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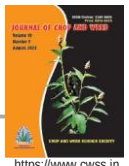

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Comparative cost analysis of finger millet (*Eleusine coracana)* threshing and pearling method

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ABSTRACT

The comparison between the cost of operation of three different methods of finger millet threshing and pearling process was done. The cost of operation, fixed cost, and operational cost were calculated along with the breakeven point and payback period for the three methods i.e. traditional method (hand beating and leg pounding) Vivek thresher for finger millet and the finger millet thresher developed at Indira Gandhi Krishi Viswavidyalaya. The cost of operation by developed thresher was found lowest as Rs. 1.23 per kg compared to other methods. The breakeven point and the payback period were found to be 222.37 hour of operation per year and 3.45 year, respectively for the developed thresher with higher output capacity. It was also concluded that there was 87.87 per cent and 91.39 percent saving in cost over the traditional method when threshing and pearling was done with the Vivek thresher and IGKV thresher respectively.

***Keywords*:** Breakeven point, cost of operation, finger millet, fixed cost, millet thresher, payback period, variable cost

Finger millet *(Eleusine coracana)* commonly known as Ragi in hindi and Madia in Chhattisgarhi dialect is one of the minor millet grown mainly in the different parts of India. Madia (Finger millet) is mainly grown by the tribal people residing mainly in the Baster regions of Chhattisgarh state. Kodo millet (*Paspalum scrobiculatum* L.*)*and the Madia are observed to be the major millet grains grown by the different people in the Baster, Sarguja, Raigarh, Rajnandgaon, Balod and other districts of the Chhattisgarh state.

The finger millet is harvested mainly by the manual method using the local available sickle. The farmers use sickle to harvest the crop by cutting off the panicles from the crop. The moisture content of the panicles at the time of harvest (16-20 %) was then reduced to the moisture level of 10-12% using sun drying method. The crop is then stored for about two month to loosen the grains and glumes for easy separation of the grain from the panicles (Singh *et al*., 2015; Patel *et al.*, 2022).

The threshing of finger millet crop was done traditionally by stick beating method, foot trampling method, stone/wood rollers operated by bullocks or tractor etc. These methods were characterized as tedious, low productivity, inefficient and expensive, poor quality product, unhygienic, labour intensive and less germination quality of seed (Singh *et al.*, 2002).

Similarly, numerous ways of pearling finger millet are used, such as rubbing and shearing of the grains filled in a gunny bags, by using local Dhenki and by using locally available stone grinders (*Jatta*) (Joshi *et al.*, 2015).Grains are filled in the hole made (engraved) in the stone block using the leg pounding method (Dhenki). Pearling is accomplished through impact and crushing as a result of the leg pounding force applied to the grains (Sreenatha *et al.*, 2010). *Jatta* is the third indigenous pearling method used for various grains consist of two stone plates with one wooden one handle. The plates are arranged such a way that one plate is at top and one plate is at bottom. The lower stone plate is fixed on the ground while the upper plate rotates freely with the help of wooden handle. The grains are filled through upper hole and pearled as the upper plate is rotates. To finish pearling, this procedure demands patience and skill (Pradhan *et al*., 2010). Both of these processes have less productivity and drudgery prone operations to the workers, as well as low pearling efficiency.

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The time required for traditional threshing and pearling operation of finger millet, in the tribal region of Bastar, Chhattisgarh would take 32 hours to thresh and winnow 20 q straw as reported by other researchers. For 5 quintals of the grains, it takes two people (4 hours per day) to remove the husk using the leg pounding method (Pradhan *et al*., 2010). The output capacities for manual threshing, bullock and tractor drawn rollers were reported to be 4–8 kg h^{-1}, 25–29 kg h^{-1} and 55–60 kg h^{-1}, respectively. Thethreshing efficiency of the above methods was 100%, 65–70%, and 80–90% respectively (Kumar *et al*., 2013). The mechanical method of threshing and pearling of finger millet crop is also available. The different power operated finger millet thresher and pearlers are also developed and studied by the various researcher (Chandrakanthappa *et al.*, 2001; Parmanand and Verma, 2015; Hanumantharaju *et al*., 2017; Powar *et al*., 2019; Patel and Naik, 2022) but not available commercially till date in Chhattisgarh region. The commercially available Vivek madua thresher is promising solution to the traditional method of finger millet processing (Singh *et al.*, 2010). Another power-operated finger millet thresher was developed at Indira Gandhi Krishi Viswavidyalaya (IGKV), Raipur by keeping in view the need of tribal people of the Chhattisgarh. The comparison of cost of operation and feasibility test of the above methods would give a solution to select the best method for finger millet threshing and pearling. Therefore, in the present study an attempt has been made to calculate and analyze the cost of operation of the three methods of finger millet processing.

