Performance Evaluation of Reaper-Binder for Wheat

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Abstract
In Ethiopia, harvesting cereal crops is one of the major attentive agricultural operations in agriculture production, which demands a considerable amount of labor. There are significant issues with labor costs and availability during the harvest of wheat crops. Therefore, it is crucial to use mechanical technologies to assure timely harvesting operations and to reduce field losses in order to increase farm productivity. The objective of this study was to evaluate the self-propelled reaper-binder performance in a farmer's field. The reaper binder's effective field capacity was determined to be 0.108 hectares per hour, with a field efficiency of 84.65 percent and an operating speed of 2.55 km per hour. Fuel consumption of 10.66 l/ha was recorded. Total grain losses during reaper binder harvesting were 2.02% compared to 3.30% during manual harvesting. Harvesting with a reaper binder and harvesting by manual cost 1,391.18 Birr per hectare and 2850 Birr per hectare, respectively. Compared to manual harvesting with a sickle, reaper binder harvesting costs were lowered by 48.82 percent. Therefore, mechanical harvesting is more feasible and economical than manual harvesting in terms of time, money, and labor.
Keywords: Harvesting, Mechanical harvesting, Reaper binder, Wheat
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INTRODUCTION

Wheat (*Triticum aestivum*) is an important cereal crop and staple food of millions of people which is grown in many countries of the world. Ethiopia is sub-Saharan Africa's largest producer of wheat accounting for over half of the total wheat area in the region. Wheat is one of the major cereal crops grown in the Ethiopian highlands. This is partly explained by the fact that wheat is a traditional crop in Ethiopia grown using traditional practices whereas, in most other countries it is of recent introduction and is grown using improved technology. The most important wheat-growing areas of Ethiopia are the highlands of the central, southeastern, and northwestern regions of the country. Of the current total wheat production area, *75.5%* is located in Arsi, Bale, and Shoa regions (Hailu Gebre-Mariam, 1991).

Harvesting is one of the most important operations of agriculture. Most regions of the country harvest manually. This is a labor-intensive seasonal activity that consumes about 18-20% of the labor required to grow cereals (Singh et al., 2008).Harvesting of the crop is one of the most labor-intensive operations in agriculture. Yet the most prevalent method of harvesting crops in Ethiopia is the manual method which is time and labor-consuming. It is estimated that harvesting and threshing consume about one-third of the total labor requirement of the complete crop production system. Harvesting of wheat crop in Ethiopia is mainly done manually using a sickle which is labor intensive and tedious. Labor scarcity during the peak period of harvesting leads to delays in harvesting and field grain losses. Also, high labor wages during peak period adds extra cost to the total cost of cultivation. Mechanized harvesting is an alternative solution to tackle this problem. Farm mechanization will also result in a lesser cost of operation. Alternative combine harvesters are introduced and promoted in some parts of the country; however, farmers are losing valuable animal feed material. Reapers on the other hand are other alternative harvesting equipment, provided straw is considered an economic by-product for animal feed. Nowadays, different types of reaper binders are being imported from China which are designed for rice harvesting. The reaper binder is found to be easy to operate in fragmented land and can reduce postharvest loss. Therefore, as an intermediate technology, it is necessary to assess the operating performance of the reaper binder for wheat under farmers' field conditions. Hence, this study was taken to evaluate the performance of imported self-propelled reaper binders for harvesting wheat crops.

MATERIALS AND METHODS

This chapter deals with the procedures adopted to evaluate the performance of the reaper binder. It also describes the crop conditions. The field experiments for the evaluation of the machine were carried out at a farmer’s wheat field in the Tiyo district of Arsi zone under the farmer’s field condition. The range of variables for the study was based on the literature reviewed and preliminary trials conducted on the machine.

