Design, construction and evaluation of a seed pod husker and testing with soybean and mung bean

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Abstract: In this research, a new rubbing threshing machine was designed, constructed and evaluated based on the equations, tables and standards of machine components design, and its performance was analyzed and compared theoretical and practical. It is made with electric motor, inverter, husking roller, mechanical jack, belt and etc. This built-in machine has a width of 300 mm, working height of 100 mm, speed between 110 to 210 r min^{-1} and a maximum power of 2 hp. The practical test was carried out on two products (soybean and mung bean). Moisture content varies between 12% and 17%, speed and the distance between drum and concave vary in three levels (110, 170 and 210 r min^{-1}) and (7, 8, 9 mm) for soybean and (6, 7, 8 mm) for mung bean, respectively. The experiments were carried out in a completely randomized design with factorial experiment in three replications. The results showed that the capacity of the machine for soybean and mung bean was 28.506 and 29.079 kg hr^{-1}, respectively. The best efficiency of the machine was 94.72%, which is related to the mung bean and was obtained at a speed of 170 r min^{-1} and a distance of 7 mm. The best separation and loss efficiency were 93.00% and 1.66%, which was achieved at a speed of 170 r min^{-1} and a distance of 7 mm for mung bean and soybean, respectively. The best germination efficiency was 95.53%, which was achieved at a distance of 7 mm and a speed of 110 r min^{-1} during mung bean test.

Keywords: seed, pod, husker, soybean, threshing, mung bean

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1 Introduction

Nowadays, due to the growing population of the world especially in the third world countries and the growing need for foods, providing food for people is one of the most important issues of the present day. Hence, people are always trying to devise new methods to increase the speed and quality of agricultural production. That's why in recent years, researchers have always tried to make farmers use the minimum facilities and available machines to mechanize farming and increase their cultivated land to achieve the ultimate goal which is increasing production and improving product quality (Noormohamadi and Zareiean, 2003). Today due to the increasing development of agriculture and its importance in providing human basic needs, effective parameters on costs, efficiency, fuel consumption and etc. are really important. One of the most important parts of agriculture is the threshing operation that greatly affects these parameters. Therefore, increasing the efficiency of threshing machines even with optimization in a small section will lead us to huge savings in energy. Among the various sources of food, plants are considered as the main source, and among the various plants, legumes and oily plants have particular importance. Soybean with scientific name *Glycine max* contains 30%-50% protein and is one of the most important sources of vegetable oil and protein that is cultivated as the main food in many countries of the world. On the other hand, mung bean with scientific name *Vigna radiata* is another source of plant protein that contains 27%-29% protein. The separation of seed from its pod is a necessary process and in most cases the grain combines are used to separate the seeds from the pod. In many rural areas of developing countries, seeds are removed manually from the pod, which can take weeks

