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Performance evaluation of knapsack type portable engine operated cotton picker

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■ **ABSTRACT :** In India entire cotton is handpicked by human labour. It is not only a slow process but is extremely tedious work. Manual picking of cotton is labour intensive, requiring 1565 man-hours per hectare. The knapsack cotton picker was required to suit one-man operator. It was tested in the laboratory in terms of fuel consumption, picking efficiency, trash content, pressure at the tip of pick-up pipe and pressure of the collection drum for speed of blower (2500, 3500, 4500 and 5500 rpm), diameter of pick-up pipe (20, 25 and 30 mm) and opening of blower bowl (50, 75 and 100 %). Fuel consumption (l/h), picking efficiency (%), trash content (%), pressure at the tip of pick-up pipe (kg/cm^2) and pressure of the collection drum (kg/cm^2) ranged from 0.72 to 1.31, 94.42 to 96.85, 8.16 to 11.33, 0.035 to 0.076 and 0.023 to 0.047, respectively. From the results laboratory performance the cotton picker was tested in the field at 5500 rpm of speed of blower, 25 mm diameter of pick-up pipe and 100 per cent opening of blower bowl. The mean fuel consumption (l/h), picking efficiency (%), trash content (%) and output capacity (kg/h) was 1.29, 96.47, 10.22 and 4.95, respectively for first and second picking. The cost of picking was 10.88 Rs. /kg when operated by kerosene. Saving in cost and time compared to conventional method was 12.96 per cent and 69.85 per cent, respectively.

■ **KEY WORDS :** Knapsack cotton picker, Speed of blower, Picking efficiency, Diameter of pick-up pipe, Opening of blower bowl

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Cotton is one of the most important commercial crop of the country. India stands first in the world cotton area with 12.19 million hectares and is second largest producer of the world. The area under *Bt* cotton hybrids increased from 38,038 hectares in 2002-03 to 9.81 million hectares in 2010-11.The yield of crop is 482 kg/ha as compared to 865 kg/ha in USA, 1326 kg/ha in China and 721 kg/ha in Pakistan (Anonymous, 2012). India is the largest cotton growing country in the world with area under cotton being around 34 per cent (12.20 million ha) followed by China (5.5 million ha).

In India cotton is harvested by human labour. This is slow and tedious process. Hand picking is known to consume a greater of man-day spent by cultivator in producing cotton crop. Manual picking of cotton is labour intensive, requiring 1565 man-hours per hectare (Selvan *et al*., 2012). 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 timeliness of operation for the subsequent crop. The pneumatic cotton picker can pick an area of

0.45 to 1 m^2 in 5 minutes and results in 38 per cent reduction in labour requirement one manual picking (Anonymous, 2008). Mechanical cotton harvesters are not considered suitable for Indian conditions, considering the cultural and agronomic practices and the staggered blooming characteristics of Indian cotton plant. Indian cotton varieties must be picked at several stages which lead to selective picking methods (Rangasamy *et al*., 2006). Therefore, pneumatic picking system was evaluated and compared with conventional method of cotton picking.

METHODOLOGY

Description of knapsack cotton picker:

The knapsack cotton picker was developed to suit one man labourer (Selvan *et al.,* 2007). The engine was fixed on the collection drum. A cotton filter of size 80 mm diameter and 160 mm height made of nylon mesh was fixed at the centre of the collection drum vertically with a suitable flange to restrict the entry of cotton inside the blower. PVC suction pipe of 50 mm diameter was fixed at one side of the collection drum on the top with tank nipples for a length of 1000 mm as pick-up pipe. Three pick-up pipes 20, 25 and 30 mm diameter and length 200 mm were attached with the suction pipe. Specifications of knapsack cotton picker are given in Table A.

Table A : Specification of the knapsack cotton picker

Technical descriptions	Cotton picker
Overall dimensions (L × B × H), mm	460×430×850
Engine model	AMB/42A
Engine power	1.8 kW
Engine C.C.	42
Minimum and maximum speed of impeller, rpm	2000, 8500
Dimension of fuel tank (B×H), mm	250×200
Mounting pattern of collection drum	Vertical
Mounting pattern of cotton filter	Vertical
Height of cotton filter, mm	160
Diameter of cotton filter, mm	80
Total length of suction pipe and pick- up pipe, mm	1200
Diameter of pick-up pipe, mm	25
Type of cotton pick-up pipe	PVC hose
Number of operator	1

Laboratory evaluation :

Procedure :

The proposed study was conducted with the technical assistance of ASPEE, Agricultural Research and Development Foundation, Mumbai. A knapsack cotton picker was selected for study and its performance was evaluated in the laboratory and field.

