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Economic Viability of the Pneumatic Suction Type Cotton Boll Picking Machine

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ABSTRACT: In many parts of India, the farmers still use human labor for many operations for cotton cultivation like planting, weeding and picking and use inefficient farm implements/machinery for those operations. The cotton harvesting is the major problems faced by the farmers by using female or male labors and near about 30% cost of cultivation of the cotton crop is required for harvesting of cotton. Manual picking of cotton is labour intensive, requiring 1565 man hours per hectare. Also day by day availability of labors is going to decreasing and small hand operated cotton pickers are not suitable for harvesting cotton on large areas. Therefore the Pneumatic suction based cotton boll picking machine to suit one operator was developed for large areas. The cost of operation per kg of cotton collected through cotton picker was worked out using the procedure recommended by RNAM test code. The cost of the machine was Rs 125000 and the cost of the picking was Rs 6.72 per kg of cotton. The saving in cost, time and energy compared to manual method of cotton was 32.80, 79.68 and 71.95 percent respectively. The Break-even point and pay-back period for the pneumatic suction type cotton picking machine were 3379.88kg /annum and 4.44 year respectively.

KEYWORDS: Pneumatic suction type cotton picking machine, cost economics, break-even point, payback period

I. INTRODUCTION

Cotton (*Gossypium* spp.), termed as “the king of fiber” and also sometimes as a “white gold” is one of the most important crops commercially grown over 111 countries throughout the world. India ranks first in the world under cotton cultivation and accounts for 11 million ha area. India is the second largest producer of cotton in the world after China with average yield of 553 kg/ha as against the world average of 580 kg/ha. Cotton (*Gossypium hirsutum* L) is most important fiber crop in the world as well as in India [1].

According to the CICR-Nagpur report of India would produce 6.45 million tons (38 m bales of 170 kg/bale) cotton fiber this season in 2016-17. In the backdrop it is relevant to take a look at cotton yields in 2015-16. The Cotton Advisory Board had recently revised the production estimates of last year (2015-16) to 33.8 m bales (5.75 million tons) from an area of 11.9 m hectares [2]. Thus the World Bank report estimates that India’s cotton production would increase by 12.0% this year over the previous one. It is nice to be optimistic but it is good to be realistic. However, ground realities actually do not seem to support the hypothesis.

II. RELATED WORK

Status of Mechanization of Cotton Harvesting in India

A similar rate of mechanization also prevails in cotton sector as in other crops for land preparation and application of fertilizers and chemicals. But regarding the harvesting operation, almost the entire cotton production in India is hand-picked by human labor spending about 0.9 man-h/kg of cotton and costing almost 10 times than irrigation and two times the weeding costs [3]. India is lagging behind many other large producers of cotton in mechanization of harvesting. In the USA, machines harvest the entire cotton crop, whereas in some regions of China, it is estimated that by 2020, about 60% of cotton will be mechanically picked. It is expected that India will soon have to mechanize its cotton harvesting operations as it is facing labor shortages and rising farm wages. It is reported that the labor availability has dropped from 70.3% of the population in 1961 to 48.9% in 2010 and cost of picking cotton from the farm has increased to Rs 10-12 a kg now from Rs 4 in 2007 [4].

The first aspect is about the spacing between the plants in the field. In our visits to the cotton farms in India, we observed that the spacing ranged from 3 feet (inter-row) by 3 feet (inter-plant) to 5 feet (inter-row) by 2 feet (inter-plant), which is much higher than what is needed for cotton plants to be harvested by mechanical picker [5]. With the above-mentioned range of spacing, the plant population comes to around four to five thousand plants per acre, whereas, from our discussion with industry personnel, it was recommended to have a population of more than 50,000 plants per acre, if mechanical picking is to be done. Secondly, the cotton plant should not be too tall and having many branches, as it will be difficult for the picker to pick all the bolls. Also, the bolls should be well of the ground so that the amount of soil and dirt collected during the picking may be reduced 20[4]. The cotton harvesting is the major problems faced by the farmers by using female or male labors and near about 30% cost of cultivation of the cotton crop is required for harvesting of cotton. Also day by day availability of labors is going to decreasing and small hand operated cotton pickers are not suitable for harvesting cotton on large areas Therefore there was developed a new cotton harvesting machine based on pneumatic suction operated by battery power [6]. The main objective of this paper is to determine the economic viability of the developed Pneumatic suction-based cotton boll picking machine.

