Analysis and comparison of wheat losses in two harvesting methods

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Abstract: Wheat losses in John Deere 955 combine was compared between stripper header and conventional header. Tests were conducted in a wheat field. At first for comparison, the optimum working condition was obtained for both type of headers and then other parameters are compared. Results showed that the optimum working condition of combine with a second gear and mediate engine speed for stripper header was obtained with 75 cm for hood distance, 60 cm for header distance and 760 r/min for rotor speeds. In stripper header, the total loss of different parts of combine was under 3.5%, although these losses in conventional header reached up to 6.5% which was the highest loss for headers. Number and weight of lost cluster in harvesting with stripper header was much less than conventional header.

Keywords: wheat, stripper header, conventional header, rotor speed, loss

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1 Introduction

In Iran, most available combines in the agricultural mechanization branch is combine 955, of which the number is 10489 (Chegini, 1385). The country's increasing need for small and cheap combines with high performance is the most important major problems in cereals harvest that has been on Iran's fields (Anon, 2004; Chegini, 2006). On the other hand, the internal components frazzle of combine and supplying them is the major problem of this combine. Another common important point about using this combine in Iran is combine immigration from south to north and from east to west for harvesting crops. This issue, due to delay of harvesting, has been causing much loss (Behrozi et al., 1994; Chegini, 2006). As such, different harvesting techniques in the world were studied. One of the best methods of harvesting among them that help resolve the aforesaid issues is using stripper header instead of conventional header. Actually, the research for optimization of harvesting with stripper header has been conducted since 1984 in Silsoe Research Institute and various crops such as wheat, barley, peas and rice were studied. Silsoe headers in 1988 by Shelbourne Company were commercialized and have been exported to more than 30 countries now (Klinner et al., 1986; 1991; Tado et al., 1998). Assessments conducted on this header in Italy and the U.S. show that stripper header, without increasing the amount of loss crop can increase harvesting capacity between 50% and 100%. In 1991 in the U.S, stripper header with conventional header was evaluated and compared. The results of the research showed that the use of stripper header with 4.2 m cut width has increased harvesting capacity up to 60% in comparison with conventional header with 4.5 m cut width. The most important result of this research is the increase of combine capacity and the decrease of grain loss (Jack, 1991). Pea harvest in Sweden: with increasing speed up to 11 km/h, it is reported that performance has increased up to 50%. In the U.S, wheat harvest was carried out with 25 combine and results showed that over speed cause to make pre-load in sieve. In Australia, increasing loss at1.5% in dry wheat and in

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rice has increased performance (Wilkins et al., 1996). In Thailand, using stripper header instead of conventional header for rice has reduced the rate of loss to 4% and enhanced efficiency at the rate of 74% (Kalsirislip and Sing 2001). In the Philippines, the establishment of enterprises associated with Silsoe to design and manufacture stripper for small rice fields has gone hand-in-hand with a swarm of success (Tado et al., 1998). Stripper header has been used in over 20 countries, including U.S, Canada, Australia, Britain, France, Italy, Germany, Sweden, south American countries, Russia, China, Japan, Thailand, Philippines and so on (Glancy, 1997; Tado et al., 1998; Li et al., 1998; Jiang et al., 2001; Kalsirislip and Sing 2001; Chen 2001; Jiang et al., 2003; Starkas, 2006). Pertaining to the conditions of each region and country, their cultural and cultivation conditions in particular, more research has to be done to correct the stripper methods so as to achieve harvest optimization (Klinner et al., 1987; Tado et al., 1998).

In Iran, only very limited research has been practiced for the sake of problems discussed above, including: heavy header with the requirement to use auxiliary jacks for lifting header, no straw harvest, stem remains on the field, high loss of crop and the lack of suitable header in the ridge and furrow field. Stripper header in the ridge and furrow field and John Deere 955 combine were used in this research. In this research, the search for the optimum working condition of stripper header, the measurement and the evaluation of losses in harvesting with stripper header and conventional header and their respective status have been carried out.

