2006 Beltwide Cotton Conferences, San Antonio, Texas - January 3 - 6, 2006

SPINDLE DESIGN EFFECTS ON COTTON QUALITY

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Abstract

Three cotton varieties were grown under furrow-irrigated conditions in southern New Mexico and hand-harvested in a way that kept individual bolls intact. The cotton bolls were conditioned in a controlled atmosphere and then subjected to a single cotton picker spindle operating at a speed of 1000 - 3000 rpm. Two spindle designs were studied, a ½" round, tapered, barbed spindle and a 3/16" square spindle that was straight and smooth. Mass measurements were taken to determine the portion of seed cotton not picked and the portion that would fly off and not stick to the spindle. A force gage was used to determine the peak force that was needed to pull the seed cotton from the spindle. Moisture content of the bolls was 9 to 10 % d.b. Results showed that the smaller, straight spindle was more aggressive in removing cotton from the boll. There was approximately twice as much flyoff from the barbed spindle than from the smaller straight spindle at any given speed. Flyoff also increased exponentially for each spindle type as the speed was increased for both spindle types. The peak force required to remove the seed cotton from the spindle ranged from 50 to 100 % more for the smaller straight spindle than from the barbed spindle. For both spindles, the peak force requirement was approximately doubled each time the speed was increased by 1000 rpm, indicating an exponential relationship between speed and wrap tightness.

Introduction

Spindle picking of cotton was developed in the 1940's as a means to speed up and reduce the cost of harvest. Prior to this, all cotton was hand-harvested. Over time, spindle picking has become the preferred method of harvesting most cotton in the U.S. Improvements to spindle pickers over the years have primarily focused on increasing the number of rows that can be harvested with 1 pass of the machine from 1 row to up to 6 rows; as well as increasing the travel speed of the harvester from around 1.5 to up to 4 miles per hour.

Improvements to the cotton harvester have primarily focused on increased capacity in order to reduce the cost of harvesting. As cotton harvesters have gotten bigger and faster, spindle speeds have increased. As the speed has increased, cotton fibers can wrap more tightly around the spindle. Spindle sizes have also decreased in both diameter and length in order to reduce the weight of the picker head. As spindle diameter decreases, cotton fibers will wrap around the spindle more and become tighter on the spindle. As spindle length decreases, cotton plants must be further compressed as they pass through the picking zone. These changes have resulted in a general decrease in cotton fiber quality, particularly regarding spindle twists, preparation, and neps (Hughs, et al. 2000).

Spindle pickers require meticulous adjustment in order to minimize harvest losses and to maximize fiber quality (Williford et al, 1994). Avoiding the harvest of high moisture cotton is another requirement to minimize harvest losses and to maximize fiber quality (Mayfield et al, 1998). Deviations from these highly recommended practices will result in significant quality degradation and increased harvest losses, both of which can cost the grower.

Objective

The objective of this study was:

- To compare fiber quality, harvest losses, and trash content of three varieties of spindle-picked cotton using three machine/speed harvest combinations.

Materials and Methods

Three varieties of cotton were grown during the 2003 growing season at the Leyendecker Plant Science Research Center, Las Cruces, New Mexico. The three cotton varieties grown were: Delta Pine 90B, a conventional upland cotton; Acala 1517-99, an upland cotton with enhanced staple length; and Pima S7, a conventional Pima cotton. All cotton was grown on ridged 40 inch rows using customary tillage practices and furrow irrigated as needed during the growing season. Chemical herbicides and insecticides were applied as needed and in accordance to customary practice for the growing region. In preparation for harvest, a chemical defoliant was applied to the cotton. 1000 bolls of each variety were hand harvested 10 days after defoliation. To harvest the cotton, entire stalks were selected at random from the plot and cut. All open bolls were harvested from each selected plant by cutting each individual boll (intact with the hull and a short section of the stem) with pruning shears. The process was repeated until the required number of bolls was obtained.

The cut bolls were laid out in a laboratory and allowed to dry thoroughly. Just prior to conducting the test, individual bolls of three cotton varieties were conditioned at 70^{o}F and 65% r.h. for 1 week, allowing them to reach equilibrium by adsorption. Foreign material (primarily leaf particles) from bolls was manually cleaned after conditioning and before testing. Then the cotton bolls were subjected to a single cotton picker spindle operating at a speed of 1000, 2000, or 3000 rpm. Two spindle designs were studied, a ½" round, tapered, barbed spindle and a 3/16" square spindle that was straight and smooth. The spindle was wetted with a soap water solution after the speed was set. The boll was presented to the spindle straight on and the power to the spindle was disconnected immediately after the boll was subjected to the spindle. Mass measurements were taken to determine the portion of seed cotton not picked and the portion that would fly off and not stick to the spindle. A force gage was used to determine the peak force that was needed to pull the seed cotton from the spindle (Figure 1).

