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Grain Losses of Wheat as Affected by Different Harvesting and Threshing Techniques

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ABSTRACT

Grain losses of wheat as affected by different harvesting and threshing techniques were studied at Adaptive Research Farm, Vehari during 2010-11. Three methods of harvesting and threshing i.e. i) manual plus thresher ii) reaper plus thresher and iii) combine harvester were used in the study. The data revealed that different harvesting and threshing techniques had considerable impact on grain losses of wheat. The harvesting losses with manual plus thresher and reaper plus thresher at the field level were observed to be 164.37kg $ha^{-1}$and 142.93 kg ha^{-1}accounting for 3.16% and 2.76%, respectively of wheat grain yield. Total grain losses during harvesting and threshing processes with manual plus thresher, reaper plus thresher and combine harvester were 222.63kg ha^{-1}, 199.41kg $ha^{-1}$and 149.87kg ha^{-1}which were 4.28%, 3.85% and 2.92% of the total yield, respectively. The minimum amount of waste belonged to reaper plus thresher (0.82%) by providing 42.58 kg ha^{-1} broken grains and inert material in the produce. The cleaning efficiency of combine was a bit poorer (98.90%) as compared to other harvesting and threshing techniques.

Keywords: Wheat, grain, harvesting, threshing, losses, quality, cleaning efficiency

INTRODUCTION

Wheat is preferred food amongst all the cereals in the world. Concerted efforts are needed to enhance food grain production in the world and to investigate problems that stand in the way of meeting food needs of humanity so as to avoid peace upsetting and famine occurrence in the world. Wheat is the leading food grain of Pakistan, and being the staple diet of the people, it occupies a central position on agricultural policies. It is the largest grown crop over an area of 8666 thousand hectares in 2011-12, showing a decrease of 2.6 percent over last year's area of 8901 thousand hectares**.** Wheat contributes 12.5 percent to the value added in agriculture and 2.6 percent to GDP (Anonymous 2011-12). Despite the introduction of improved varieties of wheat, better chemical and hydrological inputs, the production is still not enough to feed the present population. Pakistan's present problem is the augmentation of food supplies to masses in order to meet the country's needs. It could be accomplished either by bringing more area under wheat cultivation or by increasing yield per unit area. Acreage increase has limitations like scarcity of water and precariously established balance in land allocation between equally important cash crops. Any disturbance in this balance may cause another crisis, more or less of equal severity. Hence, productivity enhancement along with pre and post harvest losses management are the onlyalternativebecause of the existing differences between the national average and the potential. According to a most conservative estimate, about 10% of the cereals harvested in developing countries are lost annually (Chaudhry, 1982). Most of the Pakistani scientists strongly believe that 10% post-harvest losses of wheat are not at all uncommon in our country (Ahmad *et al*., 1992). The wheat grain losses are classified as i) pre-harvest grain loss due to the birds, rodents and environmental; ii) harvest grain loss during harvesting of the crop; and iii) post-harvest grain loss due to bundling, transporting, threshing and winnowing.

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Harvesting losses with manual wheat harvesting varied from 3 to 7% after ripening of the crop (Iqbal*et al*., 1980). Similarly Ibupoto*et al*. (1991) investigated that average grain losses for traditional methods during pre-harvest, harvest and post harvest stages were 10.9, 29 and 122.9 kg ha^{-1} or 0.28%, 0.77% and 3.28%, respectively whereas, Zafarullah (1985) observed 2.1% total manual harvesting losses. Singh *et al*. (1988) tested three tractor front mounted reapers, manufactured locally by FMI, AMRI and Ittefaq on wheat crop in Pakistan. The wheat grain losses with these reapers were 1.19, 2.63 and 2.76%, respectively. Sukhbir*et al*. (2007) compared the performance of reaper with conventional method of manual harvesting of wheat crop with sickle to see the feasibility. They recorded 5.8% to 11.8% harvesting losses with reaper. Basavaraja*et al*. (2007) concluded that grain losses during harvesting and threshing activity of wheat were 0.36 kg/q and 0.44 kg/q, respectively. Bukhari*et al*. (1983) found that the average grain losses during conventional harvesting, bundling, transporting, threshing, winnowing and cleaning were 3.67, 3.98, 0.24, 1.18, 2.46, and 4.53%, respectively.

