Madras Agric. J. 91 (7-12) : 433-440 July-December 2004
https://doi.org/10.29321/MAJ.10.A00129

Development and Evaluation of Trolley Mounted Cotton Picker

M.MUTHAMILSELVEN, K.RANGASAMY AND C.DIVAKER DURAIRAJ
Dept. of Farm Machinery, Agrl. Engg. College and Res. Instt., Tamil Nadu Agrl. Univ., Coimbatore - 3.

Abstract : Harvesting is one of the major labour intensive operations in cotton cultivation. Since cotton varieties used in our country require picking at several stages, the using of mechanical pickers is not feasible. Therefore pneumatic pickers were thought of. The dimensions of machine parameters *viz.* pick up pipe diameter, filter type, filter height, capacity of collection drum and speed of aspirator were varied and they were optimized through statistical analysis. The combination of 25 mm diameter pick up pipe, nylon mesh filter, 300 mm height drum were optimised. The maximum speed of aspirator i.e., 3500 rpm was also optimised. It was found that the field capacity in first picking (4.93 kg/h) was lesser than third picking (5.07 kg/h). The picking efficiency was less in first picking (96.35 %) and more in third picking (97.48%). The trash content was observed as maximum of 15.75 per cent in third picking done by machine. Energy consumption for the pickers was 1910.90 ± 68.28 kCal/day. Sound pressure created by picker is 86.22 db.

Key words : Cotton picker, Energy consumption, Sound pressure.

Introduction

India currently stands first in area, second in yarn production and third in raw cotton production in the world. Cotton crop is cultivated in 8.122 million ha with a production of 13.75 million bales at an average of 295 kg / ha. Nearly 60 per cent of cotton cultivation is under rainfed condition and the remaining 40 per cent as irrigated crop (Narayanan and Sundharam, 1999). In India, entire cotton is hand picked by human labour involving about 1565 man h ha^{-1} (Goyal, 1979) which is 0.9 man h kg^{-1} of cotton. It is not only tedious work but also ten times costlier than irrigation and about twice that of weeding operation. In recent years it has been observed that labour shortages appear during peak periods of cotton harvesting. The use of picking machine will be useful in minimizing drudgery involved in hand picking as well as enhancing production of cleaner grade of seed cotton. The mechanized cotton picking system will also be helpful in achieving timeniless of operation for the subsequent crop.

Keeping in view the above facts, the present investigation entitled "Development and evaluation of trolley mounted cotton picker" was taken up in the Department of Farm machinery, Tamil Nadu Agricultural University, Coimbatore during the year 2002.

Materials and Methods

Development of prototype

To increase the maneuverability and reduce the drudgery, a trolley mounted cotton picker was developed. The components were optimized for their dimensions. The components are prime mover, aspirator, collection drum, pick up pipe and trolley.

i) Prime mover

To suit required power for designed capacity, a Honda make 2.25 kW engine was selected from the market. The engine is petrol start - kerosene run type. The crankshaft is directly coupled with the aspirator impeller.

ii) Aspirator

Aspirator was specially designed for the optimized value of suction force of the two inlet pick up hoses. The entire aspirator was mounted on a specially fabricated trolley with 150 mm clearance from the trolley platform.

Table 1. Observations in optimisation of components of prototype

Sl.No.	Parameter	Range	Pressure, kg cm^{-2}
1.	Pick up pipe diameter	18 mm	0.0327
		25 mm	0.0344
		32 mm	0.0323
2.	Filter type	Nylon mesh	0.0401
		Aluminium perforated sheet	0.0320
		G.I.Mesh	0.0396
3.	Filter height	200 mm	0.0326
		300 mm	0.0348
		400 mm	0.0337
4.	Capacity of collection drum	25 litre	0.0318
		50 litre	0.0345
		100 litre	0.0336
5.	Speed of aspirator	2000 rpm	0.0059
		2500 rpm	0.0117
		3000 rpm	0.0328
		3500 rpm	0.0357

Table 2. Trash content

Sl.No.	Picker			Manual picking		
	P_1	P_2	P_3	P_1	P_2	P_3
1	9.71	12.00	18.31	3.01	5.81	6.87
2	9.14	11.73	17.56	1.58	4.73	5.94
3	7.87	10.61	13.80	1.37	3.98	6.34
4	9.37	12.73	12.98	2.11	5.76	6.31
5	10.61	12.80	16.08	2.06	5.34	5.78
Mean	9.34	11.97	15.75	2.03	5.12	6.25
SD	0.89	0.80	2.07	0.57	0.69	0.38

