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Ergo technical evaluation of the pneumatic suction based cotton boll picking machine

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Abstract

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 small and marginal farmers. And compare the performance of pneumatic suction cotton picking machine with manual picking method An investigation was carried out to ergonomically evaluate the cotton picker by determining cardio respiratory stress. Six subjects were selected for the study and they were standardized and calibrated. Heart rate were computed using polar heart rate monitor. it was observed that the working heart rate was higher (108.33 ± 1.630 beat/min) in cotton picker method as compared to the manual method (99.66 ± 2.301 beat/min). the physiological cost is lower (124.83 ± 5.528 beat/kg of cotton) incase of cotton picker method than the manual method (469.50 ± 25.367 beat/kg of cotton) of cotton picking. The mean output capacity i.e. quantity of cotton picked per thousand heart beats were 2.13 ± 0.115 kg under manual method and 8.02 ± 0.347 kg using cotton picker The field capacity of cotton picker was determined as 126 kg/day as compared to 25.6 kg/day in case of manual method.

Keywords: Pneumatic suction type cotton picking machine, manual method, Heart beat, field capacity

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 (Anon, 2011). 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 (Anonymous, 2010) ^[1]. Cotton (*Gossypium hirsutum* L) is most important fiber crop in the world as well as in India. 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. 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.

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 [M Muthumiselvan 2007]. 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 [Business line India 2012].

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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. 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 [M Muthumiselvan 07]. 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. The main objective of this paper is Ergo technical evaluation of the Pneumatic suction based cotton boll picking machine and manual picking method respectively.

Materials and Methods

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 labour in the field.

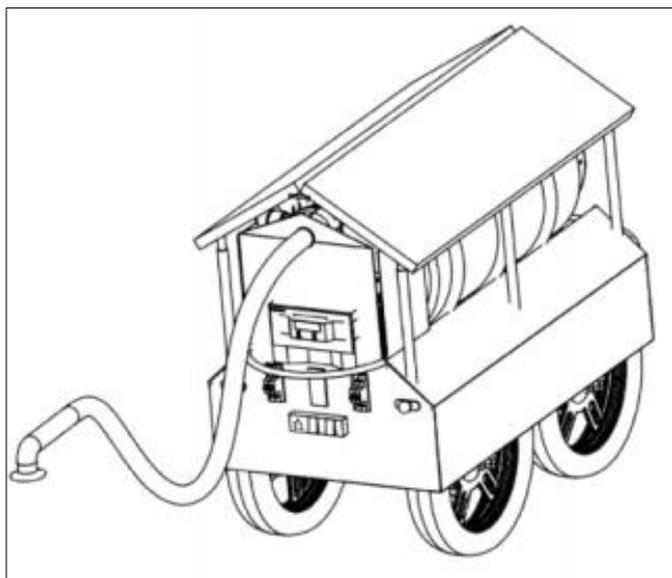


Fig 1: General view of cotton boll picking machine



Fig 2: 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 having 60.00 mm diameter made of PVC 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.

Field performance evaluation of developed pneumatic suction based cotton boll picking machine

A pneumatic type suction based cotton boll picking machine has been designed and developed, to pluck cotton from cotton boll, by using pure suction method. When D.C. electric motor gets started, impeller starts rotating and suction is created at

the outlet. By using this suction pressure, cotton can be picked from cotton boll, with the help of hose pipe having length 1.50 m. And collected in the storage tank having capacity 16.00 kg. Pneumatic cotton boll picking machine, has been designed ergonomically, having low weight and very efficient for Indian farms. It is a trolley type machine having four transport wheels useful for carrying cotton picking machine from one field to another field. The developed machine is affordable and easy to handle. Farmers can easily use pneumatic cotton-picking machine, without fatigue.

Field evaluation of developed pneumatic suction based cotton boll picking machine was conducted on the farm of cotton research station with suction pipe lengths 1.5m with plant spacing's 150x30 cm of Bt. cotton Hybrid variety of Bt. Cotton NHH44. For field performance evaluation of cotton boll picking machine 25.00× 6.00 m plots were randomly selected. Firstly counted the total number of average cotton bolls per plant, total number of Open and closed bolls per plant by taking the average of fifty randomly plants from each plot. From these observations calculate picking efficiency, theoretical and effective field capacity, field efficiency, seed cotton collected, output capacity, trash content and cost of cotton boll picking. This cotton boll picking machine field performance was compared with conventional manual cotton picking method. Above same size plot were selected and same observations were recorded and calculate picking efficiency, theoretical and effective field capacity, field efficiency, seed cotton collected, output capacity, trash content and cost of cotton boll picking.

