Estimation of operational cost of various intercultural implements

SHARAD KUMAR NAMDEV[1], RAJNARAYAN PATERIYA[2], RAJESH U. MODI[3] and BHABANI SHANKAR DASH[4]

[1]*Farm Machinery and Power Engineering, Zila Parishad Krishi Mahavidhalaya Banda, Bundelkhand University Jhansi, Uttar Pradesh -210001 ,* [2] *Farm Machinery and Power Engineering, College of Technology, G. B. Pant University of Agriculture and Technology, Pantnagar-263145 (U.S. Nagar, Uttarakhand),* [3] *Farm Machinery and Power Engineering, College of Agricultural Engineering and Technology, Punjab Agricultural University Ludhiana, Punjab-141004,* [4] *Farm Machinery and Power Engineering, College of Agricultural Engineering and Technology, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha -751003*

ABSTRACT: Agricultural engineers and economists use a variety of engineering and economic principles for calculating a machinery cost. An effective farm manager must also know these principles, and apply them when deciding to buy, lease, rent or share machinery. Thus, estimating farm machinery costs becomes essential to farmers for sound investment analysis and useful in planning, controlling production on their farms. Therefore, study was conducted to estimate operational cost of various intercultural implements namely side shift tiller, offset harrow and cultivator at Horticulture Research Center, Pantnagar. The study concluded that higher operational cost was found (641.95 Rs/ha) in side shift tiller whereas lower operational cost was estimated in offset harrow and cultivator approximately nearer (576.49 and 571.97 Rs/ha). The results also showed that operational cost of intercultural implements depends significantly on the initial cost of the implement. Therefore, side shift tiller has high operational cost because of its higher initial cost as compared to other intercultural implements.

Key words: Cultivator, intercultural implements, offset harrow, operational cost, side shift tiller

Production costs in horticultural crops are out of reach to the farm owner in the short run, but he does have control over machinery cost at a certain limit (Bucket, 1981). Good management and decision making skills are very useful for proper selection of machinery on the basis of their need and size in the farms (Kepner *et al.,* 1978). Thus, estimating farm machinery costs is essential for farmers to sound investment analysis and are useful in planning and controlling production on their farms (Barnard *et al.,* 1978). The most important parameter influencing farm profit is the operational cost of agricultural machines and equipments in farming system (Culpin, 1959). Operational cost estimation of agricultural machines plays an important role in decision making for effective farm management during intercultural operations in horticultural field (Hunt, 1973). The operational cost of agricultural machines and equipments can be influenced by the physical condition and shifting time of the machine which needs to be estimated prior to commercial use of the machine (Shculer *et al.,* 1991).

In general, intercultural operations are mainly done by conventional implements involving offset harrow and cultivator. Presently, rotavator is becoming popular in horticultural field for performing intercultural operations but area beneath the orchard remains uncultivated due to narrow space between plants. Therefore, in order to overcome this difficulty, side shift tiller came into existence and has been reported as a new revolutionary to the machine to farmers for performing efficient intercultural operation. However, estimation of operational cost of side shift tiller is necessary for commercial use in order to have effective planning in horticultural production and management (Larry *et al.,* 1997). Side shift rotary tiller requires higher initial investment as compared to other conventional intercultural implements. Therefore, prime importance has been given to understand the operational cost for executing farm management plans at horticultural fields and also to compare the different types of conventional implements in terms of operational cost, which one can understand to decide the implement to be used.

MATERIALS AND METHODS

The side shift tiller was designed and developed by CSIR-Center of Excellence for Farm Machinery, Central Mechanical Engineering Research Institute, Ludhiana (Punjab) and operational cost was estimated by Department of Farm Machinery and Power Engineering, College of Technology, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttarakhand). The side shift rotary tiller has rotating tines mounted on a horizontal shaft and can be attached to the three point linkage of 50-65 hp tractors. It is powered by PTO and provided with adjustable mechanical sensing unit which can be adjusted at any position on the frame according to the type of orchard with a side shift of 300 mm. It has seven flanges spaced 220 mm apart and each flange carries six blades. The other intercultural implements namely offset harrow and cultivator also selected for estimating operational cost, in which offset harrow was tractor mounted type 16 disc apart from 228 mm each other and contains notched disc in front gang, plain disc in rear gang with overall width of 1852 mm. The cultivator was a tractor mounted type spring loaded 11 tines of cultivator with overall width of 2300 mm. The view of side shift tiller, offset harrow, cultivators are presented in Figure 1, 2 and 3 respectively.