P_1 - First picking; P_2 - Second picking ; P_3 - Third picking

a) Impeller

It is an axial flow type (drum type centrifugal fan) designed to generate a flow of 0.1104 m^3/sec so that it can cater the needs of two suction inlets. This impeller was provided with fifteen leaves mounted in between two shrouds (closed type). The shrouds were reinforced with three m.s. flats to contain hub of impeller. The leaves were riveted to the shrouds on both sides. The impeller was locked to engine shaft with spring washer.

b) Casing

It is made up of G.I. sheet of 2 mm thick constructed convergency (volute type) to generate required suction force for above opti-

mised dimensions of impeller. The Eye of the casing was fitted with the diffuser to connect suction duct which in turn connects to the collection drum. To arrest the air entry into the casing, packing sheet was provided along with flange.

iii) Collection drum

A poly propylene 50 litre capacity drum was mounted on the trolley platform with suitable frame. The upper half of the drum was attached with two PVC tank nipples in diagonally opposite directions. These nipples were in turn provided with 25 mm diameter PVC pick up hoses for collecting cotton. The bottom of the drum was cut open and fastened with a suction duct. The suction duct was connected to the drum with an air tight flange with suitable clip. A cotton filter of size 125 mm diameter and 300 mm height made by nylon mesh was fixed at the centre of the collection drum vertically with a suitable flange to restrict the entry of cotton inside the aspirator.

iv) Pick up pipe

To facilitate the user to cover entire strips of the cotton field, 5 m length pick up hoses (2 numbers) were provided. Since the pick up hose is flexible, a 100 mm G.I. pipe nipple was provided at the tip of pick up hoses.

v) Trolley

A four wheel pushing type trolley was selected to mount all the components of cotton picker. The platform size was 1200 mm x 450 mm. A handle was attached to trolley front wheel axle for better maneuverability in turnings. The unit is shown in Fig.1.

Optimization of components of prototype

It was essential to optimize the various machine and operational parameters namely, pick up pipe diameter, filter type, filter height, capacity of collection drum and speed of aspirator which control the suction force. The engine was allowed to run steadily at different speeds and the pressure and the pressure head loss at the tip of the pick up pipe were measured with U tube monometer for different combinations for the above related parameters.

Table 3. Energy consumption

Sl.No.	Energy consumption, kCal/day		Sound pressure, db
	Picker	Manual picking	
1	1818	2042	88.19
2	1930	1906	83.83
3	1986	1928	86.69
4	1856	1988	84.37
5	1880	1832	87.40
6	1866	1902	88.74
7	2012	1892	85.15
8	2018	1840	84.22
9	1896	1945	86.92
10	1847	2040	86.65
Mean	1910.90	1931.50	86.22
SD	68.28	69.80	1.64

i) Pick up pipe diameter

A light weight PVC pipe was used as pick-up pipe to reduce frictional resistance and weight of the unit. The velocity and pressure of air flowing through the pick up pipe depends on the diameter of the pick up pipe. Hence, the diameter of pick up pipe needs to be optimized with respect to the suction force of air required to be produced to effect pneumatic picking of cotton. Three levels of pick up pipe diameter *viz.* 18 mm, 25 mm, and 32 mm were adopted

ii) Filter type

Suitable screen is provided as filter to restrict the entry of cotton into the aspirator and to allow the air alone to pass into the aspirator with less resistance from the collection tank. The net suction force depends on the type of screen adopted. Nylon mesh, aluminum perforated sheet and G.I mesh made filters were tried and the best one was optimized based on the pressure developed at the tip of pick up pipe.

iii) Filter height

Three levels of filter height *viz.* 200 mm, 300 mm, and 400 mm were taken for optimization. The variation in filter heights is necessary to accommodate the varieties in the height of collection drum. By measuring the pressure developed at the tip of the pick up pipe, the height of filter was optimized for its best performance.

iv) Capacity of collection drum

Three levels of capacity of collection drums were taken *viz.* 25 litre, 50 litre and 100 litre capacity. By measuring the pressure developed at the tip of the pick up pipe, the height of filter was optimized for its best performance.

v) Speed of aspirator

Four levels of speed *viz.* 2000, 2500, 3000, and 3500 rpm were for taken for the study. By measuring the presence developed at the tip of the pick up pipe, the height of filter was optimized for its best performance.