Figure 1. Pulling the cotton from the spindle using a force gage which records the peak force.

Eight bolls of each variety for each spindle type at each speed were done in a block of time. Four replications of the eight bolls were conducted in a blocked experimental design. Spindle type and speed were randomly varied within each replication block. Seed cotton of additional bolls was used for moisture determination using the air oven method. Each set of eight bolls were combined into a single sample. The samples will be ginned on a breeder-style gin and submitted for AFIS analysis. Sample size is too small for an HVI classification, and an HVI classification would likely show no differences among treatments.

Results and Discussion

Moisture contents were determined using an air oven method. Average moisture content of the varieties that were conditioned at 70^{o}F and 65% r.h. was 9.8 % d.b. for Delta Pine 90B, 8.8 % for Acala 1517-99, and 9.8 % for Pima S7.

Results (Table 1) showed that the smaller, straight spindle was more aggressive in removing cotton from the boll. It is suspected that this is because the barbs on the tapered spindle act as small fans and create air currents that detract from their ability to pick the cotton. Because of these air currents there was approximately twice as much flyoff from the barbed spindle than from the smaller straight spindle. It should be noted that the air systems on cotton pickers would gather any seed cotton that does not stick to the spindle, so the flyoff is not a loss. Flyoff also increased exponentially for each spindle type as the speed was increased.

The peak force required to remove the seed cotton from the spindle ranged from 50 to 100 % more for the smaller straight spindle than from the barbed spindle. The smaller distance around the spindle allows more wrap of the fibers and thus the greater force for them to be removed. For both spindles, the peak force requirement was approximately doubled each time the speed was increased by 1000 rpm, indicating an exponential relationship between speed and wrap tightness.

Table 1. Performance data for the 2005 laboratory study.

Variety	Spindle	Speed, rpm	Moisture (% d.b.)	Unpicked %	Flyoff (%)	Force (lb)
Delta & Pine Land 565	½” t.b.	1000	9.8	3.5	1.8	.30
		2000		.5	19.6	.92
		3000		.25	50.4	1.87
	3/16” str.	1000		.1	2.6	.81
		2000		0	11.8	1.86
		3000		0	25.4	3.60
ACALA 1517-99	½” t.b.	1000	8.8	2.75	3.8	.50
		2000		1.1	23.8	1.17
		3000		.15	57.2	2.26
	3/16” str.	1000		.35	.4	.78
		2000		0	10.2	1.77
		3000		0	34.2	3.21
Pima S7	½” t.b.	1000	9.8	.15	6.4	.62
		2000		0	26.1	1.52
		3000		0	43.6	2.47
	3/16” str.	1000		0	2.2	1.42
		2000		0	17.8	2.29
		3000		0	26.7	4.31

Summary

Spindle picking of cotton was developed in the 1940's as a means to speed up and reduce the cost of harvest. Improvements to spindle pickers over the years have primarily focused on increasing the number of rows that can be harvested with 1 pass of the machine from 1 row to up to 6 rows; as well as increasing the travel speed of the harvester from around 1.5 to up to 4 miles per hour. As cotton harvesters have gotten bigger and faster, spindle speeds have increased. As the speed has increased, cotton fibers can wrap more tightly around the spindle. Spindle sizes have also decreased in both diameter and length in order to reduce the weight of the picker head. As spindle diameter decreases, cotton fibers will wrap around the spindle more and become tighter on the spindle. As spindle length decreases, cotton plants must be further compressed as they pass through the picking zone. These changes have resulted in a general decrease in cotton fiber quality, particularly regarding spindle twists, preparation, and neps.

Three cotton varieties were grown under furrow-irrigated conditions in southern New Mexico and hand-harvested in a way that kept individual bolls intact. The cotton bolls were conditioned in a controlled atmosphere of 70 ^{o}F and 65 % r.h. for 1 week, attaining a moisture content of 9 to 10 % d.b. Leaf particles were manually cleaned from the bolls, then they were subjected to a single cotton picker spindle operating at a speed of 1000, 2000, or 3000 rpm. Two spindle designs were studied, a ½" round, tapered, barbed spindle and a 3/16" square spindle that was straight and smooth. Mass measurements were taken to determine the portion of seed cotton not picked and the portion that would fly off and not stick to the spindle. A force gage was used to determine the peak force that was needed to pull the seed cotton from the spindle.

Results showed that the smaller, straight spindle was more aggressive in removing cotton from the boll. It is suspected that this is because the barbs on the tapered spindle act as small fans and create air currents that detract from their ability to pick the cotton. Because of these air currents there was approximately twice as much flyoff from the barbed spindle than from the smaller straight spindle. Flyoff also increased exponentially for each spindle type as the speed was increased.

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Acknowledgements

The financial support of Cotton, Incorporated, Cary, North Carolina, for this project is greatly appreciated.