INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2003/05–1–57–60
http://www.ijab.org

Techno-Economic Feasibility of Combine Harvester (Class Denominator) – A Case Study

ABDUL REHMAN TAHIR, FAIZAN UL HAQ KHAN AND KHURRAM EJAZ
Faculty of Agricultural Engineering and Technology, University of Agriculture, Faisalabad – 38040, Pakistan

ABSTRACT

Techno-economic feasibility of using combine harvester (Class Denominator) was carried out by determining harvesting losses, timeliness of harvesting, field capacity, fuel consumption, noise and dust pollution, frequency of repair/maintenance and operating cost of the machine. The results indicated that combine had an average harvesting losses of about 1.25% of wheat yield. Grain breakage losses (5.7%) were bit higher. The machine was able to harvest 2.5 to 3.0 acres in an hour. The fuel consumption of the combine was found to be 15 L of diesel per acre. As the machine was not equipped with a proper cab, dust and noise pollution posed threat to the operator's health. The machine needed only two to three persons for its operation and costs about Rs 860/acre to the user. The combine is an efficient, economical, labor and time saving machine but its initial cost is quite high. To promote this high cost technology, it is suggested that the District Governments of present set up should make arrangements at Tehsil Council level to provide combine to the farmers on rental basis.

Key Words: Combine; Wheat; Harvesting losses; Harvesting cost; Pollution

INTRODUCTION

Harvesting of cereal crops, in Pakistan, is a problem since long as this operation is still mostly done by hands. The shifting trend of rural labor to cities and industries is the prime reason of labor shortage at the time of wheat and rice harvesting. With the introduction of high yielding varieties and chemical inputs, farmers are reaping bumper crops while the problem of labor shortage has intensified. The problem of labor shortage can be solved with the use of farm machinery which helps to bring more area under cultivation, increase cropping intensity and timely harvest crops.

Presently, wheat threshing in Pakistan is almost fully mechanized but harvesting is still a problem. Anonymous (1994) reported that the use of harvesting and threshing machinery has increased significantly over last 10 years. There are about 7933 reapers, 30 cutter-binders, 111955 threshers, 204 pull-type and 152 self-propelled combine harvesters in the country. 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. According to a conservative estimate reapers are harvesting about 18% and combines 2.5% of total wheat area of 8.14 million-ha (GOP, 2001). Studies indicate that combine harvester is an efficient, economical, and less labour demanding machine. It increases grain recovery by minimizing harvesting and threshing losses. AMRI (1987) found 2.2% wheat losses for combine as compared to 4.65% for reapers and about 7.5% for manual harvesting. Bukahri *et al.* (1983) found losses to the tone of 16% for manual harvesting and threshing as compared to about 12% for manual harvesting plus mechanical threshing and only 3.4% for combine. Small grain crops that need early harvesting and immediate threshing in order to minimize harvesting losses and fetch good market price are now possible with the use of combine harvester. The combine in view was tested for the following specific objectives.

1. To measure the pre-harvest, header, rack, shoe and quality losses while harvesting wheat crop with Class Denominator Combine.
2. To determine operating cost and net economic benefit and compare with other methods of harvesting wheat.
3. To observe noise level and dust pollution while operator is performing different combine operations.

MATERIALS AND METHODS

The combine (Class Denominator- 68) was tested at Postgraduate Agricultural Research Station (PARS), University of Agriculture, Faisalabad. The combine harvester is equipped with a 14-ft wide header unit and 125-hp diesel engine. It can harvest rice and wheat crops simply by interchanging the threshing drum. The combine is without cab. The operator can control the forward speed of the machine, reel speed, cylinder speed and concave clearance. The grain tank at the top of the combine harvester can store 2500 kg of wheat grain. Two fields i.e. acre No 5 of square No 12 and acre No. 3 of square No. 26 at PARS representing thin and thick wheat crop respectively were selected to record field and machine data. To mark sample area, a steel frame measuring 14 ft in length and 2 ft width was used to collect data of grain losses. The steel frame was randomly placed at different locations of the selected fields before and after harvesting wheat crop. From the area enclosed by the frame, loose grains and cut/uncut ear-heads

were collected to determine (i) yield of wheat crop (ii) pre-harvest losses (iii) total crop losses (iv) header losses and (v) rack losses. Samples from grain tank were also taken to compute the threshing and quality losses.

