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ESTIMATION OF WHEAT HARVESTING LOSSES UNDER DIFFERENT HARVESTING METHODS IN PUNJAB PROVINCE OF PAKISTAN

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ABSTRACT

The present study was carried out across four distinct agroecological zones within the Punjab province to assess the extent of wheat harvesting using various methods and to calculate the associated losses during harvesting and threshing. Data were collected by visiting wheat fields where three different harvesting methods were employed, and interviews were conducted with the farmers. The findings revealed that 63.2% of the wheat crop was harvested using combine harvesters, followed by reaper harvesting at 21.7%, and manual harvesting at 15%. The highest losses during both harvesting and threshing were observed with the combine harvesting method (8.75%), followed by reaper harvesting (7.18%), and manual harvesting (3.18%). The study's results underscore the importance of providing training to combine harvester owners and operators to mitigate these losses. Despite the significant losses associated with combine harvesting, it remains the most cost-effective method for wheat harvesting, covering 63.2% of the wheat-growing area in Punjab Province, primarily due to its speed and efficiency.

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INTRODUCTION

The agricultural sector serves as the cornerstone of Pakistan's economy, contributing to 22.67% of the country's GDP. In the fiscal year 2021-22, Pakistan witnessed a GDP growth rate of 5.97%, primarily attributed to the impressive 4.4% growth within the agriculture sector. This growth was driven by factors such as robust crop yields, favorable market prices for agricultural outputs, supportive governmental policies, the availability of certified seeds, pesticides, and agricultural credit. Notably, the crop sector accounts for 34.56% of the overall contribution to the national GDP from agriculture. Additionally, Important Crops play a pivotal role, contributing 56.2% to the value addition in crops, 19.44% to the value addition in the agriculture sector, and 4.41% to the national GDP (Government of Pakistan, 2022).

Wheat, as a vital staple food crop, plays a critical role in ensuring Pakistan's food security. Globally, wheat cultivation spans 124 countries, covering an area of 244.331 million hectares, with Pakistan contributing 12.94% of this total area, ranking it 9th in terms of cultivation area. Similarly, Pakistan stands at the 9th position globally in terms of wheat production, contributing 3.03% to the global production of 907.829 million metric tonnes (FAO, 2023). Wheat holds

substantial economic significance in Pakistan, with a 7.8% share in the value addition of the agriculture sector and a 1.8% share in the total GDP of the country (Government of Pakistan, 2022). Punjab province takes the lead in wheat production, accounting for over 73.5% of the total wheat production in Pakistan, while Punjab contributes 75.9% of the nation's total wheat production (GOP, 2022). Pakistan faces the challenge of a rapidly growing population, which increases the demand for wheat over time. To meet this rising demand, there is an urgent need for a substantial increase in wheat production. However, the situation in Pakistan is somewhat different. In the fiscal year 2021-22, Pakistan produced 26.294 million tonnes of wheat (Economic Survey of Pakistan 2021-22), marking a 3.90% decrease compared to the previous year's production in 2020-21 (Government of Pakistan, 2022). The introduction of agricultural machinery has ushered in a transformation in the processes of wheat harvesting and threshing, moving away from manual labor towards mechanization. The selection of the harvesting method hinges on various factors, including the availability of machinery, prevailing weather conditions, cropping patterns, the need for wheat straw, labor costs, and machinery rental expenses. Given the fluctuating climatic conditions and the unpredictable nature of weather patterns, each farmer endeavors to ensure timely wheat crop harvesting to mitigate potential losses. Presently, in Pakistan, wheat harvesting employs a combination of manual and mechanical methods in varying proportions.

To shed light on this practice, the current research was carried out across diverse agroecological zones within the Punjab Province, spanning from the southern to northern regions. The primary objectives were to assess the prevalence of different wheat harvesting methods in use and to quantify the associated losses incurred during harvesting and threshing using these methods.

