Comparative Evaluation of Developed Onion Stem and Root Cutter CumSorting Machine with Manual Cutting Method

Abstract

. In India, manual cutting of onion stem and root is still a practice. This is very labour intensive, drudgery prone and time consuming operation.For this reason, an onion stem and root cutter cum sorting machine that can be easily adapted infarmer's fieldwas developed. In this study, comparative evaluation and analysis of a developed onion stem and root cutter cum sorting machine with manual cutting method was performed.Major objective was to assess the performance, labor requirements and economic benefits of using the onion stem and root cutter over the manual cutting technique. The developed onion stem and root cutter cum sorting machine was designed to efficiently stem and root cut and separate grade onion bulbs from the onion crop with minimizing damage. The study was conducted in an onion field, comparing the cutter performance with the manual cutting method commonly employed in the region. The cost of the machine is found as 61190.00 Rs. with breakeven point was calculated as 139.79 h/year and payback period was found to be 3.38years taking profit as 20%.The newly developed machine saves 70.37% cost and 92.59% labour as compared to traditional sickle and 46.07 % cost and 82.60 % labour as compared to battery operated onion stem and root cutter at desired stem length.

Keywords: Onion, stem and root, cutter, performance, cost operations.

INTRODUCTION

Onion (*Allium cepa L.*) is one of the most popular vegetable crops,consumed in various forms and it is an important commercial crop that is widely grown in different parts of the world.In India, onions are grown in three crop seasons: *Kharif:* July–August, Late *Kharif:*October–November and *Rabi:* December–January. This crop can be grown throughout the year thus available in all season. *The Rabi* season onion crop occupies highest annual production, accounting for about 60 percent, with *Kharif* and late *Kharif* accounting for about 20 percent each. India is the second-largest producer of onions, followed by China. The total production of onion in India is 22.07 MT with a yield of 16.78 t ha^{-1} (from a cultivation area of 1.28 Mha).(Kumawat and Raheman, 2022).

Presently harvesting is done manually by farm women. Individual onions are picked and detopping is done by using sickle. This operation is time consuming and highly drudgery in nature. (Rathinakumari, *et al*.2022)

Battery-operated onion stem and root cutter machines offer convenience and efficiency in the small farms, but they come with limitations such as battery life, maintenance, and cost considerations. Users should weigh these disadvantages against the benefits to determine if such a machine is suitable for their specific needs.

The developed onion stem and root cutter is a power-operated machine designed to adapt to the farmer's field conditions. Specifically, to sustainably utilize the locally designed power operated not just for onion harvester and de-topping, but also for other operations on the farm. Thereby reducing the cost of investing in another power source to operate the machine. A farmer with high farm power beyond the requirement diminishes profit returns and prolongs the investment recovery. Hence, to assist local farmers in investing in this newly developed onion stem and root cutter machine, this study of investment cost analysis was conceptualized. Specifically, the cost parameters involves calculation ofcost of operations, break-even point and payback period and the comparison between cost of a manual and mechanical onion stem and root cutting machine(which is power-operated). Disclosing this information to farmers helps them make smart decisions in selecting the appropriate which is suitable for onion stem and root-cutting machine. Purposely, to considerably decrease stem and root cutting expenditures, thereby giving opportunities to generate more income and an increased quality of work. By providing farmers with information on investment cost parameters and comparing manual and onion stem and root cutting machines, they can make correct decisions on the most cost-effective option. This not only reduces farming expenses but also improves the overall efficiency and productivity of their work, leading to higher profits and improved output quality. Therefore it is proposed to develop a mechanical stem and root cutting with sorting machine to reduce drudgery, timeliness of operation, reducing labour requirement and cost of operation.

MATERIALS AND MATHODS

Research Design

This study involves analyzing of data collection from local onion farmers, the cost of labour, time and efficiency in both manual and developed onion stem and root cutting

operations.It focused on the cost and performance comparison using manual and the developed onion stem and root cutter. The economic measures were calculated using established equations to determine the potential benefits of using the developed cutter compared to manual methods.

