

Experimental comparison of combine performance with two harvesting methods: stripper header and conventional header

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Abstract: Residual straw status on the field after harvesting was one of the important obstacles in using stripper header in Iran. In this work, combine performance studied with two type headers, conventional and stripper in wheat farm. Residual stems after harvesting collected, baled, and two methods were compared. The results showed that fuel consumption in the stripper header was 5.68 L/ha less than the conventional header. Combines with stripper header harvested 1500 m² more than the conventional header in each hour. Stripper header in comparison with the conventional had 21% harvesting efficiency and 840 kg/h field performance which harvested more wheat. Harvesting time and fuel consumption for straw harvesting operation in the harvested field with stripper header were 1.5 minutes and 23.53 L respectively, which were higher than conventional header. However, with stripper method, 2040 kg/ha more straw were collected compared to conventional method. Stripper field status after harvesting operations was far cleaner and more ready for next operation than the other.

Keywords: straw, stripper header, combine performance

Citation: Chegini, G., and S. V. Mirnezami. 2016. Experimental comparison of combine performance with two harvesting methods: stripper header and conventional header. *Agric Eng Int: CIGR Journal*, 18(1):192-200.

1 Introduction

Comments of farmers and researchers show more advantages of the stripper header in same conditions by the conventional header (Klinner et al., 1986b). A research including British farmers using stripper header shows that the rates of harvested wheat and barley have been increased between 40% to 100% without any yield loss and between 80% and 90% straw remained on the field (Jack VR, 1991). In Italy the minimum loss for harvesting rice with this type of header has been reported 0.4% (Hobson and Metianu, 1991). In addition, assessment done on this header in Italy and the U.S. show that stripper header, without increasing yield loss can be increased harvesting capacity between 50% to 100%

compared with conventional header. Also, this type of header for harvesting grain and other crops with average stem diameter and height had an effective performance (Hobson and Metianu, 1991; Klinner et al., 1987a). In 1991, both the stripper and conventional header have been evaluated and compared in the U.S. The result of the study showed 60% increasing of harvesting capacity for stripper header with 4.2 m width, in comparison with conventional header with 4.5 m width. The most important result in this research was increasing combine capacity as well as decreasing grain loss (Jack, 1991).

Stripper header Silsoe had been evaluated for four years on different crops in the U.K., the U.S. and Australia. It has been shown 50% - 100% increasing performance. In 1986 Shelburne company bought stripper header and after two years testing, in 1988, made it as a commercial one (Klinner et al., 1987b). Stripper header tests conducted in more than 30 countries. In Germany, the performance of grain and wheat was increased 70% - 90% and it was observed, 30% less straw than conventional

Received date: 2015-02-20 **Accepted date:** 2015-10-29

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headers. It was highly dependent on operator skill. In Sweden: in harvesting pea, have been reported that the speed and performance was increase up to 11 km/h and 50%, respectively. In the U.S., wheat harvest was done with 25 combines and results indicate that by increasing speed from 5 to 8 km/h which is more than speed of header causes to overload in header. In Thailand, using stripper header instead of conventional for rice cause to decreasing loss until 4% and the efficiency was 74% (Klinner et al., 1987b; Wilkins et al., 1996). Combine performance and fuel consumption in Thailand for the Stripper header were examined (Kalsirislip and Singh, 2001). Stripper header and conventional header for loss and performance were also compared by Price (Price, 1988). Approximately in the entire world, stripper header has been used but any source has not reported about harvesting stem and chaff. So the aim of this research is answering problems such as low performance of stripper header compared to conventional and remaining stems on the field in Iran.

Considering the particular conditions of each country, especially the method of cultivation in that country, still much research is needed to be done in order to correct and optimize harvesting methods with stripper header (Tado et al., 1998; Starksas, 2007; Chegini, 2007).

