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Comparing of Different Harvesting Systems in Wheat Harvesting

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Abstract: In this study, two different harvesting systems which have conventional and stripper header were compared in terms of grain losses, fuel consumption and straw yield. One of the harvesting system was consist of a combine harvester with conventional header and a bale machine. The other one included a combine harvester with stripper header, cutter mover, wheel rake and a bale machine. The tests were conducted at three different forward speeds and moisture contents in wheat harvesting. It was found the grain losses in harvesting with stripper header decreased with an increase in forward speed and moisture content. The opposite relationship was obtained for conventional header. The grain losses for stripper header were approximately half of the conventional one. The fuel consumption decreased almost 45% in harvesting with stripper header. The harvesting with stripper header provided 10% higher straw yield.
Key words: Wheat harvesting, stripper header, grain losses, fuel consumption

INTRODUCTION

In Turkey, the usage of combine harvester in cereal harvest is about 75-80%. The big amount of these combine harvesters are tangential. Due to high purchasing cost and small farm size, most of the cereal harvest is done by combine harvester constructors. This causes high harvesting speed owing to demand of harvesting maximal area in minimal time. Furthermore, 60% of the combine harvesters which are in the place are 10 years old or more (TUIK, 2010). All these negativenesses cause about 3-4% grain losses during cereal harvest (İnce et al., 2008).

Recently, a new harvesting technique, stripping, in which only the most valuable parts of the crop are harvested has appeared and a stripping header which is used commonly in some countries such as UK, USA, Australia and Canada has been developed. Since the amount of MOG which is fed into the combine harvester is less, the cereal harvesting can be achieved with high forward speed by using this header.

It is reported that the header losses decreases rapidly at 8 km/h and more forward speed. The forward speed of combine harvester with stripping header is 1.5-2 times higher than which has conventional one. In addition, comparing with conventional header the MOG feedrate decreases 80-85% (İnce and Güzel, 1998). In this condition, the walker and sieve losses decrease considerably (Kliner et al., 1987; Price, 1989; Lazzari et al., 1990; Martin, 1991, Sugiyama et al, 1995).

Considering that the effective field capacity of combine harvester depends on the MOG feedrate, in the harvest with stripping header, threshing and separating efficiency increase. Martin (1991) determined that grain yield of combine harvester with stripping header is 55% more than conventional header at 100 kg/ha grain losses level. While straw yield decrease from 6 t/h to 1 t/h, the fuel consumption also decreased 7-15% (Pellizi et al., 1989).

The moisture content of crop does not affect the grain losses. Pellizi et al. (1989) determined that the average grain losses are 1% at 15% moisture content.

The aim of this study is to compare the performance of conventional and stripping headers in terms of grain losses, fuel consumption and straw yield.

MATERIALS and METHOD

In the field tests, Adana 99 wheat variety was harvested with New Holland TC56 combine harvester (1998 model) by using conventional and stripper header. The conventional header's width was 4.2 m and it has a standard cutting unit and a rear.

The stripper header was exported from Shelbourne Reynolds Co., England within the context of a DPT project. The stripper header which was installed instead of conventional one, has a horizontal rotor that contains 8 rows of stripping fingers that run the full width of the header. There is a adjustable deflector in front of the rotor which is used to compensate for different height crops. The fingers mounted to the rearwards spinning rotor comb through the crop and feeding the ears back into the keyhole shaped stripping area. The grain is quickly stripped from the head and paddled back into the auger through (Fig. 1). Thereby, while only the ears is being detached, the straw is left in the field. Some specifications of stripper header were given in Table 1.

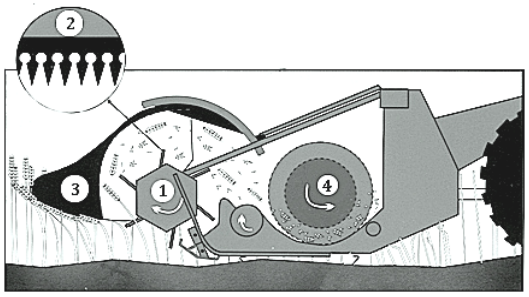


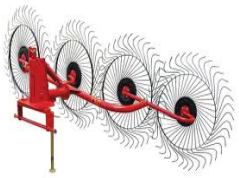
Figure 1. Schematic view of stripping header (1. Stripping rotor; 2. Stripping fingers; 3. Adjustable crop deflector; 4. Auger)

After harvesting, in order to collect the straw from the field, tractor mounted bale machine, cutter mower and wheel rake which are seen in Fig. 2 were used. A MF 365 tractor with 68 HP was used to drive these machines.

Table 1. Some specifications of CVS 20 stripping header

Specifications	*Value*
Working width (m)	6
Diameter of rotor (mm)	1 / 600
Number of stripping fingers' row	8
Rotor rpm (min^{-1})	440-770
Weight (kg)	1712

Bale machine



wheel rake

cutter mover

MF365 tractor

Figure 2. Machines used in the tests

The harvesting systems were compared in terms of grain losses, fuel consumption and straw yield.