Harvesting of wheat crop in a short possible time after maturity is necessary in order to reduce shattering losses and delay in sowing the next crop. Further, the natural calamities like rain, hailstorm and windstorm during harvesting season result in enhancing these losses. The use of reaper plus thresher or combine can solve the problems of labor shortage as these machines can reap and thresh the crop simultaneously, economically and timely. Chaudhry (1979) estimated 2.01 and 1.2% grain losses on account of tractor threshing and combine, respectively. The combine harvester not only minimizes the post-harvest losses but also helps in shortening the harvesting period. Shamabadi (2012) while evaluating the performance of eight combines observed that time of harvesting, seed moisture content, relative humidity, field topography and varietal characteristics are the major factors affecting harvest losses. He concluded that mean total loss by different combines was 6.88% at wheat harvesting stage. Mirasi *et al*. (2013) measured grain losses of different wheat varieties with different models of combine during harvest stage. They observed that average pre harvest losses in all fields of study were 31.4 kg ha^{-1} accounting for 12.71 percent of total losses. Bala *et al*. (1980) also reported 4.09% grain losses of wheat by traditional methods of harvesting and threshing. AMRI (1987) found 2.2% wheat losses for combine as compared to 4.65% for reapers and about 7.5% for manual harvesting. Begum *et al*. (2012) found 0.51 kg/quintal grain losses of wheat during the threshing activity. They concluded that threshing losses were mainly in the form of broken grains. They observed 2.35 kg/quintal post-harvest losses at farm level. The harvesting losses have added up to about 40.85 per cent.

The comparative economic benefits of manual harvesting plus mechanical threshing and combine harvester were also investigated by Razzaq *et al*. (1992). They established that combine harvester gave higher wheat yields than manual harvesting plus mechanical threshing. Combine harvester proved more economical than manual harvesting plus mechanical threshing currently practised in the country. Studies indicated that combine harvester was an efficient, economical, and less labor demanding machine. It increased grain recovery by minimizing harvesting and threshing losses. Similarly field losses and economics of combine harvester and combination of reaper with thresher were also determined by Pawar *et al*.(2008). They observed that total field loss of combine harvester (4.20%) was less than the combination of reaper with thresher (10.57%). The cost of operation for combine harvester was (Rs. 817.84 ha^{-1}) less than the combination of reaper with thresher (Rs. 1816.79 ha^{-1}). They concluded that combine harvester and combination of reaper with thresher were more suitable for large fields and small fields, respectively.

Keeping in view the benefits of combine harvester vis-a-vis manual harvesting plus thresher and reaper harvesting plus thresher the present study was designed with the following specific objectives:

- Compare grain losses of wheat under different harvesting and threshing techniques.
- Compare the profitability of different harvesting and threshing techniques.

MATERIALS AND METHODS

The present study was carried out to measure grain losses of wheat with different harvesting and threshing techniques at Adaptive Research Farm, Vehari during 2010-11. The wheat variety Sehar-2006 was sown with automatic rabi drill on November 12, 2010. Three methods of harvesting and threshing i.e. i) manual plus thresher ii) reaper plus thresher and iii) combine harvester were used in

the study. The specifications of reaper, thresher and combine used in the study are given in Table-1.Agronomic observations were recorded on ten plant basis from each randomly selected $1m^2$ plot. The crop was harvested in last week of April from an area of one hectare under each harvesting technique.

Table1. *Specifications of reaper, thresher and combine*

Machines Items	Reaper	Thresher	Combine
Model	Tractor Mounted	Tractor Mounted	NH 8060
Working width	2285mm	1700 mm	15 feet
Length	660mm	4100	--
Height	660mm	1900	--
Weight	260 kg	1500	--
Source of power	Tractor PTO shaft	Tractor PTO shaft	6 cylinder engine
Source of manufacture	Jamal Industries	Jamal Industries	Belgium
Maxi. Power output	--	--	130 hp

Pre-harvest losses: For pre-harvest losses, prior to harvest the crop a steel frame of 4 $m^2$was placed in standing crop at ten differentlocationsin each experimental unit. Loose grains and spikes fallen on theground and enclosed in the steel frame were picked up. Theweight of loose grains and of the spikes was noted torepresent grain loss in 4 m^2area which were later convertedto kg ha^{-1}.

Harvesting losses: In the manual harvesting technique wheat was harvested manually with hand sickle. While in the reaper harvesting technique reaper was used to harvest wheat crop. After sun drying, the harvested crop was bundled and heaped on tarpaulin in the centre of the field separately from both the experimental units. After transportation of bundles from the field harvesting losses were studied from the harvested area. The fallen ear heads, shattered grains, and unharvested plants from ten randomly selected 4 m^2 area were collected. The samples were threshed, winnowed, cleaned, weighed and data recorded.

