Investigation and technical comparison of new and conventional wheat combines performance for improvement and modification

Mostofi Sarkari M. R., M. Shaker, A. Mahdinia

(*Iranian Agricultural Engineering Research Institute, Karaj, Iran*)

Abstract: Wheat is one of the most important food staff in consumption pattern of each country. More than 50% of human energy is supplied from bread in developing countries. Reducing of losses and waists in combine harvesting resulte increasing considerable wheat production in country. Combine loss is less than 2%-3% in developed countries, while that of developing countries is about 15%-20% in different regions and circumstances of harvesting seasons and field conditions. Regarding to research finding that maximum total combine losses are related to combine header loss, so it is necessary to determine precise losses and their causes to improve and modify existing combine's technical characteristics. In this national research project that took place in three provinces of Tehran, Khorasan and Fars, effect of combine type and drum speed to grain losses and waists were investigated. Experimental design was split plot in a completely randomized block design with three replications. Duncan's test was used to statistical analysis of the means. Combine type in four levels of New Holland TC 56, JD 1165, JD 955 and CLASS 68 as a main-plot and drum speed in three levels of 650, 750 and 850 rpm as a sub-plot. Field experiments were carried out in the farmers field with two ha area. Different parameters and factors of each treatment were measured: 1. Pre-harvest loss, 2. Header loss, 3. Drum loss, 4. Cleaning loss, 5. Ground speed & combine field capacity, 6. Drum speed, 7. Linear drum speed, 8. Grain moisture content, 9. Cutting height. The results of Tehran province show that New Holland TC 56 and JD 955 with 1.98% and 2.15% of the total combine losses are the lowest and positioned in class a while JD 1165 and CLASS 68 with 4.29% and 4.12% located in class b. Also New Holland TC 560 has a highest combine capacity of 5187 kg/hr and gets a class of a while JD 1165 while CLASS 68 are in class b and JD 955 is in class c. The results of Fars province show that the highest total combine loss was related to JD 955 and Class 68, 2.72% and 2.84%, respectively, and JD 1165 had the lowest total combine loss (1.61%). The results of Khorasan province show that New Holland TC 56 had a lowest total combine loss (14.3 kg/ha) and got class a and JD 955, JD 1165 and CLASS 68 took class b, c and d, respectively. Also New Holland TC 56 had a highest combine capacity (5,383.58 kg/hr) while CLASS 68, JD 955 and JD 1165 positioned in b, c and d classes, respectively. Therefore, combines improvements and modifications are suggested as 1. Uniform cutting height, 2. compatible reel and ground speed, 3. using effective cutting width, 4. using proper drum speed, 5. choosing proper ground speed regarding crop density.

Keywords: combine, performance, wheat, improvement, modification

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1 Introduction

Wheat is the most prominent nutrition material in our food consumption. In fact, more than 50% of nutrition material of each Iranian is provided by different kinds of breads. Fars province is the first producer of wheat in Iran, in addition to adjustable weather leader farmers, producer's effect, research finding and using the latest scientific results have a significant role in production. The area under cultivation of wheat in Iran in year of 2005 to 2006 is estimated about 6.88 million hectare, and Khorasan province with 9.4% of whole area under cultivation of wheat has the largest area. Fars province and eastern Azarbayjan province with 8.5% and 6.4% of

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Corresponding author: Mostofi Sarkari M R, Iranian Agricultural Engineering Research Institute, P O Box 31585-845, Karaj, Iran; Email: Mostofi08@gmail.com; **M Shaker,** Email: shaker@farsagres.ir; **A. Mahdinia,** Email: a_mahdinia@yahoo.com

whole wheat yield take the second and third place in Iran. However, this year Fars province taking second place in cultivation area achieves 14.9% of total wheat production which is the highest while Khorasan and Golestan provinces with 8.2% and 6.4% take second and third places in production. The most irrigated wheat yield with 5388.92 kg is in Tehran province. The average of natural loss and combine loss in different parts including platform, other parts, the sum of different parts and the whole loss including natural loss which reported by wheat project performer in 2004 was equal to 2.2, 2.62, 2.15, 4.77, and 6.97. Decreasing wheat loss during harvesting provides considerable increase possibility in field production. Combine loss in developed countries is about 2-3% while in surveyed parts of this study total loss of combine is more than standard. Considering importance and the role of grains in providing nutrition for people and because of maximum loss in combine head, necessarily, precised amount of loss and its reasons must be identified then decreased through improvement of combines. According to related studies on this matter, it seems to be necessary that the influence of combine type and drum speed on wheat loss during harvesting being investigated.

