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A study on performance assessment of pre cleaners in processing of machine harvested cotton in India

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ABSTRACT: The analysis of results suggested that the machine picked cotton contained around 19.2 per cent total trash content among which the dry leaves were highly significant (13.4%) compared to the large foreign matters (such as sticks and burs). The overall cleaning efficiencies of pre-cleaner, stick machine and saw band cleaner were found as 20.45, 41.86 and 23.59 per cent, respectively. The average percentage of trash content present in the machine picked cotton was brought down to 3.11 per cent using saw cylinder cleaner in combination with the cylinder cleaner and stick machine. The analysis of fibre parameters suggested that the pre cleaning operations did not make any significant difference in the fibre properties.

Key words : Cleaning efficiency, cotton picker, harvesting, mechanisation, pre cleaning machines, sticks, trash content

Cotton is an important cash crop of India and plays a leading role in the industrial and agricultural economy of the country. Cotton is main source of income in India for around 6 million farmers and about 40-50 million people are directly or indirectly engaged in cotton trade and processing (Anonymous, 2010). Recently, India has surpassed China in cotton production and emerged world's largest cotton producer in the season 2014-2015. Unlike developed cotton growing countries (USA, Australia, Israel, etc.) where cotton is harvested using sophisticated machines, entire cotton in India is picked manually (Shukla *et al.,* 2006). The cost of cotton picking in India has quadrupled to around Rs. 6/kg of cotton in last 4-5 years, mainly due to high inflation rate, migration of landless farm labours to cities and implementation of the *National Rural Employment Guarantee Act* (Harish *et al.,* 2011). Moreover, delay in the cotton harvesting due to the shortage of labours results in the delay in sowing of the next crop leading to low yield. In order to meet the scarcity of labour and to reduce the cotton picking cost, efforts need to be concentrated on mechanization of cotton harvesting (Shukla *et al.,* 2006).

The average farm holding in India is less than 2 ha and size of Indian cotton fields is very small (Konduru *et al.,* 2013). The machine pickers available in the world market are very large in size and capacity, hence they are unsuitable for cotton pickings in small Indian cotton farms. Dedicated work at different Indian Cotton Research Institutes and by Indian as well as foreign agricultural machinery manufacturers is going on for past one decade towards development of a suitable cotton picking machine for small sized Indian farms. Researchers have tried different picking methods (*i.e.* pneumatic suction, pneumatic suction cum picking brushes, sensor techniques, conventional spindle type pickers, etc.) for harvesting of cotton (Muthamilselvan *et al.,* 2007). However, most of these methods did

not perform well under field conditions. The major stumble blocks in the success of these methods are non availability of a suitable cotton hybrid/variety for mechanical picking (maximum height and width of cotton crops for mechanical harvesting are 4 and 2 ft, respectively), practice of multiple pickings, non-standardization of defoliant application technology, development of suitable cleaning systems, etc.

It has been observed by the numerous researchers that among the different methods tested for cotton picking, the conventional spindle type picker based mechanism appeared to be working satisfactorily for picking of cotton. This method was also evaluated in Indian cotton farms by cotton pickers imported from then USSR. However, further progress in this direction was constrained by the fall of former USSR. Efforts have been made by the researchers and agricultural machinery manufacturers for attaching the cotton picking heads on the side of existing tractors so as to avoid high initial investment in purchasing a self-propelled spindle type picker. It is widely reported in literature (Muthamilselvan *et al.,* 2007; Sui *et al.,* 2010) that the machine picked cotton contains around 10-15 per cent trash content, which includes burs, sticks, leaves, grasses, motes, etc. However, the non standardization of defoliants under Indian conditions has resulted in around 20-25 per cent trash content in machine picked cotton. A set of special machines is required to pre clean the machine picked cotton. Such machines are not readily available in local market and import is unviable and very costly. Ginning Training Centre (GTC) of CIRCOT, Nagpur is working in tandem with the cotton picker research group towards development of a cleaning system suitable for pre cleaning of machine picked cotton.

The aim of this paper is twofold. The first part evaluates the machine picked cotton supplied by M/s. John Deere India from its Aurangabad (MS) farm. This cotton was harvested using conventional spindle picker attached at the side of a tractor in 2011-2012. The second part is devoted towards the performance assessment of cleaning machines developed at GTC of CIRCOT, Nagpur for pre cleaning of machine picked cotton. Fibre quality evaluation at each stage of cleaning operation is also presented in this work.