Threshing losses: For threshing losses the harvested wheat of 1 ha from both the experimental units was threshed using thresher machine. Ten samples of 5 kg wheat straw were randomly takenat different places from the heap of straw. The wheat straw was, re winnowed, cleaned and weighed for grains and data recorded.

Harvesting and threshing losses: To measure harvesting and threshing lossesof grains under combine harvesting technique combine harvester was used to harvest the crop from an area of 1 ha. After the combine has passed, the 4 m^2steel frame was placed at ten different locations in the field. The shattered grains and exited material from combine end was gathered from enclosed area of the frame.The samples so gathered were threshed, winnowed, cleaned, weighed and recorded as harvesting and threshing losses by combine.The harvesting and threshing losses under manual plus thresher and reaper plus thresher techniques were calculated as total of harvesting losses occurred by the respective technique plus threshing losses recorded during threshing of wheat.

Quality losses: For quality losses wheat grain sample of 5 kg was taken at different randomly selected places from each heap of different harvesting techniques. Three samples of 100 gram each were recollected from 5 kg sample. The broken grains, weed seed, straw or any other material were taken out manually and weighed employing an electric balance. The quality losses were calculated as explained below.

$$QL = \frac{W_i}{W_s} \times 100$$

Where;

QL = Quality loss (%),

W_i = Weight of inert matter, and

W_s = Weight of the sample

Cleaning efficiency: For calculating the cleaning efficiency of different harvesting techniqueswheat grain sample of 100 gram analysed for quality losses of grains was utilized. The cleaning efficiency was calculated as:

$$CE = \frac{W_c}{W_s} \times 100$$

Where;

CE = Cleaning efficiency (%),

W_c = Weight of clean grains, and

W_s = Weight of sample

Economics Analysis: An economic analysis of three methods of harvesting and threshing wasmade using cost and income figures of 2010-11 crop seasons. Prevailing cost of harvesting wheat manually and market rate for renting of reaper, thresher and combine was used to calculate harvesting and threshing cost. The combine harvester does not make bhoosa directly which is a byproduct of other two methods of harvesting. Prevailing cost of chopping wheat straw with rented wheat straw chopper and an income of 70% bhoosa was used to calculate expenditure and income of combine.

RESULTS AND DISCUSSION

Normally grain losses vary considerably depending on the variety, ripening stage, condition of crop, harvest time, sowing method and harvesting technique.The data regarding agronomical characteristics of wheat variety Sehar-2006 are presented in Table-1. Results indicated that plant height, number of tillersm^{-2}, grains spike^{-1}, 1000 grain weight, grain and straw yields and other characteristics were found normal.

Table1. *Growth and yield characteristics of wheat variety Sehar-2006*

Characters	Units
Number of plants (m^{-2})	286.20
Plant height (cm)	104.30
Number of tillers (m^{-2})	323.90
Number of grains spike^{-1}	40.60
1000 grain weight (g)	41.15
Grain yield (kg ha^{-1})	4974.00
Straw yield (kg ha^{-1})	4974.00

Grain losses of wheat by different methods of harvesting and threshing i.e. i) manual plus thresher ii) reaper plus thresher and iii) combine harvester were evaluated by measuring different losses during harvesting and threshing processes of selected field. Major grain losses of wheat which were measured during the study are discussed as under:

Pre-harvest losses: The pre-harvest losses occurred in standing crop due to shattering of grains by insects, birds, animals, windetc. The average pre-harvest losses in all the fields of study were 4.25 kg ha^{-1}. Data showed that there were minor differences in pre-harvest grain losses percentage among different harvesting and threshing techniques. The total calculated pre-harvest losses for different harvesting and threshing techniques were 0.08percent.