Ergo technical evaluation of pneumatic suction based cotton boll picking machine

In the ergo technical evaluation, the selection of subject plays an important role. For any ergonomic study, subject should be medically fit to undergo the trials and also they should be true representative of the user population. Since maximum strength/power can be expected from the age group of 25 to 45 years. six subjects (farm workers) in the age group of 25 to 45 years were selected.. It was ensured that they are free from respiratory, cardiac and other ailments. The anthropometrical data and other details of the selected subjects are given in Table 2. Subjects were asked to report in the laboratory at 8:00 a.m. and an initial rest period of 30 minutes was provided.

Subjects were abstained from smoking and taking any food. As long as they were in laboratory. Height in cm, weight in kg, Heart rate in beat/min, blood pressure, mmHg, and breathe rate no. / min were recorded. and shown in table no.2

The heart rate was noted at 6th and 15th minute because the heart rate increases rapidly in the beginning and reaches a steady state by the end of the 6th minute. The values of heart rate for each subject from 6th and 15th minute of operation were used to calculate the mean value of heart rate for determining the physiological responses of the subjects. Subjects were given complete information about the experimental requirements so as to enlist their full cooperation for conducting the trials precisely.

The subjects were familiar with the operation of the developed pneumatic suction based cotton boll picking machine. They were given initial rest and heart rates were recorded before starting the work. Actual work was started at 9:00 a.m. and continued till 4.00 p.m. with one hour lunch break. Before conducting the trials, the pneumatic suction based cotton boll picking machine was put in proper test condition. One subject was allowed to operate the machine at a time. They were allowed to continue the operation till they get 'fatigued'. Then, they were provided ten minutes rest after which they again started the work. Procedure was replicated thrice. Treatments to the subject were given at random to avoid bias, effect of training, weather, etc. The evaluation was carried out in terms of heart rate; Heart rate is the pertinent parameters for assessing the energy required for performing various types of operation. During the ergonomic evaluation of the cotton boll picking machine in the field, heart rate was measured using Polar heart rate monitor in ambulatory position. And area covered by the subjects was measured. Selected subjects were given adequate' practice to get well acquainted with the cotton boll picking machine. Each of the trials was replicated three times. The fatigue factor (which is the ratio of heart beat rate to respiration rate) was used as an index of cardio-respiratory stress The heart rate values at resting level after 6th and 15th minutes of operation were taken for determination of physiological responses of the subjects. Compared pneumatic suction based cotton boll picking machine ergonomic evaluation with conventional manual picking method of cotton.

Table 1: Basic particulars of the subjects

Sr.no.	Particulars	Subjects					
		S ₁	S ₂	S ₃	S ₄	S ₅	S ₆
1.	Age	35	38	45	34	30	32
2.	Height, cm	167	169	165	169	164	167
3..	Weight, kg	56	65	61	69	60	63
4.	Heart rate, beat/min	74	75	76	76	75	74
5.	Blood pressure, mmHg	118/79	117/79	120/80	121/80	120/80	122/80
6.	Breath rate, No./min	16	16	15	17	15	16

Results and Discussion

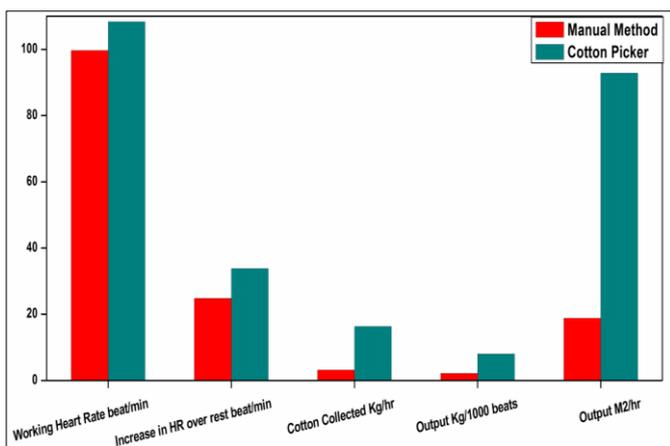
Ergo technical evaluation of pneumatic suction based cotton boll picking machine

During the ergonomic evaluation of the cotton Boll picking machine in the field, heart rate was measured using Polar heart rate monitor in ambulatory position. and area covered by the subjects were measured. Selected subjects were given adequate' practice to get well acquainted with the cotton Boll picking machine. Each of the trials were replicated three

times. The fatigue factor (which is the ratio of heart beat rate to respiration rate) was used as an index of cardio-respiratory stress. The heart rate values at resting level after 6th and 15th minutes of operation were taken for determination of physiological responses of the subjects. Compared pneumatic suction based cotton boll picking machine ergonomic evaluation with conventional manual picking method of cotton.