2 Materials and methods

Figure 1 shows the stripper and conventional header with John Deere 955 combine for comparison. Combine used in this study was John Deere 955, a combine that has worked for 10 years. With the installation of stripper header on this combine, rotor speed settings and other settings were done. This stripper header is suitable for John Deere 955 combine and its model was SR4200, Shelburne Reynolds, with 4 m efficient harvesting length, 8 rows teeth and rotor speed from 450 to 760 r/min.

a. Conventional header

b. Stripper header

Figure 1 John Deere 955 combine with headers installed on it

2.1 Field and crop

Wheat field with the center pivot irrigation system located in Shiraz was the testing field. So it can be said that conditions for a stripper header to combine a 10-year-old and rough field were stringent. Figure 2 shows the mentioned field. The type of soil was City clay and the variety of wheat was “Cross Azadi” (Marvdasht) for the purpose of measuring all the properties of the crops and field.

Figure 2 Wheat field of "Cross Azadi" with the center pivot irrigation system

2.2 Test field

The field was separated into two parts by length with consideration to two types of header (125×160 m^2 for stripper header and 125×113.4 m^2 for conventional header) and into three parts by width for test repetitions with flag bar.

2.4 Designing tests

Evaluation tests for stripper header, unlike conventional header, were conducted in two steps. First, conventional header tests were done in three steps: regulation test for primary setting of parameters of header, efficiency test for making the combine compatible with field followed by the final data measurement test. Stripper header tests were done in four steps: regulation test for primary setting of parameters of header, which is the same as conventional header, but the efficiency test was divided into two parts, namely primary and secondary, because this header was newer than the other and a more in-depth compatibility and final test for data measurement is critical. Efficiency tests were done because the condition and parameters of headers should be the same for all final tests. All tests have been conducted with completely randomized factorial design.

3 Results

Results obtained from various measurements and tests conducted previously have been analyzed. All field conditions, stripper header and optimum conditions were studied to compare with conventional header. Crop and field characteristics with the average moisture of soil, grain and stem obtained were 12%, 3.32% and 3.69% respectively. The average performance of measured crops was 4.4 ha^{-1}.

3.1 Field test with stripper header

With conducting initial tests, the optimum condition for harvesting with stripper header was 760 r/min for rotor speed, 75 cm hood position and up to 4.06 km/h forward speed. Considering the fact that the most appropriate working conditions with combine and stripper header for performance evaluation and comparison with conventional header should be obtained, other tests (201-212) were conducted. Twelve tests in three repetitions (36 tests) are conducted as in Table 1.

Table 1 Stripper header test with constant rotor speed at 760 r/min, hood and head distance and variable engine speed and forward speed

Test number	Forward speed /km · h^{-1}	Harvesting time /min	Gear	Engine speed /r · min^{-1}
T 201	1.96	3.37	1	Low
T 202	2.99	2.21	1	Medium
T 203	3.24	2.04	1	High
T 204	4.46	1.48	2	Low
T 205	4.58	1.44	2	Medium
T 206	4.85	1.36	2	High
T 207	2.04	3.23	1	High
T 208	2.19	3.01	1	High
T 209	2.80	2.36	1	High
T 210	2.91	2.27	2	Medium
T 211	2.96	2.23	2	Medium
T 212	3.30	2	2	Medium

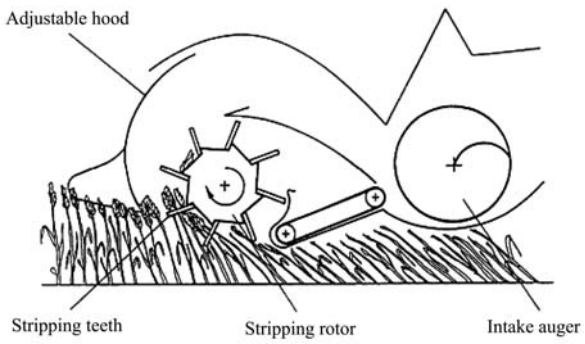


Figure 3 Stripper header with adjustable hood

With shown design in Table 1, 18 tests (6 × 3 repeats) were performed in low, medium and high engine speed, and also in gears 1 and 2.

Also, the entire loss of combine and header were measured with results shown in Table 2. Obtaining suitable forward speed and engine speed of combine for quick harvest was the aim of these tests.