Cost Analysis of Onion Stem and Root Cutting Machine

Cost economics of onion stem and root cutting machine was determined on the basis of labour charges, material price, repair and maintenance. The IS: 9164code was used to calculate the cost of machine. The Cost of operation depends on fabrication cost of machine, maintenance and labour cost. The developed onion stems and root cutter operational cost was divided into fixed and variable cost. The fixed cost was calculated by assuming the rates prevailing in the market for mild steel. The variables cost was worked out by taking the hire charges prevailing in this region for operator. (Kambo*et al.* 2012). Details and calculation involved in cost analysis is described in below Eq.1 to 9.

Fixed cost

Depreciation

It is commonly used for determination of depreciation of agricultural machine .This cost reflects the reduction in value of a machine with use (wear) and time (obsolescence). It is the loss of value of a machine with the passing of time and calculated by the formula (IS 9164: 1979). It is calculated as

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

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

Interest was calculated on the average investment of the machine, taking into consideration the value of the machine in first and last year (IS 9164: 1979)

Where,

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

C = Initial cost of implement, Rs;

S = Salvage value @ 10 % of C, Rs.

I = Interest per hour; and

i = 10% per year

H = Number of working hours per year;

Housing

Housing cost was calculated on the basis of the prevailing rate of the locality and generally taken as 1% of the initial cost of the machine per year. (IS 9164: 1979)

$$HC = \frac{C}{H} \times \frac{1}{100} - - - (3)$$

Insurance

Insurance charge is taken on the basis of actual payment to the insurance company but roughly speaking, it may be taken 1% of initial cost of machine per year.

Taxes

It may be taken as 1 % of the initial cost of machine per year.

Operating cost

The variable costs are those cost which incurred due to operation of the machine

Electricity cost

The power tariff by whopping around 34 per cent for the agriculture consumers.As against the existing tariff of Rs 4.10 per unit.

Repair maintenance cost

Cost of repairs and maintenance varies between 5 to 10% of the initial cost of the machine per year. (IS 9164: 1979)

Labour wages

Wages of labour was calculated on the basis of actual wages of the worker in present time. (IS 9164: 1979).Wages were calculated on the basis of the actual wages of the workers @ Rs 300day (8 h/day)

Labour cost = Number of worker × Wage per hour (Rs) --- (4)

Total cost of machine

The total cost of develop machine was determined by summation of total fixed cost per hour with total variable cost per hour.

Total Cost/h = Fixed Cost per hour + Variable Cost per hour --- (5)

Where,

Total fixed cost = Depreciation +Interest + Housing+Insurance; and

Total variable cost = Electricity cost + Repair and maintenance cost + Labour wages

Therefore,

Total cost = Fixed cost + Variable cost

Breakeven point (BEP)

Breakeven point (BEP) is the point at which total expenses and total revenues are equal. It was calculated by using formula given in Equation 6.by (Dewett, 2004).

$$\mathrm{BEP} = \frac{\mathrm{FC}}{\mathrm{CH} - \mathrm{C}} - - - (6)$$

Where,

BEP = Breakeven point, h y^{-1};

FC = Annual fixed cost, ₹ y^{-1};

C = Operating cost, ₹ h^{-1}, and

CH = Custom hiring charges, ₹ h^{-1}.

= (C + 20 per cent over head) + 20 per cent profit over new cost

Payback period calculation

To know the time required to get back the investing, payback period was determined for developed machine by using Equation 7 to 9.(Reddy *et al.*, 2006).

$$\mathrm{BP} = \frac{\mathrm{IC}}{\mathrm{ANP}} - - - (7)$$

Where,

PBP = Payback period, year;

IC = Initial cost of machine, ₹ ; and

ANP = Average net annual profit, ₹ y^{-1}.

$$\mathrm{ANP} = (\mathrm{CH} - \mathrm{C}) \mathrm{x}\, \mathrm{AU} \quad - - - (8)$$

$$AU = AA \times EC \quad ---(9)$$

Where,

CH = Custom hiring charges, ₹ h^{-1};

AA = Average annual use, h y^{-1}, and

EC = Effective capacity of machine, ha h^{-1}.

