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Evaluations of Cereal Combine Harvester Head Attachment for Harvesting of Sunflower and Comparison with Conventional Harvesting Methods

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Abstract

In Iran, more than 50,000 hectares of sunflowers (oil and nuts) are cultivated annually. Conventional grain combine harvesters are not compatible with the unique characteristics of sunflowers, leading to significant grain losses during harvesting. Therefore, it is currently being harvested manually. Manual harvesting increases labor hardships, energy and time consumption, and production costs. In this research, to harvest sunflower seeds, modifications were made on conventional head of a combine harvester (John deer 1055) to allow simultaneous harvesting, threshing, and cleaning of the sunflower seeds. After designing and fabricating the accessory, the improved head in field conditions was evaluated and compared with conventional harvesting methods. The field evaluation of the improved head was based on a randomized complete block design with three replications. The treatments involved three different harvesting methods: 1) using a modified combine head, 2) employing a combine equipped with pan attachment, and 3) manual harvesting. In each of the machine treatments, beating and cleaning units were set up for sunflower harvest. The results showed that there was a significant difference between the treatments concerning machine losses, field capacity, and harvesting costs, all at the 5% significance level. In the modified combine, combine with pans attachment, and manual method, combine losses were 0.72, 4.85, and 6%, and field capacity was 1.2, 1.13, and 0.12 ha h^{-1}, respectively. The profit-to-cost ratio was 13.97, 13.3, and 3.01, respectively. The grain breakage percentage was 3, 3.3, and 0.56, respectively. According to the results, due to lower losses, appropriate field capacity, and lower harvesting costs, the use of John deer 1055 combine with the modified head is recommended for harvesting of the sunflower.

Keywords: Attachment, Combine head, Harvesting, Improvement, Sunflower

Introduction

The sunflower plant is one of the most important oilseeds in the world. The origin of this plant is North America; this plant was brought to Europe by the Spaniards in the 19th century and about 80 to 90 years ago was imported to Iran. The most important countries producing sunflower in the world are Russia, the USA, China, and Argentina, respectively. In recent years, the high imports of this oilseed to Iran have been for oil production (Mozaffari & Hassanpour Darvish, 2012). The sunflower is an annual crop. The plant is physiologically ripe when the back color of the head changes

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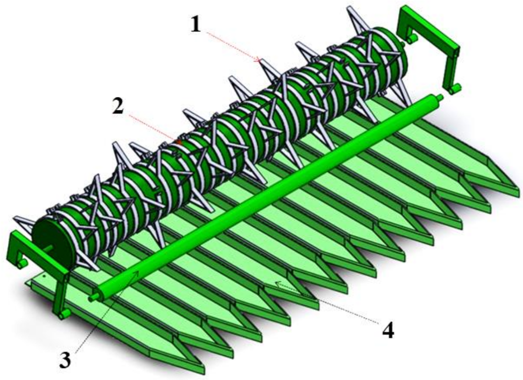
from green to yellow and is ready for harvesting; this time is routinely before drying of heads. Many farmers prefer to harvest sunflowers at grain moisture between 20-25% with a combine harvester or by hand to reduce the loss time and birds damage. Harvesting of the sunflower with high humidity causes molding on the heads, increases the percentage of lean and wrinkled grains, as well as complications during the threshing process. The sunflower is cultivated over 59,531 hectares of Iran's lands every year (Ahmadi, Ebadzadeh, Hatami, Abdshah, & Kazemian, 2020). One of the critical stages of production of this crop is harvesting operation which is done manually by workers. Manual harvesting has problems like formidable work, labor shortages, and high labor costs; therefore, mechanized harvesting of this crop is essential.