Field test were conducted based on split plots in randomized blocks that harvesting systems and moisture content of grain were chosen as independent variables. The values of independent variables were given in Table 2.

The grain losses were determined in two parts: header losses and other losses. Header losses refers to the ears and grains fallen on the ground as a result of passage of the header. Other losses are consists of free and unthreshed grains in the discharged straw.

The controls made before the tests showed that the shattering losses were neglectable. In order to obtain grain losses, "three quarter square method" was used (Akyol, 1999) (Fig. 4). In this method, frames in dimension 50x50 cm (0.25 m^2) placed randomly after passing combine harvester as shown in Fig 4. Then, the grains in the frames were collected and counted. Eqn. 1 was used to calculate the grain losses.

Table 2. The independent parameters evaluated in the test

Independent variables	Value
Moisture content	
	MC1: 16%
	MC2: 14%
	MC3: 11%
Harvesting Systems	
	HS1: Conventional Header at 9 km/h + Bale machine
	HS2: Conventional Header at 7 km/h + Bale machine
	HS3: Conventional Header at 5 km/h + Bale machine
	HS4: Stripper Header at 9 km/h + Cutter mover+Wheelrake+Bale Machine
	HS5: Stripper Header at 7 km/h + Cutter mover+Wheelrake+Bale Machine
	HS6: Stripper Header at 5 km/h + Cutter mover+Wheelrake+Bale Machine

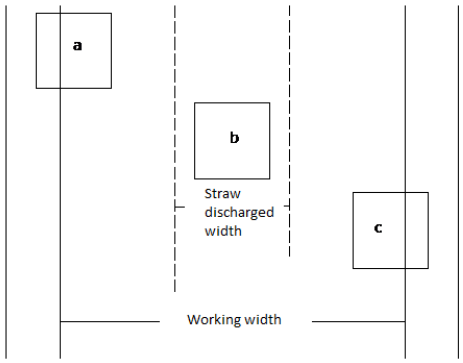


Figure 3. The method for obtaining grain losses

$$K=\frac{133\times(a+b+c)}{Q} \qquad (1)$$

where; K is the grain losses in %, a, b ,c are the weight of the grains in g and Q is the grain yield in kg/h.

The fuel consumption was determined by using "refilling method". Before starting the test, the machines' fuel tanks were completely filled. The quantity of fuel required to fill the tank after test was measured using 10 ml graduated cylinder cup. Thus, the fuel consumed during the test was calculated by Eqn. 2.

$$F=L/A \qquad (2)$$

where, F is the fuel consumption in L/da, A is the area in da; and L is the quantity of fuel fill the tank in L.

The straw yield was determined by the ratio of the straw samples in 0.25m^2 to unit area in da for all harvesting systems.

RESULTS and DISCUSSION

All results examined in the study were tabulated in Table 3.

Grain Losses

The grain losses increased with an increase in moisture content. The moisture content has a significant effect on grain losses at 0.05 probability level (Table 3). The highest grain losses have obtained at 16% moisture content due to may be low threshing ratio during harvesting with conventional header. It was followed by 11% moisture content. The reason of this can be assessed to header losses due to high speed contact of both rear and rotor to the grain.

As seen Table 3, the harvesting systems were significant on grain losses at 0.01 probability level. The average grain losses values varied between 2.11% and 0.74% for harvesting systems. The grain losses at harvesting with conventional header increased with an increase in forward speed. The most important reason of this result is increasing the amount of the material other than grain which pass through the combine, resulting with higher straw walkers losses. This relationship was opposite for the stripper header. Because, stripper harvesting involves stripping the grain from the crop without harvesting the straw. In this case, the amount of the straw handled by the combine decreases. In harvesting with stripper, the header losses increase at low and forward speeds due to long term contact with the crop. It was noteworthy that the grain losses values for stripper header at 9 km/h were lower than conventional header at 5 km/h which is ideal forward speed for conventional one. It was found that the interaction of MCxHS was not significant effect on grain losses.

Comparing the headers in terms of total grain losses depending on the forward speed, the average grain losses for conventional and stripper header were 1.58% and 0.89%, respectively (Fig4.)

