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Adaptation and Performance Evaluation of Engine Operated Reaper

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Abstract— *This harvesting machine targets the small scale farmers who have small land holding of less than 2 hectares. It has cutting blades which cut the crop in a scissoring type of motion. It runs on petrol engine of 5HP, this power from engine, is provided through pulley and chain-sprocket combination to the cutter. A collecting mechanism is provided for the collection of crops to one side after cutting. This mechanism is also powered by pulley arrangement. This compact reaper harvester is manufactured using locally available spare parts and thus, it is easily maintainable. The reaper might be the solution to the problems faced by a small scale farmer regarding cost and labour implementation. Field performance evaluation result shows that, 0.075 ha/hr and 67.57% of effective field capacity and field efficiency respectively. It took 13.33 hr to harvest 1 ha area and the fuel consumption was 13.99 l/ha or 1.05 lit/hr. After testing the reaper machine in farm it is found that the cost of harvesting using this reaper harvester is considerably less as compared to manual harvesting.*

Keywords— *Harvester, reaper, scissoring action etc.*

I. INTRODUCTION

Today agriculture plays an important role in countries like Ethiopia. Wheat is one of the most important crops and staple food of millions of people which is grown in many countries of the world includes our country. In Ethiopia wheat production is increasing but in most parts of the country the harvesting of wheat is still being done manually. Manual harvesting requires about 25% of the total labour requirement of the wheat cultivation. Depending upon the crop yield, 120 to 250 man-hour required for cutting, bundling and on farm stacking of one hectare of wheat field by using traditional sickle (Nadeem, 1983).

Labour scarcity during peak period of harvesting leads to delay in harvesting and field grain losses. Also high labour wages during peak period adds extra cost in total cost of wheat cultivation. Mechanized harvesting is an alternative solution to tackle this problem. Farm machineries are needed for timely completion of various agricultural operations and to reduce the work drudgery. Appropriate and selective mechanization is needed for post-harvest management. While mechanization would augment the post-harvest management could add 5-10% more by reducing losses (Singh, 2000a). Farm mechanization will also result in lesser cost of operation.

As a step towards mechanization of the harvesting operation for cereal crops, the farmers want to recover both grains as well as the straw from cereal crops, because they need straw for their cattle’s. An alternative straw handling and disposal technology may have to be developed and promoted where farmers have adopted combines for harvesting as throwing away of straw and farmers are losing valuable animal feed material. Reapers on the other hand are other alternative harvesting equipment provided straw is considered as economic by-product for animal feed and/or industrial applications (Singh, 2002). Hence, keeping these facts in view, this project was initiated to adapt and develop engine operated reaper to minimize the cost of harvesting of wheat crop through farm mechanization.

II. MATERIALS AND METHODS

Materials

The construction materials were selected on the basis of strength requirement of various components of the machine working mechanism.

TABLE 1. Material used for various components

Sr. no.	Component	Material used
1	Frame	Mild steel
2	Ground wheel	Mild steel and rubber
3	Shafts :- 1. Ground wheel shaft 2. Idle shaft (v-belt pulley shaft) 3. Rotating disc shaft 4. Rotating pulley shafts	High carbon steel
4	Crop divider	G.I. sheet
5	Star wheel	Plastic
6	Cutter bar	High carbon steel
7	Handles	Mild steel
8	Chain	High carbon steel
9	Belt	Rubber
10	Shaft pulley	Cast iron and aluminum
11	Sprocket	Gun metal & Mild steel
12	Bearing	Standard

Methods

This section deals with the procedures adopted to develop different functional parts of the reaper, operational parameters on the performance of the developed machine. It also describes the crop conditions. The field experiments for the evaluation of the machine were carried out at farmer’s wheat field. Range of variables for the study was conducted based on the literature reviewed and preliminary test trials conducted on the machine.

Machine Description

The developed reaper consists of the header, conveyor unit, power unit, transmission system, frame and wheels. The header carries the cutter bar and the driven-shaft of the conveyor unit (Fig. 1). When the reaper started to walk through the wheat field, the cutter bar reaps the straw using slider crank mechanism to reciprocate sets of knives moving between ledgers; the reaped straw falls on the ground.

Figure 1. The developed engine operated reaper and during harvesting

Design Assumptions and Considerations

Empirically recommended design parameters were used to design reaper functional elements. Critical speed and capacities for different elements were used in the designing process. The important functional elements in which speeds and capacities were the major design factors.

