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Field Performance Evaluation of Different Rice Threshing Methods

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ABSTRACT

Threshing operation is one of the important and effective factors on quality and quantity of paddy. In this study, effects of four threshing methods namely power tiller-operated (T_1), axial-flow thresher (T_2), tractor-type thresher (T_3) and combine harvester as a thresher (T_4) on unthreshed grain, shattering loss, damaged grain and broken rice at milling stage were investigated. The results showed that there was a significant difference between means of unthreshed grains and shattering losses in different threshing methods. The highest value of unthreshed grain of 0.56% was in T_4 and it was lowest in T_1 with the average of 0.46%. The highest shattering loss was obtained in T_2 with an average of 0.59%. The amounts of broken and hulled paddy in T_1, T2, T_3, and T_4 were 0.9, 1.59, 2.46 and 2.98%, respectively. The percentage of broken rice after milling of paddy obtained using T_1 was lowest with mean of 17.15% and that of T_4 was maximum value of 25.05%. The percentage of broken white rice using T_2 and T_3 was 19% and 22.28%, respectively. It can be concluded that the quality losses in different threshing methods were more determinant than quantity losses.

Key Words: rice, harvesting losses, rice thresher, combine harvester

INTRODUCTION

Rice is the main staple diet of Iran. One of the methods of increasing production is to increase cultivation area and introduction of high yielding varieties. In spite of efforts being made to increase cultivation area and increasing yield per hectare, losses occur due to different factors during harvesting and post harvesting. Harvesting and threshing are final stages of rice production. In most part of Guilan and Mazandaran provinces northern Iran harvesting is carried out manually by sickle. In order to decrease moisture content of harvested paddy, the crop is left in the field and then bundled and threshed. As well as harvesting methods, the threshing operation and type of cylinder play a major role on the amount of rice losses and quality. The conventional threshers have different cylinders. In Guilan province at the moment four types of thresher namely, power tiller-driven cross-flow thresher, tractor-operated axial-flow thresher, tractor-operated cross-flow thresher and combine harvester as a thresher are used.

In recent years in northern provinces of Iran T25 and T30 thresher have lost their popularity in the small fields and tractor type threshers and combine harvesters have replaced them. Although high threshing efficiency is a major advantage of large thresher but most farmers say that use of combine and large thresher have increased broken rice.

Studies in Philippine showed that amount of losses in tractor, manual, axial flow and portable IRRI threshers were 8.11%,6.82%,2.07% and1.97% respectively[1].Ichikawa and Sujiyama [2] compared the effect of two combines with axial flow and cross flow threshers on amount of rice losses. The amount of losses of threshing unit for Indica Japonica hybrid variety with high threshing potential was 0.4 to 0.7 percent. Damaged grains (broken and hulled grain) in combine were 0.4%. They also showed that threshing losses of Europe an combine with radial flow thresher was nearly 10% and concluded that axial- flow thresher has better efficiency.

Sarwar and Khan [3] compared field performance of wire-loop and rasp-bar threshing cylinders for threshing rice crop. The two cylinders were compared at three drum peripheral speeds and three concave clearances. The rasp-bar gave higher percentage of hulled grain than wire-loop for all levels of peripheral speeds and at all three concave settings. At lower concave clearance and peripheral speed of 22.35m/s, the grain damage of rasp-bar was seven times more than wire-loop at dry moisture content and eight times at wet moisture content. However, this difference decreased as the concave clearance increased and peripheral speed decreased.

Dilday [4] showed that the amount damaged grain is significantly affected by moisture content and speed of cylinder. Increasing cylinder speed from 600 to 1000 rpm, the grain damage increases twofold. Also grain damage decreased with an increase in grain moisture content.

With regards to affect of different threshing methods on the amount of rice losses and also field performance of these machines, Gummert et al. [5] in their study on the axial-flow thresher built by international rice research institute (IRRI) concluded that this type of thresher is useful for threshing wet crop, if the threshing is carried out immediately after harvesting. The most suitable linear speed of cylinder is 14 to 15m/s and increasing the amount of feed, losses and machine required power increases.

Miah et al. [6] in their research showed that percentage of grain damage and unthreshed grains are significantly affected by the threshing method. Their results also showed that germination rate and storage life depend on the method of threshing.

Pinar [7] carried out a research on the affect of cylinder types on paddy threshing properties and showed that grain losses at harvesting were 6.6 to 9.1% and concluded that conventional threshers which were imported in previous years are obsolete and are not suitable for harvesting rice. They recommended those new machines that are suitable for local conditions must be designed and manufactured.