2 Materials and methods

2.1 Combine and stripper header

Combine used in this study was John Deere 955 combine model 75 which worked for 10 years. Stripper header Shelbourne Reynolds; model S4200 with 4 meters width was used. The rotor speed and the other settings were set after installing the header on combine. Figure 1 shows combines with both conventional header and stripper header.



a- Conventional header



b- Stripper header

Figure 1 John Deere 955 Combine with two types of headers

2.2 Tractors and equipment

A John Deere 3140 tractor, two plates Mower, solar rake and baler were used in order to collect the residual stems and straws of harvesting by the two headers (see Figure 2).





Figure 2 Tractor with John Deere mower implements, solar rake and baler

2.3 Field and crop

Wheat field with the center pivot irrigation system was located in Shiraz. Conditions for stripper header according to combine 10-year-old and rough field were stringent. Type of soil was silty clay and the variety of "Cross Azadi" was used as wheat. Land area was 4 hectares with 125 meters width and 110 meters were separated for starting and finishing tests.

2.4 Experimental design

After obtaining the optimum working conditions of stripper header and conventional in harvesting wheat, the same conditions were obtained in order to compare the two headers. In the best working conditions, the stripper and conventional headers with 36 experiments (12 * 3 repeats) were compared. Experiments were conducted in six forward speeds, two types of header and three repetitions (Table 1). Concave speed, concave distance and fan speed harvested length are the constant parameters in combine.

Table 1 Combine operating conditions with stripper header and conventional header

Header type	Forward speed (km/h)	Harvesting time (min)	Rep.	Rotor speed (r/min)	Gear	Harvesting length (cm)	Header status (cm)
Stripper header	3.07	2.15	3	760	2	110	60
	3.07	2.15	3	760	2	110	60
	3.10	2.13	3	760	2	110	60
	3.11	2.12	3	760	2	110	60
	3.14	2.1	3	760	2	110	60
	3.27	2.02	3	760	2	110	60
Cutter-Bar header	2.82	2.34	3	298	2	110	30
	3.13	2.11	3	298	2	110	30
	3.16	2.09	3	298	2	110	30
	3.19	2.07	3	298	2	110	30
	3.25	2.03	3	298	2	110	30
	3.28	2.01	3	298	2	110	30
Concave speed : 4000 r/min		Concave distance :19 mm		Fan speed: 550 r/min		Harvested length : 110m	

2.5 Straw harvesting

Straw harvesting was conducted in three area fields of 3000 square meters. One field was residual stand

stems of harvesting with stripper header and two other fields were remained straw from conventional header. After straw harvesting, straw and residual materials raked

and packaged with baler. The field experiments were divided by using flags.

2.6 Performance Evaluation

Field capacity was calculated in two ways in order to assess the combine performance. Firstly, harvested area was used and secondly, by using quantity of crop. Below equations (Equation 1 to Equation 3) are used to calculate field capacity, performance and efficiency.

Field capacity = harvesting area/hours (ha/h) (1)

Field performance = Quantity of crop/hours (t/h) (2)

Field efficiency = net time of harvesting/Total time of harvesting (3)

3 Results and discussion

Results of soil properties and crop characteristic and combine performance were obtained for both of headers. Average of soil moisture, seeds and stem were 12%, 3.32% and 3.69%, respectively and the average crop performance was measured 4.4 ton in hectare.

3.1 Combine performance with conventional header

With installing the conventional header on the combine in one hectare of test field, combine performance was measured. Results of combine performance are shown in Table 2.

Table 2 Evaluation of combine performance with conventional header

Factor	Results	Description
Area harvested (ha)	8x125=1000	19 rows
Average speed (km/h)	2.51 3.11 2.57	Gear: 2, length 110 m
Reel speed	268 r/min	
Average harvest time (min)	2.07 2.11 2.34	Net total harvest for the three repeat: 42 minutes
Average revolve time, settings, and (min)	0.34 1.23 0.47	
average total time of harvest (min)	70 min	

Combine harvested in good working conditions. Average forward speed-combine was 2.73 km/h and 4060 kg of crop were harvested. Using Equation (1) to Equation (3), Field capacity, performance and efficiency were calculated 0.86 ha/h, 4.06 t/h and 60%, respectively and presented below. Fuel consumption was 16.6 L.

