Economic Affairs, Vol. 68, No. 01, pp. 463-468, March 2023
DOI: 10.46852/0424-2513.1.2023.15

AESSRA

Research Paper

Economic Analysis of Garlic (*Allium sativum*) Stalk Cutter cum Grader Machine

Charan Singh[1]*, Neha[2], Ravi Kumar[3] and Vijay Kumar Singh[3]

[1]Department of Processing and Food Engineering, CAET, Junagadh Agricultural University, Gujrat, India
[2]Department of Foods and Nutrition, I.C.COHS, CCS Haryana Agricultural University, Hisar, Haryana, India
[3]Department of Processing and Food Engineering, COAE&T, CCS Haryana Agricultural University, Hisar, Haryana, India

*Corresponding author: ckamboj9671@gmail.com (**ORCID ID:** 0000-0002-1967-174X)

Received: 12-05-2022 **Revised:** 20-01-2023 **Accepted:** 21-02-2023

ABSTRACT

Garlic is a bulbous plant of the Amaryllis family (*Amaryllidaceous*), native to central Asia. Garlic is well known for its medicinal properties such as antiseptic, antibacterial and anticancer properties. It is also used to cure several chronic diseases such as bites, headaches, intestinal worms, dermatitis and abdominal pain. Garlic is a labour-intensive crop which requires intensive labour even after uprooting. Garlic stalk cutting and grading are primary unit operations to make the product fit for the market. The manual garlic stalk cutting and grading is labour intensive and uninteresting work. To reduce the labour cost and increase the benefits to farmers, a garlic stalk cutter cum grader was developed. The capacity of the garlic stalk cum grader was 177.6 kg/h. To check the profitability of the machine to farmers, an economic analysis of the machine was conducted. The comparison of manual and machine operation revealed that the capacity of the machine was 9.83 times the manual operation. The cutting and grading cost of the machine was ₹ 75.3/q compared to the ₹ 852.48/q of manual operation. The annual profit and payback period of the machine, if operated for the whole working hours of the machine was ₹ 442910.7 and 0.112 years. The breakeven quantity analysis revealed that to avoid any losses 17.26 quintal garlic must be processed annualy using the machine.

HIGHLIGHTS

- Garlic stalk cum machine had 9.83 time more capacity as compared to manual operation.
- A profit of ₹ 519 per quintal can be generated in machine operation compared to manual operation.
- The breakeven quantity of machine was 17.26 quintal hence suitable for both small as well as big farmers.

Keywords: Garlic, Profitability, Capacity, Economic analysis, Breakeven quantity

Garlic *(Allium sativum*) is a native perennial plant of central Asia. It belongs to the Amaryllis family (*Amaryllidaceous*) and is majorly cultivated for its bulb (Morales-González *et al.* 2019). India is the second-largest producer of garlic with a production of 2926.09 metric tonnes from an area of 352.64 thousand hectares (Anonymous, 2022a). Garlic was initially used as a medicinal plant because of its potential in curing several chronic diseases and have excellent antiseptic, antibacterial and anticancer properties (Satypal *et al.* 2017). In India, garlic is generally cured (drying under shade) to extend the shelf life and sale in the off-season (Desta *et al.* 2021).

Garlic is a special crop which requires intensive labour to harvest and process. After uprooting the bulbs are dried for some time in the field itself. They are placed such that the stalk of the adjacent plant covers the bulb of the preceding plant. After that,

How to cite this article: Singh, C., Neha, Kumar, R. and Singh, V.K. (2023). Economic Analysis of Garlic (*Allium sativum*) Stalk Cutter cum Grader Machine. *Econ. Aff.*, **68**(01): 463-468.