Table 3. Effect of experimental factors on measured values and results of variance analyses

Harvesting System (HS)	Average Moisture Content, (MC) % (w.b.)	Total Grain Losses, %	Combine Harvester Fuel Consumption, L/da	Harvesting System Fuel Consumption L/da	Straw Yield kg/da
	16%	2.22	1.57bc	2.19cde	353.0efg
HS1	14%	1.99	1.47cd	2.07defg	325.0h
	11%	2.12	1.62b	2.21cd	326.7h
	16%	1.81	1.86a	2.45a	341.0fgh
HS2	14%	1.54	1.44d	2.05efg	356.0ef
	11%	1.57	1.56bcd	2.16cedf	336.8gh
	16%	1.16	1.87a	2.44a	340.0fgh
HS3	14%	1.00	1.33e	1.96gh	328.3h
	11%	0.87	1.53bc	2.15def	335.0h
	16%	0.68	0.97gh	2.20cd	375.7bcd
HS4	14%	0.74	0.72j	2.01fgh	397.7a
	11%	0.81	0.88hı	2.14def	381.3abc
	16%	0.80	1.13f	2.39ab	374.0bcd
HS5	14%	0.73	0.68j	1.90h	383.7ab
	11%	0.99	0.84ı	2.05efg	364.3cde
	16%	1.18	1.06fg	2.29bc	360.0de
HS6	14%	0.92	0.68j	1.88h	369.7bcde
	11%	1.22	0.73j	1.95gh	367.0bcde
Averages					
HS1		2.11a	1.55b	2.16ab	334.9c
HS2		1.64b	1.62a	2.22a	344.6c
HS3		1.00c	1.58ab	2.19ab	334.4c
HS4		0.74d	0.86cd	2.12bc	384.9a
HS5		0.84cd	0.88c	2.11bc	374.0b
HS6		1.11c	0.82d	2.04c	365.6b
	16%	1.31a	1.41a	2.33a	357.3
	14%	1.15b	1.06c	1.98c	360.1
	11%	1.26ab	1.19b	2.11b	351.8
P values					
MC		0.047	0.001	0.001	0.118
HS		0.001	0.001	0.002	0.001
MCxHS		0.942	0.001	0.005	0.014

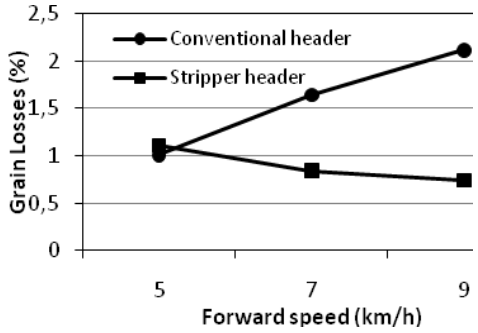


Figure 4. Changing of grain losses with forward speed

Fuel consumption

The fuel consumption was evaluated in two sections as combine and whole system. As known, the threshing process has the highest power requirements in the combine and it is difficult to thresh the moist crops. As a result of this approach, the fuel consumption increased as the moisture content increased and this relationship was found to be significant at 0.01 probability level. The fuel consumption values were found 1.41, 1.06 and 1.19 L/da for 16%, 14% and 11% moisture content levels, respectively. As seen in Table 2, the effect of the headers was highly significant on fuel consumption. The average fuel consumption of conventional and stripper header was found 1.58 L/da and 0.85 L/da, respectively. Fig 5 provides the fuel consumption values of both headers depending on moisture content and forward speed.

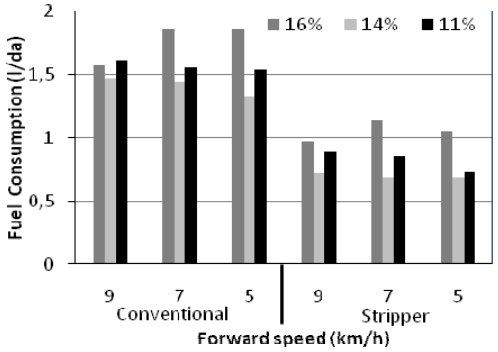


Figure 5. Changing fuel consumption with moisture content and forward speed.

Also from the results in Table 2, it can be seen that although the number of the machines in harvesting systems which stripper header was used higher than those of conventional header used, there was no big difference between these harvesting systems in terms of fuel consumption. The fuel consumptions of bale machine, cutter mover and wheel rake were obtained as 0.62 L/da, 0.45 L/da and 0.40 L/da, respectively.

Straw Yield

The straw yield was much higher in harvesting with stripper than those of conventional. The average straw yield was approximately 338 kg/da and 378 kg/da for harvesting with conventional and stripper respectively. The reason for can be explained that the stubble height in harvesting with stripper more less because of using cutter mover.

CONCLUSIONS

According to the results found in this study can be summarized as follows:

1. It was found that, within the experimental limits tested in this study, the grain losses in harvesting with stripper header decreased with an increase in forward speed and moisture content. The opposite relationship was obtained for conventional header. The grain losses for stripper header were approximately half of the conventional header.
2. The fuel consumption decreased almost 45% in harvesting with stripper header.
3. The harvesting with stripper header provided 10% higher straw yield.

This results of this study revealed that the using of stripper header in wheat harvesting is more economical than conventional one, considering the conditions of the country. Moreover, harvesting with stripper header can give some possibilities about second crop agriculture and sustainable agriculture. Additionally, selected harvest systems should comparatively be evaluated economic point of view in more detail. Timeliness factors, affected from type of crop, some local specifications and climate, for each agricultural operation for the given harvest system should be embedded into the economic calculations.

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