Determination picking force of sunflower seeds from sunflower head

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Abstract

The physical and mechanical properties of sunflower seeds and heads should be known to design threshers machines for sunflower seeds from sunflower heads. One of the most important parameters to design the thresher machine for sunflower seeds is picking force of sunflower seeds from heads. The picking force of three varieties of sunflower was measured in the present work. Effects of the loading rate, sunflower head size, location of seed on sunflower head and the number of days were studied after harvesting on picking force of sunflower seed from the sunflower head. Results indicated that, the value of picking force of seeds was decreased in all cases by increasing the number of days after harvesting from 1 day to 4 days. The values of seeds picking force were decreased by increasing the sunflower heads diameter of Sirena and Songhori varieties. With increasing loading rate from 50 to 150 g min\(^{-1}\), the values of the picking force of seeds in all cases were increased. The values of the picking force were decreased by increasing the distance between location of seeds and center of the head. The value of picking force of Sirena variety was more than the other varieties and the value of picking force of Songhori variety was less than the other varieties.

Keywords:
loading rate
sunflower seeds location
sunflower seed thresher machine
sunflower head size

1- Introduction

Sunflower (Helianthus annuus L.) is one of the most important oil crops in the world and is ranked 5th in oil production in the world (FAO, 2009), but it is the most popular one in some countries such as Iran and Turkey. The price of sunflower seeds and oil depends on their production level. Thus, the production capacity of sunflower seeds highly affects the development of the processing industry. According to the FAO reports (2010), the world supply of sunflower seed oil for 2008-2009 is estimated at 11.7 million tons (+18% compared with the previous marketing year).

Farmers use the manual methods due to unavailability of suitable machinery for sunflower threshing. During manual sunflower production, the most time and labor-consuming operation is the threshing of sunflower by beating the sunflower heads with a stick, rubbing wear heads against a rough metal surface or power tiller treading (Sangpratum, 1996). The capacity figures for these threshing methods are very low, and impurities are very high. Therefore, there is a need to develop a sunflower thresher machine.

Sharma and Devnani (1979) studied the effect of cylinder tip speed and concave clearance of a rasp bar thresher on threshing of sunflowers. Naravani and Panwar (1994) studied the impact modes effect of threshing on the thresh ability of a sunflower. Anil et al. (1998) developed a thresher used for cereals into a thresher machine which could be used for sunflower seeds. Sudajan et al. (2002) studied the effect of feed...
rate, drum, type of drum and drum speed on sunflower threshing. Sudajan et al. (2003) investigated power requirements and performance factors of a sunflower thresher. Sudajan et al. (2002) studied the effect of some drum characteristics on rasp-bar drum performance for threshing sunflowers.

In order to reduce the number of damaged seeds and decreasing the power consumption of thresher machines and also for increasing their efficiency, these machines should be designed or optimized according to the mechanical and physical properties of the sunflower heads and seeds. Therefore the physical and mechanical properties of sunflower seeds and heads must be known.

Little published literature is available about physical and mechanical properties of sunflower seeds and heads. The effects of intercepted solar radiation on sunflower seed composition from different head positions were studied by Santalla et al. (2002). Physical and mechanical properties of sunflower seeds such as dimensions, sphericity, volume of seed, one thousand seed mass, surface area, projected area, friction coefficient, bulk and true density, porosity, terminal velocity, and angle of repose in the various moisture contents were measured by Gupta and Das (1997) and Khazaei et al. (2006). The fracture resistance of both sunflower seed and its kernel, was measured by Gupta and Das in terms of average compressive force, deformation and energy absorbed per unit volume at rupture (2000). Aerodynamic properties of three varieties of sunflower seeds were studied by Gupta et al. (2006). Mass and size distributions of sunflower seeds and kernels were modeled by Khazaei et al. using Lognormal, Normal and Weibull distributions (2008). Dimensional properties, gravimetric properties and angle of repose of three varieties of sunflower seeds were determined by Mirzabe et al. (2012).