A Multiple grain moisture meter made by Dicky John, USA was used to measure moisture content and know the maturity level of crop to be harvested. Weather data including temperature and humidity were also recorded to apply temperature correction to grain moisture meter. The intensity of noise level close to the driver's seat and away from machine were recorded with the help of a noise meter. The noise levels were recorded at the time of harvesting crop and emptying the grain tank. General observations were also made regarding failure of machine components, suitability of machine to local field conditions, maneuverability, safety, ease of operation and system adjustments, etc.

RESULTS AND DISCUSSION

Technical performance of the combine was determined by measuring different harvesting losses of selected fields. The crop losses can be kept minimum by understanding the working principles of combine harvester and adjustment needed to be made at the time of harvest. A poor job of combining is a result of improper adjustments which may cause damage to grains or machine. Harvesting with improper adjustments reflect a poor understanding of machine operations. The adjustments of the combine need to be made according to type and variety of crop, moisture content of crop, time of harvest, field and crop conditions (lodged/unlodged), etc. Major harvesting losses which were measured during this study are discussed as under.

Pre-harvest losses (PL). The losses of crop are usually measured as percent of total yield. Therefore, a steel frame measuring 14 x 2 ft (28 ft^2 area) was placed at three different locations of each selected field to estimate their yield. An average yield of two selected fields (Thin & Thick) was found to be 1755 and 2217 kg/acre, respectively (Table I). The PL occur in standing crop due to shattering by insects, birds, animals, wind and rusts, etc. The steel frame discussed above was placed in standing crop at three different locations of each field. Loose grains and spikes fallen on the ground and enclosed in the steel frame were picked up. The weight of loose grains and of the spikes was noted to represent grain loss in 28-ft^2 area which was later converted to kg/acre. Average PL calculated (Table I) for thin and thick crop were about 3.5 and 1.73 kg/acre (0.2 and 0.08 % of crop yield) respectively.

Header losses (HL). The header losses represent the percent of grains lost to the field which were harvested but could not be picked up to the platform of the combine. These losses mostly occur due to shattering of crop by cutter-bar. Moisture content of crop at the time of harvest plays a major role in containing these losses. Ideally, wheat should be harvested when its moisture content range from 12 to 18% (Hunt, 1980). The moisture content of wheat crop at the time of harvesting were found to be 9.5% for Thin and 5% for Thick field. To determine HL, the combine was allowed to move about 50 ft from the border of the field. After the combine has attained a steady state speed under full load condition, it was suddenly stopped and the clutch disengaged. The header unit was lifted up and the machine was moved back about 20 ft. The steel frame mentioned above was placed in front of parked machine. The header losses were determined by weighing the loose grains and spike-grain picked up from enclosed area of the frame. Average HL for two selected fields were found to be 14.4 and 19.15 kg/acre (0.82 and 0.86% of wheat yield), respectively (Table I).

Rack losses (RL). Rack losses (Table I) were calculated by subtracting HL from machine losses; whereas, the machine losses were determined by subtracting PL from total crop losses. Total crop losses were determined by placing the steel frame behind the combine to enclose a harvested area of 28 ft^2. Loose grains and spikes were picked up and weighed. The rack losses 0.31 and 0.21% for two selected fields compared very closely to that of recommended (0.2 to 0.4% of yield) (Anonymous, 1970).

