THE RELATIONSHIP BETWEEN THE AGE OF COMBINE HARVESTER AND GRAIN LOSSES FOR PADDY

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Abstract: *Rice harvesting became recently a problem due to shortage of labor and, consequently, the increase of wages in Turkey. The aim of the study was the determination of relationship of combine harvester age and the grain losses during on paddy harvest. This study was conducted at the paddy production field planted with Karacadağ variety in Çınar District of Diyarbakır Province in 2013. The New Holland Combines which has same brand but different ages in series of 2002 model TC 56, 2006 model TC 56, 2007 model TC 56 and 2013 model TC 5070 were used in the field experiments. The header losses, which include shatter losses and cutter bar losses, threshing and separation losses, and cleaning losses were measured in the study. The total of these losses was evaluated as combine loss. According to the results, the harvest loss due to combine changed between 6.67% to 9.23%. The lowest harvesting loss was obtained in 2013 model TC 5070 combine series. This was followed by 2002 model TC 56 with 7.32% loss. This results show that the harvesting loss was not directly depended on combine age, it was affected by the factors such as combine adjustment and maintenance, operator skill, product yield, field conditions.*

Keywords: *PADDY, COMBINE HARVESTER, GRAIN LOSSES*

1. Introduction

Rice (*Oryza sativa* L.*)* is an important staple food and main source income for about half of the world population and at least cultivated in more than 100 countries in the world and it will continue to be a main stay of life for future generations (Badawi, 2001; Sessiz et al., 2011). Therefore, rice has got strategic importance for human diet. Turkey is one of the rice grower countries. Although rice cultivation area of Turkey fluctuates from year to year, it was cultivated over an area of 115.850 hectares with average rice yield of 7.940 kg per hectare and an annual production of 920.000 tons in 2015 (Anonymous, 2016). All of agricultural region in Turkey, rice can be grown. In this region, 95 % of rice cultivation area and production was performed in Şanlıurfa, Diyarbakır and Mardin provinces (especially, Karacadag region). But, the average yield (4.770 kg/ha) in this region is much less than other rice growing regions of Turkey.

In the Southeastern part of Turkey, agriculture is one of the most important economic sectors and generally public's economy heavily dependent on agriculture products and also, majority of the population is engaged in agriculture. Rice growing is generally performed in stony areas in this region. Therefore, agricultural technology application is limited. Usage of agricultural mechanization equipment, pesticide and fertilizer application are limited and crop yield is low. Harvesting and threshing operations are known as crucial and influential processes on quantity, quality and production cost of rice. Rice harvesting is performed heavily by manually. Manual harvesting of rice with sickles in the traditional way is a time-consuming and labor intensive job (Esgici, 2012). In an unfavorable climate with less labor, losses may be unavoidable. After harvesting, the reaped plant left on the field to reduce crop moisture content, and then bundled together and transformed to outside of the field for threshing operations. Rice threshing is done either by cereals thresher or by stationary combine harvesters in Southeastern region of Turkey. Recently, paddy harvesting has become a serious problem for farmers in this region due to shortage of labor. Labor shortage, rainfall and wage rise over work peak time will cause delay in harvesting operations and increase of grain and panicle shattering in consequence occurring the severe grain losses (Esgici, 2012; Alizadeh and Allameh, 2013). Undoubtedly, manual harvesting of rice is such a troublesome, time-consuming and costly operation that it needs about 100-150 labor hours to harvest one hectare of paddy field. As resulting in labor shortages during the peak farming seasons causes delay in rice harvesting both quantitative and qualitative losses. In order to overcome this situation, using of combine harvesters would be an effective solution to reduce production cost and enhance labor productivity. However, the combine harvesters cause negative impacts on the quantity and the quality of paddy grains which seriously affect the profitability of the crop. Because, the most losses are caused by improper adjustment of the machines according to crop conditions or due to improper machine ground speeds. Losses in rice production due to use of unsuitable machinery and techniques are occurring estimated 25% to 30% during harvesting season in southeastern part of Turkey. Whereas, the goal of good harvesting is to maximize grain yield and to minimize grain losses and quality deterioration. This value is quite a lot. It must be reduced to a reasonable level. If harvest losses reduced, the farmer's income will be increased. To reduce these losses, harvesting parameters need to improve for combine harvesters. Therefore, combine harvesters' adjustment and the ability of the operator play important role in rice harvesting (Hofman et al., 1978; Jung, 1981; Fouad et al., 1990; Badawi, 2001, Lesoing, 2001, Sessiz et al., 2006; Baran et al., 2012).

Considering the importance of grain loss in the header unit of the combine harvester, the amount of loss and causes of losses must be scientifically investigated through proper adjustment of operating conditions. The main objective of the study is determination of relation between the different aged combine harvester which has same brand and the grain losses during on paddy harvest. Consequently, determination of optimum conditions in harvest paddy for combine harvester will minimize the grain losses.

