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The Effect of Ground Speed, Reel Rotational Speed and Reel Height in Harvester Losses

Arman Jalali, Reza Abdi

Department of Agricultural Machinery Engineering, University of Tabriz, Iran

Corresponding author: Arman Jalali, PHD Student of Department of Agricultural Machinery Engineering, University of Tabriz, Iran

Abstract. Every year large areas of agricultural fields in Iran are under cereal cultivation. Cereal in Iran is harvested mainly by combine harvesters. Although Grain product rate is high in Iran, the grain harvest loss leads to considerable loss of grain. Investigations on Grain loss in different combine units shows that the largest losses occur in head of combine and is influenced by several reasons such as type of the combine, combine adjustments, harvest time and etc. This research was carried out to investigate the performance and grain losses on the combine harvester in East Azerbaijan province of Iran. A factorial experiment based on completely randomized design with nine replications was carried out. Three main treatments for this study were considered. Treatments consisted of ground speed (V) at three levels (1, 2 and 4 km/h), the reel rotation speed (W) at three levels (25, 32 and 40 round per minute) and the reel height (H) at three levels (87, 110 and 118 cm). The results showed that ear loss of three treatments, interaction of V × W and the triple interaction of V × W × H were significant ($P \leq 0.01$). Ground speed was the only significant factor effecting seed loss ($P \leq 0.01$). Data Mean showed that maximum loss occurred at the highest Ground speed and rotational speed of reel. The best treatment was 1 km h^{-1} Ground speed, 25 rpm reel rotational speed and 87 cm reel height.

Keywords: Bunch; harvest; ground speed; reel wheel.

1. INTRODUCTION

Wheat is one of the most important crops in Iran and considered as the self dependency cause of the country. Iran achieved self-sufficiency in wheat in 2004 [1]. Mechanized harvesting of grains has been the old targetted by farmers. Harvesting is collecting the grains on time and separating them from other parts of the crop with minimum loss and maximum quality.

According to this, selecting harvesting machine depend on crop varieties, planting method and climate condition. So, many efforts were done to increase in production and reduce the losses. A solution to decrease the losses is researching about the amount and sources of losses during harvest and ways of preventing them [2].

Different factors like combine harvester adjustments, seed type and moisture content, time of harvest, the combine harvester and etc, affect the combine losses. The header loss depends on: reel rotational speed and ground speed and cutting bar knives. Reel rotational speed and ground speed are most effective on combine losses. Crops with lower height can't be cut by cutter and seeds drop when they get in contact with reel wheel. For minimum head loss, reel wheel should be placed in 15-25 cm above the cutter bar, the height lower than low height of crop and reel speed about 1.25 - 1.5 rather than ground speed [3].

Mansouri-rad and Minaie studied the effect of ground speed on header loss and showed that header loss increased with increasing ground speed. The acceptable harvest loss was 4-5% in world whereas in Iran, it is more than the acceptable percent [4]. Wheat losses consist of two categories: (1) preharvesting and (2) harvesting. Preharvesting losses are caused by birds, weather and other natural causes. The harvesting losses are those caused by combine harvester during harvest. Proper combine adjustments and early harvest can minimize those losses [5].

Kutzbach and Schreiber found that combine losses increases exponentially with increasing the feed rate and fan speed [6]. Rahimi and Khosravani showed that 68% of loss which is the greatest part, pertain to head losses and is derived from combine life, ground and reel rotational speed and the results showed that

header loss was minimum with reel rotational speed lower than 21 rpm [7]. Tavasoli and Minaei studied effective causes on combine harvester (John Deere 955) losses and examine seven different levels of ground speed (from 1.3 to 3.5 km h^{-1}). The results of this survey show that the appropriate ground speed for wheat harvesting is 2.5 km h^{-1} [8].

Yavari and Poord studied 61 combines randomly (John Deere 995). There was an average 7.2% loss and just 3.31% was related to technical and agricultural issues [9]. Mohd, measured factors like ground speed and cutter-bar speed to examine their impact on losses. The results of their investigation pointed out among 55 studied combines which none was adjusted like the others, that the average of measured loss in first year was 9% while it was 12.7 in second year. The lowest losses in ground speed was 5.5 km h^{-1}. While the lowest losses related to concave were at rotational speed of 900 rpm [10].

John Deere 955 is one of the most common combine harvesters in Iran. Lack of research about wheat harvester losses, encouraged us to study the harvesting losses during harvesting using JD 955 harvester in East-Azerbaijan's fields. The objectives of this study were to discover the effects of ground speed, reel rotational speed and reel height on wheat harvest losses during harvest.

