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Design and Fabrication of Grain Collecting Machine and Evaluation of Some of Its Factors to Determine the Exact Losses at the Harvest Time

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ABSTRACT

This study aims to determine the Exact Losses grains that are wasted on the ground and loss in the operations of harvesting and Deign a collector capable of collecting the grains shattered in the field due to harvesting. The design was made based on certain assumptions and calculations and the collector was built, tested and evaluated. The test included pump suction speed at 3 levels (24000, 27000 and 30000 rpm), length of transferring pipes at three levels (200, 270 and 340 cm) and 3 types of grains (canola, wheat and soybean). Collecting tests for each of the 3 speeds and 3 pipe length and 3 types of grain were replicated 3 times and each time the collected grain was separated from the soil and the weight of each was obtained. The results showed that there were significant differences at 1% level between all parameters tested. Pipe length of 200 cm gave the best collection performance at any pump speed. Canola can be collected best at any speed, however, wheat and soybean need faster speed (27000 or 30000).

Keywords: Fabrication, grain, collecting machine, harvest losses.

INTRODUCTION

To check the losses of agricultural grain crops in the field, it is needed to measure the amount of grains fall to the ground during harvest by combine.. Separating the grains from the soil and collecting them from the ground and in the groove of the land by hand and by holders is a hard work and time consuming to that is not precisely done. Hence the need for a machine to collect the grains in the field has been identified. The development of a growing population increases the need of food day by day. There are several solutions to increase the production of cereals. One of the forgotten and less considered solutions is the reduction of waste after production.. Researchers have dedicated this study to this so-called hidden harvest (Omidi et al., 2005). The design basis of the grain collector machine for a farm is now based on the pneumatic conveying and several researchers have done research-based pneumatic transmission of materials some of which are listed below:

Imanmehr & Qobadian (2008) designed a horizontal pneumatic conveyor of canola. It was a mass flow rate of 90 kg per hour on the pipe with a diameter of 58 mm. First they checked at the drop in air pressure and pressure drop of materials and after checking for the maximum system pressure, a centrifugal blower was selected, and then combination of components, chassis and other designs were done. Reshadsedghy et al. (2008) designed and built portable machine to collect pneumatic Colorado beetle on potato farms. In their study, they designed and built lightweight portable machine by the user. This machine has an air blower unit for separation of the pest plant from a plant and a

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collector unit of separated pests from plant against the blower unit that during operation, the two units are placed on either side of potato plant. Airflow was provided by backpack centrifugal pumps of particle sprayer construction. Azadbakht et al. (2013) designed leaf collecting machine that is activated by the tractor empowerment. Leaf feeding is done by a worker with elastic pipe to the machine. After suction, leaves due to impact force of suction fan, through the urethra enter the tank. In the tank hydraulic jack system was devised in to compress and evacuate the leaves in a spot. When the leaves cannot be collected by the flexible pipe, the system of discharge (air pressure) is used so that the leaves are gathered in a range. Innocentini et al. (2009) designed, built and evaluated pneumatic skin isolator from broken soybeans. They used a vacuum pump to suck grains and to separate from a cyclone separator (filter) was used. In another study low pressure pneumatic conveyor was designed and built. Air transferred through the system by a fan and a 23 m length pipe. Grains in the machine were removed using an air local feeder below the grain cavity. In the cyclone filter the grains are fall down and air, with dust and fine particles, by the evacuating fan, removed from the cyclone to the filter (Güner, 2007). Researchers in an article examined the jump velocity (saltation) of wheat in horizontal flow in pneumatic conveyor. The jump velocity is defined as the airspeed that the particles start to move towards the end of the horizontal pipe. The velocity on the wheat speed and flour and the various amount of the feeding in was measured in horizontal pipe. The most important changes affecting the jump velocity, feeding rate and the average particle size and surface area (Shen et al., 1994)

Baker et al. (1984) measured the required force, pressure and particle velocity for a pneumatic conveying system equipped with drying corn device under pressure. In this study, two parameters, grain flow rate and air velocity were tested.

