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EVALUATION OF COMBINE HARVESTER OPERATION ON RICE CROP TO ASSESS SUSCEPTIBILITY TO RICE KERNEL DAMAGE

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Abstract

Rice is one of the major crops of Pakistan after wheat. Growers of rice crops complained about the damage of rice kernels during the harvesting season. As, rice is the main crop so this issue was given importance and a study was carried out to determine the causes and solutions of rice kernel damage. For this reason, a survey was carried out in some areas of Pakistan and combined harvesting and rice sellers were the targeted population. Researchers concluded that cutting of grain when moisture was there was one of the causes of rice kernel damage and the second; reason was the poor condition of harvesting machinery. So, the study has major implications for farmers and agriculturists.

Keywords
Rice, Rice Kernel, Harvesters, Pakistan

1. Introduction

Rice is the second largest staple food crop after wheat crop in Pakistan. In Pakistan, the total area under rice crop during 2005-06 was 2621.4 thousand hectares. It showed an increase of 8.2% as compared to the year 2004-05, which is mainly due to increased use of fertilizers and more cultivated area (Iqbal *et al.*, 2015).The area, production, and per hectare yield of rice are given in table 1. Table 1 depicts that, the area and production of rice in the whole country have shown an increasing trend, whereas, in the case of Punjab province, the increasing trend has only been recorded in the production. The area, production, and yield of rice, both for the whole country and the Punjab province have also been shown in the fig-1-3.

Table 1: Area, Production, and Yield in Pakistan & Punjab

	Punjab			Pakistan		
Year	Area 000 (ha)	Production 000 (tones)	Yield (Kg/ha)	Area 000 (ha)	Production 000 (Tones)	Yield (Kg/ha)
2001-02	1475.9	2266.00	1535	2114.2	3882	1836
2002-03	1412.3	2579.70	1706	2225.2	4478.5	2013
2003-04	1687.9	2871.40	1701	2460.6	4847.6	1970
2004-05	1754.3	2980.30	1699	2519.6	5024.8	1994
2005-06	1762.4	3179.60	1804	2621.4	5547.2	2116

Source: Agriculture Statistics of Pakistan 2005-06

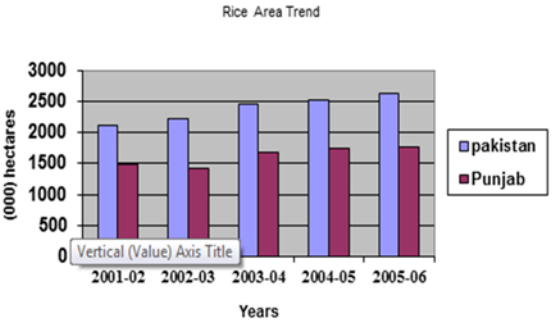

Figure 1: Rice Area Trend

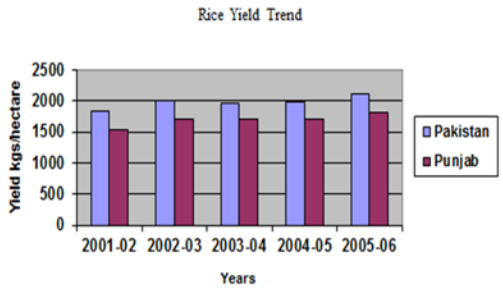

Figure 2: Rice Yield Trend

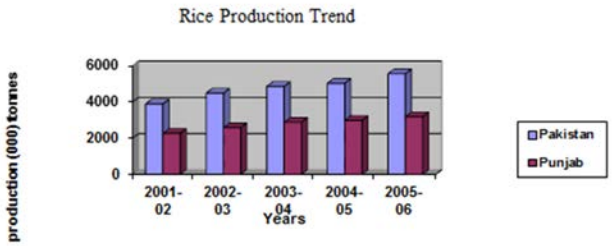

Figure 3: Rice Production Trend

1.1. Punjab Province

In Punjab, Pakistan rice is mainly grown in areas like Sheikhupura, Gujranwala, Narowal, Hafizabad, and Sialkot districts. Therefore these are the leading areas for rice production. However, the rice is also grown in some other districts of Punjab. The area and production of these leading districts are given in table 2. Table 2, indicates that during 2004-05 amongst these leading districts, the sheikhupura district has shown more area under rice crop, which is 18.59 % of the total area under rice crop in the Punjab province. Whereas the Gujranwala district ranks second both in area (17.30) % and production (18.04) %.