There is no economic justification for constructing a head attachment of sunflower harvester in combine factories, so local workshops make this attachment. Modifications are applied to the cutter bar and the reels. The conventional reel is replaced by a reel with three thin arms attached to a plate. In the case of the cutter bar, 7.5 cm wide long pans are attached and act as the stripper. The plates attached to the reel pass through two pans and push the plant straw to the auger. Pans guide the stem and prevent seeds loss (Grower, 1971). Researchers evaluated various brands of different harvesting mechanisms for sunflower crops in one study; these mechanisms consist of four essential components including: the dividers, the pans, the reel, and the plates attached to the reel (Nyborg, Thauberger, Gregory, & Pool, 1980). The conventional cutter bar and reel can be used, but long pans should be used to guide the stems and reduce the loss (Husiman, 1977). The cereal combine harvesters can be used to harvest sunflower and most of the combines used for this crop follow the principles of stripper harvester (Hoffman, Berglund, & Hellevarge, 1982). Another study showed that conventional fine-grains cutter bars can be used to harvest sunflower by modifying the dividers and reel (Dekalb, 1987). The sunflower harvesting losses using the conventional head were higher than the row crop head and the head equipped with the pans. The conventional head loss was between 24-30%, while under the similar conditions, these losses in the head equipped with the attachment were between 4-5% (Thierstin, 1990). The Prairie Institute tested the tractor sunflower harvester. The special pans (pentagonal plates) were used for row spacing. A small reel equipped with a hydraulic motor with feeder's fingers was implemented above the cutter bar. The pans wide were considered according to the distance between the rows of sunflower cultivation. The plant passed between the pans and was delivered to the reel. The pans were long enough to collect any fallen seeds. The working width was 3.8 m and the distance between the pans (center to center) was 76 mm. The performance of pans and dividers was appropriate. The flow of the crop was smooth and there was a suitable match between the reel speed and forward speed. Optimal speed is dependent on crop conditions (especially moisture). The ideal speed was 7km.h^{-1}. The grain losses were low and pans covered 84% of the cutter bar; however, the reel with dry grains increased grain losses (ZACH, 1981). The fine-grained combine harvesters can be modified to harvest sunflowers. The kinds of head attachments are available, and many of them work according to the operating principles of strippers. Attachments were designed to collect only sunflower heads (non-harvested stems). The most important components of the attachments were the pans, the deflectors, and the reels. The deflector was positioned atop the pans, guiding the stems inward and delivering them directly to the cutter bar. The pans were available in different widths, from narrow (23 cm) that were suitable for 30 cm row spacing to 94 cm for 102 cm row spacing. The deflector was a curved sheet metal with a combine work width that was mounted on the reel retaining arm. The reels usually had 3-4 arms with 41-51cm diameter and were installed at 10-13 cm above the pans; thus, when the sunflower heads were in contact with the reel, they were directed towards the auger (NDSU, 2014). A study was conducted to evaluate the effectiveness of a combine harvester in the sunflower crop harvest. The effects of some important parameters such as forward speed, threshing cylinder speed, and concave distance were studied; the results showed that the favorable conditions in terms of low grain losses and energy consumption, and high field capacity were achieved at a forward speed of 3.3 km h^{-1} and grain moisture content of 15.15% (based on dry weight). The grain losses, energy consumption, and field capacity were 3.12%, 11.38 kW ton^{-1}, and 1739 kg h^{-1}, respectively. In this situation, the fuel consumption was 5.5 liters per hour (Sayed & Abd El Maksoud, 2012). In one study, the effects of forward and reel speed on the sunflower harvest losses were studied. The results showed that the combine forward speed did not have a significant effect on the total losses, but the effect of the reel speed on the loss was significant. Finally, the most suitable forward speed and reel speed in terms of low losses were 6 km h^{-1} and 30 rpm, respectively; under these conditions, the reel index was five (Elfatih Mohammed, 2014). In a study to harvest the sunflower, a combine equipped with a four-row crop head, the grain purity was 96.64%, the number of damaged seeds at a moisture content of 5.1%, was 1.5% and the total loss was less than 1%. One of the reasons for the low losses in this type of head was the lack of sunflower stems entering threshing units. On the other hand, the high percent of purity and the low percent of breakage indicated the proper performance of the combine cleaning and threshing units (Shaforostov & Makarov, 2019). In a study in the Ukraine region, a new head for the sunflower harvesting was introduced and evaluated. The results showed that the most important factor in reducing crop losses was the forward speed. The minimum losses were achieved at 2.5-5 km h^{-1}, the cutting height was 0.5-0.7 m, and the harvesting period was less than five days. Using this technology, the loss rate was reduced by 1.4 times. In this technology, the sunflower crop was directed to a special channel by the dividers. Two rollers were installed on the head that made the stem stable, and with the lower fingers, the plant stem was cut and directed backward. At the end of the head was another blade that cut the head from the bottom. In the next step, it was guided backward and inside the combine by the elevator belt (Nalobina *et al.*, 2019).In a study titled Modeling Grain Losses in Mechanized Harvesting of Oilseed Sunflower, the effect of the height of the crop's sleeper rod on head and combine grain losses was significant at the 1% and 5% levels, respectively, but the effect of head height and the interaction effect of head height × rod height was significant only on head grain losses at the 5% level. With increasing rod height from 20 to 70 cm, the average head and combine losses increased from 4.7 to 18.6% and 3.4 to 4.5%, respectively, but with increasing cutting height from 60 to 120 cm; the average grain losses in the combine decreased from 3.4 to 1.5% and the average head grain losses increased from 10.8 to 12.4%. The regression model showed the relationship between the independent and dependent parameters. The output of the regression model showed that by adjusting the cutting height and the crop-laying bar, the total losses of the combine, including losses at the head and rear of the combine, can be reduced to less than 5% (Ghiasi & Safari, 2021). According to the researches mentioned, different mechanisms have been used for the mechanized harvesting of the sunflower. Conventional harvesting methods primarily fall into two categories. The manual method faces numerous challenges, particularly concerning labor costs and operational difficulties. The other method involves using a wheat harvesting combine that has been equipped with pans. This method has high loss due to using reel during sunflower harvesting. In this research, the conventional head was modified with minimum cost and evaluated in the field for harvesting of sunflower (Fig.1).