In the present work, a spiked cylinder pre cleaner, a three stage stick remover machine and a saw band cleaner were used to pre clean the machine picked cotton. These machines were developed at GTC of CIRCOT, Nagpur for processing of machine picked cotton. The stick remover machine mainly utilizes the sling off action of saw cylinders for removal of trash content while the spiked cylinder cleaner mainly uses the centrifugal action of spiked cylinders for trash content removal. However, the saw band cleaner employs both the centrifugal action of spiked cylinders and sling off action of saw cylinders for removal of fine trash content from machine picked cotton. The sequence of the cleaning machinery adopted in this work for processing of the machine picked cotton is given in Fig. 1.

The cylinder cleaner (700 mm width) used

Fig. 1. Sequence of machines employed for pre cleaning of the machine picked cotton

in this work consists of 6 spiked cylinders arranged at an inclination of 30^0 from horizontal. This machine removes breaks the cotton wads and removes small particles from the machine picked cotton such as sand, dust, pin trashes, bracts, motes, etc. through grid bars by centrifugal action of cylinders and scrubbing of loosened cotton over grid bars. The stick machine (600 mm width) used in this work consists of 2 stages of cleaning and 1 stage of reclaiming saw band cylinders. It removes large vegetative matters of the machine picked cotton by using sling off actions of the saw band cylinders. The first saw band cylinder served as the primary sling off cylinder for the first stage of extraction and the second saw cylinder served as reclaimer. The reclaimed seed cotton was then redirected to the third saw cylinder for second and final stage of cleaning. The saw band cleaner (890 mm width) consists of 2 cylinder cleaners, 1 stage each of saw band cleaner and reclaimer (Fig. 2) for cleaning of fine trash content from the machine picked cotton. Cotton is kicked to the saw band cleaning stage after passing through the cylinder cleaning stage. Therefrom, the cotton is fed to reclaiming stage of machine where useful fibres from waste of the first stage are separated.

One way analysis of variance (ANOVA) was performed using Tukey Kramer honesty significance difference (HSD) test facility of JMP Genomics 4 module of statistical analysis software, SAS with a null hypothesis (á = 0.05) that the fibre parameters of each cleaning treatment was unequal and cleaning efficiency of each cleaning treatment was same.

Since the machine picked cotton contains a significant amount of the dry leaves, which are broken and completely mixes with the lint and cottonseed during ginning operation, it becomes very difficult to determine the trash content in the machine picked cotton by usual procedure (*i.e.* ginning of cotton and determination of trash content using trash separator). Therefore, the trash content of the machine picked cotton was evaluated by manual

(a) (b) (c)

Fig. 2. Pre cleaners used in this study (a) cylinder cleaner (b) stick machine (c) saw band cleaner

separation of large trash content. Three samples weighing 0.3 kg each of the machine picked cotton were analysed for their trash content.

Due to limited availability of the machine picked cotton, the present study was limited to only one trial of 200 kg for performance evaluation of cleaning machines. The cotton was fed manually and uniformly to each machine. Three samples of 0.6 kg each was collected after passing from each machines. The cleaned cotton obtained from each machine and the control were ginned on a double roller gin. The lint samples obtained after ginning were analysed on MAG-SlTRA trash separator for fine trash content and on High Volume Instrument (HVI) for its fibre properties. The moisture content and temperature during each cleaning operation was maintained at 5 per cent and 39°c, respectively.

Analysis of trash content : The comparative data on trash content percentage in machine picked cotton on lint basis evaluated in the present study and previous reports are given in Table 1. It can be seen from the data in the table that the total trash content in the present work is almost equal to that of Wanjura *et al.,* (2012). However, the trash content in the present work in considerably higher than that of Faulkner *et al.,* (2011), probably due to comparatively lesser amount of dry leaves present in the machine picked cotton in case of Faulkner *et al.,* (2011) as compared to the present work. In the present work, the dry leaf content in the machine picked cotton is about 70 per cent of the total trash content. In contrast to the previous study, the percentage of large trash content present in the machine picked cotton is significantly on the lower side as depicted in Table 1. Hence, the trash content in the machine picked cotton can be reduced by restricting the amount of leaves during harvesting operation by means of optimising defoliant application.

The length and diameter of the sticks separated from the samples of 0.3 kg machine cotton have been given in Table 2 and Table 3. It can be seen from the data in Table 2 that the length of the sticks found in the machine picked cotton varied from around 2 mm to 40 mm. However, the majority of the sticks were in the range of 2 to 25 mm length. Similarly, the measurement of diameter of the sticks shows that sticks lies in the diameter range of 0.1 to 2.5 mm. It can be concluded from this measurement that the sticks present in the machine picked cotton are very small in size. Separated foreign matters from a sample of 0.3 kg machine picked cotton are depicted in Fig. 3.