Description of the machine

Table 1. Description of the reaper binder

Function	Harvesting and binding of grain crops in single operation
Crops	Wheat, Rise, Barley and Oats
Engine	10 hp Air cooled diesel engine
Gear	2 Forward and 2 reverse
Cutter width (mm)	500
Height of cut (mm)	100 - 200
Weight of machine (Kg)	400
Overall dimension (L×W×H) (mm)	2400*700*1000

The reaper binder is a crop harvesting machine suitable for harvesting cereal crops. It has a cutter bar of 0.5 m wide and is operated by a 10 hp diesel engine. Two forward and two reverse gears are provided in the machine. It is steered by hand-operated brakes for turning left or right. The crop row dividers help the standing crop to enter the machine, by the 'raising ups' gently pushing the crop towards the cutter bar and pushing the crop onto the crop conveying chain. The star wheel keeps the cut crop in an upright position toward crop conveyers. The crop is gathered at the knotter mechanism when a sufficient quantity of crop is gathered; the bundle is tied and ejected by the ejecting finger out of the machine.

Performance evaluation of the reaper binder

Performance testing of the reaper binder was done to obtain data on overall machine performance, operating accuracy, work capacity, and adaptability to harvesting conditions. In performance testing, the data were categorized as data for test conditions and data for performance measures. The data for test conditions included the condition of the crop, condition of the field, and condition of the machine and operator. Performance measures were harvesting capacity, accuracy, work rate and labor requirements based on standards conform to FAO testing and evaluation procedures for agricultural machinery published in 1994.

Figure 1. Performance testing during harvesting

Condition of the crop

Condition of the crop includes crop kind, crop variety, plant density, lodging angle of the crop plant, plant height, moisture content of the stem and the grain at the time of harvesting as well as yields per hectare. The crop conditions influence the performance of the harvesting machine.

Height of plant

Plant height was measured from the base of the stem to the tip of the top most panicle at five randomly selected places of each test plot by measuring tape.

Plant population

The populations of the harvested crops were counted within a 1 m^2 square frame at five random places in the plot. The number of plants from these places gave plant population per meter square.

Height of cut

The height of the cut both for reaper binder harvesting and manual harvesting was measured from the base of the stem to the tip of the top cutting tip at five randomly selected places of each test plot by measuring tape.

Moisture content of the crop

During the testing, the samples of grain were weighed and the sample box with the sample was placed in an oven for 24 hours at 105^0C. The straw samples were chopped into small pieces and samples were weighed and dried as described for grain. The moisture content was calculated as follows:-

$$Moisture\ content\ ,\% = \frac{W_1 - W_2}{W_2} \times 100 \qquad (1)$$

W_1 = initial weight of the grains,
W_2 = final weight of the grains after drying.

Performance measure of the machine
The preliminary testing of the reaper-binder was carried out before the actual performance test evaluation is done to check its functional performance, such as working of the cutter bar, gathering and knotting devices, speed of the cutter bar, etc. To evaluate the performance of the reaper-binder the field parameters such as speed of operation, the width of operation, total time taken to cover the given area, height of cut, effective field capacity, harvesting losses, field efficiency, fuel consumption, labor requirement, and economics were worked out as per FAO test standards (FAO, 1994).

Actual working time
The actual working time was measured in the field using a stopwatch. The time losses due to turnings were not taken into account. Time lost in adjustments and breakdowns was recorded and deducted from the total time.

Speed of operation
The working speed was determined by marking the length of 40m and the reaper-binder was operated in the marked run length. A stopwatch was used to record the time for the reaper binder to travel the marked run so that the speed of travel was computed in ms^{-1}.

Effective field capacity
Effective field capacity was measured by the actual area covered by the reaper-binder, based on its total time consumed and its width. Effective field capacity (EFC) was determined by the following relationship (Kepner, *et al*., 1987).

$$EFC\ ,\frac{ha}{hr} = \frac{Total\ area\ cover}{Total\ time\ taken} \qquad (2)$$

Theoretical field capacity
Theoretical field capacity (TFC) is computed from the rate of field coverage of the machine, based on 100 percent of the time at the rated speed and covering 100 percent of its rated width. The theoretical field capacity was determined by using the following relationship (Prakash et al., 2015).

$$TFC\ ,\frac{ha}{hr} = \frac{Width(m) \times Speed\ (\frac{km}{hr})}{10} \qquad (3)$$