2. MATERIALS AND METHODS

2.1 Data Collection

To evaluate wheat losses during harvesting 2012, a field (5 ha) in East-Azerbaijan province, Iran (38° 9′ 0″ N, 47° 4′ 12″ E), was chosen randomly. The adjustments were performed according to the combine operator manual. A factorial experiment was carried out based on completely randomized design with three replications for combine performance evaluation.

The experiments with three replications conducted using the following parameters: ground speed, reel rotational speed and reel height (each in three levels). The levels of treatments showed in Table 1.

Table 1. Functional specification of the used combine during each experiment

Treatment		No level		
		1	**2**	**3**
Ground speed (km h^{-1})	V	4	2	1
Reel speed (rpm)	W	25	32	40
Reel height (cm)	H	118	110	87

To measure total yield of the field, 65cm×38.5cm frame was put on 10 different places of the field then the wheat in frame was cut and transported to the laboratory in separate pockets. The kernels inside the frame were counted and weighed, total yield of the field was calculated that was 4200 kg ha^{-1}. Crop harvested with harvesting moisture content of 11.Reel rotational speed counted by round per minute. For measuring the losses two steps including preharvest and during harvest measurements were done.

2.1.1 Preharvest measurements

2.1.1.1 Natural loss

Before combine harvester enter the plots, natural losses was measured. 65cm×38.5cm frame was used to determine the natural loss. The frame was put at 10 different places of field; then the dropped kernels and ears in the frame on the soil were gathered finally and counted at laboratory. Then multiplied by grain weight (1000 kernels =41.53 g) and the calculated natural loss was 21.9 kg ha^{-1}.

2.1.2 Measuring during harvesting

2.1.2.1 Head loss

For measuring the header loss of combine harvester, at the end of each harvested row, combine went back along the harvest path about 8 m (length of harvester). Then three 65 cm×38.5 cm metal frames put in three places (Fig 1. each at one-third of left, middle and right of the header length) then kernels and ears gathered finally at laboratory in order to be counted. Then head loss was calculated using the following relations:

Head loss = (A-B) ×1000grain weight×4×10^{-2} (kg.ha^{-1}) (1)

Head loss %= $\frac{Head\ loss}{P} \times 100$ (2)

A= total grains and ears counted at the head.

B= total grains and ears counted in the natural loss section.

P= total yield of the field.

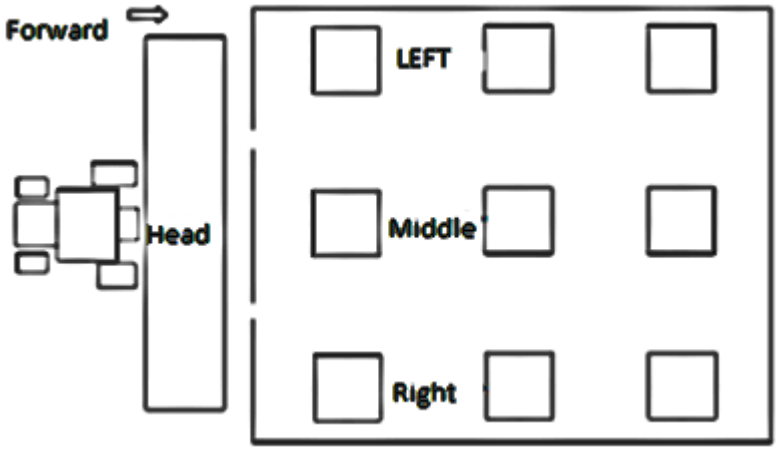

Fig. 1. Head loss sample

2.1.2.2 Rear loss

In order to calculate the rear loss, three 60 cm×33.5 cm (effective area is 0.2 m^2) wooden frames with cloth at bottom were used. Frame was thrown along the combine travel direction then grains and ears that comes out from harvester's threshing unit, gathered in frame and this was repeated three times in each

harvest row. Then all ears and kernels were separated and counted at laboratory. The rear loss of the combine calculated for kernels and ears by following equations:

Rear loss= C×1000 Grain weight× 5×10^{-2} (3)

$$Rear\ loss\ \% = \frac{c}{p} \times 100 \quad (4)$$

C= total grains and ears counted on the frames.

P= total yield of the field.