Also this field of research examines different harvest losses that some of them are mentioned as follows:

Minaei et al. (2010), in their study, to determine the loss rate of wheat harvest by John Deer and Class combines while making use the positive attributes of traditional methods of measuring harvest losses and waste, measured the natural grain losses (pre-harvest) and losses platform of cutting, threshing unit and separating unit and two wheat types in two combine (JD and Class). Yavari, I. & Yavari F. (2005) examined the waste in different units of popular combines used in grain harvest. Then selected the places to evaluate the platform waste and at these sites with the action of framing the whole product collected and weighed the falling harvest loss. Pari et al. (2012) studied the reduction of the effective yield of the canola harvest in Italy. They looked to harvest losses of grain from the cultivation to the harvest stage. The losses were measured by putting the tray on the floor between rows of cultivated crop. Cavalieri et al. (2014) examined the relationship between broken and unbroken the canola pods, and measured the grains losses. They measured the losses by collecting grains and pod casting in the tray. Asoodar et al. (2009) examined the rate of loss in terms of falling of canola grain in direct harvesting by three types of platform combines. The count or collecting tiny canola from a surface of the land especially when there are relatively many micro cracks and grooves are difficult and time-consuming and imprecise. In this method measuring tray for the losses was used.

This study aims to determine the Exact Losses grains that are wasted on the ground and loss in the operations of harvesting and Design and evaluate a collector capable of collecting the grains shattered in the field due to harvesting.

2. Materials and Methods

2.1 Design and Manufacturing Devices

After the needs assessment and evaluation of parameters required for first the grain Collecting machine designed as shown in Figure 1. After checking the different parameters required of the machine, in the mechanical engineering workshop of Biosystems of Gorgan University of Agricultural Sciences and Natural Resources the machine was built, then in the number one farm of the University of Agriculture and Natural Resources of Gorgan it was evaluated. Figure 1 shows the various components of the machine.

2.2 The Machine Design

To present the original plan for the grain collecting machine, it is necessary to provide the design assumptions. These include: to have mobility on rough terrain of the farm, to be transferable by the workers, to be used for a variety of agricultural crops (the canola, wheat, soybean, beans, etc.), and to have the ability to collect tiny grains from deep grooves.

In the chassis a hollow shaft of 35 mm diameters and of 3 mm thickness was used. In order to be strength and easily removable by the workers. technical specifications of this hollow shaft was obtain from DIN standard table and was considered in the design of chassis (Valinejad, 2005).

The advantage of centrifugal pumps is that they are less sensitive to dust (Srivastava et al., 1993). That's why a centrifugal pump was selected. The pump had a stationary part and a rotating part. Suction created by the rotation of the rotating components.

For convenient carrying device by a worker, device must be an independent unit and have the lowest feasible size and weight. That's why a generator was used for power generation. Generator was ASTRA-AST 3700 made in South Korea. Generator works by gasoline engine. The size of which was 450 cm × 450 cm × 650 cm and weighs 40 kg. The rate of voltage was 220 V, Frequency of 50 Hz and output power of 2 up to 2.5 Kw...

In the suction machine consists of pump, pipes, cyclone, etc., materials must be separated from the air flow. For that, a cyclone was used. In the cyclone by reducing suction, grains fall to the bottom of the cyclone and separated from air flow. (Srivastava et al. 1993). The tank of the cyclone was cone with a height of 29 cm and the diameter 8.5.After entering the air with the grains in the cyclone, grains are separated and the air after going through a strainer which is in the tank, comes out of cyclone.

Since the grain collector works in the field, dust and fine particles may damage the pump. For this reason, the paper air filter was used.

A reactionary pipes pipewas used to transfer the air and grain to cyclonepipe. The components consist of pump, air filter, cyclone filter were connected by pipes. A pipepipe with a length of 70 cm connected pump to the air filter. Another pipe with a length of 100 cm connected air filter to the pipecyclone. And the cyclone by pipe with a lengths of 100 cm was connected to a collection point on earth. The pipepipe was 4 cm in diameter and a thickness of 4 mm.

2.3 Methods of Applying the Apparatus

At the first, machine was taken by workers to the field and sample location. Then gasoline generator is turned on. When the power generator was started, 220-volt electricity was generated to operate the suction pump. The electrical suction centrifugal pump is connected to generator by an industrial dimmer. This dimmer allows that depending on the amount of needed suction, the pump be adjusted. Then, the flexible pipe was carried by the worker to the desired location for sampling. If the weight of the grain is large or the land groove is deep, the pump speed is increased by dimmer. The suction pump with an elastic pipe was connected to the air filter. The air filter was connected to the cyclone filter. So, when the suction is performed, the grains were collected in the cyclone chamber.