'Solar 60' variety was selected for the laboratory testing of the knapsack cotton picker. Cotton plants were brought from the field to the laboratory and arranged in the iron pots. Two U-tube manometers were used for the measurement of the vaccum pressure. One was used for the measurement of the vaccum pressure at the tip of pick up pipe and another was used for the measurement of the vaccum pressure of the collection drum. One was connected from pick-up pipe to the U-tube manometer and another was connected from collection drum to the U-tube manometer. Engine of the cotton picker was started and speed of blower, pick-up pipe diameter and opening of blower bowl was selected. The speed of blower was measured by the engine pulse tachometer. In the U-tube manometer the difference of water was measured and vaccum pressure was calculated. After picking cotton from one plant engine was stopped and time was measured. Fuel consumption was measurement by the top up method. Picking efficiency was calculated by number of bolls before and after picking. Trash content was calculated by the separating trash from picked cotton and weight of the trash was measured. The process was repeated for other speed of blower, diameter of pipe and opening of blower bowl. RNAM test code and procedure for harvester was followed (Anonymous, 1995). Laboratory testing of knapsack cotton picker is shown in Fig. A.

Fig. A : Testing of knapsack cotton picker in the laboratory

Independent variables :

Speed of blower :

Four speeds *viz.*, 2500, 3500, 4500 and 5500 rpm were selected for laboratory evaluation of cotton picker. The best speed was selected for field evaluation of cotton picker by measuring the pressure created at the tip of the pick-up pipe.

Pickup pipe diameter :

The velocity and pressure of air flowing through the suction pipe was dependent upon the diameter. Hence, the diameter was required to be optimized with respect to the suction force necessary for pneumatic picking of the cotton balls from the plant. Pipe diameters of 20 mm, 25 mm and 30 mm were selected for the experiments. The total length of suction and pick-up pipe when it was fixed to the collection drum was 1200 mm. The front portion of the suction pipe was made of mild steel and was termed as pick-up pipe. The length of this pipe was 200 mm. A 25 mm diameter pick-up pipe is shown in Fig. B.

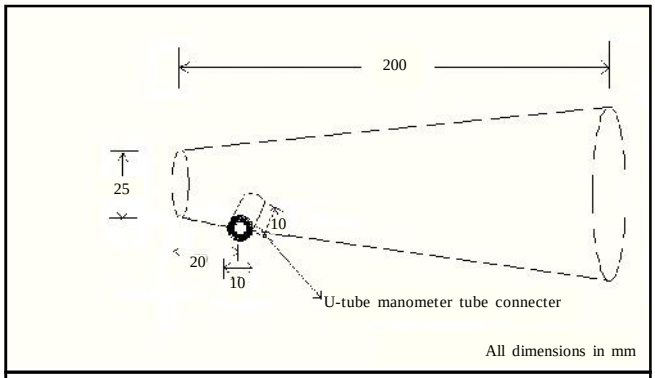


Fig. B : Pick-up pipe

Opening of blower bowl :

50, 75 and100 per cent opening of blower was selected for the experiment as 25 per cent opening of blower bowl could not create sufficient vaccum pressure for picking of the cotton.

Dependent variables :

Fuel consumption :

Fuel consumption of the cotton picker was measured at different speeds of blower. It was measured in litre per hour. Fuel consumption was measured by standard top up method.

Picking efficiency :

Number of bolls on the plant was counted before and after picking. The picking efficiency was determined from the following formula (Rangasamy *et al*., 2006).

$$\eta_p = \frac{n_1 - n_2}{n_1} x100$$

where,

ηp= Picking efficiency, per cent

n_1 = Number of bolls present before picking, and

n_2 = Number of bolls present after picking.