Table 2 Measured data from combine loss with stripper header (secondary test)

Test number	Not stripped/%		Header loss /%	Sieve, walker losses/%	Total grain losses/%	Purity of grain /%	Fractured grain /%	Cluster number /N	Straw losses /%
	Header	S.walker							
T 201	0.00	1.72	0.60	1.73	2.33	95.10	4.90	5.00	0.86
T 202	0.00	0.40	0.71	0.92	1.63	94.60	3.40	2.00	0.20
T 203	0.70	2.37	1.77	1.05	2.82	96.30	3.70	8.00	1.53
T 204	0.66	0.80	1.44	1.06	2.50	98.30	1.50	9.00	0.73
T 205	1.15	2.36	1.15	1.77	2.91	91.10	8.90	12.00	1.75
T 206	0.06	0.88	1.36	1.00	2.36	94.10	3.90	4.00	0.47

Figure 4 shows the relationship between combine losses in different forward speeds. Figure 4 shows that losses of not stripped and total losses of combine were less than 2.5% but the engine speed variation do not show the same pattern. Minimum losses were achieved in 2.92, 4.46, 5.85 km/h forward speed.

When checking field condition after harvesting and obtaining loss, it is apparent that the suitable gear and engine speed was gear 1 with high speed and gear 2 with medium speed. Amore comprehensive survey studying these two working conditions in other 18 tests (207-212) depicted results which are shown in Table 3.

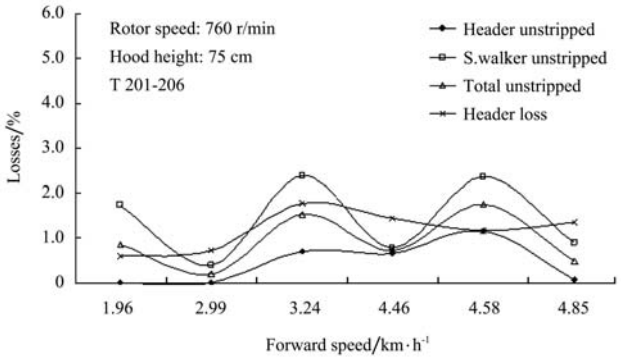


Figure 4 Effect of forward speed in combine loss in 760 r/min for rotor speed and 75 cm for hood height

Table 3 Results of measured data in combine with stripper header (secondary testing)

Test number	Not stripped/%			Header loss /%	Sieve, walker losses/%	Total grain losses/%	Purity of grain /%	Fractured grain /%	Straw number /N	Straw Losses /%
	Header	S.walker	Total							
T 207	0.14	0.72	0.43	3.04	1.41	4.45	96.60	3.40	4.00	0.43
T 208	0.54	0.62	0.58	1.13	1.72	2.85	96.60	3.40	5.00	0.58
T 209	1.11	1.05	1.08	1.50	0.18	1.68	95.60	4.40	12.00	1.08
T 210	0.24	0.10	0.17	1.38	0.52	1.90	96.60	3.40	1.00	0.17
T 211	0.73	0.39	0.56	1.96	1.26	3.22	95.60	4.40	8.00	0.56
T 212	1.02	0.99	1.00	1.56	0.38	1.94	95.60	4.40	18.00	1.00

