HARVEST TIMING AND TECHNIQUES TO OPTIMIZE FIBER QUALITY IN THE TEXAS HIGH PLAINS

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Abstract

Production conditions typical to the Texas High Plains region can produce cotton crops with high short fiber and nep content, both of which have a detrimental impact on ring spinning performance. Since Texas now produces nearly 50% of the US cotton crop annually, it is critical that research focuses on finding ways to maximize fiber quality in order to improve the competitiveness of US cotton on the world market. In 2009 and 2010, a joint project was conducted between research personnel from USDA - ARS and the Texas AgriLife Extension Service in Lubbock to compare various harvest timings and techniques. The objectives of this work were to 1) investigate differences in fiber quality and maturity of cotton harvested using conventional equipment (e.g. a spindle picker and a brush-roll stripper with field cleaner) at different levels of final crop maturity, and 2) evaluate the economic feasibility of using these new harvesting techniques in irrigated cotton. Treatments containing a stripper component had higher bur cotton yields, and therefore higher ginning costs, than those with picker components only. In 2009, no significant differences were observed among treatments for lint yield. However, in 2010, the pick then strip and the conventional strip treatments resulted in higher lint yield than the pick then pick treatment. After subtracting harvest aid, ginning and harvest costs, net value for the pick then pick treatment was significantly lower than all other treatments in 2010 but not in 2009. This was attributed to lower lint yield, lower loan values, and higher harvest costs. Loan values were observed to be affected more by harvest timing than by harvest machinery. Micronaire values were higher for the initial harvesting events than for the sequential or conventional harvest events in 2009 and 2010. The higher micronaire values resulted in lower loan values due to not being in the premium range of 3.7 to 4.2. Loan values can also be negatively influenced by higher color grades due to lint staining from the initial green picker harvest event if ginning is not performed within a relatively short period of time, as was observed in 2009. Based on these results, either conventional picker harvesting or conventional stripper harvesting may be employed for optimum yield and quality as opposed to green picked followed by picker harvesting. More research is needed to determine the benefit, if any, of the green pick harvest event in low micronaire situations.

Introduction

Cotton produced in the Texas High Plains has exhibited substantial improvements in terms of yield and fiber quality over the last decade. These improvements are due primarily to new cultivars and improved irrigation practices. However, cotton produced in the region continues to receive larger price discounts from buyers compared to cotton of equal grade and classification produced in other areas of the US. Foreign mills attribute inferior ring spinning performance of west Texas cotton to increased levels of neps and short fibers, both of which are not reported in fiber testing results from the USDA Agricultural Marketing Service using the high volume instrument (HVI) classification system.

The amount of neps and short fiber contained in ginned lint is influenced by many factors including: variety, fiber maturity, harvest method, and ginning practice. Inclement weather, periods of excessive soil moisture from rainfall or irrigation, and limited heat unit accumulation (< 2500 dd60's) are production conditions experienced on the High Plains that tend to produce immature fiber with low micronaire (MIC). Cotton harvest is traditionally accomplished using brush-roll strippers that indiscriminately harvest seed cotton from bolls regardless of physiological maturity. Consequently, MIC for stripper harvested cotton has been shown to be reduced by 0.3 units compared to spindle picker harvested cotton of the same variety (Faulkner et al., 2009). Spindle pickers employ a selective harvesting mechanism which harvests seed cotton only from open bolls, leaving seed cotton in less-open/less mature bolls. Moreover, aggressive ginning practices that expose seed cotton to excessive mechanical action tend to break fibers and cause fiber entanglements (i.e. neps) (Anthony et al., 1986).

Objective

The goal of this work is to improve fiber quality and value of cotton produced in the Texas High Plains through new harvesting techniques utilizing conventional harvesting equipment applied at various stages of final crop maturity. The specific objectives are:

- Investigate differences in fiber quality and maturity of cotton harvested using conventional equipment (e.g. a spindle picker and a brush-roll stripper with field cleaner) at different levels of final crop maturity, and
- Evaluate the economic feasibility of using these new harvesting techniques on irrigated cotton.

