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The Effect of Grain Moisture Content and Forward Speed on Grain Losses of Three Varieties of Chickpea in Mechanical Harvesting using Feeder and Cutter Mechanism

Hussein Mostafavand
Department of Agricultural Machinery,
College of Agriculture, Shiraz University, Shiraz, Iran

Saadat Kamgar
Department of AgriculturalMachinery,
College of Agriculture, Shiraz University, Shiraz, Iran
Email: kamgar@shirazu.ac.ir

***Abstract* – Chickpeas are grown in the Mediterranean, western Asia, the Indian subcontinent and Australia. Chickpeas are more challenging to harvest than cereals. The grain is more fragile and the crop pods closer to the ground, making pickup more difficult. In this study, the effect of grain moisture content at three level of 14, 11 and 8% on wet basis and forward speed at three level of 1.5, 3 and 4.5 km h-1were studied on three variety of chickpea produced commercially in Iran, Arman, Hashem and Flip 95-233C using feeder and cutter mechanism. Increasing forward speed from 1.5 to 4.5 km h-1 and decreasing grain moisture content from 14 to 8% increases grain losses at studied chickpea varieties. The maximum and minimum values of grain losses were 117.85 and 65.53 kg ha^{-1} for "Flip 95-233C", 106.8 and 60.3 kg ha^{-1} for "Hashem" and 82.1 and 60.7 kg ha^{-1} for "Arman" variety. The lowest and highest value of grain losses at all levels of forward speed was associated to Arman and Hashem varieties respectively.**

***Keywords* – Chickpea Harvest, Grain Loss, Feeder, Cutter Mechanism.**

I. Introduction

Chickpeas are grown in the Mediterranean, western Asia, the Indian subcontinent and Australia. Chickpea is the third largest produced food legume globally, after common bean (Phaseolus vulgaris L.) and field pea (Pisumsativum L.). Chickpea has a high nutritive value in ruminant nutrition and its straw is a very feedstuff compared with other cerealstraws (Corp *et al*., 2004). They are as short as 30 cm and the land is too rough for conventional grain combines to be able to harvest the product (Behroozi & Huang, 2002). However, one of the major problems limiting chickpea production is the lack of suitable mechanical harvesting system. Mature grains are harvested when the pod tips of the uppermost branch of the plant turn yellow. Harvesting is done manually by pulling the plants, after which they are sun- dried in the field (Corp *et al*., 2004).After harvest; the crop is allowed to dry in the sun for a few days. Threshing is done either by beating the plants with sticks or with a thresher (Tado *et al*., 1998). Manual harvesting is very labor intensive, while labor is becoming increasingly scarce and expensive. On the other hand the main problem impeding mechanical harvesting of chickpea is the excessive grain losses at initial cutting and feeding of the crop. The difficulties are associated with plant characteristics include uneven ripening, lodging, and shattering of grain and pods growing close to the ground (Sidahmed & Jaber, 2004). In this study, the authors focused on feeder and cutter mechanism for mechanical harvesting of chickpea. Some operating conditions such as grain moisture content and forward speed needs to determine for decreasing yield losses at mechanical harvest. Srivastava *et al,* (1993) discussed some feeder and cutter mechanism for plants such as Cabbage, carrots, strawberries, corn and other plants. Some researcher studied the effect of grain moisture content and forward speed on yield losses as follows; Andrews*et al.,* (1993) reported that Feedrate was the most important factor affecting combine harvest loss. Also, they founded that Moisture content, by itself, was significant only in the 'Newbonnet' variety but affected loss rate in the 'Lemont' variety by influencing feedrate and MOG/G ratio.One study indicated that each day of delay after maturity of wheat reduced yield 12 pounds per acre due to shatter and other losses (Arkansas university report). Twenty percent moisture content is a good recommendation for starting to cut if the heads are uniformly ripe. Field loss and kernel damage are normally lowest at this grain moisture level(Huitink, 2005).Similar results were reported by Abdi and Jalali (2013) and Adisa (2009).Based on header performance studies and southern rice varieties in (Geng*etal*., 1984)there were no differences in efficiency between the conventionally and stripper header types at speeds less than 1 mph. increasing forward speed from 1 to 4.5 mph increased yield losses in studied varieties. Another research reported that the grain loss was 178-380 kg ha-1 for Ryhe variety rice where grain losses increased with the increased forward speed (0.8-2.9 km h^{-1}) (Swapan*et al.,* 2001).

