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COST ANALYSIS OF ENGINE OPERATED REAPER AND ITS COMPARISON WITH TRACTOR MOUNTED REAPER

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Economic recession in Pakistan emphasize the small farmers to use small farm machinery to save their time and high labor cost. Being an agricultural country, Pakistan is producing good quantity wheat and other crops, which does not only full fill the food and fiber demand of Pakistan, but also a major source of foreign exchange. High initial cost of machinery and heavy taxes from Government are considered the major hindrance in adoption of agriculture machinery is Pakistan. The current study was carried out to evaluate the operating costs of traditional tractor operated reaper and engine operated reaper. It is concluded that engine-operated reaper can save Rs. 1517.80 ha^{-1} (\$ 18.97 ha^{-1}). This study also showed that farmer could have their own small harvesting machinery with low initial cost as compared to the tractor mounted reaper. Breakeven analysis showed that farmer could get back its original investment within 15 days of operation.
Keywords*:* Breakeven analysis, cost analysis, , engine operated reaper, tractor mounted reaper, wheat harvesting

INTRODUCTION

Pakistan is one of the agro-based countries in South Asia. Agriculture plays an important role in the economy of Pakistan. It contributes 24% of the country's GDP and 48% of the workforce (Zaheer, 2013; Economic Survey of Pakistan, 2013).

About 67% of Pakistan's residents are living in villages. They are attached (directly or indirectly) with agriculture for their survival (Economic Survey of Pakistan, 2013, FAO, 2004). The agriculture sector is not only fulfilling the demand for food and fiber in Pakistan, but also contributes 75% of the foreign exchange (Raza *et al.*, 2012). There are four important inputs in every agricultural operation such as seed, fertilizer, soil and mechanization. Mechanization is one of the important input. Agricultural mechanization includes chemical technology, hydrological technology and mechanical technology to increase the farm yield. Mechanization can also be defined as the use of agricultural machinery for the betterment of agricultural sector. (Iqbal *et al.,* 2015; Roohi, 2007).

Agricultural sector is facing many challenges. These challenges may include the climatic changes, depletion of water, soil degradation, soil compaction, salinity, air and water contamination through pesticides, labor shortage, high cost of production (Velten *et al*., 2015).

The shortage of labor remains the biggest problem during the peak season of harvesting in Pakistan. The farmers have to pay more money for harvesting (Nadeem *et al.,* 2015; Rahman *et al.,* 2011; Alha and Yonzon 2011). Even harvesting with mechanical harvester is very costly and farmers do not get the straws for their animals. The focus of this paper is to introduce a cost effective harvesting machine (engine operated reaper) for small farmers in developing countries like Pakistan and present a cost analysis of this harvesting machine.

Conventionally, the tractor-mounted reaper is very famous for harvesting rice and wheat in Pakistan. The development of harvesters not only reduces the timing of harvesting, but also overcomes the labor shortage and facilitates the multi-croping pattern in Pakistan. High prices of agricultural machinery and small land holdings in Pakistan are the main restrictions for the adoption of agricultural machinery (Nadeem *et al.,* 2015; Tahir, 2003).

Many researchers (Nadeem *et al*., 2015; Ramani *et a*l., 2015; Shreen *et al*., 2014; Zami *et al*., 2013; Parida, 2008; Alizadeh *et al*.,2007) developed and evaluated the performance of self-propelled reapers. Nadeem *et al.*, (2015) developed an engine-operated reaper and evaluated its performance. This reaper was tested for % slippage, % shatter losses and % field efficiency on three different forward speeds and three different moisture contents for wheat, rice and brassica crops.

The study concluded that the use of self-propelled reaper not only overcomes the increasing demand of labor but also a very cheap option for small farmers.

Ramani *et al.* (2015) evaluated the performance of manual reaper (battery operated imported reaper ACI) with the manual traditional harvesting (sickle harvesting) of rice crop. They concluded that labor requirement for harvesting with manual reaper was very low (24 men-hr-ha^{-1}) as compared to the manual traditional harvesting method (180 men-hr-ha^{-1}). They also reported that manual reaper is 11.2 times more efficient as compared to the manual traditional harvesting. The breakeven of manual reaper was achieved at 0.4 ha.