2.4 Testing and Evaluating of the Machine

To evaluate the field grain collecting machine, a 80 g of grains randomly harvested from the field then manually scattered in a wooden box area of 0.25 m2 ,then they were collected by the grain collecting machine. The effect of pump rotation speed (24000, 27000, 30000 rpm), pipe length (200, 270, 340 cm) and types of grains (canola, wheat and soybean) on collected grains and collected soil were studied. The experiments were performed in triplicate. The reason for choosing three types of grains is the size variation. The high performance of the system means that all grains that wasted are collected and the soil collected is the lowest. Increasing amount of the soil collected with the grains cause to separation process be difficult.. Experiments were performed in the field number 1 of Gorgan University of Agricultural Sciences and Natural Resources with loamy clay soil. Data analysis was conducted using SAS software and LSD test as a factorial experiment in randomized complete design..

3. Results and Discussion

3.1 Calculation of the Static Pressure

To determine the static pressure first the amount of the air volume within a sector of suction impeller should be calculated. Then multiply it by the total number of blades to obtain the amount of the total volume of air transfer in a spin of suction impeller (Azadbakht et al., 2013).

Suction pump had 9 blades, impeller diameter (D) of 0.11 m, blade length (L) of 0.08 m, maximum blade width 0.015 m and minimum blade width of was 0.005 m. To calculate the volume of air in the suction pump solid works software was used. First, the chamber of pump was drawn with the desired dimensions and then volume was calculated.

$$V = 8.4751 \times 10^{-5} \qquad (1)$$

V: Air volume in terms of m^3

As a result, the flow rate according to equation (1) is:

$$Q = V \times n = 2.54253 \qquad (2)$$

Q: Air flow in terms of $m^3\ s^{-1}$, V: the volume of air in the suction impeller in terms of m^3, n: rotational speed in terms of rpm.

Produced static pressure at the outlet of any particular suction, while working at any particular time, change in accordance with the output of the suction flow. This means that if a hypothetical suction at a given speed, air flow rate to be considered specifically, the pressure difference between inlet and outlet of the suction should not exceed a certain limit. Otherwise, the flow is reduced. The graph for this phenomenon for any type, size and speed is unique. The static pressure of the pump design according to equation (2) is obtained (Bleier, 1997).

$$SP = \rho u_2^2 - \frac{\rho Q u_2}{\pi d_2 b_2 \tan\beta_2} \qquad (2)$$

That, $\rho = 1.2\ (kg\ m^{-3})$ (air density)

According to the standard formula Calculation of formula will be 3 to 6 values:

The amount of inside diameter (d_1) and the outer diameter of impeller intake (d_2), respectively are 0.035 m and 0.11 m, then in the degree of $\beta_1 = 50^\circ$, $\beta_2 = 70^\circ$ of angles, $d_1/d_2 = 0.318$ (Bleier, 1997).

According to the analysis of speed vectors of suction impeller speed, we will have:

$$\tan\beta_2 = \frac{V_{f2}}{u_2 - V_{u2}} \qquad (3)$$

β_1 = angle at the beginning of blade and β_2 = the angle at the end of the blade,

V_{u2}= the blade speed at the leading edge or at the beginning of blade

u_2 = environmental speed suction impeller

V_{f2} -the radial velocity of V_2 in the output

V_2 -the relative speed of the air at the end of the blade.

The amount of V_{f2} from equation (4) is obtained.

$$V_{f2} = \frac{Q}{\pi d_2 b_2} = 467.263\ (m\ s^{-1}) \qquad (4)$$

Q (m^3/s) Air flow rate, d_2 (m) the outer diameter of impeller suction and b_2 (m) is the blade passage width in the output.

According to the values $\beta_2 = 70^\circ$, $V_{f2} = 467.263\ (m\ s^{-1})$ and the linear speed suction impeller (5), for the value from the equation (6) will be obtained:

$$u_2 = \frac{\pi d_2 n}{60} = 172.78\ (m\ s^{-1}) \qquad (5)$$

$$〚v〛\_u2 = u\_2 - 〚v〛\_f2/\tan 〚β\_2〛 = 2.7101\ (\mathrm{m}\ s^{\wedge}(-1)) \quad (6)$$

As a result, the pump static pressure will be 562.419 Pa.