MATERIALS AND METHODS

There were numbers of traditional and mechanical method available for the threshing and pearling of finger millet. But in the current study the comparison between the cost of operation of different finger millet threshing and pearling method i.e. traditional method i.e. manual hand beating by stick and leg pounding by Dhenki as shown in Fig. 1(a) and (b), Vivek finger millet thresher cum pearler (Fig. 1(c)) developed by ICAR-VPKAS, Almora and newly developed thresher for finger millet crop by IGKV, Raipur (Fig. 1(d)) was done.The salient specification of the two threshers is given in Table 1. The calculation of the cost of operation was done by following the standard method (Anon., 1979) as described in IS: 9164 -1979.

Economics of the threshing and pearling finger millet

Cost of threshing operation was calculated based upon the current market price of thresher, labour charges and the repair and maintenance charges according to the norms. For calculation of cost of machine assistance was drawn from cost of different machine components along with fabrication charges. The detail of the cost of machine developed at IGKV was given in the Table 2. The procedure for calculation of cost of operation of thresher is given below.

Fixed cost of machine (FC)

The depreciation of the machine over the time period, interest on investment and cost for the housing or storage purposes cumulatively said to be fixed cost of the machine. These costs were required throughout the life of the machine whether the machine is in use or not. The owner of the machine has to bear the fixed cost of the machine throughout the machine life. The various costs under the fixed cost were calculated as follows:

Depreciation/devaluation

The devaluation as the name suggests is the cost which occurs due to use and obsolescence of the machine. Depreciation is said to be the loss in the selling price of the machine with the passing of time. There were numbers of method to calculate the depreciation value of the machine over time such as straight line method, sum of year digit method, declining balance method etc. The straight line method was used to calculate the depreciation value using following formula (IS 9164: 1979):

$$D = \frac{C - S}{L \times H} \quad \text{..... (1)}$$

Where,

D = Depreciation per hour;
C = Initial cost of implement, Rs;
S = Salvage value @ 10 % of C, Rs;
L = Working life of machine in years; and
H = Number of working hours per year.

Interest

The interest cost imposed by the investment made by the owner of the machine is taken into consideration. This cost is the type of fixed cost due to investment made by the owner to purchase and was considered as fixed cost of the machine. The formula used to calculate the interest is given as follows (IS 9164: 1979):

$$I = \frac{C+S}{2} \times \frac{i}{H} \quad \text{..... (2)}$$

Where,

I = Interest per hour; and
i = 10% per year;

Shelter/ housing cost

The housing or shelter cost of the machinery may be defined as the cost required building the shelter or room to store the machinery or equipment. These cost is generally 1 per cent of the initial cost or capital cost of the machine as per the IS 9164:1979.

Therefore,

Total fixed cost = Depreciation +Interest + Housing

Variable cost

Similarly, there is some variable cost of the machine which is cost that occurs when the machine is operational. These costs include the cost of power required to operate the machine. It may be electricity or fuel charges. The other cost in the variable cost includes wages to be paid to the operator and the workers, repair and maintenance cost etc.

Electricity cost

The thresher used the present study is operated by the single phase electric motor. Hence the cost of electricity was calculated by the measuring the electricity consumed per hour with the help of energy meter. The electricity charges are than calculated by considering the actual prevailing rate of electricity.