Field capacity = 1/1.10 = 0.86 ha/h

Field performance = 4060/1 = 4.06 t/h

Field efficiency = 42/70*100% = 60%

3.2 Weight of harvested wheat

For studying combine performance, total of harvested seeds in both methods were measured according to the field area. Results are shown in Table 3. Natural capacity was 4400 kg/ha and obtained losses which is the average of total loss in two fields were 2% for stripper header and 7% for conventional header 7%.

Table 3 Amount of harvested crop fields with two headers

Field	Area (ha)	Weight of harvested crop (kg)	Average of whole loss* (kg/ha)	Crop performance (t/ha)
Stripper header	2	8620	88	4.310
Conventional header	1.425	5785	308	4.06
Boundary	0.05	200	-	
Total	3.475	13950	-	

3.3 Comparing of combine performance and fuel consumption with two headers

Another comparison done for evaluation of two headers was combine fuel consumption and performance of it. Tests results are shown in Table 4 and also comparative diagrams are shown in Figure 3.

Table 4 Comparison of combine performance for two headers

Test Number	T 213-218 Stripper header	T 219-224 Cuter-bar header
Parameters	Quantity	
Area (m ²)	24*110	26*110
Time of harvesting (min)	12.67	12.65
Total time of harvesting (min)	18	33
Fuel consumption (L)	3	5
Fuel consumption (L/ha)	11.36	17.06
Field capacity (ha/ h)	0.88	0.52
Field efficiency (%)	70	49
Field capacity (t/ha)	4.310	4.06
Field performance (t/h)	3.96	3.12

Figure 3 shows combine fuel consumption rate for two headers. The fuel consumption rate in the stripper header was 5.68 L/ha less than the conventional header. It can be said, in a 10-hectare field, there is about 60 L fuel savings.

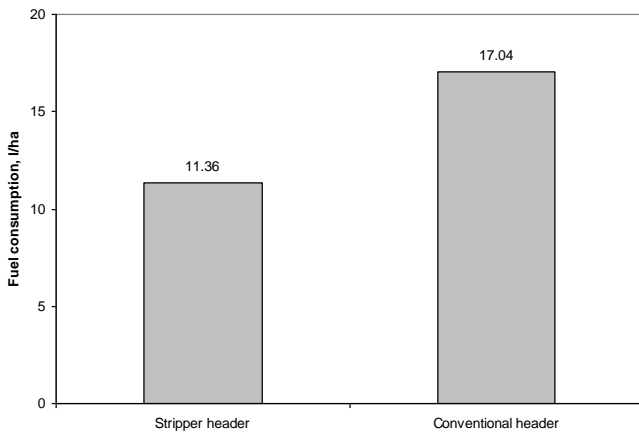


Figure 3 Fuel combine consumption in both harvesting methods

Figure 4 shows the combine field capacity for two headers. Field capacity shows harvesting speed and harvesting rate in one hectare. Harvesting rate with the stripper header in one hectare was 200 kg more than the conventional type. In addition, combine with the stripper header harvested 1500 m²/h more than the conventional header.