Source of Support: None; **Conflict of Interest:** None

they are further cured under shade for selling in the offseason. The bulb separation from the stalk is one of the most important unit operations in processing garlic which makes it fit for transportation and increases its market demand. Manual stalk cutting using hand tools is generally practised in India which is time inefficient and uninteresting work. Grading of the bulbs based on size increases the market demand for the product. Similar to stalk cutting grading is also done manually or isn't performed at all in many areas. The efficiency of manual grading is less and demands skilled labour (Barman *et al.* 2015; Paltrinieri, 2014). These unit operations demand high labour charges and ultimately reduce the economic benefits to the farmer. A similar practice of using hand labour for stalk cutting and grading is practised in Egypt (Ibrahim and Athai, 2018). The average agricultural labour wages per day for unskilled agriculture work in 2019-2020 reached ₹ 286.6 in India (Anon., 2022b). Apart from it, the demand for garlic is season-specific which requires rapid supply to the market to increase the fortune to the farmer. However, due to decreasing labour and increasing labour charges, the ultimate benefit to garlic growers is decreasing. To increase the economic benefit to the farmer there is a need to mechanize the bulb separation and grading operation. Several machines are available in the market to perform the above-discussed unit operations. However, they can perform either unit operation at a time or their capacity is not up to mark. Several detopping machines are discussed in the literature such as power-operated garlic stem and root cutter (Barman *et al.* 2015), garlic root and stem cutting machine (Ibrahim and Athai, 2018) and onion detopper machine (Rani and Srivastavm, 2012). Given the above-discussed point, a garlic stalk cutter cum grading machine was developed.

The economic analysis of the machine compared to manual labour is necessary to decide the profitability and acceptability of the machine. The economic analysis also involves the cost of various parameters such as maintenance, wear and tear, energy requirement and labour requirement to operate the machine. Keeping in mind the objective of the current study is to evaluate the economic profitability of garlic stalk cutting cum grading machines. To accurately measure the economic feasibility break-even point analysis of the machine and reduction in stalk cutting cum grading cost was also analysed.

Garlic stalk cutter cum grading machine description

The developed garlic stalk cutter cum grading machine has four major units namely cutting unit, grading unit, reciprocating assembly and transmission system. The garlic stalk cutter cum grading machine is shown in Fig. 1. A reciprocating blade of stainless steel (SS304) was used to separate the bulb from the stalk. The blade was aligned between guides which also served as feeding slits (4 slits for two workers) for the garlic stalk. To achieve a constant length of leftover stalk metal guides are provided behind the feeding slits. The operator of the machine needs to force the garlic stalk through feeding on the reciprocating blade. A safety cover with its slope away from the machine is provided to avoid any contact of the hand with the blade. After separation from the stalk, the bulbs drop on the collection tray which guides them to the grading section. The grading unit was made of divergent type with four trapezoidal lanes. The grading unit was provided with a step increase in clearance according to grade size. The machine was designed to grade the garlic in three sizes viz. Class I (<30 mm), Class II (30-45mm) and Extra class (>45 mm). The grading unit was made a removable type to use for grading other spherical crops. The grading unit was placed on the reciprocating assembly of the machine. The force required to move the bulb through the grading section was provided by the reciprocating motion of the reciprocating assembly. A motor of 1hp was used to provide the necessary motion to the machine. The machine consumes 0.8 kWh of electrical energy. The total cost of the garlic stalk cutter cum grader machine was ₹ 49500.

MATERIALS AND METHODS

Estimated garlic stalk cutter cum grader machine cost

The working parameters of the garlic stalk cutter cum grader machine were first optimized using response surface methodology before economic evaluation. The working parameters of the machine were the feed rate and moisture content of the garlic stalk. The machine was optimized considering

several dependent parameters such as capacity, bulb damage, grading efficiency, plant spilt and cutting efficiency. At optimized conditions, the machine had a capacity of 177.6 kg/h (Singh, 2017). The performance of the garlic stalk cutter cum grader machine was evaluated by an operating machine for 8 h/day by three workers. The average daily wages of India (₹ 286.6) were considered in economic analysis as per the data provided by the reserve bank of India on the state-wise daily wages of different states for the year 2019-2020 (Anon., 2022b). The machine was operated by unskilled workers for 8 hours. The average per unit electric charge (₹ 6.09/ kWh) of India in 2019-2020 was used in calculations (Anon., 2022c). Similarly, to compare the machine with the manual process, nine unskilled workers performed the manual garlic detopping and grading for 8 hours. Both manual and machine work was conducted in similar environmental conditions.