Field evaluation of prototype

The cotton picker was evaluated for its performance. Twenty plots in which twenty varieties taken for this study were randomly distributed. The picker was evaluated in each variety. The actual time of operation, time lost for unloading cotton, time lost in adjustment, number of bolls left unpicked were observed during field trial.

i) Field capacity

To evaluate the designed machine, the field with varieties of cotton crop was randomly selected. An area of 3 x5 m plots of suitable number for three replications in all the varieties were enmarked. The labourers were allowed to operate the machine (variety wise) for known period of time. The weight of the seed cotton picked by the machine was analyzed in comparison with manual picking. The same procedure was repeated during three picking of cotton (first picking, second picking an third picking). The field capacity was computed with the following formula

$$FC = W/T$$

where

FC = field capacity, kg/h
W = weight of seed cotton kg
T = time taken, h

ii) Picking efficiency

The picking efficiency of cotton picking for twenty varieties with the picker was determined. The number of bolls in plots selected for determining field capacity including plots for replication was counted before and after picking. The procedure was repeated for all three picking (first picking, second picking and picking). The picking efficiency was determined with the following expression.

$$\eta_p = (n_1 - n_2) / n_1 \times 100$$

where,

η_p = picking efficiency, per cent
n_1 = number of bolls present before picking
n_2 = number of bolls present after picking

iii) Trash content

The trash content was estimated for the samples collected from three picking with the machine and manual picking. The estimation was done by using trash analyzer in which the trash is separated when the cotton is fed through inlet after ginning. The trash content was determined as

$$T = (W_1/W_2) \times 100$$

where,

T = trash content, per cent
W_1 = weight of trash separated, g
W_2 = weight of cotton fed, g.

iv) Energy consumption

Polar pacer heart rate monitor which is a compact portable instrument was used in the field directly to measure the heart beat rate and hence the energy consumption during working of three cotton pickers (Ramana, 1999).

Components of polar power heart beat monitor.

The polar pacer has three basic components *viz.* i) chest belt transmitter, ii) elastic strap and iii) receiver unit. The chest belt transmitter has two electrodes, grooved rectangular area on the underside of the belt transmitter which picks up heart beat rate from the body of subject and converts into electromagnetic signals. For better sensing the electrodes are wetted with water. The belt transmitter should fit snugly and comfortably and allow normal breathing. The receiver is a unit which receives the signals from the transmitter and displays it on screen. This receiver unit must be placed with in one matter range and it can be fitted in watch strap. This receiver has two buttons below the screen to operate the heart beat rate monitor. This has provision to set up high target zone and low target zone limits. When the subjects reach that limits of heart beat it will indicate through alarm, or visual alarm, so that we can stop exerting the subjects beyond this level. Similarly the low heart bear rate target zone will be helpful in certain critical condition.

Calibration of subjects

The subjects were calibrated to make the relationship between the heartbeat rate and oxygen consumption by using Tread mill, Benedict apparatus and Telemetry system. The oxygen consumption and heart beat rate with respect to time was recorded during the test as explained below (Narsinghrao, 1996 and Ramana, 1999). The tread mill conveyer belt slope was kept constant at 5 per cent and the velocity varied at an interval of 1.5 kmph from a starting speed of 1.5 kmph to 7.5 kmph for the calibration. Chest belt transmitter was fastened with elastic strap under the pectoral muscles (breasts) as comfortable. The receiver unit was held by an observer to monitor the heart beat rate. The conveyer belt speed was slowly brought to required level by adjusting the speed control knob. In the Benedict Ruth apparatus, the Spiro meter bell was filled with oxygen and mouth piece was given to the subject by placing the nose clip in position. The subject inhales the atmosphere air through mouth piece at the initial stage. Heart bea rate was monitored with polar pacer heart rate monitor. After the heart beat rate reaches the steady state, the saddle valve was turned 'ON' to oxygen. The kymograph starts recording the oxygen consumption pattern of the subjects on the chart continuously. Simultaneously the heart beat rate was noted down by the observer at an interval of 5 sec. The procedure was continued for about ten minutes and saddle valve was turned 'OFF'.

The heart beat rate was averaged for the above period and oxygen consumption rate was measured from the chart for six uninterrupted minutes. The same procedure was repeated by setting different speeds and allowing the subjects to exercise on the tread mill. The oxygen consumption rate was converted into energy units for each speed setting and calibration graph was prepared between the heart beat rate and the energy units for each speed setting.