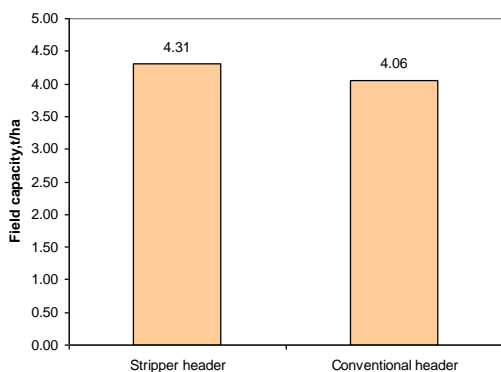
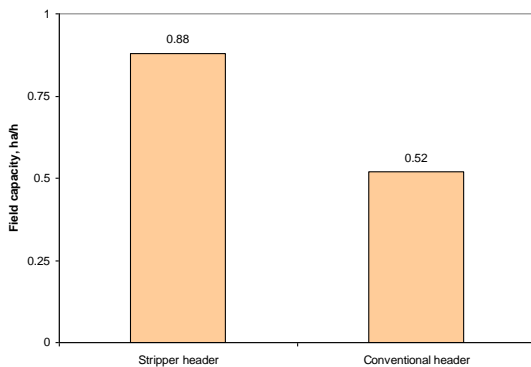
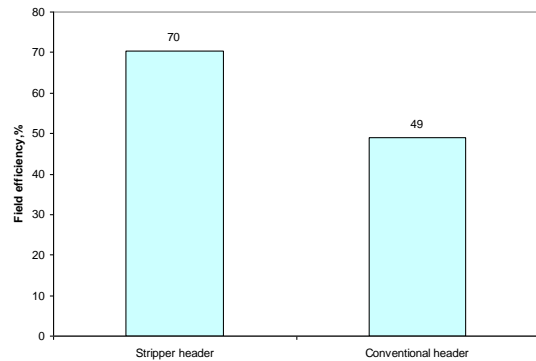
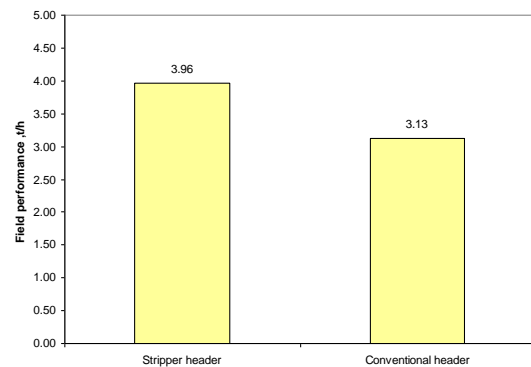


Figure 4 Combine field capacity with stripper and conventional header

Figure 5 shows harvesting efficiency and field performance for the combine with two headers. Figure 5(a) shows 21% more efficiency and Figure 5(b) shows 840 kg/h more wheat harvested by the stripper header in comparison with the conventional.



a



b

Figure 5 Efficiency and combine field performance for two headers

3.4 Study of straw collecting condition in two harvest methods

Another important parameter that should be examined is the situation of residual straw after harvesting with the stripper header. Figure 6 shows field with stand stems after harvested crop in two methods. As it is shown in figure, in the stripper method, all size of stems remained on the field while, by using conventional header, stems with the size between 30 - 50 cm remained on the field and created problem for tillage operations. However, some research showed that residual stems and straw increased soil richness and prevented water erosion (Wilkins et al., 1996; Li et al., 1998). Basically straw

should add to soil by adding other minerals for helping soil fertility.



