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EFFECT OF PADDY HARVESTING METHODS ON RICE QUALITY AND HEAD RICE RECOVERY

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ABSTRACT

Mechanization of paddy harvesting is on the rise in Pakistan by the introduction of combine harvesters. However, milling quality in terms of head rice recovery has been low due to paddy harvesting at higher moisture content by combine harvesters. Due to shortage of combine harvester, farmers have no choice, but to harvest their paddy crop even at higher moisture content when a combine harvester is available in a village. The objective of the study was to determine the effect of prevailing harvesting methods and different crop maturity levels on milling quality of Super Basmati rice. In this study Super Basmati rice variety was harvested at 0-5 green grains maturity levels (known as harvesting stages) by manual harvesting and threshing, head feeding combine harvester, and conventional combine harvester. Paddy samples from threshed or combine harvested paddy were sun dried, cleaned and milled using laboratory rice milling equipment. Data on milling yield, head rice and broken rice were collected and analyzed using MSTAT statistical package. The effect of harvesting methods was statistically significant at 5 % probability level on milling yield in terms of head rice recovery and broken rice. The mean value of head rice recovery (49.5 %) of manual harvesting and threshing method was higher than conventional combine harvester (44.9 %) and head feeding combine harvester (46.5 %). Due to shortage of manual labour for harvesting rice, a head-feeding combine harvester is recommended for harvesting Super Basmati rice in Pakistan.

Keywords: harvesting methods, harvesting stages, rice quality, head rice recovery.

INTRODUCTION

In the Punjab province of Pakistan, rice is harvested manually or with a combine harvester. The manually harvested rice is left in the field for a few days for drying. During drying, grains are exposed to different day and night temperature regimes and are thus exposed to alternate drying and wetting. The dried paddy is then threshed manually against raised mud ridge, steel drum or wooden log and grains with low moisture are internally damaged. Such practices may cause substantial losses and deteriorate grain quality.

Rice milling is the process where in paddy is transformed into a form suitable for human consumption, therefore, it has to be done with utmost care to prevent breakage of the kernel and improve the recovery. Milling yield is the weight percentage of rough rice that remains as milled rice, i.e., the sum of head rice and broken rice. In case of long grains, head rice is defined as rice grains without chipped portion (whole kernel) and rice grains that are 75 % or more the length of whole kernel. The broken rice is defined as grains less than 75 % of the length of whole kernel (Anonymous, 1995). Rice milling losses may be qualitative or quantitative in nature. Quantitative or physical losses are manifested by low milling recovery, whereas low head rice recovery or high percentage of broken kernel reflects the qualitative loss in rice grains.

Grain factors, which affect milling efficiency, are the production and postproduction operations, such as harvesting, drying, storage and handling and varietal characteristics, such as length and thickness of grains, amount of chalky or immature kernels, and hull thickness. The rice milling is, therefore, a complex process, which is affected by numerous factors. Premature cutting of rice keeps the grain from reaching maturity and can cause serious losses in the quality of the product. Furthermore, immature grains, due to too early harvest, result in high percentage of broken and low milling recovery. Maximum head rice recovery was obtained when the rice crop harvested at 35 days after 50 % flowering at moisture content ranging from 20-30 %. The recovery reduced with delay in harvesting beyond this time. Harvesting 33-39 days after 50 % flowering gave significantly higher head rice recovery than 27-30 days or 42 days after flowering (Salim and Sagar, 2003).

In Pakistan, paddy reaping is accomplished manually at moisture content between 20 and 24 %. There is a significant difference in moisture contents between the most mature and least mature kernels on a rice plant. A variation up to 20 % in moisture contents between rice grains from the top of most mature panicle to the bottom of least mature panicle had been reported (Chau and Kunze (1982**)**. The field moisture only represents the average moisture in a sample. In a sample of 22 % moisture content, the rice grains with low moisture of 15 % and high moisture of 45 % had been reported (Kunze and Calderwood, 1985). Studies on the relationship between grain moisture at harvest, total milled rice and head rice revealed that there was no visible effect of grain moisture at harvest on the total milled rice quantity. However, the head rice recovery increases with increase in grain moisture at harvest time. When rice contains a high percentage of moisture, hardness decreases, and rice with low hardness is easily damaged (Anonymous, 1995). A new genetic trait labeled “tolerance to delayed harvest” permits grain to dry in the field to low levels (19 %), thereby allowing flexibility in harvesting without inducing losses due to breakage during milling (Berrio, *et al.* 2002).

