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EFFECT OF THRESHING DRUM SPEED AND CROP MOISTURE CONTENT ON THE PADDY GRAIN DAMAGE IN AXIAL-FLOW THRESHER

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ABSTRACT - The effects of threshing drum speed of an axial-flow thresher at five levels of 450, 550, 650, 750 and 850 rpm, and paddy moisture content of at three levels 17.0, 20.0 and 23.0 % (w.b.) on the broken and cracked grains were examined. The results revealed that the most broken grains of 0.677 was recorded at drum speed of 850 rpm and paddy moisture contents of 17 % and the least value was obtained at drum speed of 450 and 550 rpm and paddy moisture content of 23.0 %. The cracked grains increased from 7.0 to 37.0 %, 6.67 to 25.0 % and 14.0 to 17.30 % at paddy moisture contents of 17.0, 20.0 and 23.0 %, respectively as the drum speed increased from 450 to 850 rpm. The most grain damage was measured at moisture content of 17.0 % and the least was obtained at moisture content of 23.0 %.

Key words: Paddy threshing; Axial-flow thresher; Drum speed; Paddy moisture content; Rice damage; Crop losses.

INTRODUCTION

Rice (*Oryza sativa* L.*)* is an important staple food in Iran and grown on an area about 615 thousand ha with a total paddy production of about 3.0 million tones. Main rice cultivated areas in the country are located in northern provinces of Guilan and Mazandaran producing 75 % of Iran's rice crop (Alizadeh *et al*., 2006). In most of rice farms, harvesting is carried out by sickle or mechanical reapers. 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.

As well as harvesting method, threshing is on of the important practice which can affect the quantitative and qualitative losses of rice. In Iran's rice fields, four main

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types of paddy thresher are used, i.e. tractor operated cross-flow type, tractor operated axial-flow thresher, small thresher equipped with wire loop threshing drum and using combine harvester as a stationary thresher. Recently, IRRI model axial-flow thresher widely adopted in many rice fields, because of its easy application and better output for paddy threshing.

A number of researchers have been noted the effects of some parameters on the performance of rice threshers. Sarwar and Khan (1987) compared the performance of rasp-bar and wire-loop cylinders for threshing rice crop. They reported that the rasp-bar gave higher percentage of husked grain than wire-loop for all levels of evaluated peripheral speeds Alizadeh and Bagheri (2009) reported that the threshing method significantly affected breakage of rice and fissured grains, resulted in lower head rice in milling process. The effect of threshing time on losses of wheat grain was investigated by Agha *et al*. (2004). The results of their study indicated that grain losses were considerably influenced by threshing timings. Chukwa, 2008, assessed performance of a locally manufactured paddy thresher in Niger State and reported that the percenrage of de-husked grain was 3.0 %. Askari Asli-Ardeh *et al*., 2008, during the test of a power tiller operated small thresher concluded that grain damage increased with increasing peripheral speed and decreasing crop moisture content. Chimchana *et al.*, 2008 developed an unequal speed co-axial split-rotor thresher for rice. Results of their study indicated that optimum speed for threshing rotor was considered to be 600 rpm (with 0.8 m diameter threshing rotor) and by increasing this speed above 800 rpm the grain damage was increased.

A review of the literature has revealed that there is a little data on the effects of machine-crop parameters on the performance of axial-flow threshers. Therefore, this study was undertaken with the purpose of determining and selecting appropriate threshing drum speed and crop moisture content for reducing grain damage and producing better quality of grain in post-harvest operations.

MATERIALS AND METHODS

This study was carried out at the Department of Agricultural Engineering, Rice Research Institute of Iran (RRII), Rasht, Iran. The axial-flow thresher used for the experiments was like to model as International Rice Research Institute (IRRI). The thresher has an open axial-flow peg tooth threshing drum; a throw-in feed opening and straw throwing pedals at the end of drum. Normally in axial-flow thresher, 80 % of grains are separated in the first half of drum, whereas, only 20% of grains are removed at later half of the rotor. A semi-hexagonal cover of the threshing drum with spiral louvers which support axial crop movement is used for easy fabrication (Gummert *et al*, 1992; Chimchana *et al*. 2008). Some technical specifications of the thresher used for this study are given in *Table 1*.

Table 1 - Technical specifications of the axial-flow thresher used in the test

Item	Description
Type of Thresher	Axial-flow
Model	IRRI 110
Type of threshing drum	Spike tooth
Drum diameter (mm)	500
Drum width (mm)	1100
Number of spike	80

A local long-grain paddy variety widely cultivated in northern part of Iran, namely Alikazemi was used for the tests. Some physical characteristics of the variety are listed in *Table 2*. The crop was cut 30-40 cm above the ground and collected for the experiments. The paddy moisture content at harvesting and threshing time was measured using a grain moisture meter (GMK-303 RS). Three levels of paddy moisture contents of 23.0, 20.0 and 17.0 % (w.b.) were considered for the tests.