III. METHODOLOGY

Functional components of the Pneumatic suction-based cotton boll picking machine

The main functional components of the developed Pneumatic suction-based cotton boll picking machine shown are Electric motor with suction pump, Inlet suction hose pipe, outlet hose pipe, Battery, Inverter, Solar panels and cotton storage tank;

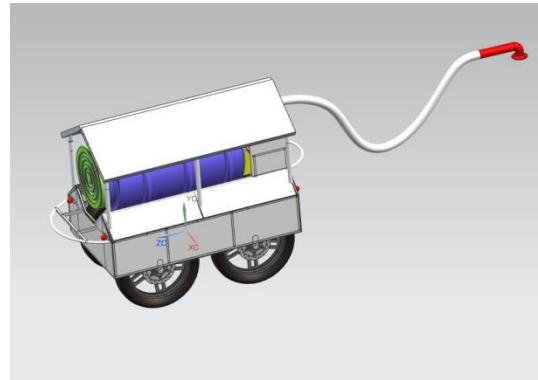
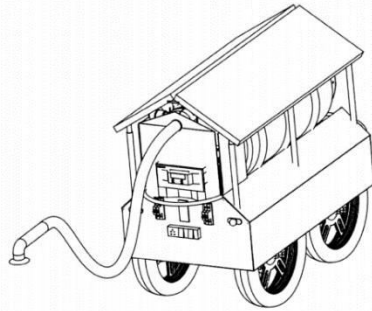
The whole components of Pneumatic suction-based cotton boll picking machine was mounted on frame made from steel material. The Pneumatic suction-based cotton boll picking machine was operated by one person or labor in the field. The developed Pneumatic suction-based cotton boll picking machine specifications were given in Table.1.

Table:1: Specifications of suction-based cotton boll picking machine

Sr. no.	Particulars	Specifications
1.	Overall dimensions (LxBxH) mm	1810 x 790 x1200
2.	Electric motor	D. C. Motor 1.3kw 20,000rpm
3.	Battery , volt	12v ,100Ah
4.	Exide Solar hybrid UPS , VA	2200 VA, 24 volt
5.	Speed of impeller, rpm	15,000
6.	Size of trolley ,mm,	1406 x790 x890
7.	Diameter of Trolley wheels, mm	600
8.	Capacity of cotton boll collection Tank , kg	20
9.	Total length of suction pipe ,mm	1500 and 3000
10.	Total length of outlet pipe with bend ,mm	450
11.	Diameter of suction pipe, mm	55
12.	Diameter of outlet pipe, mm	60
13.	Type of cotton suction and pickup Pipe	PVC hose and Aluminum pipe
14.	Type of suction pipe mechanism	Pneumatic suction
15.	Solar panel no's and size ,mm	4nos, 600 x 450 mm,
16.	Capacity of each solar panel, watt	50
17.	Total capacity of solar panel, Watt	200
18.	Total weight of the machine, kg	180
19.	No. of Operator	1



IV. EXPERIMENTAL RESULTS



General view of cotton boll picking machine



Field trial of cotton boll picking machine

The pneumatic suction based cotton boll picking machine was powered by 1.3 Kw electric dc motor with suction pump having 20,000 rpm impeller speed. Two Batteries having capacity of each battery is 12v, 100 Ah attached with Exide Solar hybrid inverter having capacity 2200 VA, 24 volt connected and fitted below the electric dc motor. A PVC container of 200 litre capacity was used as a collection tank for collecting cotton bolls picked by the machine. It was fixed on the steel body frame and the top of the collection tank was attached to the outlet pipe of the machine to collect the cotton bolls. Suction hose pipe of 1.50 m and 3.0 m lengths having 60.00 mm diameter made of PVC and Aluminum material respectively used for harvesting the cotton bolls from plant with the help of mechanical type of rotating spindle attached to the one end of suction pipe and another end of suction pipe was attached to the inlet of suction pump. Outlet pipe of 0.75 meter length having 60.00 mm diameter made of PVC material were attached to the outlet of suction pump and another end of outlet pipe attached to the collection tank with the help of holding clips for collecting the cotton bolls. The different components of pneumatic suction based cotton boll picking machine was mounted on steel frame which was light weight, durable and anticorrosive. It was fabricated from light weight stainless steel pipe material. The dimensions of frame i.e. Length, width and height were 1810, 790 and 1200 mm respectively. The pneumatic suction based cotton boll picking machine was provided with four motor cycle wheels for easy transportation of machine from one field to the other. The diameter of transport wheel was 600 mm. Each wheel was provided with five spokes made from aluminium casting material. These spokes were welded at one end to the inside of the rim having diameter 450.00 mm and at other end to the transport wheel bush. The 40 mm inside diameter bush was provided on both the side for easy motion. These transport wheels were mounted on 20 mm diameter M.S. shaft of 100 mm length.