Table I. Combine harvesting losses measured as percent of yield for selected wheat fields

Field	Yield (kg/acre)	PL (%)	HL (%)	RL (%)	Total Losses (%)
Thin Crop	1755	0.20	0.82	0.31	1.33
Thick Crop	2217	0.08	0.86	0.21	1.15

Quality losses. Quality losses include unthreshed heads, broken kernels and weeds in the grain tank of the combine. Broken or damaged grains are the result of low moisture content, narrow concave clearance or high speed of threshing cylinder. Weeds in the grain tank reflect inefficient cleaning that may be due to excessive weeds in the field or sieve openings too wide open. Thin field was heavily infested by Poli and Lily weeds. Whereas, Thick field was weed free and upright stand. The wheat crop of Thin field had higher moisture content (about 9.5% at the time of harvest) than that of Thick field which measured to be 7.5%. Based on crop and field conditions, more weeds and less broken grains were expected for crop harvested from Thin field. Whereas more broken grain and weeds were expected for crop harvested from thick field.

Threshing and grain breakage losses (TL & BL). For threshing and grain breakage losses, a sample was taken from the grain tank of the combine. Un-threshed heads and broken grains were picked up from the sample and weighed. This weight was divided by the sample weight to get threshing losses. Threshing and breakage losses for selected

fields are given in Table II. As expected, the crop with less moisture content (7.5%) had greater TL (about 6%) as compared to crop with higher moisture content (9.5%). The crop with low moisture content (Thin field) had more broken grains (5.7%) than crop with high moisture content which had about 1.5% as broken grains. The reason of more breakage losses may be narrow concave clearance, which needed to be increased as crop gets dryer.

Cleaning efficiency (CE). The cleaning efficiency of the combine reflects the amount of weeds present in the grain sample. It was calculated by dividing the weight of clean grains by total weight of sample (clean grains + weeds). As expected, the CE of the combine was a bit poorer (about 99%) for weed infested field than for clean field. The results of Table II reveal that the CE of the combine was quite satisfactory even in weedy fields. The quality losses are quite consistent with field conditions and as expected.

Table II. Quality losses for selected wheat fields

Field	Weeds	GMC (%)	TL (%)	BL (%)	CE (%)
Thin Crop	Heavy	9.5	3.4	1.5	98.8
Thick Crop	Rare	7.5	5.9	5.67	99.5

GMC= Grain Moisture Content; TL= Threshing Losses; BL= Breakage Losses; CE= Cleaning Efficiency

Field capacity. The data of field capacity was taken as total acreage harvested in a specified time or total time taken by the combine to harvest a given field. The combine in view was able to harvest 2.4 to 3.0 acres of wheat per hour depending upon the field and crop conditions. Thick crop took more time to harvest. Similarly, small fields with too many bunds wasted more time and fuel of the machine in taking turns and stoppage. The data of fuel consumption was taken by recording the quantity of fuel required to refilling the fuel tank to its full mark after harvesting a given field. An average fuel consumption of the combine was found to be 15 L of diesel per acre.

Repair and maintenance. The frequency of repair and maintenance is an important factor in the evaluation of a combine. The combine needed very little repair and maintenance during whole harvesting season of about 20 days. The cutter bar of the combine experienced an accident with the iron-bar of an electric pole hidden under the crop while harvesting square No 11. The damaged cutter bar was replaced with a new one on the same day. Oil and air cleaner filters were changed only once during harvesting season. Oil of the combine harvester was also changed after 50 h of operation.

Environmental conditions. The cab of the combine is open from all sides. Too much dust and chaff affect the efficiency of the operator and create unhealthy working environment. Noise of the working combine was another pollution factor, which affected the hearing of operator. The noise level of the combine near operator's seat was measured with the help of a sound meter. The noise level during harvesting crop was 92.6 dB whereas it was 88 dB while emptying the grain tank. This noise level is just above the recommended level (82 dB) and is not desirable for the health of the driver over extended working hours. The temperature during harvesting season remains in he range of 42 to 47°C. Higher temperature also affected the efficiency of the operator. A small fan close to driver's seat may be provided to improve ventilation.

