The Pharma Innovation Journal 2023; 12(11): 780-783

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(11): 780-783

www.thepharmajournal.com
Received: 08-08-2023
Accepted: 13-09-2023

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Comparative analysis of manual and paddy straw size cutter machine

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Abstract
Paddy straw cutting by hand has been consuming a lot of energy in the past few years. Researchers are working to identify the issue faced by farmers. There are several ways that new methods will contribute to a decrease in usage. The method for developing and utilizing a low-cost size cutter for producing mushrooms from paddy straw is suggested in this research. The main components included in the machine were frame, belt drive attachment, electric motor, shaft and blade. The main study focus was on the machine's design. The cutting's working width is 400 mm, its capacity is 146 kg/h and the prototype unit costs is approximately Rs 23490/-. The machine capacity and operating costs were compared in regard with traditional ones. Research indicates that the recently developed machine reduces costs by 69.11% when compared to the conventional *Katti* machine and by 57.34% when compared to the chaff cutter when it comes to sizing paddy straw to the optimum length. The machine's payback period was determined to be 0.97 years (194 hours) of operation. A farmer with a mushroom farm could easily accomplish this. The machine is therefore relatively economical.

Keywords: Paddy straw, straw size cutter, BEP, PBP, cost operations

Introduction
In India, Total production of Rice during 2021 is estimated at record 127.93 million tonnes. Compared to the average production of 116.44 million tonnes during the previous five years, it was higher by 11.49 million tonnes. (Anonymous, 2022) [1]. For every kilogram of grain harvested, between one to 1.5 kg of straw are produced (Maiorella, 1985) [5]. India produces approximately 112 million tons of milled rice and 140 million tons of paddy straw every year. Amid in the current scenario there is no sustainable and permanent solution in hand to manage this huge quantity of straw. Most of the farmers rely on the in situ burning of straw that is creating numerous ecological, environmental, health and economic issues in many states of the India (Singh and arya 2021) [7]. Presently, the amazing culinary and medicinal qualities of mushrooms have made them extremely popular worldwide. Mushroom demand locally is also growing rapidly. The first attempts at systematic cultivation of paddy straw mushrooms were made in 1943; however they were initially cultivated in 1940 in India. Currently, coastal areas like Orissa, Andhra Pradesh, Tamil Nadu, Kerala and West Bengal are where this mushroom is most popular, although it may be grown in other states where the climate is suitable and where there is abundance of agricultural waste present. Typically, paddy straw is used to produce mushroom. Paddy straw that is long and well-dried is desired. The straw is bundled into 8–10 cm diameter bundles. A cleaver knife (*Katti*) is then used to trim the bundles to a uniform length of roughly 70–80 cm. When cutting paddy straw, it uses a lot of energy. One of the labor-intensive procedures in the growing of mushrooms is the sizing of straw.

Materials and Methods
Research study
In order to identify the specific practices in the local paddy straw field, especially in the size-cutting operation, this study used a descriptive research approach. It concentrated on comparing costs between the manual and the newly developed paddy straw size cutter. As the study's effects became apparent, the economic measurement computations modified the standard based equations.

Evaluation of investment costs

The machine's economic feasibility was assessed using the evaluation of investment characteristics. These include cost of operations, payback time, and break-even point analysis. The produced paddy straw size cutter's economics and associated costs were assessed by accounting both fixed and variable costs, as well as the energy used and process-related expenses. Calculating the fabrication, fixed and variable costs allowed us to determine the cost of operation for cutting with various blades. The fixed cost was computed using the mild steel market rates as a starting point. By using the operator hire fees that are typical in this area, the variable cost was calculated. Based on the machine's cutting rate, the cutting rate per operating hour was computed. Equations (1) to (9) were used for the calculation

Depreciation

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

Where,
D= Depreciation per hour;
C = Capital investment;
S = Salvage value, 10% of capital;
H = Number of working hours per year; and
L= Life of machine in year.

Interest

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

Where,
I = Interest per hour; and
i = % rate of interest 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)

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

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 percent 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 200 day (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 = Fixed Cost + Variable Cost (5)

Where,
Total fixed cost = Depreciation +Interest + Housing+ Insurance; and
Total variable cost = Electricity cost + Repair and maintenance cost + Labour wages

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) [3].

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

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 percent over head) + 20 percent 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 8 (Reddy *et al*., 2006) [6].

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

Where,
PBP = Payback period, year;
IC = Initial cost of machine, ₹; and
ANP = Average net annual profit, ₹ y^{-1}.

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

$$AU = AA\ x\ EC \quad (9)$$

Where,
CH = Custom hiring charges, ₹ h^{-1};
AA = Average annual use, h y^{-1}, and
EC = Effective capacity of machine, ha h^{-1}.