Materials and Methods

One variety of cotton, FiberMax 9180 B2F, was grown in a sub-surface drip irrigated field at the USDA - ARS Plant Stress Lab in Lubbock, TX. The crop was planted to 40 inch row spacing with drip lines under each row on 6-May, 2009 and on 19-May, 2010. Seeding rates of 5 seed/row-ft (65,000 seed/acre) and 4.1 seed/row-ft (54,000 seed/acre) were used in 2009 and 2010, respectively. Subsequent plant stand counts indicated average populations of 4.2 plants/row-ft (55,500 plants/acre) in 2009 and 4.2 plants/row-ft (54,885 plants/acre) in 2010. By plot soil sampling was conducted in both years prior to planting to a depth of 24 inches to determine residual fertility levels. Accounting for residual N, supplemental N was applied through the irrigation system to achieve a yield goal of 4 bales/acre (Hons et al., 2004). No supplemental phosphorous, potassium, or micronutrients were applied. In 2009 early season irrigation was conducted by an automated irrigation controller at a rate of 0.2 acre-in/day. However, cut-out (defined as < 4 nodes above white flower) was observed earlier than expected on 28-Jul, 2009 due to heat stress and daily irrigation was increased to 0.31 acre-in/day to help retain fruit load. Total irrigation amount was 17.5 acre-in with an additional 5.9 acre-in from rainfall. Total irrigation amount in 2010 was 10.5 acre-in (0.24 acre-in/day) with 16.1 acre-in supplemental rainfall for a total of 26.6 acre-in of moisture from 1-May to first harvest event on 20-Oct.

Harvesting treatments evaluated in the study consisted of applying a conventional six-row cotton picker (John Deere model 9996) and a conventional six-row brush-roll stripper with field cleaner (John Deere model 7445) in various sequences at different levels of final crop maturity. Treatments are included in table 1. Finish 6 Pro was applied at 24 and 30 oz/acre in 2009 and 2010, respectively with Ginstar at 8 oz/acre over all plots to defoliate the crop and open bolls subsequent to the initial picking event for the pick then pick and pick then strip treatments. Following the second picking event for the pick then pick treatment and once over picking for the conventional pick treatment, Gramoxone Inteon was applied at 32 oz/acre (in 2010, 1 oz/acre Aim 2EC was included as a tank mix) to the remaining plots to desiccate the crop for stripper harvesting.

Table 1. Treatment descriptions.

Treatment Description	
Treatment #1 - Pick then Pick	Picker harvest (~80% OB in 2009 and 50% OB in 2010) prior to application of crop harvest-aid chemicals followed by a second picking (~100% open bolls) after crop defoliation
Treatment #2 - Pick then Strip	Picker harvest (~80% OB in 2009 and 50% OB in 2010) prior to application of crop harvest-aid chemicals followed by stripper harvesting (~100% open bolls) after defoliation and desiccation
Treatment #3 - Conventional Pick	Once over picker harvest (~100% open bolls) after crop defoliation
Treatment #4 - Conventional Strip	Once over stripper harvest (~100% open bolls) after crop defoliation and desiccation

The field was sub-divided into four blocks to which each treatment was randomly applied once (tables 2 and 3). The blocks, serving as replications, each contained four 6-row plots (24 rows/block). Statistical analyses were performed according to a randomized complete block design with field reps serving as blocks. Statistical analysis was conducted using the General Linear Model procedure in SAS (SAS v. 9.1, SAS Institute, Cary, NC). Differences were determined using Fisher's Protected LSD method.

Table 2. Field layout and treatment assignment for 2009.

Replication #	Treatment Assignment	Plot #
Rep 1	Treatment #3 - Conventional Pick	1
	Treatment #4 - Conventional Strip	2
	Treatment #1 - Pick then Pick	3
	Treatment #2 - Pick then Strip	4
Rep 2	Treatment #2 - Pick then Strip	5
	Treatment #4 - Conventional Strip	6
	Treatment #3 - Conventional Pick	7
	Treatment #1 - Pick then Pick	8
Rep 3	Treatment #2 - Pick then Strip	9
	Treatment #3 - Conventional Pick	10
	Treatment #1 - Pick then Pick	11
	Treatment #4 - Conventional Strip	12
Rep 4	Treatment #2 - Pick then Strip	13
	Treatment #1 - Pick then Pick	14
	Treatment #4 - Conventional Strip	15
	Treatment #3 - Conventional Pick	16

Table 3. Field layout and treatment assignment for 2010.