Figure 1: Side shift tiller

Figure 2: Offset harrow

Figure 3: Cultivator

Technical specification of a side shift tiller

S.L. No.	Specification	Units
1.	Power requirement	50 hp
2.	Number of flanges	7
3.	Type of blades	L- Shape
4.	Number of blades	42
5.	Flange plate diameter	400 mm
6.	Rotor shaft diameter	280 mm
7.	Spacing between flange plates	235 mm
9.	The overall height of side shift tiller	1120 mm
10.	The overall width of side shift tiller	2000 mm
11.	The overall length of side shift tiller	400 mm
12.	Rated width of cut	1800 mm
13.	Hydraulic shift	370 mm

Field Testing of Side Shift Rotary Tiller

The field experiments were conducted at the Horticulture Research Center Pattherchatta, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, (Uttarakhand). The field testing of side shift tiller was evaluated in during the field experiments in different orchards like mango, guava, and litchi respectively.

Selection of Orchards

The Bureau of Indian Standard (IS: 6288-1971) recommended the minimum area for testing of tractor drawn machine should be one hectare and the ratio of width and length of the plot should be, as far as possible, 1:2. An experimental plot in orchard having 6000 m^2 area was selected and it was divided into subplots of the size of 15×30 m^2. Some of the basic information and selected parameters related to plants and their geometry like the average size of canopy of plant, pruning height of canopy from the ground surface and the horizontal distance between outer points of canopy to the stem of tree are shown in Table 1and Table 2. The details of soil conditions for different orchards field for field experiments are also shown in Table 3.

Operational Cost Parameters

Cost Parameters

The sum of fixed cost and variable cost is operational cost. This calculation is done for estimating the operational cost per hour of any implement to identify the economic viability of operation. If the implement is given for hiring purpose then it helps in deciding the cost for hiring. In this way fixed cost and variable cost are considered.

Table 1: Data recommended by National Horticulture Board for Different Orchards

Sl. No.	Orchards	Variety	Canopy, m	Plant height, m	Plant girth, m	Plant age, years	Plant branch height, m	Plant mature period, years
1.	Mango	Dasheri	5	6-8	0.5-1.5	40-50	1.5-2	6-7
2.	Guava	Pant Prabhat	5	5-6	0.4-0.6	25-30	1.5-1.8	3-4
3.	Litchi	Rose Scented	5	5-6	0.5-0.7	40-50	1.2-1.5	6-7

Table 2: Various parameters observed in different orchards

Orchard	Plant girth, m	Plant canopy, m	Heading height of branches from ground, m
Mango	0.92	4.82	1.72
	0.90	4.52	1.45
	0.93	4.95	1.53
	0.95	5.05	1.86
	0.98	4.74	1.97
Average	**0.94**	**4.82**	**1.71**
Guava	0.46	4.51	1.66
	0.40	4.34	1.48
	0.42	4.15	1.30
	0.45	4.23	1.54
	0.48	3.90	1.76
Average	**0.43**	**4.22**	**1.55**
Litchi	0.65	4.75	1.67
	0.73	4.60	1.43
	0.75	4.73	1.35
	0.70	4.80	1.58
	0.68	4.63	1.84
Average	**0.79**	**4.70**	**1.57**

Table 3: Soil properties of mango, guava and litchi orchards

Sl. no.	Soil type	Moisture content. % (d.b)	Bulk density kg/m^3 before Interculture	Cone index at 8 cm depth, kg/mm^2
		Mango orchard field		
1.	Clay Loam	9.26	1310	0.0052
2.	Clay Loam	9.01	1210	0.0038
3.	Clay Loam	8.7	1340	0.0030
4.	Clay Loam	13.2	1750	0.0025
5.	Clay Loam	6.4	1440	0.0059
	Average	9.26	1441	0.0040
		Guava orchard		
1.	Clay Loam	17.23	1120	0.0040
2.	Clay Loam	18.05	1160	0.0037
3.	Clay Loam	14.22	1250	0.0045
4.	Clay Loam	22.13	1300	0.0023
5.	Clay Loam	13.23	1220	0.0031
	Average	16.97	1210	0.0024
		Litchi orchard		
1.	Clay Loam	12.45	1500	0.0032
2.	Clay Loam	14.54	1420	0.0027
3.	Clay Loam	9.48	1490	0.0043
4.	Clay Loam	15.23	1220	0.0035
5.	Clay Loam	10.64	1330	0.0042
	Average	12.46	1390	0.0035

Fixed cost

The estimated costs of depreciation, interest, taxes, insurance, and housing are added together to find the total ownership cost. If the tractor/machinery is used 500 hours per year, the total ownership cost per hour is: Ownership cost/use hours per year.