One of the most important parameters to design thresher machine for sunflower is picking force of seeds from the sunflower head (SH). A little published literature is available on picking and cutting force of seeds, grains or fruits of agricultural crops. Threshing and cutting force of Korean rice under quasi-static load were examined in this study. Loading rate was adjusted using a regulator to maintain a constantly increasing quasi-static load of 120 g/min of water supplied from a constant level tank to ascertain the spikelet attachment strength (Lee and Huh, 1984). Their results indicated that the threshing force value in tension is significantly higher than the one applied in bending to detach the grain from the panicle. The silique picking force of three canola varieties (Brassica napus L.), at three stems moisture content, three amounts of fertilizer and three pull out velocities were measured by Hoseinzadeh et al. (2010). The shear strength and picking force of pyrethrum flower were determined by Khazaei et al. (2002). The effects of moisture levels and the cross-sectional area of stem as well as the variety, blade bevel angle, blade type and cutting speed on static and dynamic cutting force of stems for Iranian rice varieties were investigated by Tabatabae Koloor and Borgheie (2006). Shear strength and shear energy per unit area of saffron (Crocus sativus L.) stalk, picking force and energy of saffron flower were determined as affected by tension velocity and age of plant by Hassan-beygi et al. (2010). Cutting energy of rice stem as influenced by internode position and dimensional characteristics of different varieties were studied by Alizadeh et al. (2011). Harvest moisture content, maximum bio-yield point of force and maximum ultimate point of force in the cutting, average needed energy to cut a stem, maximum bending rupture force, average needed energy for bending a stem, relation between bio-yield force, failure force, elasticity and diameter in the cutting, and some other parameters that are important for calculating the power consumption and designing an optimized mower were measured by Mahmoudi and Jafari (2010).

The aim of the present research is to determine the picking force of sunflower seeds from the head to design the new thresher machine; therefore, the effect of loading rate, size of sunflower head, location of seed on sunflower head, and number of days after harvesting on picking force of sunflower seed from the SH for three sunflower varieties namely Mikhi, Songhori and Sirena, were studied which are widely cultivated in Iran.

2- Materials and methods

- sampling preparation:

Three varieties of sunflowers, namely Mikhi, Songhori, and Sirena, which are widely cultivated in Iran, were used in the present work. The Mikhi, Songhori and Sirena varieties are native of Iran. All varieties were planted on June 17th, 2011 in local farms of Foodan located on Shahreza, Isfahan, Iran. The sunflowers were harvested manually in late September, after they were matured completely. 100 sunflower heads with different sizes were selected randomly from each variety.

The head diameter of each sunflower was measured to examine the effect of sunflower head size on picking force of seeds. The flowers were classified into three categories based on value of sunflower head diameter. If the value of SH diameter ranged from 6 to 16 cm, it was named small SH. If the value of SH diameter ranged from 16 to 26 cm, it was named medium SH. If the value of SH diameter ranged from 26 to 36 cm, it was named big SH. Sunflower heads were selected with a diameter of 10-12, 20-22 and 30-32 cm.
In order to examine the effect of sunflower seeds location on picking force of seeds, the selected sunflower heads were divided to three regions namely central region (CR), middle region (MR) and side region (SR), as shown in Figure 1.

In order to study the number of days’ effect after harvesting on picking force of seeds, after harvesting, sunflower heads were left in the atmosphere to decrease moisture content.

- Experimental method:

A schematic diagram of the experimental set up was used to measure the picking force of the seeds, shown in Figure 2. The apparatus made to measure the picking force of the seeds works as follows:

The water is sucked out of the reservoir (1) using a water pump (2). The water pump was driven by armature which works with 3.5 v DC power. The water is pumped to flow control valve (3). By regulating flow rate of the flow control valve, the loading rate is regulated and water enters to the off-on valve (4). Water comes out of off-on valve and enters a plastic beaker (5) which is connected to a clamp (6) with a string (7). The clamp holds the sunflower seed. The plastic beaker and the clamp were made in a way that their mass is equal. Disc holder (8) holds the sunflower head. In order to study the effect of seed position on picking force, a groove was made on the machine’s frame as a guiding sign, the disc could move in it. The water enters the beaker until the seed is picked. As soon as the seed is picked, the off-on valve stops the water flow. Mass of the water in beaker was quantified to measure picking force of seeds. Value of picking force of seeds was equal to mass value of water in the beaker. Mass of the water was measured using digital balance with an accuracy of 0.01 g. In each case, the picking force of sunflower seeds from the heads was determined by a repetition of ten times.