METHODOLOGY

The field survey was undertaken by a team of researchers from the Adaptive Research division of Punjab. This team was comprised of members from four distinct Agro-ecological zones, specifically Gujranwala, Sheikhupura (associated with the Rice-wheat cropping system), Vehari (connected with the cotton-wheat cropping system), and Rahim Yar Khan (linked to the sugarcane-wheat cropping system). The main objective of this survey was to assess the extent of harvesting and threshing losses incurred when employing various wheat harvesting methods. These methods included manual harvesting, reaper harvesting followed by threshing, and combined harvesting using combine harvesters. The primary data for this study were collected during the wheat crop harvest in the Rabi-2021-22 season.

Sample Size, Sampling Method, and Data Collection

A total of 118 farmers were interviewed to collect primary data for this study. Among these, 25 farmers were from each of the Sheikhupura and Rahim Yar Khan districts, while 26 and 42 farmers were interviewed from the Gujranwala and Vehari districts, respectively. The data were collected from the respondents selected using a convenience sampling technique on a pre-tested, well-structured questionnaire. The collected primary data was initially entered into MS Excel and later imported into Statistical Package for Social Sciences (SPSS) for analysis.

Estimation of Harvesting and Threshing Losses Using Different Methods

Manual Harvesting

In the case of manual harvesting, six samples, each measuring one square meter, were randomly selected from the manually harvested field. All the grains and un-threshed spikes within the one-meter square area were collected and weighed separately. Additionally, a seventh sample was obtained as a composite sample from a heap of wheat straw, considering both its outer and topmost parts. This composite sample underwent a process to separate grains from wheat straw. The average weight of all seven samples was calculated by summing the weights of each sample and then dividing the total weight by the number of samples. The sample weight in grams per square meter was converted into pounds per acre.

Reaper Harvesting

Similar to the manual harvesting method, six one-meter square samples were taken from fields harvested with a reaper. The seventh composite sample was gathered from the heap of wheat straw after threshing the wheat plants. The average weight of all seven samples was determined using simple arithmetic means. The weight

of one square meter in grams per square meter was converted into pounds per acre to ensure comparability with other methods.

Combine Harvesting

To estimate harvesting and threshing losses when using the combine harvesting method, a methodology inspired by South Dakota State University (SDSU) was adopted. The entire field was divided into three parts: i) pre-harvest losses from the standing crop (shattering losses), ii) losses from the harvesting swath (header losses), and iii) losses from the disposal swath (threshing, separation, and cleaning losses). Five samples, each measuring one square meter, were collected from each of these three different portions: the standing crop, harvesting swath, and disposal swath of the combine-harvested field. The average weight of samples from each of these three parts was calculated individually. The average weight of all five samples taken from the standing crop was labeled as "A," while the average weight of all five samples taken from the harvesting swath was labeled as "B." The average weight of all five samples obtained from the disposal swath of the combine harvester was designated as "C."

Header Losses

To estimate header losses, the average weight of all five samples taken from the standing crop was subtracted from the average weight of all five samples collected from the harvesting swath. This calculation can be represented using the following formula:

Header Losses= B-A

Where;

A=Average weight of all the 05 samples taken from standing crop

B Average weight of all the 05 samples taken from harvesting swath of combine harvester

Threshing, Separation and Cleaning Losses

To estimate threshing, separation and cleaning losses, the average weight of all 05 samples from the harvesting swath was subtracted from the average weight of all the 05 samples taken from the disposal swath of the combine harvester multiplied by the ratio of residue width and harvesting swath width. This can be shown through the following formula:

Threshing, Separation and Cleaning Losses=(C-B) x (residue width/width of harvesting swath)

Where;

B=Average weight of all the 05 samples taken from harvesting swath of combine harvester

C= Average weight of all the 05 samples taken from the disposal swath of the combine harvester

Total Combine Losses

To calculate total losses with a combine harvester, both header and threshing, separation and cleaning losses were added and can be shown with the help of the following formula:

Total Losses= Header Losses+ Threshing, Separation and Cleaning Losses

Total Yield and Estimation of Percent Losses

Total yield was estimated by adding harvested yield and the machine losses which can be shown with the following formula:

Total Yield=Combine Losses+ Harvested Yield

Percent combined losses were calculated by dividing the combined losses by total yield and can be shown with the following formula:

$$\% \text{ Combine Losses} = \frac{\text{Machine Losses}}{\text{Machine Losses+Harvested Yield}} \text{x100}$$

$$\% \text{ Header Losses==} \frac{\text{Header Losses}}{\text{Combine Losses+Harvested Yield}} \text{x100}$$

$$\% \text{ Threshing, Separation and Cleaning Losses=} \frac{\text{(Threshing,Separation \& Cleaning Losses)x100}}{\text{Threshing,Separation \& Cleaning Losses+Harvested Yield}}$$

Similarly, percent losses in manual and reaper harvesting and threshing were calculated with the following formula:

$$\% \text{ lossess} = \frac{\text{Lossess in manual or reaper harvesting}}{\text{Manual or Reaper lossess + Harvested yield}} \text{ X 100}$$

RESULTS AND DISCUSSION

Basic Characteristics of Respondent Farmers

The research study was conducted in 04 different agro-ecological zones of Punjab namely rice wheat (Gujranwala and Sheikhupura districts), cotton wheat (Vehari district) and sugarcane wheat (Rahim Yar Khan district). Zone-wise frequency distribution of respondent farmers is given below in Figure 1.

Figure 2 shows that 37% of the respondent were small farmers having an area of less than 12.5 acres followed by large farmers (36%) and medium farmers 27% (having an area >12.5 but <25 acres. Almost 96.6% of

the respondents' farmers have having education matric and above. There were only 3.4% of respondents who had primary-level education whereas none of the interviewed farmers was illiterate. Distribution of respondent farmers concerning their tenancy status shows that the majority of the respondent farmers were owners (63.6%) followed by owner cum tenant (22.9%) and tenants (13.6%).

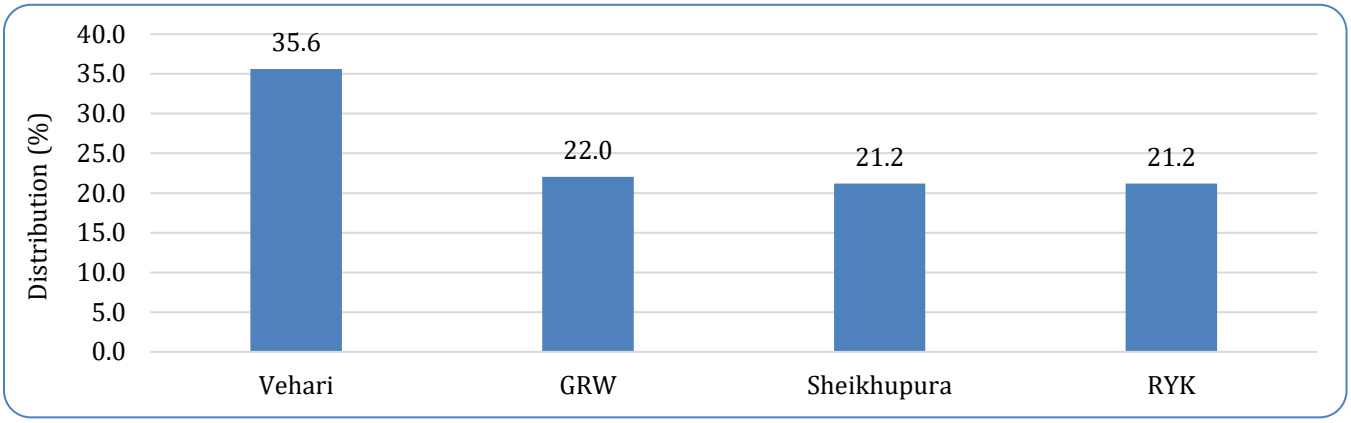

Figure 1. Distribution of study participants from four districts.