Determination of crop cutting unit

Width of cutting (length of cutter bar) (Lc):- based on the standard the row to row spacing of cereal crops (wheat row to row spacing: - 20 cm).

Therefor the length of cutter bar selected on the base of above condition Lc = 0.5 m selected

Type of cutter bar: - a reciprocating type cutter bar having 76.2 mm stroke length and two cuts per stroke is generally used.

$$No.of\ knife\ section = \frac{L_C}{Size\ of\ knife\ section} \quad 1$$

$$No.of\ knife\ section = \frac{500}{76.2} = 6.56 \approx 7$$

The velocity of knife section is a function of forward speed of the machine expressed as:-

$$V_K = R \times V_f \quad 2$$

Where, V_K = average knife velocity, m/s

V_f= forward speed of the machine, m/s

R = velocity ratio

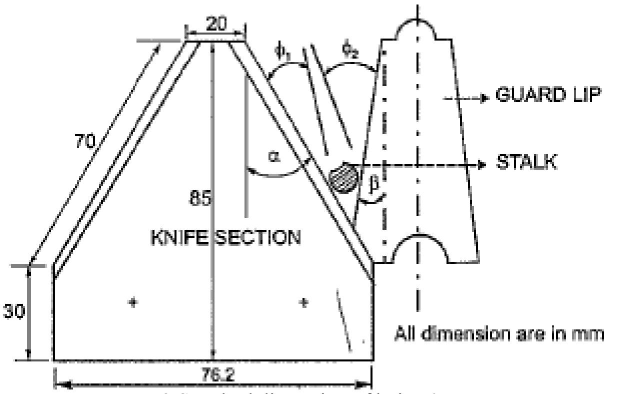

Figure. 2 Standard dimension of knives' section

According to Klenin (1985) and Bansal(1989)for α of 31^0 the knife velocity should be 1.5 m/s the value of R falls between 1.3 to 1.4 with available cutter knives.

Let take R=1.4 and forward speed of machine (V_f) of 0.75 m/s and putting the value in the above equation, we get:-

$$V_K = 1.4 \times 0.75 = 1.1 m/s$$

Also we know that: - $V_K = X \times \frac{N_K}{30}$ 3

Where, X= stroke length or standard knife section 76.2 mm

N_K= Rotational speed (rpm) of knife section (rotational speed)

V_K = average knife velocity, m/s

Therefore, $N_K = V_K \times \frac{30}{X}$

$$N_K = 1.1 \times \frac{30}{0.0762} = 433 rpm \approx 450 rpm$$

Based on the above discussions on design parameters, the dimensions of different components of crop cutting units selected are summarized in table 2.

TABLE 2. Specification of selected crop cutting unit of the reaper

Particulars	Specifications
Type of cutter bar	Reciprocating knife sections
Material	High carbon steel
Length of cutter bar	500 mm
Knife section	Standard
Types of blade	Serrated
stroke length	76.2 mm
Angle between cutting edge &axis of knife section (α)	31^0

Shafts

Four shafts were used as parts of the components for the construction of the reaper machine. They are: the shaft to drive the machine wheel and the shaft to drive the conveyor-roller and the driven-shaft; and the shaft to transmit power away from the petrol engine.

Slider crank mechanism

The slider crank mechanism is used to convert rotary motion to linear sliding motion. Scissoring action is obtained due to reciprocating movement of cutter blade over stationery blade is used to cut the crops.

Star wheel

The cut crop is conveyed with the help of star wheel at one side by the lugged belt conveyer for easy collection and bundling. The star wheel was designed on the basis of minimum required speed of star wheel. According to Datt, P. and Prasad, J., (2000) for good performance of the machine the optimum inclination of the star wheels should be 22° with the horizontal.

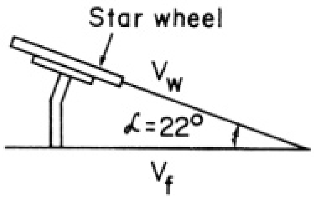

Figure 3. Side view of star wheel

The horizontal component of star wheel velocity should be greater than or equal to forward speed of machine (Datt, P. and Prasad, J., 2000) and the velocity of star wheel (Vsw) is given by:-

$$\frac{V_f}{\cos\alpha} \angle V_{sw} \quad (4)$$

Where, V_{sw} = average speed of star wheel, m/s
V_f = forward speed of machine, m/s
α = angle of inclination of star wheel.

