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Impact of the pressure plates of picker cotton platforms on the efficiency and quality of cotton fibers

Hiago Renrique R. Zanetoni[1], Renildo Luiz Mion[1]*, Nayra Fernandes Aguero[1], Renato Bassini[1], Cíntia Michele Baraviera[1], Carlos Alberto Viliotti[1], Jean Louis Belot[2], Sérgio Gonçalves Dutra[1], Myllena Teixeira Martins[1], Luiza R. Cabral Da Silva[1], William Lima Crisostomo[1] and Carlos Alberto Viliotti[1]

[1]Agricultural Engineering Department, Federal University of Mato Grosso, Campus Rondonópolis, Rondonópolis, Mato Grosso, Brazil.
[2]Mato Grosso Cotton Institute, Primavera do Leste, Mato Grosso, Brazil.

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An experiment was performed in a cotton-producing property located in Primavera do Leste - MT - (Brazil). the quantitative losses and the presence of bark and stems in the cotton fiber quality measuring instrument as analyzed by High Volume Instrument (HVI) was noted . The study was conducted to investigate a combined speed of work with a mechanical adjustment of the distance of the pressure plates and the screws on the platform. Another objective of this study was to determine reducing quantitative and qualitative losses of cotton fiber. The platform was set at three different velocities (1.02, 1.38 and 1.60 m s^{-1}). Two different distances (plate with pressure – 3 mm and plate without pressure 6 mm were set as the distance between the spindles and the pressure plates. At these distances, the plants are pressed onto the spindle exerting pressure on the spindles. The collected fiber content of impurities and the efficiency of the machine were analyzed as a function of the total productivity and quantitative losses. Factorial statistical analysis was performed on the data using the Tukey test at 5% probability. A greater presence of impurities and lowest cotton crop losses was observed at the smallest distance between the spindles and the pressure plates.

Key words: Picker, cotton, fiber quality, harvest efficiency, losses.

INTRODUCTION

In the State of Mato Grosso, all cotton is harvested mechanically. In the 2013/2014 season, 61,310 ha from the 613,100 ha planted included systems with narrow lines less than 0.50 m (AMPA, 2015). With the exception of dense crops that are generally harvested with machine stripper type comb platforms, most of the State Mato Grosso cotton is harvested with a machine picker.

The main collection system used by cotton growers

*Corresponding author. E-mail: renildomion@gmail.com.

involves the use of rotary spindle platforms. This is also known as a picker and it functions in a manner similar to manual picking. The performance of the cotton picker with a picker platform can affect the quantity and quality of harvested cotton. Movement speed, variety, line spacing, plant conditions, defoliation, the plume humidity, and adjustments associated with harvesting units are among the factors that affect the harvest efficiency.

Baker et al. (2003) studied the effects of harvester pickers with respect to qualitative and quantitative losses. They found that the interaction between the machine speed and the cultivated variety was significant. They also noted that small adjustments in the collection of units and speed were highly effective in reducing losses and waste in the presence of cotton fibers.

Baker and Hughes (2008) evaluated the impact of changes in the length and diameter of the rotation axes and spindles on cotton losses, trash content, and quality of cotton fibers. They concluded that the rotation of the spindle should be at least 2000 rpm. They also indicated that the changes in length and shaft diameter did not significantly affect the amount of waste present in the samples.

During the harvest, losses should be monitored in order to detect and fix possible errors that may occur during the process. Significant investments in the agricultural production and its importance on the world stage require the reduction of losses in quantity and quality in order to contribute to increased farmer profitability (Mion et al., 2015).

The cotton harvest is a crucial moment for reducing quantitative losses. Hence, losses can be partially avoided or substantially minimized by taking certain precautions. These precautions include closer monitoring of working speeds, settings, plates adjustments; proper cleaning and maintenance of knowledge embedded electronics; regular maintenance intervals and the refilling of grease, water and detergent humidification systems.