Fixed cost per annum

The fixed annual cost is a summation of the interest cost and depreciation cost per year of the machine. The annual charges of interest were calculated as 12% average investment on the machine (Singh and Mehta, 2015). The useful life of the power-operated chaff cutter was reported to be 10 years (Sunil *et al.* 2016) and of a mango, the grader was reported to be 15 years (Anon., 2013). Based on this, the useful life of the machine was considered 10 years. The residual value of the machine was taken 5% of the purchase price (Singh and Mehta, 2015). The formula for depreciation and interest cost is given in Eq. 1 and 2, respectively.

$$\text{Depreciation cost per year} = \frac{\text{Machine cost} - \text{Residual value}}{\text{Useful life of the machine}} \quad \ldots(1)$$

$$\text{Interest cost per year} = \frac{\text{Machine cost} + \text{residual value}}{2} \times 0.12 \quad \ldots(2)$$

Variable cost per annum

The variable cost includes repair & maintenance of the machine which was considered 5% of the initial cost (Singh and Mehta, 2015) and wages of the agricultural labour. As per the data provided by the reserve bank of India on the state-wise average daily wages of different states for the year 2019-2020, the average daily wages of ₹ 286.6 was considered (Anon., 2022b). The electricity charges are also included in the variable cost of the machine. The formula for calculation of annual wages of the workers and total variable cost is given in Eq. 3 and 4, respectively.

$$\text{Wages} = \frac{\text{No of workers} * \text{Working hours of the machine in a year} \times \text{Daily charge}}{\text{Working hours of workers in 1 day}} \quad \ldots(3)$$

$$\text{Total variable cost per annum} = \text{Repair \& maintenance} + \text{Wages} + \text{Electricity} \quad \ldots(4)$$

Total annual cost per annum

The total annual cost per annum of the machine was a summation of the fixed cost and variable cost of the machine (Eq. 5).

$$\text{Total annual cost per annum} = \text{Total variable cost} + \text{Total variable cost} \quad \ldots(5)$$

Machine productivity per year

The machine productivity was calculated as the multiplication of the hourly capacity of the machine multiplied by the annual working hour of the machine (Eq. 6).

$$\text{Machine productivity per annum} = \text{Total working hour/year} * \text{actual capacity} \quad \ldots(6)$$

Payback period

The payback period of the machine was calculated by dividing the cost of the machine by the annual profit of the machine (Eq. 7).

$$\text{Payback period} = \frac{\text{Machine cost}}{\text{Annual profit}}$$

Breakeven quantity

The breakeven quantity of garlic stalk cum grader machine was calculated using the given in Eq. 8.

Profit × QBE = Fixed Cost + (Variable cost per quintal × QBE) …(8)

Q_{BE} = Breakeven quantity

RESULTS AND DISCUSSION

Economic aspect

The average capacity of the manual stalk cutting and grading resulted in 48.2 kg in 8 hours per person. The capacity of the machine at optimized conditions was 177.6 kg/ hour. As the machine was operated by three persons, the machine's productivity was compared with the combined capacity of three workers. The capacity of the machine was 9.83 times more than the manual operation.

Breakeven quantity for garlic stalk cum grader machine

The important parameters related to economic analysis are given in table 1.

Table 1: Economic parameters of the machine and manual operation

Sl. No.	Parameters	Values
1	Cost of machine (₹)	= ₹ 49500
2	Fixed cost	
	Interest cost per year @ 12 % (₹)	= {(C + S)/2}*12 = 3118.5
	Depreciation cost per year @ 10 % (₹)	= {(49500 – 2475)/10} = ₹ 4702.5
	Total fixed cost per annum (₹)	= ₹ 7821
3	Variable cost per annum (₹)	
	Repair and maintenance @ 5 % of initial cost (₹)	= ₹ 2475
	Wages (₹) of three workers per annum	= ₹ 51588
	Electric charges per annum	= ₹ 2307.84
	Total variable cost per annum (₹)	= ₹ 56370.84
5	Total annual cost (₹)	= ₹ 64191.84
6	Machine's productivity per year	= 480 * 177.6 = 852.48 q
	Cutting cost of the machine (V/q)	= ₹ 75.3/q
7	Wages of three workers for manual cutting and grading	= ₹ 859.8
	Capacity of manual stalk cutting and grading of three workers	= 1.446 q
	Cost of hand cutting and grading (₹/q)	= ₹ 594.6/q
8	Saving/profit per quintal (₹/q)	= ₹ 594.6 – ₹ 75.3 = ₹ 519.3
9	Saving/profit per year	= 852.9*519.3 = ₹ 442910.7
10	Payback period (year)	= 49500 / 442910.7 = 0.112 year
11	Breakeven point	= 17.26 q

