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Determination the Effect of a Vacuum Cleaning System on the Quality of Wheat Harvesting in Combines

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Abstract: Conventional combines have a set of **straw walkers** for separation of the grain from the straw because the crop passes the concave very quickly and a lot of threshed grains are therefore still contained in the straw. All combines contain a **cleaner** in which chaff, immature grains and small straw particles are separated from the grains. After cleaning system, seeds are conveyed to tank and then the chaff and straw are thrown a way from the combines. In eastern countries, straw is very valuable material and for this reason farmers would like to gather them along with the seeds during wheat harvesting. In order to collect the straw, a major modification should be made on conventional combines and this is a costly operation. The objective of this resarch was to design a vacuum type cleaning system for both separation of the grain from the straw and for collecting the straw. For this reason, a traditional combine was modified with vacuum cleaning system and was compared with conventional combines for wheat harvesting in Azerbeijan. The experiment was conducted with three combines; two different conventional combines and one modified combine at two different revolutions of thresher, 650 and 750 rpm. According to the results; vacuum type cleaning system was found statistically successful for both separation of the grain from the straw and for collecting the straw. Although this new cleaning system allows collecting the straw, the field capacity was found to be low as compared to the traditional combines. The field capacites were found to be 0.90, 0.96 and 0.30 ha h^{-1} for traditional combines and the modified combine, respectively. It should be stated here that the modified combine is the prefferred one by the farmer since obtaining the straw costs less eventhough the field capacity is one third on the conventional ones.
Key words: Wheat harvest, combine, thresher, cleaning system

INTRODUCTION

Conventional combines have a set of **straw walkers** for separation of the grain from the straw because the crop passes the concave very quickly and a lot of threshed grains are therefore still contained in the straw. All combines contain a **cleaner** in which chaff, immature grains and small straw particles are separated from the grains. After cleaning system, seeds are conveyed to tank and then the chaff and straw are thrown a way from the combines. In eastern countries, straw is very valuable material and for this reason farmers would like to gather them along with the seeds during wheat harvesting. In order to collect the straw, a company in Piran Shahr has modified a conventional combine. This modified combine was equipped with vacuum type cleaning system from which straw can be collected easily (Figure 1).

Figure 1. The modified wheat harvesting combine

Mansoori and Minaee (2003) determined the effect of cylinder rotational seed and cylinder concave

clearance on losses in threshing unit. The authors found that an increase in cylinder concave clearance resulted in less breakage of grain. According to the survey study made by Rahimi & Khosravani (2003) in Fars province, it was found that average loss of wheat harvesting from combines was 4.81 percent of production. Asghari Meydani, 2003 investigated the harvesting two differetn varities of dry land wheat by 2 types of combines (Class and John Deer) in two periods of harvesting time in the interval of 15 days (on time and late harvesting period). The results have indicated that late harvesting caused loss 9 kg/ha for each late day comparing to the on time harvesting. Yavari and Poordad investigated randomly selected 61 combines (John Deer 955) in a survey made in 2003. According to the findings in Kermanshah province, there was found an average wheat loss of 105.42 kg/h which is 7.2%. This was decreased to 29.06 kg/h which is 3.31% by simply technical adjustments made on the combines. Tavasoli and Minaei 2002 investigated effective factors on drum, separator and cleaner performance and studied their effects on combine loss. The processing loss of combine (John Deer 955) manufactured by Iran-Arak Combine Company in 7 different levels of ground speed (from 1.3 to 3.5 km/h) for wheat harvesting was measured. The results of this survey show ground speed of 2.5 km/h for wheat harvesting is appropriate. The capacity of combine (John Deer 955) harvesting for the speed of 2.5 and field yield of 6 ton/h was estimated about 6.3 ton/h. Sheradian and Gulan 1991 carried out a study about harvesting hours and date influence on wheat loss in Pakestan. The results has indicated, the least loss was for the hours of 8-12 am while until 10 days after appropriate time, the loss was a little but after it because of harvesting delay, there is an increase in loss. In addition, grain moisture content in linear was decreased with a harvesting delay and resulted in grain loss. Finally, appropriate moisture content for on harvesting time and loss decreasing was suggested about 14-15 percent. Arvinder et al. (2001) studied the effect of grain moisture, cylinder speed and feeding rate on mechanical damage inflicted upon the grain during combine harvesting as well as on seed germination. Dreszer and Gieroba (1999) carried out experiments to determine the mechanical damages introduced into several kinds of grains during harvest by multi-drum combines. Gill et al. (2002) tried to determine combine's thresher unit performance by considering the different factors effective in efficient wheat combine harvesting. Kowalczuk (1999) presented data obtained from combine harvesting of soybean in different regions in Poland. Santokh et al. (2002) evaluated field performance in combine harvesting of rice. Tahir et al. (2003), while experimenting on a denominator model of Class combine in Pakistan reported an average grain loss of 1.25%. Singh et al. (2002) investigated the effect of crop and machine parameters on threshing effectiveness and seed quality of soybean. They determined the external damage inflicted on the grain by finding the weight of broken grains in specified samples. They found that external damage increased with increase in cylinder speed at all moisture levels and variations in cylinder speed had little effect on germination rate. Investigations carried out by Kirkkari et al. (2001) in Finland on rye grain mechanical damage during threshing indicated an increase in germination rate followed by a decrease in cylinder speed. Kumar and Goss (2000) used data obtained from 224 field experiments to present models for combine performance. Model presented for broken seeds indicated significant correlation between cylinder speed and seed breakage. They found that an increase from 6 to 9% in broken seeds could be observed by an increase in cylinder speed from 20 to 25 m sec-1. Andrews et al. (1993) in Philippine studied the effects of operational parameters in rice combine harvesting on crop quality and losses. It was demonstrated that feeding rate is the determining factor in rates of loss.