Notation

λ	Kinematic index, dimensionless
U	Peripheral speed in ms-1
F.S	Forward Speed of feeder and cutter mechanism in ms-1
G.M.C	Grain Moisture Content
S.W	Seed Weight
GL_A	Grain Loss of Arman variety
GL_H	Grain Loss of Hashem variety
PHL	pre-harvest loss, kg ha-1
MHL	mechanical harvest loss, kg ha-1
ANS	average Number of seeds per quadrate
Rep	Replication

Y.E Yield performance
GLF Grain Loss of Flip variety

Also Hunt (1995) stated that Excessive forward speed cause to Knocks ears off before they enter the gathering throat and May cause plugging in high-yielding corn due to overloaded gathering units. Stickley (1979) reported the effect of moisture content on the efficiency of conventional snapping rolls. A minimum loss occurs near 25% kernel moisture contents. At high moisture contents the loss characterized by crushed ears and at lower moisture contents by shelling loss at the snapping rolls.
The objective of this study was to study the effect of moisture content, forward speed and variety on grain losses in mechanical harvesting of chickpea using feeder and cutter mechanism. The functional requirements were to harvest relatively dry chickpeas with negligible shattering grain losses and to operate at a low cutting height without being affected by the presence of stones.

II. Design of Feeder and Cutter Mechanism

A. Design and operation

The main components of the experimental harvester are the header, elevator conveyor, tank and power unit, all carried on a chassis mounted on tiller (M "Kubota A650", Japan) with power of 7.5 hp. The header consists of a V-shape guide who in turn consists of slats and chain, two belts for fixing and transferring of plant, and four identical pulleys. Chain feeder guide the plants to the cutter unit which consist of a notched wheel and counter shear which exposure the below of the front pulleys. The rear pulley drives the front ones via the feeder belts and by using of two gears, which placed down the rear pulleys. The diameter and thickness of cutter wheels are 125 and 1.5 mm, respectively. The diameter of each pulley is 100 mm (Sidahmed & Jaber, 2004). The distance between the front and the rear pulleys is 200 mm. when the plants were cut the belts carry the cut stems to the elevator conveyor at the rear of the header. The elevator is an endless belt with reinforced galvanized notch plate which collects the plants and grains which held by feeder belts, along the inclined surface of the conveyor in to the tank. The power transmitted from the tiller power take off shaft to the gear reduction units. The reduction gear directs power to the rear pulleys of the feeder and cutter mechanism and conveyor's power comes from tiller power take off shaft directly. All moving parts and chains are covered for safety. Fig.1. Show the actual view of prototype feeder and cutter mechanism.

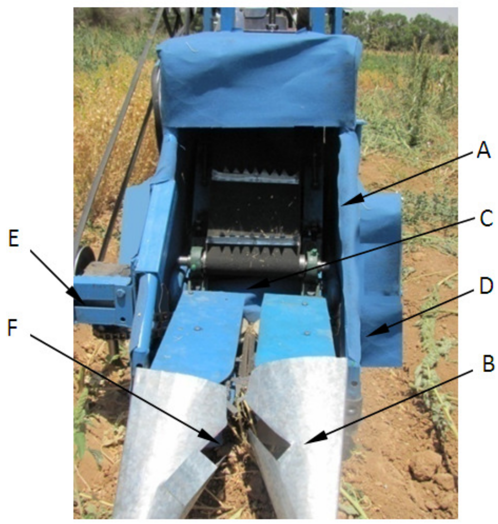

Fig.1. Actual view of prototype harvester, A: chassis, B: dividers, C: elevator conveyor, D: tank, E: gearbox and F: cutter wheel counter shear disk and slat and chain feeder.

B. Kinematic index for feeder-cutter mechanism

An important consideration in the design of feeder and cutter mechanism was the kinematic index of chain feeder and cutter wheel λ (the peripheral speed of belts is equal to peripheral speed of cutter because they have been coupled together) which is a dimensionless parameter defined by the (1) (Kleninet al., 1985)

$$\lambda = \frac{U}{F.S} \qquad (1)$$

Where
U is the peripheral speed in ms^{-1} of the chain feeder, notched wheel and belt
F.S is the forward speed of the feeder and cutter mechanism in ms^{-1}

An essential requirement for slat and chain feeder to proper working was to maintain $\lambda > 1$ otherwise the chickpea plants would be either stationary relative to the slat and chain feeder (if $\lambda = 1$) or pushed away from the slat and chain feeder (the case of $\lambda < 1$). the value of λ which satisfies the requirements for proper working of the chain and slat feeder was 1.7 (Sidamed& jabber, 2004).