3.2 Calculation the Power Required for Suction Pump

The power provided to suction to transfer a certain amount of air, for the sucker output FAN_{eff} the amount 75% or 85% is expressed as the percentage that the amount of power consumption of suction pump was obtained about 7 (Bleier, 1997):

$$P\_p = Q \times SP = 1429.967\ \mathrm{W} \quad (7)$$

As a result:

$$P\_bhp = P\_p/(\eta\ ) = 1906.622\ \mathrm{W} \quad (8)$$

3.3 Testing and Evaluation of the Apparatus

The results of variance analysis of the impact of rotation changes, the pipe length and the type of grain on grain collection and the amount of soil collected is shown in Table 1.

Table 1. Analysis of variance of the evaluation of the grain collectoing machine

Source of variance	Degree of freedom	Collect of grain (%)	Collect of soil ($g.m^{-2}$)
RPM	2	338.481**	50948.148**
Length	2	206.37**	8635.259**
Type of grain	2	154.481**	116.148**
RPM × Length	4	29.259**	48.592*
RPM × grain	4	32.037**	12.148ns
Length × grain	4	23.925**	13.925ns
Error	8	2.981	9.925

** Significant difference at 1% level (p <0.01), * Significant differences at 5% level (p <0.05), ns not significant

Table 2. The effects of pipe length at different rotation speeds of the pump on collected grain, %

Length of pipe	RPM		
	24000	27000	30000
200 cm	95.33 ^{aA}	100 ^{aA}	100 ^{aA}
270 cm	85 ^{bB}	99.33 ^{aA}	98.33 ^{aA}
340cm	80 ^{bB}	92 ^{aA}	94.66 ^{aA}

Similar lowercase letters in each row, similar uppercase letters in each column represent no significant difference

Table 3. The effects of different types of grain at different pump rotation speeds on grain collected, %

Type of grain	RPM		
	24000	27000	30000
Canola	94.66 ^{aA}	99 ^{aA}	99.33 ^{aA}
Wheat	86.66 ^{bB}	98 ^{aA}	98.66 ^{aA}
Soybean	79 ^{bB}	94.33 ^{aA}	95 ^{aA}

Similar lowercase letters in each row, similar uppercase letters in each column represent no significant difference

3.3.1 The Grain Collected

As shown in table 1 , the percentage of collected grain significantly affected by the engine rotation speed, length of the pipe and type of grainpipe. The mutual effect of rotation speed with pipe length, rotation speed with grain type , grain type with pipepipe length were significant at 1% probability on the percentage of grain collected. Therefore, comparison of the mean through LSD method and the results are stated in Table 2, 3 and 4.

In the Table 2, the effects of pipe length in pump's different rotations on the percentage of grain collected have been shown. According to the table, the highest and lowest percentage of grain collected is 100% and 80%, respectively, in the 30000 and 24000 (rpm) and 200 and 340 cm in the length of the pipe.

As shown in Table 2 at the levels 27000 and 30000 rpm, changes in pipe length are not significant and only at 24000 rpm level, the pipe length 200 cm is different from the other pipe lengths in the percentage of grains collected.

It was also observed that when the length of the pipe was 200 cm pipe, the rotation of the pump was affected the percentage of grain collected ineffectively. So regardless of the grain type, the rotation of 27000 rpm and pipe lenth of 200 cm are more appropriate.

Table 3 shows the grain type effect at different pump rotation on the percentage of the collected grain. According to Table 3, the highest and lowest percentage of collected grain were 99.33% and 79%, respectively, at 30000 and 24000 (rpm) rotation speed of the pump, with the canola and soybean.

As seen in Table 3 at 27000 and 30000 rpm levels, changes in the type of grain is not significant and only at the 24000 rpm rotation level canola is different from the other grains, on the percentage of collected grain. It was also observed that canola due to the low weight; the effect of the pump rotation is ineffective on the accumulated grain. The effect of changes in rpm in soybean and wheat gathered on the percentage of the grain collected is different. So the 24000 rpm level for the canola and also to 27000 rpm level is more appropriate for soybean and wheat.

