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Study of some technical indicators to the sunflower threshing machine locally designed and manufactured

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Abstract

The current study focused on improving the productivity and quality of sunflower through technical design that achieves the best productivity with the least loss by separating the grains from the husks, the reduction in the loss in the produced grains percentage is the separating methods the grains from the straw and the clearance between the cylinders and the cylinder rotation speed in addition to an important hope which is the sunflower grains moisture to be processed. The study aimed to determine the locally designed and manufactured threshing machine based on some technical indicators under different speeds 120, 160 and 200 rpm and at three moisture levels 11-13%, 13-15% and 15-17%. The experiments were conducted in a factorial experiment under complete randomized design with three replications. The speed 120 rpm was significantly superior to the other two levels of 160 and 200 rpm in all studied parameters, the power required and cracked grain ratio, were, 10.38 kW and2.782% except for productivity and efficiency achieved the best results with speed 200 rpm were 1.542t.hr^{-1} and 84.47% respectively under the same operating conditions for threshing machine. The results showed that the grain moisture 11-13% was significantly better than the 13-15% and 15-17% in all studied conditions .

Keywords: maize, machine, threshing, grains moisture, speeds

I. Introduction

Sunflower (*Helianthus annuus L.*) is one of the most important strategic oil crops for the Asteraceae family. It tolerates harsh climatic conditions such as drought or high temperatures, so its cultivation is successful in all climatic conditions. Since Iraq suffers from a large deficit in the vegetable oils production, attention must be paid to the oil crops cultivation, the most important of which is the sunflower crop, due to the oil percentage high in its seeds, which reaches more than 45%. In addition, sunflower oil is characterized by its high chemical and physical properties, it also contains a high percentage from protein and is an important source in the animal feed preparation [1]. Maize is considered an important crop to meet the market's need for oils, which are a major source of food components. Therefore, it requires great care in seed productivity during the manufacturing stages to reduce the seeds loss, which is reflected in a high economic return for the farmer[2,3,4].

The threshing process is the result of separating the grains from the cobs and depends mainly on a number of factors, i.e., the variety, grain moisture, drying methods and threshing process techniques that play a fundamental role in the separating process depending on the machine type and its clearance. The higher the clearance, the higher the machine productivity with a decrease in the broken grains percentage and accompanied by an increase in the non threshing grains percentage [5,6]. The grains removal from the tablets is affected by the machine type used, the mechanical speed, clearance, and the grains moisture content provided for manufacturing [7,8]. Sunflower crop is the leading field crop in the oil production, which most of the world's population depends on for their food, most researchers have relied on using modern technological methods in the grains manufacture with the least damage and the highest productivity [9,10].

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Study of [11,12], shows that when evaluating a threshing machine under the different speeds influence and feed rates, showed that increasing the threshing cylinder's threshing speed leads to an increase in the machine's productivity at different feed rates. [13], the cylinder rotational speed has an effective effect on the threshing efficiency, and the increase in the threshing efficiency is linked to the increase in the rotational speed of the threshing unit. The energy consumption amount is affected by the rotation speed of the threshing cylinder, the higher the speed, the lower the energy consumed amount. This is due to the engineering technique of designing the machine, the crop cultivar to be processed in relation to the thickness, length, shape, and grains moisture content.

When the grain is subjected to pressure, it behaves as a viscoelastic elastic body that exhibits creep, stress relaxation and subsequent elastic effects due to high humidity. So, if the moisture amount in the grain is high, it enters the plasticity stage, which makes the threshing process impossible and very difficult. Therefore, it takes longer time to complete the threshing process, which leads to a decrease in the machine productivity [14]. Improving the threshing machine performance with the least energy consumption and the highest grain separation efficiency depends on the machine speed, the grains moisture, and the threshing cylinder clearance. All the factors mentioned have an impact on the machine productivity, the product quality, and the extent of its acceptance by the consumer, which is reflected in a high economic return when wishing to purchase [15,16]. threshing is the most important aspect of post-harvest operations. Threshing or threshing is one of the most important preparation operations to separate the grains from the heads or plants and prepare them for marketing. Traditionally, threshing is done manually and this requires a lot of hard work. The grains are separated from the dried heads manually or by a mechanical device, which is known as shelling. This process is labor intensive and arduous, in addition to increasing energy consumption and greater losses of grains in terms of quantity and quality [17,18], the prime object of this study is to evaluate a sunflower threshing at different speed and grains moisture content.