The normal walking speed of human is about 0.7- 0.8 m/s. therefore; 0.75 m/s forward speed of machine is selected. Thus, for a 22°angle the above expression simplifies to: $V_{sw} > 1.08\ V_f$

Therefore, $V_{sw} = 1.08 \times 0.75 = 0.81$ m/s

TABLE 3. Selected standard star wheel specification

Particular	Specification
Outside diameter (Do)	300 mm
Inside diameter (Di)	150 mm
Internal diameter of star wheel (d)	15 mm
Material of star wheel	Plastic

The star wheel which is driven by the conveyor belt lug has a linear speed at the tip equal to the conveyor belt. The star wheel rotates with their own axis and the angular speed of the star wheel can be calculated as:-

$$\omega_{sw} = \frac{V_{sw}}{R_{sw}} \quad (5)$$

Where: -R_{sw} = radius of star wheel and equal to 150mm.
V_{sw} = linear speed of star wheel and equal to the speed of belt conveyor.
ω_{sw} =Angular speed

$$\omega_{sw} = \frac{0.81}{0.15} = 5.4 rad/\sec = 52 rev/\min$$

The star wheels have outer diameter of (Do = 300 mm) and inner (Di = 150 mm). The length of star wheel wing can be calculated from the relation of its star wheel diameter.

$$L_s = \frac{D_O - D_i}{2} \quad (6)$$

Where - L_s =length of star wheel wing

$$L_s = \frac{300-150}{2} = 75mm$$

Crop conveyor

The cut crop by the machine is conveyed to one side by the lugged belt conveyor at an angle of 90 for easy collection and bundling. For this purpose the conveyor of the machine must convey the bunch of cut crop on a vertical platform continuously without blockage. Therefore, the rate of cut crop conveyed by the conveyor should be greater than the crop cut by the cutting unit of the reaper. The speed of lugged belt conveyor is given by:-

$$V_b = 1.4 \times V_f \quad (7)$$

Where, = Peripheral speed of flat belt (m/s)
V_f = Machine forward speed (m/s)

Therefore, $V_b = 1.4 \times V_f$
$V_b = 1.4 \times 0.75 = 1.05$ m/sec

Working principle

The machine will be a walking behind type of reaper which is powered by the engine. The engine power is transmitted to cutter with the combination of V-belt and chain-sprocket mechanism. Reciprocating cutter blade slides over fixed blade and creates scissoring action responsible for cutting the crops. After cutting, the cut crop is conveyed with the help of star wheel at one side by the lugged belt conveyer for easy collection and bundling.

Performance evaluation of the machine

Performance evaluation was conducted based on FAO (1994) standards of agricultural machineries performance evaluation procedures. The performance data were categorized as data for test conditions and data for performance measures. The data for test conditions included, crop parameters, condition of the field, and condition of the machine and operator. Performance measures were harvesting capacity, harvesting efficiency, harvesting losses and labour requirements.

Crop parameters

Condition of the crop include crop kind, crop variety, susceptibility to shattering, ripening stage, plant density, lodging angle of the crop plant, moisture content of the stem and the grain at the time of harvesting as well as potential yields per hectare. The crop conditions have influence on the performance of harvesting machine.

Height of plant

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

Plant population

The populations of the harvested crops were counted within 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 cut both for reaper harvesting and manual harvesting were measured from the base of stem to the tip of the top cutting tip at five randomly selected places of each test plots by measuring tape.

Moisture content

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

$$\text{Moisture content},\% = \frac{W_1 - W_2}{W_2} x100 \quad 8$$

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

Machine performance parameters

Performance of the machine includes the operational speed, field capacity (ha/h), percentage of grain losses, fuel consumption per hour (L/h) and man-hours required of machine harvesting and conventional method which was harvesting by sickle. The field performance evaluations of the machine were conducted as per FAO test standards (FAO, 1994).

Speed of operation

The working speed was determined by marking the length of 20m and the reaper was operated in the marked run length. A stop watch was used to record the time for the reaper to travel the marked run length so that the speed of travel was computed in ms^{-1}.