The preliminary design of feeder and cutter mechanism made during the test phase by Mostafavand (2011) at the faculty of agriculture, Shiraz University, Shiraz, Iran is not discussed here so that only the final design is presented. The all trials were performed at three level of moisture contents 8, 11 and 14% and three level of forward speed of cutter- feeder mechanism, 1.5, 3 and 4.5 km h-1using three chickpea variety "Flip 95-255C", "Hashem" and "Arman" in Iran is represented in Fig.2. A split plot design based on a randomized complete design was used to determine the effects of moisture content and forward speed on grain losses of studied variety on grain losses.

Fig.2. Chickpea varieties, (a): Flip 95-233C (b): Arman (c): Hashem

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The field was plowed with a 4- bottoms moldboard plow followed by disk harrowed. The field was pressed with a Cambridge roller as a final operation. The chickpeas were planted on the 20th February 2010, with a single row corn planter with 50 cm inter-row spacing. 0.2 ha was ploughed and disk harrowed for planting chickpeas using grain drill. This area was divided into three blocks and each block was further divided into three main plots representing forward speed at harvest operations with grain moisture content as a subplot treatment factor. Also, three blocks for determine the effect of chickpea variety at different moisture content on grain losses, each block divided into three main plots representing grain moisture content with chickpea variety as a subplot treatment factor. In each trial two 10 m long rows were harvested by prototype feeder and cutter harvester. The cutting height was adjusted at 90 mm (above the ground) to take on the whole of grains approximately. The moisture content of grains at harvesting operation was measured by using of digital grain moisture tester ("KU" M "EE-KU") with accuracy of ±0.3. To determine moisture content, the device is calibrated for chickpea grain and then 50 g of grains collected randomly in each plot and was cast in the grain moisture tester. This was done repeatedly until the harvest done at desired moisture content. To estimate crop yield, number of grains per 500 mm of drill row collected and counted. The average of grains per 500 mm of row divided by the appropriate known constant for chickpea (based on 100- Seed weight and row spacing) will provide crop yield. To calculate pre-harvest and front losses of experimental harvester, used of three sided and complete sampling quadratics frame with an area 0.1 m^2 (316 mm× 316 mm) using Eq. [2, 3]respectively. In each trial, 10 three sided or four sample quadratic at the Middle 6 meter of each row was placed. The pods and grains in the sampling quadratic collected and counted.

These arrangements were also used to test the effect of moisture content and forward speed on grain losses of three chickpea varieties.

$$\text{PHL (kg/ha)} = \text{ANS} \times \frac{100 \text{ seed weight (gr)}}{100 \times 1000} \times \frac{10000}{0.1\text{m}^2} \quad (2)$$

$$\text{MHL (kg/ha)} = \text{ANS} \times \frac{100 \text{ seed weight (gr)}}{100 \times 1000} \times \frac{10000}{0.1\text{m}^2} - PHL \quad (3)$$

Table 1: Measurement of 100 S.W, Y.E and PHL for different varieties before harvest operation

Variety	100 S.W (g)	Y.E (kg ha-1)	PHL (kg ha-1)		
			8%	11%	14%
Arman	27 (±2.1)*	890 (±35)	47.25(±5.6)	17.01(±2.5)	11.88(±1.9)
Flip 95-233C	32(±2.31)	1120 (±43)	51.2(±4.2)	15.04(±2)	13.76(±1.6)
Hashem	19(±1.98)	670 (±24)	32.68(±4.8)	11.78(±2.3)	10.26(±1.73)

*Numbers in parentheses are standard deviation

III. Results and Discussions

Table 2, shows the Results of variance analysis of effects of grain moisture content (M.C.) in three levels 8%, 11% and 14% on wet basis and forward speed (Fs) of feeder and cutter mechanism 1.5, 3 and 4.5 km/h on grain losses in studied Chickpea varieties. From table 2, The ANOVA results for the split plot design indicated that the forward speed of feeder and cutter mechanism and grain moisture content had significant effect on grain losses in all varieties ($P<0.01$). The interaction between forward speed and grain moisture content on grain losses was not significant ($P>0.05$).Also comparison between varieties at grain moisture content of 8% and different forward speed showed that The "Hashem" Variety had greatest grain loss in all levels of forward speed. In the following paragraphs, the effect of each factor on the grain losses is comprehensively discussed.