The manually harvested rice is left in the field for 2-3 days for drying. Its grains are subjected to drying and wetting during day and night. There are few grains with low moisture in the harvested mass of high moisture. These grains re-adsorb moisture from the surrounding grains resulting in their fissuring and hence increases broken rice percent during milling (Kunze, 1985). The dried harvested paddy is brought to a threshing floor in small bundles and threshed manually against raised mud ridge or steel drum or wood. There is internal damage to low moisture grains during manual threshing. An increase of 1.6 % in ratio of cracked kernels was reported by Japan International Cooperation Agency JICA) in manual threshing of Basmati 370 variety (Anonymous, 1986).

Reconditioned wheat combine harvesters with or without paddy kits are being used for harvesting paddy, which cause a lot of grain damage. Moreover, timely availability of combine harvesters is difficult and farmers either harvest immature or over-ripe crop. This results in a great internal damage to paddy grain and ultimately affects milled rice quality. Japanese head feeding combine harvesters are also being used for paddy harvesting in Pakistan. Presently 40 % of paddy area in the Punjab is harvested by combine harvesters, particularly Super Basmati variety. There is no suitable arrangement for mechanical cleaning or drying of paddy at farm level. The lack of proper drying at farm level causes mixing of paddy with different moisture contents and subsequently reduces the milling recovery and increases the proportion of broken grains.

There is no suitable arrangement for mechanical cleaning or drying of paddy at farm level. The lack of proper drying at farm level causes mixing of paddy with different moisture contents and subsequently reduces the milling recovery and increases the proportion of broken grains. Paddy is dried at millers' or shellers' premises. The shellers do sun drying in yards with concrete or mud floors. The paddy is spread on these floors under sun, frequently stirred by hand, feet, rake etc. during daytime. In the evening, it is collected in heaps and covered with canvas. The main defect in sun drying is that it produces sun cracks in paddy grains and increases broken rice percentage in milling. It also affects the marketability and reduced profitability of rice. In contrast, the rice mills have mechanical dryers of mixing and non-mixing column (deep bed) types. The non-mixing column (deep bed) dryers can produce moisture-adsorbing environments that can fissure low moisture grains in freshly harvested rice. It was confirmed in an experiment conducted by placing low moisture grains on top of a bed of high moisture rice before the bed of rice was dried (Kunze and Prasad, 1978). During mixing, paddy harvested at different maturity levels with different moisture contents are broken. Broken grain also depend on drying methods i.e. sun drying with various layer thickness and mechanical drying. The percent of broken grain is less, increase in thickness layer from 4 to 7 and mechanical drying (Anonymous, 1985).

Keeping in view the colossal yield losses and deterioration in the grain quality, this study was carried out on Super Basmati variety. The objective of this study was to study the effect of prevailing harvesting methods and crop harvesting stages on milling yield and head rice recovery.

MATERIALS AND METHODS

Data collection and analysis

The study was carried out on Super Basmati paddy variety and study area was mainly along Maridke-Narowal Road near Rice Research Institute, Kala Shah Kaku (RRI, KSK). Three harvesting and threshing methods (manual harvesting and threshing Figure-1, harvesting by conventional European combine harvesters Figure-2 and harvesting by Japanese head feeding combine harvester were included in this study. The Super Basmati paddy fields with 0-5 green grains (known as harvesting stages) in their panicles were selected randomly. Paddy moisture contents were measured using a portable grain moisture meter for each harvesting stage. In combine harvesting fields, standing paddy crop was manually harvested and threshed and paddy samples weighing 3 kg were placed in cotton bags. Paddy samples of 3 kg were also collected from combine harvested fields. In total, 50 samples were collected in this study comprising 21, 21 and 8 samples from manual harvesting, harvesting with conventional combine harvester and head feeding combine harvester, respectively. The paddy samples were sun dried Figure-3 at KSK in the range of 9.0 to 11.5 percent. These were cleaned and 1-kg dried paddy samples were milled using rice milling equipment at RRI, KSK Food Technology Laboratory. The percent of brown rice, milled rice, head rice and broken rice of each sample was determined. The data was compiled in tabular form and analyzed using MSTAT computer package.