(a)

(b)

Fig. 1. (a) Components of the new system attached to the grain combine head:
1- Reel finger, 2 - Reel cylinder, 3 - Plant sleeper rods, and 4 - Seed pans.
(b) Combine harvester with modified header and combine harvester with conventional header equipped with pans

Materials and Methods

Cereal combine harvesters have a reel to guide the crop inward, a cutter bar to cut the crop, an auger to move the crop to the feeder elevator, a threshing unit to beat the crop, and a cleaning unit to clean the crop. The heads of these combine harvesters were designed for cereal harvesting and wasn't suitable for sunflower crops, so the necessary modifications were carried out on the head, and adjustments applied to the combine threshing and cleaning units to reduce harvest losses. In this research, an attachment was designed and constructed, and installed on the John deer combine (1055). This research was carried out in two phases: the development of the attached system and the field evaluation of its effectiveness.

Construction of the prototype attachment

This system consists of separate components as follows:

Crop guidance pans mechanism

The spacing for the sunflower plants was set at 60 cm between the rows and 15 cm between the plants within each row. Therefore, inter-row seed pans on the combine head were designed based on a coefficient of 30 cm. The length and width of the seed pans were 140 and 25 cm, respectively (Fig.1). The head width was 4.27 m and included 16 pans. The pan's thickness was 1.5 mm with suitable shapes that provided minimum friction with the crop. The position of the pans was such that the crop was guided to the cutter bar with minimal loss. Under the pans were the retaining metal belts, which connected the pans to the cutter bar. The pans prevented heads from falling and controlled crop losses.

Feeder cylinder and crop sleeper rod mechanism

The sleeper rod consisted of a steel pipe with 4m long and 10cm diameter, which is supported by a reel retaining rod on both sides (Fig.1). The sleeper rod was positioned on the pans, ensuring that the cutting unit effectively severed the plant's stem. The same conditions existed in the combine that was equipped with pans made in the local workshops of Shiraz, Iran. To guide the sunflower heads, the reel was released from the head, and the feeder cylinder with 30 cm diameter and radial appendages with 30 cm length were installed. The sleeper rod was bending the crop and the feeder drum moved the crop towards the auger. Additional walls were installed in the sidewalls of the head to stop the crop from falling outside.

Evaluation of head attachment

This mechanism was compared with other methods in an oil sunflower field in Kermanshah, Iran. The experiment design was completely randomized blocks with three replications. The variety of sunflower was Azargol. The harvesting methods studied were as follows:

1- Manual harvesting (MH)

2. Equipped Machine Harvester (EMH): Harvesting with a conventional wheat combine harvester with conventional head equipped with seed pans (Fig1-b)

3- Improved Machine Harvester (IMH): Harvesting with grain combine equipped with a new improved head

The combine threshing and cleaning units were set up for sunflower harvesting before field harvesting. The threshing clearance distance was 3 cm at the front and 1.5 cm at the rear. Rotational cylinder speed was 750 rpm. The straw sieves in the cleaning unit were completely open. The grain sieve holes were selected according to sunflower seed size. The dimensions of each experimental plot were 5×20 m.

In the manual method, the sunflower heads were removed from the plant by the laborer and then transferred to the place where the heads were pounded (Fig. 2).

Fig. 2. Manual harvesting method and separating the grain from heads

The studied important technical indicators included the natural and combine losses. The grain damage percentage and grain purity were measured as well. The sampling included measuring grain moisture at harvest time, plant height, and height of harvest residues, field capacity, natural losses, hand-harvested grain losses, combine losses (cutting platform and combine end losses), and quality losses. Combine losses were considered equal to the total losses of the threshing unit, separating unit, and cleaning unit. By measuring the time required for harvesting 20 meters in 3 repetitions, the average forward speed was calculated. To determine the harvesting height, the height of the standing sunflower stems from the ground was measured. The rotational speed of the threshing cylinder was obtained by the combine panel. By determining the cutting width (4.27 m) and the forward speed and considering field efficiency of 80%, the field effective capacity was calculated. Grain moisture content was assessed using 100 g samples, which were then transported to the laboratory for analysis. The average grain moisture content was 10.49% (based on the wet weight of grain).