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(Adewunmi, 2000). Of course, in a different way, for husking the seed pod products, the product is poured into the bag and beat on it with a stave to remove the seeds from the pod. This will cause serious damage to the seeds and cause high dust (Changrie, 1999). Various studies have been carried out on the operation of threshing machines in order to optimally use this device to reduce power consumption and improve threshing process. For example, Srison et al. (2016) evaluated the working condition parameters for a centrifugal corn husker. In their experiment, the length of the husking unit was 0.9 m and its diameter was 0.3 m. Working condition factors were evaluated at three levels of humidity, feeding rate and linear velocity. Their results showed that moisture content had a significant effect on grain failure and energy consumption. As the moisture increases, the seeds breakage and energy consumption increase. But it doesn't effect on the losses of husking unit. Their results about the speed of knocking showed that with increasing speed, the amount of broken seeds and fuel consumption increased, but losses of husking unit decreased. The material feeding rate affected on energy consumption, as feeding rate increased, fuel consumption was increased, but it didn't affect the amount of broken seeds and husking unit losses. Another husker that was made for walnut in Turkey made up of four sections consist of: feeding unit, husking unit, upper and lower separation section. This machine had an effective husking length of 200 mm and rotating plates had a maximum speed of 150 r min^{-1}. The distance between the husking plates was adjustable from zero to 50 mm. The results of the experiments showed that the capacity of the machine varies from 1170 to 2085 kg hr^{-1} and the device had a maximum separation efficiency of 99.32% and maximum losses of 2.78% (Beyhan et al., 2009). Shirzad et al. (2013) studied the effect of drum and concave distance in seeds breakage in the tank. Independent variables included the drum and concave distance and fan rotational speed. The amount of seeds breakage in the combine tank was also defined as the dependent parameter. The results of variance analysis showed that the effect of both factors on the seeds breakage in the tank is significant at 1% probability level and its interactions are insignificant. Kirkkari et al. (2001) studied to reduce the mechanical damage to oats in Finland. Their results indicated that the rate of germination of harvested seeds increased with decreasing rotational speed. However, reduction of the drum and concave distance did not affect the germination. Kowalczuk (1999) during five years working on a soybean harvesting machine in Poland announced that loss of threshing unit is 0.84% and mechanical damage is 9.9%. Singh, Garg and Sharma (2001) determined the effect of seed moisture, rotational speed and feed rate on mechanical damage and germination in the combine. They reported apparent mechanical damage 0.6%-4.1%, internal mechanical damage 17.6%-28% and germination 69.8%-82.3%. Also, the results of this study showed that with decreasing seed moisture, increasing rotational speed and decreasing feeding rate, the amount of internal mechanical damage and germination percentage decreased. Dres'zer and Gieroba (1999) performed experiments to determine mechanical damage to several types of cereals with multi-cylinder combines. The amount of the damage was influenced by the steps that were taken to remove the seeds. Also, the amount of injuries depended on the type of grain. Barley and oat varieties showed greater resistance to damage while rye and wheat were less resistant. The lowest damage occurred when the rotating speed was less than 78 radians per second. Increasing the drum and concave distance also reduced the mechanical damage of the product. In 2017 researchers in Germany designed the prototype of *Jatropha Curcas L.* huller in the Catia software environment based on the physical properties of the crop. In this project they used steel St12.03 as the main material. The cracking rotor consisted of a 450 mm long cylinder and 220 mm outer diameter. The rotor was placed in a housing, the inner wall of which was used as cracking area (i.e. a concave) where 30 metal bars (4 mm × 4 mm) were welded to increase the friction at one side of the housing. They tested the drum efficiency at four feed rates at constant speed and distance. Ultimately the maximum yield was 98.8%, which was achieved at 477 kg hr^{-1} feeding rate (Romuli et al., 2017). Mozafari et al. (2008) studied the effect of the drum rotating speed and the size of concave hole on the performance of sugar beet seeds threshing. They made the tests and analyzed it with MSTATC software and reported that in order to access the optimum mode of knocking in the sugar beet seed threshing, it is better to consider the size of concave hole of 8 mm and a drum rotating speed of 680 r min^{-1}. Mansoori and Minaee (2003) in a study measured the effect of drum rotating speed and the distance of drum and concave on the amount of threshing unit losses. The results of this study showed that broken seeds were more than doubled, due to rising threshing speed ranges from 750 to 950 r min^{-1} and increasing the drum and concave distance had a decreasing effect on the seeds breakage. Based on the research conducted by Tahir et al. (2003) on a harvester *Claas* combine dominator model in Pakistan, combine working parameters were evaluated and average wheat loss and wheat broken seed was announced 1.25% and 5.7%, respectively. Singh and Singh (1981) studied the effect of product and machine parameters on the threshing rate and quality of soybean. To identify the damage of the products, they measured the apparent breakage through the weighting of broken seeds in certain samples and internal damage through germination test. In this study, it was found that seeds apparent damage in all moisture increases with increasing rotational speed, but rotational speed changes have little effects on germination percentage. Singh et al. (2002) reported the amount of apparent damage to seeds 2.5% to 3.5% by examining the combine's farm performance in rice harvesting according to the combine speed, rotational speed and seeds moisture content. Mailander et al. (1983) measured harvesting losses for soybean, corn, and wheat in a flow combine and concluded that the feed rate of the materials would have the greatest effect on the losses rate. Haffer et al. (1991) tested several adjustment of combine on two varieties of chickpea. Combine speed had a significant impact on losses. They also reported that the speed and type of plant variety did not have much effect on broken seeds and the distance between the drum and concave and the fan capacity played a more important role. Also, the distance between the drum and concave and the speed of the fan did not effect on the threshing losses. Datt and Annamalia (1991) in designing and manufacturing of threshing drum with pig tooth, considered the linear speed of the drum 17 m s^{-1}. The results of the experiment on rice products with moisture content of 16%-25% and a feed rate of 1800-3000 kg hr^{-1} were shown that the percentage of unthreshed seeds varied from 0.02%-0.07% and there were no damaged seeds under these conditions. In the following, three common problems of threshing unit are mentioned:

1. The teeth on the drum damage the seeds. Also, due to the separation, the seeds are placed between the drum and concave and it causes damaging of the seeds. This process can damage the viability of seeds, thus the grains cannot be used as seed (Alonge and Adegbulugbe, 2000).

2. The construction and production of this type of threshing machine is done in a rotary and anti-rotary manner with a cylindrical shape. And putting fixed bars or teeth on rotating outer environment will make manufacturing technology more difficult for these types of devices (Adewunmi, 2000).

3. Another negative effect of this type of device is the breakage of pods, which spends a lot of energy and cause seed separation more difficult to perform (Singh et al., 2012).

According to the studies conducted in common rotators, most of the seeds are separated from the pod by impact, but the aim of this research is to design and optimize a seed pod husker on a laboratory scale in which the separation of seeds from the pod is based on rubbing and then used in field conditions.

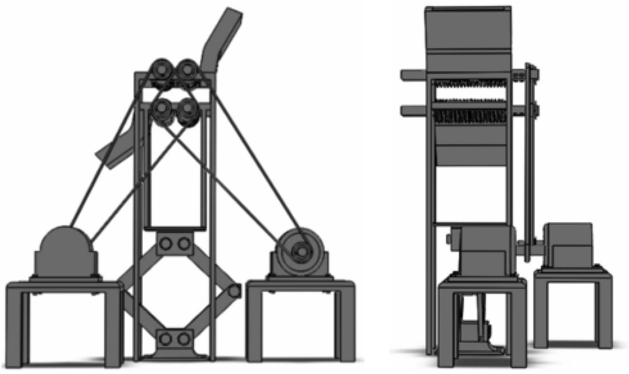
2 Materials and methods

2.1 Device modeling in software

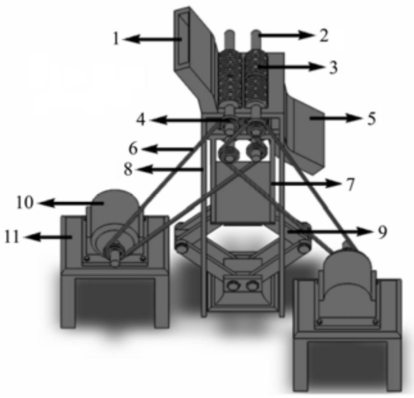
After examining the physical and mechanical properties of various seed pod crops, especially soybean and mung bean, a new seed pod husker machine was modeled in the SolidWorks 2013 software environment. This machine included 1: Husking roller, 2: Roller shafts, 3: Top rollers plate, 4: lower rollers plate, 5: Mechanical jack, 6: Pulley, 7: Belt, 8: Motor and etc.

2.1.1 Husking roller

In the design of this device, 50 mm diameter and 300 mm height roller was used for husking operations. In order to make husking easier, Archimedean screws were created on the external surface of these cylinders. The number of rounds of these Archimedean screws was 17 rounds and these screws pitch had a size of 9 mm. Half of the height of these rollers had a right arch and the other half had a left arch to move the products to the center and have a tougher operations. Threaded was triangular type that its base was 8 mm and its height was 7 mm. At the center of these cylinders, a hole of 16 mm was fitted to drive the main axis of the roller operator.



