Investigation and technical comparison of new and conventional wheat combines performance to improve and modification

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Abstract

Wheat is one of the important food staff in consumption pattern of each country. More than 50% of human energy is supplied from bread in the developing country. Reducing of losses and waists in combine harvesting resulted increasing considerable wheat production in country. Combine losses is less than 2-3% in developed countries, while in developing country is about 15-20% in different regions and circumstances of harvesting seasons and field conditions. Regarding to research finding that maximum total combine losses is 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 types in four levels of New Holland TC 56, JD 1165, JD 955 & Class 68 as a main plot and drum speed in three levels of 650, 750 & 850 rpm as a sub plot. Field experiments were carried out in the farmers field with 2 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 & JD 955 with 1.98 and 2.15% had lowest total combine losses and positioned in class a while JD 1165 & Class 68 with 4.29 and 4.12 % located in class b. Also New Holland TC 56 had a highest combine capacity of 5187 kg/hr and got a class a while JD 1165 & Class 68 were in class b and JD 955 was 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 (5383.58 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: Uniform cutting height – compatible reel and ground speed – using effective cutting width – using proper drum speed – choosing proper ground speed regarding crop density.

Key Words: combine, performance, wheat, improvement, conventional

1. INTRODUCTION

Wheat is the most prominent nutrition material in our food consumption. In fact, more than 50 percent of each Iranian nutrition material is provided by different kinds of breads. Fars province is the first producer of wheat in country, in addition to adjustable weather leader farmers, producer's effects, research finding and using the latest scientific results has a significant role in production. The under cultivation area of wheat in country in the year of 2005-2006 was estimated about 6.88 million hectare, and Khorasan province with 9.4 percent of whole area wheat cultivation has the most area. Fars province and eastern Azarbayjan province with 8.5 and 6.4 percent of whole wheat yield has the second and third place in country. However, in this year Fars province had second place in level but with 14.9 percent of wheat production has had the first place while Khorasan and Golestan provinces with 8.2 and 6.4 percent has second and third place. The most irrigated wheat yield with 5388.92 kg is for 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, 6.97. Decreasing wheat loss during harvesting provides considerable increase possibility in field production. Combine loss in developed countries is about 2-3 percent while in surveyed parts of this study total loss of combine has been more than standard. Considering importance and the role of grains in providing nutrition for people and because of maximum loss in combine head, necessarily, précised amount of loss and its reasons must be identified then decreased through improvement of combines. According to related studied on this matter, it seems to be necessary that the influence of combine type and drum speed on wheat loss during harvesting be investigated.

Rahimi & Khosravani (2003) in a survey from Fars province resulted average loss of wheat harvesting stage in Fars province was 4.81 percent 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, 2003 investigated 2 types of combines (Class, John Deer) in two times of harvesting in time of 15 days on two kinds of dry land wheat. The results have indicated second time, means harvesting with delay comparing to first time has more loss while it increase about 9 kg/h for each day.

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

Mansouri & 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 in creasing 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 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.
Mohd, 1997 investigated wheat loss during combine harvesting. They measured parameters like 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 percent while it was 12.7 in second year. The mentioned suitable moisture content for harvesting was about 9-14 percent. 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 of new combines with common ones.
2. Presenting reformation recommendation and optimization them

With reference to the history of presented survey, it can bee understood choosing proper drum speed in common combines of country, 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 effect of combine type and drum speed on wheat loss during harvesting was investigated. For statistical analysis, there were used from statistical design of split plot in the completely randomized block design in 3 replications and Duncan test.
Combine types in 4 levels: Class 68S, John Deer 955, John Deer 1165 and New Holland TC 56 were chosen as a main-plot while drum speed in 3 levels of 650, 750 and 850 rpm were chosen as a sub-plots.
Test was performed in a field about 2 hectare. Crop was adjusted with harvesting moisture content of 14%, combine ground speed according to crop density 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 with using ground speed and effective width of combine, 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 according to percent was measured with sampling available wheat in combine storage and with 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 are represent.

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

Dependent Variable: TOTAL LOSS

		DMRT	
COMBINE TYPE	Mean	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

According to 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 % are illustrated in table 2 to 4.

Table 2. Effect of combine type on overall combine loss

Dependent Variable: TOTAL LOSS

Source	Type III Sum of Squares	df	Mean Squar	F	Sig.
Rep	.879	2	.440	.721	.491
CT	34.527	1	34.527	38.970	.000
Error	5.317	6	.886		
LBT	33.361	6	5.560	9.113	.000
CT * LB	19.760	2	9.880	16.193	.000
Error	31.727	52	.610		
Total	136.050	71			

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

Table 3. Effect of linear drum speed on overall combine loss

Dependent Variable: TOTAL LOSS

		DMRT	
LINEAR BEETER SPEED	Mean	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	.890	a	a
23.94	2.347	b	ab
26.96	2.931	bc	bc
27.14	4.136	b	bc

Considering 3 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

Dependent Variable: TOTAL LOSS

		DMRT	
inters	Mean	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	.890	a	a
TC-56-26.96	2.931	bc	bcd

The results reveals the least overall loss of combine was 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 of 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 increase its efficiency and decrease 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 that's because of having small diameter of drum in comparison with tested combines. That's resulted lower linear drum speed. Finally, combine JD 1165 have a different problems because of national manufacturing so most of operators did not family with its applications and adjustments. Therefore it has the highest combine loss and needs the combine proper usage education to 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 was calculated and analyzed which it is shown in Tables 5-8.