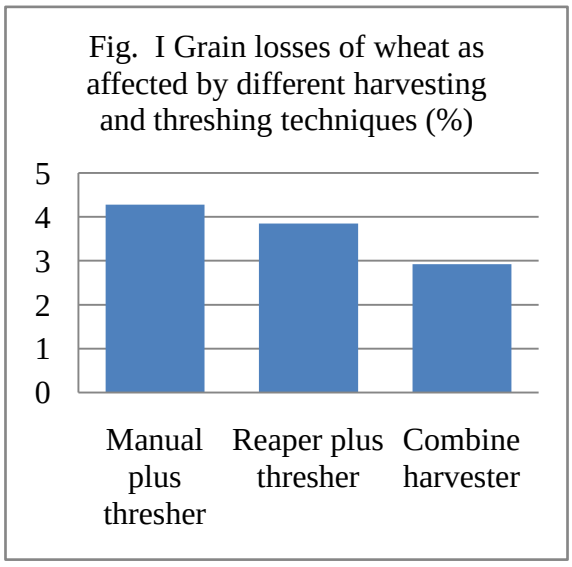
Harvesting losses: The harvesting losses represent the percent of grains lost in the harvested field. These losses mostly occur due to fallen ear heads, shattered grains during harvesting, bundling and transportation, and un harvested plants. Factors such as time of harvest, crop moisture, humidity, variety, topography, sowing method and lodging plays a major role to assess these losses. The data given in Table-2 demonstrated that more grain losses were found in the field where wheat was harvested manually as compared to the plot where reaper was used to harvest wheat crop. Data showed that harvesting losses of grains for manual and reaper harvesting were 164.37 and 142.93 kg ha^{-1} which were 3.16% and 2.76% of wheat yield, respectively. The results are in accordance with the findings of Iqbal *et al*., 1980 who also reported 3 to 7% harvesting losses with manual harvesting of wheat. Similar results are also reported by Zafarullah (1985) who observed 2.1% total manual harvesting losses. The results regarding harvesting losses by reaper are also in good agreement with the findings of Singh *et al*. (1988).

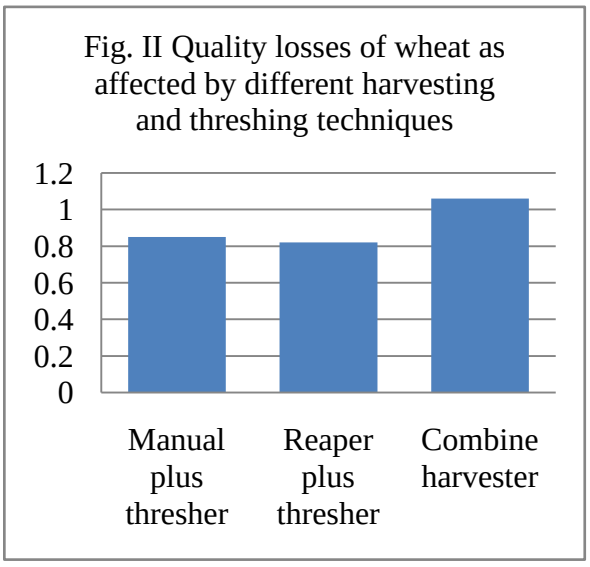
Table2. *Grain losses of wheat as affected by different harvesting and threshing techniques*

Harvesting Technique	Grain losses (kg ha^{-1})			Grain losses (%)			
	Harvesting	Threshing	Harvesting/ Threshing	Harvesting	Threshing	Harvesting/ Threshing	Inc./ Dec.
Manual plus thresher	164.37	58.26	222.63	3.16	1.12	4.28	48.55
Reaper plus thresher	142.93	56.48	199.41	2.76	1.09	3.85	33.06
Combine harvester	-	-	149.87	-	-	2.92	-

Threshing losses: The data regarding threshing losses of wheat grains are presented in Table-2. The data showed that threshing losses were not influenced by threshing under various harvesting techniques. Less threshing losses were observed where wheat was harvested with reaper than manual harvesting. Un threshed grains found from the wheat straw for manual and reaper harvesting were 58.26 and 56.48 kg ha^{-1} (1.12 and 1.09% of wheat yield), respectively. The results are in line with the findings of Basavaraja *et al*. (2007) who concluded that grain losses during threshing activity of wheat were 0.44 kg/q.

Harvesting and threshing losses: The shattered grains and threshed or un threshed spikes collected behind the combine harvester represent the harvesting and threshing losses of the combine. The data given in Table-2 and Fig. I showed that the minimum harvesting and threshing losses of wheat grains by the combine recorded from the field were 149.87 kg ha^{-1} (2.92% of wheat yield) as compared to the harvesting and threshing losses for manual plus thresher and reaper plus thresher i.e. 222.63 kg ha^{-1}and 199.41 kg ha^{-1} (4.28 and 3.85% of wheat yield), respectively. The results are in good agreement with the findings of Bala *et al*. (1980) who also reported 4.09% grain losses of wheat by traditional methods of harvesting and threshing. The highest total harvesting and threshing losses were happened with manual harvesting and threshing wheat with thresher. From the perusal of data it was observed that higher grain losses of 48.55 and 33.06% were recorded by manual plus thresher and reaper plus thresher, respectively as compared to combine harvester. Similar results were also demonstrated by AMRI (1987) who found 2.2% wheat losses for combine as compared to 4.65% for reapers and about 7.5% for manual harvesting.