2.1.2.3 Total Loss

Total grain losses determined by following equation:

Head loss + Rear loss = Total loss

2.2 Analysis

A factorial experiment on the basis of completely randomized design with nine replications was carried out. Analysis of variance (ANOVA) and the means were compared in accordance with the Duncan's multiple test ($P\leq 0.05$), using SPSS 16.0 software.

3. RESULTS AND DISCUSSION

Table 2. ANOVA of the effects of V, W, H and their interactions on total combine grain losses

Mean of squares			Freedom degree	Treatments
Total loss				
Total	Kernels	Bunch		
45.965**	23.295**	6.714**	2	V
20.408**	0.325^{ns}	17.147**	2	W
1.882^{ns}	0.611^{ns}	3.015**	2	H
2.455^{ns}	0.310^{ns}	1.377**	4	V×W
0.389^{ns}	0.841^{ns}	0.928*	4	V×H
0.821^{ns}	0.929^{ns}	0.514^{ns}	4	W×H
1.748^{ns}	0.790^{ns}	1.266**	8	V×W×H
1.093	0.666	0.362	216	Error

ns,,** non significant and significant difference at 5 and 1% probability respectively.*

3.1 Total Loss (Grain and Ears)

Main effects of ground speed and reel rotational speed were highly significant for total loss (Table 2). Mean of the ground speed of the combine showed the greatest loss related to maximum ground speed. The lowest rate of loss was related to minimum ground speed but there was no significant difference between two treatments of ground speed (Fig. 2).

Qarnar-uz-Zaman and et al. showed the losses increased with increasing ground speed [11]. Mostofi found that the best ground speed for JD 995 was 1.32 km h^{-1} [12].

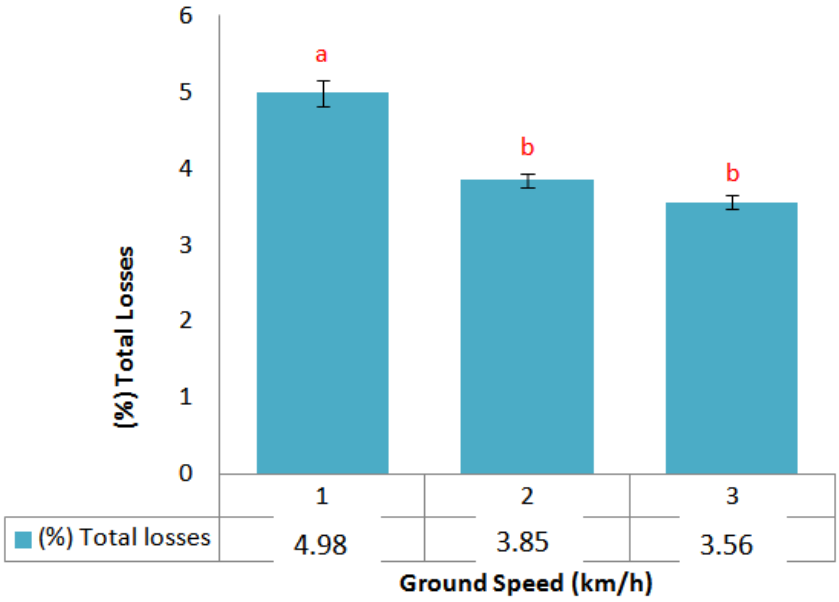

Fig. 2. Effect of ground speed on the total grain losses

The mean for reel rotational speed showed also the maximum losses occur when the reel rotational speed was maximum and the best rotational speed of reel (lowest loss rate) was minimum reel rotational speed but there was no significant difference observed between the rotational reel speed of 25 rpm and 32 rpm (Fig. 3). Junsiri and Chinsuwan showed that head grain loss increased with increase in reel rotational speed and reel height [13].