The quality of cotton commercially available is influenced by several physical factors. These physical factors can be affected at each stage of production. This underscores the importance of the variety, environment, harvesting processes and processing of cotton plumes.

The cotton is classified based on the length and uniformity of fiber micronaire, color, and trash. The amount of waste present in the crop and its subsequent removal from the cotton may affect some properties such as fiber, degree of color, and trash. Additionally, it may heavily impact the spinning and textile manufacturing industry.

The cotton is then separated from other plant materials in the field or cotton with cleaning devices. When compared with manual harvesting, mechanical cotton harvesting reduces costs and harvesting time. However, mechanical harvesting generally decreases the cotton fiber quality, particularly in terms of increases in the level of NEP content and foreign matter in the fiber (Calhoun et al., 1996; Hughs et al., 2000; Baker and Brashears, 2000; Willcutt et al., 2002; Baker and Hughes, 2008; Faulkner et al., 2012). As noted by Funk et al. (2005), mechanically harvested cotton contained approximately 10 to 35% of foreign matter, including leaves, bark, sticks, stem, seeds and other debris.

The objective of this study was to determine the effects of the travel speed of the cotton picker and the pressure plate of the units on the qualitative and quantitative performance of the cotton fiber harvested in the State of Mato Grosso - Brazil.

MATERIALS AND METHODS

The study was conducted in an area of 0.81 ha, on a property in Primavera do Leste municipality – MT, Brazil. The variety of cotton sown was FM 944GL, with spacing of 0.90 m.

Cultural planting practices defoliation followed agronomic recommendations. The peeling occurred 20 days before the harvest. The machine used was a cotton blue 2805 model cotton harvester with picker platform brand Montana (Figure 1) with 4 units, and 16 bars with 20 spindles each, totaling 320 spindles per drum.

The experimental area consisted of 24 plots with an area of 108 m^2 (3.6 × 30 m). Prior to the passage of the harvester, productivity and the pre-harvest loss (action on climatic conditions and cultural practices) were estimated. For this, an area demarcated as 9.0 m^2 (5.0 × 1.9 m) within the sampling area was used. All the cotton present in plants and on the soil surface was manually collected.

Following the passage of the harvester in the plot, post-harvest losses were obtained by using a marquee on 9 m^2. These losses were related to the cotton that is retained in the stem of the culture after the passage of the machine and knocked to the ground by the action of the machine.

During the harvest, cotton lint was collected in the harvester basket in order to determine the impurities present in the cotton fiber. Approximately 3 kg of seed cotton was randomly collected within each portion and packed in raffia bags. All samples were identified and tied to prevent contamination at the time of storage.

Before sending the samples to the laboratory, a ginner with 20 saws was used to separate the fiber from the seeds. The middle portions of the samples were collected. Both the tops and the ends of the ginned cotton were discarded to avoid the increase in long and short fibers.

The experimental design was a randomized block design with four replications in a 2x3 factorial. Two distances of 6 mm and 3 mm were set between the pressure plates and the screws on the platform. Three harvest velocities of 1.02, 1.38, and 1.60 m s^{-1} were employed. The moisture of the fiber was instantly determined during the harvest period and was monitored with the aid of a portable measuring apparatus of Hygron mark. During the experiment, the moisture level was close to 7%, and it reduced during the experiment.

The collected materials were properly stored, identified and later sent to the laboratory to be analyzed and measured during the HVI analysis. Impurities constitute the materials that are not considered as production losses. These were manually separated from the fiber. The total losses were determined from the sum of the results obtained for the soil loss and the plant loss.

These impurities were separated into two categories (stem and bark) and the weights were noted to measure the amount of contaminants present on the fiber. Prior to manual separation of the impurities, the total sample was weighed. The weight of impurities in the fiber, and the weight of the total sample were obtained as a

(A) (B) (C)

Figure 1. Harvester (A) harvesting unit (B) and adjustment of the nip pressure plate (C).

percentage of branches and bark determined in relation to the total weight of the sample (Figure 1).