Field efficiency
Field efficiency is computed from the ratio of effective field capacity and theoretical field capacity. It takes into account the time losses encountered in the field due to various reasons. It was calculated as follows.

$$Field\ effeciency\ ,\% = \frac{EFC}{TFC} \times 100 \qquad (4)$$

Fuel consumption
The fuel consumption was having a direct effect on the economics of the machine. The fuel consumption was measured by the refill method. The fuel tank of the reaper-binder was filled at its full capacity. The machine was run in the field at a constant speed. After completion of the harvesting operation, the fuel was refilled in the tank up to the top level. The quantity of refilled fuel was expressed as $l\ h^{-1}$ and $l\ ha^{-1}$.

Harvesting losses
Pre harvesting losses
To measure the pre-harvest loss an area of $1m^2$ was harvested manually using a sickle. Care was taken that there were no shattering losses. The grains and ear heads, which had fallen within a $1m^2$ metal frames were collected and weighed. This pre-harvest loss (W_1) was repeated at seven different places chosen randomly in every plot.

Harvesting loss
It was the amount of the grains and ear heads fallen on the ground due to the harvesting action of the reaper

binder and manual harvesting. After harvesting operation with reaper binder and manual harvesting the grains and ear heads, which had fallen within a 1m^2 metal frames were collected and weighed. This harvesting loss (W2) was repeated at seven different places chosen randomly in each plot. The same procedure of pre-harvesting losses was repeated to get harvesting loss (W2) in g/m^2**.**

Conveying loss

Conveying loss is defined as the amount of grain an ear heads fallen during harvesting and bundling of the crop. To measure this loss a 2 m long and 1 m wide polythene sheet was laid adjacent to the standing crop. The harvest crop fell on the polythene sheet was picked and the grain and ear heads remaining on the polythene sheet were collected and weight. This gave conveying loss (W3) in g/m^2. Thus, the total harvesting losses were calculated described as follows (Mohammad Reza et al., 2007).

$$W_t = W_1 + W_2 + W_3 \qquad (5)$$

Where; Wt = Total losses, g m^{-2}

W_1 = Pre-harvest losses, g m^{-2}

W_2 = Shattering losses, g m^{-2}

W_3 = conveying losses, g m^{-2}

After measuring the number of losses at different stages, the percentage of harvesting losses was determined by the following equation:-

$$H = \frac{W_t - W_1}{Y_g} \qquad (6)$$

Where: - H = Percentage of harvest losses, %

W_1 = Pre-harvest losses, g m^{-2}

W_t = Total harvest losses, g m^{-2}

Y_g = Grain yield, g m^{-2}

Harvesting cost estimation

Harvesting cost of the reaper-binder included the cost of labor, machine depreciation, machine repair, fuel, and lubricants. Labor costs included wages for the machine operator and the assistant operator. The harvesting cost for the reaper-binder is calculated based on fixed and variable costs. The local purchase price of the reaper was 149,500 birr.

Fixed Costs

The fixed cost of the machine is the cost that is involved irrespective of whether the machine is used or not. These costs include; depreciation costs, interest on investment and taxes, shelter, and insurance. Depreciation cost was calculated by the straight line method. The useful life of the reaper binder is considered to be 10 years. The salvage value was also considered to be 10% of the purchase price.

$$Annual\ depreciation, D = \frac{P - S}{L} \qquad (7)$$

Where; P = purchase price (Birr),

S = selling price (Birr),

L = Useful life, yr.

Interest on Investment is an actual cost in agricultural machinery calculated by the straight line method.

$$Intrest\ on\ investment, I = \frac{P + S}{2} \times i \qquad (8)$$

Where, P = Purchase price, Birr.