There has been no research published on comparison of amount of losses for different threshing methods in Northern provinces of Iran. Therefore the aim of this study is to compare different threshing methods in terms of amount of quality losses and damages to paddy in threshing operation and also their effects on the amount of broken rice at milling stage.

MATERIALS and METHODS

This study was carried out at the Rice Research Institute of Iran (RRII), Rasht, Iran. The paddy varieties used in this study were Hashemi and Khazar which are local and improved varieties, respectively. In order to reduce moisture content of paddy and straw, the harvested crop was left in the field for 24 hours and then bundled and transferred to suitable storage. The moisture content of the grains and stems were determined by standard oven method drying at 105℃ for 24 hours.

The moisture content of Hashemi and Khazar paddy at harvesting were 20.3 and 20.7% (w.b.).

The threshing methods used in this study were: Power tiller-driven cross-flow thresher (T_1), Tractor-operated axial-flow thresher (T_2), Tractor-operated cross-flow thresher (T_3) and Combine harvester as a thresher (T_4). The main specifications of the threshers are given in Table 1.

Table 1. Specifications of threshers used in the study

Thresher type	Specifications			
	Drum type	Drum width (mm)	Drum diameter (mm)	Drum speed (rpm)
Power tiller-operated (T_1)	Wire-loop	740	490	600
Axial-flow (T_2)	Spike-tooth	1100	400	627
Tractor-type (T_3)	Spike-tooth	1200	580	645
Combine harvester (T_4)	Spike-tooth	1040	600	623

Threshing drum speed and the clearance between drum and concave in each type of thresher were adjusted based on operator's manual of threshers. For measuring drum speed (rpm), a digital tachometer (Lurton DT-2236) was used. For each experimental run, five bundles of harvested crop were manually fed into the threshing chamber at a uniform rate and the time requirement for threshing was recorded. The threshing capacities were measured by collecting grains in all outlets of the thresher. The percentages of unthreshed grain, shattering loss and broken and hulled grains were calculated by the following equations [8]:

$$UG = \frac{H}{A} \times 100 \tag{1}$$

Where;

UG : Percentage of unthreshed grain

H : Weight of unthreshed grain at all outlets (kg)

A : Total grain input by weight (kg)

$$LG = \frac{G}{A} \times 100 \tag{2}$$

Where;

LG : Percentage of shattering loss

G : Weight of whole grain, broken and hulled grain and unthreshed grain scattered at chaff and straw outlets (kg)

A : Total grain input by weight (kg)

$$BG = \frac{E}{A} \times 100 \quad (3)$$

Where;

BG : Percentage of broken and hulled grain

E : Quantity of broken and hulled grain collected at all outlets (kg)

A : Total grain input by weight (kg)

For measuring the percentage of fissured grain, three samples of 100 g paddy were randomly selected before and after threshing. In each sample, fifty grain were picked and precisely peeled by hand and placed on a fissure tester [9] to identify the number of fissured grain. In order to evaluate the effect of threshing method on the percentage of broken milled rice, grains were cleaned by a vibratory screen, while the unfilled grains were removed by aspiration. From the cleaned samples, 200g of paddy were hulled with the use of a laboratory rubber-roll huller (Satake rice machine, THU-35A). After hulling, in each replication,120g brown rice were polished using a laboratory rice whitener machine (McGill miller, No:2)for duration of 45 seconds. The broken rice in milled samples was separated by hand-sorting. A kernel having equaled to or more than 75 % intact was considered as whole kernel. The percentage of broken rice was determined by the following relation:

$$BP = \frac{W_b}{W_m} \times 100 \quad (4)$$

Where;

BP : Percentage of broken rice

W_b : Weight of broken kernel (g)

W_m : Weight of milled rice (g)

The experiment was carried out with four treatments and four replications in randomized complete block design. All data were statistically analyzed by using analysis of variance (ANOVA).

RESULTS AND DISCUSSIONS

The mean values of threshing capacity for different threshing methods are given in Fig.1. The average threshing capacities of T_1, T_2, T_3 and T_4 threshers were 5.54, 1.81, 0.90 and 0.77 t/h, respectively. The threshing capacity depends on crop conditions and machine operational parameters as well as the feeding rate of materials into the threshing chamber [6] .Threshing capacity is an important factor that effects the duration of threshing per hectare and therefore influences harvesting costs.