Table 4. Effect of grain type with pipe length on the collected grains, %

Type of grain	Length of pipe (cm)		
	200	270	340
Canola	99.66 ^{aA}	98.33 ^{aA}	95 ^{aA}
Wheat	98.33 ^{aA}	95 ^{aA}	90 ^{aA}
Soybean	97.33 ^{aA}	89.33 ^{aA}	81.66 ^{bB}

Similar lowercase letters in each row, similar uppercase letters in each column represent no significant difference

Table 5. Effect of pipe length with grain type on collected soil, g

Length of pipe	RPM		
	24000	27000	30000
200 cm	184 ^{cA}	244 ^{bA}	329.33 ^{aA}
270 cm	148 ^{cB}	197.33 ^{bB}	297.33 ^{aB}
340 cm	121.33 ^{cC}	178.66 ^{bC}	273.33 ^{aC}

Lowercase letters in each row, uppercase letters in each column represent no significant difference

Table 4 shows the effects of different types of grains in the different pipe length on the percentage of the grain collected. According to Table 4, the highest and lowest percentage of grain collected is equal to 99.66 % and 81.66 % respectively over the pipe length 200 and 340 cm and it was in canola and soy.

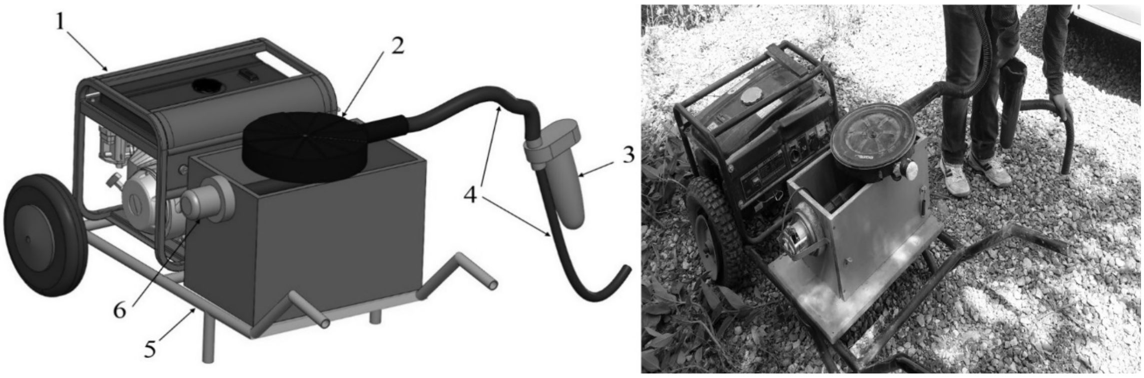
As table 4 shows at the 200 and 270 cm length of the pipe, changes in the type of grain are not significant and only at 340 cm, the soybean is different from the other grains in the percentage of grain collected. It was also observed that at canola and wheat grain effect of the pipe length on grain collected isn't significant. The effect of changes at pipe length in soybean on the percentage of grain collected is significant. So, the 270 and 200 cm pipe length is the same for all grains. But according to the results presented in Table 2, at 200 cm pipe length more grains is collected, therefore, pipe length of 200 cm is more suitable.

3.3.2 The Amount of Soil Collected

As Table 1 shows, changes in engine rotation, pipe length and type of grains are significant at 1% of probability on the amount of soil. Also, the mutual interaction effect of rotation and pipe length at 5% of probability, on the amount of soil collected has been significant. Therefore, comparison of the mean through LSD method and the results are stated in Table 5. In Table 5, the effect of pipe length at different engine rotation speed have been shown on the amount of soil collected. According to table 5, the highest and lowest soil collected is equal to 329.33 and 121.33 (g m^{-2}), respectively, in the 30000 and 24000 (rpm) and 200 and 340 cm at length of the pipe.

As shown in Table 5 at each level of the pump rotation, by increasing the length of the pipe, the amount of soil collected becomes less due to the fact that the less, the soil collected, the easier is the separation of the grain from the soil; Therefore, so at the 24000 rpm level and 340cm are more appropriate.

According to the Figure 2, the amount of soil collected at the canola was more than wheat and soybean. And there was no significant difference between the amounts of the soil collected at the wheat and soybean. This is for two reasons, the first that larger grains can be mixed with the soil less than the smaller grains. and the second that device can transfer constant volume of materials, because the soybean and the wheat is greater, the amount of soil is less.