S = Resale value, Birr.

i = annual interest rate, %

Shelter, Tax, and Insurance costs of the machine were annually estimated as follows:-

$$Shelter, Tax\ and\ Insuranc, STI = 2.5\%\ P \qquad (9)$$

$$Total\ Fixed\ cost\left(\frac{Birr}{Yrs}\right) = D + I + STI \qquad (10)$$

$$Fixed\ cost\left(\frac{Birr}{ha}\right) = \frac{Total\ fixed\ cost\left(\frac{Birr}{yr}\right)}{Total\ area\ coverage\left(\frac{ha}{yr}\right)} \qquad (11)$$

Variable Costs

Fuel, oil, labor, repair, and maintenance costs were considered as variable costs of the machine and determined by the following formulas:-

$$\text{Fuel cost}\left(\frac{\text{Birr}}{\text{ha}}\right) = \frac{\text{Fuel consumed}\left(\frac{\text{liter}}{\text{day}}\right) \times \text{Price}\left(\frac{\text{Birr}}{\text{liter}}\right)}{\text{Area coverage}\left(\frac{\text{ha}}{\text{day}}\right)} \quad (12)$$

$$\text{Oil cost}\left(\frac{\text{Birr}}{\text{ha}}\right) = 15\%\text{ of fuel cost, F} \quad (13)$$

$$\text{Labor cost}\left(\frac{\text{Birr}}{\text{ha}}\right) = \frac{\text{Sum of wages of labour}\left(\frac{\text{liter}}{\text{day}}\right)}{\text{Area coverage}\left(\frac{\text{ha}}{\text{day}}\right)} \quad (14)$$

$$\text{Repair and maintenance,}\left(\frac{\text{Birr}}{\text{yr}}\right)\ \ 3.5\%\text{ Purchase price} \quad (15)$$

$$\text{Total variable cost}\left(\frac{\text{Birr}}{\text{ha}}\right) = (F + O + L + R + M)\left(\frac{Birr}{ha}\right) \quad (16)$$

$$\text{Total cost of Harvesting}\left(\frac{\text{Birr}}{\text{yr}}\right) = Fixed\ cost\left(\frac{Birr}{ha}\right) + variable\ cost\left(\frac{Birr}{ha}\right) \quad (17)$$

Break-even point

The break-even point is that area in which the harvesting cost per unit area is equal for machine and manual, determined by the following equation described by Alizadeh *et al.,* (2013).

$$\text{Break} - \text{even point, B} = \frac{\text{F}}{\text{V}_\text{a} - \text{V}_\text{m}} \quad (18)$$

Where B = Break-even point (ha/year),
F = Fixed costs of machine harvesting (Birr/year)
V_a = Variable costs for manual method (Birr/ha)
V_m = Variable costs for machinery method (Birr/ha)

Data analysis and comparison

FAO (1994) testing standards use averages to compare different parameters. In this test, data relating to environmental conditions were taken to enable the reaper user to interpolate the performance to other local environments. During reaper testing, the data on an hour's requirement, harvesting cost per hectare, and grain loss were collected for both manual and reaper harvesting. The data obtained from reaper harvesting were compared with the data obtained from manual wheat harvesting.

RESULTS AND DISCUSSION

The reaper binder was evaluated for its performance by harvesting wheat during the 2018/19 harvesting season. The experiments were carried out in the extent of 0.24 ha at a model farmer's field. The performance evaluation of the reaper binder was obtained during the field tests by harvesting of wheat crop. The performance of the reaper binder was based on the average height of cut, forward speed, the actual width of cut, actual field capacity, field efficiency, fuel consumption, labor, and the loss occurring in the field while harvesting is shown in table 2 and 3.

Crop parameters

The crop parameters required for the evaluation of the reaper-binder were observed. The crop parameters such as crop variety, the height of the crop, number of tillers m^{-2}, condition of crop stand, and moisture content of the grain and straw were presented in Table 2.

Table 2. Details of crop parameters

Particulate	Harvesting Methods				
	Reaper binder harvesting				Manual harvesting
	Trial			Mean value	
Crop	Wheat				Wheat
Height of plant, cm	113	99	117	109.67	107.2
Number of tillers	5	4	6	5	5
Plant population per sq. m	260	286	264	270	268
Height of cut, cm	20	17	18	18.33	35
Condition of crop	erect	erect	erect	-	erect
Grain moisture content, %	10.3	10.6	9.89	10.26	10.35
Straw moisture content, %	9.32	8.97	9.28	9.19	9.42

Machine Performance

The wheat crop was harvested using a self-propelled reaper binder. Based on the field performance evaluation conducted during the harvesting season of the 2011 Ethiopian colander, it was observed that the actual cutting width of the reaper binder was 0.50 m. The actual field capacity of the reaper binder was 0.108 ha/h with a field efficiency of 84.65% at an average operating speed of 2.55 km/hr (Table 3). It took 9.25 hr to harvest 1 ha area and the fuel consumption was 9.25 l/ha or 1 lit/hr.