Performance assessment of cleaning machines : The data in Table 4 showed the average weight of trash content and percentage of trash content to the lint of the control and after each cleaning treatment. It can be seen from the data in this Table that the total trash content present in the control is around 8.8 per cent, which is much below the 19.2 per cent trash content depicted in Table 1 for the machine picked cotton. It is mainly due to the reason that the dry leaves which are dominantly present in the machine picked cotton get crushed and finely mixed during ginning leading to separation of finely mixed particles partly through the grids along with the cottonseed and partly along with the lint, which could not be even separated using the trash separator.

Data in Table 4 showed that the average percentage of foreign matter content present in cotton is reduced to 7.0 per cent from 8.8 per cent after processing in the six cylinders cleaner. Thus, the overall cleaning efficiency of this machine is found to be 20.45 per cent as

Table 1. Trash content (%) in machine picked cotton

	Bracts/ Burrs	Sticks	Green leaves	Immature seeds/motes	Dry leaves	**Total trash content**
Present work	3.8	0.7	0.9	0.4	13.4	**19.2**
Wanjura *et al.,* (2012)	3.9	1.2	-	-	13.2	**18.3**
Faulkner *et al.,* (2011)	5.7	1.8	-	-	7.5	**15.0**

Table 2. Length and number of sticks present in the machine picked cotton

Length of sticks (mm)	2-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	2-40
No. of sticks	2	7	10	6	7	1	3	3	39

Table 3. Diameter and number of sticks present in the machine picked cotton

Dimensions of sticks (mm)	0.1 to 0.50	0.50 to 1.00	1.01 to 1.50	1.51 to 2.00	2.01 to 2.50
No. of Sticks	1	15	17	5	1