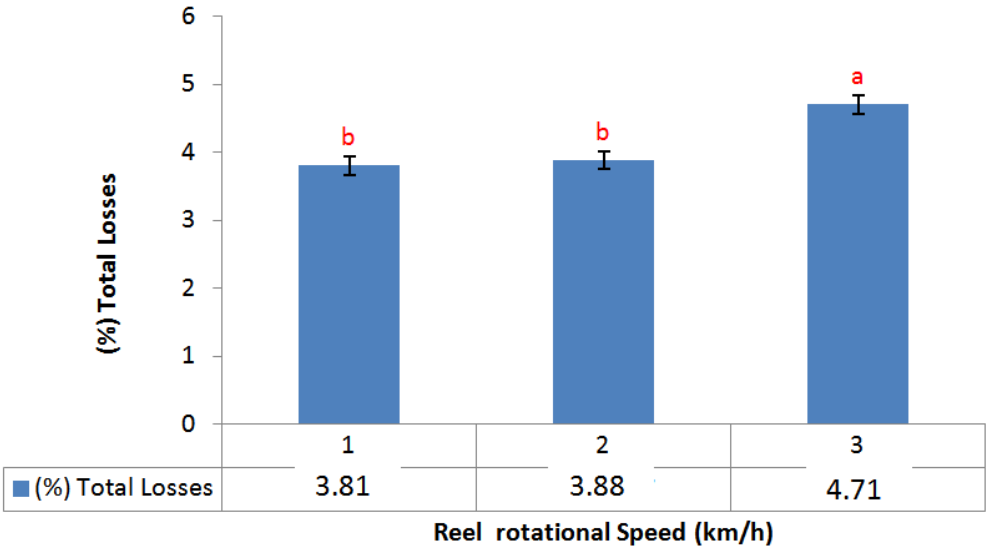

Fig. 3.Affect of reel rotational speed on the total grain losses

3.2 Ears Losses

Analysis of variance (Table 2) indicates that the ears loss rate in triple interaction effect was significant at the 1% level. Mean comparison of triple interaction showed (Table 3), the largest loss occurred in first ground speed level, third reel rotational speed level and first reel height level (4 kmh^{-1}, 40 rpm and 118 cm respectively) and the lowest loss occurred at third level of ground speed and first level of reel rotational speed and third level of reel height (1 kmh^{-1}, 25 rpm and 87 cm respectively).

Table 3.The average values of grain losses (in %) for combined research: V - ground speed, W - wheel reel rotational speed, H - height of reel

V	W	H	Mean	V	W	H	Mean
1	1	1	2.446	2	2	3	1.870
1	1	2	2.366	2	3	1	2.707
1	1	3	2.821	2	3	2	2.401
1	2	1	2.413	2	3	3	3.003
1	2	2	2.074	3	1	1	2.27
1	2	3	2.297	3	1	2	2.211
1	3	1	3.917	3	1	3	1.473
1	3	2	3.736	3	2	1	2.490
1	3	3	2.831	3	2	2	2.058
2	1	1	2.048	3	2	3	2.360
2	1	2	1.495	3	3	1	3.193
2	1	3	2.043	3	3	2	2.723
2	2	1	2.484	3	3	3	2.212
2	2	2	1.951				

3.3 Grain Losses

Analysis of variance (Table 2) showed that ground speed was the only factor effecting the total grain losses in combine, which was significant at the 1% level. The highest and the lowest mean of grain loss were related to the highest and lowest ground speed respectively (Fig. 4).

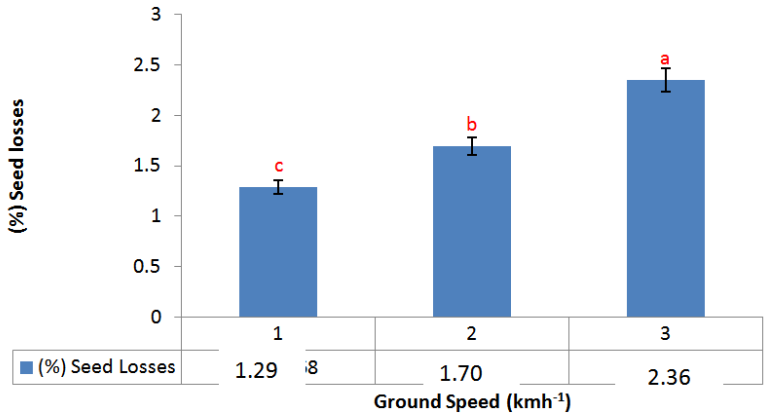

Fig. 4. Effect of ground speed on the seed losses

4. CONCLUSION

In this study, the total grain losses for JD 995 was studied in East Azerbaijan province of Iran. Farm selected through a complete random sampling technique. The following results obtained:

1. The results revealed that best ground speed; reel rotational speed and reel height were, 2 kmh-1, 32 rpm and 87 cm, respectively. Proper setting of these three factors will result in minimum losses in header and rear.
2. Combine grain losses isamplified with increase in reel rotational speed and ground speed.
3. Head grain losses was increased by increase in reel height.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration with all authors. AJ designed the study, collected data, wrote the protocol, and wrote the first draft of the manuscript. RA managed the analyses of the study. SM performed the statistical analysis and interpreted the results. RA managed the literature searches. All authors read and approved the final manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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