Manual harvesting with a sickle, on average can harvest 80 m^2 /hr, but this amount can differ concerning crop condition, laborer ability, and weather conditions. The required time for harvesting one hectare of wheat in manual harvesting and bundling was 152 man-h/ha compared to 18.51 man-h/ha for the reaper binder (Table 3). The reaper binder was 8.21 times faster compared to manual harvesting.

Table 3: Test results of reaper binder harvester compared with manual harvesting by sickle

Parameter	Harvesting Methods				Manual harvesting and bundling
	Mechanical harvester				
	Plot no.				
	1	2	3	Average	
Actual area covered (ha)	0.04	0.04	0.04	0.04	0.04
No. of Labours	2	2	2	2	8
Total time of operation (min)	21.69	22.56	22.17	21.14	45.28
Effective working width (cm)	50	50	50	-	-
Operating speed (km/h)	2.63	2.57	2.46	2.55	-
Theoretical field capacity (ha/hr)	0.132	0.128	0.123	0.127	-
Effective field capacity (ha/hr)	0.110	0.106	0.108	0.108	0.0066
Field efficiency %	83.33	82.81	87.80	84.65	-
Labour requirement, man-hr/ha	18.18	18.86	18.51	18.51	152
Fuel consumption (lit/hr)	1.24	1.23	1.00	1.15	-
Fuel consumption (lit/ha)	11.21	11.53	9.25	10.66	-
Potential grain Yield (gm/m^2)	632.46	672.67	619.06	641.4	641.4
Harvesting losses (g/m^2)	5.40	4.30	2.50	4.07	6.67
Harvesting losses (%)	0.85	0.64	0.40	0.63	1.04
Conveying loss (g/m^2)	9.42	8.86	8.32	8.87	14.50
Conveying loss, %	1.49	1.32	1.34	1.38	2.26
Total harvesting loss, %	2.34	1.96	1.74	2.02	3.30

The actual field capacity of the reaper-binder to harvest the wheat crop was compared with the harvesting by sickle, which reveals that the maximum average actual field capacity (0.108 ha/h) was found with the reaper-binder whereas by local sickle harvesting (0.0066 ha/hr). Karahle (2015) reported that 0.36 ha/hr field capacity at 3.22 Km/hr operating speed and 152.2 cm effective working width during harvesting of wheat by self-propelled reaper binder and 0.075 ha/hr for manual harvesting. Anurag Patel *et al.,* 2018 reported that the performance of the reaper binder is based on an average forward speed of 2.28 km hr^{-1} and actual width of cut 940 mm, field capacity of 0.166 ha hr^{-1}, field efficiency of 73.46 %, and fuel consumption 1.12 lt hr^{-1}.

Harvesting Losses

The amount of grain loss due to harvesting, conveying losses, windrowing, collection and bundling for reaper binder and manual harvesting with sickle are shown in table 4. The mean percentage of conveying losses in reaper binder and manual harvesting for the wheat crop was 1.38% and 2.26% respectively and that of harvesting losses were 0.63% and 1.04% respectively. The percentages of total grain (conveying and harvesting) losses in manual harvesting were high at 3.30% as compared to reaper binder harvesting at 2.02%. In an earlier study, Karahle (2015) reported that 0.93% harvesting loss during harvesting of wheat by self-propelled reaper binder against a 1.83% loss of manual harvesting.