Depreciation cost

Depreciation is the reduction in the value of a machine with time and use. It is often the largest single cost of machine ownership, but cannot be determined until the machine is sold. However, several methods are available for estimating depreciation.

$$\text{Depreciation cost} = \frac{C\text{-}S}{L \times H} \times 100 \quad \dots (1)$$

Where,
D = Depreciation cost (Rs./h)
C = Purchasing price (Rs.)
S = Salvage cost (10 % of purchasing cost)
L = Useful life of tractor (years)
H = Working hours in a year

Interest cost

A charge for interest is included as a fixed cost because the money which is invested in machinery could have been invested in other productive enterprises or investments. The interest rate that is used in the "Guide to Machinery Costs" is the interest rate that can be obtained on a medium- term (5 year) investment.

$$\text{Interest cost} = \frac{(C+S) \times i}{2H} \times 100 \quad \dots (2)$$

Where,
I = Interest cost per h.
i= Rate of interest

Total fixed cost

$$\text{Total fixed cost} = D+i \quad \dots (3)$$

Where,
Tax insurance and shelter are taken 3 % of purchase cost

Variable Cost

Fuel consumption cost

Fuel costs can be estimated by using average fuel consumption for field operations in liter per hour. Those figures can be multiplied by the fuel cost per liter to calculate the average fuel cost per h/ha.

Lubrication cost

Surveys indicate that total lubrication costs on most farms average about 15 percent of fuel costs. Therefore, once the fuel cost per hour has been estimated, it can be multiplied by 0.15 to estimate total lubrication costs.

Repair and maintenance cost

These costs are difficult to estimate as they vary greatly depending on operating conditions, management, maintenance programs, local costs, etc. It is generally agreed that repair costs will increase with age but are unlikely to increase proportionally. Repair costs per hour of use will increase with age but tend to level off as the machine becomes older (Kepner *et al.,* 1978). It will be 5 percent of the purchasing cost.

Labour cost

Labour cost also is an important consideration in comparing ownership to custom hiring. Actual hours of labour usually exceed field machine time by 10 to 20 percent, because of travel time and the time required lubricating and servicing machines. Consequently, labour costs can be estimated by multiplying the labour wage rate times 1.1 or 1.2. Using a labour value of Rs 50 per hour for our tractor. Different wage rates can be used for operations requiring different levels of operator skill.

Implement cost

Costs for implements or attachments that depend on tractor power are estimated in the same way as for the example tractor, except that there is no fuel, lubrication, or labour costs involved. Costs for implement it will be considered as 300 Rs/day.

Total variable cost

Fuel consumption cost + Lubrication oil cost + Repair and maintenance cost + Labour cost … (4)

Total operational cost

Total operational cost = Total fixed cost + Total variable cost …(5)

Table 4: Basic parameters for operational cost estimation of different intercultural implements

Sr. No.	Power Equipments	Initial Cost, Rs	Useful Life, Year	Annual Use, h	Work Capacity, h/ha
1.	Tractor	700000	10	1000	-
2.	Side Shift Tiller	182000	8	720	1.45
3.	Offset Harrow	42500	10	720	1.25
4.	Cultivator	27000	10	720	1.06

Table 5: Operational cost involved in various intercultural implements

Parameters	Intercultural Implements		
	Side Shift Tiller	Offset Harrow	Cultivator
Initial cost, Rs	182000	42500	27000
Depreciation cost, Rs/ha	32.76	5.31	3.375
Interest cost, Rs/ha	24	3.89	2.47
Shelter cost @ 1% of purchase cost, Rs/ha	3.60	0.590	0.375
Repair and maintenance cost @ 5% of purchase cost, Rs/ha	18.20	2.95	1.8
Lubrication cost @ 30% of fuel cost, Rs/ha	49.50	49.50	49.50
Labour cost, Rs/ha	31.25	31.25	31.25
Total fixed cost, Rs/ha	60	9.79	6.42
Total variable cost, Rs/ha	18.20	2.95	1.8
Total operational cost, Rs/ha	641.95	576.49	571.97