3- Results

The results of picking force of Mikhi variety are shown in Figure 3. Average values of moisture content for 1, 2, 3 and 4 days after harvesting was found to be 33.4, 28.5, 25.3 and 23.5% (w.b.) after harvesting, respectively. The result indicated that in all cases the values of picking force of seeds were decreased after harvesting from 1 day to 4 days by increasing the number of days. The results showed that the values of picking force on central region of medium SHs were more than the values of picking force on central region of small SHs. The values of picking force on middle region of medium SHs were less than the values of picking force on middle region of small SHs; but the difference between the values of picking force of medium and small SHs were very low. Values of picking force of medium SHs were more than the big and small SHs on central region. The difference between values of picking force on big SHs and medium SHs was more than the difference between medium and small SHs. The results indicated that difference between values of picking force on central region and middle region was less than the difference between middle and side region. According to Figure 3, when the loading rate equals to 150 g min-1, the values of picking force were more than when the loading rate equals to 50 g min-1.

Results of picking force of Songhori variety are shown in Figure 4. Average values of moisture content for 1, 2, 3 and 4 days was found to be 31.0, 27.7, 24.6 and 22.1% (w.b.), after harvesting, respectively. The result indicated that in all cases by increasing the number of days the values of picking force of seeds were decreased after harvesting from 1 day to 4 days. Results showed that the value of picking force was decreased with increasing SH diameter. Difference between values of picking force on small and medium SHs was less than the difference between medium and big SHs. Results indicated that difference between the values of picking force on central region and middle region was less than the difference between middle and side region for 2 and 4 days after harvesting; for 1 day and 3 days after harvesting the difference between values of picking force on central region and middle region were more than the difference between middle and side region. According to Figure 4, when the loading rate equals to 150 g min-1, the values of the picking force were more than when the loading rate equals to 50 g min-1.

The results of picking force of Sirena variety are shown in Figure 5. Average values of moisture content for 1, 2, 3 and 4 days after harvesting was found to be 35.2, 29.7, 26.6 and 23.9% (w.b.), respectively. Result indicated that in all cases, the values of picking force of seeds were decreased with increasing the number of days after harvesting from 1 day to 4 day. The results showed that the value of picking force was decreased with increasing SH diameter. Difference between values of picking force on small SHs and medium SHs was less than the difference between medium and big SHs. The results indicated that difference between values of picking force on central region and middle region was less than the difference between middle and side region. According to Figure 5, when the loading rate equals to 150 g min-1, the values of the picking force were more than when the loading rate equals to 50 g min-1.
4- Discussion

The result showed that when the loading rate equals to 150 g min⁻¹, for big, medium and small SHs of Mikhi, Songhorì and Sirena varieties, the average of picking force ratio on middle region to central region (average of 1 day, 2 days, 3 days and 4 days after harvesting), ranged from 0.776 to 0.859. Maximum and minimum values of picking force ratio on middle region to central region were obtained for Sirena and Songhori varieties. When the loading rate equals to 50 g/min, the corresponding values would be 0.775 and 0.847, respectively. Maximum and minimum values of picking force ratio on middle region to central region were obtained for Sirena and Songhori varieties.

The result showed that when the loading rate equals to 150 g min⁻¹, for big, medium and small SHs of all varieties, the average of picking force was ranged from 0.474 to 0.663 on side region to central region (average of 1 day, 2 days, 3 days and 4 days after harvesting). Maximum and minimum values of picking force ratio on middle region to side region were obtained for Sirena and Mikhi varieties. When the loading rate equals to 50 g min⁻¹, the corresponding values would be 0.464 and 0.644, respectively. Maximum and minimum values of picking force ratio on side region to central region were obtained for Sirena and Mikhi varieties.