Electricity Cost (Rs.) = Electricity consumed (kW-h^{-1})× Electricity charges (Rs.-kWh^{-1})

Repair and maintenance cost

The cost for the repair and maintenance of the machine required if the machine gets damaged or unoperational is categorized in this cost. Most commonly this cost is taken as 5 to 10 per cent of the total capital cost of the machinery per year. (IS 9164: 1979)

Labour wages

The wages given to the worker or the operator of the machine is termed as the labour wages. It is also a variable/operating cost that is decided based upon the actual rate of wages at that time (IS 9164: 1979).

Therefore, Total operating cost = Cost of electricity charge + Cost due to repair and maintenance + Wages (if any)

Total cost of operation

It is basically the cost that is required to bear by the owner or the farmer to use the machine. The total operation cost sums the fixed cost of the machine as well as operating cost of machine and given by following formula.(IS 9164: 1979)

$$C_{TC} = FC_T + VC_T \quad \text{.....(3)}$$

Where,

C_{TC} = Total cost of operation, Rs. h^{-1};

FC_T = Total fixed cost, Rs. h^{-1}; and

VC_T = Total variable cost, Rs. h^{-1}.

4. Break-even point

Break-even point can defined as the point of no profit and no loss. It is basically a stage or time at which the profit gained by the machine surpasses the total operational cost of the machine**.**The break-even point was calculated by following formula (Sharma and Jain, 2007). The graphical representation of BEP is given in Fig 2.

$$BEP = \frac{FC_a}{C_{CH} - V} \quad \text{..... (4)}$$

Where,

BEP = Break-even point, h-$year^{-1}$;

FC_a = Annual fixed cost, Rs $year^{-1}$;

V = Variable cost, Rs. h^{-1}; and

C_{CH} = Custom hiring charge, Rs. h^{-1}.

5. Payback period

The time period in which the profit made by the machine or equipment is equal to the capital cost of the machine. In other word the time period essential to get back the total investment made to own the machine.It can be calculated by following formula (Sharma and Jain, 2007):

$$PBP = \frac{I}{R} \quad \text{..... (5)}$$

Where,

PBP = Payback period, years;

I = Total investment, Rs; and

R = Net return annually, Rs.

RESULTS AND DISCUSSION

Cost Economics of the threshing and pearling method

The cost comparison was done by considering the three methods namely traditional method, by Vivek thresher and by the developed IGKV thresher. As discussed earlier the traditional method of threshing and pearling of the finger millet crop required the 2 workers. The threshing was done manually by beating with the help of stick followed by the leg pounding by locally available *Dhenki* (Fig. 1(b)) for pearling of the threshed grains. The cost of the operation was found to be Rs. 78.75 per hour with the output capacity of the only 5.5 kg pearled grains per hour. The detailed calculation of the cost of operation by traditional method is given in Table 4. It was also calculated that Rs 14318.18 will be required to thresh the one ton of finger millet crop.

Similarly, the cost of operation and cost required to thresh and pearl the finger millet grains by the Vivek thresher was worked out. The detailed calculation is presented in the Table 4. The fixed cost, variable cost and total cost of the operation by Vivek thresher was found to be Rs. 21.50, 93.70 and 115.20 per hour respectively. It was observed that the cost required to handle the one ton of crop will be Rs 1772.30 with Vivek

Table 1: Salient specification of Vivek thresher and IGKV finger millet thresher

Particulars	Vivek Thresher	IGKV Thresher
Name	Vivek madua thresher cum pearler	IGKV finger millet thresher cum pearler
Type of thresher	Tangential flow fed in type	Axial flow fed in type
Length, mm	1000	1750
Width, mm	590	1200
Height, mm	1331	1400
Weight, kg	60	150
Power unit	1 hp single phase electric motor	1 hp single phase electric motor
Peripheral speed, m/s	7.97	9.34
Type of drive	V-belt and pulley	V-belt and pulley
Feeding chute type	Vertical hopper	Horizontal chute
Length of threshing cylinder	172	650
Diameter of threshing cylinder	120	300
Threshing element	Rasp bar type	Peg and canvas strip
Peg to peg distance, mm	-	60
Peg length, mm	-	120
Concave	Detachable MS sieve	10 mm square bars with 5 mm gap
Concave clearance, mm	5	5
Cleaning unit	Throw cum blower	Reciprocating sieve with aspirator
Sieve	Punctured MS sheet	2 perforated MS Sheet
Hole diameter, mm	2	3 (upper), 1 (lower)
Aspirator blower	Direct flow	Centrifugal fan
Transport wheel	Absent	Present

thresher. It was also noted that during the experiment the operator has to push the finger millet panicles continuously because of the small feeding hopper of the machine. The machine was observed to be get choked after some time of operation and operator or worker has to clean the threshing chamber manually. These problems hinder the efficiency of the workers. Moreover the cleaning efficiency of the threshed grains were also observed to be low.