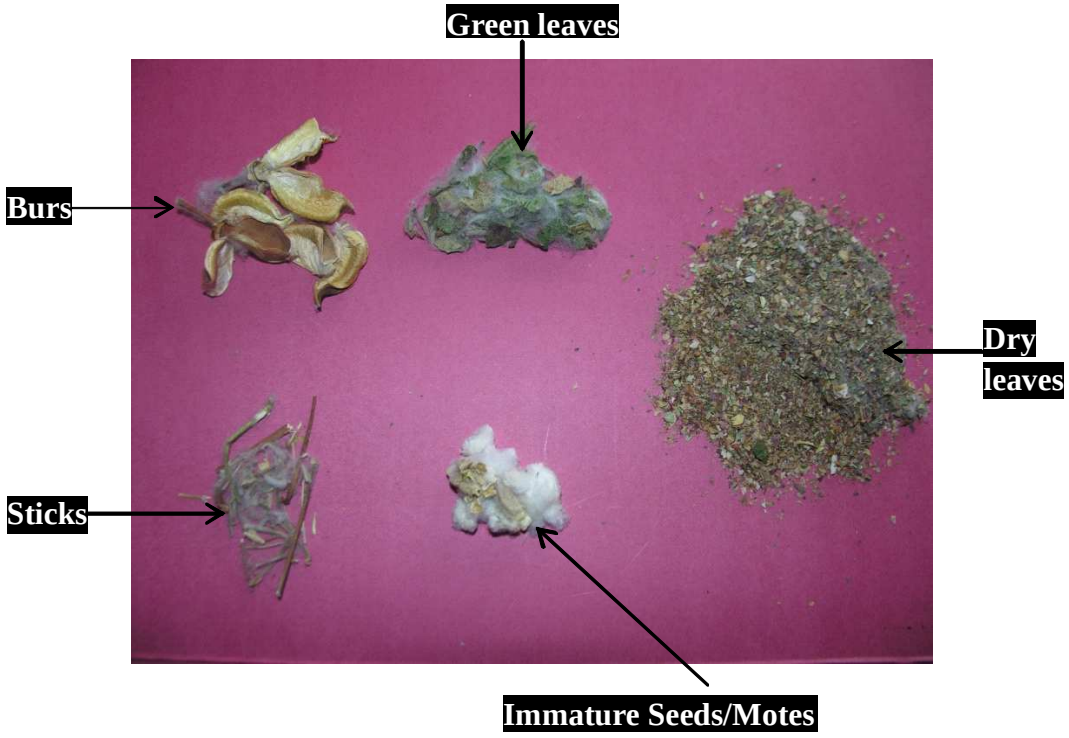

Fig. 3. Trash content separated from the machine picked cotton

depicted in Table 5. Hence it is evident that the cylinder cleaner is very efficient in removing fine trashes from the machine picked cotton. On the contrary, the stick and burs removal efficiencies of this machine have been found as 10.17 per cent and 15.38 per cent only. This phenomenon can be explained with the working principle of the cylinder cleaner. The cylinder cleaner removes the trash content by scrubbing and beating the cotton over its grid bars. Hence the fine trash content and the heavy particles which are not tightly entangled with the fibres

Table 4. Constituents of trash content of machine picked cotton at various cleaning machines

Treatments	cotton (10^{-3} kg)	Lint (10^{-3} kg)	Trash content	Bracts/ Burrs	Sticks	Green leaves	Immature seeds/ motes	Dry leaves	**Total**
T_1 Control	600	241		6.9	1.4	5.21	0.3	7.4	**21.21**
			(10^{-3} kg)	2.86	0.59	2.16	0.12	3.07	**8.8**
			(per cent)						
T_2 Cylinder	600	238	(10^{-3} kg)	5.77	1.27	2.93	0.1	6.6	**16.67**
cleaner			(per cent)	2.42	0.53	1.23	0.04	2.77	**7**
T_3 Stick	600	230	(10^{-3} kg)	2.06	0.72	1.38	0	5.2	**9.36**
machine			(per cent)	0.9	0.31	0.6	0	2.26	**4.07**
T_4 Saw	600	228	(10^{-3} kg)	1.01	0	1.19	0	4.9	**7.1**
band cleaner			(per cent)	0.44	0	0.52	0	2.15	**3.11**

Table 5. Effectiveness of cleaning machines in percentage for removing trash content from machine picked cotton

Treatments	Bracts/ Burrs	Sticks	Green leaves	Immature seeds/motes	Dry leaves	**Total**
T_1 Cylinder cleaner	15.38 a*	10.17 ab	43.06 f	66.67 i	9.77 gh	**20.45 k**
T_2 Stick machine	62.81 b	41.51 cd	51.22 g	100 g	18.41 ik	**41.86 l**
T_3 Saw band cleaner	51.11 c	100 ef	13.33 h	0 h	4.87 lm	**23.59 m**

are separated while the trash content, which are present in the inner lock of the cotton and particles which are tightly entangled with the fibres could not be separated in this machine. In addition to the removal of fine trash content, the cylinder cleaner opens the wads of the cotton resulting in the separation of the large trash particles in the next cleaning machines

When comparing different removal efficiencies (across rows), different letters denote statistically significant differences using Tukey Kramer honesty significance difference (HSD) test at the 5 per cent level.

Data in Table 4 shows that the average percentage of trash content present in the machine picked cotton has been reduced to 4.07 per cent after processing in the stick machine in combination to inclined cylinder cleaner. Hence, the overall cleaning efficiency of this machine is 41.86 per cent as shown in Table 5. In addition, the burs removal, sticks removal and green leaves removal efficiencies of this combination have been found as 62.81, 41.51 and 51.11 per cent, respectively. It is evident from this data that the stick machine is very efficient in removing large foreign matter content from machine picked cotton. It is mainly due to reason that the combing and sling off actions of this machine dislodge the large trash content from the cotton leading to their separation. The trash removal efficiency of a pre-cleaner depends on the amount of initial trash content present in cotton, the control cotton contained maximum amount of burs followed by green leaves and sticks that resulted in highest amount of bur removal efficiency of the stick machine compared to the removal of sticks and green leaves.

Table 4 further depicts that the average percentage of foreign matter content present in the machine picked cotton has been brought down to 3.11 per cent using saw cylinder cleaner

Table 6 Fibre parameters of the machine picked cotton at each cleaning machine

Treatments	2.5 per cent Span length (mm)	Micronaire (µg/inch)	Bundle strength (g/tex)	UR[1] (%)	Colour readings	
					Reflectance (Rd %)	Yellowness (+b)
T_1 Control	29.9 a*	3.2 b	22.3 c	46 d	73.8 e	8.4 i
T_2 Cylinder cleaner	29.4 a	3.1 b	23.7 c	49 d	75.4 f	8.3 i
T_3 Stick machine	29.0 a	3.1 b	22.1 c	49 d	76.5 g	8.4 i
T_4 Saw band cleaner	29.8 a	3.1 b	22.0 c	48 d	79.8 h	8.4 i