3.1. Forward speed

Increasing the forward speed from 1.5 to 4.5 kmh^{-1} increases grain losses at studied chickpea varieties (Fig. 3, 4 & 5), due to impacts of divider and slats to chickpea stalks increase. Also increase of feed rate lead to stalks chewed instead of being cut at higher speeds. The values of grain losses varied from 63.75 to 94.66 kg ha^{-1} at different varieties between forward speeds of 1.5 to 4.5 km/h respectively. From table 3, Duncan test results of studied parameters on grain losses showed that there was no significant difference at 1% level between forward speed of 1.5 and 3 km h^{-1}($P>0.01$) but there was significant difference between 3 and 4.5 km/h in all varieties ($P<0.01$). Andrews *et al.*, (1993) reported that Feedrate was the most important factor affecting combine harvest loss. similar results of effect of forward speed on grain losses were reported by Behroozi Lar and Huang (2002), Mansouri Rad and Menaei (2003), Sidahmed and Jaber (2004), Adisa (2009), Mostofi (2011) and Abdi and Jalali (2013).

3.2. Moisture content

The ANOVA results indicated that the grain moisture content at harvest operation had significant effect on grain losses by feeder and cutter mechanism. Decreasing grain moisture content from 14 to 8% on wet basis increases grain losses. Because reduction of chickpea plant moisture content lead to reduce the peduncle resistant at the junction to pod and also the stalk of chickpea break when exposed to the divider or cutter wheel. The values of grain losses varied from 64.6 to 105.5 kg ha^{-1} at different varieties between moisture content of 14 and 8% respectively. According to table 3 Duncan test results showed that the values of grain losses were significantly affected by grain moisture content at 0.01 probability level in studied varieties except in Arman variety between moisture content of 11 and 14%. Similar results were reported by Adisa (2009), Andrew *et al;* (1993) and BehrooziLar and Huang (2002).

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3.3. Variety

The "Hashem" Variety had greatest grain loss because this variety has recumbent growth than other varieties (Fig. 6). The maximum and minimum values of grain losses were 117.85 and 65.53 kg ha^{-1} for "Flip 95-233C" variety, 106.8 and 60.3 kg ha^{-1} for "Hashem" variety and 82.1 and 60.7 kg ha^{-1} for "Arman" variety. Also, the effect of grain moisture content on grain losses in Arman variety between 11% and 14% levels was not significant ($P<0.01$).This effect was significant at all levels of grain moisture content in Hashem and Flip varieties. Andrew *et al,* (1993) reported that Moisture content was significant only in the 'Newbonnet' variety but affected loss rate in the 'Lemont' variety by influencing feedrate and MOG/G ratio. Presence of stones did not affect the operation of the prototype chickpea harvester, due to the protection provided by the header covers.

Table 2: Results of variance analysis of effects of grain moisture content (G.M.C.) and forward speed (F.S) of feeder and cutter mechanism on grain losses in studied Chickpea varieties

		Arman			**Flip95-233C**			**Hashem**		
Sources	Df	SS	MS	F value	SS	MS	F value	SS	MS	F value
Replication(Rep)	2	47.19	23.95	4.14ns	42.71	21.357	0.838ns	17.98	8.99	0.4ns
Forward speed (F.S)	2	528.24	264.12	45.7**	1468.52	734.26	28.82**	3053.83	1526.9	68.35**
Rep*F.S	4	23.124	5.78		101.87	25.47		89.36	22.34	
Moisture content (G.M.C.)	2	371.87	185.93	18.65**	6111.18	3055.59	67**	2236.12	1118	46.4**
F.S*G.M.C.	4	72.91	18.23	1.83ns	109.88	27.47	0.6ns	206	51.5	2.13ns
Error	12	119.63	9.97		547.16	45.6		288.83	24.1	
Total	26	127148			202409			5892.1		

**significant at 1% level, ns: not significant

Table 3: Duncan test results of studied parameters on grain losses

Treatments	Level	Varieties		
		Arman	Flip 95-233C	Hashem
F.S	4.5 km/h	74.3a	94.66a	93.9a
	3 km/h	66.87b	82.69b	73.5b
	1.5 km/h	63.75bc	76.96bc	69.7bc
G.M.C.	8%	73.4a	105.5a	90.5a
	11%	66.9b	78.4b	78.4b
	14%	64.63bc	70.4c	68.22c

a-c Different letters shows significant difference, Duncan 1%

Fig.6.Showed harvest operation by prototype feeder and cutter mechanism.