Shreen *et al.* (2014) evaluated two different methods of harvesting. One is conventional or traditional harvesting (sickle cutting) and second is semi mechanized harvesting (tractor-mounted reaper, self-propelled reaper, reaper cum binder). They concluded that if wheat is harvested at high moisture contents with medium travel speed then shatter losses can be reduced and cutting efficiency of harvesting machinery can be increased significantly. Zami *et al.* (2013) compared the performance of locally made reaper with Chinese reaper and manual harvesting. They concluded that manual harvesting needs more work force (248 men-hr-ha^{-1}) as compared to Chinese (69 men-hr-ha^{-1}) and locally made BRRI reaper (68 men-hr-ha^{-1}). They suggested to local farmers to use BRRI reaper because of its low cost (almost half) as compared to the china made reapers.

Parida (2008) evaluated a tractor-mounted reaper and three different self-propelled reapers. A large difference was found between the field capacities of tractor mounted (0.34 ha-h^{-1}) and self-propelled reapers (0.19 ha-h^{-1}). Alizadeh *et al.* (2007) compared the performance of manual harvesting with a self-propelled rice reaper. The field capacity of manual harvesting (0.170 ha-h^{-1}) was significantly different from self-propelled rice reaper (0.008 ha-h^{-1}). The labor requirements for manual harvesting (128 men-h-ha^{-1}) were significantly higher than those of mechanical harvesters (5.88 men-h-ha^{-1}).

Keeping in view the above discussion, the present study was designed to evaluate the different costs of engine-operated reaper and compared the cost with tractor mounded reaper. Several dealers are selling small machineries in different parts of the country without proper maintenance. The Government of Pakistan has imposed heavy taxes on the import of agricultural machinery, which is the biggest obstacle to the adoption of small machines in this country. These issues emphasized the production of small machineries for small farmers with an affordable price. The focus of this study is to evaluate the costs of conventional tractor mounted reaper with newly designed engine operated reaper. This cost analysis will help small farmers in selecting the reaper based on their farm size and capacity. The division of the land among off springs and the increasing population will certainly increase the demand for such small machinery in Pakistan.

MATERIALS AND METHODS

The current research was conducted in three different fields of wheat in the research area of the University of Agriculture, Faisalabad (UAF), Pakistan. All the mechanical work was done in the Department of Farm Machinery & Power, Faculty of Agricultural Engineering, University of Agriculture, Faisalabad (UAF), Pakistan.

***General specifications of engine operated reaper*:** This machine consists of the following parts: 1) Handrail 2) diesel engine 3) gearbox construction 4) platform (cutter bar, row divider, crop distributor, conveyor chain) 5) grain trailer (Fig. 1)

The total length, width and height of the reaper are 2.33, 1.65 and 1.05 m respectively. The total swath width of the cutter bar is 1.54 m (which is always less than the total width of the machine). Two conveyor chains mounted in the front of reaper are used to transport the cut crop on the right hand side. The power source of this machine is a diesel engine of 5.74 kW.

For more details of design and other specifications, please see the Nadeem *et al.* (2015).

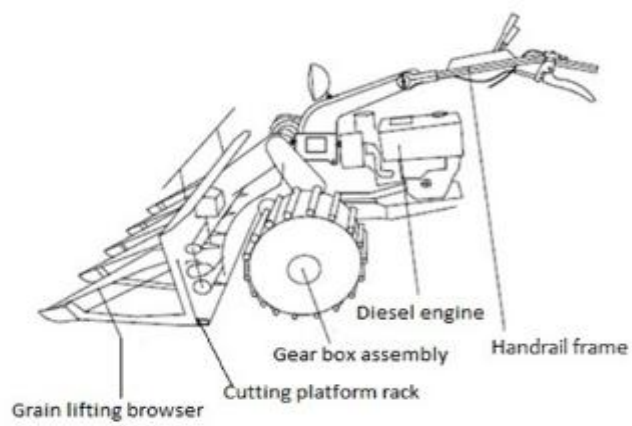

Figure 1. Schematic representation of the engine operated reaper

***Cost analysis of reaper*:** Machine management includes an important element of finance. This element is more than the cost of the machine itself (Edwards, 2015). The following two types of costs were calculated for an engine operated and a tractor mounted reapers.

1. Ownership cost
2. Operating cost

Ownership cost: Ownership costs of machines are the costs of the machine at the time of purchase, also called fixed costs. Fixed costs always occur in the ownership of a machine, regardless of how much it is used. Fixed costs are influenced more by how long a machine is owned than how much it is used. Fixed costs can vary from 60 to 80 percent of the total machine costs (Jacobs and William, 1987). In general accounting practices the fixed cost consists of the following five elements: depreciation, interest (alternative costs), insurance, housing and maintenance costs (Edwards, 2015).