Quality losses: Quality losses of wheat include broken grains, weeds seed or any other material found in the produce. The wheat field under experiment was weed free and upright stand. Based on field conditions, more broken grains and less weeds seed were found in the produce. Data presented in Table-3and Fig. II depicted that 44.23, 42.58 and 54.46 kg ha^{-1} inert material were found under manual plus thresher, reaper plus thresher and combine harvester techniques. The quality losses were mainly in the form of broken grains, which were slightly higher, when the produce was threshed by combine as compared to manual plus thresher and reaper plus thresher. The data revealed that wheat harvested and threshed with combine had 1.06% inert matter whereas 0.85% and 0.82% inert material

was found with manual plus thresher and reaper plus thresher, respectively. Grain losses observed during threshing activity of wheat are in accordance with the findings of Begum *et al*. (2012).

Table3. *Quality losses of wheat as affected by different harvesting and threshing techniques*

Harvesting Technique	Quality losses		Cleaning efficiency
	(kg ha^{-1})	(%)	(%)
Manual plus thresher	44.23	0.85	99.11
Reaper plus thresher	42.58	0.82	99.14
Combine harvester	54.46	1.06	98.90

Cleaning efficiency: The cleaning efficiency of different harvesting techniques reflect the amount of inert material present in the grain sample. The data given in Table-3 revealed that the cleaning efficiency of the combine was a bit poorer (98.90%) than manual plus thresher (99.11%) and reaper plus thresher (99.14%). The cleaning efficiency of all the harvesting techniques weresatisfactory that might be due to unweedy wheat field and upright crop stand. The quality losses are quite consistent with prevalent conditions.

ECONOMICS ANALYSIS

An economicanalysis of three methods of harvesting and threshing i.e. manual plus thresher, reaper plus thresher and combine harvester was made (Table-4) using cost figures of 2010-11. Data showed that cost of manual plus thresher and reaper plus thresher was Rs. 18315 ha^{-1}and Rs. 17206 ha^{-1} while combine harvester costs Rs. 11590 ha^{-1}only.A benefit of about Rs. 6725 ha^{-1}may be realized by using combine harvester when compared to manual harvesting of wheat. From the results of the study it was concluded that minimum benefit ofRs.2867 ha^{-1} and Rs. 1196 ha^{-1} were obtained by using combine harvester over manual plus thresher and reaper plus thresher, respectively. This cost analysis and the results of preceding section showed that the use of combine harvester is economical and technically feasible. The results of the study are quite in line with the findings of Razzaq *et al*. (1992) who concluded that combine harvester is an efficient, economical, and less labor demanding machine. Similarly field losses and economics of combine harvester and combination of reaper with thresher were also determined by Pawar *et al*. (2008) who concluded that cost of operation for combine harvester was (Rs. 817.84 ha^{-1}) less than the combination of reaper with thresher (Rs. 1816.79 ha^{-1}).

Table4. *Comparison of different harvesting and threshing techniques*

Charges	Manual plus thresher	Reaper plus thresher	Combine harvester
Expenditures			
Harvesting/bundling/heaping	7030	5866	-
Threshing with thresher	11285	11340	-
Harvesting/ threshing with combine	-	-	4916
Wheat straw chopper	-	-	6674
Total expenditures	18315	17206	11590
Income			
Wheat grains	112845	113397	114573
Wheat straw	18653	18653	13057
Total income	131498	132050	127630
Net income	113173	114844	116040
Additional benefit of combine over manual plus thresher	-	-	+2867
Additional benefit of combine over reaper plus thresher	-	-	+1196

Manual harvesting/bundling/heaping	296 kg ha^{-1}
Reaper harvesting/bundling/heaping	247 kg ha^{-1}
Threshing with thresher	4 kg/40 kg wheat
Harvesting/threshing with combine	207 kg ha^{-1}
Straw chopper	281 kg ha^{-1}
Price of wheat grains	Rs. 23.75 kg^{-1}
Price of wheat straw	Rs. 3.75 kg^{-1}

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