Rahimi and Khosravani (2003) in a survey from Fars province resulted average loss of wheat harvesting stage in Fars province was 4.81% of production. The maximum amount of loss related combine loss was 68% and after it the amount was for natural loss, sieve loss, drum loss then quality loss.

Asghari Meydani, Rahim Zadeh and Eskandari (2003) investigated two types of combines (Class, John Deer) on two kinds of dryland wheat in two times of harvesting, 15 days for each time. The results indicated that harvesting with delay in the second time has more loss compared with the first time while it increased about 9 kg/h for each day.

Yavari and Poordad (2003) randomly investigated 61 combines (John Deer 955) in a survey. According to the finding in Kermanshah province there was an average of 105.42 kg/h which was equal to 7.2% of loss resulted from harvesting. That was decreased to 29.06 kg/h which was equal to 3.31% because of technical and agricultural points.

Mansouri and Minaei (2003) investigated the effects of combine parameters on wheat loss in combine of John Deer. In this study the effects of combine ground speed, drum speed, the distance between drum and concave, and fan speed on loss amount were investigated. The results show with increasing ground speed cutting edge loss will increase dramatically. Drum speed increasing causes grain breaking and drum loss decreasing while grain breaking resulted from drum speed loss decreasing while grain breaking resulted drum speed from 750 to 950 rpm, was doubled.

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 km/h 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 harvesting time and loss decreasing was suggested about 14%-15%.

Mohd et al. (1997) investigated wheat loss during combine harvesting. They measured parameters including ground speed, drum speed, sieves openness rate, fan adjustment and grain moisture content. The results of their investigation pointed out among 55 studied combines no one adjusted like the others. The average of measured loss in first year was 9% while that was 12.7% in second year. The mentioned suitable moisture content for harvesting was about 9%-14%. The least loss in ground speed was 5.5 km/h while the least drum

loss in drum speed was 900 rpm.

Consequently, current survey with following objectives will be performed:

1. Performance comparison between new combines and common ones

2. Reform recommendation and optimization of them at present

With reference to the history of presented survey, it can be understood choosing proper drum speed in common combines of rural areas, considering appropriate moisture content for harvesting and moving speed require more researches that show the necessity of performing it.

2 Materials and methods

In this study, the effects of combine type and drum speed on wheat loss during harvesting were investigated. For statistical analysis, there were used from statistical design of split plot in the completely randomized block design in three replications and Duncan test.

Combine types in four levels: Class 68S, John Deer 955, John Deer 1165 and New Holland TC 56 were chosen as a main-plot while drum speed in three levels of 650 rpm, 750 rpm and 850 rpm were chosen as a sub-plot.

Test was performed in a field about two hectare. Crop was adjusted with harvesting moisture content of 14%, and combine ground speed according to crop density was between 2.5 to 3 km/h. In each treatment, following factors were measured and investigated:

1. Natural loss

2. Header loss

3. Drum loss

4. Separator and cleaning loss

5. Ground speed and combine field capacity

With measuring traverse time of specified length of field, combine ground speed during harvesting was measured using ground speed and effective width of combine, and the field capacity was measured.

6. Drum speed

Drum speed and fan speed were measured and adjusted using tachometer. Linear drum speed was calculated using diameter of each drum and the results were analyzed.

7. Grain moisture content

Grain moisture content was achieved by measuring in percentage with sampling available wheat in combine storage by using grain moisture content meter.

8. Cutting edge height during harvesting

This factor was determined with measuring wheat stalk height that remained after harvesting.

Loss was measured in different parts of combine, and then whole loss of combine with capacity factor of each combine was measured and analyzed. In order to decrease loss reformation matters with common combine optimizing were represented.

3 Results

3.1 Tehran province

The results of project performing in Tehran province are illustrated in Table 1.

Table 1 Variance analysis of results on overall combine loss

Combine type	Mean	DMRT	
		5%	1%
TC-56	1.987	a	a
JD-1165	4.299	b	b
JD955	2.154	a	a
CLASS 68	4.123	b	b

Dependent Variable: TOTAL LOSS.

As is shown in Table 1, combine type treatments and drum linear speed treatments and their interaction has a significant difference while whole loss rate in probability level of 5% and 1% which are illustrated in Table 2 to Table 4.