Table 4: Harvesting losses of reaper binder and manual harvesting

Parameter	Harvesting Methods				Manual harvesting
	Mechanical harvester				
	Plot no.				
	1	2	3	Average	
Potential grain Yield (gm/m^2)	632.46	672.67	619.06	641.4	641.4
Harvesting losses (g/m^2)	5.40	4.30	2.50	4.07	6.67
Harvesting losses (%)	0.85	0.64	0.40	0.63	1.04
Conveying loss (g/m^2)	9.42	8.86	8.32	8.87	14.50
Conveying loss, %	1.49	1.32	1.34	1.38	2.26
Total harvesting loss, %	2.34	1.96	1.74	2.02	3.30

Farmer's feedback

The reaction of the local village people to the operations of the reaper binder was as follows: The local people felt that the reaper binder reduces the labor requirement of harvesting. They appreciated the tremendous reduction in grain losses by using the reaper binder. They appreciated the fact that the use of a reaper binder would make the harvesting of crops timely. The people complained of the problems maneuverability of the machine on non-uniform lands.

Harvesting costs

The fixed and variable costs for harvesting wheat with both reapers binder and manually are shown in Tables 5 and 6. The working hour of the reaper binder was assumed to be 300 hr/year as per ISI standards (Devani, 1985). Costs of harvesting by the reaper binder were estimated at its optimum conditions with field capacities of reapers as 0.108 ha/hr. The local purchase price of the reaper was 149,500 Birr. The annual fixed and variable costs of 21,304 Birr and 23,729.93 were found in the calculation respectively. The fixed cost and variable costs for both reaper binder and manual harvesting are presented in Table 5. In this study, manual harvesting required 19 man-days to harvest one hectare of the wheat field. Considering the labor cost as 150 Birr per day, 2850 Birr/ha was required for manual harvesting, whereas 1,391.18 birr/ha was calculated for reaper binder harvesting (Table 5). The percent saving in the cost of operation is 48.82% by harvesting wheat with a reaper binder over manual harvesting. Net savings per hectare area as shown in Table 6, indicate that 2,444.01 Birr/ha could be saved as compared to reaper binder harvesting against manual harvesting. This net saving comes because of the higher field capacity of the reaper binder than manual harvesting. In a previous study, net savings (1770 Bhat/ha) was found by Bora and Hansen (2007) who harvested rice by a reaper (40 Bhat = 1US$).

Break-even Point Analysis

Harvesting cost by a reaper binder is found to be decreased gradually with the increase in harvesting area. However, the break-even point is 10 ha of land where the same cost was found for both reaper binder and manual harvesting. This break-even point indicates that the reaper binder would be beneficial to the farmers when the area of the harvesting land is more than 10 hectares of land per year. Figure 1 shows that a farmer having only one hectare of land has to incur a harvesting cost of 21,304 by reaper binder. From this analysis, it was found that the reaper would be beneficial to the farmers when the harvesting area exceeds the break-even point.