Grain losses in manual harvesting

In manual method, natural loss was determined before harvesting. Then, the sunflower heads were harvested manually and put in special bags for threshing and cleaning. The grains that were left inside the sunflower heads during the threshing and cleaning stages were considered as post-harvest losses. All manual method losses included grain losses during field harvesting and grain losses after harvesting.

$$P_n = \frac{W_b}{W_a + W_b} \times 100 \quad (1)$$

Where:

P_n: Natural grain losses (%)

W_a: Mass of grains in standing classes per unit area (g)

W_b: Mass of grains shed per unit area - shed before the combine entered the field (g)

$$Y_t = \frac{10 \times (W_a + W_b)}{A_k} \quad (2)$$

Where:

Y_t: total grain produced per unit area (kg ha^{-1})

A_k: Sampling area (m^2)

Natural grain losses

The natural losses included grains and sunflower heads that were dropped on the ground before harvesting. The cause of this loss was the wind, hail, rain, pests, diseases, birds, crop lodge, and rodents. At a distance of 20 m in each experimental plot, the number of heads and grains shed before harvesting were collected. The total weight of grains in the sheds and the grains on the ground was considered as natural losses. The field yield was determined in three replications by the plots with dimensions of 2×1. The sunflower seeds from these plots were harvested and subsequently weighed to calculate the percentage of natural loss.

$$P_i = \frac{W_q \times 1000}{Y_t \times A_k} - p_n \quad (3)$$

Where:

P_i: Percentage of grain losses per head (%)

W_q: Total mass of grains collected at a distance of 20 meters (g)

Head losses

The head losses included sunflower heads and grains that fell before being transferred to the threshing and cleaning units. This loss was attributed to the incorrect operation of the cutter bar, feeder speed, and an improper distance between the feeding unit and the cutter bar. Fallen seeds and heads were collected inside experimental plots after harvesting at a distance of 20 meters.

Combine rear losses (threshing, separating, and cleaning units)

The losses of the threshing unit included the grains in the sunflower head and semi-threshed seeds that came out of the end of the combine. A rectangular wood frame with an internal dimension of 33 x 61 cm was placed under the combine while the combine harvester was normally harvesting. The floor of this frame was covered with fine wire mesh that collected uncut and semi-crushed sunflower heads. Then the healthy and breakage grains separated, and their net weight was recorded. The threshers, cutter bar, and sieve losses were recorded as end-of-combine losses.

$$P_Z = \frac{K + M + N + R}{T} \times 100 \quad (4)$$

Where:

P_z: Percentage of impurities (%)

K: Mass of broken grains in the sample (g)

M: Mass of straw in the sample (g)

N: Mass of weed in the sample (g)

R: Mass of gravel and soil in the sample (g)

T: Total sample mass (g)

Percentage of impurities and quality loss

During the harvesting by the combine, part of the grains are broken down and transferred to the combine tank, which is known as quality loss. Impurities from the harvested crop also included weed seeds, soil, pebbles, and straw. The percentage of qualitative loss was obtained from the ratio of the weight of broken grains to the healthy grain weight. The percentage of impurities was obtained from the ratio of the weight of total impurities (weed seeds, soil, pebbles, and straw) to the total weight of the sample.

Theoretical capacity

This factor indicates the number of surfaces covered by the machine regardless of the wasted time. This index is a function of the forward speed and width of the machine and can be calculated from Equation 5:

$$C_t = (V \times W)/10 \quad (5)$$

Where:

V = Forward speed (km h^{-1})

W = Working width (m)

C_t = Theoretical capacity (ha h^{-1})

To determine the forward speed, the time required for a distance of 20 meters was measured.

Effective field capacity

This capacity represents the actual operating hours of the machine with considering wasting time (some time is wasted during operation for turning, adjustments, lubrication, repairs and service, rest, etc.) and is a function of theoretical capacity and field efficiency:

$$C_e = C_t \times \eta \quad (6)$$

Where:

η = field efficiency (%)

C_e = effective field capacity (ha h^{-1})

Another method for determining the effective field capacity is to determine the time required to harvest one hectare, which has been used manually method.