II. Material and methods

The test was conducted in 2024 to evaluate the performance of the locally designed sunflower threshing machine, manufactured machine characteristics, its speed is 600 rpm because the machine gives the best performance in the shortest time, the current is 220volts, the machine's productivity is 2000Kg.hr^{-1}. Its dimensions are 11136*567*896 mm, it can be operated using an internal combustion engine or an electric motor. Fig.1. The machine was tested with two factors, i.e., three levels of threshing cylinder speed of 120, 160 and 200 rpm and three levels of grain moisture at of 11-13%, 13-15% and 15-17%. Sunflower crop was harvested at full maturity and the crop moisture content was determined after drying it in the oven at a temperature of 103 for 48 hours [19,20], and carefully monitored to determine the grains moisture according to the moisture factor for this study according to the method approved by [21,22], the machine productivity, the energy consumed, the threshing efficiency and the cracked grains ratio.

Figure 1 Machine used for thresher sunflower

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Moisture Content of the Grain: Was calculated as follow, [23,24].

$$W = \frac{W_W}{W_d} \times 100$$

Where, W grain moisture content (%) W_W wet weight W_d dry weight.

Machine productivity

It was calculated according to the method followed by [25,26].

$$Q = \frac{W \times 60}{T \times 1000}$$

Where: Q, machine productivity ton.hr^{-1}, T, time (min)

Power required

It was calculated according to the method followed by [27,28]

$$P = \frac{\sqrt{3}}{1000} \times V \times I \times \cos \emptyset \times E_T$$

Where; P; power required Kw, V; voltage, I electric, $\cos \emptyset$; angle between current and voltage, E_T motor efficiency (90%).

Cracked grain ratio:- Was calculated as follow, [29].

$$P_{Cg} = \frac{W_{Cg}}{W_S} \times 100$$

Where, P_{Cg} is cracked grain ratio (%), W_{Cg} is cracked grain weight (g)

III. Results and Discussion:

The effect of speed and development level and their interaction in the machine productivity (t.hr^{-1})

The results of Table (1) showed that there is a highly significant effect of both speed and moisture content factors in sunflower discs and their effect on machine productivity values. The machine productivity values differ according to the rotation speed of the active member. The results show that there is a significant superiority of speed (200 rpm) where the highest values were recorded with an average of (1.542 t.hr^{-1}) by (92.52 t.hr^{-1}) compared to the two speeds (160 and 120 rpm) where the values reached an average of (1.42 t.hr^{-1}) and (1.224 t.hr^{-1}). This increase in productivity was proportional to the increase in the machine rotation speed, which was reflected in the increase in the loss of discs and the decrease in the cases of suffocation that occur in the machine. This is consistent with [8,12].

There was a significant superiority in the overall productivity of the machine for the moisture percentage treatment in sunflower seeds (11-13%), which gave the highest values with an average of (1.795 t.hr^{-1}) by (107.7 t.hr^{-1}), while the moisture percentage treatments (13-15 and 15-17) % recorded the lowest values by (1.260 and 1.134 t.hr^{-1}), respectively. The increased productivity of the machine may be a result of using sunflower discs with a low moisture

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content, which in turn leads to easy seed loosening and separation from the discs carrying them, which is positively reflected in increasing productivity values compared to discs with relatively high moisture content, which is an obstacle to easy loosening from the discs carrying them, and this is consistent with what was confirmed in the study [16].