(a) Front view (b) Left view



(c) Isometric view

1. Input 2. Shaft 3. Roller 4. Pulley 5. Output 6. Belt 7. Lower roller plate 8. Higher roller plate 9. Mechanical jack 10. Motor 11. Motor chassis

Figure 1 Husker designed in SolidWork 2013 software environment

(a) Front view (b) Left view (c) Isometric view

Figure 2 Husking roller

2.2 Calculations

After examining the physical and mechanical properties of various seed pod crops, especially soybeans and mung beans, first, the required power of the electric motor was calculated for the designed husker. In this project, the effective working width of the machine was 300 mm and the machine's working capacity was assumed to be about 30 kg hr^{-1}. The torque required for seed separation from the pod was measured by a torque meter (TQ8800 model, Lutron manufacturing company in Taiwan). The torque meter was installed on a cylinder with circular, square and triangular surface which have three thrust fingers (blade) as shown in Figure 1(b). These cylinders were used to measure the amount of torque needed to separate the seeds. By connecting these cylinders to the torque meter and inserting the pod inside the cylinder and rotating the torque meter, the torque needed to separate the seeds from the pod was obtained. By examining different references, it was found that, on average, a speed range of 300 to 900 r min^{-1} is used for drums (Ukatu, 2006; Mansoori and Minaee, 2002; Mozafari et al., 2008). However, since the criterion for this study was to separate the seeds from the pod, based on rubbing and not by the impact, and according to the initial evaluations of the device, it was preferred to use a speed range of 110 to 210 r min^{-1}. Because, firstly, speeds less than 110 r min^{-1} cannot open the pods, and secondly, velocities higher than 210 r min^{-1} cause excessive movements and the device will be in trouble for opening the pods. The required power for simultaneous entry of 10 pods, the required torque of 3 N m for the separation of seed from its pod and the maximum rotating speed of 210 r min^{-1} were calculated from the following equation.

$$P_{EM} = \frac{(T \times N)}{9550} \qquad (1)$$

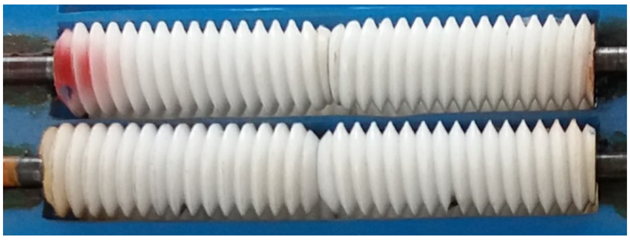
where, P_{EM} is the required power in kilowatts (kW); T is the torque of the electromotor in N m, and N is the rotational speed in r min^{-1}.

(a) Torque meter for measuring the torque (b) Cylinder attached to the torque meter

Figure 3 Torque measurement components

2.3 Machine working

Soybeans and mung bean pods on the flank side, on the principle of minimum required force (Sadeghi, 2012) enter the slope of the device to enter into the threshing unit. Knocking pods are done based on the rotational force imported with the upper and lower rollers in the opposite direction to the crust of the product. In addition, the torque produced by the thresher is due to the rotary motion of the roller bearings, which is applied to the product shell and causes the seed to be separated from the pod. On the roller shafts, there are pulleies that are driven by rotary transfer belts with a three-phase, 0.75 kW electric motor (China’s Stream model). To prevent the transition of the axial, the set is placed inside the bearing, with its outer shell fixed to the frame. Due to the need that roller are in contact with pods and also to separate easier, it was preferred to use a right arch and a left arch screws on the surface of rollers. In this research, four shafts were used, with a pair of rollers mounted on each shaft which had the opposite Archimedean screw to bring the product to the center of it and have threshing operation. Since various seed pod crops have different sizes, it was necessary to vary the distance between the upper and lower rollers. For this purpose, mechanical jack was used to lower the axle of the lower rollers as much as desired and to prevent damage, such as breaking, cracking and damage to seed viability.



(a) Roller made by Archimedes screw

(b) Mechanical jacks for raising and lowering the lower roller

Figure 4 Height changing system

In most of the combine, the threshing unit works with drum and concave and also on the basis of the impact. In addition, with the breaking and crushing pods, the need for a fan is essential for separating the seeds from straw and chaff. Due to the addition of seed separation stage, the required power in this type of threshing increases. With regard to the current threshing function, it is rare to break and crush the pod. Separating can be done only with the help of a fan and without any other operations. Seeds and pods in this type of thresher, like all other threshers, are not separated by the impact and this will reduce the damages. In this type of threshing, the seeds are separated by rubbing forces and as well as the torque created by the pair of upper and lower rollers. This will make the pods separate clean and less force is used to clean the seeds from the pod.