Economic assessments

In the economic evaluation, harvesting methods were compared using the partial budgeting method, and factors such as additional income and costs arising from the new technology were determined (Roth & Heyde, 2002). The results were statistically analyzed by SPSS software using Duncan's test method at 5% and 1% levels.

Results and Discussion

Field capacity

There was a significant difference between the used machines and manual methods in terms of field capacity at the level of 5%. There was no significant difference between a combine equipped with a pan and an improved combine (Table 1). The capacity of the improved combine, combine equipped with pans, and manual method were 1.2, 1.13, and 0.12 hectares per hour, respectively. These results that are presented in Fig. 3 showed that the sunflower harvesting capacity in machine methods was 10 and 9.4 times of the manual method (Table 2). Although the working width of the combine was the same, the slight difference between the machine methods could be due to the different speeds or the field efficiency (Fig. 3).

Grain fracture rate

There was a significant difference between the machine and manual methods in terms of grain fracture percentage at the level of 5%. In the improved machine and equipped with pans, the fracture percent was 3% and 3.3%, respectively. There was no significant difference between these methods (Fig. 4). In the manual method, the fracture rate was 0.56%, which showed a significant difference with the machine methods. In a study on a combine equipped with a 4-row head for sunflower harvest, the purity percentage was 96.64% and the number of damaged seeds at a moisture content of 5.1% was 1.5%, which indicates the proper performance of the threshing and cleaning units (Shaforostov & Makarov, 2019). In this study, one of the reasons for the low loss and grain fracture (twice the fracture rate of this study compared to the study mentioned), may be due to the type of hammer, which in the current study was rasp bar type, but these researchers used nail studs for sunflower harvesting. However, the amount of breakage in oily sunflower seeds does not matter much and a high percentage of purity that is the removal of the input stem in the combine has been reported.

Purity

There was no significant difference between harvesting methods in terms of purity percentage (Table 1). The percentage of impurities in the improved head methods, machine with the pans equipped, and manual method was 6.19, 6.67, and 4.67 percent, respectively (Fig. 5). These results showed that in terms of quality, the quality of grains in the combine tank has the same conditions and the necessary settings have been applied to the crusher and anti-crusher cleaning units. Threshing and purity have been acceptable. In the manual method, the beating and cleaning steps have been done properly. The maximum acceptable impurity in oil sunflower mill factories was 10% (Anonymous, 2019), so all harvesting methods in this study were acceptable purity. The results of a study conducted by Shaforusto and Macro (2019) on a four-row combine for sunflower harvesting showed the impurity rate was 1.38%, which was less than the results of this study. The harvesting head used by these researchers was similar to corn harvesting machines and had feed rollers that were sloping on the dividers and guided the crop from the bottom according to the harvest to the feeding elevators (Shaforusto & Macro, 2019). A key factor contributing to the low impurity observed in this study was the separation of the head from the stem prior to its entry into the thresher. The efficiency of these units has increased because the stems do not enter the threshing and cleaning units.

Table 1- Analysis of variance of the effect of levels of the sunflower harvesting methods

Variation source	Degree of Freedom	Head loss	Back loss	Total loss	Grain fractures	Seed purity	Field capacity
Replication	2	1.29 ns	0.34 ns	2.74 ns	0.35 ns	0.74 ns	0.05 ns
Harvesting method	2	15.56**	24.65**	23.14**	6.74ns	3.27 ns	1.10**
Error	2	0.39	0.33	0.68	11.80	1.24	0.02
Coefficient of change	C.V	29.05	34.09	21.34	9.54	1.18	16.06

** Significant difference at 1% level, and ns: No significant difference

Table 2- Comparison and classification of the mean of studied traits in different harvesting methods

Harvesting method	Head loss (%)	Back loss (%)	Total loss (%)	Grain fractures (%)	Seed purity (%)	Field capacity (ha.h^{-1})
Modified head	0.70 b	0.02 b	0.72 b	3.00a	93.81 a	1.20 a
Pans head	4.78 a	0.05 b	4.85 a	3.30 a	93.33 a	1.13a
Manual method	1.00 b	5.00 a	6.00 a	0.56 b	95.33 a	0.12 b

In each column, the difference between the means that have at least one common letter, is not significant.

Tall stems that remain in the field after harvesting sunflower can interfere with the cultivation of subsequent crops. Therefore, if the combine can be equipped with stem shredding units, the problem of the remaining residues in the field will also be solved. The highest losses in combines were in their header part. Unlike natural losses, this factor was a function of combine performance. According to Tables 1 and 2, there was a significant difference between machine methods in terms of losses in the header of the combine. The combine equipped with pans experienced the most significant loss, reaching 4.78%. The average loss of the improved header was 0.7%.

