Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
POLJOPRIVREDNA TEHNIKA
Godina XLI
Broj 1, 2016.
Strane: 1 – 10

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
AGRICULTURAL ENGINEERING
Year XLI
No. 1, 2016.
pp: 1 – 10

338.26:332

Originalni naučni rad
Original scientific paper

COMPUTER PROGRAM FOR COST ESTIMATION OF AGRICULTURAL MACHINES

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Abstract: A user-friendly computer program is developed in Visual Basic environment to determine the all types of machinery costs on hour and hectare basis. The program is also capable to compute breakeven area and time of use of machines to get back return on investment. The input parameters of the developed program are mainly initial price, life of machine, rate of interest, fuel cost, labor wages etc. for power source as well as implement. The total cost is being calculated in two heads namely fixed and variable cost. The fixed cost consists of depreciation, interest, taxes, housing and insurance cost, while variable costs includes fuel, lubrication, wages, repair and maintenance cost. The developed program successfully calculates the cost of operation in rupees per hour and in rupees per hectare of different combinations of power sources and implements. The breakeven analysis of any combination of the power source and implement can also be analyzed. This program can be a useful tool for suggesting the farmers in purchasing a machine as well as in deciding the custom hiring rates etc. This can also help to entrepreneurs who are engaged in custom hiring services to decide the hiring rate of different machinery on the basis of breakeven analysis.

Key words*: cost of operation, breakeven point, computer program*

INTRODUCTION

Agriculture is the most important sector of Indian economy. As per recent trends, workers are migrating from agriculture to other sectors which is leading to unavailability of sufficient manpower in farm and also enhancing the labor wages. In this situation, farmers are required to use big machines/machinery such as tractor, thresher, combine

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harvester etc. for overall profitability. About 78% Indian farmers belong to small and marginal category who cannot afford to purchase all costly machinery for agricultural works. Consequently, these farmers hire the machines on payment basis either per hectare or hour basis, which is known as custom hiring. Due to increasing demands of agricultural machine, several custom hiring centers are being established by entrepreneurs, Government and non-government organizations. Calculation of operational cost as well as breakeven point is very essential to finalize the rate of custom hiring. In the absence of this information, customs hiring charges either under or over the optimum value. In both the cases, centers are running in loss because in one hand less return per hour and other hands less demand. The calculation of this information is not possible without an expert. Further, these cost calculation is regular exercise as because of frequent change in price of diesel, labor wages etc.

Many scientists have attempted to compute the cost of agricultural machineries in last decades. Beaton *et al*. [1] developed a quick and adaptable method for calculating the per unit cost to own and operate farm machinery. Abubakar *et al*. [2] provided a mathematical model for the repair and maintenance costs for the State of Nigeria but limited to the specific models of the tractor. Oluka [3] has also reported on the various factors that contribute to the ownership costs of farm tractors and the various techniques of estimating tractor costs in Nigeria under three different management systems. Khatibi and Jawawi [4] illustrated several existing methods for software cost estimation and discussed their aspects. Popovic [5] managed agricultural company through monitoring total cost of maintenance for tractor. Similarly, Todorovic [6] also worked on economically justified amount of investment in purchase of harvester at family farms. These works are basically region specific and none of the work is found for Indian condition.

Keeping these facts in mind, a study was formulated to develop a user friendly computer program for calculating the operational cost as well as breakeven analysis of agricultural machines.

THEORETICAL CONSIDERATIONS

Fixed Cost. Ownership costs are independent of use and are often called as fixed costs. It includes depreciation on equipment, interest, taxes and general overhead expenses. These costs are mathematically calculated [7] which are discussed in following sub-sections.

Depreciation means a loss in the value of a machine due to time and use. Often, it is the largest of all among fixed costs. Depreciation can be calculated in different ways, however Straight-line method is simple and easiest which is given by:

$$D = \frac{P - S}{L \times H} \tag{1}$$

where:

D [₹·h^{-1}] - depreciation cost,
P [₹] - purchase price of the machine,
S [₹] - salvage value which is an estimate of the sale value of the machine at the end of its economic life. S = 10% of purchase price.

L [years] - useful life of machine,
H [h·year^{-1}] - working hour per year.