Table 2: Area, Production, and yield in leading Districts of Punjab

Districts	Area (000) ha	Production (000) tonnes	% Of Punjab	
			Area	Production
Sheikhupura	274.4	455.2	18.59	20.09
Gujranwala,	244.4	465.4	17.30	18.04
Narowal	80.4	141.2	4.76	4.92
Hafizabad	119.4	217.4	6.81	7.30
Sialkot	177.70	294.10	10.08	9.25

1.2. Rice Harvesting

Rice production mechanism is very much labor intensive right from land preparation up to harvesting and threshing. During the past years, the introduction of mechanical rice transplanters for rice nursery transplanting could not survive due to various reasons. Therefore, manual transplanting of rice nurseries still exists. However, one component of the crop cycle i.e. mechanical harvesting over manual harvesting, gained popularity when wheat combine harvesters originally imported for wheat harvesting were also used for rice harvesting with some modifications (Liang Zhao & Tang 2017). Therefore at present rice harvesting is mostly being done with these combine harvesters although there exists manual harvesting but at a small scale. In the rice area, there is an established network of combined harvesters along with workshops even in the rural areas of the Pakistan district. Although With the passage of time these old combine harvesters have completed their economic life even then these are still being operated.

1.3. Purpose of the Study

The farming community in some areas of the Pakistan district has made complaints that the rice kernel damage during the combined harvesting operation is occurring. The project under study was to assess the kernel damage in the rice crop during harvesting season by these combine harvesters. At the same time, the related information's from rice shellers & workshops owners were also planned to be collected to know the real picture of the causes of rice kernel damage.

1.4. Study Area

The survey was conducted in some field areas of Pakistan. The Combine harvester, Repairing Workshops and rice shellers in the target area were major components for the present study.

1.5. Objectives of the Study

The followings are the major objectives of the study.

- To access/calculate the extent of rice kernel damage through combine harvesters.
- To study the breakage level during husking in rice sellers.
- To access the existing workshop repairing facilities.
- To make recommendations to the farmer, combine harvester owners and workshop owners.

2. Review of Literature

Some field studies have already been conducted to assess the damage of the rice kernel with combine harvesters. The kernel damage while harvesting with combined harvesters ranged from 4-10%. The rice kernel damage up to 4-6% as explained in the study was normal. (Lorenz and Lund 1981)They further found that the basic reasons for kernel damage were immature crop harvesting, the poor operating condition of the combine harvester, unskilled operator, poor quality repair, improper/ unjustified modifications in the combine harvester header, and threshing kit. Manufacturing of poor quality/ sub-standard combine harvester parts and poor physical condition of various systems of the combine harvesters were also responsible for rice kernel damage (Fu, Chen, Han & Ren 2018).

Farm Machinery Institute, Islamabad conducted a study a field study entitled, "Effect of Paddy Harvesting Methods on Rice Quality and Head Rice Recovery" and concluded that rice quality and head rice recovery was low due to paddy harvesting at higher moisture contents by combine harvesters. It was further concluded that farmers had no choice but to harvest their paddy crop even at higher moisture content, mainly due to the shortage of combine harvesters in villages. The number of immature paddy grains had a major effect on head rice yield and quality. The immature kernels are slender and chalky, resulting in excessive production of bran and broken grains (Zareiforoush, Komarizadeh & Alizadeh 2010). The optimal stage to harvest grain is about 20-24 percent grain moisture. If the harvest is too late, many grains are lost through shattering and are cracked during threshing, which causes grain breakage during milling". (Farooq *et al*., 2006) Agricultural Engineer, Rice Research Institute, Kala Shah Kaku concluded that rice kernel damage was normally 5% due to immature crop harvesting, poor conditions of harvesters, and un-skilled operating staff of combine harvesters. (Boonstra *et al*., 1997).

Paddy yield and milling recovery were influenced by harvesting and threshing time. (Akbar, Abdul and Sagar 1990). The study indicated that both paddy yield and head rice recovery was maximum when the crop was harvested almost 32-34 days after flowering followed by threshing within a day. Optimum harvesting time was found with a grain moisture content of 20-22%. The study also showed that significant field and milling losses occurred if harvesting and threshing were carried out before or after the optimum time (Ehsanullah *et al*., 2007).