In a study, the effect of reel rpm on the rate of sunflower harvesting losses was significant. The appropriate rpm and proper forward speeds were 30 rpm and 6 km h^{-1}, respectively. Therefore, one of the reasons for the high losses in the combine harvester equipped with pans was the high rpm of the reel (Elfatih Mohammed, 2014). In the current study, the average speed of the reel in the combine equipped with pans was 20 rpm and the speed of the reel was low. So, it can not be considered as the cause of grain loss.

Rear combine losses

The rear combine losses weren't significant in combine harvesters, but there was a significant difference between the combine harvesters and manual methods at the level of 5%. On the other hand, the rate of the rear of combine losses in the tested combines was very low and insignificant.

Total combine losses

The average natural loss was 0.9%, which showed that the field crop was not affected by natural loss factors such as storms and excessive drought. There was a significant difference between the experimental methods in terms of total losses at the level of 5%. The rate of losses of the improved combine harvester, combine equipped with pans, and manual method were 0.72, 4.85, and 6%, respectively. These results indicate that the losses in the improved combine were low (Fig 6). Efficient hybrid operations should be applied to minimize harvest losses. Natural losses play a major role in reducing losses. Total product losses should not exceed 5% of the yield. These losses include pre-harvest, header, beating, and cleaning losses. In one study, pre-harvest sunflower harvesting losses, header, thresher, cleaner, and total loss (including natural losses) were 2.2, 5.3, 0.1, 1.8, and 9.4%, respectively (Anonymous, 2005). The loss, without natural loss, was 7.2%, which was lower than the current research.

In one study, a major factor in increasing grain losses was the combine forward speed. The rate of loss was directly proportional to the rate of forwarding speed. Increasing the forward speed from 3.2 km h^{-1} to 5.6 km h^{-1} increased grain losses by 4% (Nalobina *et al*., 2019). In the current study, the average forward speed was 3.51 km h^{-1}, which did not have a significant effect on the grain losses.

In another study, using a 4-row sunflower harvesting header, the grain loss rate at 5.1% grain moisture content was less than 1%. The heads were cut from the lower parts by sloping dividers. It reduced the entry of the plant stem into the threshing and cleaning units. Reduced plant entry increased the threshing and threshing efficiency, and reduced the overall grain losses in combine harvesting (Shaforostov & Makarov, 2019). The results of these researches in terms of overall combine losses were consistent with the results of this study for harvesting sunflower with the help of the modified header.

Economic assessment

The yield per hectare of the farm was 2200 $kg.ha^{-1}$. The guaranteed purchase price of oil sunflower seeds was $0.128 (Anonymous, 1397) and the net income was $281.6. The renting cost of the combine for sunflower harvesting was $20. The harvesting costs were $88 in the manual method including 22 people per day per hectare for harvesting, threshing, and cleaning. The net income of the improved combine methods equipped with pans and manual method were $279.6, $267.9, and $264.7, respectively (Figs 7 and 8). The costs per hectare were $20, $20, and $88, respectively, and the benefit-to-cost ratio in these methods was 13.97, 13.3, and 3.01, respectively.

Conclusion

1- The field capacity of sunflower combine was about nine times that of the manual method; therefore, harvesting by combine in a short time can effectively prevent pre-harvest losses such as birds attack, pests, and grain loss.

2- The percentage of fractures in the manual harvesting method was lower than harvesting by machine methods. One of the reasons for the increase in grain fracture in combine harvesters is due to the abrasive threshing unit.

3- The variations in grain purity percentages were not significant across the improved combine harvesting method, the combine equipped with pans, and the manual harvesting method. These percentages were 93.93, 93.33, and 95.33%, respectively.

4- The lowest and highest grain losses were related to the use of improved combine and manual methods, respectively.

5- Using the combine harvesters with the new improved header and equipped with pans reduced costs compared to the manual method by 76.3% and 74.46%, respectively.

Finally, the use of an improved combine (equipped with a new improved header) was recommended for sunflower harvesting due to reducing harvesting costs, grain losses, grain impurity, and suitable field capacity.

Declaration of competing interests

The authors declare that they have no conflict of interest.