1. Power Generator, 2. Air filter, 3. The cyclone filter, 4. Transitional pipes, 5 chassis, 6. Suction pump

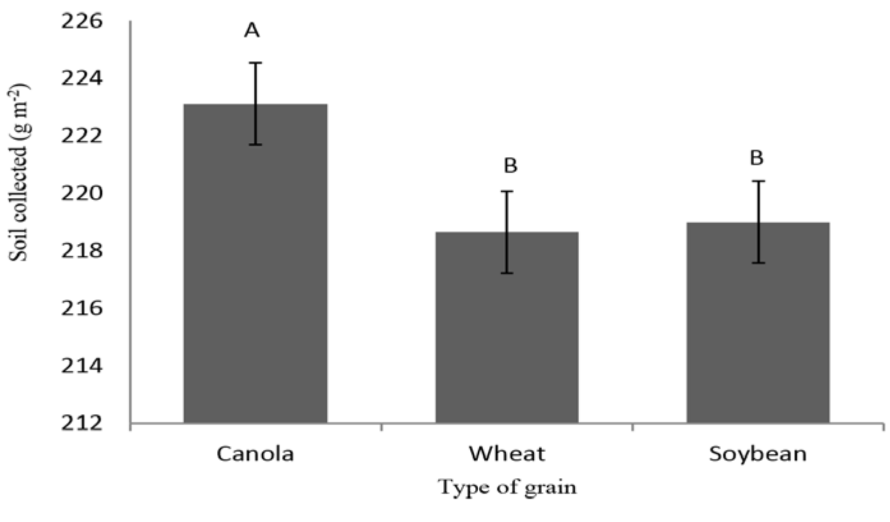


Fig. 2. Effect of grain type on the amount of collected soil.

4. Conclusion

The obtained static pressure of the machine's suction pump was 562.419 Pa and power 1906.622 W only was used for suction fan. The power of the generator which can be suitable for the collecting machine must be 2000 W at least. . In terms of selecting the length of pipe to collect all three types of grains the level 200 cm and considering the rotation of the pump to collect the grains of canola the level 24000 rpm and the 27000 rpm is more appropriate for soybean and wheat. The 200cm pipe length was because the machine must collect all the grains that were wasted on the ground, although the amount of soil collected was more, it is possible to separate the grains from the collected soil.

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تصميم وتصنيع آلات جمع الحبوب وتقييم بعض العوامل الرامية إلى تحديد دقة الخسائر في وقت الحصاد

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ملخص

تهدف هذه الدراسة إلى تحديد المقدار الدقيق للخسائر في الحبوب التي تهدر على الأرض بالإضافة الى الخسائر الناجمة عن عمليات الحصاد، وتصميم آلة قادرة على جمع الحبوب المحطمة خلال عمليات الحصاد في الحقل. وجاء التصميم على أساس افتراضات وحسابات معينة صممت على أساسها آلة جمع الحبوب وتم اختبارها وتقييمها. وتضمن الاختبار تقييم سرعة مضخة شفط على ثلاثة مستويات مختلفة (3000، 2700، 2400) دورة في الدقيقة ، وطول الأنابيب الناقلة على ثلاثة مستويات متباينة (270،340، 200) سم بالإضافة إلى ثلاثة أنواع من الحبوب (الكانولا ، والقمح، وفول الصويا). تم تكرار جميع الاختبارات لكل من السرعات الثلاثة، وأطوال الأنابيب الثلاثة، والثلاثة أنواع من الحبوب ثلاث مرات، وفي كل تكرار كان يتم فصل الحبوب عن التربة والحصول على أوزانها. أظهرت النتائج وجود فروقات ذات دلالات احصائية معنوية عند المستوى (1%) بين جميع المعايير التي تم اختبارها. وقد كان طول الأنبوب (200 سم) الأفضل أداءً من ناحية جمع الحبوب عند جميع السرعات المستخدمة. ووجدت الدراسة أيضا أنه يمكن جمع حبوب الكانولا عند جميع السرعات المختبرة، لكن جمع كل من حبوب القمح وفول الصويا يحتاج الى سرعة كبيرة اجمالاً (2700 أو 3000) دورة في الدقيقة.

الكلمات الدالة: تصنيع، الحبوب، آلة جمع، خسائر الحصاد.

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