The best payback period should be as shortest as possible. Getting repaid or recovering the initial cost of a machine or an investment should be achieved as quickly as possible.

Costcomparisonofmanualand power operated stem and root cutting

The manual and machine stem and root cutting of onion in kg/hrorton/hrisactualdatagatheredduringtheperformance test of the machine. A comparative study was done on capacity of machine and cost of operation. The newly developed machine saves cost and saving over labour as compared to traditional sickle cost and saving over labour as compared to battery operated onion stem and root cutter at desired stem length. Theaveragetimeformanualcutting and machine cuttingwascalculated. Thecostofmechanicalcutting wascalculated using the data collected for capacity purpose.

Power operated onion stem and root cutter cum sorting machine

The onion stem and root cutter cum sorting machine shown in Figure 1 is an onion stem and cutter machine capable of cutting, grading, and collecting onion bulbs in one operation. This machine has 19 grooves in it. 5–6 onion crops are placed in each groove. This machine is driven by an electric motor with a crank, cutter bar, and brush unit that cuts the stem and root of the onion and collects onion bulbs in different three-grade sizes. The parts were made of locally available materials and fabricated by a local manufacturer. It has five main assemblies: the mainframe, cutter bar and brush unit, sorter, power transmission system, and outlet tray. The developed power operated onion stem and root cutter cum sorting machinetechnical parametersinvolved in the calculation.

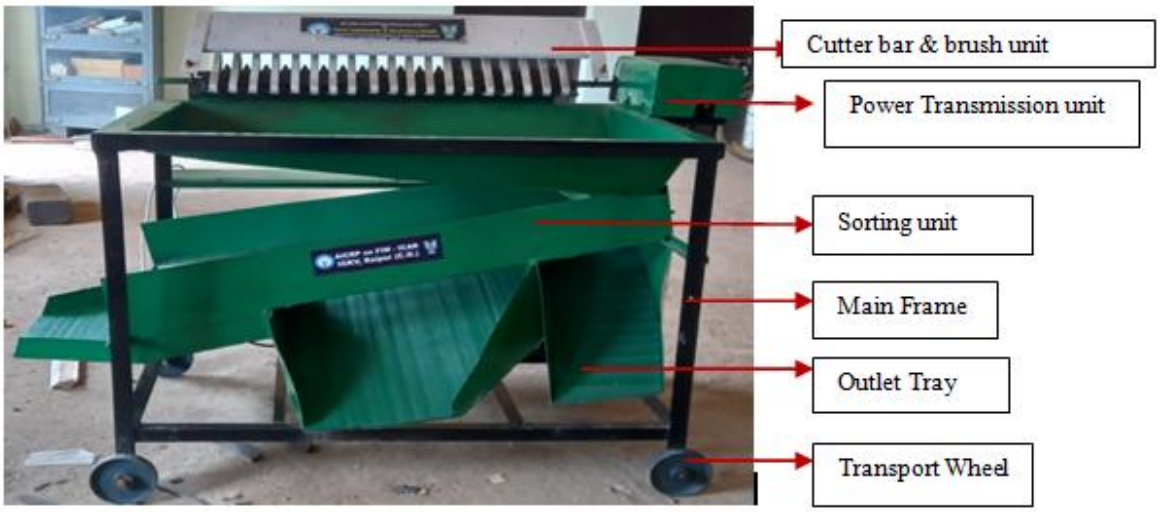

Fig.1 : Developed onion stem and root cutter cum sorting machine

Manualstem and root cutting

The manual stem and root cutting of onion shown in Figure 2 is the pillar for the development of this study.