Table 2 - Some physical characteristics of paddy variety of Alikazemi used in the experiment

Item	Description
Paddy grain yield (ton/ha)	3.8
Plant height (cm)	93.4
100 grains mass (g)	3.0
Length of panicle (cm)	6.9
Length of grain* (mm)	7.2
Width of grain (mm)	2.1
Slenderness ratio	3.4

* white rice

At each level of paddy moisture, five levels of drum speeds of 450, 550, 650, 750 and 850 rpm (equivalent to peripheral speeds of 12.01, 14.67, 17.35, 20.01 and 22.37 m/s, respectively) were examined. The drum speed was measured with a digital tachometer (Lutron DT-2236). At each test run, five bundles of paddy crop were fed to the threshing chamber at a constant rate. To obtain the percentage of broken grain, three samples of 100 g were randomly chosen from the outlet of the thresher. The broken grains were separated by hand from the whole paddy grains and the weight of the broken grain was recorded. In order to determine the percentage of cracked grain, at each test runs, three samples of 50 grains were randomly selected from the outlet of the thresher and manually husked. The husked paddy grains (brown rice) were put on a crack tester and the number of cracked kernels was recorded.

The data was analyzed by using a complete randomized design 5×3 (five levels of drum speed and three levels of paddy moisture content) with three replications in each treatments. All statistical tests were done using MSTATC software and mean values were compared by Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Statistical analysis of the data showed that the drum speed and paddy moisture content had significant effect ($P<0.01$) on the broken and cracked grains. Also, interaction of the drum speed and paddy moisture content had significant effect ($P<0.01$) on the cracked grains (*Table 3*). Effect of drum speed on the percentage of damaged grains is illustrated in *Figure 1*. The results indicated that the broken and cracked grains increased from 0.00 to 0.592 % and from 9.50 to 25.20 %, respectively, as the drum speed increased from 450 to 850 rpm.

It can be seen from the *Fig.1* that at low drum speed of 450 and 550

rpm, there was not any broken grains in the samples collected from at the outlet of the thresher. However, at higher drum speed, the percentage of broken grains significantly increased. This could be attributed to that at higher drum speed, the peripheral speed at the tip of peg tooth increased, and leading to more impact on the grains. A similar trend has been observed by Askari Asli-Ardeh *et al.,* 2008 and Saeed *et al*., 1995 for threshing paddy, Vejasit and Salokhe, 2004 for soybean and Spokas *et al*., 2008 for wheat.

Table 3 - Statistical data analysis of variance for variables affecting on grain damage in the evaluated axial-flow thresher

Source of variation (S.V.)	Degree of freedom (d.f.)	Mean square (M.S.)	
		Broken grain	Cracked grain
Drum speed	4	0.202**	0.016**
Moisture content	2	0.030*	0.021**
Drum speed × Moisture content	8	0.009^{ns}	0.019**
Error	30	0.008	0.003

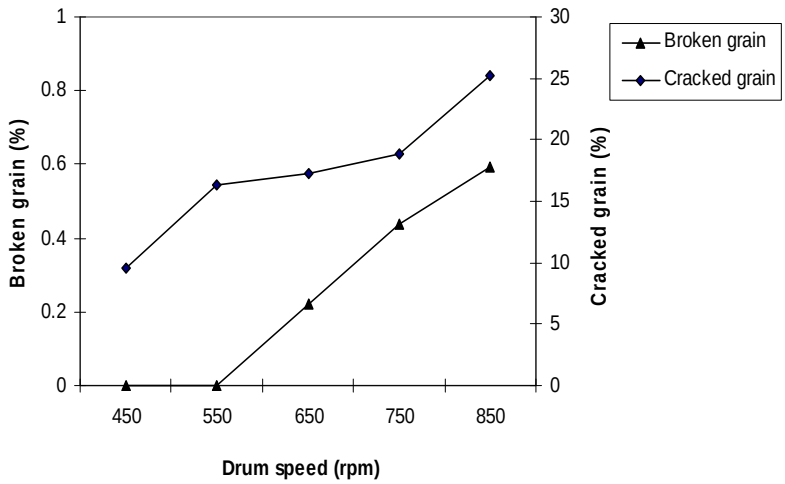

Figure 1 - Effect of threshing drum speed on the broken and cracked grains

Effect of paddy moisture content on the percentage of damaged grain is presented in *Fig. 2*. The results revealed that broken and cracked grains increased significantly from 0.167 to 0.338 % and from 15.0 to 20.0 %, respectively as the paddy moisture content decreased from 23.0 to 17.0 % (w.b.) It was observed that at each level of drum speed tested, the damaged grain increased with decreasing of paddy moisture content. The means for broken grains at the moisture content of 17.0, 20.0 and

23.0 % were 0.338, 0.247 and 0.167 %, respectively (*Fig. 3*) and that of the cracked grain was obtained 20.0, 15.6 and 15.0 %, respectively (*Fig. 4*). This may be probably due to that at lower moisture content; the grain has lower strength against impact force. This result was also reported by Askari Asli-Ardeh and Abbaspour-Gilandeh, 2008, for paddy threshing by a head-feeding thresher and Sabir *et al*, 2005 for wheat.