(a) Soybean

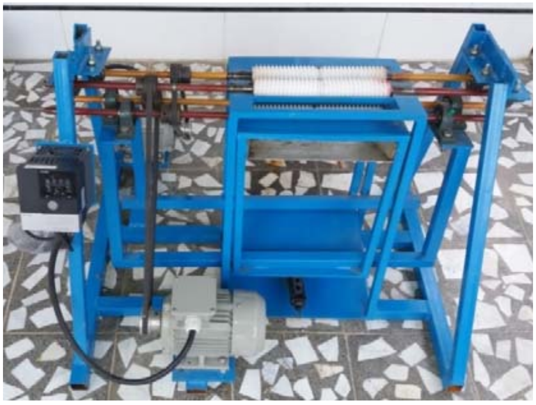
(b) Mung bean

Figure 5 Opened pods of products

Figure 6 Device while working

Since the machine was designed for husking on the basis of rubbing, therefore, the rotational speeds were considered less, until the seed texture will not be damaged, and the seed will not be exposed to cracks or breaks during the separating process. For this purpose, a 1.5 kW inverter (N700E, Hyundai) was used which was made in South Korea. With the help of this inverter, the roller r min^{-1} is adjusted to the desired level.

(a) Inverter to adjust the velocity of husker



(b) Overview of seed pod husker

Figure 7 Electrical system of husker

Data analysis was performed for rotating speeds and distances in three levels (110, 170 and 210 r min^{-1}), (6, 7 and 8 mm) for mung bean and (7, 8 and 9 mm) for soybean respectively, and three replications by analysis of variance (ANOVA) with a completely randomized factorial design test and comparison of mean values and parameters by using SPSS 22 software. Comparison of the meanings was done by Duncan's multiple range tests at 1% probability level.

3 Results and discussion

3.1 Initial evaluation of the device

After soybean and mung bean husking operation (four days, five hours every day) all moving parts such as belts and pullies, rotating shafts and bearings, fixed components and joints were reviewed and no technical problems were observed. Also, according to objective observations, the performance of the new roller for the soybean and mung bean, according to the triangular threads of the rollers, was as expected, acceptable and pods wrapping and sticking were not seen around the rotating shafts.

3.2 Determining the optimal machine working conditions

The results of variance analysis of the measured parameters under the influence of the test factors and their interactions in the soybean and mung bean are presented in Table 1 and 2, respectively. Comparing the mean values of the measured parameters under the influence of the rollers speed and the distance between the rollers at the desired moisture content are shown in Table 3 and 4, respectively.

Table 1 ANOVA of the variable effect on device performance during soybean test

Source of variation	(df)	Mean of square (%)			
		Efficiency	Separation	Loss	Germination
Distance (mm)	2	4.095**	0.004**	0.004**	0.004**
Speed (r min^{-1})	2	2.087**	1**	0.004**	5**
Distance×Speed	4	0.004**	4**	3**	1**
Error	54	8	6	1	7

Note: ** significant at 1% probability levels. The effect of distance, speed and interactions of distance and speed was significant for all four studied parameters for soybean at 1% probability level.

Table 2 ANOVA of the variable effect on device performance during mung bean test

Source of variation	(df)	Mean of square			
		Efficiency	Separation	Loss	Germination%
Distance (mm)	2	0.004**	1**	0.004**	7**
Speed (r min^{-1})	2	0.004**	0.004**	2**	1.039**
Distance×Speed	4	5**	11**	1**	5**
Error	27	9	6	1	6

Note: ** significant at 1% probability levels. The effect of distance, speed and interactions of distance and speed was significant for all four studied parameters for mung bean at 1% probability level.

Table 3 The effect of variables in the average efficiency of the device, the separation efficiency, total losses and germination efficiency during soybean test

Seed	Speed (r min^{-1})	Distance (mm)	Measured parameter (%)			
			Efficiency	Separation	Loss	Germination
Soybean	110	7	91.66a.b	88.82c	1.90a.b	93.21a.b
		8	91.23b	90.05b	3.21b.c	93a.b
		9	92.15a.b	89.71b.c	2.85b	93.25a.b
	170	7	92.51a	89.4b.c	1.66a	91.93b
		8	91.66a.b	90.35b	2.98b	92.22b
		9	93.07a	90.01b	3.03b	91.16b.c
	210	7	92.23a	92.27a	3.90c	93.25a.b
		8	90.41b	89.55b.c	1.70a	92.06b
		9	91.88a.b	89.47b.c	3.22b.c	93.63a

Note: Similar letters at each line indicating no significant difference.