3. Result and Discussion

3.1. Rice Combine Harvesting

The results of seed kernel damage are based on the analysis of the samples of rice kernels collected during rice harvesting in the rice fields. Initially, these samples collected were checked for visual breakage and it was found that there was almost 1-2 % breakage in these samples. At the same time, these samples were checked for moisture levels.

The important factor considered for the breakage of rice kernel harvested with combine harvester is the moisture content level. The % moisture contents found in the analyzed samples ranged from 17.1-19.7%, which was very close to the maturity level moisture contents i. 20%. The moisture levels of these samples are shown in figure 4. The viewpoints of the farmers

of the target area were also recorded and 85 % of the farmers were of the view that they have no such complaint regarding rice kernel damage on their fields as the combine harvesters working on their farms were in good conditions. However, the remaining 15 % thought that the very old combine harvesters might be responsible for rice kernel damage but they have not experienced such a situation by that time.

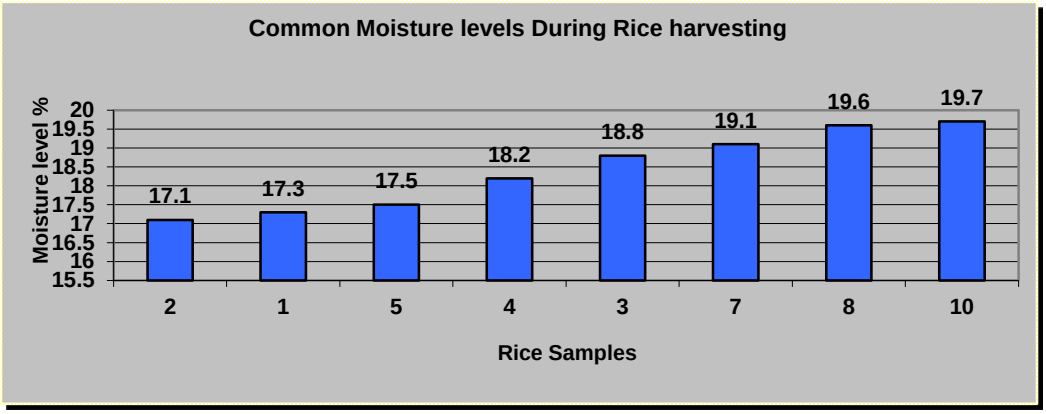

Figure 4: Common Moisture Levels during Rice Harvesting

3.2. Combine Harvesters Owners

There exists a network of the owners of the combine harvester in the Pakistan area. During survey 10, Combine harvesters' owners were interviewed to analyze the situation. When explained to the combine harvester owners about the aim of the study, 100 % of them explained that the farmers/rice growers only have the decision powers to decide for the harvesting of the rice. Out of these, 85 % further admitted that the early harvesting of the rice causes rice kernel damage and it was mainly due to high moisture contents at the time of harvesting.

However, 100% of them expressed their view that the main reason for the early harvesting is that high moisture contents in rice kernels weigh more and farmers prefer to gain more benefit of higher weight. Out of these, 15 % of the combine harvester owners told that the rice kernel breakage if observed might be due to some poorly adjusted or very old model combine harvesters. However, they were satisfied with the performance of their combined harvesters (Chung *et al.*, 2016: Myhan & Jachimczyk 2016: Yore, Summers & Jenkins 1998).

3.3. Repairing Workshops/Spare Parts Manufacturers

During the survey, it was observed that there is various combine harvester-repairing workshop scattered in the city as well as in the rural area of the rice zone. These are engaged in repairing and manufacturing different parts of the combined harvester. Out of these 5 workshops were visited to assess the repairing facilities. It was concluded that in almost all the five workshops, there was no quality consideration regarding different repairs and parts manufacturing. However, these workshops are regularly repairing the combine harvester after each crop harvesting season (World Health Organization. 2017).