Replication #	Treatment Assignment	Plot #
Rep 1	Treatment #2 - Pick then Strip	1
	Treatment #3 - Conventional Pick	2
	Treatment #4 - Conventional Strip	3
	Treatment #1 - Pick then Pick	4
Rep 2	Treatment #3 - Conventional Pick	5
	Treatment #2 - Pick then Strip	6
	Treatment #1 - Pick then Pick	7
	Treatment #4 - Conventional Strip	8
Rep 3	Treatment #1 - Pick then Pick	9
	Treatment #3 - Conventional Pick	10
	Treatment #2 - Pick then Strip	11
	Treatment #4 - Conventional Strip	12
Rep 4	Treatment #4 - Conventional Strip	13
	Treatment #1 - Pick then Pick	14
	Treatment #3 - Conventional Pick	15
	Treatment #2 - Pick then Strip	16

After each plot was machine harvested, the bur or seed cotton was weighed in a weigh wagon with integral digital scale system. A 250 lb sample was subsequently collected for ginning at the USDA – ARS Cotton Production and Processing Research Unit in Lubbock, TX. Each bur or seed cotton sample was weighed and processed through commercial scale ginning equipment. Lint samples were collected after the second stage lint cleaner and sent for HVI and advanced fiber information system (AFIS) fiber analysis at the Texas Tech University Fiber and Biopolymer Research Institute in Lubbock, TX. Commodity Credit Corporation (CCC) loan values for the fiber samples from both years were calculated according to the 2010 loan chart using HVI fiber classification results. Total lint and seed weights were recorded for each sample and used to calculate lint and seed turnout values.

Lint values were calculated by multiplying the lint yield by the loan values, seed values were calculated using $175.00/ton, and ginning costs were calculated using $3.00/100 lbs seed/bur cotton. Net values were determined by subtracting harvest aid, ginning and harvesting costs from the total value (lint value plus seed value). Harvest costs were calculated using $0.08 lb/lint for custom stripper harvest and $0.10 lb/lint for custom picker harvest.

Results and Discussion

Total bur cotton, lint and seed yields and resulting economic parameters for 2009 are shown by harvest treatment in table 4. Significant differences were observed among treatments for bur cotton yield, ginning costs and harvest costs only. For total bur and seed cotton yield and subsequent ginning costs, the conventional picker treatment was significantly lower than all other treatments. Furthermore, harvest costs were significantly greater for the conventional picker and the picker followed by picker harvest treatments than the two treatments containing a stripper harvesting component. Lint yield averaged 1644 lbs/acre and ranged from a high of 1685 for the pick then pick treatment to a low of 1611 for the pick the strip treatment. However this difference was not significant. After adding lint and seed values and subtracting harvest aid, ginning and harvest costs, the net values ($/acre) were not significantly different. Net values ranged from a high of $856.81/acre for the conventional pick treatment to a low of $781.56/acre for the pick then strip treatment.

Table 4. Yield and economic results for 2009.

Treatment	Bur cotton yield	Lint yield	Seed yield	Lint value	Seed value	Total value	Harvest aid cost	Ginning cost	Harvest cost	Net value
	---- lb/acre	----	----	----	----	---- $/acre	----	----	----	----
Conventional Pick	5227	1652	2957	949.05	258.75	1207.80	29.00	156.80	165.18	856.81
Pick then Pick	5816	1685	3158	920.69	276.32	1197.01	29.00	174.47	168.50	825.05
Pick then Strip	6140	1611	3203	881.28	280.27	1161.55	43.89	184.20	151.90	781.56
Conventional Strip	6039	1627	3002	924.71	262.67	1187.38	43.89	181.15	130.19	832.16
Test average	5805	1644	3080	918.93	269.50	1188.43	36.45	174.16	153.94	823.89
CV, %	5.7	4.8	6.9	4.5	6.9	4.9	--	5.7	4.8	5.1
OSL	0.0154	0.5914	0.3444	0.2118	0.3443	0.7184	--	0.0154	0.0002	0.1550
LSD	532	NS	NS	NS	NS	NS	--	15.95	11.71	NS

For net value/acre, means within a column with the same letter are not significantly different at the 0.05 probability level.
CV - coefficient of variation.
OSL - observed significance level, or probability of a greater F value.
LSD - least significant difference at the 0.05 level, NS - not significant.
Note: some columns may not add up due to rounding error.