***Depreciation*:** The most important costs of a machine are the first costs. However, a machine will last for several years. Fixed costs are therefore amortized over several years (spread evenly). Buying a machine may mean that you borrow money and pay on installments. As a machine ages, it loses value or decreases. The age of a machine thus reflects its value. A new machine is worth more than an old one. There are different methods to determine the depreciation, for this research, the linear depreciation method is used. (Zandin, 2005).

It is the most conventional method of depreciation. In this method, the salvage value of the machine is determined first, which is usually 10 to 15% of the first costs, but sometimes vary from 15 to 20% (Edwards, 2015). The residual salvage is then subtracted from the initial costs and the remainder is divided by the number of years of useful life (Zandin, 2005).

$$D_s = \frac{P-S}{L} \qquad (1)$$

Where; D_s= depreciation by straight line method, P=purchase vale (first value), S = salvage value, L= life as useful years

***Interest*:** The costs of owning machines include a fee for interest. Interest is considered an opportunity cost. This means that by investing in machines, we have lost the opportunity for interest on a savings account or other interest income. The amount of interest charged, including financing, is determined by half of the purchase and residual value times the interest charge (Edwards, 2015).

Interest was calculated by using the following formula (Edwards, 2015).

$$I = \frac{P+S}{2} \times i \qquad (2)$$

Where, I = interest, P= purchase value, S= salvage value, i= interest rate

***Taxes, housing and insurance (THI)*:** Taxes, housing and insurance are much smaller than depreciation and interest. Machines are a personal property and are taxed according to state and local legislation. The need for machine housing varies depending on the climatic conditions in the country. It is generally agreed that machines that are protected against the effects of the weather would require fewer repairs. Housing for machines may include the service center for maintenance and repair. Insurance must be added for unforeseen circumstances in future. THI is usually 1-2% of the average value of the machine (Edwards, 2015, Jacobs and William, 1987, Yasin *et al*. 1986).

***Operating costs*:** Operating costs are the costs that arise as a result of the actual use of the machine. They vary with the amount of annual use. In the general accounting practices, the variable cost consists of the following labor costs for operating the machine, fuel and lubrication costs, repair and maintenance costs (Edwards, 2015).

***Labor to operate the machine*:** There is some hesitation in including labor costs in operating costs when we do our own work. However, labor is an important operational cost and must always be assigned a value. The cost of labor becomes an important factor in evaluating the size of the machine to be purchased. The hours used to store a large machine often prove to be an important decision factor. When hired labor is used to operate the machine, the actual hourly rate is used to calculate labor costs (Yasin *et al*. 1986).

***Fuel and lubricants*:** Tractor and engine operated reapers are powered by an internal combustion engine, which requires fuel and lubricants to work. The fuel consumption varies depending on the power of the engine and the type of fuel being used. A well-maintained tractor engine produces the most power for the fuel used. Lubrication costs are normally considered as 15% of the fuel costs. (Edwards, 2015).

***Repair and maintenance*:** Agricultural machinery must be kept in the right operating condition to be reliable. Timeliness of activities is one of the critical factors for achieving maximum crop production. The repair and maintenance costs vary depending on the life of the machine. Normally this is considered to be 15% of the average value of the machine (Edwards, 2015, Yasin *et al*. 1986).

***Breakeven analysis*:** For cost analysis, fixed costs and variable costs of the reaper were determined to find the break-even point of the machine.

RESULTS AND DISCUSSION

***Cost analysis of an engine operated reaper*:** The first requirement of a newly developed machine is to perform the intended function satisfactorily. However, economic aspect of machine plays a vital role in its adoption by the end user (farmers). Cost analysis of engine operated multi crop reaper and tractor-mounted reaper was undertaken to assess the economic feasibility. The detail discussion is given below:

***General information for cost calculations*:** Price of an engine operated reaper P = Rs. 120,000

Salvage value, S (10% of P) = Rs. 12,000

Expected machine life = 10 years

Annual use of the machine, (h) = 800 h

Total lifetime, (h) = 8000 h

***Fixed costs*:** Depreciation is calculated using the following linear method as given below (Zandin, 2005).

Ds = (P-S) / L (1)

Ds = Rs. (120000-12000) / 10 = Rs.10800

Assumed life 10 years, storage = 10%

Interest @ 12% at capital involvement = 0.12 × (120000 + 12000) / 2 = Rs.7920 year^{-1}