Economic analysis of harvesting operation. An economic analysis of three methods of harvesting and threshing i.e. manual plus thresher, reaper plus thresher and combine was made (Table III) using cost figures of 2001. An average yield of 35 maunds/acre (1440 kg) was assumed. The combine was assumed to work 8 hrs/day, 60 days in a year with a field capacity of 2.5 acres/hr while consuming 15 liters of diesel per acre. Prevailing costs of harvesting (3 maunds/acre) and threshing (6 kg/maund) were used to calculate total cost of harvesting for manual method. The market price of wheat was assumed as Rs300 per maund. The market rate of Rs 800/acre for reaper renting was used to calculate harvesting cost with reaper.

Data of Table III shows that the manual and reaper harvesting methods cost about the same i. e. Rs2400/acre while combine harvester costs only Rs860/acre. A benefit of about Rs1600/acre may be realized by using combine harvester when compared to conventional methods of wheat harvesting. The combine harvester does not make bhoosa which is a byproduct of other two methods of harvesting. After debiting the cost of bhoosa the minimum benefit of using combine harvester comes out to be Rs 731/acre. This cost analysis and the results of preceding section shows that the use of combine harvester is economical and technically feasible and should be adopted without delay.

Table III. Comparison of different harvesting methods when average yield is 1440 kg/acre (35 maunds)

Method	Harvesting Cost (Rs/acre) (1)	Threshing Cost (Rs/acre) (2)	Total cost (Rs/acre) (1+2)	Benefits of Combine over other methods of Harvesting (Rs/acre)	
				Without cost of Bhoosa	With cost of Bhoosa
Manual	900	1575	2475	2475-860 =1615	831
Reaper	800	1575	2375	2375-860 =1515	731
Combine	-	-	860	-	-

CONCLUSIONS

Following conclusions may be drawn from the results

discussed in the preceding paragraphs.

1. The machine losses (header + rack losses) were recorded to the tone of 1.07% for thick and 1.13% for thin crops. These losses are much less than other methods of harvesting and threshing which vary from 6 to 12% (AMRI, 1987).
2. Threshing and grain breakage losses were higher (about 6%) for crop with low moisture content than for crop with high moisture content (1 to 3%) mainly due to narrow concave clearance.
3. The cleaning efficiency of combine (about 99%) was quite satisfactory even in weedy field.
4. The combine could harvest 2.4 to 3.0 acres in one hour. The average fuel consumption of the combine was 15 L/acre. The results showed that the combine is an efficient, economical and less labor and time consuming machine.
5. The environmental conditions during harvesting are not very conducive for the operator. Dust and noise both endanger the health of the operator.
6. The combine needed routine repair and maintenance during entire wheat harvesting season.
7. A minimum net benefit of Rs730/acre may be realized by harvesting wheat with combine in addition to 2 to 3 weeks saving in harvesting time.

RECOMMENDATIONS

1. The combine increases grain recovery by reducing post-harvest losses and saves time and labor. Therefore, it should be adopted without further delay.
3. A chaff-making unit should be designed as an attachment to the combine so that the farmers who want chaff for their animals may be able to use it.
2. The cab of the combine should be modified to minimize noise and dust pollution. A small electric fan should be arranged within the cab to facilitate combine operator.

REFERENCES

AMRI, 1987. Comparative study of different methods of wheat harvesting and threshing in the Punjab Province. Report.

Anonymous, 1970. *Combines and Combining Manual.* Ohio State Department of Education, Ohio, USA

Anonymous, 1994. *Census of Agricultural Machinery*. Gulberg III, Lahore.

Bukhari, S.B., J.M. Buloch and F.M. Rather, 1983. Losses in Wheat harvesting and threshing. *AMA, Japan*, 14: 61–7.

GOP, 2001. *Economic Survey of Pakistan 2000-2001*. Economic Advisor's Wing, Finance Division, Govt. of Pakistan, Islamabad.

Hunt, D., 1980. *Farm Power and Machinery Management.* Iowa State Univ. Press, Ames, Iowa, USA

(Received 10 October 2002; Accepted 11 December 2002)