.96	0.000	1.00
S	-0.001601	0.000094	-16.95	0.000	1.00

Separation rate=106.859 - 1.5789D - 0.03501F 0.001601S, R^2=0.91

Investigation of the relationship between the effects of experimental factors and the percentage of broken pods.

Figure 11 shows the feeding rate interaction and the thresher-concave distance on the percentage of broken pods. Increasing the feeding rate increased the percentage of broken pods. That could be due to the thick layer created by the high feeding rate between the thresher and the concave. At a feeding rate of 750 $kg \cdot h^{-1}$, the percentage of broken pods increases with increasing thresher-concave distance. At a feeding rate of 850 and 950 $kg \cdot h^{-1}$, the percentage of broken pods reduces with increasing the thresher-concave distance. On the other hand, increasing the thresher-concave distance to 8 cm increased the percentage of broken pods.

Khan and Chaudhry (1990) found that the total loss of the threshing machine (total percentage of seed not separated from the cluster and not removed from the percentage of straw) and the damaged seed at a rotational speed of 850 rpm (linear velocity= 20 $m \cdot s^{-1}$) was minimal.

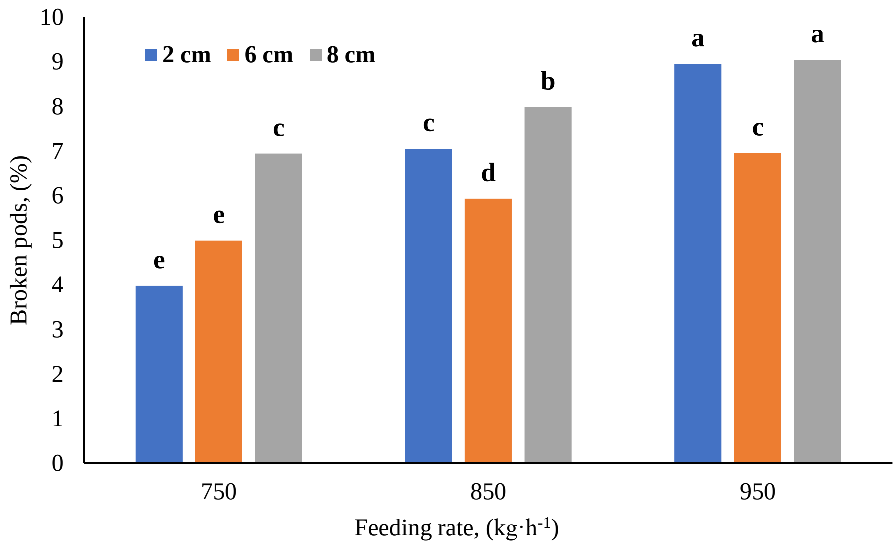

Figure 11. Impact of the relation between the thresher-concave distance and the feeding rate on the percentage broken pods.

Figure 12 shows the relation between the thresher-concave distance and the rotational speed of the thresher on the percentage of broken pods. The percentage of broken pods was higher when the rotational speed was increased. It was found that at rotational speed of 150 rpm, the percentage of broken pods increased as the thresher-concave distance increased, but at the rotational speed of 200 and 300 rpm and increasing the distance to 6 cm the percentage of broken pods decreased. The percentage of broken pods increased again with increasing the thresher-concave distance to 8 cm. Past studies have reported that the optimal selection of threshing rotational speed and the thresher-concave distance can increase the threshing efficiency and also reduce the broken pod percentage simultaneously. These results are consistent with the results achieved in this study (Aboegela and Mourad, 2021; Senthilkumar et al., 2017; Srinivasan et al., 2021; Vennela et al., 2018).

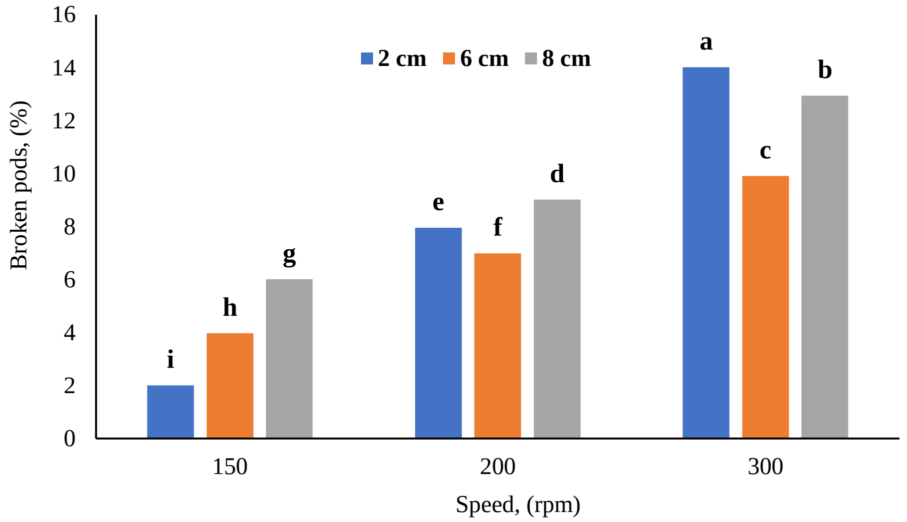

Figure 12. Interaction of the distance between the thresher and the concave in rotational speed on broken pods percentage.