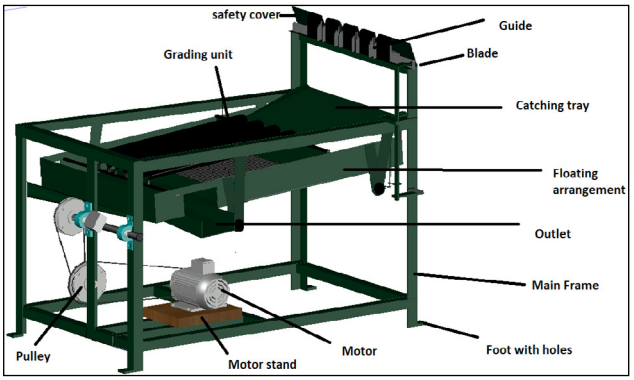

Fig. 1: 3D Diagram of garlic stalk cutter cum grader machine

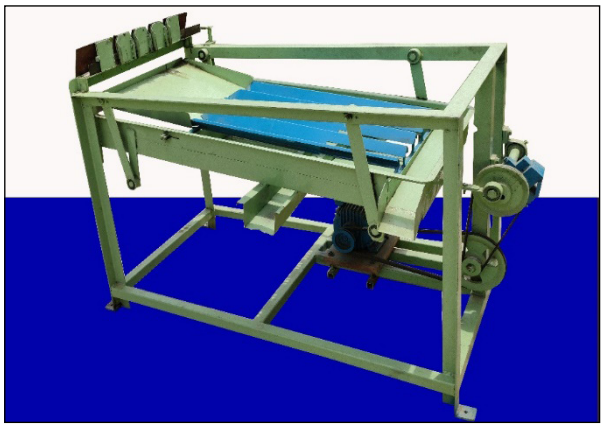

Fig. 2: Developed garlic stalk cutter cum grader machine

Based on necessary assumptions made, the total fixed and variable annual cost for the operating machine was calculated as ₹ 7722 and ₹ 56370.84 respectively. The total annual cost of operating the machine including electricity charges was ₹ 64191.84. The productivity of the machine per year was calculated 852.48 q which was very high compared to manual operations. The cutting and grading cost of the machine and manual labour resulted in ₹ 75.3/q and ₹ 594.6/q, respectively. It was observed that the machine operator has a profit of ₹ 519 per quintal of garlic detopped and graded which can result in an annual profit of ₹ 442910.7 if the machine is operated all the annual working

hours. Based on the annual profit, the payback period of the machine was 0.112 years.

To achieve profit from the machine, the information regarding the breakeven quantity i.e. the minimum quantity to be processed by the machine to avoid any losses must be known. The breakeven quantity was calculated using the equation given in Eq.8. The total fixed cost of the machine was calculated as ₹ 7821 and the variable cost per quintal of detopped & graded garlic was ₹ 66.125/ quintal. The breakeven analysis showed that to generate profit from the machine, a quantity of 17.26 quintal must be processed using the machine. The breakeven analysis graph is shown in Fig. 3.

