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AGRONOMY AND SOILS

An Evaluation of Alternative Cotton Harvesting Methods in Northeast Louisiana – A Comparison of the Brush Stripper and Spindle Harvester

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ABSTRACT

In response to increases in cotton production costs, producers are seeking ways to reduce input expenses. Because brush strippers are less expensive to operate than spindle harvesters, research was performed to compare the efficiency of a brush stripper harvester to a spindle harvester. Yield and high volume instrumentation (HVI) data were analyzed from paired comparisons of stripper- and spindle-harvested plots to examine the economics associated with each harvesting system. Additionally, advanced fiber information system (AFIS) analysis was performed on lint to further examine fiber properties associated with cotton from both harvesting methods. Weights of harvested material (seed cotton plus trash) were higher in plots harvested with a brush stripper, but gin turnout was lower. In 2000, lint yields were not significantly different, but in 2001 lint yields were significantly higher in stripper-harvested plots at two of four locations. Trends in HVI data displayed decreased micronaire values and increased color grade values in stripper-harvested plots. Both changes were likely a result of the greater efficiency of the stripper in harvesting bolls that had been partially rotted and/or "hard-locked". Factoring yield data, HVI data, and reductions in input costs, stripping significantly increased overall dollar value per hectare at two locations and numerically increased revenue at one of the two remaining locations in 2001. Based on AFIS analyses, increased foreign matter, neps immature fibers, and short fibers, which are negative fiber characteristics, were recorded in the stripper-harvested cotton. Because these fiber characteristics can lead to discounting and even rejection of cotton at the mills, a better understanding of the cost and benefits of brush stripper harvesting are needed.

Consistent increases in cotton production costs have caused cotton producers in Northeast Louisiana to either shift acreage to crops requiring fewer input costs or to seek means of reducing cotton production input costs. Harvest machinery is a significant expense in cotton production, and there has been recent interest in examining brush stripper harvesters as an alternative to spindle harvesters. Yield and quality of lint both impact producer profitability and must be examined with changes in technology, so an economic comparison of the brush stripper and spindle harvester in Northeast Louisiana cotton production is warranted.

The majority of cotton in Northeast Louisiana is harvested with spindle harvesters. This type of equipment is used to harvest cotton planted in 91- to 102-cm row spacings, and is efficient in maintaining yield and quality. Spindle-harvested cotton generally has a higher lint turnout than cotton harvested with a stripper (Vories and Bonner, 1995). Spindle-harvested cotton has less total foreign matter (burs, sticks, and fine trash) than brush stripper-harvested cotton, but there are few significant differences in high volume instrumentation (HVI) measurements of staple, micronaire, strength, length, and uniformity (Brashears and Baker, 2000; Brashears and Hake, 1995).

High volume instrumentation is used by all USDA classing offices to identify specific fiber quality characteristics associated with all bales produced in the USA. Discounts received based on HVI data include color grade, staple length, micronaire, staple length, and fiber strength. HVI does not reflect all characteristics important to fiber processing, so mills

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use the AFIS system to further assess neps, short fiber content, immature fiber content, and other factors that impact the milling process. Cotton quality characteristics, as measured by AFIS, have been shown to be more desirable in spindle-harvested cotton (Willcutt et al., 2002). While spindle harvesters have been shown to consistently harvest a high-quality product, they are expensive and difficult to maintain.

Brush strippers are less expensive and require less maintenance than spindle harvesters. Cost savings at harvest may be achieved with a brush stripper by increasing the number of first-pick hectares and omitting second picking (scrapping) (Spurlock et al., 1991). Brush strippers harvest more material than spindle harvesters, but lower gin turnout is expected (Sappenfield et al., 1984) because of increased levels of foreign materials in seedcotton harvested by the brush stripper (Brashears and Baker, 2000). Stick content in stripper-harvested cotton can be reduced without affecting the yield by adjusting the roll spacing (Wanjura and Brashears, 1983; Supak et al., 1992). AFIS quality characteristics, including neps, short fiber content, visible foreign matter, and immature fiber content, have been adversely affected by harvesting cotton with a brush stripper (Willcutt et al., 2002). These characteristics are important to mills because they affect yarn breakage, dye retention, yarn integrity, processing costs, and quantity of imperfections in finished products.