Sound pressure

Sound is the sensation produced when longitude vibrations of the molecules in the

external environment, i.e, alternate phases of condensation and rectification strike the tympanic membrane. The speed of sound wave increases with temperature and altitude. The amplitude of sound wave can be expressed in terms of maximum pressure change or the root mean square of the pressure at the ear drum, but a relative scale is more convenient. The decibels scale is such a scale. The sound pressure was measured using an integrating sound level meter which measures in terms of decibels. (Sulaimanov, 1990). The cotton pickers were kept in clean and quite environment free of air movement. The engine was started and the sound meter was held near the engine. At the maximum speed of engine, sound pressure in terms of disables was noted.

Results and Discussion

Optimization of components of prototype

i) Pickup pipe diameter

The effect of pick up pipe diameter on pressure developed in pick up pipe was studied. From the statistical analysis, (Factorial Completely Randomised Block Design) the variation in diameter shows positive correlation and the maximum pressure was obtained in 25mm diameter pick up pipe as shown in Table 1.

The improved pressure in 25 mm diameter pick up pipe may be due to drag coefficient during suction of seed cotton. In real action, the seed cotton, is shrunk (squeezed) about half of its projected area due to suction force on cotton which matches with the 25mm diameter pick up pipe. In the case of 18 mm diameter pick up pipe, entry becomes narrow and takes lot of time. In the 32 mm diameter pickup pipe drag force gets affected due to every large difference between shrunk seed cotton projected area pick up pipe cross sectional area, which makes atmosphere air entry and nullify the effect on seed cotton.

ii) Filter type

The effect of three filters *viz.* nylon mesh filter, aluminum perforated filter and G.I. mesh filter on pickup pipe pressure is given in Table 1. There was very strong correlation between the filter type and pressure in the pick up pipe. It is clear that the pressure of 0.0369 and 0.0349 kg/cm^2 is almost same for nylon and G.I mesh respectively. But, with the aluminum perforated sheet the pressure of 0.0320 kg/cm^2 was drastically affected. This variation among the filters may be due to the major variation in office configuration. Though the effect of nylon mesh filter and G.I mesh filter were the same on pressure, the nylon mesh was selected because of its light weight and its anti corrosive property. From the statistical analysis also, it is evident that the nylon mesh filter is best suited for the picker.

iii) Filter height

The effect of filter height on pressure was shown statistically significant. The maximum pressure could be obtained for the filter height of 300mm. It was evident that the filter height has significant effect on pressure. Further increase of the filter height above the particular height might create losses in suction (turbulence effect) due to abstraction at the top of the collection drum for free flow of air (Table 1).

iv) Capacity of collection drum

Three types of capacities were selected. *viz.* 25, 50 and 100 litre capacity. The variation in capacities is given in Table 1. From the statistical analysis, the variation in height has correlation with the pressure in pick up pipe. From the analysis, it is also optimised the capacity of collection drum as 50 litre. Further increase in capacity of collection decreases the pressure developed in the pick up pipe.

v) Speed of aspirator

From the statistical analysis, it is evident that the speed of the aspirator is having strong positive correlation with pressure in the pick up pipe. These ranges of speed were strong in accordance with the prime mover used in the picker. In general the pressure in the pick up pipe increases with increase in the speed

of aspirator. Hence the maximum speed of prime mover, i.e., 3500 rpm was optimised.

Field evaluation of prototype

i) Field capacity

The field capacity for different varieties of cotton crop with the picker and the manual picking were estimated. There was a significant difference in field capacity of machine in comparison with manual cotton picking. In general the increase in field capacity was about three times with picker (with two women labourers). It was also observed that the field capacity in first picking was 4.93 kg h^{-1}. This may be due to the presence of fully matured cotton bolls during third picking. The field capacity was highest in SRT 1 variety (7.61 +_ 0.13 kg h^{-1}) followed by RSP 4 variety (7.58 +_ 0.02 kg h^{-1}) and lowest in 70 E variety (7.28 +_ 0.06 kg h^{-1}) followed by G 27 variety (7.34 +_ 0.12 kg h^{-1}).

ii) Picking efficiency

The maximum picking efficiency of 99.26 +- 0.23 per cent was observed with manual cotton picking. The picking efficiency was highest in MCU 9 variety (95.05+_ 1.57 per cent) and lowest in MCU 7 variety (90.66 +- 0.09 per cent). It was also observed that picking efficiency increases with the time of picking. i.e., less first picking (96.35 per cent) and more in third picking (97.48 per cent). This shows that the maturity aspect plays a positive role in mechanized cotton harvesting.