Table 1 shows the study coefficients in the machine productivity values, as it was shown that there is a significant effect of the coefficients of the rotation speed of the active member of the machine in interaction with the moisture content level of the sunflower discs on the machine productivity values, as the machine speed of 200 rpm in interaction with the moisture content of 11-13%, respectively, showed a significant superiority with the coefficients (13-15 and 15-17)%, as the machine productivity values ranged (1.477, 1.915 and 1.995 $t.hr^{-1}$) compared to the machine speed coefficients in interaction with the moisture content, which ranged (1.107, 1.243 and 1.430 $t.hr^{-1}$) and (1.087, 1.115 and 1.201 $t.hr^{-1}$) respectively. Increasing the machine productivity values at speed 200 in conjunction with the moisture content in the discs (11-13, 13-15 and 15-17%) means increasing the efficiency of discharging the grains as a result of increasing the number of revolutions of the active member carrying the discharging fingers, which was positively reflected in increasing productivity. However, in transactions where the machine speed decreases, the actual productivity values of the machine decrease as a result of the decreased rotation of the active member carrying the fingers fixed inside it, and thus the efficiency of discharging decreases, leading to a decrease in machine productivity [15].

Table 1: Effect of speed, humidity level and their interaction on machine productivity

speed (rpm)	Moisture level (%)			Average
	11-13	13-15	15-17	
120	1.477	1.107	1.087	**1.224**
160	1.915	1.243	1.115	**1.424**
200	1.995	1.430	1.201	**1.542**
Average	**1.795**	**1.260**	**1.134**	---
L.S.D. values: Velocity: 0.0048*, Moisture: 0.0048*, Interference: (0.0075*.) *P≤0.05.				

The effect of speed, humidity level and their interaction on consumption capacity.

The data in Table (2) indicate that the study factors and the interaction between them recorded a significant effect on this characteristic, as the speed (200 rpm^{-1}) was significantly superior compared to both speeds (120 and 160 rpm^{-1}), which recorded the highest rate of consumed power, reaching (12.24 kW), compared to both speeds, which did not differ significantly between them. And that by increasing the rotational speed of the discharge cylinder, the consumed energy increases, as the power required when operating the machine increases with the increase in the rotational speed of the discharge disc [8].

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As for the effect of the moisture level, the level (15-17%) was significantly superior compared to both levels (11-13 and 13-15%), as it recorded the highest rate and average power consumed (12.39 kW), and the level (13-15) was also significantly superior compared to the level (11-13) with an average of (11.21 kW). The reason for the increase in the power consumed when the moisture content in the seeds increases is due to the increase in their weight compared to dry seeds, and thus the grains are exposed to collision and collision as a result of the rotational movement, which makes them behave as a flexible body of viscous plastic that shows creep and relaxation in stress and other elastic effects [9,11].

As for the interaction between the study factors and their effect on the studied trait, it showed a highly significant effect between the rotation speed of the active member of the machine and the moisture content of the sunflower discs on the consumed power values, as it was noted that the machine speed (200 rpm $^{-1}$) interacted with the moisture content (15-17%) and recorded the highest level of consumed power, which amounted to (16.13 kW), while the machine speed (120 rpm $^{-1}$) at the moisture level (11-13%) gave the lowest level of consumed power, which was (9.10 kW). The moisture content has a significant effect on all results, and with the decrease in moisture content, the efficiency of discharging increases and grain losses decrease [6].

Table 2: Effect of speed, humidity level and their interaction on consumed power

speed (rpm)	Moisture level (%)			Average
	11-13	13-15	15-17	
120	9.10	10.24	11.82	**10.38**
160	10.08	11.06	12.21	**11.12**
200	11.21	12.34	13.16	**12.24**
Average	**10.13**	**11.21**	**12.39**	---
L.S.D. values: Velocity: 0.0059*, Moisture: 0.0059*, Interference: (0.009*.) *P≤0.05.				

The effect of speed, humidity level and their interaction on the threshing efficiency (%)

From the data in Table (3), it is clear that there is a significant effect between the rotation speed of the effective threshing member of the machine and the moisture content in the sunflower discs and their effect on the threshing efficiency. The values of the threshing efficiency differ according to the rotation speed of the effective member, as the speed (200 rpm) recorded the highest percentages in the threshing efficiency, reaching (84.47%) compared to the speeds (120 and 160 rpm) (79.89 and 82.33) %, respectively. Increasing the rotational speed in the threshing unit increases the threshing efficiency, as the high speed of the threshing member's rotation throws the discs at maximum speed to the periphery of the circle away from the center of rotation. This gives the discs additional torque that helps in easily threshing the seeds from the discs as a result of their collision with each other, as well as with the inner wall of the rotating member of the machine [18,22].