Trash content :

After picking the cotton trash was separated by hand from cotton seed picked by the knapsack cotton picker. The weight of cotton and trash collected was recorded in grams. The trash content was determined by the following formula (Rangasamy *et al*., 2006).

$$T = \left(\frac{W_1}{W_2}\right) x\,100$$

where,

T = Trash content, per cent

W_1= Weight of trash separated, g and

W_2= Weight of cotton fed, g.

Pressure at the tip of pick-up pipe :

The pressure at the tip of pickup pipe was measured with the help of U-Tube manometer. Manometer tube was connected at the outer end of pick-up pipe. Difference in water level during picking cotton was measured and pressure at tip of pick-up pipe was calculate in terms of kg/cm^2 from the following formula.

$$P_{oe} = \rho g h_1$$

where,

P_{oe} = Pressure at the outer end of pick-up pipe, kg/cm^2

ρ = Density of the water in the tube, in kg/m^3

g = Acceleration due to gravity, that is, 9.81 m/s^2

h_1 = Difference between the heights of the water in each limb, in mm

Pressure of the collection drum :

The pressure of the collection drum was measured with the help of U-Tube manometer. Manometer tube was connected to the collection drum. The difference in water level during picking cotton was measured and pressure of the collection drum was calculated in terms

of kg/cm^2 from the following formula.

$$P_{cd} = \rho g h_2$$

where,

P_{cd} = Pressure of the collection drum, kg/cm^2

ρ = Density of the water in the tube, in kg/m^3

g = Acceleration due to gravity, that is, 9.81 m/s^2

h_2 = Difference between the heights of the water in each limb, in mm.

Field evaluation of cotton picker :

In the field the cotton picker was evaluated for its output capacity, picking efficiency, trash content and fuel consumption.

Procedure :

25 mm diameter pick-up pipe, 5500 rpm of the blower speed and 100 per cent opening of blower bowl was selected for the field testing of the knapsack cotton picker. In the field three 2×4 m plots were randomly selected for the testing of the machine. The knapsack cotton was placed in one of the plot. The engine was started on petrol fuel and then run on kerosene. Matured cotton bolls were counted in the plot. Matured cotton bolls were picked from the plants and collected in the collection drum. The picking was continued till the all matured cotton bolls were picked. The engine was stopped and time taken to complete picking was measured. Numbers of cotton bolls collected were counted and their weight was recorded. Trash was separated manually from the picked cotton bolls. Weight of the trash removed was then recorded. Output capacity, picking efficiency, trash content and fuel consumption were calculated as follows.

Fig. C : Field testing of cotton picker

Output capacity :

The output capacity was determined by the ratio of the weight of seed cotton picked by the machine to the time taken to pick the cotton as given below (Selvan *et al*., 2004).

$$OC = \frac{W}{T}$$

where,

OC = Output capacity, kg/h

W = Weight of seed cotton, kg

T = Time taken, h.

Fuel consumption, picking efficiency and trash content was calculated by the formula given in laboratory evaluation.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

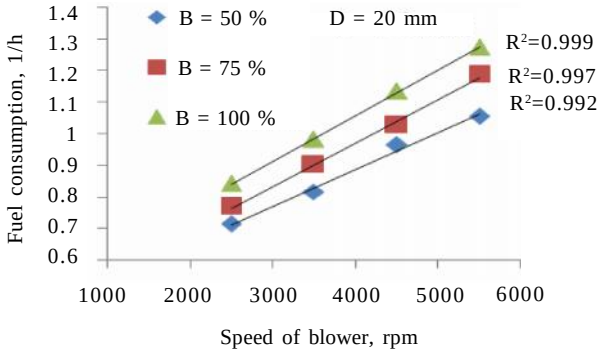
Laboratory performance evaluation :

Fuel consumption :

Effect of speed of blower on fuel consumption for 20 and 30 mm diameter of pick-up pipe is presented in Fig. 1. The figure shows that fuel consumption increased with speed of blower for all diameters of pick-up pipe. The maximum fuel consumption was 1.31 l/h with 5500 rpm of the blower speed at 30 mm diameter of the pick-up pipe and 100 per cent opening of blower bowl. The minimum fuel consumption was observed to be 0.72 l/h at 2500 rpm for 20 mm diameter of pick-up pipe and 50 per cent opening of blower bowl. Analysis of variance revealed that opening of blower bowl had significant effect on fuel consumption.