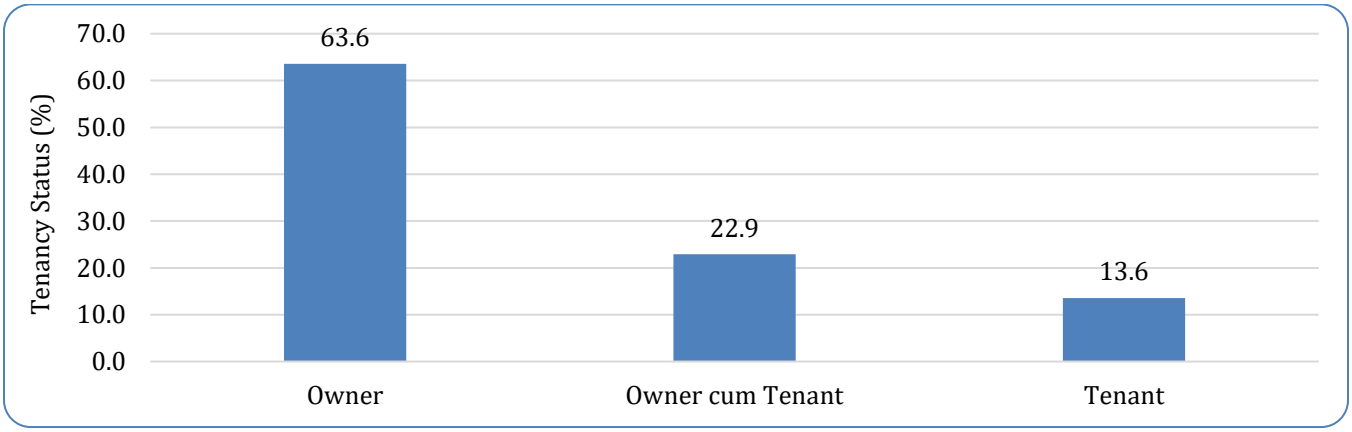

Figure 2. Tenancy status of farmers.

On an overall basis, the respondent farmers were growing 18 different wheat varieties and 97% of the wheat area of the respondent farmers was under 10 wheat varieties out of which the Akbar-2019 wheat variety was having top position with 49.7% area under its cultivation followed by Faisalabad-2008, Anaj-2017, Galaxy-2013 and Fakhar-e-Bhakkar having 21.4%, 5.5%, 4.3% and 3.7% of wheat area respectively. The frequency distribution of respondent farmers growing different number of wheat varieties at their farms shows that the majority of the respondents (57%) was growing only one wheat variety followed by 30%, 11% and 2% growing two, three and four different wheat varieties (Figure 3).

Harvesting & Threshing with Different Methods

According to the Figure 4, 50.4% of the respondent were harvesting their wheat crop through combine harvesters followed by 26.2% farmers harvested (15%) manually and and 21.7% with the help of reaper. Farmers who are harvesting their wheat area manually or with reaper are the farmers who are also rearing livestock and they need wheat straw for their livestock. Moreover, the availability of combined harvesters also affects decision-making of these farmers for opting for manual or reaper harvesting. The majority of the combined harvesters (73.06%) are owned by farmers/investors in the rice-wheat cropping system, mainly the upper Punjab i.e. Gujranwala and Lahore Divisions (Punjab Development Statistics 2021). With the onset of the wheat harvesting season, they start their operations from Sindh province (southwest of Punjab province) and move to the

Southern to central to upper Punjab areas as the harvesting season proceeds.