Fig.2: Manual cutting of onion stem and root (sickle)

Battery operated onion root and shoot cutting machine

This machine consists of blade, DC motor and plates assembly which is mounted on top side of stable platform on frame. It operates on charging spray pump battery. The power operated onion leaf and root cutter is operated by 12 watt single phase DC motor having 150 rated rpm. When power is supplied to the machine, the DC motor turns direct current into mechanical energy, which aids in the rotation of the blade. The blade is inserted between the plates, which include two slots for onion insertion, allowing the roots and leaves to be sliced independently.

The onions are inserted in the slots manually, after that the cutting of root and shoot bulb moves downward. On a single machine, two people can cut the leaves and roots at the same time.

Fig .3: Battery operated onion root and shoot cutting machine

RESULTSANDDISCUSSION

Cost economics of different onion stem and root cutting methods

Cost of prototype of onion stem and root cutter cum sorting machine is estimated as ₹ 61190.00. Following assumption was made for economic analysis of power operated onion stem and root cutter cum sorting machine:

a) Expected life = 10 years
b) Annual Working hour (H) = 250 h y^{-1}
c) Salvage value (S)= 10% of initial cost
d) Rate of interest = 10% per annum
e) Labour required =02
f) Electricity cost = Electricity consumed (kW) ×Electricity charges (Rs/kWh)
g) Repair and maintenance = 5% of initial cost
h) Shelter, insurance and tax cost = 2% of initial cost

However, when both fixed costs and operational costs were taken into account, the machinery cost per hour was computed to be Rs. 240.00, as compared with other cutting methods, as seen in Table 1.

Table1: Cost of operation of different onion stem and root cutting methods

Particulars	Developed machine	Stem and root cutting with sickle/*Pahsul*	Battery operated onion stem and root cutter
Cost of machine (C), Rs.	61190.00	-	2500.00
Useful life of machine, year	10	-	2
Annual working hour, h	250	-	250
Salvage value (10% of C)	6119.00	-	250.00
Fixed cost			
Depreciation , Rs./h	22.03	-	0.90
Interest, Rs./h	11.01	-	0.45
Shelter, insurance and tax cost	4.90		0.20
Housing , Rs./h	2.45	-	-
Total fixed cost, Rs/h	40.39	-	1.55
Variable cost			
Electricity charges, Rs./unit	4.10	-	4.10
Electricity consumption, unit/h	0.74	-	1.1
Electricity cost, Rs/h	3.05	-	4.55
Repair and maintenance cost, Rs./h	12.24	-	0.50
Labour required,	2	1	2
Labour cost, Rs./day	300.00	300	300
Working hour, h/day	8	8	8
Labour wages, Rs./h	75.00	37.50	75.00
Total variable cost, Rs./h	90.29	37.50	80.05
Total cost of operation, Rs./h	130.68	37.50	81.60
Output capacity, t/h	0.544	0.015	0.108
Total cost of operation out, Rs./t	240.00	2500.00	755.00
Breakeven point, h/year	139.79	-	-
Payback period, year	3.38	-	-

The machine breakeven point was calculated as 139.79 h/year and payback period was found to be 3.38years taking profit as 20%.The costs associated with each stage of cutting straw are listed in Table 1. An onion farmer could easily accomplish these operating hours per year.

Comparisonofdifferent onion stem and root cutting methods

A comparative study was done on capacity of machine and cost of operation (Table 1 and Table 2). It shows that the newly developed machine saves 70.37% cost and saving over labour 92.59% as compared to traditional sickle and 46.07 % cost and saving over labour 82.60 % as compared to battery operated onion stem and root cutter at desired stem length. It was also observed that the present developed machine is far better and efficient than the traditional. The cost of operation by the developed onion stem and root cutter was recorded as Rs 240/t, where as for the traditional method (sickle) and for battery operated cutter it was Rs 810/t and Rs 445/t. The average capacity of the machine was 544 kgh^{-1} and requires only 0.2 man days to complete 1 ton onion stem and root along with sorting in a day, whereas in case of traditional methods the sorting also required additional labour charges.The result showed that the cutting capacity of human has a mean of 45 kg/hr while the cutting capacity of human has a mean of 108 kg/hr. Onion Stem and Root Cutter Cum Sorting Machine cutting efficiency was found to be 544 kg/h shown in Table 1 and 2.