Authors Contribution

M. Safari: Corresponding author and conductor of the research

P. Ghiasi: Contribution in conducting the project in the field

A. Rohani: Contribution to writing and editing the article

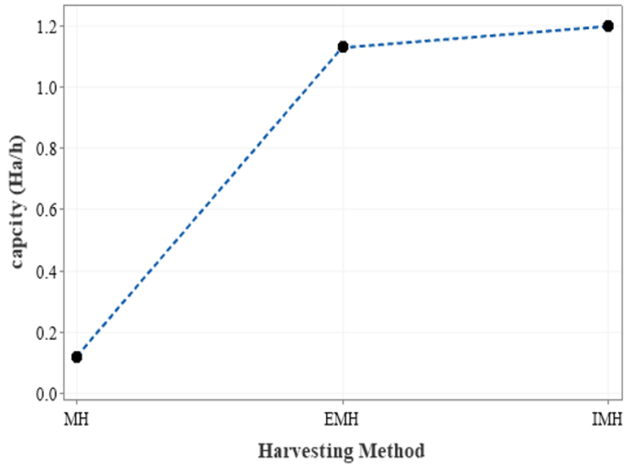


Fig. 3. Farm capacities in various harvesting methods

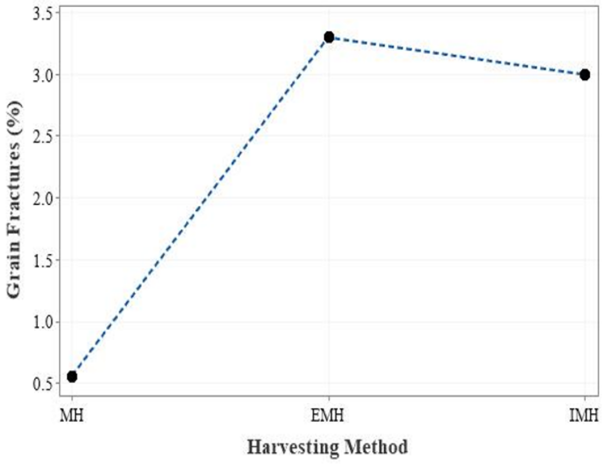


Fig. 4. Grain fractures in various harvesting methods

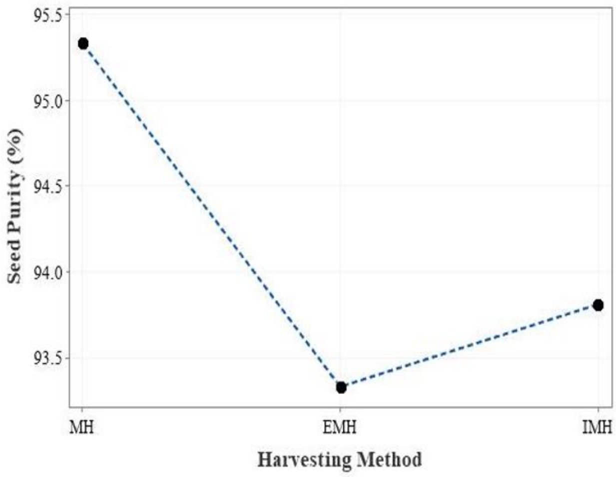


Fig. 5. Seed purity in various harvesting method

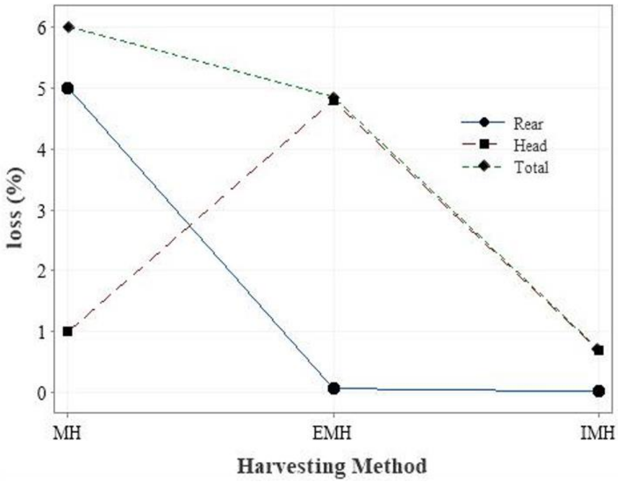


Fig. 6. Loss in various harvesting methods for three parts of Rear, Head, and Total