Table 4 The effect of variables in the average efficiency of the device, the separation efficiency, total losses and germination efficiency during mung bean test

Seed	Speed (r min^{-1})	Distance (mm)	Measured parameter (%)			
			Efficiency	Separation	Loss	Germination
Mung Bean	110	6	92.54b.c	90.79b	2a	93.01c
		7	93.71a.b	90.33b.c	2.82b	95.53a
		8	92.61b.c	90.39b.c	2.77b	93.45b.c
	170	6	93.29b	88.16c.d	3.04b.c	93.19b.c
		7	94.72a	93.00a	3.8c	94.68a.b
		8	92.33b.c	90.97b	3.39b.c	94.18b
	210	6	94.43a	91.50a.b	3.47b.c	94.90a.b
		7	91.52c	89.02c	2.47a.b	94.16b
		8	93.79a.b	91.56a.b	4.24c.d	91.19c.d

Note: Similar letters at each line indicating no significant difference.

3.3 Effect of test factors on the machine's efficiency

The results of this research showed that in both soybean and mung bean, the efficiency of the machine was increasing as the machine speed progress (Figure 8), As long as it reached to its maximum yield, then it will slow down as the speed rises. The best efficiencies for soybeans and mung bean were obtained at 170 r min^{-1}, which was 92.41% and 93.44%, respectively. In the efficiency of the machine, only seed separating from the pod was checked, therefore, it seemed reasonable that efficiency of the device increased by increasing the rotating speed and improve the device's ability to separate seeds. But in this example, with increasing velocity, the movements of the pods may increase and part of it remains intact. On the other hand, as shown in Figure 9, with the increase of distance for soybeans, the efficiency first decreased and then increased but in the mung bean diagram the device efficiency was declining with increasing distance. In these two charts, the best soybean efficiency was obtained at 9 mm distance which was 92.36%. For mung bean, the best efficiency was 93.42% that was at 6 mm distance. It may be possible to explain the high efficiency at low distances in this way, by decreasing the distance, the compression of the material layer in the space between the rotary rollers reduced and the impact faces with the least depreciation on its pods. The machine's efficiency is consistent with Ukatu (2006) reported yield.

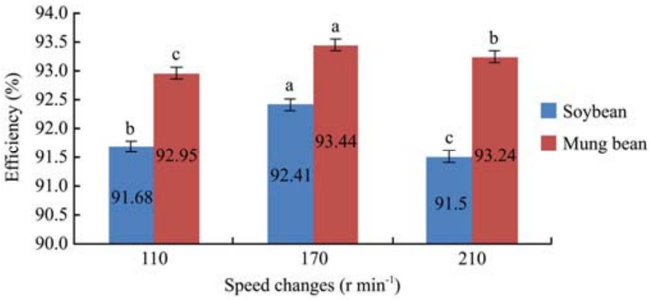


Figure 8 The effect of speed changes on system efficiency

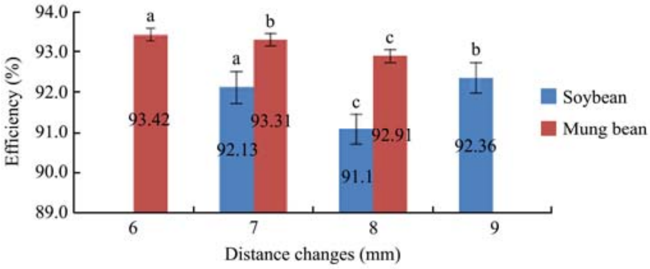


Figure 9 The effect of distance changes on system efficiency

3.4 Effect of test factors on device separation

By increasing the rotary speed, the seed separation efficiency increased (Figure 10). So that the best separation efficiency for soybeans at 210 r min^{-1} was 90.43%. This efficiency was 90.69% which was obtained for mung bean at a speed of 210 r min^{-1}. Generally, at higher rotating speeds, the performance of the threshing components on the product is more powerful and produces more rubbing force and results better separation. As shown in Figure 11 and in the soybean graph, with increasing the distance, the separation efficiency had a downward trend, so at 9 mm, it reached the lowest value of 89.73%. It can be said that for soybeans, more distance makes the force unnecessary to separate the seed from the pods. On the other hand, at great distances, the amount of rubbing force which is considered as an effective factor in seed separation from the pod decreased and separation in soybeans decreased. But about mung bean it can be concluded, with increasing distance, the separation efficiency increased dramatically and at 8 mm, the rollers reached their highest level of 90.97%. This separation efficiency corresponded to the separation efficiency reported by Ukatu (2006) and Mirzazade et al. (2011).