Picking efficiency :

Statistical analysis (CRD) showed that opening of blower bowl had significant effect on picking efficiency. Effect of speed of blower on picking efficiency for 20 and 30 mm diameter of pick-up pipe is shown in Fig. 2. Picking efficiency increased with speed of blower for all diameter of pick-up pipe. The maximum picking efficiency was 96.85 per cent at 5500 rpm of speed of blower for 30 mm diameter of pick-up pipe and 100 per cent opening of blower bowl. The minimum picking efficiency was 94.42 per cent at 2500 rpm of speed of blower for 20 mm diameter of pick-up pipe and 50 per



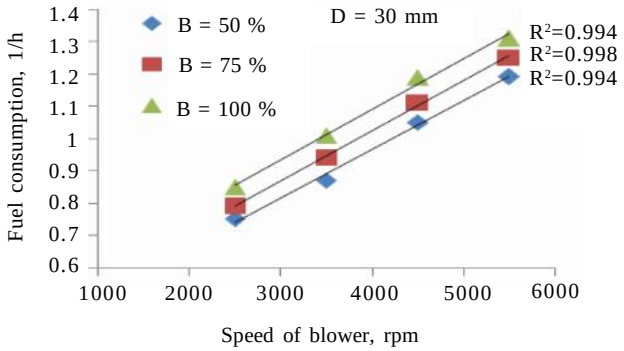
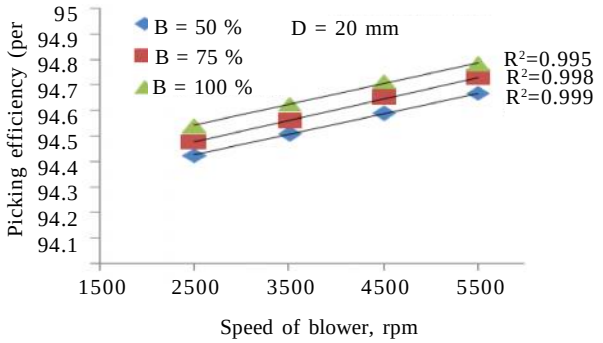


Fig. 1 : Effect of speed of blower on fuel consumption for 20 and 30 mm diameter of pick-up pipe



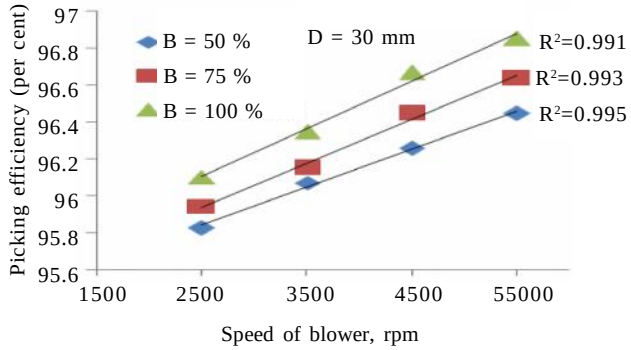
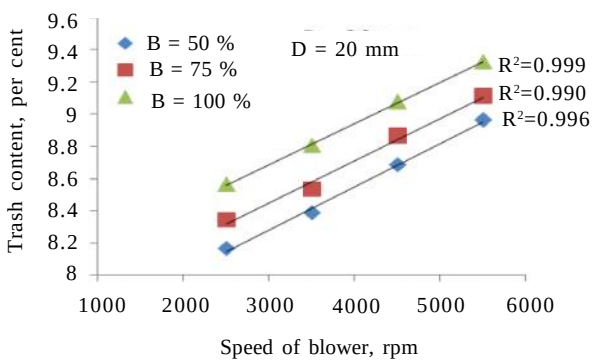


Fig. 2 : Effect of speed of blower on picking efficiency at 20 and 30 mm diameter of pick-up pipe

cent opening of blower bowl.

Trash content :

The statistical analysis, revealed that the trash content had a strong positive correlation with speed of blower, diameter of pick-up pipe and opening of blower bowl. The minimum trash content was 8.16 per cent at 2500 rpm for 20 mm diameter of pick-up pipe and 50 per cent opening of blower bowl. The maximum trash content was 11.33 per cent for 30 mm diameter of pick-up pipe at 5500 rpm of speed of blower and 100 per cent opening of blower bowl (Fig. 3).