The dependency of grain losses of Arman, Flip 95-233C and Hashem varieties on grain moisture content and forward speed of feeder and cutter mechanism was approximated respectively to:

$$GL_A = 7.24\ FS^2 + 2.65\ G.M.C^2 - 14.94FS - 6.88G.M.C + 0.26FS\times G.M.C + 76.3,\quad R^2=94\%$$

$$GL_F = 3.11\ FS^2 + 9.59\ G.M.C^2 - 9.44FS - 26.6G.M.C + 2.9\ FS\times G.M.C + 85.9,\quad R^2=91\%$$

$$GL_H = 8.71\ FS^2 - 8.6\ G.M.C^2 - 12.05\ FS + 49.3\ G.M.C - 3.86\ FS\times G.M.C + 23.3,\quad R^2= 89.5\%$$

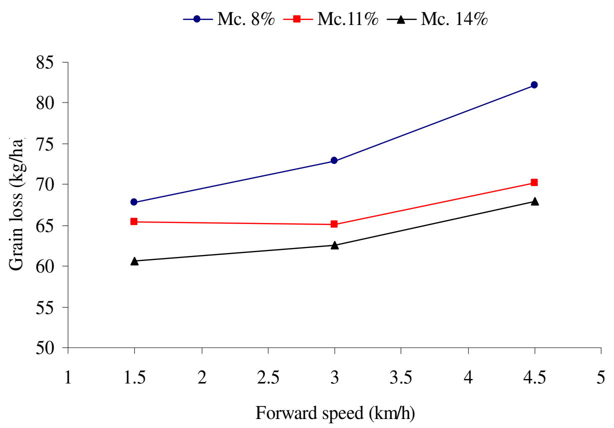

Fig.3. Grain losses versus forward speed of feeder and cutter mechanism for Arman variety harvest

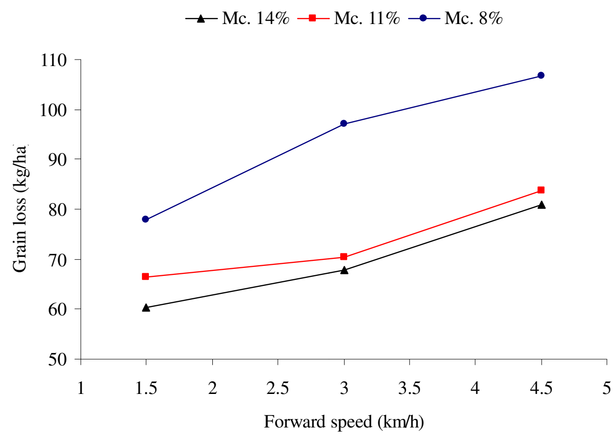

Fig.4. Grain losses versus forward speed of feeder and cutter mechanism for Hashem variety harvest

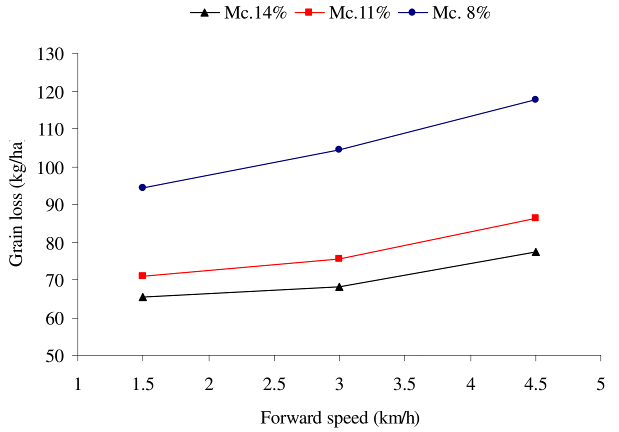

Fig.5. Grain losses versus forward speed of feeder and cutter mechanism for Flip variety harvest

At final, the studied varieties compared together at moisture content of 8% and different forward speed of feeder and cutter mechanism. The value of grain loss of each variety measured by grain loss of feeder and cutter mechanism after harvest operation divided to yield performance. "Hashem" variety has more grain losses than other varieties. The maximum and minimum grain losses were 15% and 8% related to "Hashem" and "Arman" Varieties at forward speed of 4.5 and 1.5 km h-1, respectively.