Cost analysis:

The cost analysis was made as per RNAM test code. The cost of operation per kg of cotton collected by pneumatic suction based cotton boll picking machine was worked out using the procedure recommended by RNAM test codes [7]. This cost was compared with the cost of picking of one kg of cotton by manual method. The saving in cost time and energy by using cotton picker against manual method was compared. The break-even point and pay-back period also were computed for the cotton picker [8-10].

V. RESULTS AND DISCUSSION

Cost Economics:

The cost economics of the Pneumatic suction-based cotton boll picking machine was analysed as per the RNAM test code and procedure for harvesters.

1) **Cost of operation of developed Pneumatic suction-based cotton boll picking machine**

Cost of cotton boll picking machine P, Rs	=	1,25,000
Life of cotton boll picking machine. L, year	=	10
Salvage value. S, percentage	=	10
Working hours per year. H,	=	480
Working hours per day. H,	=	8
Interest rate for farmer. I, percentage	=	12
Wages of operator. Rs/day	=	200

A] Fixed cost

$$\begin{aligned}
 \text{a) Depreciation (Rs/hr.)} &= \frac{P-S}{L \times H} \\
 &= \frac{1,25,000 - (1,25,000 \times \frac{10}{100})}{10 \times 480} \\
 &= \frac{1,25,000 - 12,500}{4800} \\
 &= \text{Rs } 23.44
 \end{aligned}$$

$$\begin{aligned}
 \text{b) Interest rate/hr.} &= \frac{(P+S)}{2} \times \frac{I}{H} \\
 &= \frac{1,25,000 + 12,500 \times 0.12}{2 \times 480} \\
 &= \frac{16,500}{2 \times 480} \\
 &= \text{Rs } 17.18
 \end{aligned}$$

c) Housing @ 1.5 % of cotton picker price (Rs/hr.)

$$\begin{aligned}
 &= \frac{P}{H} * I \\
 &= \frac{1,25,000 \times 0.015}{480} \\
 &= \frac{1875}{480} \\
 &= \text{Rs } 3.90
 \end{aligned}$$



d) Taxes @ 1% of cotton picker price (Rs/hr.)

$$= \frac{1,25,000 \times 0.01}{480}$$

$$= \text{Rs } 2.60$$

e) Insurance @ 1% of cotton picker price (Rs/hr.)

$$= \frac{1,25,000 + 12,500}{2} \times \frac{0.01}{480}$$

$$= \text{Rs } 1.44$$

Total fixed cost = a+b+c+d+e

$$= 23.44 + 17.18 + 3.90 + 2.60 + 1.44$$

$$= \text{Rs } 48.56$$

B] Variable Cost

a) Repair and maintenance @ 8% of cost price

$$= \frac{1,25,000 \times 0.08}{480}$$

$$= \text{Rs } 20.84$$

b) Wages of operator @ 250/day of 8 hours

$$= \text{Rs } 31.25/\text{hr.}$$

c) Fuel cost @ Rs 28 per day of 8 hours

$$= \text{Rs } 3.5/\text{hr.}$$

Total Variable Cost = a + b + c

$$= 20.84 + 31.25 + 3.5$$

$$= \text{Rs } 55.59$$

Total cost of operation of planter

$$= \text{Total Fixed cost} + \text{Total Variable cost}$$

$$= \text{Rs } 48.56 + 55.59$$

$$= \text{Rs } 104.15$$

C) Output capacity of cotton-picking machine = 15.50kg/hr.

D) Cost of picking = $\frac{104.15}{15.50} = \text{Rs } 6.72/\text{kg}.$

2) Cost of picking by conventional Manual method: -

Wage per labor per day = Rs. 250.00

Amount of cotton picking per day = 25.0 kg

$$\text{Cost of picking} = \frac{250}{25} \text{Rs/kg.}$$

$$= \text{Rs. } 10/\text{kg.}$$

Saving in cost, percent =

- 1) Cost of picking with cotton picking machine, Rs/kg = 6.72
- 2) Cost of picking by manual method, Rs/kg = 10.00



$$\text{Saving in cost, percent} = \frac{10.00-6.72}{10} \times 100 = 32.80$$

3) Break-even point:

$$\text{BEP,kg/annum} = \frac{\text{Annual fixed cost}}{\text{custom fee}_{\text{hr}}^{\text{Rs}} - \text{Operating cost rs/hr}} \times \text{effective output capacity}$$

$$\text{Annual fixed cost, Rs/year} = 23312.50$$

$$\text{Custom fees, Rs/hr.} = (\text{Cost of operation, Rs/hr.} + 25\% \text{ overhead charges}) \times 25\% \text{ profit over new cost}$$

$$\text{Custom fees, Rs/hr.} = (104.15 + 104.15 \times \frac{25}{100}) \times 1.25$$