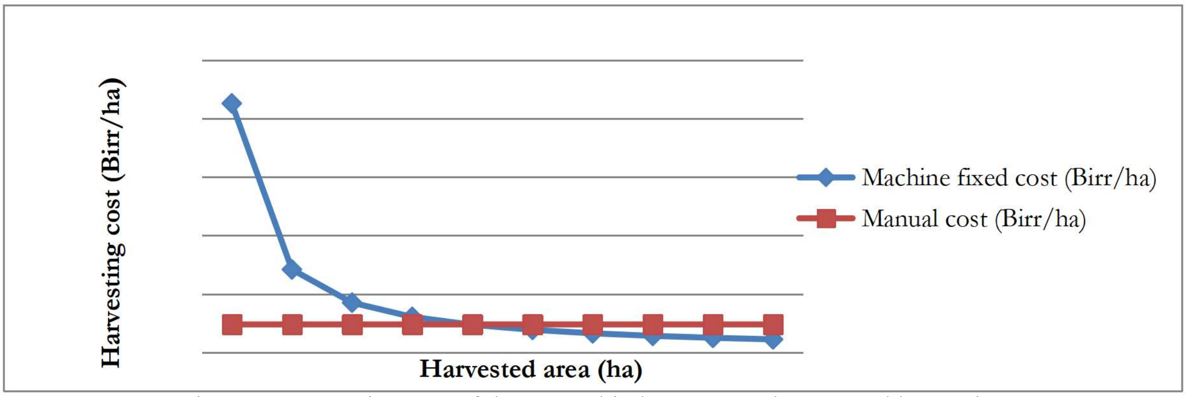

Figure 2. Harvesting cost of the reaper binder compared to manual harvesting

Table 5: Estimated total cost of reaper binder and manual harvesting for wheat

Machine harvesting cost				Manual harvesting cost	
Cost items	Birr/Year	Birr/ha	Birr/hr	Birr/ha	Birr/hr
Fixed cost				2850	18.75
Depreciation	13,455	415.28	44.85		
Interest	4,111.25	126.89	13.70		
Taxes, insurances, and shelter total	3,737.5	115.53	12.46		
fixed cost	21,304	657.70	71.01		
Variable cost					
Fuel	6,323.85	195.18	21.08		
lubrication	948.58	29.58	3.19		
labor	11,225	347.22	37.5		
Repair and maintenance	5232.50	161.50	17.44		
Total variable cost	23,729.93	733.48	79.21		
Harvesting cost	45,033.93	1,391.18	150.71	2850	18.75

Table 6: Comparison of savings by the reaper harvesting per hectare

Particulars	Calculation	Amount (Birr)
Cost of manual harvesting (19 man-days/ha)	19×150	2850
Cost of machine harvesting/ha	1,391.18	1,391.18
Gross savings	2850 − 1,391.18	1,458.82
Cost of total output (6414 kg/ha @ 12 birr/kg)*	12×6414	76,968
Loss in reaper binder harvesting, (2.02%)	76,968 ×0.0202	1554.75
Loss in manual harvesting (3.3%)	76,968 ×0.033	2539.94
Excess loss due to manual harvesting	2539.94 − 1554.75	985.19
The net savings per hectare	1,458.82 + 985.19	2,444.01

*Considered the production of wheat 64.14 quintals per hectare

SUMMARY AND RECOMMENDATION

The performance of the reaper binder was conducted on the wheat field concerning field capacity, field efficiency, fuel consumption, harvesting losses, labor requirement, and cost of operation were studied and compared with manual harvesting. The performance of the reaper-binder at the farm was satisfactory. Based on the experimental results following conclusions are drawn. From the study, it can be concluded that the reaper binder could be used successfully harvest wheat with the effective field capacity of the reaper binder was found 0.108 ha/hr with a field efficiency of 84.65 percent at an average operating speed of 2.55 km/hr compared to 0.0066 ha/hr for manual harvesting. The area of 0.864 ha can be harvested per day if the field capacity is kept at 0.108 ha/h. The fuel consumption was found 10.66 l/ha. Labor requirements for reaper binder and manual harvesting were 18.52 and 152 man-hr/ha, respectively. The harvesting losses for reaper binder and manual harvesting were 2.02 and 3.3 percent respectively. The cost of harvesting operation was 2850 birr/ha for manual harvesting and 1,391.18 birr/ha for mechanical harvesting. The harvesting cost of the reaper binder was reduced by 48.82% compared to the manual harvesting method with a sickle.

Considering 300hrs of harvesting hours per year, the maximum area that can be harvested using the self-propelled vertical conveyor reaper will be 32.4 ha. If the machine is used for the maximum usage of 32.4 ha in a year, the cost of reaper binder harvesting cost will be 1,391 Birr/ha as compared to 2850 birr/ha in case of manual harvesting. Thus it is a feasible solution to minimize the cost of harvesting and farmers' work drudgery. It can be concluded that the use of a reaper binder harvester to harvest wheat is much more economical and efficient than manual harvesting. Therefore, in fields where the use of a reaper binder harvester is possible, it will play an important role in reducing production costs.

From the study, it was found that the use of a reaper was more beneficial than manual harvesting for the harvesting of wheat. The present study is carried out only for wheat cutting, but the same machine can be applied for cutting barley, rice, etc. This field operation was carried out for a small fragmented plot with three replications. But to get a more satisfactory result it should conduct on large size plot with several replications.

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