Figure-1. Manual threshing of paddy.

Figure-2. Harvesting of paddy by a conventional combine harvester.

Figure-3. Sun drying of paddy samples.

RESULTS AND DISCUSSIONS

Harvesting methods

The milling yield, head rice recovery and broken rice data (in percentage) were arranged for three harvesting and threshing methods used in the study as shown in Tables-1, 2 and 3. There is a narrow range in milling yield among the harvesting and threshing methods as shown in Table-1. The average values of milling yield of all the three methods employed in the study were not much different from each other with highest value of 70 % for head feeding combine harvester and the lowest value of 68 % for conventional combine. There was wider range in values of head rice recovery (38-59 %) in manual harvesting as compared with conventional combine harvester (36.5-50 %) and head feeding combine harvester (40-51 %). The mean values of head rice recovery were 49.5 %, 46.5 %, and 44.9 %, respectively for paddy harvested and threshed by manual method, head feeding combine harvester and conventional combine harvester, respectively. The mean value of head rice recovery was higher in head feeding combine harvesting (46.5%) than conventional combine harvesting (44.9%). The statistical analysis of the data to know the effect of harvesting methods on head rice recovery indicated statistically significant effect at 5 % level. Similar trend regarding range in values was observed with broken rice for all methods Table-3. The mean value of broken rice (19.5 %) of manual harvesting and threshing method was lower than conventional and head feeding combines harvesting. The losses in milling could be attributed to machine factors, such as improper machine adjustment and selection, improper arrangement and combination of machine components, lack of maintenance and lack of proper training of mill operators, which the mill owners can possibly control. Losses could also be attributed to the inherent quality of paddy or grain factors which the mill owner may have no control. The mean value of broken rice was lower in head feeding combine harvesting (23.2%) than conventional combine harvesting (23.6%). Manual harvesting and threshing put little internal stress on paddy grains as compared with conventional and head feeding combine harvesters. Similarly, there was less impact on grains in head feeding combines as compared with conventional combines. The results of the study have confirmed that the manual harvesting and threshing is the best method followed by head feeding combine harvester as far as head rice recovery and broken rice are concerned. Though it is not practical approach to cut and thresh all the paddy area in the Punjab manually, the use of combine harvesters is inevitable. There is a need of training of combine harvester operators for improving operation of harvesters and hence increasing the head rice recovery more than 55 %. There is also a need for indigenous production of head feeding combine harvesters for their availability in the country as these not only improve head rice recovery but also do not bruise paddy straw.

Table-1. Effect of harvesting method on milling yield of Super Basmati.

Harvesting method	Milling yield range (%)	Average (%)
Manual	67-71.5	69
Conventional Combine	66-70	68
Head Feeding Combine	69-71	70

Table-2. Effect of harvesting method on head rice recovery of Super Basmati.

Harvesting method	Head rice recovery range (%)	Average (%)
Manual	38.0–59.0	49.5
Conventional Combine	36.5-50.0 -	44.9
Head Feeding Combine	40.0-51.0	46.5

Table-3. Effect of harvesting method on broken rice of Super Basmati.

Harvesting method	Broken rice range (%)	Average (%)
Manual	9.5-31.0	19.5
Conventional Combine	17.0-29.5	23.0
Head Feeding Combine	18.5-29.0	23.5

Harvesting stages

The moisture contents and number of green grains (known as harvesting stage) in the top panicles of paddy fields were recorded at the time of harvesting. There were 5 harvesting stages ranging from 0 to 5 green grains with moisture contents ranging from 17 to 26 %. A positive correlation (R = 0.74) was found between harvesting stage and moisture contents of harvested paddy grains. The average values of head rice recovery and broken rice for different stages of harvesting are shown in Table-4. The graphical presentation of the data is shown in Figures-4 and 5. Statistical significant effects were found at 5 % level of harvesting stages on head rice recovery and broken rice. The head rice recovery increased with harvesting stage up to 2 green grains and after that the effect of harvesting stage is inconsistent. Similar trend was observed in case of broken rice.