In determining the travel speed, a distance of 50 m was demarcated. The time taken to walk the distance was monitored. Three repetitions were performed resulting in the average length of machine traveled.

The efficiency of the harvester was determined in accordance with Rodriguez (1977) as per the following Equation (1):

$$\text{Picker efficiency} = \frac{100 \times \text{harvested cotton}}{\text{harvested cotton} + \text{post harvest losses}} \quad (1)$$

All results obtained in the experiment were subjected to analysis of variance by the F test. When significant, the Tukey test at 5% probability was performed using ASSISTAT software (Silva and Azevedo, 2014).

RESULTS AND DISCUSSION

The results presented in Table 1 demonstrate that irrespective of the working speed, the cotton harvested by a harvester without a pressure plate had lesser amount of cargo hulls. The shell contents without the pressure plates ranged from 2.01 to 2.29% and the shell contents with pressure plates ranged from 3.28 to 2.93%. These results were in agreement with the increased presence of impurities due to clamping plates noted by Belot and Vilela (2006) and Willcutt et al. (2006).

These results also indicated the presence of bark similar to that obtained by Faulkner et al. (2011) and Sui et al. (2010) with values ranging between 1 and 4% for harvesters using a picker system. Sui et al. (2010) state that the separation and the cleaning process of the cotton fibers needs to be more aggressive as increasing the peel can contribute to increasing the amount of short fibers in the samples.

The low pressure on the board and the increased speed decreased the amount of bark in the cotton fiber by approximately 29.39, 38.71 and 21.81% for the three velocities, respectively when compared to the values with the pressure plates. According to Bragg et al. (1995) increased bark concentrations did not significantly reduce the quality, but the number of yarn breaks during spinning increased by about 66% for each percent increase in bark content.

Table 2 shows the percentage of stems present in the cotton fiber. This percentage demonstrates that the interaction between the pressure plates and travel speeds was not significant. The interaction demonstrated that the unfolding of the pressure plates contributed to increasing the amount of stems present in the cotton samples. An important function of the pressure plate is to

Table 1. Average barks (%) based on the pressure plates and the travel speed (m s^{-1}).

Pressure plates	Velocity (m.s^{-1})		
	1.02	1.38	1.60
Plates without pressure	2.21^{aA}	2.01^{aA}	2.29^{aA}
Plates with pressure	3.13^{bA}	3.28^{bA}	2.93^{bA}

The averages followed by the same letter did not show statistically significant differences for the Tukey test at 5% probability.

Table 2. Average stem (%) present in the basket of the combined samples with and without pressure plates as a function of the velocities (m s^{-1}).

Treatments	Average
Plates without pressure	0.51^{b}
Plates with pressure	0.65^{a}
Velocity (m.s^{-1})	**Average**
1.02	0.56
1.38	0.60
1.60	0.59

The averages followed by the same letter did not show statistically significant differences for the Tukey test at 5% probability.

Table 3. The efficiency of the cotton harvester (%) with and without pressure on the plate and as a function of the velocities (m.s^{-1}).

Treatments	Average
Plates without pressure	89.18[b]
Plates with pressure	92.96[a]
Velocity (m.s^{-1})	**Average**
1.02	90.90
1.38	91.41
1.60	90.89

The averages followed by the same letter do not show statistically significant differences for the Tukey test at 5% probability.

press the capsule cotton from the spindles. This contributes to the increased presence of branches in the cotton load.

The values ranged from 0.51 to 0.65% for the boards with pressure and without pressure, respectively. The plates with pressure contributed to a 21.5% increase in the amount of stalks in the harvested fiber. Table 3 shows the associated travel speed data for the presence of stem variable. It was observed that regardless of the displacement speed, there were no differences in the amount of cotton in the stem load.

The average values of the cotton picker efficiency shown in Table 3, demonstrate that the tightening of the pressure plates increased the harvest efficiency (92.96%) compared to the values with no pressure plates (89.18%). In this case, the increase in harvest efficiency was approximately 4.06%. These results were consistent with Belot and Vilela (2006) who concluded that the tightening of the pressure plates of the bodies of procurement units increased the harvesting efficiency.