3.5 Effect of test factors on total device losses

Diagram of machine losses during soybean test had relatively horizontal slope, so that the highest losses which was 3.39% occurred at 210 r min^{-1} and this reflected this fact that as the roller speed increased, the energy transferred to the seeds increased and a tougher encounter occurred between the seeds and the roller surface. This caused an increase in damaged seeds. On the other hand, the mung bean chart was approximately as same as the soybean chart. With the difference, that maximum loss which was happened at 170 r min^{-1} was 3.41%. The reason for this may be that at this velocity, part of the tested product had less moisture than other parts, which decreased the seed resistance against the impact and the damage done (Figure 12). As shown in Figure 13 and in the graphs of soybeans and mung bean, the total loss of the device increased with increasing the threshing distances. The reason for this is likely to be a lethal increase in the mobility of the seed and its excessive impact which has caused the device to run upside. In the soybean graph, the maximum damage occurred at a distance of 9 mm, which was 3.03% and this parameter had reached to its highest value at 8 mm which is 3.46% for mung bean. The losses of the device were consistent with the losses reported by Mesquita et al. (2000).

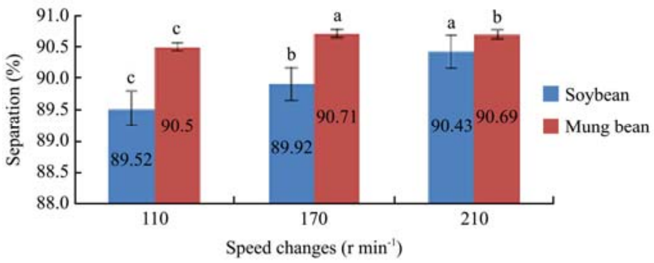


Figure 10 The effect of speed changes on system separation efficiency

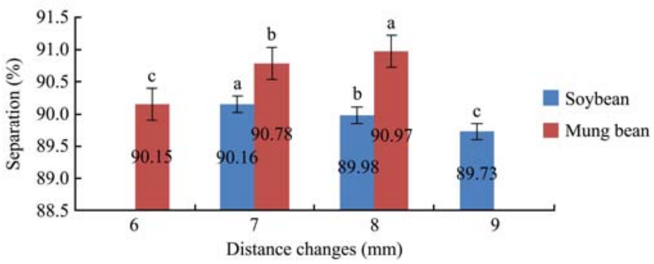


Figure 11 The effect of distance changes on system separation efficiency

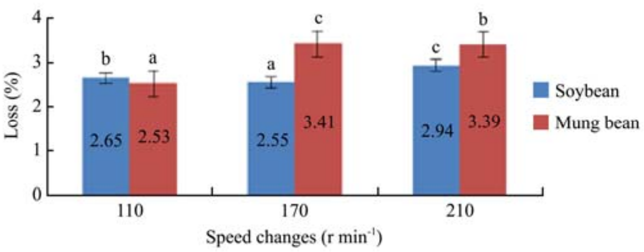


Figure 12 The effect of speed changes on system loss

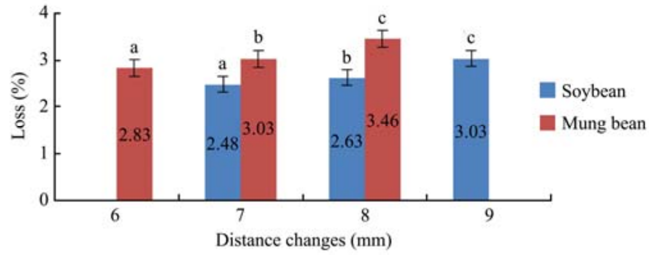


Figure 13 The effect of distance changes on system loss

3.6 Effect of test factors on seed germination

The highest amount of germination of soybeans which was occurred at 110 r min^{-1} was 93.15%, and the highest amount of mung bean germination was 94.01% which happened at 170 r min^{-1} (Figure 14). In the case of soybeans, it can be said that with increasing speed the germination decreased and then increased. This is probably due to the fact that when the speed of the machine reached 170 r min^{-1}, the seeds released from the threshing chamber were pulled out and were not exposed to further impact, which will have a minimal impact on their ability to germinate. It can be said about mung bean, with the increase in roller speed, the impact of the seeds has decreased firstly and then increased, which has affected its ability to grow and the percentage of germination is reduced. In the soybean graph, the highest germination percentage occurred at 92.79% at a distance of 7 mm. By increasing the distance, the percentage of germination decreased