Although the brush stripper may be a feasible option for harvesting machinery in Northeast Louisiana, problems due to late crop and adverse weather conditions can be compounded by the action of the stripper (Vories and Bonner, 1995). Consequently, climate may limit the use of the brush stripper (Sappenfield et al., 1984), but using the brush stripper as a supplement to the spindle harvester instead of a replacement could reduce the impact of a late crop if it occurs (Vories and Bonner, 1995). The objectives of this study were 1) to compare lint yields when using a brush stripper versus a spindle harvester and 2) to compare fiber characteristics from both systems using both AFIS and HVI techniques.

MATERIALS AND METHODS

Paired comparisons of plots harvested with stripper and spindle harvesters were conducted at four locations in Northeast Louisiana during the 2000 and 2001 cotton growing seasons. Producer cooperators were Jay Hardwick (Newellton, LA), Boyd Holley (Bastrop, LA), Jack Dailey (Extension, LA) and Charles Noble (Mangham, LA). The approximate plant population was 99,000 plants ha^{-1} and row spacing was 96.5 cm at all farms, except for 101.6 cm at the Holley farm. All locations, except the Hardwick farm in 2001, were irrigated on an as-needed basis. At each location, a new John Deere model 7455, 4-row brush stripper with 152 cm seed cotton cleaner was used to harvest plots randomly designated for stripper harvest. Each stripper bar was equipped with alternating brushes and rubber bats. Following defoliation, plots were picked once at an approximate travel speed of 5.8 km h^{-1}. The remaining plots were harvested with the producer's commercial 4-row cotton spindle harvester following defoliation. Cultivar, planting date, harvesting date, and harvest machinery for each location and year is provided in Table 1. Louisiana Cooperative Extension Service pest management recommendations were followed at each location to minimize economic yield and quality losses from nutrient deficiencies, diseases, weeds, and insects.

Table 1. Planting date, cultivar, harvesting date, spindle harvester and stripper harvester brands and models in 2000 and 2001

Year	Farm	Planting Date	Cultivar	Harvest Date	Spindle Harvester	Brush Stripper Harvester
2000	Dailey	27 Apr.	Deltapine 20 B	15 Sept.	John Deere 9965	John Deere 7745
2000	Noble	1 May	Deltapine 458 BR	18 Sept.	Case I.H. 2044	John Deere 7745
2000	Holley	16 May	Deltapine 409 BR	20 Sept.	Case I.H. 2055	John Deere 7745
2000	Hardwick	7 May	Stoneville BXN 47	12 Sept.	John Deere 9965	John Deere 7745
2001	Dailey	18 Apr.	Deltapine 422 BR	4 Oct.	John Deere 9965	John Deere 7745
2001	Noble	23 Apr.	Deltapine 422 BR	26 Sept.	Case I.H. 2044	John Deere 7745
2001	Holley	2 May	Paymaster 1218 BR	26 Oct.	Case I.H. 2055	John Deere 7745
2001	Hardwick	2 May	Stoneville 4892 BR	22 Oct.	John Deere 9965	John Deere 7745

The treatments were replicated four times at all locations, except for the Dailey farm with three replications and the Hardwick farm that was not replicated in 2001. Because treatments were not replicated at the Hardwick farm in 2001, the data from this location were not statistically analyzed. Plots in all other locations and years were arranged in a randomized complete block design. Plot size varied with location from 0.32 ha to 3.56 ha. Harvested material (seed cotton plus trash) from each plot was loaded onto a separate trailer, weighed, and delivered to the commercial gin used by each producer. The seed cotton was weighed, ginned, baled, and reweighed to determine gin turnout and lint yield per acre for each plot. Lint samples from each bale were sent to the USDA Cotton Classing Office at Rayville, Louisiana, for determination of fiber properties and grades. Government loan discount assessments (Commodity Credit Corporation) for 2000 and 2001 were used to assign discounts to the cotton. AFIS analysis was performed on lint samples sent to Cotton Incorporated (Cary, NC). All data were statistically analyzed by year because of environmental variation across years using analysis of variance procedures (SAS Institute; Cary, NC).

RESULTS AND DISCUSSION

In 2000, harvested material (seed cotton plus trash) at each location was significantly higher with the stripper harvester than with the spindle harvester. Differences in harvested material averaged 33% at the Dailey farm, 22% at the Noble farm, 10% at the Holley farm, and 19% at the Hardwick farm. The average increase in harvested material was approximately 20%. Gin turnout for spindle-harvested cotton (35.6%) was significantly greater than for the stripper-harvested cotton (31.5%) at the Holley and Hardwick farms. At the remaining locations, the gin turnout of spindle-harvested cotton was higher than stripper-harvested cotton, but the differences were not significant. This difference in gin turnout is likely due to increased trash content in seed cotton harvested with the stripper (Vories and Bonner, 1995).