Table-4. Effect of harvesting stage on head rice and broken rice.

Harvesting stage (No. of green grains)	Milling yield (%)	Head rice recovery (%)	Broken rice (%)
0	69.5	41	28.5
1	68.9	45.5	23.4
2	69.3	48.9	20.4
3	68.5	47.5	21
4	69	49.8	19.2
5	68.5	47.8	20.7

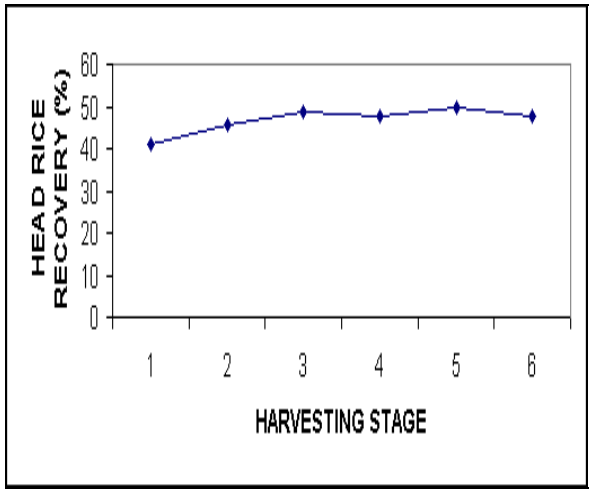

Figure-4. Effect of harvesting stage on head rice recovery.

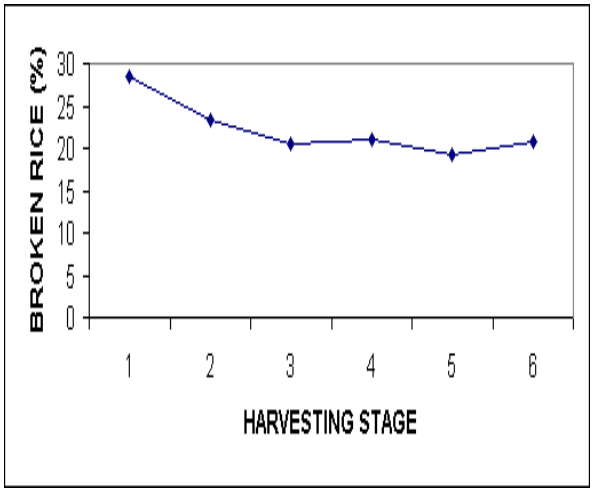

Figure-5. Effect of harvesting stage on broken rice.

CONCLUSIONS

Effect of harvesting methods on milling yield in terms of head rice recovery and broken rice was significant. The mean value of head rice recovery (49.5%) of manual harvesting and threshing method was higher than conventional and head feeding combine harvesting methods. The mean value of head rice recovery was higher in head feeding combine harvested paddy (46.5%) than conventional combine harvested paddy (44.9%). A positive correlation (R = 0.74) was found between harvesting stage and moisture contents of harvested paddy grains. The effect of harvesting stages on head rice recovery was not significant at 5 % probability level. The head rice recovery increased with harvesting stage up to 2 green grains and after that the effect of harvesting stage is inconsistent. Similar trend was observed in case of broken rice. The Super Basmati is a popular paddy variety and occupies 70 % of Basmati rice area in the Punjab. It is difficult to thresh manually and needs head-feeding combines for optimum head rice recovery and saving of paddy straw used for animal feed. Efforts are needed for the timely availability of head feeding combines through their import in reconditioned form in the beginning and then local manufacturing. The farmers and operators should be trained in proper use and maintenance of the combine harvesters for improving the milling yield and hence head rice recovery.

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