The cost economics of the IGKV developed thresher was also carried out and presented in Table 3. The total cost of operation, breakeven point and payback period of the IGKV developed thresher-cum-pearler was calculated based on the total cost of the machine. The total cost of the machine was estimated as Rs. 60,736.00 (Table 2) based upon the bill of materials. The cost of operation includes fixed cost and operational cost of developed finger millet thresher cum pearler was found to be Rs. 43.53 per hour and Rs. 104.40 per hour.Table 3 represents the detailed description of the cost of operation of machine.The total cost of operation was found to be Rs. 147.92 per hour and Rs. 1.23 per kg considering the output capacity of machine as 120 kg/ h. The breakeven point (Fig. 3) and payback period was also calculated and found to be 222.37 hour per year and 3.45 year, respectively. The working of the developed thresher is similar to the axial flow type thresher. The worker puts the finger millet panicles into the hopper and the crop is threshed easily without any choke problem unlike the Vivek thresher. The cleaning efficiency of the thresher is somewhat higher than the other thresher. Similar type study has been also conducted by (Powar *et al*., 2019 and Singh *et al*., 2010) for finger millet threshing and pearling. Other studies were also done by various researchers to compare the performance of pedal operated rice thresher by (Samadder and Saha, 2018).

Calculation of Breakeven point and payback period

The breakeven point was calculated by considering the overhead charges and the profit margin. Both the margins add to the profit to owner if the machine is send to the custom hiring. The detail about the calculation of the breakeven point is given below.

S No.	Particulars	Value
1	Fixed cost (FC), Rs. h^{-1}	43.53
2	Variable cost (VC), Rs. h^{-1}	104.40
3	Variable cost + 25% OH (Overhead charges) Rs. h^{-1}	130.49
4	25 % Profit, Rs. ha^{-1}	32.62
5	Custom hiring (CH) charges, Rs. h^{-1}	163.12

The custom hiring charges as calculated is found to be Rs. 163.12.

Table 2: Bill of material and cost of fabrication

S. No.	Material	Specifications	Quantity, No.	Unit price, Rs	Amount, Rs
1.	MS Angle	25×25×5mm - 5.5 m	2	1800	3600.00
		35 ×35×5mm -5.5 m	2	2200	4400.00
		45×45×5mm- 1.5 m	1	1200	1200.00
2.	MS polish shaft	x 32 mm, 1.5 m	1	1800	1800.00
3.	MS Sheet	18 gauge, 8×4 feet	2	3200	6400.00
4.	MS flat plate	30×30 mm, 5.5 m	1	1620	1620.00
		40×10 mm, 3 m	1	1120	1120.00
5.	MS thick plate	200×200 mm	2	600	1200.00
6.	Pedestal bearing	UCP 206, 30 mm	2	550	1100.00
7.	Ball bearing	6205	4	230	920.00
8.	Pulley	2.5 inch, B type	1	230	230.00
		6 inch, B type	1	460	460.00
		2.5 inch, A type	1	170	170.00
		5 inch, A type	1	340	340.00
9.	V belts	B62	1	250	250.00
		A36	1	140	140.00
10.	Rubber belt	40×5 mm, 10 m	1	700	700.00
11.	Canvas belt	150×5 mm, 15 m	1	2925	2925.00
12.	Fan	Centrifugal , 15 cm	1	150	150.00
13.	Perorated sheet	x 2 mm, 3×4 ft	1	1080	1080.00
		x 4 mm, 3×4 ft	1	1080	1080.00
		x 5 mm, 3×4 ft	1	1080	1080.00
14.	Transport wheel	5 inch	4	240	960.00
15.	Nut and bolts	3 kg, different sizes	1	3250	3250.00
16.	Paint	Asian paints, yellow 1 liter	1	310	310.00
		Asian paints, red, 500 ml	1	175	175.00
		Asian paints, black, 500 ml	1	175	175.00
17.	Electric motor	CG single phase 1 hp	1	9885	9885.00
				Material cost	46720.00
18.	Fabrication charges	30 % of material cost	-	-	14016.00
				Total	**60736.00**