Table 2: Comparison of average capacity, ton/h cutting operation machine/methods

S. No.	Cutting operation machine/methods	Capacity, kg/h	Man days per ton	Cost, Rs./ton	Saving in cost, %	Saving in labour
T1	Developed onion stem and root cutter	544	0.2	240.00	-	-
T2	Stem and root cutting with sickle/*Pahsul*	45	2.7	810.00	70.37	92.59
T3	Battery operated onion stem and root cutter	108	1.15	445.00	46.07	82.60

CONCLUSION

The aim of this research paper was to compare the manual and power-operated onion stem and root cutter machines. Manual cutting is most common method of onion stem and root cutting in farmer field which is very labour intensive, drudgery prone and time consuming

operation. Use of power operated machine for cutting stem and root with sorting onion crop is very limited. The research found that the power-operated onion stem and root cutter cum sorting machine had a capacity of 544 kg/h, while the specific capacity of the manual onion stem and root cutter machine was only 200 kg/h. This significant difference in capacity indicates that power-operated machines can process and handle a much larger quantity of onions in a shorter amount of time, thereby increasing productivity and reducing labor costs. The cost of the machine is found as 61190.00 Rs. with breakeven point was calculated as 139.79 h/year and payback period was found to be 3.38years taking profit as 20%.The newly developed machine saves 70.37% cost and 92.59% labour as compared to traditional sickle and 46.07 % cost and 82.60 % labour as compared to battery operated onion stem and root cutter at desired stem length.

REFERENCES

Gopakkali, P., and Sharanappa.2014.Effect of organic farming practices on growth, yield, quality and economics of onion (Allium cepa) in dry zone of Karnataka.Indian Journal of Agronomy. 59(2):336-340.

Gunathilake, D., Wasala, W., and Palipane, K., 2016.Design, development and evaluation of a size grading machine for onion.Procedia food science, 6:103-107.

Kale, V.K., Kawade, D.K., Shinde, T.S., Vhanamane, P.S. and Pagar, K., 2018.Onion Leaf Cutting Machine. International Research Journal of Engineering and Technology, 5(4): 2902-04.

Kamboj, Parminder&Khurana, R. & Dixit, A.2012. Farm machinery services provided by selected cooperative societies. 14:123-133.

Kumawat, Lokesh and Raheman, Hifjur. (2022). Mechanization in Onion Harvesting and its Performance: A Review and a Conceptual Design of Onion Harvester from Indian Perspective. Journal of The Institution of Engineers (India): Series A. 103. 10.1007/s40030-021-00611-3.

LorenzenJr, C. 1950. "The development of a mechanical onion harvester." Agricultural Engineering 31 (1):13-15.

Lorenzo Abenavoli,M., Giametta, F., and Morabito, S., 2005. Onion: harvesting and postharvesting mechanized operations. CIGR International Conference· Beijing Sponsored by CIGR, CSAM and CSAE Beijing, China.

Nadeem, Muhammad and Ghani, Muhammad. (Muhammad Nadeem1,*, Abdul Jabbar2, Faisal Baig3, Hafiz Usman Ghani4, Waseem Akram5 and Kamran Ikram6)2018. Cost analysis of engine operated reaper and its comparison. J. Glob. Innov. Agric. Soc. Sci., 2018, 6(1): 1-6.

Naik, M. A. Pateriya, R. N. and Ramulu, Ch. 2021.Optimization of performance parameters of onion digger with cutter bar topping unit. Journal of The Institution of Engineers (India): Series A , 103: 71–79.

Rathinakumari, A.C; SenthilKumaran, G.2022.Onion detopping machine - an emerging horticultural enterprising.Journal of Horticultural Sciences, 17(1):199-205.

Reddy, A. S., Loh, S. and Kane, R.A. 2006. Budget variance analysis of a department wide implementation of a PACS at a major academic medical center.Journal of Digital Imaging. 19(1): 66–71.