Comparison of traditional and developed machine paddy straw size cutter

The study only focuses on the comparison between the recently developed machine, traditional cutting tools and chaff cutters, neglecting the potential advantages or disadvantages of other modern cutting tools available on the

market. A comparative analysis of machine capacity and operating costs was conducted. It demonstrates how the recently developed machine compares to chaff cutters and other traditional cutting tools (*Katti*) for sizing paddy straw to the desired length.

Results and Discussion

Developed machine paddy straw size cutter

The paddy straw size cutter shown in Figure 1 is a power operated paddy straw size cutter capable of cutting and collecting size cut straw in one operation. It cuts sizes of paddy straw with single operation at minimum speed. The parts were made of locally available materials and fabricated by a local manufacturer. It has main assemblies: the mainframe, blade, V belt drive, electric motor and outlet. The developed machine paddy straw size cutter technical parameters involved in the calculation are the cutting capacity of 0.146 ton/h and 1 man day/ton.

Fig 1: Developed power operated paddy straw size cutter

Traditional paddy straw size cutter

The traditional paddy straw size cutter is shown in Figure 2. The result showed that the cutting capacity of labour has a mean of 0.022 ton/hr and 44 man day/ton.

Fig 2: Traditional paddy cutting equipment (*Katti*)

Cost Analysis

The machine's operating costs, both in terms of hours and tons were estimated. The machine was only used for 200 hours a year. The machine's yearly usage is the primary factor influencing its operating costs, according to calculations. The current assumptions resulted in fixed costs of Rs. 36.28 and operating costs of Rs. 91.48 per hour. However, when both fixed costs and operational costs were taken into account, the machinery cost per hour was computed to be Rs. 127.76, as seen in Table 1.

Table 1: Calculation of cost of traditional equipment *katti*, chaff cutter and developed straw cutter per hour and per ton

S. No.	Particular	Tradition equipment *katti*	Chaff cutter	Power operated Straw cutter
1.	Cost of machine, ₹	750	1000	23490.00
2.	Life of the machine (year)	2	8	4
3.	Annual use (h)	200	240	200
4.	Depreciation, ₹/h @ 10%	0.84	4.68	26.42
5.	Interest, ₹/h @ 15%	0.24	2.75	9.68
Total (4+5)	Fixed cost (₹/year) annual use is 200 h			
A	Fixed cost (₹/h)	1.08	7.95	36.28
B	Variable cost			
	Electricity cost			54.6
	Repair and maintenance cost at 10 % of initial cost, (₹/h)	0.37	2.08	11.74
	Housing cost, insurance and taxes each 1 % of initial cost, (₹/h)	0.00	0.52	0.14
	Wage of operation (200/day), (₹/h)	25	25	25
∑(1 to 3)	Total operational cost, (₹/h)	1.45	27.6	91.48
(A+B)	Machinery cost, (₹/h)	2.53	35.55	127.76
	Machine capacity, ton/h	0.022	0.021	0.146
	Total machinery cost in, (₹/ton)	1175	1692	500
	Breakeven point, ton/year	-	-	8.742
	Payback period, year	-	-	0.97

The machine's BEP was determined to be 8.742 t/year, or 8742 small 1 kilogram bales each year. For batch mushroom growing, a farmer typically needs 0.6–0.8 tons of straw in one lot.

Farmers used more than 1.2 tons/year for the entire year. As a result, farmers will have no trouble reaching the BEP. The costs associated with each stage of cutting straw are listed in Table 1. The machine's payback period was determined to be 0.97 years (194 hours) of operation. A mushroom farmer could easily accomplish these operating hours per year. The machine is therefore very economical.

Comparison of traditional and developed machine paddy straw size cutter

A comparative analysis of machine capacity and operating costs was conducted (Table 2). It indicates that when it comes to sizing paddy straw to the desired length, a newly developed machine saves 69.11% more money than traditional cutting equipment (*Katti*) and 57.34% more money than a chaff cutter. Additionally, it was noted that the mycelium growth in the case of the newly developed machine was better than the traditional. It can be the result of the present machine's non compact cutting action.

Table 2: Comparison of traditional and developed machine paddy straw size cutting methods.

S. No	Cutting operation machine/equipment	Capacity, ton/h	Man day per ton	Cost, Rs./ton	Saving over, %
1	Developed Power operated Straw cutter	0.146	1	500.00	-
2	Chaff cutter	0.021	24	1662.00	69.11
3	Traditional equipment (*Katti*)	0.022	44	1175.00	57.44

The developed paddy straw size cutter operating cost was recorded at Rs 500/ton, whereas the traditional straw cutter cost was Rs 1175/ton. The machine's effective capacity was 0.146 ton/h, and it only takes one man-day to finish one ton of straw size in a day.

Conclusion

The investigation was conducted in the experimental farmer field and the power-operated straw size cutter paddy straw to the proper size with satisfactory results. It drastically reduces labour requirement for completion of task, also saving enormous time which can be utilized for other farming operations. By utilizing the equipment, production profitability and productivity might improve. Paddy straw of several types was used in the study.

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