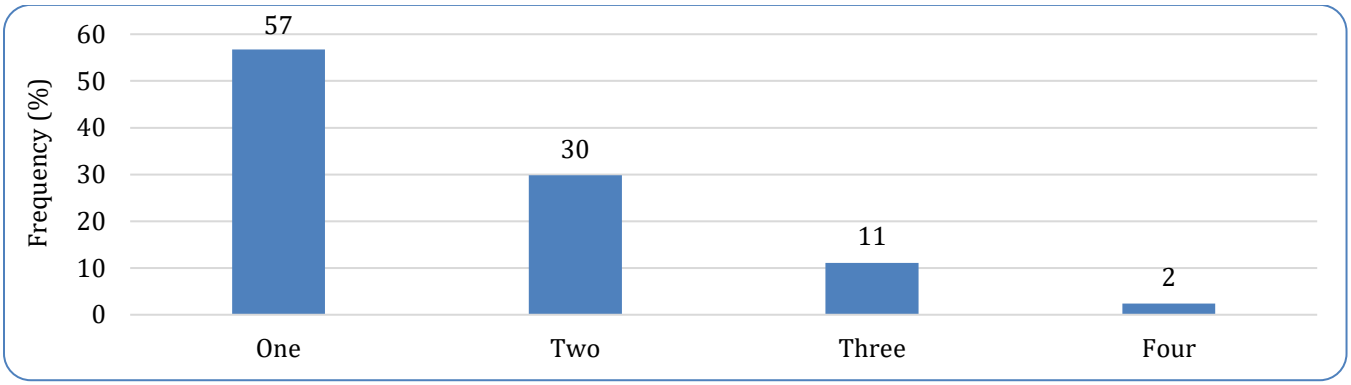

Figure 3. Frequency Distribution of Respondents W.R.T Growing Different No. of Wheat Varieties (%).

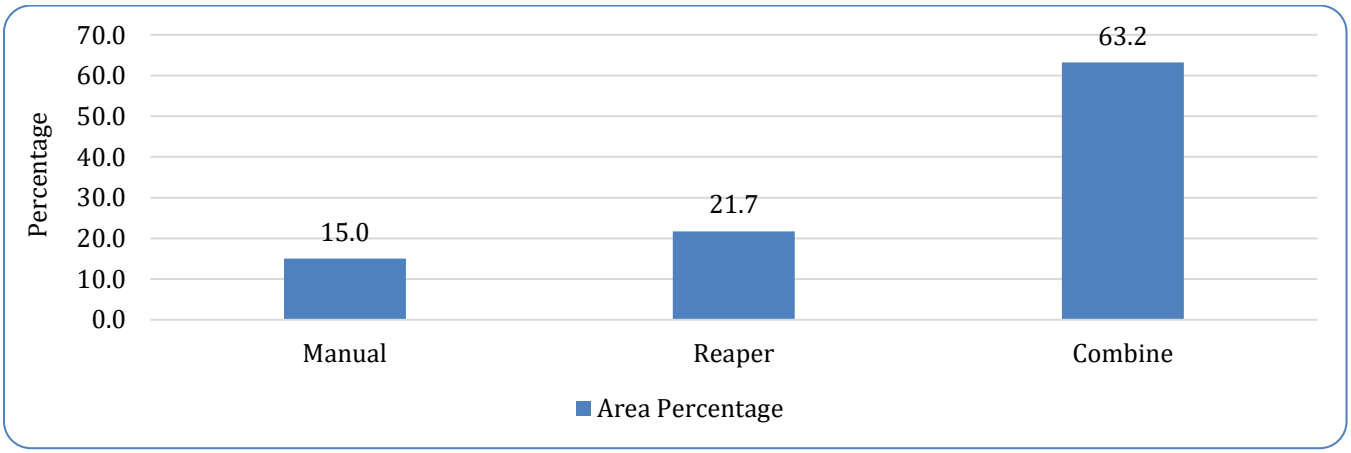

Figure 4. Wheat Area Harvested with Different Methods of Harvesting (%).

With the advancement in the mechanical industry, new machines are being introduced in the agriculture sector for farm operations. One such machine is a wheat straw chopper which choppes the standing stubbles of wheat after combined harvesting. Before the introduction of this machine, all the standing stubbles of wheat crop were burnt leading to increased prices of wheat straw (as 63.2% of the wheat area is being harvested with combine harvesters resulting decrease in the supply of wheat straw) on one hand whereas on the other hand causing environmental pollution. Wheat area being harvested with combine harvester is increasing day by day with the introduction of this machine.