A large expense item for agricultural machinery is interest. Interest rates vary but usually will be in the range of 9 to 12%. The following formula is used for calculating the interest:

$$I = \frac{P + S}{2 \times H} \times \frac{i}{100} \tag{2}$$

where:
I [₹·h^{-1}] - interest,
i [%·year^{-1}] - rate of interest,

Insurance is necessary against the risk of accident or disaster and is obtained from the following equation:

$$In = \frac{P \times rp}{H} \tag{3}$$

where:
In [₹·h^{-1}] - annual insurance fee,
r_p [fraction] - premium rate.

Tax is expressed in terms of rate to initial cost and approximately 0.5% to 1% is taken into account. Generally yearly taxation and its sum are calculated as follows:

$$Tx = \frac{P \times rtax}{H} \tag{4}$$

where:
Tx [₹·h^{-1}] - annual taxes,
$rtax$ [fraction] - tax rate.

Housing expense will be obtained from the following equation:

$$h = \frac{P \times rgc}{H} \tag{5}$$

where:
h [₹·h^{-1}] - annual garage cost,
rgc [fraction] - garage cost rate.

The total fixed cost of equipment is calculated by adding the depreciation cost, interest, housing, insurance and tax.

$$F = D + I + In + Tx + h \tag{6}$$

Variable cost. Costs for operation vary directly with the use are termed as variable cost which has the relation to the volume of output. This includes the fuel, lubricating, wages, and repair and maintenance cost which are calculated (Hunt, 2013 and IS: 9164-1979) as follows:

$$Fl = FC \times FR \tag{7}$$

where:
Fl [₹·h^{-1}] - fuel cost,
FC [l·h^{-1}] - fuel consumption,
FR [₹·h^{-1}] - rate of fuel.

Surveys indicate that total lubrication costs on most farms average about 15% of fuel costs and hence can be estimated by multiplying the fuel cost by 0.15.

Repair and maintenance expenditures are taken into account as it is necessary to keep the machine functional. This cost is typically variable which is directly related to the use of the machine. As per IS: 9164 (1979), the first year repair and maintenance cost of tractor is 3.2% of initial cost, however, in 10^{th} year it is 14.5%. Therefore, average repair and maintenance cost may be assumed at 6% of initial capital cost of purchase per year.

Labor cost is also an important consideration in comparing ownership to custom hiring. Actual hours of labor usually exceed field machine by 10 to 20% because of travel and the time required lubricating and servicing machines. Consequently labor costs can be estimated by multiplying the labor wage rate by 1.1 or 1.2 times.

The total operating cost is the summation of fuel, lubrication, repair and maintenance, and labor costs. And hence total cost of operation is the total fixed cost and total variable cost.

Cost Calculation on Hectare Basis. The field capacity of a farm machine is the rate at which it performs its primary function, i.e., the number of hectare that can be covered per hour. The theoretical field capacity can be defined as:

$$FC = \frac{W \times V}{10} \tag{8}$$

where:

FC [ha·h^{-1}] - field capacity,
W [m] - width of operation,
V [km·h^{-1}] - velocity of operation.

Machinery cost on the basis of hectare can be calculated as:

$$\textit{Machinery cost (₹·ha}^{-1}\textit{)} = \textit{Machinery cost (₹·h}^{-1}\textit{) / Actual field capacity (ha·h}^{-1}\textit{)} \tag{9}$$

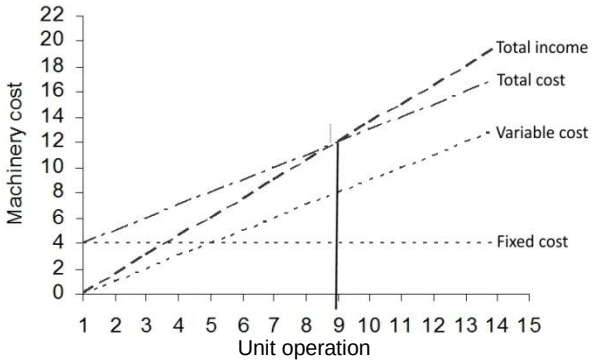

Figure 1. Breakeven analysis

Breakeven Analysis. Breakeven analysis computes the volume of operation at a given price necessary to cover all costs. The breakeven point is the intersection of the total cost line and the total income line (Fig.1). The total income line is the gross value of the output. A vertical line down from this point shows the level of operation necessary

to cover all costs. Operation greater than this level generates positive revenue; losses are incurred at lower levels of operation.