Significant differences were observed among treatments for all yield and economic parameters measured in 2010 (table 5.) Bur or seed cotton yield averaged 4505 lb/acre for the pick then strip treatment which was significantly greater than the pick then pick treatment (4223 lb/acre) and the conventional pick treatment (3857 lb/acre) but not the conventional strip treatment (4444 lb/acre). Lint yield was significantly greater for the pick then strip treatment (1225 lb/acre) than for the pick then pick treatment (1131 lb/acre) only. After adding lint and seed values, total values ($/acre) ranged from a high of $896.79/acre for the conventional strip treatment to a low of $815.47/acre for the pick then pick treatment. When subtracting harvest aid, ginning and harvesting costs from the total value, net value for the conventional strip treatment was significantly greater than the pick then pick treatment but not the conventional pick or the pick then strip treatments.

Table 5. Yield and economic results for 2010.

Entry	Bur cotton yield	Lint yield	Seed yield	Lint value	Seed value	Total value	Harvest aid cost	Ginning cost	Harvest cost	Net value
	----------------- lb/acre	-----------------		---------- $/acre						----------
Conventional Strip	4444	1220	2268	698.36	198.43	896.79	45.82	133.31	97.56	620.10 a
Conventional Pick	3857	1185	2092	677.77	183.02	860.80	28.98	115.71	118.51	597.59 a
Pick then Strip	4505	1225	2176	690.77	190.43	881.20	45.82	135.17	122.48	594.57 a
Pick then Pick	4223	1131	2059	635.36	180.12	815.47	28.98	126.69	106.70	536.27 b
Test average	4257	1190	2149	675.56	188.00	863.56	37.40	127.72	111.31	587.13
CV, %	2.5	3.5	4.9	4.2	4.9	4.2	--	2.5	3.5	5.3
OSL	<0.0001	0.0402	0.0774†	0.0486	0.0779†	0.0510†	--	<0.0001	<0.0001	0.0214
LSD	169	67	136	45.50	11.93	46.75	--	5.06	6.30	49.36

For net value/acre, means within a column with the same letter are not significantly different at the 0.05 probability level.
CV - coefficient of variation.
OSL - observed significance level, or probability of a greater F value.
LSD - least significant difference at the 0.05 level, †indicates significance at the 0.10 level.
Note: some columns may not add up due to rounding error.

HVI fiber quality analysis results for lint samples collected after two stages of lint cleaning are presented in table 6 for 2009 and in table 7 for 2010. In general, the initial harvest events for the pick then pick and pick then strip treatments resulted in higher micronaire than the conventional pick, conventional strip and the sequential harvest events for the pick then pick and pick then strip treatments for both years. Furthermore, in 2009 and 2010, picker harvest events tended to have higher staple values than stripper harvesting. The same was true for uniformity in both years. Differences in strength values were observed among treatments for both years, however, those differences were small (1.2 g/tex in 2009 and 1.8 g/tex in 2010) and did not contribute to lower loan values. Color grades were mostly 21 and 31 in 2009 and mostly 11 and 21 in 2010. Loan values tended to be lower for the initial harvest events for the pick then pick and pick then strip treatments in 2009 and 2010. These differences were attributed to higher micronaire values which were not in the premium range.

Table 6. HVI and loan values for 2009.