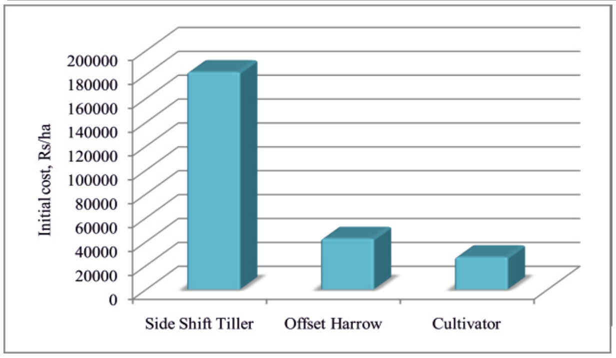

Figure 4: Variation of initial cost of different intercultural implements

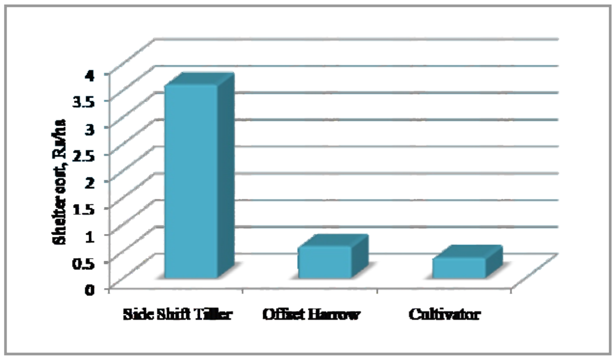

Figure 7: Variation of shelter cost of different intercultural implements

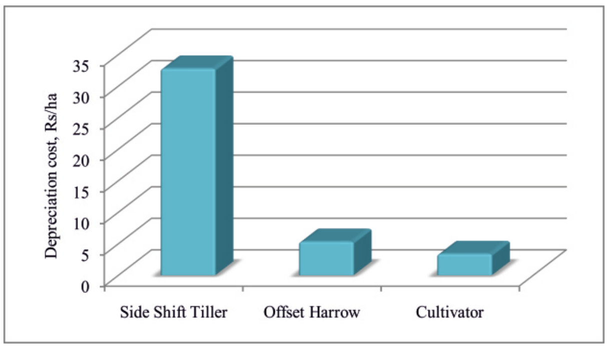

Figure 5: Variation of depreciation cost of different intercultural implements

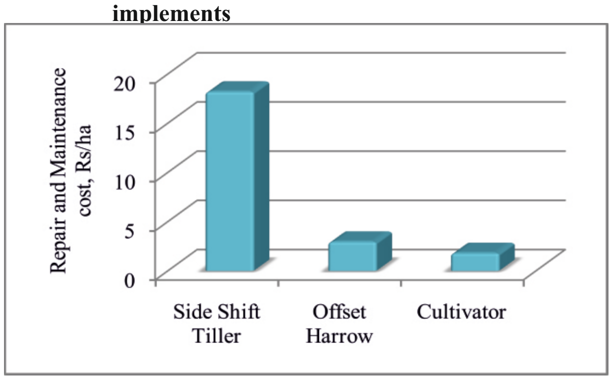

Figure 8: Variation of repair and maintenance cost of different intercultural implements