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While the efficiency of dispersion at the humidity level (11-13) gave the highest values with an average of (85.02%) compared to both levels (13-15 and 15-17) % respectively. While the level (13-15%) was significantly superior with an average of (81.34%) compared to the humidity level (15-17%) which recorded the lowest value of (80.34%).

It was noted from the data in Table (3) that the interaction between the speed of rotation of the active member of the machine and the moisture content level of the sunflower discs on the threshing efficiency had a highly significant effect, as the speed of the threshing machine (200 rpm) at the moisture level (11-13%) recorded the highest threshing efficiency of (87.81%), while the speed of the machine (120 rpm) at the moisture level (15-17) gave the lowest threshing efficiency of (78.14%). The rotation speed of the threshing member and the decrease in moisture content had a clear and positive effect on the threshing efficiency, and vice versa, when the moisture content increased, it became difficult to remove the grains from the sunflower discs due to the increased fixation of the seed in its seat inside the sunflower disc. [14,20].

Table 3: Effect of speed, humidity level and their interaction on threshing efficiency%

speed (rpm)	Moisture level (%)			Average
	11-13	13-15	15-17	
120	81.93	79.61	78.14	**79.89**
160	85.31	81.24	80.54	**82.33**
200	87.81	83.17	82.42	**84.47**
Average	**85.02**	**81.34**	**80.34**	---
L.S.D. values: Velocity: 0.0047*, Moisture: 0.0047*, Interference: (0.0081*.) *P≤0.05.				

The effect of speed, humidity level and their interaction on the percentage of cracked grains %

Table (4) shows a significant effect between the study factors, as the grain cracking rate at speed (200 rpm) reached (3.481%), which is the highest percentage compared to the speed of the loosening rotation (120 and 160 rpm), where the grain cracking rate was recorded at (2.782 and 3.173%), respectively. Increasing the rotational speed of the machine increases the ejection and collision of the discs carrying the seeds, which generates latent energy in the discs, leading to deformations represented by cracks on the seeds and their covers. [21,24].

As for the effect of the moisture level (15-17%), it was high, as the average percentage of grain cracking reached (3.579%) compared to the moisture level (11-13%) and (13-15%), where the average percentage of grain cracking reached (2.739 and 3.118), respectively. The reason for cracking seeds with high moisture levels is attributed to the fact that their covers cannot withstand impact and collision during the rotation of the automatic dethreshing member. [16].

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The results of the significant interaction between the rotational speed of the threshing member and the relative humidity rate of the seeds are clear. The highest cracking rate of the grains was recorded at the speed (200 rpm) overlapping with the moisture level of the sunflower discs (15-17%) (4.033%), and the lowest values were recorded at the rotational speed (120 rpm) and the moisture level (11-13%) and were (2.413). The reason for seed cracking appears when high speed overlaps with high humidity due to the moment of inertia carried by the seeds with high weight due to high humidity, which generates a high collision force that allows for high cracking rates in the seed coats, and vice versa, cracking rates decrease at low speeds overlapping with seeds with low humidity for the same reason.

Table 4: Effect of speed, humidity level and their interaction on cracked grain percentage%

speed (rpm)	Moisture level (%)			Average
	11-13	13-15	15-17	
120	2.413	2.915	3.018	**2.782**
160	2.809	3.023	3.687	**3.173**
200	2.995	3.415	4.033	**3.481**
Average	**2.739**	**3.118**	**3.579**	---
L.S.D. values: Velocity: 0.0069*, Humidity: 0.0069*, Interference: (0.0107*.) *P≤0.05.				

IV. Conclusions:

1. The machine was designed to separate sunflower seeds.

2. It was successfully tested and good results were obtained in terms of performance and efficiency.

3. It is recommended to use the machine and encourage farmers to use it, which is reflected in encouraging the cultivation of large areas of sunflower seeds.

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