Theoretical field capacity

Theoretical field capacity is computed from the rate of field coverage of the machine, based on hundred percent of time at the rated speed and covering hundred percent of its rated width. The theoretical field capacity was determined by using the following relationship:-

$$\text{Theoretical field capacity,ha h}^{-1} = \frac{\text{Width (m)} \times \text{Speed (km/h)}}{10} \quad 9$$

Effective field capacity

Effective field capacity is computed from the actual area covered by the reaper based on its total time consumed to harvest a given plot and computed by the following relationship:-

$$\text{Effective field capacity,ha h}^{-1} = \frac{\text{Total area covered,ha}}{\text{Total time taken,h}} \quad 10$$

Field efficiency

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

$$\text{Field efficiency,\%} = \frac{\text{Effective field capacity, (ha/h)}}{\text{Theoretical field capacity, (ha/h)}} x100 \quad 11$$

Fuel consumption

The fuel consumption was having direct effect on economics of the machine. The fuel consumption was measured by refill method. The fuel tank of the reaper-binder was filled at its full capacity. The machine was run in the field at constant speed. After completion of 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

Harvesting loss is the amount of grains and ear heads fallen on the ground due to harvesting actions. After harvesting, grains and ear heads which has been fallen within 1m^2 metal frames was recorded. This harvesting loss (W_2) was repeated at seven different places chosen randomly within a plot.

Conveying loss

Conveying loss is the amount of grain and 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 the grain and ear heads remaining on the polythene sheet were recorded as conveying loss (W_3) in g/m^2.

Thus, the total harvesting losses were calculated described as follows (Mohammad Reza *et al.*, 2007).

$$W_t = W_1 + W_2 + W_3 \quad 12$$

Where; - W_t = 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}

Percentage of harvesting losses

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

$$H = \frac{W_t - W_1}{Y_g} x100 \quad 13$$

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

Harvesting cost for both manual and reaper were determined. In machine harvesting, the costs included labour, machine depreciation, machine repair, fuel and lubricants. Labour cost included wages for the machine operator and the assistant operator. The harvesting cost for reaper calculated on the basis of fixed and variable costs.

Fixed Costs

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

$$\text{The annual Depreciation, D} = \frac{P - S}{L} \quad 14$$

Where, P = purchase price (Birr),
S = selling price (Birr),
L = Useful life, yr.

Interest on Investment is an actual cost in agricultural machinery was calculated by Straight Line Method.

$$\text{Interest on Investment, I} = \frac{P + S}{2} i \quad 15$$

Where, P = Purchase price, Birr.
S = Resale value, Birr.
i = annual interest rate
Shelter, Tax and Insurance cost of the machine were annually estimated as follows:-

$$\text{Shelter, Tax and Insurance, STI} = 2.5\% p \quad (16)$$

$$\text{Total Fixed Cost}\left(\frac{\text{Birr}}{\text{Yr}}\right) = D + I + \text{STI} \quad (17)$$

$$\text{Fixed Cost}\left(\frac{\text{Birr}}{\text{ha}}\right) = \frac{\text{Total Fixed Cost}\left(\frac{\text{Birr}}{\text{Yr}}\right)}{\text{Total Area Coverage}\left(\frac{\text{ha}}{\text{Yr}}\right)} \quad (18)$$

Variable Costs

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

$$\text{Fuel Cost}\left(\frac{\text{Birr}}{\text{ha}}\right) = \frac{\text{Fuel consumed}\left(\frac{\text{Litre}}{\text{Day}}\right) \times \text{Pr}\,ice\left(\frac{Birr}{Litre}\right)}{\text{Area Coverage}\left(\frac{\text{ha}}{\text{Day}}\right)} \quad (19)$$

$$\text{Oil Cost}\left(\frac{\text{Birr}}{\text{ha}}\right) = 15\% \text{ of fuel cost} \quad (20)$$

$$\text{Loubor Cost}\left(\frac{\text{Birr}}{\text{ha}}\right) = \frac{\text{Sum of wages of loubors}\left(\frac{\text{Birr}}{\text{Day}}\right)}{\text{Area Coverage}\left(\frac{\text{ha}}{\text{Day}}\right)} \quad (21)$$

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$$\text{R\&M}\left(\frac{\text{Birr}}{\text{Yr}}\right) = 3.5\% \text{ of purchase price} \quad (22)$$

$$\text{Total Variable Cost}\left(\frac{\text{Birr}}{\text{ha}}\right) = (\text{F} + \text{O} + \text{L} + \text{R\&M})\frac{Birr}{ha} \quad (23)$$

$$\text{Total cost of Harvesting}\left(\frac{\text{Birr}}{\text{Yr}}\right) = \text{Fixed cost}\left(\frac{\text{Birr}}{\text{ha}}\right) + \text{Variable cost}\left(\frac{\text{Birr}}{\text{ha}}\right) \quad (24)$$