Table 3: Cost of operation of developed IGKV finger millet thresher cum pearler

S. No.	Particulars		Amount
1.		Capital cost of machine, Rs.	60736.00
2.		Useful life of machine, year	6.00
3.		Annual working hour, h	300.00
4.		Fixed cost	
	a.	Depreciation , Rs. h^{-1}	30.37
	b.	Interest, Rs. h^{-1}	11.13
	c.	Housing , Rs. h^{-1}	2.02
	d.	Total fixed cost, Rs. h^{-1}	43.53
5.		Variable cost	
	a.	Electricity charges, Rs. h^{-1}	5.40
	b.	Repair and maintenance cost, Rs. h^{-1}	20.25
	c.	Labour wages for 2 labours, Rs. h^{-1}	78.75
	d.	Total variable cost, Rs. h^{-1}	104.40
6.		**Total cost of operation, Rs. h^{-1}**	**147.92**
7.		**Total cost of operation @ 120kg/h output, Rs. kg^{-1}**	**1.23**
8.		**Breakeven point, h-y^{-1}**	**222.37**
9.		**Payback period, y**	**3.45**

Table 4: Cost of operation of different finger millet threshing and pearling methods

Particulars	Developed fingermillet thresher cum pearler	Traditional method (Hand beating)	Vivek finger millet thresher cum pearler
Capital cost of machine (C), Rs.	60736.00	-	30000.00
Useful life of machine, year	6	-	6
Annual working hour, h	300	-	300
Salvage value (10% of C)	6073.60	-	3000.00
Fixed cost			
Depreciation , Rs. h^{-1}	30.37	-	15.00
Interest, Rs. h^{-1}	11.13	-	5.50
Housing , Rs. h^{-1}	2.02	-	1.00
Total fixed cost, Rs. h^{-1}	**43.53**	**-**	**21.50**
Variable cost			
Electricity charges, $Rs.unit^{-1}$	4.50	-	4.50
Electricity consumption, unit h^{-1}	1.2	-	1.1
Electricity cost, Rs. h^{-1}	5.40	-	4.95
Repair and maintenance cost, Rs. h^{-1}	20.25	-	10.00
Labour required,	2	2	2
Labour cost, Rs. day^{-1}	315.00	315.00	315.00
Working hour, h day^{-1}	8	8	8
Labour wages, Rs. h^{-1}	78.75	78.75	78.75
Total variable cost, Rs. h^{-1}	**104.40**	**78.75**	**93.70**
Total cost of operation, Rs. h^{-1}	**147.92**	**78.75**	**115.20**
Output capacity, kg h^{-1}	**120**	**5.5**	**65**
Total cost of operation, Rs. t^{-1}	**1232.66**	**14318.18**	**1772.30**

Table 5: Cost comparison of different threshing cum pearling methods used for finger millet

S. N.	Method	Threshing capacity, Kg h^{-1}	Total cost of operation, Rs.h^{-1}	Total cost of operation, Rs. kg^{-1}	Per cent saving in cost over the traditional method
1.	Traditional method	5.30	78.25	14.76	0.00
2.	Vivek thresher	64.32	115.20	1.79	87.87
3.	IGKV finger millet thresher cum pearler	116.33	147.92	1.27	91.39

$$\text{Breakeven point (BEP), h} = \frac{FC \times AU}{CH - VC}$$

$$\text{Breakeven point (BEP), h} = \frac{43.53 \times 300}{163.12 - 104.40} = 222.37\,\text{h}$$