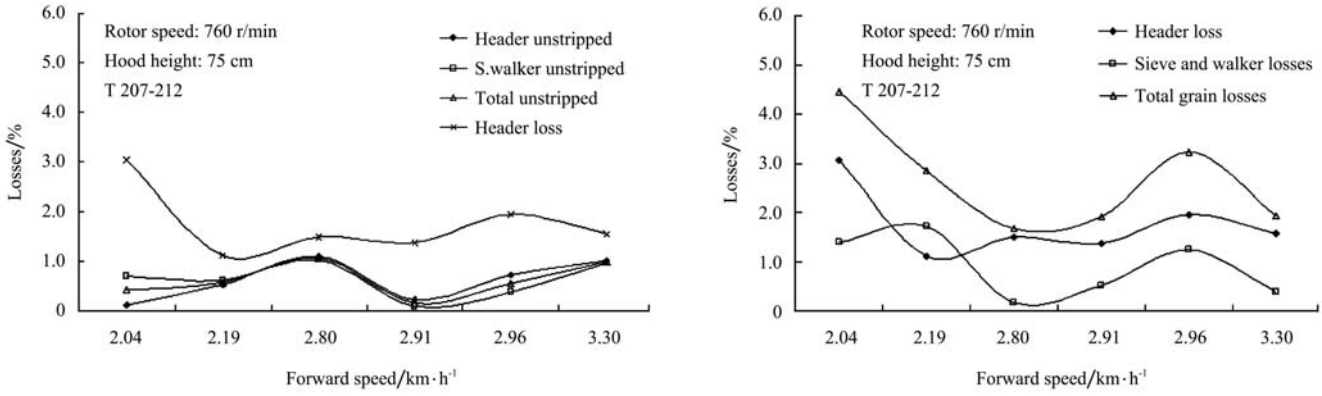
Figure 5 shows results of obtained data from Table 3 in a diagram format. Figure 5 shows that combine loss with increasing forward speed is reduced and in two figures a and b, combine losses in the second gear and medium speed was less than 1% and 2% (second part of diagram). For the first gear and high speed, combine losses was more than 2% and 3%. In the figure it is clear that the optimum working conditions for combine with stripper header was the second gear with medium speed. By comparing the two series of field tests, the most appropriate or optimal working conditions for combine were obtained with the second gear and medium engine speed being the crucial findings. As for stripper header, hood and head distances of 75 cm and 60 and 760 r/min rotor speed were the results obtained.

3.2 Harvest comparison between stripper header and conventional header

To compare combine loss with stripper and conventional header, completely optimal and suitable conditions for both headers were vital. For stripper header, the most suitable combine was the one with the second gear and medium engine speed while the second gear with low engine speed was suitable for conventional header. In stripper, hood and head distance of 60 and 75 cm and rotor speed of 760 r/min were obtained and for conventional, they were 286 r/min for rotor speed and 30 cm for head distance. In the comparative test (finally), the number of performed tests was 36 (12 × 3)

which is shown in Table 4.

Table 5 shows the results of measuring comparative data for two headers. In this Table, the entire not stripped or not harvested losses by two headers, different parts of combine losses, number of not harvested clusters and harvested crop quality were measured.



a b

Figure 5 Effect of combine forward speed on crop loss with 760 r/min for rotor speed and 75 cm for hood height

Table 4 Combine working condition for two headers

Test number	Forward speed /km · h^{-1}	Harvesting time /min	Rotor speed /r · min^{-1}	Gear /cm	Engine speed /r · min^{-1}	Harvesting length /cm	Head position /cm	Hood position /cm
T 213	3.07	2.15	760	2	Medium	110	60	75
T 214	3.07	2.15	760	2	Medium	110	60	75
T 215	3.10	2.13	760	2	Medium	110	60	75
T 216	3.11	2.12	760	2	Medium	110	60	75
T 217	3.14	2.1	760	2	Medium	110	60	75
T 218	3.27	2.02	760	2	Medium	110	60	75
T 219	2.82	2.34	298	2	Low	110	30	
T 220	3.13	2.11	298	2	Low	110	30	
T 221	3.16	2.09	298	2	Low	110	30	
T 222	3.19	2.07	298	2	Low	110	30	
T 223	3.25	2.03	298	2	Low	110	30	
T 224	3.28	2.01	298	2	Low	110	30	