2. Materials and Methods

Combine test were conducted at the paddy production field of a commercial farm cultivating Karacadağ variety in Çınar District of Diyarbakır Province in 2013. The New Holland Combine harvesters which has same brand but different ages in series of 2002 model TC 56, 2006 model TC 56, 2007 model TC 56 and 2013 model TC 5070 were used in the field experiments (Figure 1). The average values of grain and stalk moisture content were changed between 24.00%-28.85% and 61.00% -71.93% during harvesting, respectively.

Figure 1.*View of combine harvester operation in paddy field.*

The conventional combine harvester is less suitable for rice harvesting. Therefore, before starting tests, in order to avoid of wrapping of straw and the clogging of sieve, rasp-bar threshing beaters were changed with spike tooth beater (Figure 2). Combine speed was determined for each plot by using stop watch to monitor time required to travel 35 m. Beater speed were setting of gears in the header drive unit. Header and hood height were regulated with hydraulic system in the combine cab. Field experiments were replicated three times at each plot (Chegini, 2013). The operating parameters of combine harvesters during the rice harvesting were chosen as 750-800 rpm beater rotational speed, 750 rpm fan speed and 20-25 cm high of plant. Combine ground speeds of 3.2 km h^{-1} was determined. The reel speed was automatically synchronized to ground speed.

Figure 2. *A spike- tooth that used for threshing unit.*

In general, crop loss occurs from natural phenomena before harvest besides physiological, mechanical and physical parameters during harvesting. This publication reports only on the physical characteristics.

Therefore, before harvesting experiment, some important properties related to crop were measured in terms of plant height, number of plant per unit area, number of seed per m^2, length of panicle, number of grain in each panicle, grain and straw moisture content and weight of 1000 grains. To determinate the plant properties in each experiment plots, 25 panicle were selected for measurement. The average physical properties of crop are presented in Table 1. Grain and stalk moisture content (wb) were determined by oven-drying method at harvest time according to ASAE standard (Anonymous, 2003). For each sample, 25 g weight with a balance to the nearest 0.01 g. Rice seeds and stalks was dried by using air method at 130 °C for 18 h (ASAE S352.2FEB03, 2003; Sessiz et al., 2011).

To determine quantitative loss before and after harvesting, a 1m×1m metal frame was used and thrown out randomly four replicate for each plot. Then, the all grains inside the frame were gathered, weighted and recorded. To determine percentage of broken, cracked and husked grains, four samples of 50 g rough rice was randomly taken from the grain tank of combine harvesters and separated manually and weighted. Then, all losses were determined separately. The percentage total grain losses were the sum of pre-harvest losses, header bar losses, threshing losses, straw walker losses and shoe losses. Also, to measurement of header losses during harvesting operation, the combine harvesters were allowed to move forward for 50 m to attain a steady constant speed and it was suddenly stopped. The header unit was lifted up and the machine was moved back for about 5m. The quadrate with an area of 1 m^2 was placed in front of the parked machine and the grains and panicles were manually picked up. The panicles were then manually threshed and the header losses were determined by weighing the fallen grains and panicle grains collected. The percentage of harvesting loss computed by following equation (Alizadeh and Allameh, 2013; Bawatharani et al., 2015).

$$HL = \frac{W_{gt} - W_{go}}{Y} \times 100$$

Where;

HL : harvest loss, %
W_{gt} : total harvest loss, g m^{-2}
W_{go} : pre-harvest loss, g m^{-2}
Y : grain yield, g m^{-2}

Table 1*. Mean values of some agronomic properties of rice plant during harvesting for each plot.*

Properties of plant	TC-56 (2002)	TC-56 (2006)	TC 56 (2007)	TC 5070 (2013)
Plant height, cm	93.50	87.90	86.20	85.90
Panicle length, cm	14.10	13.90	16.40	13.80
Weight of 1000 grain, g	32.30	32.72	32.27	32.86
Panicle number per m^2	379.00	344.00	327.00	312.00
Grain losses, gr m^{-2}	550.00	616.6	423.00	470.00
Seed moisture content, %w.b.	26.00	25.12	28.85	24.00
Stem moisture content, % w.b	66.00	67.63	71.93	61.00

Figure 3 shows the sampling points around the combine harvester. The methods determining the various losses are as below.