*When comparing different removal efficiencies (across rows), different letters denote statistically significant differences using Tukey-Kramer honesty significance difference (HSD) test at the 5 per cent level.

in combination with the cylinder cleaner and stick machine. Hence, the overall cleaning efficiency of this machine is 23.59 per cent. In addition, this machine is very efficient in removing the burs from the machine picked cotton. It can be observed from Table 5 that all the sticks present in the machine picked cotton have been successfully removed using the specified sequence of machinery. It is evident from Table 5 that the saw band cleaner is almost equally efficient for removal of all type of foreign matter content. In the present study, the overall cleaning efficiency of pre-cleaners was found as 64.66 per cent, which is in accordance with the previous study (Wanjura *et al.,* 2012).

Fibre properties measured by High Volume Instrument (HVI) : The results of fibre property analysis (Table 6) indicated minimal fiber quality differences among the cleaning treatments. No significant differences at 95 per cent confidence level were observed in any of the fibre properties (2.5% span length (SL), uniformity ratio (UR), micronaire value and bundle strength) presented in Table 6 by cleaning treatments. This finding has also been confirmed by the recent published work (Porter *et al.,* 2017). However, ANOVA indicated the difference in colour readings represented by reflectance percentage (Rd per cent). The cleaning treatments have resulted in the removal of trash content from the machine picked cotton leading to improvement in the cotton reflectance.

CONCLUSIONS

The results of the present work showed that the machine picked cotton contains around 19.2 per cent total trash content among which the percentage of dry leaves is highly significant (13.4%) compared to the large foreign matters (such as sticks and burs). The length and diameter of sticks present in the machine picked cotton varied from 2-40 and 0.1-2.5 mm, respectively. The overall cleaning efficiencies of pre-cleaner, stick machine and saw band cleaner were found as 20.45, 41.86 and 23.59 per cent, respectively. The average percentage of trash content present in the machine picked cotton was brought down to 3.11 per cent using saw cylinder cleaner in combination with the cylinder cleaner and stick machine. The analysis of fibre parameters suggested that the pre-cleaning operations did not make any significant difference in the fibre properties and the colour readings represented by the reflectance percentage have improved in cleaning treatments.

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REFERENCES

Annoymous, **2010.** *India: Country statement on cotton*, In: 69th Plenary Meeting of the International Cotton Advisory Committee at Lubbock, ICAC, Texas, USA,

Faulkner, W. B., Wanjura, J. D., Boman, R. K., Shaw, B. W. and Parnell, C. B. 2011. Evaluation of modern cotton harvest systems on irrigated cotton: Fiber quality, *Appl Eng Agric.,* **27** : 497-06

Harish, B. G., Nagaraj, B., Chandrakanth, M. G., Murthy, P. S. S., Chengappa, P. G. and Basavaraj, G. 2011. Impacts and implications of MGNREGA on labour supply and income generation for agriculture in central dry zone of Karnataka, *Journal-AERR (India),* **24** : 485-94

Konduru, S., Yamazaki, F. and Paggi, M. 2013. A study of mechanization of cotton harvesting in india and its implications, *J. Agric. Sci. Technol.,* **B 3**, 789-97

Muthamilselvan, M., Rangasamy, K., Ananthakrishnan, D. and Manian, R. 2007. Mechanical picking of cotton - a review, *Agric. Rev.,* **28** : 118-26

Porter, W. M., Wanjura, J. D., Taylor, R. K., Boman, R. K. and Buser, M. D. 2017. Tracking cotton fiber quality and foreign matter through a stripper harvester, *J. Cotton Sci.,* **21 :** 29-39

Shukla, S. K., Patil, P. G. and Arude, V. G. 2006. Design development and performance evaluation of a saw cylinder cleaner for mechanically picked cotton, *AMA-Agr. Mech. Asia Af.,* **37 :** 25-29

Sui, R., Thomasson, J. A., Byler, R. K., Boykin, J. C. and Barnes, E. M. 2010. Effect of machine fibre interaction on cotton fibre qulity and foreign matter particle attachment to fibre, *J. Cotton Sci.,* **14 :** 145-53

Wanjura, J. D., Faulkner, W. B., Holt, G. A. and Pelletier, M. G., **2012.** Influence of harvesting and gin cleaning practices on southern high plains cotton quality, *Appl Eng Agric.,* 28, 631-41.

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