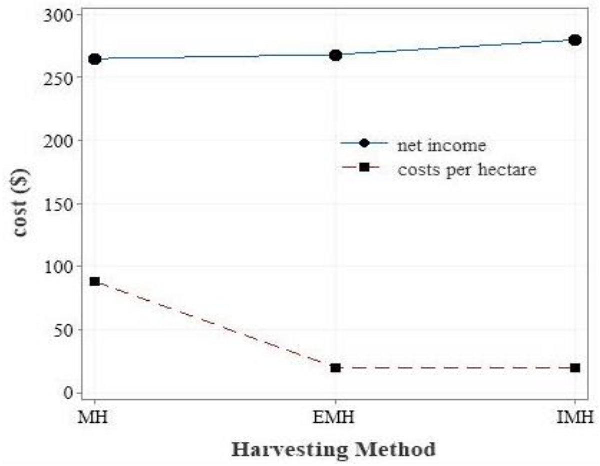


Fig. 7. Net income and costs per hectare for harvesting methods

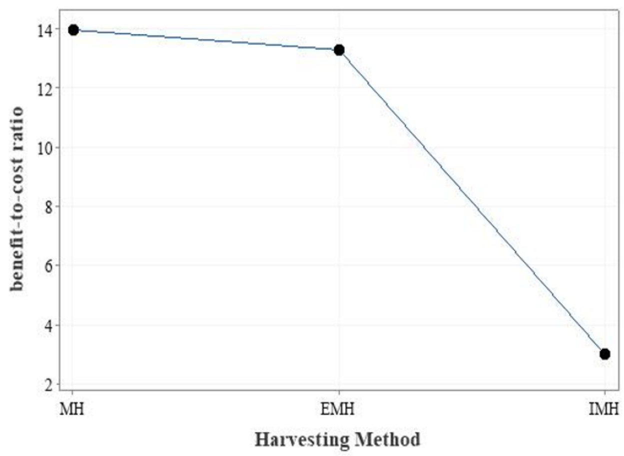


Fig. 8. Benefit-to-cost ratio for three harvesting methods

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مقاله پژوهشی

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ارزیابی ضمیمه هد کمباین غلات برای برداشت آفتابگردان و مقایسه با روش‌های برداشت مرسوم

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چکیده

در ایران هرساله بیش از ۵۰ هزار هکتار آفتابگردان روغنی و آجیلی، کشت می‌شود. به علت سازگار نبودن کمباین‌های غلات موجود در کشور با ویژگی‌های بوته و طبق آفتابگردان، مقدار زیادی دانه توسط کمباین تلف می‌شود. لذا، هم‌اکنون برداشت آن به‌صورت دستی انجام می‌شود. برداشت دستی باعث افزایش مشقت‌های کارگری، انرژی مصرفی و هزینه تولید گردیده است. در این تحقیق، به‌منظور برداشت مکانیزه این محصول، اصلاحاتی بر روی هد موجود کمباین غلات (جاندیر ۱۰۵۵)، اعمال گردید تا بتوان با آن عملیات برداشت، کوبش و بوجاری آفتابگردان را به‌طور همزمان انجام داد. پس از طراحی و ساخت الحاقیه، هد به‌سازی‌شده در شرایط مزرعه، ارزیابی و با روش‌های برداشت مرسوم مقایسه شد. ارزیابی مزرعه‌ای هد به‌سازی‌شده در قالب طرح بلوک‌های کامل تصادفی با سه تکرار بود. تیمارها شامل: ۱) برداشت توسط کمباین غلات مجهز به هد اصلاح‌شده، ۲) برداشت توسط کمباین غلات مجهز به قایقی و ۳) برداشت به روش دستی بود. در هرکدام از تیمارهای ماشینی، واحدهای کوبنده و تمیزکننده به‌منظور برداشت آفتابگردان تنظیم گردید. نتایج نشان داد که بین تیمارهای آزمایشی از نظر تلفات کمباینی، ظرفیت مزرعه‌ای و هزینه‌های برداشت، اختلاف معنی‌داری در سطح ۵٪ وجود دارد. در کمباین اصلاح‌شده، کمباین شیراز و روش دستی، تلفات کمباینی به‌ترتیب ۰/۷۲، ۴/۸۵ و ۶ درصد، ظرفیت مزرعه‌ای به‌ترتیب ۱/۲، ۱/۱۳ و ۰/۱۲ هکتار بر ساعت و نسبت سود به هزینه به‌ترتیب ۱۳/۹۷، ۱۳/۳ و ۳/۰۱ بود. بین تیمارها از نظر افت طبیعی و درصد خلوص اختلاف معنی‌داری در سطح ۵٪ وجود نداشت. با توجه به نتایج به‌دست‌آمده، به دلیل پایین بودن تلفات، ظرفیت مزرعه‌ای مناسب و هزینه برداشت پایین، استفاده از کمباین جاندیر ۱۰۵۵ مجهز به هد اصلاح‌شده برای برداشت آفتابگردان روغنی قابل‌توصیه است.

واژه‌های کلیدی: آفتابگردان، برداشت، به‌سازی، ضمیمه، هد کمباین

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