Fig.6. Harvest operation by prototype chickpea harvester

Conclusion

- The lowest and highest of grain losses was associated to 14% and 8% grain moisture content in all varieties. Forward speed had significant effect on grain losses in all varieties. There was no significant difference between forward speed of 1.5 and 3 km h^{-1} in all varieties.
- Grain moisture content had significant effect on grain losses in all varieties. There was no significant difference between G.M.C of 14 % and 11% in "Arman" variety harvest.
- Increasing the forward speed from 1.5 to 4.5 km h^{-1} and decreasing grain moisture content from 14 to 8% on wet basis increases grain losses at studied chickpea varieties.
- The lowest and highest percent of grain losses at all levels of forward speed was associated to Arman and Hashem varieties respectively.

References

[1] A k. Srivastava, C E. Georing, and R P. Rohrabach, *Engineering principle of agriculture machines*.Published by American society of agricultural engineers, 2nd ed. 1993. 437-490
[2] AF. Adisa, Development and Performance Evaluation of a Pedestrian Controlled Rice Stripper.UnpublishedP.hD. Thesis, Ahmadu Bello University, Zaria, Nigeria. 2009.
[3] C J M. Tado, P. Wacker, H D. Kutzbach, and D C. Suministrado, Development of stripper harvester.A review. J. Agric. Eng. Res. 1998. 71:103–112
[4] D. Hunt, *Farm power and machinery management* - 9th edition. Iowa State University Press. Ames, Iowa, USA. 1995.
[5] N I. Klenin, I F. Popov, and V A. Sakun, *Agricultural Machines design*," Russian Translations Series 31.*Gidson Printing Works*, India, New Delhi. 1985.
[6] G. Huitink,2005.Harvesting GrainSorghum. Retrieved from http://www.uaex.edu/Other_Areas/publications/PDF/MP297/8_harvesting.pdf
[7] H. Mostafavand, Design, development and evaluation of a feeder and cutter mechanism for mechanical harvesting of chickpea.MS Thesis, Shiraz University, Shiraz, Iran. 2011.
[8] H. Mansouri, and S. Minaei, Assessment of machine parameters effect on wheat loss in combine JD 955. Abstract of Paper on First National Conference of Assessing Agricultural crops Waists. Agricultural Faculty of TarbiatModaress University, 2003.45-51.
[9] K A. Stickley, A preliminary study of an oscillatory ear corn snapping- husking mechanism, MS thesis, the Ohio state university, Ohio, USA. 1979.
[10] K R. Swapan, J. Kamaruzaman, W I W. Ismaeil, and A. Desa, Performance evaluation of a combine harvester in Malaysian paddy feilds, Asia Pacific Advanced Network (APAN), University Science Malaysia (USM). 2001.
[11] M. Behroozi L and B K. Huang, Design and development of chickpea combine Agriculture mechanization in Asia, Africa and Latin America (AMA). 2002, 33: 35-38
[12] M. Corp, S. Machado, D. Ball, R. Smiley, S. Petrie, M. Siemens, and S. Guy, Chickpea production guide. Dry land cropping system. EM 8791-E, Oregon state University.2004.
[13] M M. Sidahmed, and N S. Jaber, The design and testing of a cutter and feeder mechanism for the mechanical harvesting of lentils, Biosystems engineering, 2004.88: 295-304
[14] MR. Mostofi, Investigation and technical comparison of new and conventional wheat combine performance to improve and modification. Agricultural Engineering International, CIGR Journal 2011. 13(3): 63-68
[15] R . Abdi, and A. Jalali, Mathematical model for prediction combine harvester header losses. Intl J Agri Crop Sci. 2013. 5: 549-552.
[16] S B. Andrews, T J. Seibenmorgen, E D. Vories, D H. Loewer and A. Mauromoustakos, Effects of combine operating parameters on harvest loss and quality in rice. Transactions of the ASAE. 1993. 36(6): 1599-1607.
[17] S. Geng, J F.Williams, and EJ. Hill, .harvest moisture effects on rice milling quality. In California Agriculture.Nov.-Dec.11-12. 1984.
[18] Wheat Production in Arkansas, Wheat Harvesting. University of Arkansas Division of Agriculture, http://www.aragriculture.org/crops/wheat/harvesting.htm

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AUTHOR'S PROFILE

Hussein Mostafavand
place of birth: Broujerd, Iran. Date of birth: 12/1985. Bachelor's degrees and Ms.cgraduated of agricultural machinery from Shiraz University, Shiraz, IRAN.
He is workingin the floating electro pump manufacturer in Mashhad City and has not any experience in the military organization.

Saadat Kamgar
Place of Birth: Shiraz, Iran. Date of Birth:8/1960. Assistant Professor of Agricultural Machinery.
He is working in theShiraz University and has not any experience in the military organization.