It is important to note that the values found relating to the performance of the harvester are above those accepted by manufacturers that specify a 95% limit for the efficiency of platforms with rotating spindle units. Corroborating this, Öz et al. (2011) evaluated different spacing and varieties. They observed that losses in cotton harvesting should not exceed the 5% limit. Bassini (2014) reported that the collection efficiency varied with plant height, seed and lint moisture, density, and plant productivity. The author also commented that regardless of these variables, the harvesting efficiency should exceed 95%, in order to justify the high costs of cotton harvesting borne by farmers.

The results of cotton losses due to the variation in the speeds are shown in Table 3. The harvesting efficiency values are below those recommended by the machine manufacturers (98%). This demonstrates the need for the farmer to pay attention to the management of cultures that can influence the efficiency. Regardless of the speed, these values are close to those specified by Vieira et al. (2001) where ideal losses are cited as between 6 and 8%. However, we have to ensure that these losses do not exceed 5%.

Table 4. Average results of HVI elongation, strength, short fiber index, trash, uniformity, micronaire, reflectance, color and length.

Pressure plates	Velocity (ms^{-1})		
	1.02	1.38	1.60
Elongation (%)			
Plates without pressure	7.63	7.25	7.48
Plates with pressure	7.43	7.23	7.53
Strength (gf/tex)			
Plates without pressure	30.93	30.45	30.35
Plates with pressure	29.15	30.18	30.75
Short fiber index (%)			
Plates without pressure	8.65	7.53	7.83
Plates with pressure	9.03	8.45	8.30
Trash (%)			
Plates without pressure	6.75	7.50	7.00
Plates with pressure	6.50	5.75	7.00
Uniformity (%)			
Plates without pressure	81.28	82.35	81.78
Plates with pressure	81.03	81.56	81.75
Micron air (µg/in)			
Plates without pressure	4.04	4.05	3.91
Plates with pressure	4.07	4.06	4.09
Reflectance			
Plates without pressure	73.08	72.30	73.60
Plates with pressure	71.68	72.83	71.93
+b			
Plates without pressure	8.35	7.95	8.38
Plates with pressure	8.33	8.53	8.28
Length (mm)			
Plates without pressure	29.08	29.27	28.26
Plates with pressure	28.45	29.08	29.45

The averages followed by the same letter do not show statistically significant differences for the Tukey test at 5% probability. *plates without pressure – (distance 6 mm). **plates with pressure – (distance 3 mm).

For the analysis of fiber quality for each treatment, the average of HVI results are shown in Table 4. It can be observed that the variation of the pressure plate velocities and the interaction between them was not statistically significant for all the variables. However, as this factor can vary based on the year, varieties, harvest season, defoliation, type harvester, and environment, it should be noted that these differences may be noticed in years with adverse conditions. This was noted by Kerby et al. (1986) by using different harvesting systems.

Willcutt et al. (2002) also analyzed several factors inherent in the presence of trash and samples. In a similar vein, Faulkner et al. (2008) compared three different crop systems.

Bragg et al. (1995) found that elevated concentrations peels did not significantly reduce the quality of the yarn produced with an early spinning rotor structure. However, they find that the number of yarn breaks during spinning increased to approximately 66% for each percent increase in bark content.

Conclusion

The increased distance between the spindles and the pressure plates reduced the quantity of the shells during independent cotton harvest picking speed. Thus, it was important to reduce the aggression fibers at the time of ginning, and to reduce the use of electricity to remove the impurities in the cotton. The distance between the spindles and lower plates reduced the amount of stems in the cotton. The shortest distance between the spindles and the plates exerted a higher pressure. This is because there was a reduction in the area that the cotton mass must flow to. Hence, the losses due to the contact between the spindle and the boll were lower. The quality of the fibers was not affected by the change in velocities and the distance between the spindles and the plates.

Conflict of Interests

The authors have not declared any conflict of interests.

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