Payback period

$$\text{Payback period (PBP)} = \frac{C}{ANP}$$

C = Purchase price of the machine, Rs.
ANP = Annual net profit, Rs.
ANP=(CH-VC) ×AU
ANP=163.12-104.40×300 = Rs. 17616.71
Payback period PBP, y= 60736/17616.71⇒3.45 y

Comparison of cost of operation of different threshing and pearling methods

The cost of operation of the traditional method (hand beating and leg pounding), the Vivek finger millet thresher and the developed prototype was compared and presented in Table 4 and 5 respectively.The data revealed that total cost of operation for finger millet threshing and pearling by Vivek finger millet thresher cum pearler and developed finger millet thresher cum pearler were found 87.87 % and 91.39 % cheaper than the traditional method of threshing done by hand beating through a bamboo and pearling by local *Dhenki*. This may be due to reason that the low output capacity by the traditional method. Also the work is mainly carried out by the women workers and it was found to be very drudgery prone, laborious and tiresome operation compared to

Fig. 1: Available methods of threshing and pearling of finger millet:(a) manual beating with stick, (b) Pearling with *dhenki,*(c) Vivek finger millet thresher cum pearler, (d) IGKV finger millet thresher cum pearler

the threshing done by the mechanical threshers. (Dutta, 2012) studied on comparative economics of jute and mesta cultivation and found that traditional method of cultivation adds to more labour and cost requirement. Similarly, Deka *et al.*, 2020 conducted a studied on comparative cost economics of different tillage practice and reported that conventional tillage practice is not beneficial as compared to other methods.

Similarly, the cost required by the mechanical thresher i.e. Vivek thresher and IGKV thresher was compared. It was found that the cost required by the IGKV thresher is 30.44 per cent less than the cost required by the Vivek thresher to thresh the one ton of the finger millet crop. Additionally, operation with the developed thresher was observed to be smooth and easy as compared to both the methods. The capital cost (Purchase price) of the Vivek thresher was observed to be 50 per cent less as compared to the developed IGKV thresher however the low output capacity and the chocking of crop in the thresher is major concern. Due to low output capacity the operation cost of the Vivek thresher is higher than the developed thresher. Hence, from the above study it can be concluded that traditional method of threshing and pearling requires more labour and time and also it is uneconomical to the farmers. The Vivek finger millet thresher has less total cost of operation per hour as Rs 115.20 as compared to IGKV thresher but the output capacity and the efficiency was