a- Stripper header



b- Conventional header

Figure 6 Field condition after harvesting with two methods,

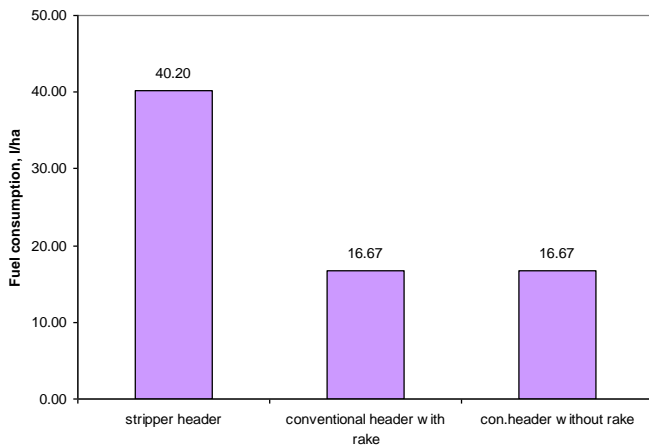
Straw are used as livestock food in some parts of Iran. Although straw has low nutritional value, it is used in order to regulate and balance animal digestive system. In the most region of field they should be picked up for doing next tillage operations faster. So it's one of the most harvesting problems in using stripper header. So in this study, another device was used instead of Benz to harvest straw and all conditions for the two headers were compared and examined. In this paper, three equal parts of field were considered for final harvest testing. Whole of straw remained on the earth was harvested and then packaged by using the field mower, stripper header, rake and baler. In these tests, fuel consumption, harvest time and other parameters shown in Table 5 were measured and compared.

Table 5 Measured data for harvesting and packing straw

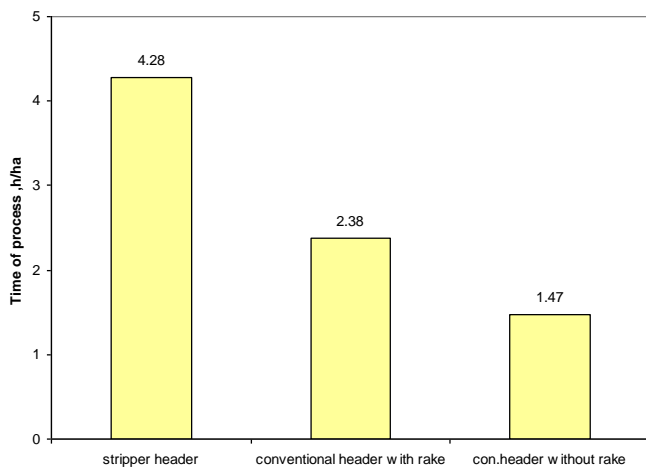
Process	Area		Harvesting Time		Fuel consumption		Forward speed Km/h	Number of bail	Weight of bails kg	Total straw weight t/ha
	m ²	min	Min/ha	L	L/ha					
mover	17000	143	84.12	40.00	23.53	4.28	-	-	-	
Rake, stripper field	3000	26	86.67	2.50	8.33	5.45	-	-	-	
Rake, conventional field	3000	18	60.00	2.50	8.33	5.62	-	-	-	
Baler, stripper field	3000	29	96.67	2.50	8.33	3.10	13	72	3.12	
Baler ,conventional with rake field	3000	15	50.00	2.50	8.33	3.33	9	50	1.50	
Baler ,conventional, without rake field	3000	14	46.67	2.50	8.33	3.46	9	36	1.08	

As shown in Table 5, there are three filed conditions: harvesting with the stripper header, harvesting with the conventional header then rake and also without rake. Tractor fuel consumption, number and weight of each package are the parameters measured with the three methods in the total harvest time. Straw harvest time and fuel consumption are shown in Figure 7. Harvest

time and fuel consumption in the stripper header were 1.90 L and 23.53 minutes, respectively more than the conventional. Time and fuel have been spent for mower operation. Figure 8 shows number and weight of harvested straw in each of three methods.