Housing, insurance and taxes @ 2% = Rs. 2400 year^{-1}

Total fixed costs = 10800 + 7920 + 2400 = Rs. 21120 year^{-1}

Assuming that engine operated-reaper is working 800 hours year^{-1}

The fixed costs per hour = Rs. 26.40 h^{-1}

***Variable cost*:** Repair & maintenance @ 15% = 0.15 x 120,000 = Rs.18000 year^{-1} = Rs. 22.5 h^{-1}

Bundle that makes costs (for 1 wages) = Rs. 150 h^{-1}

Diesel used per hour = 1 Lh^{-1}
Diesel costs @ 109.25 per liter = Rs.109.25
Lubricant price @ 15% fuel costs = Rs.16.38

Labor costs

An operator calculated Rs.700 per day (10 hours working)
Driver costs per day = Rs.700
Driver cost per hour = Rs.70
Total variable costs = 22.5+150+109.25+16.38+70
= Rs.368.13

***Total costs of a engine operated reaper*:** Total costs (fixed costs + variable costs) = 26.40 + 368.13 = Rs. 394 h^{-1}

One hectare harvested in five hours (measured experimentally), therefore

Total fixed costs + Total variable costs per hectare = Rs. 394.53 × 5 = Rs.1972.65 ha^{-1}

***Cost of the tractor*:**

General information for cost calculations

Purchase price of tractor MF-240, P = Rs. 671,600
Salvage Value, S (10% of P) = Rs. 67.160
Expected lifespan of machine = 10 years
Annual machine life, (h) = 1000 h
Total life = 10000 h

***Fixed costs*:** Depreciation was calculated using the following linear method as given below (Zandin, 2005).

D = (P-S) / L = (671600-67160)/10 = Rs. 60,444 $year^{-1}$
Assumed life = 10 years
Capital Involved = Rs. 369,380
Interest at 12% (anonymous, 2007) = Rs. 44325.6 $year^{-1}$
Taxes, insurance and accommodation @ 2% of the initial costs = Rs. 13432
Total fixed costs = Rs. 118201 $year^{-1}$
Assuming the tractor was used 1000 hours per year
Then the fixed costs per hour = Rs. 118 h^{-1}

***Variable Cost*:** Fuel used per hour = 5 l h^{-1}
Fuel cost per hour at Rs. 109.25 per liter = Rs. 546.25
Lubrication cost / hour @ 15% or Fuel cost = Rs. 81.93 h^{-1}
Repair @ 15% or initial cost per hour = Rs. 100 h^{-1}
Operator cost / hour @ Rs. 400 per 8 hour = Rs.50 h^{-1}
Total variable cost per hour = Rs. 778.8 h^{-1}
Total cost = total fixed + total variable cost = Rs. 896.18 h^{-1}

***Conventional tractor mounted mower*:**

General information for cost analysis

Manufacturing cost of reaper, p = Rs. 65,000
Salvage value, S (10% of P) = Rs. 6500
Expected lifespan of machine = 10 years
Annual use of the machine, (h) = 300 h
Total lifetime, (h) = 3000 h

***Fixed costs*:** Depreciation, D = (P-S) / L = (65000-6500) / 10 = Rs. 5850 $year^{-1}$
Interest @ 12% = 0.12 × (65000-6500) / 2 = Rs. 4290 $year^{-1}$
Total fixed costs = 5850 + 4290 = Rs. 10140 $year^{-1}$
Total fixed costs per hour = Rs.33.8 h^{-1}

***Variable cost*:** Repair & maintenance @ 15% = Rs. 9750 yr^{-1} = Rs .32.5 h^{-1}
Bundle making cost Rs.950 for 5 work & 2.5 hours = Rs.380 h^{-1}
Total variable costs = Rs. 32.5 + 380 = Rs. 412.5 h^{-1}
Total costs (fixed costs + variable costs) = 446.3 h^{-1}

***Variable cost*:** Repair & maintenance @ 15% = 0.15x65000 = Rs. 9750 yr^{-1} = Rs.32.5 h^{-1}
Bundle making cost Rs. 950 for 5 labor & 2.5 h = Rs. 380 h^{-1}
Total variable cost= Rs. 32.5 + 380 = Rs. 412.5 h^{-1}
Total cost (Fixed cost+variable cost) =33.8+412.5=446.3 h^{-1}

***Total operational costs of tractor mounted reaping unit* :** Total operational costs of the target stone. i.e.,

Table 1. Summary table for cost analysis.