Table 2 Effect of combine type on overall combine loss

Source	Type III Sum of squares	df	Mean squar	F	Sig.
Rep	0.879	2	0.440	0.721	0.491
CT	34.527	1	34.527	38.970	0
Error	5.317	6	0.886		
LBT	33.361	6	5.560	9.113	0
CT*LB	19.760	2	9.880	16.193	0
Error	31.727	52	0.610		
Total	136.050	71			

Dependent Variable: TOTAL LOSS.

However, the results show TC 56 and JD 955 which are placed in class a have less loss comparing to CLASS 68S and JD 1165 in probability level of 5% and 1%.

Table 3 Effect of linear drum speed on overall combine loss

Linear beeter speed	Mean	DMRT	
		5%	1%
15.31	3.996	c	c
17.66	2.837	b	bc
20.04	5.535	d	d
20.61	2.140	b	ab
20.75	3.196	b	ab
23.78	0.890	a	a
23.94	2.347	b	ab
26.96	2.931	bc	bc
27.14	4.136	b	bc

Dependent Variable: TOTAL LOSS.

Considering three levels of drum speed and different diameters of tested combines, the linear drum speed was calculated and analyzed. According to results the least loss was related to TC 56 that is in class a with probability level of 5% and 1% and indicate a significant difference with others. Overall loss derived from combine linear drum speed of JD 1165, Class 68S and JD 955 are place in subsequent cases.

Table 4 Interaction between combine type and linear drum speed on overall combine loss

Inters	Mean	DMRT	
		5%	1%
CLASS-68-15.31	3.996	cd	cde
CLASS-68-17.66	2.837	bc	bcd
CLASS-68-20.04	5.535	fg	ef
JD-1165-20.75	4.395	de	de
JD-1165-23.94	2.369	b	abc
JD-1165-27.14	6.134	g	g
JD-955-20.75	1.998	ab	ab
JD-955-23.94	2.325	b	abc
JD-955-27.14	2.138	ab	ab
TC-56-20.61	2.140	ab	ab
TC-56-23.78	0.890	a	a
TC-56-26.96	2.931	bc	bcd

Dependent Variable: TOTAL LOSS.

The results reveal the least overall loss of combine is related to interaction of TC 56 and linear drum speed of 23.78 m/s which happened with angular drum speed of 750 rpm and is among significant class a. Other combines systematically including JD 955, Class 68S, JD 1165 are located in subsequent significant classes which are indicated with probability level of 1% and 5% in Table 4. This means New Holland combines due to new parts, planned adjustment that are affected by each other and equipped with grain loss monitor have lower overall loss and are placed in class a. In other classes of JD 955, according to familiarity of operator with combine adjustment, popularity in country that has the most production and distribution. In new types of it high power engine of Perkins 1000 increases its efficiency and decreases combine overall loss. CLASS 68S combine has gained the most appropriate response to machine performance in hillside area with cold and temperate weather. It has lower loss rate in lower yield than country mean yield in comparison with high yield area which is because of having small diameter of drum in comparison with tested combines. That resulted lower linear drum speed. Finally, combine JD 1165 has a different problem that most of operators are not familiar with its applications and adjustments. Therefore it has the highest combine loss and there needs the combine proper usage training for operators.

Also capacity of each combine has affected from two mentioned treatments and based on effective field capacity, grain feed rate, MOG feed rate and total feed rate were calculated and analyzed which are shown in Table 5 to Table 8.

Table 5 Variance analysis of results on combine capacity

Source	Type III Sum of squares	df	Mean squar	F	Sig.
Rep	0.001	2	0.001	0.004	0.996
CT	17.943	1	17.943	8971.500	0
Error	0.010	6	0.002		
LBT	0.062	6	0.010	0.061	0.999
CT*LBt	0.031	2	0.015	0.090	0.914
Error	8.843	52	0.170		
Total	82.405	71			

Dependent variable: COMBINE CAPACITY.

As is shown in Table 5, effect of combine type, linear drum speed and interaction of two treatments on combine capacity were significant in probability level of 5% and 1%.

Table 6 Effect of combine type on combine capacity

Combine type	Mean	DMRT	
		5%	1%
TC-56	5.187	a	a
JD-1165	3.893	b	b
JD955	2.346	c	c
CLASS 68	3.693	b	b

Dependent variable: COMBINE CAPACITY.