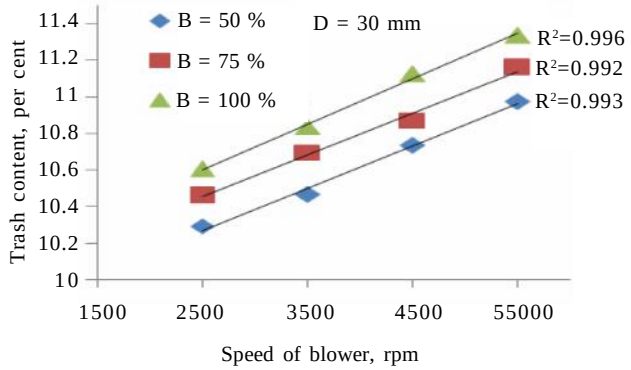


Fig. 3 : Effect of speed of blower on trash content at 20 and 30 mm diameter of pick-up pipe

Pressure at the tip of pick-up pipe :

From the statistical analysis, the diameter at the tip of pick-up pipe had a strong positive correlation with pressure (Fig. 4). Minimum pressure was 0.035 kg/cm^2 at 2500 rpm, 20 mm diameter of pick-up pipe and 50 per cent opening of blower bowl while maximum pressure was observed to the 0.082 kg /cm^2 at 5500 rpm of blower speed, 25 mm diameter of pick-up pipe and 100 per cent opening of blower bowl. Maximum pressure was obtained at 25 mm diameter of pick-up pipe for all speed of blower and all opening of blower bowl. This may be due that at 20 mm diameter of pick-up pipe suction of the cotton bolls take more time with a 30 mm diameter of pick-up pipe that is large difference between the projected area of the squeezed cotton bolls and pick-up pipe cross sectional diameter which in turn affected the drag force, resulting in entrance of atmosphere and this shown no effect on the cotton bolls.

Pressure of the collection drum :

Statistical analysis showed that diameter of pick-up pipe had a positive correlation with pressure of the collection drum. Fig. 5 showed effect of diameter of pick-up pipe on pressure of the collection drum. The maximum pressure was obtained at 25 mm diameter for all opening of blower bowl and all speed of blower. Maximum pressure of the collection drum was 0.049 kg/cm^2 at 5500 rpm of speed of blower, 25 mm diameter of pick-up pipe and 100 per cent opening of blower bowl while minimum pressure was 0.023 kg / cm^2 at 2500 rpm of blower speed, 20 mm diameter of pick-up pipe and 50 per cent opening of blower bowl. As the pressure at the tip of pick-up pipe was maximum for 25 mm diameter of pick-up pipe, also showed maximum pressure at the collection drum during picking of the cotton bolls for the same diameter of pick-up pipe.

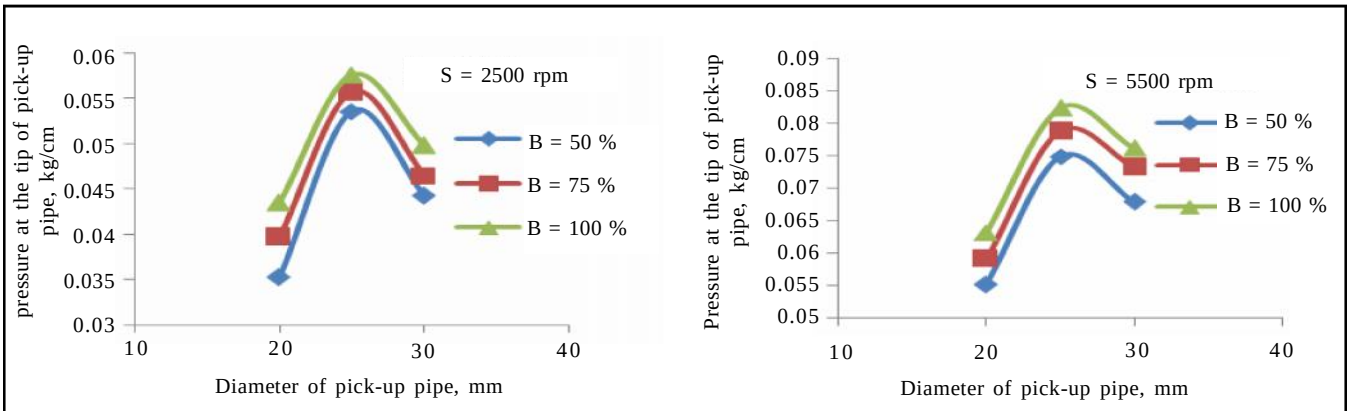


Fig. 4 : Effect of diameter of pick-up pipe on pressure at the tip of pick-up pipe at 2500 and 5500 rpm of speed of blower