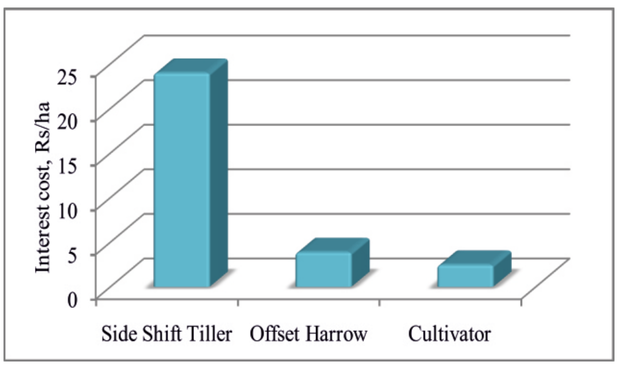

Figure 6: Variation of interest cost of different intercultural implements

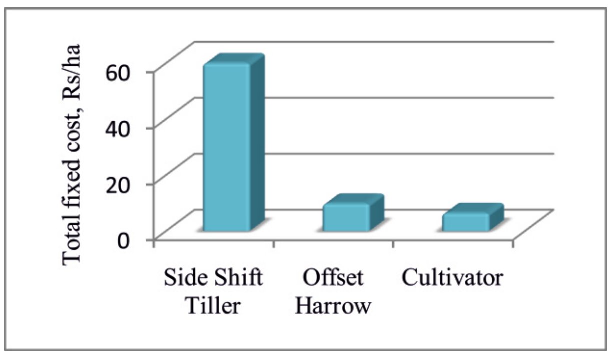

Figure 9: Variation of total fixed cost of different intercultural implements

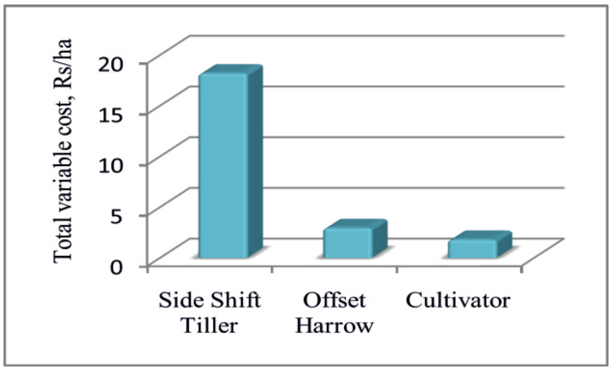

Figure 10: Variation of total variable cost of different intercultural implements

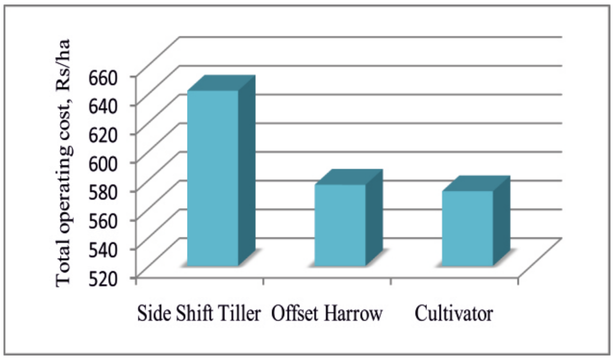

Figure 11: Variation of total Operational Cost of different intercultural implements

RESULTS AND DISCUSSION

Estimation of operational costs involved in various intercultural implements

The basic parameters for operational cost estimation of different intercultural implements have been shown in Table 4 whereas operational cost of different intercultural implement was calculated and presented in Table 5. The variation in operational cost parameters like initial cost, depreciation cost, interest cost, shelter cost, repair and maintenance cost, total fixed cost, total variable cost and total operational cost of different intercultural implements have been shown in Figure 4 to Figure 11, The operational cost of side shift tiller was calculated 641.95 Rs/ha whereas, in case of offset harrow and cultivator, operational cost was found nearest 576.49 and 571.97 Rs/ha. The result indicates that operational cost of intercultural implements significantly depends on the initial cost of the implement. Therefore, operational cost of side shift tiller was found to be high because of its higher initial cost and on the other hand operational cost was estimated low in offset harrow and cultivator due to lower initial cost. Thus, it is finally concluded that implement subjected to high initial cost tends to increase in operational cost.

CONCLUSION

1. The study found that operational cost of side shift tiller was higher and on the other hand, cost of offset harrow and cultivator was found approximately similar.
2. The result showed that, operational cost of intercultural implements mainly depends on the initial cost of the implement. Therefore, side shift tiller is subjected to high operational cost because of its higher initial cost as compared to offset harrow and cultivator.

REFERENCES

AGFACTS, (April 2009). Agricultural machinery price comparisons.

Barnard, C.S. and Nix, J.S. (1978). Farm planning and control. Cambridge University, Cambridge. Chapter 4.

Bucket, M. (1981). An introduction to farm organization and management. Pergamon Press. Oxford. Chapter 8.7.

Culpin, C. (1959). Farm mechanization management, crosby Lockwood and Son Ltd, London. Chapter 2 Pp 12–27. Appendix tables 2.3.

Hunt, E. (1973). Farm power and machinery management, *7*, Iowa State University Press, Iowa Pp 5, 43, Chapter 4.

Kepner, R.A., Baines, R and Barger, E.L. (1978). Principals of farm machinery management, 3rd Ed, AVI, Connecticut Pp 31–37.

Larry K. Bond and Beard, R. (1997). The cost of owning and operating farm machinery. *Utah State University Extension Bulletin*, Pp 1-60.

Shculer, R.T. and Frank, G.G. (1991). Estimating agricultural field machinery costs, *Agricultural Bulletin*, Pp 1-12

Received: December 27, 2019
Accepted: December 28, 2019