The objective of this research was to design a vacuum type cleaning system for both separation of the grain from the straw and for collecting the straw. For this reason, a modified combine was constructed with vacuum cleaning system and was compared with conventional combines for wheat harvesting in Azerbeijan.

MATERIALS and METHODS

In this study, to evaluate of a modified combine with vacuum cleaning system, the effect of combine type and drum speed on wheat loss during harvesting was investigated.

Alternative to the combines, the combine was modified by replacing the sieve mechanisms with pneumatic system to reduce separation space from 9

m^2 to 1.5 m^2 in which a container was mounted to collect the straw (Figure 2).

Figure 2. Modified combine with straw container to collecting the straw.

The experiment was conducted with three combines; Class 68S, John Deer 1055, and modified combine (designed and manufactured by Drogar e Kordestan) at two different revolutions of thresher, 650 and 750 rpm in Piran Shahr (West Azerbaijan province). The dimension of each plot was 4.5 × 40 m^2. Wheat samples were collected after each combine has reached predetermined steady forward speed. Crop was harvested when they reached the moisture content of 12%. Working speeds were between 2.2 to 2.8 km/h for two conventional combines and 0.98 to 1.4 km/h for modified combine. In each treatment following factors were measured and investigated:

1) Grain losses from the header
2) Grain losses from the Separator and cleaning
3) Grain losses from the drum
4) Processing loss (the losses from the drum, Separator and cleaning systems)
5) Total loss (totaling loss from header, drum, and separator)
6) Field capacity of combines

The experiments were carried out based on a split plot design. Six (3*2) treatments in the form of completely randomized block design with 3 replications and in total, 18 cases were considered. Data obtained from field and laboratory experiments were analyzed. Once the variance analysis (ANOVA) of resulting data based on complete block design model between different levels of three main factors (the combine types) and subplots at two different revolutions of thresher, 650 and 750 rpm conducted. The mean major effects of factors were classified through Duncan test ($p < 0.05$). The statistical analysis was performed by using Mstat-c software.

RESULTS

According to the results; vacuum type cleaning system was found statistically successful (Table.1, 2 & 3) for both separation of the grain from the straw and for collecting the straw. Although this new cleaning system allows collecting the straw, the field capacity was found to be low as compared to the traditional combines. The field capacites were found to be 0.90, 0.96 and 0.30 (ha h^{-1}) for traditional combines and the modified combine, respectively (Fig.3).