$$\text{Custom fees, Rs/hr.} = 130.18 \times 1.25$$

$$\text{Custom fees, Rs/hr.} = 162.73$$

$$\text{Operating cost, Rs/hr.} = 55.59$$

$$\text{Effective output capacity, Kg/hr.} = 15.50$$

$$\begin{aligned} \text{BEP,kg/annum} &= \frac{23312.50}{162.73 - 55.59} \times 15.50 \\ &= \frac{23312.50}{106.91} \times 15.50 \\ &= 3379.88 \end{aligned}$$

$$\begin{aligned} \text{Annual utility, Kg} &= \text{Effective output capacity, Kg/hr.} \times \text{Annual utility period, Hr.} \\ &= 15.50 \times 480 \\ &= 7440 \end{aligned}$$

$$\begin{aligned} \text{Therefore, BEP, percent} &= \frac{3379.88}{7440} \times 100 \\ &= 45.4 \end{aligned}$$

4) Payback period, year

$$\text{Payback period, year} = \frac{\text{Initial cost of machine}}{\text{Average net annual benefit}}$$

$$\text{Initial cost of cotton-picking machine, Rs} = 125000$$

$$\text{Average net annual benefit, Rs} = (\text{Custom fee, Rs/hr.} - \text{Total cost of operation, Rs/hr.}) \times \text{Annual utility rate}$$

$$\begin{aligned} &= (162.73 - 104.15) \times 480 \\ &= 28118.40 \end{aligned}$$

$$\begin{aligned} \text{Payback period, year} &= \frac{125000}{28118.40} \\ &= 4.44 \end{aligned}$$

5) Time appraisal:

$$\text{Time required by cotton picker, h/kg/person} = \frac{1}{15.5 \times 1} = 0.065$$

$$\text{Time required in conventional method, h/Kg/person} = \frac{1}{3.12 \times 1} = 0.320$$

Saving in time compared to conventional (Manual) method,

$$\text{Percent} = \frac{0.320 - 0.065}{0.320} \times 100 = 79.68\%$$



6) Energy appraisal

Field capacity in manual picking, kg/person/day	=	25	
Energy requirement in manual picking, K/Cal/Kg	=		$\frac{1931.50}{25}$
	=	77.26	
Field capacity of pneumatic suction type cotton picking machine, kg/person/day	=	15.50×8	
	=	124.00	
One-manlaborer is used to operate the machine. K Cal/kg			
1-manlabor energy equivalent, k Cal	=	2389.70	
Energy requirement, K/Cal/kg	=		$\frac{2389.70}{124}$
	=	19.70	
Fuel consumption, l/Rs	=	Rs 3.5/hr.	
Fuel consumption, l/kg	=		$\frac{3.5 \times 8}{124}$
	=	0.22	
Fuel energy, k Cal/kg	=		$\frac{0.22 \times 10850 \times 0.827}{1000}$
Energy required, for cotton picker, kcal/kg	=	19.70+1.97	
	=	21.67	
Saving in energy compared to conventional method, percent	=		$\frac{77.26 - 21.67}{77.26}$
	=	71.95	

Table: 2 :Cost economics of suction type cotton picking machine and manual cotton picking

Sr.no.	Particulars	Cotton picker	Manual picking
1.	Cost of cotton picker Machine, Rs.	1,25,000	-----
2.	Cost of picking Rs/kg	6.72	10.00
3.	Saving in cost compared to conventional picking method per cent	32.80	-----
4.	Time required hr/kg	0.065	0.32
5.	Saving in time compared to conventional picking method per cent	79.68	-----
6.	Saving in energy compared to conventional picking method per cent	71.95	-----
7.	Payback period, year	4.44	-----
8.	Energy required Kcal/kg	21.67	77.26
9.	Break-even point, kg/annum	3379.88	-----



VI. CONCLUSION

1. The cost of pneumatic suction type cotton picking machine is Rs. 1,25,000/-
2. The cost of picking with pneumatic suction type cotton picking machine and conventional manual method was Rs. 6.72 and 10.00 and required 0.065 hours and 0.32 hours to pick per /kg of cotton. respectively.
3. The energy required kcal/kg for picking of cotton with pneumatic suction type cotton picking machine and conventional manual method was 21.67 and 77.26 respectively.
4. The Saving in cost and time and energy compared to conventional manual picking was 32.80, 79.68 and 71.95 per cent respectively.
5. The Break-even point and pay-back period for the pneumatic suction type cotton picking machine were 3379.88kg /annum and 4.44 year respectively.
6. The use of pneumatic suction type cotton picking machine helps to reduce the cost and time of harvesting.

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