Mathematically, the breakeven point is calculated with the following formula:

$$BEP = F / (C - V) \quad (10)$$

where:

BEP [h·year^{-1}] - breakeven point,
F [₹·year^{-1}] - total fixed costs,
V [₹·h^{-1}] - variable costs per unit of operation,
C [₹·h^{-1}] - custom rate.

MATERIAL AND METHODS

Input Parameters. The input parameters for the developed computer program are mainly divided in two parts, namely power source input and implement input. The power source inputs include initial cost, life of machine, working hour per year, interest rate, taxes, housing rate, fuel consumption, fuel cost, and labor charges. Similarly, the inputs for implement are initial cost, implement life and working hour per year. The program window for input parameter is shown in Fig. 2. For breakeven analysis, a separate input is created which is shown in Fig. 3. The flow chart of the developed program is shown in the Fig. 4.

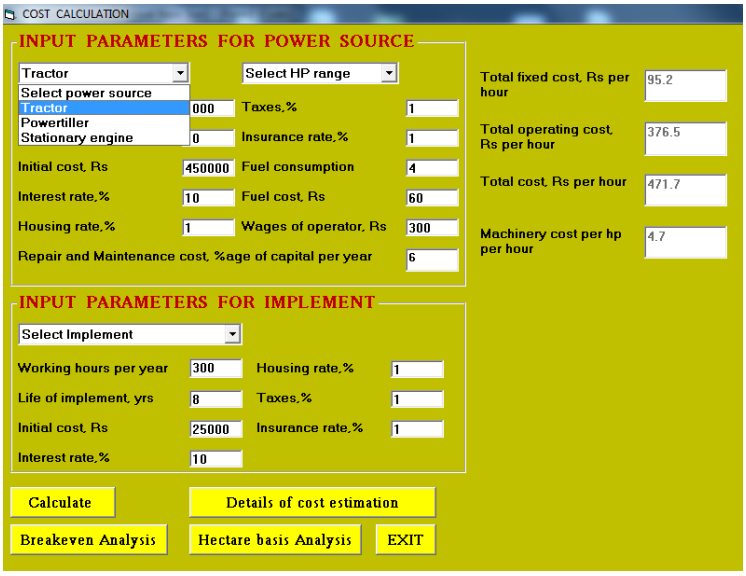

Figure 2. Program window for the input parameters

Output Parameters. The outputs of the program are mainly cost of operation on hour and hectare basis including interest, housing, taxes, insurance, fuel, lubrication, and wages cost for power source and implement separately. The output program window is shown in Fig. 5.

Figure 3. Program window for the breakeven analysis

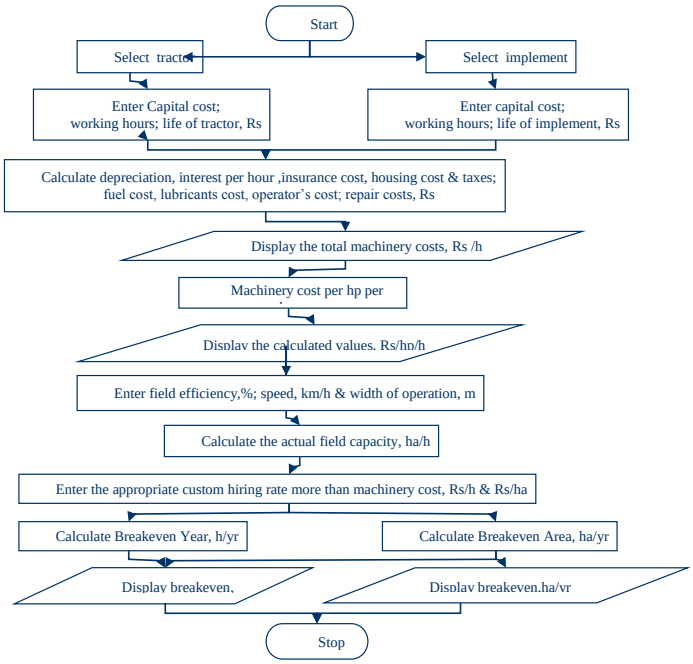

Figure 4. Flow chart of the developed program

Figure 5. Program window for the output parameters

RESULTS AND DISCUSSION

General Outputs of Software. The developed computer program was operated for three different combinations which are tractor with mould board plough, power tiller with rotavator and stationary engine with thresher. The input parameters for these combinations are given in Table 1. The software output for these runs is given in Table 2. Table indicates that the developed program is capable of calculating all components of fixed and operating cost of power source as well as for implement.