There were few differences in HVI fiber quality data for spindle-harvested and stripped cotton in 2000 (Table 2). At the Dailey, Noble, and Holley Farms, all bales received color grade values of 21, 31, or 41. At the Hardwick Farm, many of the bales from the spindle harvester and stripper treatments

Table 2. Effect of harvest method on classing information, yield, and lint value of cotton from four locations in Northeast Louisiana, 2000

Harvester	Color grade[x]		Leaf content	Extra. matter[y]	Mic	Seed cotton plus trash (kg ha^{-1})	Lint (kg ha^{-1})	Turnout (%)	Loan value ($ kg^{-1})	Lint value ($ ha^{-1})
	Gray	Yellow								
Dailey farm										
Brush stripper	3.67 a[z]	1.0 a	2.33 a	21 a	4.27 a	2763 a	1007 a	36.4 a	0.93 b	936 a
Spindle	3.33 a	1.0 a	2.00 a	0 b	4.40 a	2084 b	869 a	41.7 a	1.01 a	912 a
Noble farm										
Brush stripper	2.87 a	1.0 a	3.12 a	0 a	4.42 b	3860 a	1065 a	27.7 a	1.18 a	1251 a
Spindle	3.00 a	1.0 a	2.12 b	0 a	4.70 a	3168 b	1001 a	31.5 a	1.16 a	1164 a
Holley farm										
Brush stripper	2.05 a	1.0 a	2.75 a	0 a	4.17 a	3694 a	1123 a	30.4 b	1.20 a	1345 a
Spindle	2.25 a	1.0 a	2.45 a	0 a	4.22 a	3352 b	1132 a	33.8 a	1.20 a	1357 a
Hardwick farm										
Brush stripper	4.35 b	1.7 a	2.65 a	0 a	4.85 a	3629 a	1136 a	31.3 b	1.06 a	1208 a
Spindle	4.83 a	1.5 a	1.95 b	0 a	4.90 a	3042 b	1072 a	35.2 a	1.03 a	1101 a

[x] Gray color grade values are averages of the first digit of the USDA color grade. Larger values denote increasing grayness, and lower values denote increasing whiteness (reflectivity). Yellow color grade values are averages from the second digit of the USDA color grade. A value of one indicates that all bales were in the white range, and values greater than one denotes increasing yellowness and occurrence of "light spotting".

[y] Extraneous matter is any substance in the cotton other than fiber or leaf.

[z] Means for each parameter within a farm followed by the same letter are not significantly different at $P \leq 0.05$.

received color grade values of 51 or 52 due to slight graying and light spot. Light spotting tended to be associated with stripper-harvested cotton and was likely due to increased levels of foreign material. Overall, discounts for color grade were similar for the spindle- and stripper-harvested cotton at the Hardwick farm.

In 2000, leaf content was consistently higher in stripper-harvested cotton than in spindle-harvested cotton, but these differences were generally not significant (Table 2). These increases in leaf content in stripper-harvested cotton had little effect on loan value. At the Dailey farm, all stripper-harvested bales were contaminated with grass. As a result, the cotton at this location was discounted 445 points for extraneous matter (Table 2). Consequently, loan value of the stripper-harvested cotton at the Dailey farm was significantly lower than spindle-harvested cotton. Extraneous matter (grass, bark, etc.) was not found in spindle-harvested samples from the Dailey farm or in any samples from the Noble, Holley, and Hardwick farms.

Staple length, strength, and uniformity were generally not influenced by harvest method in either year at any location (data not shown). Spindle-harvested cotton had significantly greater strength than stripper-harvested cotton at the Dailey farm. Micronaire of stripper-harvested cotton was significantly lower than spindle-harvested cotton at the Noble farm, which may have been due to a higher proportion of less mature bolls that were higher and further out on the plant (Table 2). At all other locations, micronaire of stripper-harvested cotton was numerically lower but not significantly different than spindle-harvested cotton. In several instances, the lower micronaire of the stripper-harvested cotton resulted in a premium of 15 points. In addition, several spindle-harvested bales received a 395 point discount for micronaire above 5.0. These results may have significant economic implications for producers in years when overall micronaire values are high.