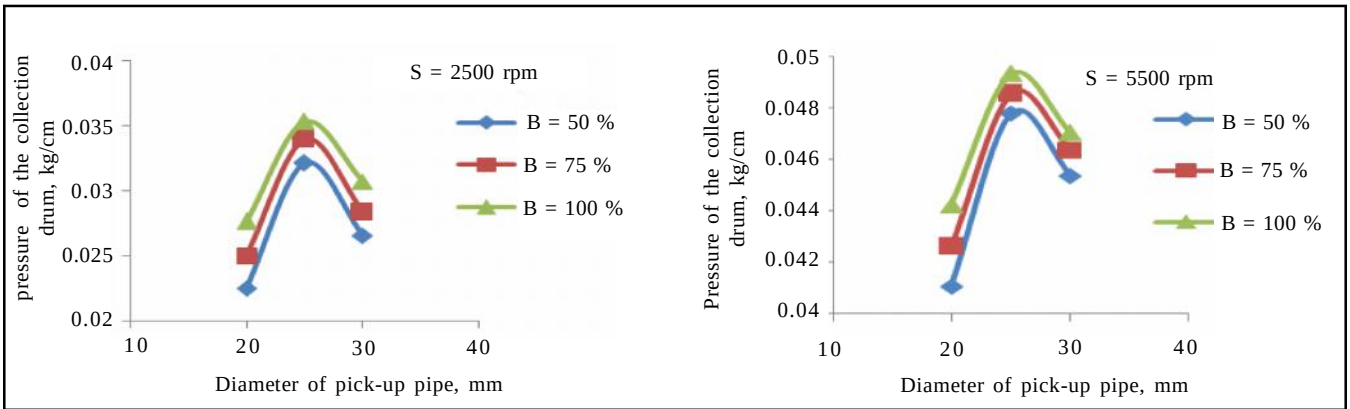


Fig. 5 : Effect of diameter of pick-up pipe on pressure at the collection drum at 2500 and 5500 rpm of speed of blower

Field performance of cotton picker :

The cotton picker was evaluated in the field at 5500 rpm of speed of blower, diameter of pick-up pipe 25 mm and 100 per cent opening of blower bowl. There was a significant difference in output capacity of the machine in comparison with manual cotton picking. The machine harvested about 5 kg/h or 40 kg/day. This was a more than three times increase in output capacity with picker compared to manual picking. The picking efficiency of the picker was 96.25 and 96.70 per cent for first and second picking. Picking efficiency increased with the time of picking. This showed that the maturity aspect played a positive role in mechanized cotton harvesting. The trash content from the picker was 10.15 and 10.30 per cent. Picking time showed significantly the trash content, picking efficiency and output capacity. Fuel consumption of cotton picker was about 1.29 l/h for both picking.

Cost economics :

The cost of knapsack cotton picker was Rs. 8000. The cost of picking of cotton with knapsack cotton picker was Rs. 10.82 per kg and requires 0.202 hours / kg of cotton seed Saving in cost and time compared to manual picking was 12.96 per cent and 69.85 per cent, respectively. Break-even point and pay-back period was calculated as 278.46 kg/annum and 0.549 year, respectively.

Conclusion :

- Fuel consumption, picking efficiency and trash content increased with increase in speed of blower for all pick-up pipe.
- Maximum pressure at tip of pick-up pipe was 25 mm diameter of pick-up pipe at 5500 rpm of speed of blower and 100 per cent opening of blower bowl.
- Output capacity, trash content and picking efficiency was less in first picking compared to second picking.
- The cost of picking with knapsack cotton picker was Rs. /kg 10.88 and required 0.202 hours to pick / kg of cotton.

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