Result shows that combine capacity of TC 56 was the highest and it is replaced in class a. Combines JD 1165, CLASS 68S and JD 955 are replaced in other classes of significance, respectively.

Table 7 Effect of linear drum speed on combine capacity

Linear beeter speed	Mean	DMRT	
		5%	1%
15.31	3.698	b	b
17.66	3.743	b	b
20.04	3.639	b	b
20.61	5.179	a	a
20.75	3.119	c	c
23.78	5.245	a	a
23.94	3.158	c	c
26.96	5.137	a	a
27.14	3.082	c	c

Dependent variable: COMBINE CAPACITY.

The highest combine capacity was occurred in 23.78 m/s linear drum speed which related to combine TC 56 and replaced in class a. Capacity of combines CLASS 68S, JD 1165 and JD 955 are replaced in other classes respectively.

Table 8 Interaction between combine type and linear drum speed on combine capacity

Inters	Mean	DMRT	
		5%	1%
CLASS-68-15.31	3.698	b	b
CLASS-68-17.66	3.743	b	b
CLASS-68-20.04	3.639	b	b
JD-1165-20.75	3.889	b	b
JD-1165-23.94	3.972	b	b
JD-1165-27.14	3.818	b	b
JD-955-20.75	2.349	c	c
JD-955-23.94	2.344	c	c
JD-955-27.14	2.346	c	c
TC-56-20.61	5.179	a	a
TC-56-23.78	5.245	a	a
TC-56-26.96	5.137	a	a

Dependent variable: COMBINE CAPACITY.

Interaction between combine type and linear drum speed on combine capacity was significant. The combine capacity of TC 56 was the highest and replaced in class a. Other combines of JD 1165, CLASS 68S and JD 955 were replaced in other classes respectively. By attention to this point that combine capacity is equal to field capacity multiplied by crop yield so with high field capacity of combine TC 56, high grain feed rate and MOG feed rate and finally total feed rate is caused. Therefore, the least overall combine loss is obtained the highest combine capacity. By the same reason, combine JD 1165 has those specifications and replaced in significant class b. Bbecause of having high field capacity, combine CLASS 68S was replaced in same class with combine JD 1165. Finally because of low field capacity and low total feed rate, the combine capacity of JD 955 was the lowest and replaced in the other classes.

3.2 Fars province

The results of this province are reported as follows:

1) Mean ground speed of combines was measured and equal to 2.07, 1.96, 1.32 and 2.84 km/h for combine New Holland TC 56, Class 68S, JD 955 and JD 1165, respectively.

2) The high combine capacity was related to combine JD 1165 with 1.28 ha/h and after that the rest combines capacity was equal to 0.75, 0.73 and 0.26 related to combines CLASS, TC 56 and JD 955, respectively.

3) The highest overall loss was happened on Class combine with 2.94% and the lowest one was on combine JD 1165 with 1.60%.

4) The highest overall loss was occurred on 750 rpm drum speed with 2.27% and the lowest one was on 650 rpm with 2.11%.

5) Combines CLASS and JD 1165 had a lowest overall loss with 2.82% and 1.33% on 650 rpm drum speed, respectively.

3.3 Khorasan province

The results show that New Holland TC 56 had a lowest total combine loss (14.3 kg/ha) and got class a while JD 955, JD 1165 and CLASS 68 took class b, c and d, respectively. Also New Holland TC 56 had a highest combine capacity (5383.58 kg/hr) while CLASS 68, JD 955 and JD 1165 positioned in b, c and d classes, respectively.

Finally New Holland TC 56 had a good situation on overall combine loss view. Drum loss was affected not only from combine type, and the kind of crop variety, cutting height, moisture content during harvesting were also very vital.

4 Conclusions and recommendations

1) Combine New Holland TC 56 has the lowest overall loss the value of which is 1.98% and the highest combine capacity which is 5.18 ton/h.

2) Combine JD 955 has the lowest overall loss which is eual to 2.15% and is replaced in class a while it has 2.35 ton/h combine capacity and replaced in class c.

3) Combine JD 1165 with 4.29% overall loss and 3.89 ton/h combine capacity is replaced in class b.

4) Combine Class 68S with 4.12% overall loss and 3.69 ton/h combine capacity replaced in the same class of b.

5) Strategy of improvement and modification of assessed combines are shown as follows:

a. Uniform cutting height

b. Adjusting reel rpm with ground speed

c. Using effective cutting width in harvesting

d. Using proper drum speed

e. Choosing and using proper ground speed according crop density

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