As determined by AFIS analysis, stripper-harvested cotton contained significantly higher levels of dust, trash, and visible foreign matter at three locations and a numerical increase at the fourth location in 2000 (Table 3). Lint containing excessive dust and trash is difficult and expensive for mills to process (Cotton Incorporated, personal communication, 2003).

Although there were numeric trends towards an increase in neps, seed coat neps, short fiber content, and immature fiber content in stripper-harvested cotton, none of these differences were significant between harvest methods. Neps can result in increased yarn breakage and adversely affect the dyeing process. Increased short fiber content can result in reduced yarn strength and increased imperfections, while higher levels of immature fibers reduce dyeing

Table 3. Effect of harvest method on cotton Advanced Fiber Information System (AFIS) values from four locations in Northeast Louisiana, 2000

Harvester	Neps (g^{-1})	Dust count (g^{-1})	Trash count (g^{-1})	Visible foreign matter (%)	Short fiber content (w) (%)	Seed coat neps (g^{-1})	Immature fiber content (%)
Dailey farm							
Brush stripper	**317 a[z]**	**329 a**	**96.0 a**	**2.0 a**	**9.8 a**	**32.3 a**	**6.5 a**
Spindle	**275 a**	**112 b**	**39.0 b**	**0.9 b**	**9.1 a**	**21.3 a**	**6.0 a**
Noble farm							
Brush stripper	**230 a**	**240 a**	**64.5 a**	**1.5 a**	**8.0 a**	**19.0 a**	**6.1 a**
Spindle	**179 a**	**187 a**	**45.5 a**	**1.1 a**	**6.9 a**	**18.8 a**	**5.8 a**
Holley farm							
Brush stripper	**283 a**	**280 a**	**76.3 a**	**1.7 a**	**9.1 a**	**17.0 a**	**6.3 a**
Spindle	**255 a**	**228 b**	**60.0 b**	**1.4 b**	**8.5 a**	**16.3 a**	**6.3 a**
Hardwick farm							
Brush stripper	**202 a**	**267 a**	**68.3 a**	**1.5 a**	**8.5 a**	**18.3 a**	**5.3 a**
Spindle	**181 a**	**159 b**	**42.8 b**	**0.9 b**	**7.7 b**	**15.0 b**	**4.9 b**

[z] Means for each parameter within a farm followed by the same letter are not significantly different at $P \leq 0.05$.

potential (Cotton Incorporated, personal communication, 2003).

There were no significant differences in lint yield or, using the calculated loan value, in value/hectare between stripper- and spindle-harvested treatments at any locations in 2000 (Table 2). There was a slight increase (approximately \$52 ha^{-1}) in gross lint value per hectare with stripper-harvested cotton averaged across the four locations and without considering the reduced costs associated with operating a stripper harvester.

In most instances in 2001, color grade values for spindle-harvested cotton were better than for stripper-harvested cotton (Table 4). This was probably a result of the increased efficiency of the stripper in harvesting bolls that had been partially rotted and/or "hard locked" by several pre-harvest rains. In addition, several stripper-harvested bales from the Holley and Hardwick farms were contaminated with extraneous matter (grass). Otherwise, HVI fiber quality data of stripper- and spindle-harvested cotton was similar.

Generally, harvested material (seed cotton and trash) and lint yields from brush stripper-harvested plots were consistently higher at all locations in 2001(Table 4). Yield increases were likely a result of greater efficiency by the stripper harvester for harvesting "hard-locked" bolls that could not be harvested with the spindle harvester. As expected, gin turnout was higher for the spindle- harvested treatments, because of the reduced trash content in the seed cotton compared with stripper-harvested treatments.

Unfortunately, cotton samples were only available for AFIS analysis from one location, the Hardwick farm in 2001. The AFIS analyses revealed numerical increases in both dust and trash content for the stripper-harvested cotton (Table 5). Although there were no statistical differences, trends of higher neps g^{-1}, short fiber content by weight, percentage of visible foreign matter, and percentage of immature fiber content in stripper-harvested cotton were similar to those observed in 2000.