Table 5 Measured data in comparative tests for two headers

Test Number	Unstripped/%			Header losses /%	Sieve walker losses/%	Total grain losses/%	Purity of grain/%	Fractured grain/%	Straw number /N	Grain weight /g	Straw losses /%
	Header	S.walker	Total								
T 213	0.00	0.20	0.10	0.30	1.40	1.70	97.40	2.60	2.00	4.05	0.10
T 214	0.00	0.09	0.04	0.54	0.71	1.25	98.10	1.90	2.00	2.01	0.04
T 215	0.00	0.68	0.34	1.11	0.39	1.49	97.50	2.50	2.00	2.68	0.34
T 216	0.26	0.74	0.50	2.11	1.26	3.38	98.40	1.60	5.00	5.08	0.50
T 217	0.32	0.58	0.45	2.38	0.84	3.22	98.50	1.50	7.00	3.59	0.45
T 218	0.00	0.77	0.38	0.46	0.70	1.16	97.20	2.80	2.00	3.70	0.38
T 219	3.03	3.39	3.21	3.05	1.47	4.53	95.30	4.70	19.00	12.52	3.21
T 220	4.43	2.06	3.24	4.93	1.23	6.16	96.60	3.40	20.00	8.36	3.24
T 221	2.61	0.85	1.73	2.61	0.76	3.37	97.70	3.00	10.00	4.06	1.73
T 222	2.55	1.01	1.78	2.55	1.62	4.17	94.80	5.20	12.00	6.67	1.78
T 223	2.48	1.15	1.82	2.48	3.95	6.43	96.10	3.90	11.00	13.20	1.82
T 224	1.63	1.74	1.69	1.63	2.58	4.22	95.00	5.00	12.00	11.06	1.69

Figure 6 shows the results of combine losses for not harvested clusters in two harvesting methods and different forward speed. As shown in Figure 6, losses of not stripped crop in stripper header are less than 1%

although in conventional method the percentage of no harvested losses is between 1% and 4%. In harvesting with conventional header, the percentage of not harvested clusters was higher in lower speeds, contrary to the results with stripper header which indicated higher speeds.

Figure 7 shows different parts of combine losses in both headers together. This figure shows that the loss of header and cleaning unit and the total loss of combine compared with conventional header are considerably lower. In stripper header the total losses are lower than 3.5% although in conventional header these losses reached up to 6.5%. However, most losses are related to the header instead of the cleaning unit. Diagrams in Figure 8 show losses of combine and not harvested clusters in two harvesting methods together. Differences of loss in the two methods are clear when the two diagrams are compared.

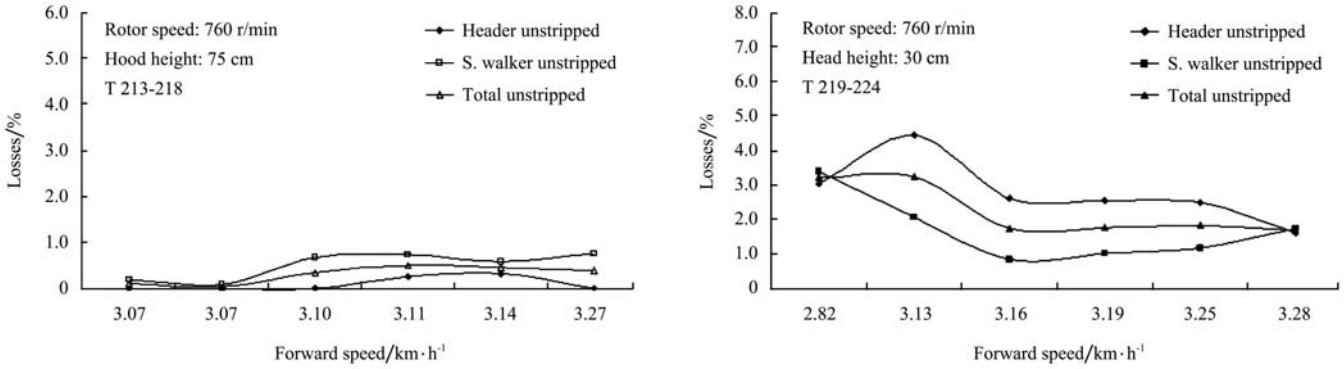


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Figure 6 Not stripped losses and not harvested cluster with stripper and conventional header