Sr. No	Particulars	Engine Operated Reaper	Tractor (MF-240)	Tractor mounted Reaper
1	Purchase price, P (Rs.)	120000	671600	65000
2	Salvage value, S (Rs.)	12000	67160	6500
3	Useful life, L (Year)	10	10	10
4	Annual use (hrs)	800	1000	300
Fixed cost				
5	Depreciation (Rs./hr)	13.5	60.44	19.5
6	Interest, I (Rs.)	9.9	44.33	14.3
7	THI (Rs.)	3.0	13.43	-
8	Total fixed cost, (Rs.)	26.4	118.20	33.8
Variable cost				
9	Repair & Maintenance (Rs)	22.50	100.00	32.5
10	Fuel charges (Rs)	109.25	546.25	-
11	Lubricant charges (Rs)	16.38	81.93	-
12	Driver charges (Rs)	70.00	50.00	-
13	Bundle making cost (Rs)	150.00	-	380.0
14	Total variable cost (Rs)	368.13	778.18	412.5
15	Fixed + variable cost	394.53	896.18	446.3

(Reaper + tractor) = 446.3 + 896.18 = Rs. 1342.48 h^{-1}
One hectare harvested in two hours and 40 minutes
Total fixed costs + Total variable costs per hectare = Rs. 1342.48 × 2.6 = Rs. 3490.44 ha^{-1}
Table 1 shows all costs of a mower driven by a motor, mounted on a tractor.
1 CAD = Rs. 80.53* (According to June 20, 2016)
Total cost of reping with an engine operated reaper per hour = Rs. 394.53 ($ 4.89)
Total operational costs of tractor mounted reaper per hour = Rs.1342.48 ($ 16.67)
Total costs of reaping with an engine operated reaper per hectare = Rs. 1972.65 ($ 24.49)
Total operational costs of tractor mounted reaper per hectare = Rs.3490.44 ($ 43.34)
Advantages = 3490.44-1972.65 = Rs. 1517.80 ha-1 ($ 18.97 ha^{-1})
Table 1 shows that if farmers use the engine operated reaper instead of tractor mounted reaper, they can save Rs. 1517.80 ha^{-1}. After evaluating the cost benefits, the breakeven analysis of this engine was performed. All data used for breakeven analysis are taken from table 1.

***Breakeven analysis*:** Breakeven analysis focuses on the profitability of an organization / machine. Specific attention in break-even analysis is the identification of the processing level that results in a zero gain. Break even analysis is a very important tool for organization / machine when launching new products. The break-even point is a useful reference point in such a way that it indicates at which level the total income is equal to the total costs.

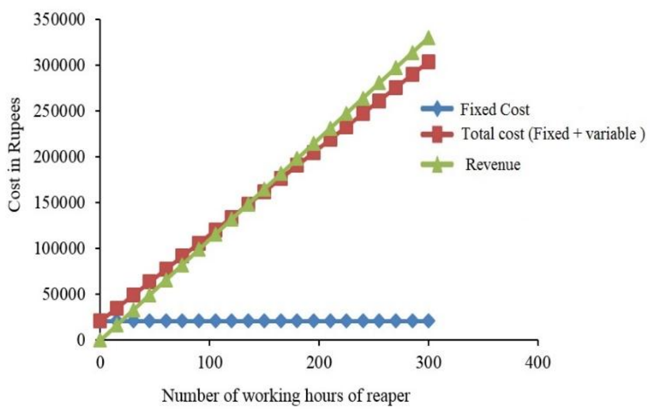

Figure 2. Break-even analysis of the engine operated reaper

The total cost of the engine-operated reaper is plotted against the total number of working hours for this reaper. Figure 2 shows that the total costs of a engine operated reaper and number of working hours cross each other at 151 hours. Therefore, the break-even point of this reaper can be reached after 15 days of use at a rate of 10 hours per day. In other words, the farmer can get his original investment back within 15 days using this reaper.

Conclusion: The study was intended to compare the feasibility of a engine operated reaper with that of the tractor-mounted reaper. The study showed that an engine operated reaper is a viable option for small farmers with very low initial costs. In addition, the use of an engine operated reaper can save Rs. 1517.80 ha^{-1}. The initial costs of tractor and tractor mounted reaper are very high. These high costs are not affordable for many small land owners in Pakistan. The results of this study also showed that farmers could reach the break-even point of this reaper just after 15 days of operation. The repair and maintenance costs of this mower are much lower than those of the tractor mounted reaper. This reaper can be a good alternative of tractor mounted reaper and manual harvesting method.

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