iii) Trash content

The trash content of the harvested cotton was estimated and the results are listed Table 2, The trash content was 12.35 per cent while using the picker. In comparison with manual picking, machine picking incorporates more trash content. It was also observed that picking time also influences the trash content in seed cotton significantly, It was minimum at 9.34 per cent in first picking, 11.97 per cent in second picking and maximum of 15.75 per cent in third picking (Table 2).

iv) Energy consumption

The heart beat rate of the operator during the operation of the picker was recorded with polar pacer heart beat monitor. The average heart rate is given in Table 3 and the variations in heart beat rate can be seen from the same table.

From Table 3, it is evident that there is not much difference in energy consumption for manual cotton picking and the machine picking. The energy consumption for the picker was 1910.90 +_ 68.28 kCal / day which was on par with the manual cotton picking (1931.50 +_69.80 kCal /day). The results are in accordance with the finding of Kumar and Parvathi(2001).

v) Sound pressure

The sound pressure measured with integrated sound level meter of the picker placed in a clean and quite environment with free air movement was listed in Table 3. The sound pressure created by the picker (86.22 db) is well below the threshold auditory limit of human ear of 140db.

Conclusions

1. As the combination of 25 mm diameter pick up pipe, nylon mesh fitter, 300 mm height of fitter, 50 litre capacity of collection drum developed maximum pressure, these parameters were selected.
2. The maximum speed of aspirator was selected as 3500 rpm.
3. It was found that the field capacity in first picking was less 4.93 kg h^{-1} and more in third picking (5.07 kg h^{-1})
4. The picking efficiency was less in first picking (96.35%) and more in third picking (97.48%)
5. The trash content was observed as maximum at 15.75 per cent in third picking in machine picking.

6. The energy consumption for the picker was 1910.90 ± 68.28 kCal /day. The sound pressure created by the picker is 86.22 db.

References

Annonymous (1995). RNAM Test codes and procedures for farm machinery, RNAM bangkokk, Thailand.

Anonymous, (2001). Annual report. 2000-2001. Central Institute for cotton Research, Nagpur. pp3.

Goval, M.R. Byg, D.M. and Singh, K. (1979). Appropriate technology for cotton production in India. *Agricutural mchanization in Asia, Africa and Latin America. Spring:* 73–78.

Idiyatulin, R.G., Gorn, V.N. and Pazliev, B. (1984). Eletrifyimg cotton harvesters. Mekhanizaisiya-i-Elikirifikaisiya-Sel 'skogo-Khozyaisiva, No.2, 41-43.

Kumar, V.J.F. and Parvathi, S. (2001). Ergonomics of rural women for selected dry farming operations. Paper submitted in International Conference on humanizing work and work environment conducted at Indian Institute of technology, Mumbai.

Narasinghrao, S. (1997). Ergonomic analysis of man-machine system on sprayers, Unpublished ME (Ag) thesis. Department of Farm machinery, Tamil Nadu Agricultural University, Coimbatore.

Narayanan, S.S. and Sundharam, V. (1999). Improved sustainability of cotton in India by enhancing its production and improving quality. Paper presented in International seminar on cotton an its utilization in the 21st century held at CIRCOT, Mumbai during 1) December 10-12th, 1999. Book of papers: 4-15.

Nelson, J,., Misra, S.K. and Brrashears, A. (2000). Costs associated with alternative cotton striper – harvesting systems in Texas. *J. cotton Science,* 4: 70-78.

Ramana, C. (1999). Investigations on design parameters of hand tools in relation to operational comfort of Agricultural workers. Unpublishing ME (Ag) thesis. Department of Farm Machinery, TNAU, Coimbatore.

Sappenfield, W.P., Boon, W.D. and Ward, J.N. (1984). Conventional and short season cottor production and harvesting systems. *Transactions of the ASAE:* 1287-1291.

Sulaimanov, S.S. (1990). Noise reduction in cottor harvesters. *Traktory in sel'skokho-zyaisnnye mashiny,* No. 1:14.

Tupper, G.R. (1964). New concept of stripper harvesting of cotton in Arkanas. *Transaction of the ASAE:* 306.

(Received: November 2002; Revised : April 2004)