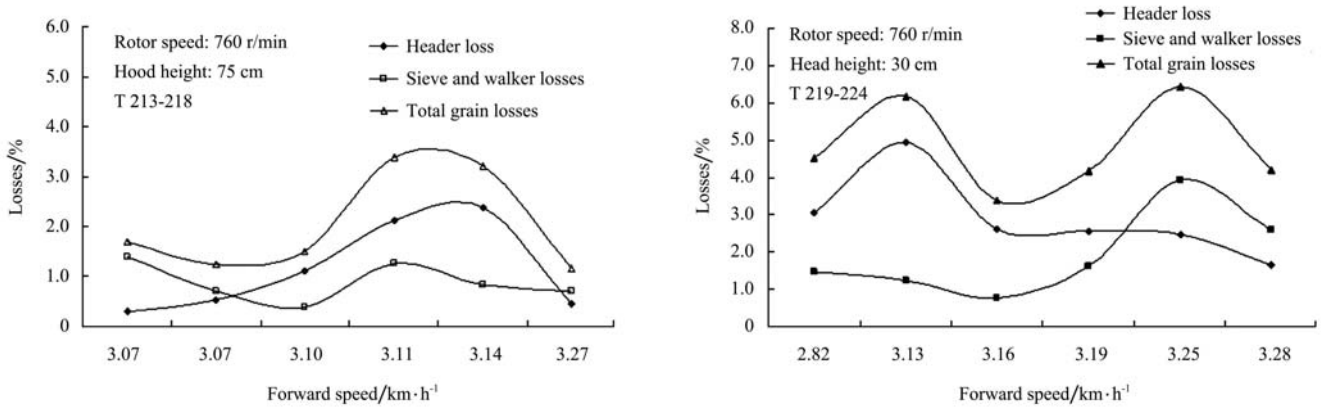

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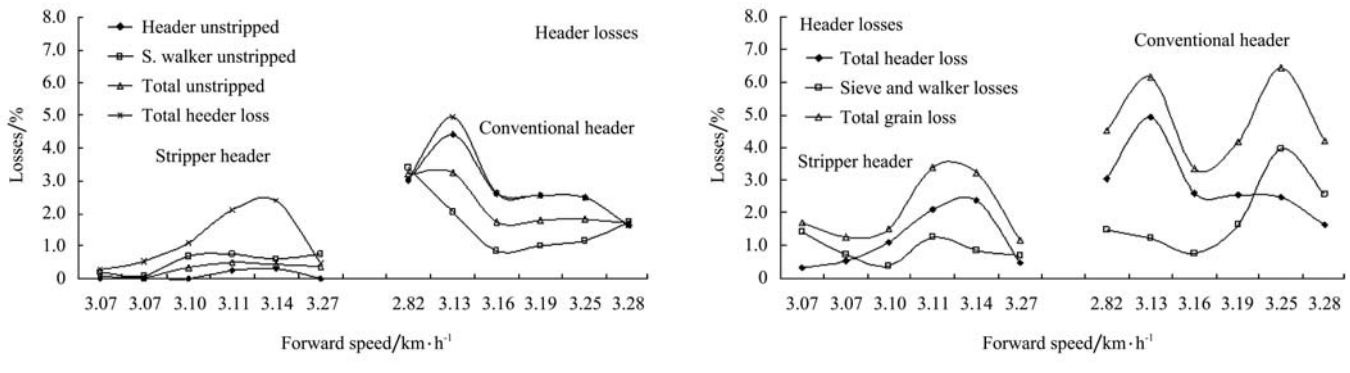
Figure 7 Combine losses with conventional header in various forward speed



a b

Figure 8 Comparison of combine losses in stripper and conventional header

Another parameter that has to be studied in harvesting with two headers was the condition of field after harvesting. Harvest condition in Figure 9 and the weight of wheat and the number of lost clusters in Figure 10 are shown from both harvesting method in various working conditions for two headers. Also, purity percentage and harvested grains fracture in both methods were compared, showing results in Figure 11.

a. Conventional header

b. Stripper header

Figure 9 Field condition from loss viewpoint

On the surface of harvested field with conventional header, there was a lot of crop loss, especially valid clusters which had lost. While in harvesting with stripper header, the status of harvest was far better. Figure 10 shows the number of lost clusters and their weight in harvesting with stripper header which was much less than that with conventional header. In conventional header method, there were straws in different sizes on the field although in stripper header method only wheat protective shells instead of a large percentage of straw were on the field.