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).

$$\text{Break-even point, B} = \frac{F}{V_a - V_m} \quad (25)$$

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)

III. Results and Discussion

The reaper was evaluated for its performance by harvesting of wheat during 2018/19 harvesting season. The experiments were carried out in the extent of 0.24 ha at farmer's wheat field. The performance evaluation of the reaper was obtained during the field tests by harvesting of wheat crop. The performance of the reaper was based on average height of cut, forward speed, 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 4 and 5.

Crop Parameters

The results of field performance based on test conducted are summarized in Table 4. The mean values of plant height, number of tillers, plant population and height of cut were 109.67 cm, 5,270/m^2 and 16 cm respectively.

TABLE 4. Details of crop parameters

Particulate	Harvesting Methods				
	Reaper 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	15	17	16	16	35
Condition of crop	erect	erect	erect	-	erect
Grain moisture content, %	10.29	10.60	9.89	10.26	10.35
Straw moisture content, %	9.32	8.97	9.28	9.19	9.42

Machine Performance parameters

TABLE 5: Test results of reaper harvester compared with manual harvesting by sickle

Parameter	Harvesting Methods				Manual harvesting
	Mechanical harvester				
	Trial				
	1	2	3	Average	
Actual area covered (ha)	0.03	0.03	0.03	0.03	0.03
No. of Labours	1	1	1	1	5
Total time of operation (min)	25.02	23.00	24.20	24.07	44.40
Effective working width (cm)	50	50	50	-	-
Operating speed (km/hr)	2.21	2.25	2.17	2.21	-
Theoretical field capacity (ha/hr)	0.111	0.113	0.109	0.111	-
Effective field capacity (ha/hr)	0.072	0.078	0.075	0.075	0.008
Field efficiency %	64.86	69.03	68.81	67.57	-
Labour requirement, man-hr/ha	13.89	12.82	13.33	13.35	125
Fuel consumption (lit/hr)	1.02	1.13	0.99	1.05	-
Fuel consumption (lit/ha)	14.20	14.53	13.25	13.99	-
Potential grain Yield (gm/m^2)	632.46	672.67	619.06	641.4	641.4
Harvesting losses (g/m^2)	19.60	18.30	19.50	19.13	14.50
Harvesting losses (%)	3.10	2.72	3.15	2.98	2.26
Conveying loss (g/m^2)	6.40	6.86	6.32	6.53	6.67
Conveying loss, %	1.01	1.02	1.02	1.02	1.04
Total harvesting loss, %	4.11	3.74	4.17	4.00	3.30

Table 5 presents the field performance results of reaper for wheat crop. The mean values of the performance parameter that include cutting width, cutting height, operating speed, theoretical field capacity, effective field capacity and field efficiency are presented in Table 4 and 5. The cutting width was 0.5 m and the operating forward speed of the machine was found 2.21 km/h. The actual field capacity of the reaper for wheat crop was 0.075 ha/hr. The theoretical field capacity of the machine is a function of speed of travel and cutting width and computed result is 0.111ha/h. Field efficiency of reaper harvesting machine was 67.57%. In manual harvesting with sickle, on average one person can harvest $80m^2$ /hr, but this amount can be differ with respect to crop condition, laborer ability and weather condition. The required time for harvesting one hectare of wheat in manual harvesting was 125 man-h/ha compared to 13.35 man-h/ha for the reaper (Table 5). The reaper was 9.36 times faster compared to manual harvesting.

Harvesting Losses

The amount of grain loss due to harvesting, conveying losses, windrowing, collection and bundling for reaper and manual harvesting with sickle are shown in table 5. The mean percentage of conveying losses in reaper and manual harvesting for wheat crop were 1.02% and 1.04% respectively and that of harvesting losses were 2.98% and 2.26% respectively. The percentage of total grain (conveying and harvesting) losses in reaper harvesting was recorded 4%. Similar results were reported by Singh *et.al.* (1988).The higher harvesting loss may happen due to unleveled field. Devani and Pandey (1985) designed and developed a vertical conveyor belt windrower for harvesting wheat crop. They concluded that, the total harvesting losses were in the range of 4 to 6 % of grain yield when grain moisture content was 7 to 11 %.