Table 5. Variance analysis of results on combine capacity

Dependent Variable: COMBINE CAPACITY

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Rep	.001	2	.001	.004	.996
CT	17.943	1	17.943	8971.500	.000
Error	.010	6	.002		
LBT	.062	6	.010	.061	.999
CT * LBT	.031	2	.015	.090	.914
Error	8.843	52	.170		
Total	82.405	71			

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

Table 6. Effect of combine type on combine capacity

Dependent Variable: COMBINE CAPACITY

		DMRT	
COMBINE TYPE	Mean	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

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

Dependent Variable: COMBINE CAPACITY

		DMRT	
LINEAR BEETER SPEED	Mean	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

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

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

Dependent Variable: COMBINE CAPACITY

		DMRT	
inters	Mean	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

Interaction between combine type and linear drum speed on combine capacity was significant and TC 56 was the highest combine capacity and replaced on class a. The rest of combines JD 1165,

Class 68S and JD 955 were replaced on 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 was 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 on significant class of b. Combine class 68S because of having high field capacity was replaced in same class of combine JD 1165. Finally combine JD 955 because of low field capacity and then having low total feed rate had the lowest combine capacity and was replaced on 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 combines 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 on was on 650 rpm with 2.11%.
5. Combine Class and JD 1165 had a lowest overall loss on 650 rpm drum speed with 2.82% and 1.33%, 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 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 (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 but also kind of crop variety, cutting height, moisture content during harvesting were very vital.

4. CONCLUSION AND RECOMMENDATION

1. Combine New Holland TC 56 has the lowest overall loss the highest combine capacity and equal to 1.98% and 5.18 ton/h, respectively
2. Combine JD 955 has the lowest overall loss and equal to 2.15% so replaced in class a but 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 same class of b.

5. Strategy to improvement and modification of assessed combines are 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

5. REFERENCES

1. Asghari Meydani, J., R. Rahim Zadeh and A. Eskandari. 2003. Points around Applied Strategy to Reduce Wheat Waist on Harvesting. Abstract of Paper on First National Conference of Assessing Agricultural Crops Waists. Oct. 2003. Agricultural Faculty of Tarbiat Modaress University. Tehran.

2. Dillon, J., L. Hardaker and J. Brian. 1993. Farm Management Research for Small Farmer Development. FAO Farm Systems Management Series. FAO. No.6:302p.

3. Mansouri, H. And S. Minaei. 2003. Assessment of Machine Parameters Effect on Wheat Loss in Combine JD 955. Abstract of Paper on First National Conference of Assessing Agricultural Crops Waists. Oct. 2003. Agricultural Faculty of Tarbiat Modaress University. Tehran.

4. Mohd, A.A., A.R. Omar, E .A. Mutasim and I. D. Mamou. 1997. On Farm Evaluation of Combine Harvester Losses in the Geezer She in the Sudan. AMA. 28(2): 23-25.

5. Mostofi, M. R. 2008. Investigation and technical comparison of new and conventional wheat combines performance to improve and modification-10th International Congress on Mechanization and Energy in Agriculture, 14-17 October 2008- Antalia-Turkey.

6. Rahimi, H. A. And A. Khosravani. 2003. Assessment of Decreasing Wheat Losses Methods on Harvesting Stages in Fars Province. Abstract of Paper on First National Conference of Assessing Agricultural Crops Waists. Oct. 2003. Agricultural Faculty of Tarbiat Modaress University. Tehran.

7. Sheraddin, B. And J.Ghulan. 1991. Influence of Timing and Date of Harvest on Wheat Grain Losses. AMA. 22 (2): 56-58, 62.

8. Sing, K.N., T .N. Mishra, D .K. Pathak, B. Singh and P.Reddy. 1991. Optimum Replacement Time of Combine Harvesters. AMA. (4): 37 – 41.

9. Tavasoli, A. And S. Minaei. 2002. Assessment of Processing Loss on John Deer Combine and Its Ground Speed. Abstract of Paper on Second National Congress of Agricultural Machinery and Mechanization. Nov. 2002. Karaj. Iran

10. Yavari, A. And S. Poordad. 2003. Assessment of Waist Rate on Different Sections of Combine in Wheat Harvesting on Kermanshah Province. Abstract of Paper on First National Conference of Assessing Agricultural Crops Waists. Oct. 2003. Agricultural Faculty of Tarbiat Modaress University. Tehran.