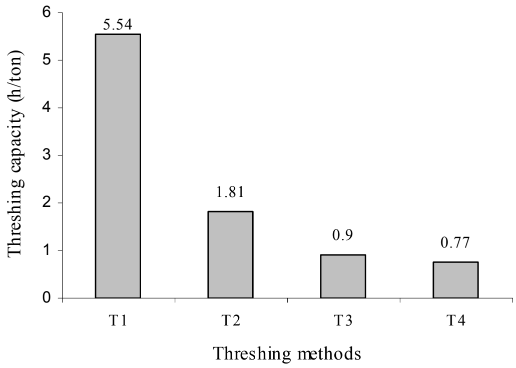

Fig.1. Average threshing capacities for different threshing methods

The mean values for shattering and unthreshed losses of the two varieties are shown in table.2.The highest shattering loss of Hashemi (0.62%) and Khazer (0.56%) were obtained by T_2. The least shattering losses Hashemi (0.46%) and Khazer (0.43%) were obtained by T_1. Grain losses occur at sieve and straw outlet and also due to unsuitable adjustment of fan speed, drum speed and drum and concave clearance. Furthermore crop condition especially paddy moisture content and feeding rate to threshing unit is also effective factors in shattering losses. In general shattering losses in different threshers were about 0.5% which is much higher compared with losses occurring due to broken and hulled grain.

Table 2. Comparison of percentage of shattering loss and unthreshed grains broken for different threshing methods

Threshing method	Hashemi		Khazer	
	Shattering loss (%)	Unthreshed grain (%)	Shattering loss (%)	Unthreshed grain (%)
T_1	0.46^c	0.44^c	0.43^b	0.47^a
T_2	0.62^a	0.48^{bc}	0.56^a	0.50^a
T_3	0.52^b	0.54^{ab}	0.54^b	0.49^a
T_4	0.57^{ab}	0.58^a	0.52^{ab}	0.54^a

Numbers in columns followed by similar letters are not significant, $p>0.05$, Duncan's test

The results showed that threshing methods significantly ($P<0.01$) affects damaged grains. Table 3 shows that the least amount of broken and hulled grain for the two varieties were obtained by T_1 and the highest were obtained by T_4.This same trend can also be seen for fissured grains. In this research threshing drum speed and drum and concave clearance were adjusted based on manufacturing recommendation and permissible linear speed of drum (approximately 15 m/s) for threshing rice. The amount of damaged grain has affected the price of paddy in the market, so that rice threshed by T_1 is 5% more expensive than T_4.

Table 3. Comparison of percentage of broken and hulled grain and fissured grain in different threshing methods

Threshing method	Hashemi		Khazer	
	broken and hulled grain(%)	fissured grain(%)	broken and hulled grain(%)	fissured grain(%)
T_1	0.98^d	8.25^d	0.83^d	8.00^d
T_2	1.38^c	9.50^c	1.80^c	10.25^c
T_3	2.36^b	12.75^b	2.57^b	11.75^b
T_4	2.82^a	13.25^a	3.14^a	13.00^a

Numbers in columns followed by similar letters are not significant, $p>0.05$, Duncan's test

Fissures created in grain are dependent on factors such as moisture absorption and deabsorption during harvesting time and mechanical damages sustained by grain during threshing process. Harvesting condition for the two varieties of Hashemi and Khazer were the same in all threshing methods experiments, therefore the reason for increased percentage of fissured is associated to method of threshing. The fissure created in grain is the main reason for broken rice in milling process.

The effect of different threshing methods on breakage of milled rice is shown in Fig.2.The highest amount of broken rice of Hashemi and Khazer varieties belongs to T_4.The percentage of broken rice (mean of two varieties) for T_3, T_2, T_1 were 22.28, 19 and 17.15%, respectively. Regardless of the type of thresher being used, mean value of broken grains of Hashemi and Khazer varieties were 21.16 and 20.58%, respectively and there was no significant difference. Therefore in addition to the environmental effect of creating fissures in grain, mechanical damages to grain (fissures created during threshing) also affects amount of broken rice during milling process. The results of this study correspond to the research carried out by Ali et al [10].

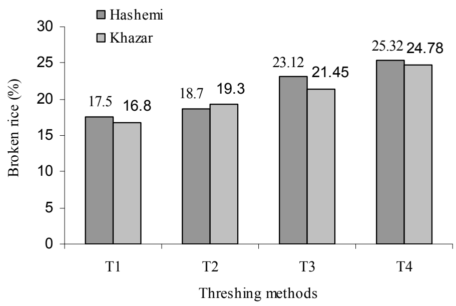

Fig.2. Effect of different threshing methods on breakage of milled rice

CONCLUSION

The results of this research showed that regardless of type of varieties, threshing method significantly affected percentage of quantitative and qualitative losses. So that the highest percentage of losses (broken and hulled grain and fissures grain) were attributed to combine harvester (used as a thresher) and the least percentage of losses were attributed to power tiller operated thresher. However with regards to low threshing capacity of power tiller operated thresher (5.54 h/ton), axial flow thresher is recommended in order to achieve optimum threshing capacity and least losses.

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