Cost Analysis

The estimated production cost of the reaper including engine costs are 34,541birr. The annual fixed and variable costs of the reaper were computed as 21,303.75 birr and 15,886.92 respectively. The working hour of the reaper was considered 240 hours per year. The fixed cost and variable costs for both reaper and manual harvesting are presented in Table 6. In this study, manual harvesting required 16 man-days to harvest one hectare of wheat field. Considering the labor cost as 150birr per day, 2400 birr/ha was required for manual harvesting, whereas 1021.52 birr/ha was calculated for reaper harvesting (Table 6).

Net savings per hectare area (Table 7) of 839.70Birr/ha could be saved as compared reaper harvesting against manual harvesting. This net saving comes because of higher field capacity of reaper 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 is found to be decreased gradually with the increase of harvesting area. However, break-even point is 3 ha of land where same cost will be found for both of reaper and manual harvesting. This break-even point indicates that the reaper would be beneficial to the farmers when the area of the harvesting land is more than 3 hectare of land per year. From this analysis, it was found that reaper would be beneficial to the farmers when the harvesting area exceeds the break-even point.

TABLE 6: Estimated total cost of reaper 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					
Depreciation	3,108.69	205.60	12.95	2400	19.20
Interest	949.88	62.82	3.96		
Taxes, insurances and shelter	863.53	57.11	3.60		
Total fixed cost	4,922.10	325.53	20.51		
Variable cost					
Fuel	4,186.42	276.88	17.44		
lubrication	627.93	41.53	2.62		
labor	4,500.01	297.62	18.75		
Repair and maintenance	1208.94	79.96	4.98		
Total variable cost	10,523.30	695.99	43.79		
Harvesting cost	15,445.4	1021.52	64.30	2400	19.20

TABLE 7: Comparison of savings by the reaper harvesting per hectare

Particulars	Calculation	Amount (Birr)
Cost of manual harvesting (16 man-days/ha)	16×150	2400
Cost of machine harvesting/ha	1021.52	1021.52
Gross savings	2400−1021.52	1,378.48
Cost of total output (6414 kg/ha @ 12 birr/kg)*	12×6414	76,968
Loss in reaper harvesting, (4.00%)	76,968 ×0.04	3078.72
Loss in manual harvesting (3.3%)	76,968 ×0.033	2539.94
Excess loss due to manual harvesting	2539.94 - 3078.72	-538.78
The net savings per hectare	1,378.48+ (-538.78)	839.70

*Considered the production of wheat 64.14 quintal per hectare

IV. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Wheat crop was harvested using engine operated reaper. Based on the field performance evaluation was observed that the actual cutting width of the reaper was 50 cm. The effective field capacity of the reaper was 0.075 ha/hr with a field efficiency of 67.57%. It took 13.33 hr to harvest 1 ha area and the fuel consumption was 13.99 l/ha or 1.05 lit/hr.

The labour requirement was found to be 13.35 man hours per hectare without including manual collection and bundling of the harvested crop compared to 125 man hours of labour per hectare in manual harvesting, without collecting and bundling of the crop. Thus, it saved 111 man hours of labour per hectare.

From the study, it can be concluded that the engine operated reaper could be used successfully with a labour saving of 111 man hours per hectare and reducing the drudgery of labours. The area of 0.60 ha can be harvested per day if the field capacity is kept as 0.075 ha/hr. Considering the two months harvesting season, the maximum area that can be harvested using the engine operated reaper will be 18 ha.

If the machine is used for the maximum usage of 18 ha in a year, the cost of mechanical harvesting will be 1021.52 birr/ha as compared to 2400 birr/ha in case of manual harvesting. Thus it is feasible to minimize the cost of operation of wheat harvesting. Thus mechanization in wheat harvesting is a feasible solution for reducing the cost of harvesting of wheat crops.

Recommendations

From the study it was found that the use of reaper was more beneficial than manual harvesting for harvesting of wheat. Based on the advantages of mechanization provided by reaper, there is the need to improve and explore its full potential. Thus, the following are recommended for the future improvement of the reaper:

i. Grain loss in reaper should be minimized by improving its ground wheel from metal wheel to tire and land leveling should be considered, so as to avoid grain losses.

ii. Further studies should be conducted to determine the performance measure of the reaper in different cereal crops such as barley and rice harvesting as well as determining reaper performance at different speeds.

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