Regression analysis showed that thresher-concave distance was the highest effect on broken pods. The feeding rate and rotational speed ranked second and third. The determined coefficient value of 0.93 shows that the percentage of broken pods depends on the parameters investigated in this research.

Table 5.
Statistical characteristics of stepwise regression model for predicting the broken pod percentage based on the thresher-concave distance, the thresher rotational speed and the feeding rate.

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-13.61	1.11	-12.31	0.000	
D	1.91	0.188	10.2	0.000	16.69
R	0.054	0.008	6.69	0.000	5.57
S	0.00027	0.00013	20.63	0.000	5.57
D*R	-0.0041	0.00139	-2.96	0.004	8.52
D*S	-.00021	0.00002	-9.6	0.000	18.31

Pod breakage rate=-13.6 +1.914D +0.0548R + 0.00271S-0.0042D*R-0.000215D*S R^2=0.93

Conclusion

In field experiments, the effects of thresher rotational speed, the thresher-concave distance, and the feeding rate of the peanut crop on the threshing machine performance were investigated. The following results were achieved:

1. By increasing the thresher-concave distance, the threshing efficiency sharply decreased. Also, with an increase in the feeding rate, the threshing efficiency is reduced. When the rotational speed of the thresher and the thresher-concave distance were increased, the threshing efficiency decreased. The maximum threshing efficiency was 95% at a rotational speed of 150 rpm and a thresher-concave distance of 2 cm.
2. The separation rate decreased sharply with the increasing thresher-concave distance. Moreover, the separation rate decreased with the increasing rotational speed of the thresher. At a rotational speed of 150 rpm and a thresher-concave distance of 2 cm, the separation rate was 96%. The separation rate decreased to 76% with increasing rotational speed and the thresher-concave distance to 300 rpm and 8 cm, respectively. Also, the separation rate decreased linearly with increasing feeding rate.
3. The percentage of broken pods increased with increasing rotational speed and feeding rate of the thresher. However, the thresher-concave distance showed different effects with different rotational speeds and different feeding rates. In total, a distance of 6 cm is the optimal distance to reduce the amount of broken pods.

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BADANIE I OCENA CZYNNIKÓW WPŁYWAJĄCYCH NA WYDAJNOŚĆ MŁOCARNI ORZESZKA ZIEMNEGO

Streszczenie. Orzeszki ziemne są ważnym produktem w globalnym łańcuchu żywnościowym ze względu na jakość oleju i wysoką zawartość białka w ziarnach. Ze względu na znaczenie produkcji orzeszków ziemnych w Iranie, opracowano wysokiej jakości młocarnię do zbioru, aby zmniejszyć koszty zbioru i nakład pracy. W trakcie szeregu eksperymentów polowych mających na celu ocenę wydajności maszyny, prędkość obrotową młocarni przyjęto na trzech poziomach 150, 200 i 300 obr·min^{-1}. Pozostałe czynniki doświadczalne to: szczelina robocza młocarni: 2, 6 i 8 cm oraz prędkość podawania produktu: 750, 850 i 950 kg·h^{-1}. W wyniku przeprowadzonych pomiarów obliczono i oceniono skuteczność omłotu, stopień separacji oraz procent rozdrobnionego produktu. Wyniki wykazały, że wraz ze wzrostem prędkości obrotowej młocarni, przyrostu prędkości podawania produktu oraz odległości młocarni od wklęsłego klepiska, sprawność młocarni maleje. Maksymalną sprawność omłotu wynoszącą 95% uzyskano przy prędkości obrotowej 150 obr·min^{-1} i odległości 2 cm. Również przy zwiększaniu prędkości obrotowej do 300 obr·min^{-1} i odległości 8 cm sprawność omłotu malała do 75%. Szybkość oddzielania malała intensywnie wraz ze wzrostem odległości młocarni od wklęsłości. Ponadto stopień oddzielenia maleje wraz ze wzrostem prędkości obrotowej młocarni. Przy prędkości obrotowej 150 obr·min^{-1} i odległości 2 cm wskaźnik separacji wyniósł 96%, ale wraz ze wzrostem prędkości obrotowej do 300 obr·min^{-1} i zwiększeniem odległości do 8 cm wskaźnik separacji spadał do 76%. Wraz ze wzrostem prędkości obrotowej i szybkości podawania wsadu wzrastał procent rozdrobnionych strąków. Maksymalną wartość 16% uzyskano przy prędkości obrotowej 300 obr·min^{-1}, prędkości podawania 950 kg·h^{-1} i odległości 2 cm.

Słowa kluczowe: orzeszki ziemne, stopień separacji, efektywność młócenia, młocarnia