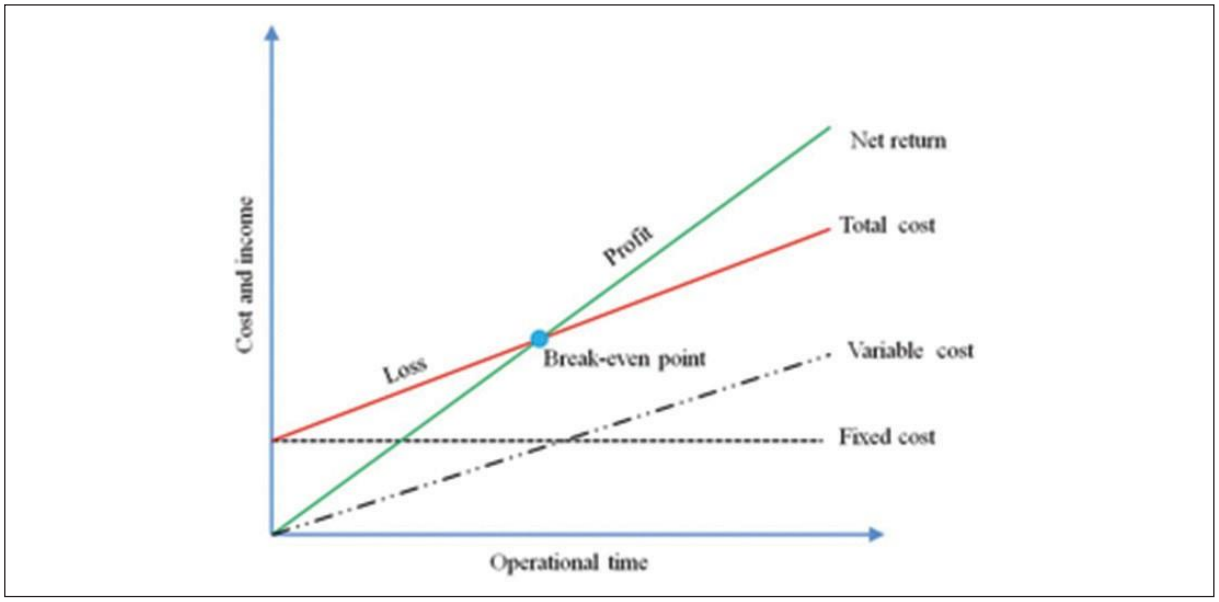

Fig. 2: Graphical representation of break-even point (BEP) (Cafferky, 2014)

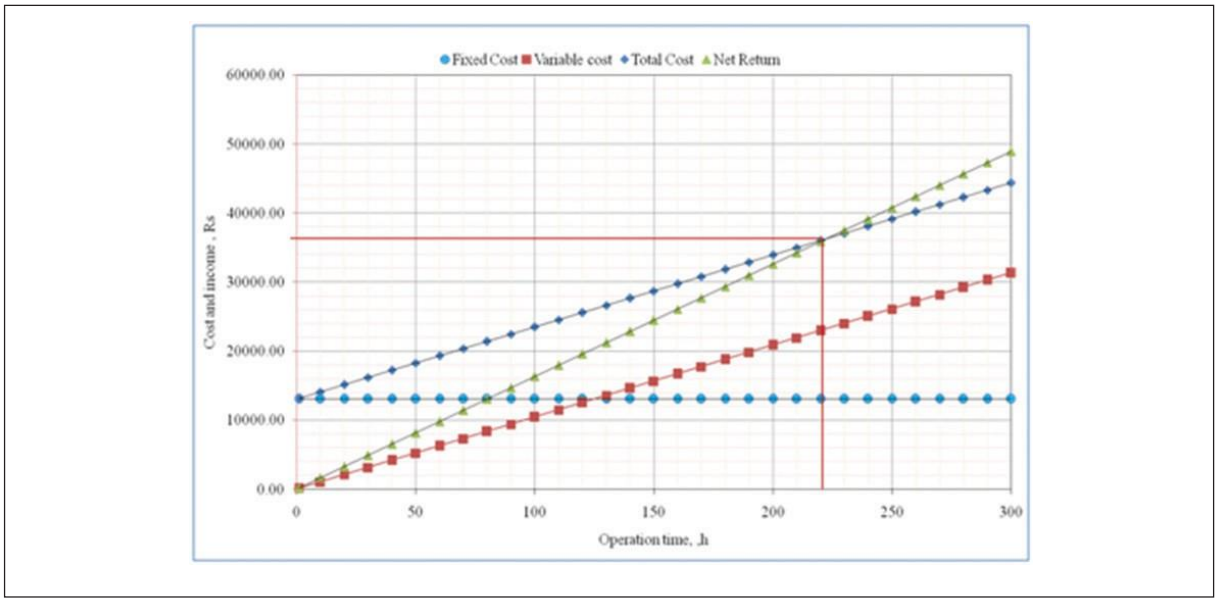

Fig. 3: Breakeven point of developed finger millet thresher cum pearler

not at par with the IGKV developed finger millet thresher-cum-pearler. However, the initial cost of the IGKV model was found significantly highest as compared to VPKAS model.

CONCLUSION

The cost comparison was done between the three methods of finger millet threshing and pearling and from the above study following recommendation can be drawn as follows:

1. The traditional method of threshing and pearling of finger millet is laborious as well as costly operation.
2. The Vivek thresher is better than the traditional method as it gives more output, easy operation, less time consuming etc.
3. The developed thresher at IGKV was found to be superior among the above method in terms of cost as well as performance parameters. However the initial cost to purchase the machine much higher than the Vivek thresher. The higher purchase price can be compensated

by the lower payback period of the machine. So it is recommended that for threshing and pearling of the finger millet crop panicles, the IGKV developed thresher may be a good option to the small and marginal farmers.

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