In several instances, the loan value of the spindle-harvested cotton was significantly improved compared with stripper-harvested cotton, because of color grade and presence of extraneous matter in stripper cotton. As a result of increased lint yield for

Table 4. Effect of harvest method on classing information, yield, and lint value of cotton from four locations in northeast Louisiana, 2001

Harvester	Color grade[w]		Leaf content	Extra. matter[x]	Mic	Seed cotton plus trash (g ha^{-1})	Lint (g ha^{-1})	Turnout (%)	Loan value (kg^{-1})	Lint value (\$ ha^{-1})
	Gray	Yellow								
Dailey farm										
Brush stripper	3.90 a[y]	1.9 a	3.28 a	0 a	4.5 a	3317 a	852 a	25.7 b	1.05 b	894 a
Spindle	3.30 b	1.1 b	2.60 b	0 a	4.3 b	1850 b	589 b	31.8 a	1.10 a	646 b
Noble farm										
Brush stripper	4.00 a	2.0 a	2.56 a	0 a	4.5 a	3259 a	954 a	29.3 b	1.04 b	998 a
Spindle	4.00 a	1.1 b	2.50 a	0 a	4.6 a	2165 b	763 b	35.3 a	1.14 a	872 b
Holley farm										
Brush stripper	4.58 a	1.0 a	3.54 a	1.4 a	5.1 a	3674 a	1297 a	35.3 b	0.88 a	1146 a
Spindle	4.00 a	1.0 a	3.00 a	0.1 b	5.2 a	2824 b	1077 b	38.1 a	1.00 a	1083 a
Hardwick farm[z]										
Brush stripper	4.00	1.0	3.90	2.2	4.5		1168		1.07	1252
Spindle	3.70	1.0	3.60	0	4.6		967		1.15	1116

[w] Gray color grade values are averages of the first digit of the USDA color grade. Larger values denote increasing grayness and lower values denote increasing whiteness (reflectivity). Yellow color grade values are averages from the second digit of the USDA color grade. A value of one indicates that all bales were in the white range and values greater than one denotes increasing yellowness and occurrence of "light spotting".

[x] Extraneous matter is any substance in the cotton other than fiber or leaf.

[y] Means for each parameter within a farm followed by the same letter are not significantly different at $P \leq 0.05$.

[z] Plots were not replicated, so the data was not statistically analyzed.

Table 5. Effect of harvest method on cotton Advanced Fiber Information System (AFIS) values from the Hardwick farm in Northeast Louisiana, 2001

Harvester	Neps (g^{-1})	Dust count (g^{-1})	Trash count (g^{-1})	Visible foreign matter (%)	Short fiber content (w) (%)	Seed coat neps (g^{-1})	Immature fiber content (%)
Brush stripper	240 a[z]	330 a	73.6 a	1.5 a	12.1 a	21.5 a	5.4a
Spindle	236 a	292 a	66.5 a	1.3 a	11.2 a	20.4 a	5.3a

[z] Means for each parameter followed by the same letter are not significantly different at $P \leq 0.05$.

stripper-harvested cotton, lint value per hectare was significantly increased at two of the locations despite the slightly reduced loan value. Thus, the yield increase with the stripper offset the reduction in fiber quality with this harvest system. Differences in yield and quality between spindle- and stripper-harvested cotton were greater in 2001 than in 2000. Lint value increases were significant at two locations and ranged from \$63.25 ha^{-1} at the Hardwick farm to \$247.77 ha^{-1} at the Dailey farm in 2001. In 2001, these lint values were significantly greater in brush stripper- than in spindle-harvested systems. Without factoring differences in machinery costs, the average increase in lint value across locations was \$143.18 ha^{-1}.

SUMMARY

Yield and HVI results of this study indicate harvesting conventionally grown cotton in Northeast Louisiana with a brush stripper may be an economically feasible option for producers. If (i) costs of machinery operation, (ii) fuel costs required to carry the extra weight associated with stripper-harvested material, (iii) energy required to gin harvested material from stripper harvested material, (iv) costs associated with dealing with extra gin trash, and (v) ultimately discounts mills assign to brush stripper-harvested lint are factored into the gross returns, the margin between the two systems might still be maintained due to reduced costs associated with a stripper operation. AFIS results indicate lint harvested with a brush stripper may be inferior to spindle-harvested lint due to increased foreign matter, neps, immature fibers, and short fibers. Because mills have the right to refuse delivery of stripped cotton in the Midsouth, a better understanding of the cost and benefits of brush stripper harvesting is necessary. Additional research is also needed to quantify effects of stripper set-up/adjustment, environmental conditions, cultivars, production practices, defoliation/desiccation, and other factors affecting yield and fiber quality.

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DISCLAIMER

Mention of a trademark, warranty, proprietary product, or vendor does not constitute a guarantee by and does not imply approval or recommendation of the product to the exclusion of others that may be suitable.

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