Entry	Micronaire	Staple	Uniformity	Strength	Rd	+b	Color grade		Loan
	units	32^{nds} inches	%	g/tex	reflectance	yellowness	color 1	color 2	$/lb lint
Conventional Pick	4.3 b	38.6 a	82.8 a	32.5 a	82.0 a	7.5 b	2.3	1.0	0.5736 a
Conventional Strip	4.2 bc	37.6 c	81.6 b	31.6 bc	81.6 a	6.7 c	3.0	1.0	0.5673 a
Pick then Pick - Initial	4.5 a	38.5 a	82.7 a	31.3 c	74.8 c	10.1 a	3.0	2.0	0.5360 c
Pick then Pick - Sequential	4.1 cd	38.2 ab	82.0 b	32.1 ab	81.1 a	7.4 b	2.8	1.0	0.5701 a
Pick then Strip - Initial	4.4 a	38.6 a	82.9 a	32.0 abc	75.5 c	10.1 a	2.5	2.0	0.5450 bc
Pick then Strip - Sequential	4.1 d	37.8 bc	81.7 b	31.8 abc	79.0 b	6.7 c	3.8	1.0	0.5496 b
Test average	4.3	38.2	82.3	31.9	79.0	8.1	2.9	1.3	0.5569
CV, %	1.6	0.8	0.5	1.4	0.8	2.2	--	--	1.2
OSL	<0.0001	0.0017	0.0012	0.0345	<0.0001	<0.0001	--	--	<0.0001
LSD	0.1	0.5	0.6	0.7	0.9	0.3	--	--	0.0097

CV - coefficient of variation.
OSL - observed significance level, or probability of a greater F value.
LSD - least significant difference at the 0.05 level, NS - not significant.

Table 7. HVI and loan values for 2010.

Entry	Micronaire	Staple	Uniformity	Strength	Rd	+b	Color grade		Loan
	units	32nds inches	%	g/tex	reflectance	yellowness	color 1	color 2	$/lb lint
Conventional Pick	4.3 b	37.9 ab	82.0 bc	30.3 ab	80.2 b	8.5 b	2.0	1.0	0.5719 a
Conventional Strip	4.3 b	37.7 b	81.9 c	30.4 a	81.6 a	8.4 b	1.5	1.0	0.5728 a
Pick then Pick - Initial	4.6 a	38.3 a	82.6 a	29.8 bc	78.7 d	10.2 a	1.3	1.8	0.5573 b
Pick then Pick - Sequential	3.9 c	38.1 a	81.4 d	30.0 abc	79.8 bc	8.6 b	2.0	1.0	0.5725 a
Pick then Strip - Initial	4.6 a	37.9 ab	82.4 ab	29.6 c	79.1 cd	10.0 a	1.3	1.5	0.5608 b
Pick then Strip - Sequential	3.7 c	37.6 b	81.3 d	29.9 bc	80.0 b	8.7 b	2.0	1.0	0.5714 a
Test average	4.2	37.9	81.9	30.0	79.9	9.1	1.7	1.2	0.5678
CV, %	2.6	0.9	0.4	1.0	0.7	3.7	--	--	1.2
OSL	<0.0001	0.0876†	<0.0001	0.0254	<0.0001	<0.0001	--	--	0.0147
LSD	0.2	0.4	0.5	0.5	0.8	0.5	--	--	0.0102

CV - coefficient of variation.
OSL - observed significance level, or probability of a greater F value.
LSD - least significant difference at the 0.05 level, †indicates significance at the 0.10 level, NS - not significant.

Conclusions

As was expected, the treatments containing a stripper component had higher bur cotton yields, and therefore higher ginning costs, than those with picker components only. In 2009, no significant differences were observed among treatments for lint yield. However, in 2010, the pick then strip and the conventional strip treatments resulted in higher lint yield than the pick then pick treatment. After subtracting harvest aid, ginning and harvest costs, net value ($/acre) for the pick then pick treatment was significantly lower than all other treatments in 2010 but not in 2009. This was attributed to lower lint yield, lower loan values (initial harvest event), and higher harvest costs. Loan values were observed to be affected more by harvest timing (initial vs. sequential/conventional) than by harvest machinery (picker vs. stripper). Micronaire values were higher for the initial harvesting events than for the sequential or conventional harvest events. In low micronaire years, this may be beneficial but in 2009 and 2010 the higher micronaire resulted in lower loan values due to being outside the premium range of 3.7 to 4.2. Loan values can also be negatively influenced by higher color grades due to lint staining from the initial harvest (green pick) event if ginning is not performed within a short period of time, as was observed in 2009. Based on these results, either conventional picker harvesting or conventional stripper harvesting may be employed for optimum yield and quality as opposed to green picker followed by picker harvesting. More research is needed to determine the benefit, if any, of the green pick harvest event in low micronaire situations.

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