slightly and then increased to the same amount. In the soybean graph, it can be said that the germination percentage of the product was independent from the threshing distance (Figure 15). About the mung bean it can be said that with increasing distance, germination increased and then decreased, so, at 7 mm distance, the most germination percentage was 94.79%. In the case of this diagram, it can be said that in a short distance, the impact is more intense on the pods and the percentage of germination was low but at 7 mm, this distance was optimal and the highest germination percentage was obtained. At 8 mm distance, the seeds and pods movements increased, and consequently the impacts to the seeds increased and germination decreased. These germination efficiencies were consistent of what reported by Singh and Singh (1981).

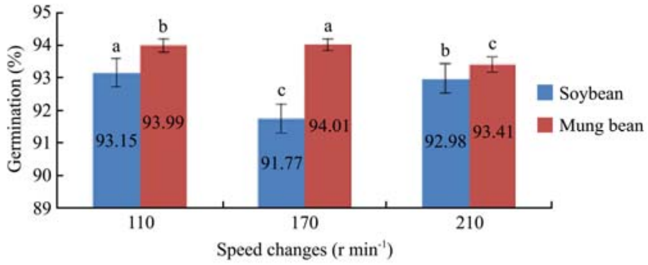


Figure 14 The effect of speed changes on seeds germination

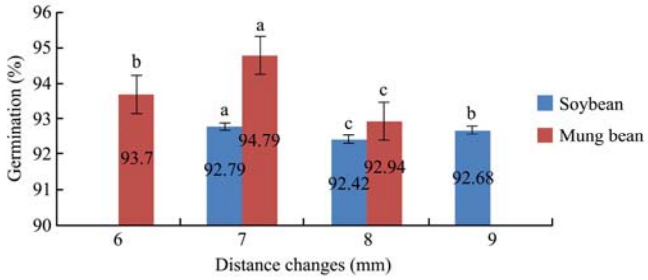


Figure 15 The effect of distance changes on seeds germination

4 Conclusion:

In this research, design, construction and evaluation of a seed pod husker by using the relationships, tables and standards of machine components design on the laboratory scale were presented and its performance was evaluated in terms of efficiency, separation, total losses and germination. The results of practical tests and qualitative observations showed that the device has enough strength against the maximum torque produced by the crop. The results of the scientific test from the analysis of variance showed that effect of rotating speed and distance between rollers on efficiency, separation, total losses and germination were significant at 1 percent probablity (P<0.01). The capacity of the machine for soybeans is 28.506 and for the mung bean is 29.079 kg hr^{-1}. To achieve maximum efficiency, maximum separation, minimum losses and maximum germination for soybean, combination of (170 r min^{-1} - 9 mm), (210 r min^{-1} - 7 mm), (110 r min^{-1} - 7 mm) and (210 r min^{-1} - 9 mm) can be used, respectively. In order to achieve maximum efficiency, maximum separation, minimum losses and maximum germination for mung bean, combination of (170 r min^{-1} - 7 mm), (210 r min^{-1} - 8 mm), (110 r min^{-1} - 6 mm) and (110 r min^{-1} - 7 mm) can be used respectively. Finally, it is recommended to investigate and analyze the device performance for other crops and for other parameters such as electric conductivity, ergonomics issues such as noise and vibration of the device and as well as the effects of other factors, including the length of the roller, number of rollers in shafts and their rotation and the type of threads created on the rollers in the practical test.

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