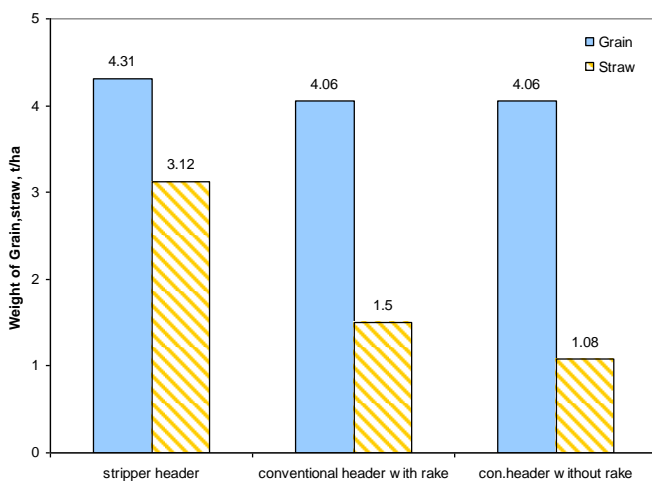


a-Tractor fuel

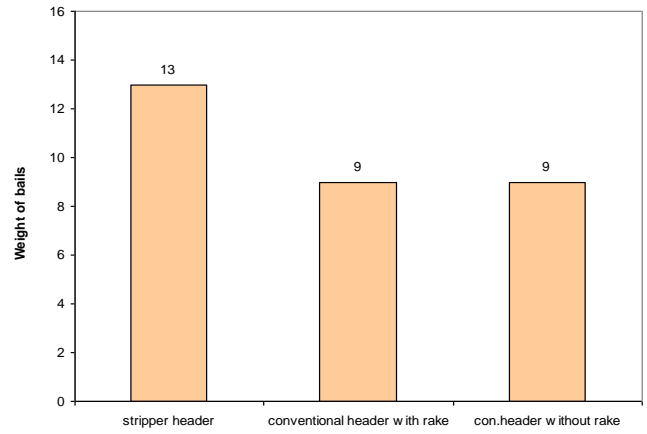


b- Straw harvest time

Figure 7 Tractor fuel and straw harvest time on three different field conditions



a-Weight of wheat and straw



b-Weight bails

Figure 8 Harvested wheat and straw condition with stripper and conventional header

In each 3000 meters field, in the stripper field, there were more 36 packages and the weight of each package was 4 kg more. Furthermore, the total number of 72 packages was obtained from the harvested straw in the stripper field. However, with rake operation and without it 50 and 36 packages were obtained in the conventional field (Figure 8). Therefore, with the stripper header in per hectare 2040 kg more straw has been gathered. Generally, it can be elaborated that, in harvesting with the stripper header method, by using optimal management, more straw can be harvested from the field.

3.5 Field condition after collecting straw

Straw harvest and cleaning field of straw is very important for our country. Unfortunately, in some cases, fields were fired after harvesting. This practice will not only pollute the environment but also damage microorganisms and nutrients in the soil seriously. Figure 9 shows an example of a field with burned straw. Another notable result in harvesting of stripper field was ready statuses and clean field for next operation in comparison with the conventional fields. So, the next operation could be started fast and performed more easily. As shown in Figure 10, the amount of straw remained on the stripper field is minimal, while in harvested field with common methods, the minimum height of straw remained

on the field is between 30 up to 50 cm in which tillage problems and firing straw will still remain. Hence, management and field timing can be optimally in harvesting with the stripper method.



Figure 9 Burning straw after harvesting with a conventional header



a- Stripper header



b- Conventional header

Figure 10 Field Status after harvesting with stripper header and conventional header

4 Conclusions

Combine performance was investigated with two methods including the stripper and conventional headers. The results showed that fuel consumption rate in the stripper header were 5.68 L/ha less than the conventional header. Harvesting rate with the stripper header in the one hectare was 200 kg more than the conventional type. Moreover, combine with the stripper header harvested 1500 m²/h more in comparison with the conventional header. Stripper header compared to the conventional, harvested more wheat with 21% efficiency and 840 kg/h field performance. When the stripper header was used, harvesting time and fuel consumption for straw harvesting operation in harvested field were 1.5 L and 23.53 minutes, respectively higher than conventional header. Furthermore, in the field harvested by the stripper header 2040 kg/ha has been collected more straw in comparison with the other. The stripper field status after harvesting was far cleaner and more ready for next operation than the conventional field.

Acknowledgements

Thanks are due to University of Tehran, Iran Combine Company for funding a major part of this work and Shiraz center of mechanization development, Shiraz University for their cooperation.

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