Different harvesting and threshing methods have their pros and cons concerning losses, time, ease of doing harvesting and threshing operations etc. Different scientists have tried to find out harvesting and threshing losses by adopting different methodologies. Tripathi *et al*. (2018) compared harvesting losses of wheat with reaper and traditional manual harvesting and found that harvesting losses with reaper are higher (about 1.5%) as compared with manual harvesting with sickle (<1%). They also found that harvesting losses with reaper in the case of linseed are more (17%) as compared to manual harvesting with sickle (<2%).

Esgici et al. (2016) estimated combine harvesting losses in paddy in Turkey with different aged combine harvesters of the same brand i.e. New Holland Combines, starting from 2002 model TC 56, 2006 model TC 56, 2007 model TC 56 and 2013 model TC 5070 and found that combine harvesting losses changed from 6.67% to 9.23% with combine harvesters of different models being lowest in 2013 model TC 5070 series (6.67%) followed by 2002 model TC 56 having losses as 7.32% loss, 2006 (9.23%) and 2007 model (9.22%). Moussa (2008) tested 03 combine harvesters at 03 different service lives i.e. 25 years, 15 years and 02 years and compared with another mower than thresher method

also compared with traditional sickle thresher and found that the highest grain losses with combine harvesters having 25 years, 15 years and 02 years' service life and mower than thresher were 10.36, 7.19. 3.14 and 3.98 % respectively at a field speed of 3.9 km/h and grain moisture content of 12.1 % whereas the highest sickle loss was found at 2.01 % at a moisture content of 12.1 %.

Average Gain Yield, Losses and Percent Losses

Table 1 shows that average grain losses were more in the case of combine harvesting (3.55 monds/acre) followed by reaper harvesting (3.06 monds/acre) and manual harvesting (1.31 monds/acre). Average yield and total yield have also been worked out for the calculation of grain losses as percent of total yield. Losses were highest in the case of combined harvesting (8.75%) followed by reaper harvesting (7.18%) and manual harvesting (3.18%). Despite huge harvesting losses with combine harvesters, 63.2% of wheat area in Punjab is harvested with combine harvesters because combine harvesting still is the most economical method of wheat harvesting as reported by Sattar *et al.* (2015) and Tahir *et al.* (2018), Hassena *et al.* (2000) and Vishwakarma *et al.* (2020). There is a need to impart training to the machine owners and the operators regarding Standard Operating Procedures (SOPs) of machine operations and maintenance to reduce the harvesting and threshing losses as in the current scenario, combined harvester offers the most viable solution for in time completion of wheat harvesting & threshing operation.

Table.1. Average Grain Yield, Grain Losses and % Losses.

Variables	Harvesting & Threshing Losses		
	Manual	Reaper	Combine
Average Losses (Monds/acre)	1.31	3.06	3.55
Average Yield (Monds/acre)	39.99	39.55	37.00
Total Yield (Monds/acre)	41.30	42.61	40.55
Losses as Percent of Total Yield (%)	3.18	7.18	8.75
Harvesting and threshing charges (Rs. /acre)	16307	13108	4177
Value of Losses @Rs.3000/40 Kg (Rs. /acre)	3940	9172	10638
Total Cost (Rs. /acre) of harvesting & threshing	20247	22280	14815
Total Revenue @ Rs.3000/40 Kg (Rs. /acre)	123912	127828	121638
Cost as % of Total Revenue (%)	16.3	17.4	12.2