Table 1. Input parameters

Input parameters	*Tractor with MB plough*		*Power tiller with rotavator*		*Stationary engine with thresher*	
	Tractor	*Plough*	*Power tiller*	*Rotavator*	*Engine*	*Thresher*
Initial cost [₹]	*400000*	*20000*	*150000*	*10000*	*30000*	*10000*
Power [kW]	*26*	*0*	*8.94*	*0*	*3.7*	*0*
Working [hour·year^{-1}]	*1000*	*300*	*800*	*300*	*1000*	*300*
Life [years]	*12*	*8*	*10*	*8*	*10*	*8*
Fuel consumption [l·h^{-1}]	*4*		*2*		*1*	
Insurance, Housing and Taxes [%]	*1 each*					
Interest rate [%]	*10*					
Wages [₹·day^{-1}]	*300*					
Fuel cost [₹·l^{-1}]	*50*					

Table 2. Output parameters

Output parameters	*Tractor with MB plough*		*Power tiller with rotavator*		*Stationary engine with thresher*	
	Tractor	*Plough*	*Power tiller*	*Rotavator*	*Engine*	*Thresher*
Depreciation [₹·h^{-1}]	*30*	*7.5*	*16.9*	*3.8*	*1.8*	*3.8*
Interest [₹·h^{-1}]	*22*	*3.7*	*10.3*	*1.8*	*1.1*	*1.8*
Housing, Insurance and Taxes [₹·h^{-1}]	*12*	*2.1*	*5.4*	*0.9*	*0.6*	*0.9*
Fixed Cost [₹·h^{-1}]	*64*	*13.2*	*32.8*	*6.6*	*3.5*	*6.6*
Fuel Cost [₹·h^{-1}]	*200.0*		*100.0*		*50.0*	
Operator's wages [₹·h^{-1}]	*37.5*		*37.5*		*37.5*	
Lubricating Cost [₹·h^{-1}]	*60.0*		*30.0*		*15.0*	
Repair and Maintenance Cost [₹·h^{-1}]	*24.0*		*9.0*		*1.2*	
Total Operating Cost [₹·h^{-1}]	*321.5*		*176.5*		*103.7*	
Total Fixed Cost [₹·h^{-1}]	*77.2*		*39.4*		*10.1*	
Machinery Cost [₹kW^{-1}·h^{-1}]	*15.3*		*24.1*		*30.7*	

Effect of Initial Cost on Machinery Cost. The developed program was run for different initial cost of tractor with plough of 30-50 HP range to calculate various costs which is given in Fig. 6. From the figure, it is evident that fixed cost and total cost increases significantly with increase of initial cost of tractor. However, variable cost increases marginally with the increase of initial cost. The variable cost mainly depends

upon fuel, lubricating and labor costs which are independent of variable cost. The repair and maintenance is the only variable cost which depends on initial cost of tractor.