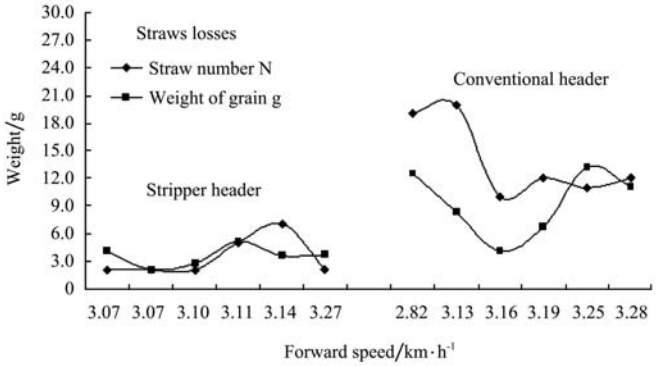


Figure 10 Comparison of the number and weight of lost clusters in harvesting with stripper and conventional header

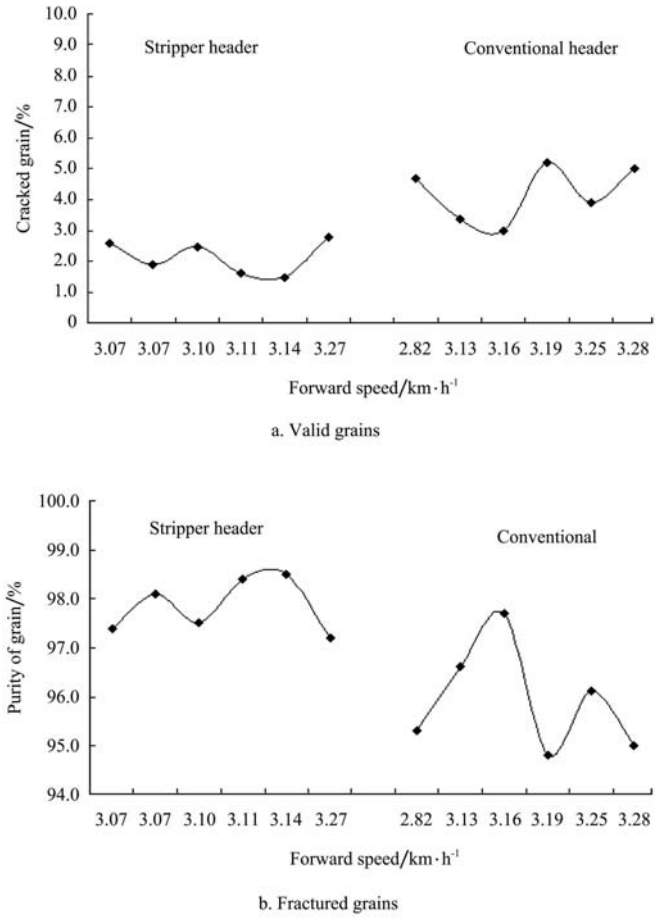


Figure 11 Status of seeds in two harvesting methods

As shown in Figure 11, the average grains purity percentage in harvesting with stripper header is more than 98% although the average with conventional header is 96% which hinges on not harvested straw by stripper header. The average of fractured grains in stripper header was 2.5% and 3.5% in conventional header, indicating the positive relationship between losses and speed.

4 Conclusions

Performance of John Deere 955 combine with stripper and conventional header were compared. Outcome from this study showed that when comparing two headers, the combine optimum working conditions for both headers should first be obtained before comparing other same parameters. Used combine had 60% performance, 0.86 ha/h field capacity and 4,060 kg/ha harvested crop. By checking files after harvesting, the best or most optimum working conditions for combine was with the second gear and medium engine speed and by comparing two series of stripper header tests, 75 and 60 cm hood and head distance and 760 r/min rotor speed were obtained. In stripper header the total losses is less than 3.5% with the absence of harvesting straw but in conventional header these losses reached 6.5%. In conventional header method, there were straws of different sizes on the field while in the stripper header method there were only wheat protective shells without leaving a large percentage of straw on the field. When harvesting with conventional header, the percentage of not harvested clusters was higher in lower speeds, but it was the other way round in the case with stripper header. However, most losses are related to the header instead of the cleaning unit. The number of lost clusters and their weight in harvesting using stripper header was much less than those using the conventional header. Generally, it can be said that both loss and performance of combine with stripper header was a whole lot better than conventional header in wheat-harvesting.

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