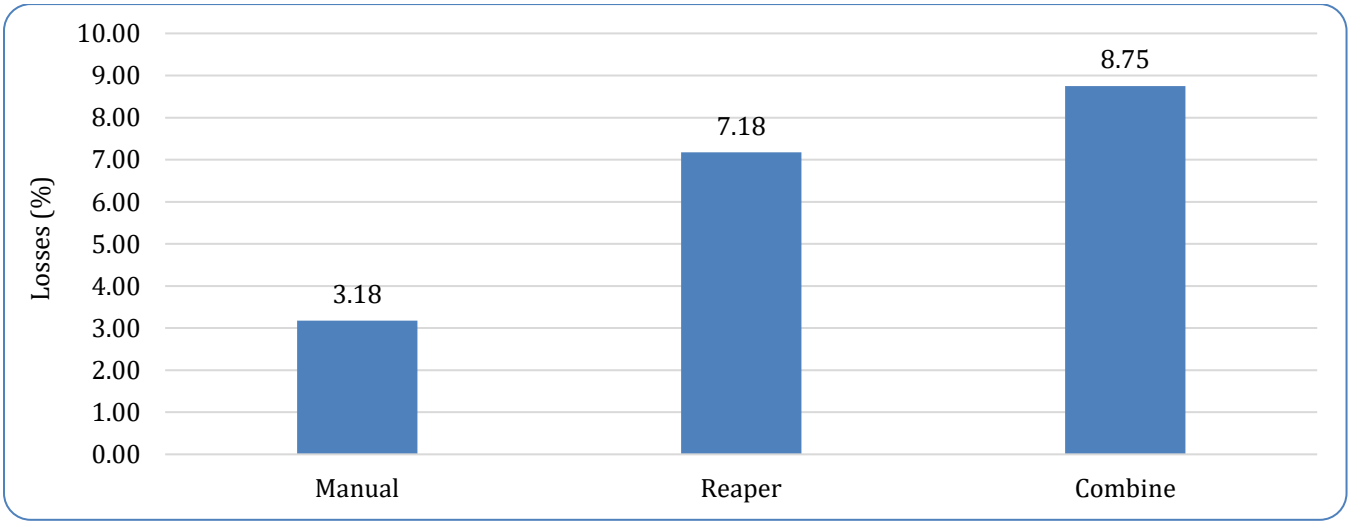

Figure 5. Harvesting Losses as Percent of Total Yield with Different Methods of Harvesting (%).

Figure 5 show that 90% of the combine harvesters being used in the field are of New Holland brand of 1980s having age more than 40 years. The combine harvesters being used in Punjab Pakistan are not the 1st hand rather

imported as refurbished which have completed their economic life in the developed countries. Results of the study are supported by Mesquita *et al.* (2006) who found that harvesting and threshing losses are significant in the case of combines 15 years old or more and losses are significantly low in the case of combines having 05 years are less age. Moreover, Harvesting & threshing losses with combine harvesters depend upon several factors including machine age, its adjustment and maintenance, operator skill, the convergence of objectives of the farmer and the machine owner/operator, crop condition, field yield and time of harvesting & threshing (during the day or the night) as reported by Tripathi *et al*. (2018).

Table 2. Harvesting Losses at Punjab Level.

	Manual	Reaper	Combine	Total
Punjab wheat area (acres)		16210000		
Acres Harvested with (acres)	2439043	3525526	10245430	16210000
Harvesting Losses (Monds/acre)	1.31	3.06	3.55	
Total Wheat Losses @ harvesting losses (Monds)	3203485	10779283	36330968	50313736
Value of Harvesting Losses @ Rs.3000/mond (Rs. Million)	9610	32338	108993	150941
Losses (Rs. Billion)	9.6	32.3	109	150.9

Table 2 shows that wheat was grown on an area of 16210000 acres in Punjab province out of which 15%, 21.7% and 63.2% are harvested with manual labour, reaper and combine harvester respectively. Wheat produce being lost through different harvesting methods is sufficient to feed 16.1 million population (equivalent to 14.64% of the total population of Punjab) @ 125kg/person/year. The annual value of harvesting & threshing losses (calculated @PKR.3000/40kg) with different methods on the Punjab level comes to PKR.150.9 billion which, if losses are reduced by 50%, will save wheat worth PKR.75.47 billion which can feed 8.050 million population for a year @ 125kg/person per year.

CONCLUSION AND RECOMMENDATIONS

It is evident from the study results that average grain losses are highest in the case of combined harvesting followed by reaper and manual harvesting. Machine harvesting is needed of the hour but due focus is required on reducing the harvesting losses as wheat is a staple food of Pakistani people. Currently 63.2% wheat area in Punjab is being harvested with combined harvesters. There is a need to educate the machine operators about the current scenario of harvesting losses and the loss accruing to the nation in the context of human nutrition, wastage of resources and high import bill of wheat.

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