The owners of the combine harvesters were quite satisfied with the repairs carried out by these workshops. This was mainly due to the reason that there was no alternate repairing facility available to combine harvester owners. Almost all the owners

acknowledged that repairing/manufacturing of threshing kits and other parts of the combine harvester without proper skill and design might cause kernel damage loss of up to 10%. They suggested that the loss could have been reduced up to 2-3% by adapting standards of the manufacturing process, which they lack in their repairing workshops. It was also noticed that the poor quality parts such as pegs of threshing kit, auger, and other grain conveying units, low-quality repair from roadside mechanics were the main causes of rice kernel damage (Falsini Fumarola & Schiraldi 2010). Modification in header and threshing kit such as extension in header size and installation of extra pegs on the standard threshing drum was also a source of kernel damage. It was further observed that the repair of conveyors and augers was not properly done such as improper clearance in the auger, worm out auger flights, extra sharp edges of the auger, and bad/heavy repair of augers are also a cause of damage in rice kernels. The workshop mechanics of all the workshops visited, told that the conventional combined harvesters with poor physical conditions were creating the problem of excessive kernel damage whereas the axial flow type combines harvesters were working with a low percentage of rice kernel damage.

3.4. Rice Shelling/Husking

To assess the breakage level of the rice during shelling, the samples were taken from 10 different rice sellers located in the Pakistan area. The samples were analyzed and the results are given in table-3. It was observed that during the shelling process, the paddy passes through various machines. At the end of the process, there is an outlet with three separate openings. At the first point, the whole rice drops through a delivery, whereas the broken rice at the second and very minute almost round shape drops of rice at the third opening (El-Khateeb & Saad 2008).

Table 3: Rice Analysis at the Delivery Point

Total weight of the shelled rice (gms)	**Whole (gms)**	**Broken (gms)**	**% Breakage**	**Foreign matter (gms)**
334.59	306.77	27.72	8.3	0.10
309.48	284.68	24.65	8.0	0.15
503.93	475.85	27.88	5.5	0.20
203.48	187.85	15.50	7.6	0.13
476.17	457.14	18.92	4.0	0.11
141.25	130.82	10.26	7.3	0.17
124.29	114.50	9.70	7.8	0.09
203.84	186.56	17.22	8.4	80.06
677.68	639.60	37.38	5.5	0.70
648.82	616.31	32.11	4.9	0.40

These samples were collected at the point where these three divisions/deliveries start. The samples were separated w.r.t. Whole rice, broken rice, and foreign matter. Then these were weighed. The analysis result is listed below in table-3. The data analyzed from table 3, depicts that the breakage of the kernel during the

process of shelling in the shellers ranged from 4.0% to 8.4%. The main reason for the different breakage levels as explained by the owners/ Sheller operators was mainly due to the different types and ages of machines of the shellers. During the processing of shelling, the rice kernel passes through different processes. It was further informed by the sheller's owner/ operators that the breakage of rice in shellers cannot be eliminated but can be reduced to some extent through the installation of the latest machinery. But the very important information given by them was that the whole, broken, and very minute round shape rice was equally good, and none of these was considered as wastage.

4. Conclusion

1. Based on the results obtained from the field survey, it is concluded that the breakage of the rice kernel in the rice area wherever occurs is mainly due to early harvesting when there are higher moisture contents causing damage to the kernels.
2. The physical/technical conditions of some of the combine harvesters were not so good. However, these were being used for Rice and other crop harvesting by making regular repairs.
3. Another important issue about the existence of these combines' harvesters even after completion of their economic life was that there does not exist any check and balance about the condition of the combine from any corner.
4. Based on information collected from the farmers and rice shellers owners it is concluded that these very old and partially modified combine harvesters were causing kernel damage.
5. It is also concluded that there do not exist any operating and repairing standards.
6. There was no check on the working of the operators and combine harvester performance during the field operation.
7. The local repairing of these combine harvesters was not standardized, as the technicians in the visited workshops were not trained through any technical institution. Further, they were not holding any technical diploma regarding repairing farm machinery. They learned from the elder technicians and then with time they have set up their workshops resulting in the substandard fabrication and repairing of the combine harvester's parts. Ultimately these combines had created problems like damage to rice kernels during harvesting.
8. There were improper/unjustified modifications in the header and threshing kit of the combined harvesters.
9. Contrary to the rice kernel damage caused by combine harvesters, Rice breakage also occurred during the process of rice shelling. As the results of the sample showed breakage of rice ranged from 4.0% to 8.4%. This breakage of the kernel at this stage can't be avoided, however, it could have been reduced if new and latest machines were installed.
10. No extension services for mechanized rice harvesting were being provided by any organization to the combine operators, workshop mechanics, and the rice growers.

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