Table 2: Heart rate response of the subjects

Sr. no.	subject	Working heart rate (HR) beat/min		Increase in HR over rest, beat/min		Cotton collected kg/hr		Increase in HR/kg of cotton, beat/min		Output kg/1000beats		Output M ² /hr		Moisture content in cotton %		Increases in productivity over Manual method
		Manual method	Cotton picker	Manual method	Cotton picker	Manual method	Cotton picker	Manual method	Cotton picker	Manual method	Cotton picker	Manual method	Cotton picker	Manual method	Cotton picker	
1	S ₁	98 (74)	106	24	32	3.09	15.50	465.00	124.00	2.15	8.06	19	88	4.55	3.85	374.33
2	S ₂	101 (75)	109	26	34	3.25	16.75	480.00	122.00	2.08	8.19	18	95	4.75	3.79	393.75
3	S ₃	99 (76)	108	23	35	3.15	15.75	438.00	134.00	2.28	7.46	19	89	4.10	4.02	327.19
4	S ₄	100 (76)	110	25	34	3.00	16.00	500.00	128.00	2.00	7.81	19	95	5.10	3.90	390.5
5	S ₅	102 (75)	110	27	35	3.30	17.10	491.00	123.00	2.03	8.13	20	98	4.25	4.00	400.49
6	S ₆	98 (74)	107	24	33	3.25	16.90	443.00	118.00	2.25	8.47	18	92	4.85	3.95	376.44
	Mean	99.66 (75)	108.33	24.83	33.83	3.17	16.33	469.50	124.83	2.13	8.02	18.83	92.83	4.60	3.91	377.11
	SD	1.630 (0.890)	1.630	1.470	1.169	0.114	0.667	25.367	5.528	0.115	0.347	0.752	3.868	0.376	0.088	26.46



Graph 1: Heart rate response of the subjects

The heart rate response of the subjects selected for the study for the cotton picking activity under manual method and using cotton picker has been furnished in table 3. From the table it was observed that the working heart rate was higher (108.33 ± 1.630 beat/min) in cotton picker method as compared to the manual method (99.66 ± 2.301 beat/min) where as the physiological cost is lower (124.83 ± 5.528 beat/kg of cotton) in case of cotton picker method than the manual method (469.50 ± 25.367 beat/kg of cotton) of cotton picking. As the study was spread over 30 days, mean values of increase in heart rate over rest were adopted for the comparison of different trials to eliminate the effect of different days as well as the time of experiment during the particular day. The mean increases in heart rate over rest were 24.83 ± 1.47 and 33.33 ± 1.169 beat/min in Manual method and cotton picker methods respectively. The mean output capacity i.e., quantity of cotton picked per thousand heart beats were 2.13 ± 0.115 kg under manual method and 8.02 ± 0.347 kg using cotton picker. The cotton collected kg/hr observed that 16.33 kg in cotton picker method as compared to manual method 0.667 kg. where as area Output M²/hr in cotton picker method observed was 92.83 M²/hr as compared to 18.83 M²/hr in manual method which was five times less. Therefore, 377.11 ± 26.46 per cent increases in productivity over conventional method was achieved by using cotton picker and the cotton picker proved its superiority in respect of physiological cost of operation. The field capacity of cotton picker was determined as 126 kg/day as compared to 25.6 kg/day in case of manual method. Thus the findings show that cotton picker gives good productivity with lesser physiological cost. The heart rate of the workers will also be within the permissible limit as per

physiological norms. This reference was verified by the subjective opinion of the workers who participated in the study. It is clear from table 3 that the average work pulse rate of the subjects varied from 98 to 110 beat/min. The lowest and highest values of heart rate were recorded for subject 1 for manual method of picking and subject 5 for picking with cotton picker respectively. It was also observed that the variation in work pulse rate in a particular operation among all the subjects was small.

Conclusions

- The working heart rate was higher (108.33 ± 1.630 beat/min) in cotton picker method as compared to the manual method (99.66 ± 2.301 beat/min)
- The physiological cost is lower (124.83 ± 5.528 beat/kg of cotton) in case of cotton picker method than the manual method (469.50 ± 25.367 beat/kg of cotton) of cotton
- The mean increases in heart rate over rest were 24.83 ± 1.47 and 33.33 ± 1.169 beat/min in Manual method and cotton picker methods respectively.
- The mean output capacity i.e., quantity of cotton picked per thousand heart beats were 2.13 ± 0.115 kg under manual method and 8.02 ± 0.347 kg using cotton picker.
- The cotton collected kg/hr observed that 16.33 kg in cotton picker method as compared to manual method 0.667 kg
- Area Output M²/hr in cotton picker method observed was 92.83 M²/hr as compared to 18.83 M²/hr in manual method which was five times less.
- The field capacity of cotton picker was determined as 126 kg/day as compared to 25.6 kg/day in case of manual method.

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