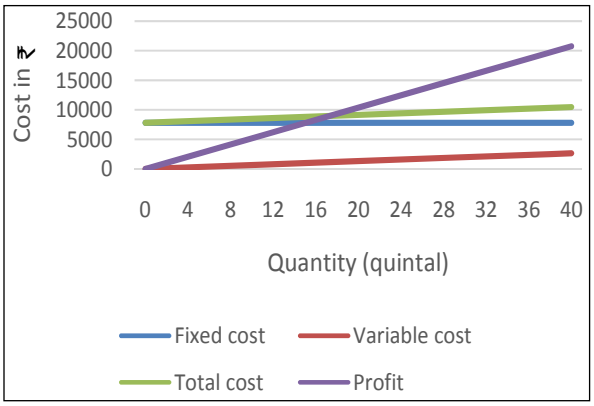

Fig. 3: Breakeven point of garlic stalk cum grader machine

CONCLUSION

The garlic stalk cutter cum grader machine was developed viewing high labour cost and lower efficiency of the manual operation. The capacity of the machine was evaluated 177.6 kg/h. On comparing manual and machine operation it was observed that the capacity of the machine was 9.83 times that compared of manual operation. The processing cost of the machine and manual was ₹ 75.3/q and ₹ 594.6/q, respectively which results in a profit of ₹ 519.3/q. The payback period and breakeven quantity of the machine was 0.112 years. The breakeven analysis revealed that to avoid losses machine should process a minimum of 17.26q per year. It was concluded that the machine can benefit both small and big farmers as the breakeven quantity was low. The machine can be adopted by the farmer as well by the middleman in a large industry. The machine requires less labour and had a high capacity which solves the problem faced in manual operation.

REFERENCES

Anonymous 2013. Depreciation Rates for machinery used for grading, sorting and packing produce. https://www.taxtechnical.ird.govt.nz/en/determinations/depreciation/general/dep-83-depreciation-rates-for-machinery-used-for-grading-sorting-and-packing-produce (Last Accessed on 9th May, 2022).

Anonymous, 2022a. Selected State-wise Area, Production and Productivity of Garlic in India (2019-2020). https://www.indiastat.com/table/agriculture/selected-state-wise-area-production-productivity-g/1418851 (Last Accessed on 9th May, 2022).

Anonymous, 2022b. State-wise Average Daily Wage Rates in Rural India (Men - General Agricultural Labourers). https://m.rbi.org.in/scripts/PublicationsView.aspx?id=20083 (Last Accessed on 9th May, 2022).

Anonymous, 2022c. Average cost of state electricity supply across India from financial year 2009 to 2019 (in Indian rupees per kilowatt hour). https://www.statista.com/statistics/808201/india-cost-of-state-electricity-supply/#:~:text=During%20fiscal%20year%202019%2C%20the%20capacity%20of%20approximately%20356%20gigawatts (Last Accessed on 9th May, 2022).

Badhe, V.T., Singh, P., and Bhatt, Y.C. 2011. Development and evaluation of mango grader. *J. Agril. Engineer.*, **48**(2): 43-47.

Barman, C., Bhatt, Y.C., Jain, H.K., and Vyas, S.S. 2015. Performance Evaluation of Power Operated Garlic Stem and Root cutter. *Agril. Engineer. Today*, **39**(3): 57-61.

Desta, B., Woldetsadik, K. and Ali, W.M. 2021. Effect of Harvesting Time, Curing and Storage Methods on Storability of Garlic Bulbs. *The Open Biotechno. J.*, **15**(1).

Ibrahim, M.M. and Athai, M.S. 2018. Development of a garlic root and stem cutting machine. *Misr J. Agril. Engineer.*, **35**(3): 807-826.

Morales-González, J.A., Madrigal-Bujaidar, E., Sánchez-Gutiérrez, M., Izquierdo-Vega, J.A., Valadez-Vega, M.D.C., Álvarez-González, I., Morales-González, A. and Madrigal-Santillán, E. 2019. Garlic (*Allium sativum* L.): A brief review of its antigenotoxic effects. *Foods*, **8**(8): 343.

Paltrinieri, G. 2014. Handling of fresh fruits, vegetables and root crops: A training manual for grenada. Rome, Italy: Food and Agriculture Organization of the United Nations, pp. 20-22.

Rani, V. and Srivastava, A.P. 2012. Design and Development of Onion Detopper. *Agril. Mechanization in Asia, Africa and Latin America*, **43**(3): 69-73.

Satypal, P., Craft, J.D., Dosoky, N.S. and Setzer, W.N. 2017. The chemical compositions of the volatile oils of garlic (*Allium sativum*) and wild garlic (*Allium vineale*). *Foods*, **6**: 63.

Singh, K. and Mehta, C.R. 2015. Decision support system for estimating operating costs and break-even units of farm machinery. *Agril. Mechanization in Asia Africa and Latin America*, **46**(1): 35-42.

Singh, C. 2017. Design and development of garlic (*Allium sativum*) stalk cutter machine. Thesis M Tech, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India.

Sunil, V.R., Chandel, B.S. and Makarabbi, G. 2016. Economics of milk production in Mandya district of Karnataka. *Econ. Aff.,* **61**(4): 659.