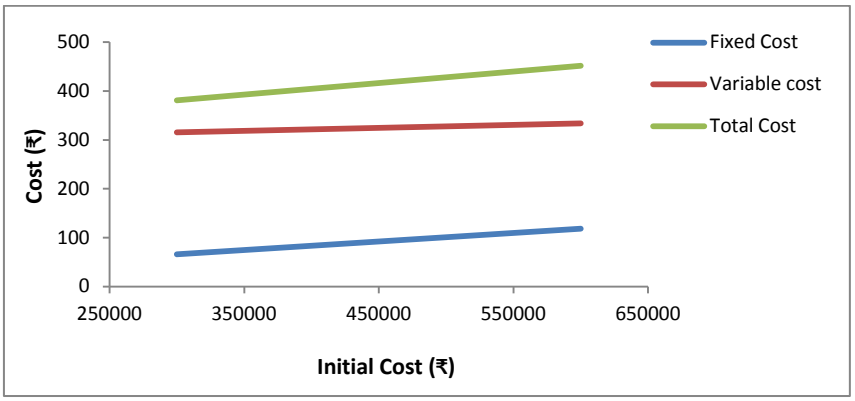

Figure 6. Relationship between initial cost and machinery cost

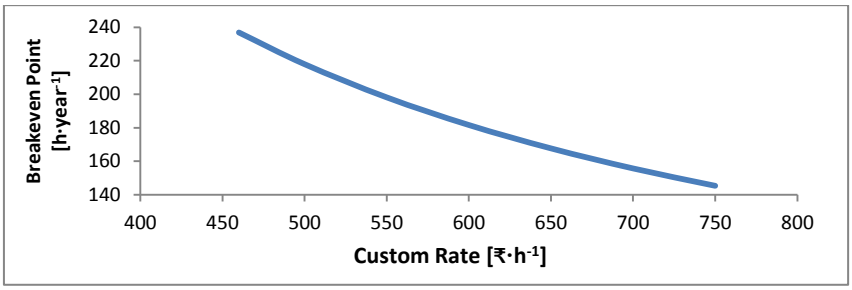

Figure 7. Relationship between custom hiring and BEP on hour basis

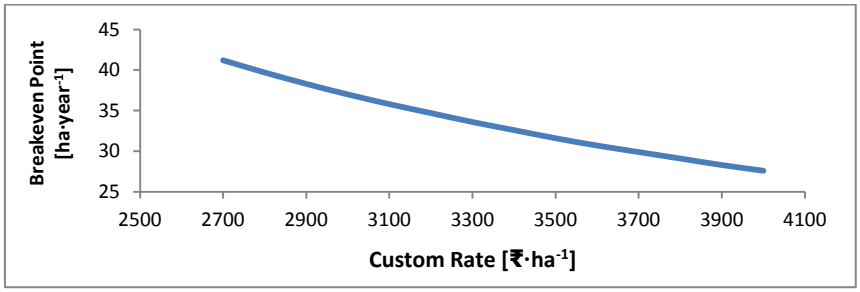

Figure 8. Relationship between custom hiring and BEP on hectare basis

Effect of Custom Hiring Rate on Breakeven Point. The effect of hour basis and hectare basis custom hiring rate at the breakeven point for a tractor is shown in Fig. 7 and Fig. 8, respectively. It clearly indicates that as custom hiring rate increases breakeven point decreases drastically for both the case either hectare basis or hour basis. For an example, if the custom hiring rate is fixed at the rate of *Rs* 550 per hour, it means

it has to operate minimum 200 hours per year to be no profit and no loss. More than 200 hours per year there will be give profit.

CONCLUSIONS

The developed software is capable to calculate the cost of operation in Rupees per hour and in Rupees/hectare of different combinations of power sources and implements. Increase in cost of operation was observed with the increase in initial cost of tractor. The breakeven point decreases with the increase of custom hiring rate for tractor. This program can be a useful tool for suggesting the farmers in purchasing a machine as well as in deciding the custom hiring rates, profit and loss. This can also help to entrepreneurs who are engaged in custom hiring services to decide the hiring rate of different machinery on the basis of breakeven analysis.

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RAČUNARSKI PROGRAM ZA PROCENU TROŠKOVA POLJOPRIVREDNIH MAŠINA

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Sažetak: Kompjuterski program prilagođen korisniku je razvijen u Visual Basic okruženju da odredi sve tipove troškova mašina po času i hektaru. Program takođe

omogućuje izračunavanje oblasti izjednačenja i vreme upotrebe mašina do povraćaja investicije. Ulazni parametric razvijenog programa su uglavnom početna cena, radni vek mašine, kamatna stopa, troškovi goriva, troškovi rada itd, za pogonske mašine i priključke. Ukupni troškovi se izračunavaju u dve grupe, fiksni i varijabilni troškovi. Fiksni troškovi se sastoje od depresijacije, kamate, poreza, smeštaja i osiguranja, dok varijabilni troškovi uključuju gorivo, mazivo, plate, popravke i održavanje. Razvijeni program uspešno izračunava troškove rada po času rada i po hektaru, za agregate različitih pogonskih i priključnih mašina. Analiza bilansa svakog agregata takođe može da se izvede. Ovaj program može da bude korisno sredstvo za preporuke farmerima pri kupovini mašina, pri određivanju cene iznajmljivanja i sl. Ovo takođe može da pomogne preduzimačima u servisima da odrede cene iznajmljivanja različitih mašina na osnovu analize bilansa.

Ključne reči: *troškovi rada, tačka izjednačenja, računarski program*

Prijavljen: *Submitted*:	08.05.2015.
Ispravljen: *Revised*:	17.12.2015.
Prihvaćen: *Accepted*:	20.03.2016.