Physiological maturity of sunflower heads starts from the side region to the central region. So when the sunflower head matured, there are immature seeds in central region which are still absorbing nutrition from the plant; therefore, in most cases in the central region, maturity does not happen completely and so, picking force of the seeds in central region are more than the side and middle region.

In all cases, the value of the picking force on central region was more than the middle region and value of picking force on middle region was more than the side region; because for each head, seeds located on the side region of the head reach maturity before the seeds located on the middle region of the head. Also, seeds that are located on the middle region of the head reach maturity before the seeds that are located on the side region of the head.

With increase in the maturity of seeds, the moisture content of head and seeds decreased and some physiological changes (for example increasing Abscisic acid) happened. When the moisture content decreased and the physiological changes made, tensile cutting force of xylems that contacted the seeds to head was decreased; therefore, the picking force of the seeds decreased.

The result showed that for big, medium and small SHs of Mikhi, Songhori and Sirena varieties, when the loading rate increased from 50 to 150 g min⁻¹, the picking force value of seeds is increased in central, middle and side regions.

The effect of loading rate and moisture content on picking and cutting force of agricultural crops was also reported by pervious researchers. Hemmatian et al. (2012) investigated shearing properties of sugar cane stems at five moisture content levels, three shearing speeds and at ten positions on the stem. The results of variance analysis indicated that effect of the shearing speed was significant at 1% probability level. Shearing strength and specific shearing energy increased with an increase in shearing speed and so shearing strength and specific shearing energy decreased with decreasing in stem moisture content. Shahbazi and Nazari Galedar (2012) determined bending stress, Young's modulus, shearing stress, and shearing energy of safflower stalk as a function of moisture content and stalk region. The results indicated that shearing strength and shearing energy increased with increasing in stem moisture content. Also the results of El Hag et al. (1971) showed that the effects of loading rate on tensile strength of cotton stem were influenced further by density of stem. For high density specimens, the tensile strength increased directly with increasing loading rate. Results of Hassan-Beygi et al. (2010) showed that with increasing tension rate the required tensile strength per unit, area of saffron stalk increased significantly. Khazaee et al (2002b) reported that the area of pyrethrum flower increased significantly with increasing tension rate of required energy per unit.

The results indicated that for Mikhi, Songhori and Sirena varieties, the value of picking force of seeds decreased with increasing the number of days after harvesting from 1 day to 4 days. Also for Songhori and Sirena varieties the value of picking force of seeds decreased with increasing the SHs diameter. Results of Mikhi variety indicated that picking force of medium SHs on central region was more than the big and small SHs.

According to the obtained results, the value of picking force of Mikhi and Songhori varieties was less than the Sirena variety. Designing of the sunflower thresher machine should be done based on the critical state. Therefore, the better values of picking force of the Sirena variety will be used to design the sunflower thresher machine.
5- Conclusions

The effect of loading rate, size of sunflower head, location of seed on sunflower head, and the number of days after harvesting on picking force of sunflower seeds from the SH for three sunflower varieties were determined to design sunflower thresher machine. The results indicated that:

1. Value of picking force of seeds decreased with increasing the number of the days after harvesting from 1 day to 4 days.
2. The value of picking force of seeds was decreased in most cases with increasing the SHs diameter.
3. When the loading rate increased from 50 to 150 g min-1, the values of the picking force of seeds was increased in all cases.
4. In all cases, the value of the picking force on the central region was more than the middle region and the value of picking force on the middle region was more than the side region.
5. In all cases, the value of the picking force of sunflower seeds of Sirena variety was more than the other cases.

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7- References


Fig. 1- Three regions of SH.
1. Central region (CR) 2. Middle region (MR) 3. Side region (SR)

Fig. 2- Experimental set up used to measure the picking force of the seeds
Fig. 3- Effect of loading rate, seed location, SH diameter and moisture content on picking force of seeds from SH for Mikhi variety.
Fig. 4- Effect of loading rate, seed location, SH diameter and moisture content on picking force of seeds from SH for Songhori variety.
Fig. 5- Effect of loading rate, seed location, SH diameter and moisture content on picking force of seeds from SH for Sirena variety.