Table 1 shows the effects of evaluted treatments; combine types and cylinder rotational speeds on diferant harvesting loss as obtained through analysis of variance. As revealed by figures in the table, there exists a significant relationship (at different levels of probability) between total combine harvesting loss and seperating loss effected by the following: combines types and cylinder rotational speed. But no significant relationship was observed between drum loss and head loss and between types of combines and cylinder rpm.

Results of comparison of means are shown in Table 2. Minimum total loss was observed in modified combine, while the maximum loss measured from John Deere 1055. Seperation loss rate was found the least in John Deere as 0.048%, whereas it was found maximum in Class685.

A comparison of means (Table 3) reveals the effect of cylinder rotational speed on total harvesting loss. A cylinder rotational speed of 750 rpm resulted in the least total harvesting loss, whereas the most loss came from a cylinder rotational speed of 650 rpm. Increasing loss from the cylinder speed was accompanied by increasing grain mechanical damage which was the case obtained from the studies made by Dreszer & Gieroba, 1999; Kirkkari et al., 2001; Santokh et al., 2002; Mansoori & Minaee, 2003; Tahir et al., 2003). But no significant difference was observed between cylinder rotational speed and the losses from head, separater and drum.

Table 1. Variance analysis of results on evaluated factors

	df	Header loss	Separator and cleaning loss	Drum loss	Processing loss	Total loss
		(%)			Mpa	
YEAR	1	0,049	0,166	0,269	0,765	2,271
YEAR*REP	3	1,712	0,002	0,091	0,088	2,785
Combine(A)	2	5,321 ns	0,028 **	0,081 ns	0,155 ns	7,290 *
YEAR*A	2	2,81	0,046	0,054	0,106	5,825
Error	6	1,312	0,001	0,022	0,040	1,274
RPM (B)	1	1,323 ns	0,01 ns	0,070 ns	0,097 ns	4,095 *
YEAR*B	1	0,011	0,015	0,055	0,092	0,011
A*B	2	0,870 ns	0,022 **	0,068 ns	0,13 **	1,995 ns
YEAR*A*B	2	0,561	0,017	0,036	0,070	0,819
Error	6	1,487	0,003	0,028	0,029	2,116
% CV		48,41	70	50,10	42,21	52,77

Table 2. Means of combines on evaluated factors

	Header loss (%)	Separation loss	Drum loss	Processing loss	Total loss
Modified Com.	2,2	0,0725 b	0,3	0,4	2,265 b
John Deer 1055	3,2	0,048 b	0,3	0,3	3,526 a
Class 685	2,2	0,129 a	0,4	0,5	2,479 b

Table 3. Means of RPM on evaluated factors

	Header loss (%)	Separat loss	Drum loss	Processing loss	Total loss
650 rpm	2,7	0,1	0,4	0,5	0,3 a
750 rpm	2,4	0,1	0,3	0,4	2,5 b

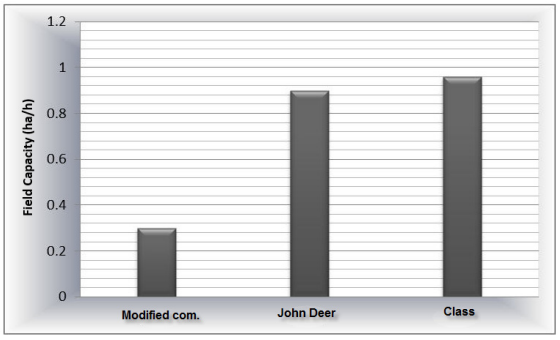

Figure 3. Combine field capasity for three eveluted combines

DISCUSSION and CONCLUSION

Since the evaluated combines included similar cutting head so there was not significantly difference in header loss. Minimum separator loss was observed from the John Deer and the modified combine statistically in the same level, while the maximum seperator loss was measured from Class.

Acording to the results, the modified combine equipped with peneumatic seperation system to separate wheat from straw, can be alternative to conventional combines in Azerbaijan province. Since the field capacity of the moidified combine was low, further studies are required to increase the field capacity of the moidifid combine.

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