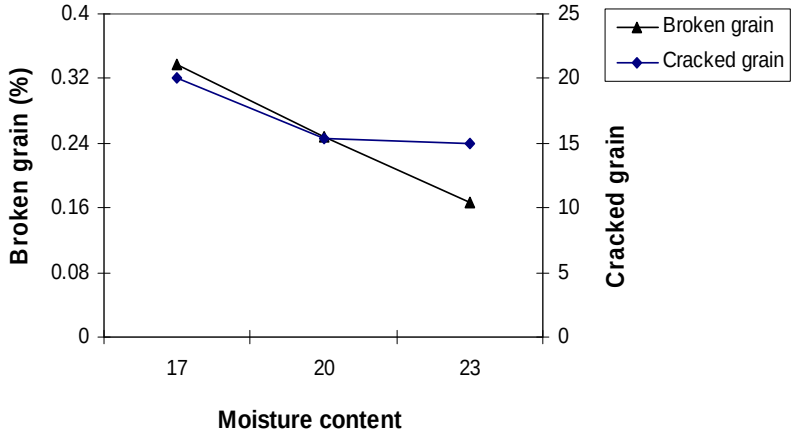

Figure 2 - Effect of paddy moisture content on the broken and cracked grains

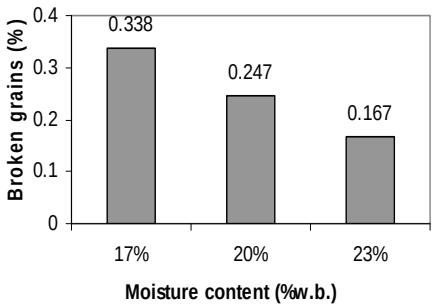

Figure 3 - Independent effect of paddy moisture content on the broken grains

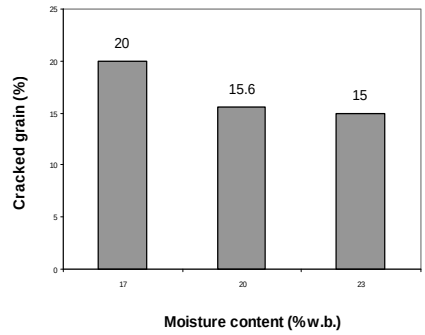

Figure 4 - Independent effect of paddy moisture content on the cracked grains

The interactive effect of drum speed and paddy moisture content on the value of broken grain is shown in *Fig. 5*. It can be seen that at each level of paddy moisture content tested, the broken grain increased significantly as the drum speed increased from 450 to 850 rpm. However, higher value of broken grain was obtained at lower moisture content. The most broken grain of 0.677 % was obtained at drum speed of 850 rpm and paddy moisture content of 17.0 % and the least value of 0.193 % was observed

at drum speed of 650 rpm and moisture content of 23.0 %. It was observed that, there was not any broken grain at the drum speed of 450 and 550 rpm and moisture content of 17.0 and 23.0%, and also the drum speed of 450, 550, and 650 rpm and moisture content of 23.0%. The combined effect of drum speed and moisture content on the percentage of cracked grain is illustrated in *Fig. 6*. A rise in the drum speed from 450 to 850 rpm resulted in increase of cracked grain at each level of moisture content. However, at a given drum speed, the lower cracked grain observed at higher paddy moisture content.

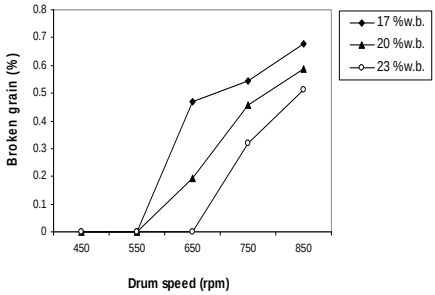

Figure 5 - Interaction of drum speed and paddy moisture content on the broken grains

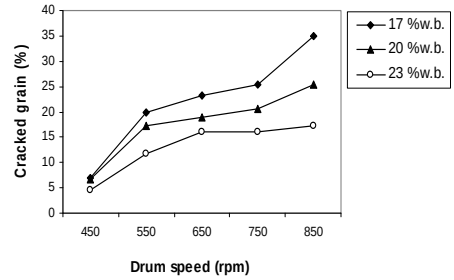

Figure 6 - Interaction effects of drum speed and moisture content on the cracked grains

CONCLUSIONS

The paddy moisture content and drum speed significantly affected the grain damage during paddy threshing by the axial-flow thresher tested.

The most damage grain was obtained at drum speed of 850 rpm and moisture content of 17.0 %.

In order to minimize the effect of moisture content on damaged grain in the axial-flow thresher, it is recommended that the threshing operation should be performed immediately after crop harvesting.

It is necessary to investigate the effects of other machine-crop parameters such as feed rates, concave open and paddy variety on the performance of the axial-flow thresher.

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