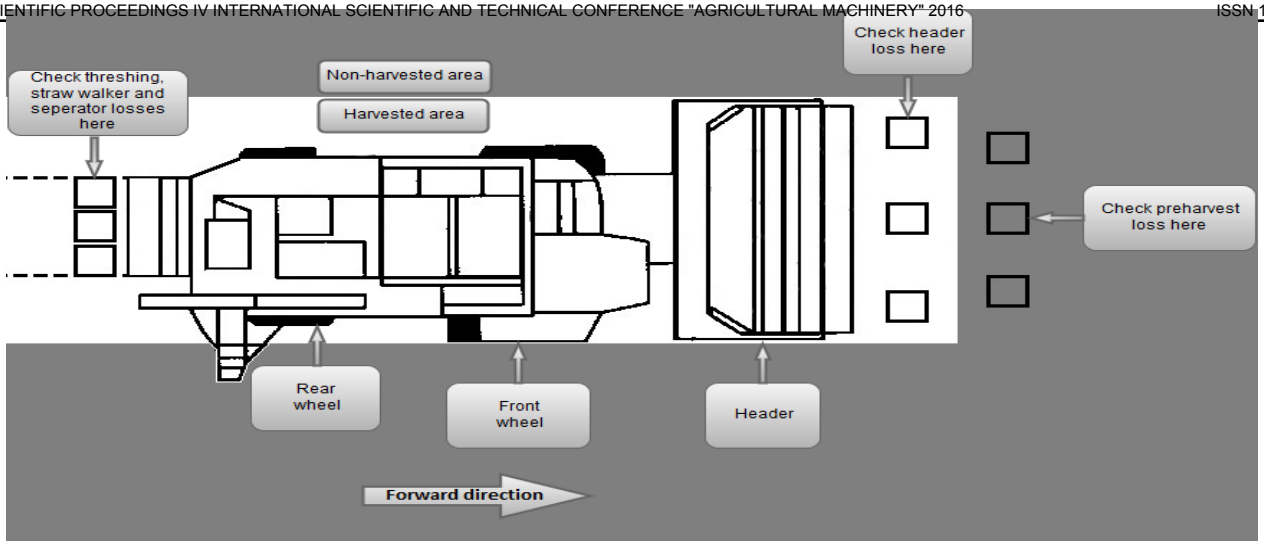

Figure3.*Measurement of grain losses and sampling points around the combine harvester.*

Figure 4 . *Measurements of rice grain losses in paddy field.*

3. Results and Discussion

The average results of grain losses for same brand but different ages in series combine harvester are separately summarized in Table 2. The total grain losses in the field are consisted of pre-harvest loss, header loss, threshing loss, straw walker and separator loss. The machine losses includes in header loss, threshing loss and separator loss (Roy et al., 2001). The table shows that grain losses varied greatly among combine harvesters. While the highest header losses were obtained in model of 2013 TC 5070 series as 22.08 kg da^{-1}, the lowest value were obtained in model 2000, TC 56 series, as 18.76 kg da^{-1}. In model of 2006, TC 56 series, grain losses were obtained as 21.53 kg da^{-1}. In model of 2007, TC 56 series, grain losses were observed as 19.35 kg da^{-1}. The header losses shows that combine harvester not adjusted accordingly. The structural and operational parameters of combine harvester need to be adjusted accordingly for reduced grain losses. Because, the lowest grain losses were observed at the older combine harvester of 2002 model. Therefore, grain losses not only depends on combine age but also field and crop conditions, plant densities, adjustment of header, forward speed, ability of operator affecting on grain losses.

Table 2*. Average grain losses for each combine harvester per* m^2

	TC56 (2002)	TC56 (2006)	TC 56 (2007)	TC5070 (2013)
Field yield, kg da^{-1}	550.00	470.00	423.00	616.60
Pre-harvest grain losses, gr m^{-2}	2.53	3.16	2.40	7.73
Header losses, gr m^{-2}	18.76	21.53	19.35	22.08
Threshing-separation and cleaning losses, gr m^{-2}	18.39	19.72	14.65	10.68
Total machine losses, gr m^{-2}	37.15	41.25	34.00	32.76
Total grain losses, gr m^{-2}	39.68	44.41	36.40	40.49
Total losses (Pre-harvest + machine losses), %	7.32	9.23	9.22	6.67

However, while the highest header losses were found at combine of model 2013, the lowest threshing-separation and cleaning losses were determined the on the same combine harvester as 10.68 kg da^{-1}. The values were found approximately 50% lower according to the others combines. It can be said that threshing-separation and cleaning losses is higher at new combine harvester than older. According to these results, the lowest total machine losses (32.76 gr m^{-2}) and percentage of total grain losses (6.67%) were determined in TC 5070 model in 2013. There was not any difference between 2006 and 2007 models combine harvesters. This results was found compatible with Mesquita et al. (2006). They found that combines more than 15 years old left significantly more seeds in the field than units up to 5 years old. On the other hand, field losses for machines up to 5 years old did not differ significantly from those occurring with combines between 5 and 15 years old. They also concluded that field losses appeared to be more related to factors such as operator skills, maintenance, and crop conditions than combine age. With careful maintenance, adjustment and operation, harvest losses should be reduced lowest value.

4. Conclusions

From these results we conclude that the grain losses varied among combine harvesters. While the lowest total machine losses were determined in TC 5070 model of 2013 year as 32.76 gr m^{-2}, the highest value were observed in TC 56 model of 2006 year as 41.25 gr m^{-2}. As a result of this study, it is seen that the machine grains losses are not directly depend on the age of combine harvester. On the other hand grain losses are related with field yield,

the field operation conditions, machine adjustment and especially maintenance of machine and ability of operator.

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