Cost/Benefit Analysis of Bur Extractors in Cotton Harvesting

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Abstract: *The objective of this research was to estimate the effect of using bur extractors in cotton stripping on foreign material in harvested cotton, on both quality attributes and lint turnout, and to determine the minimum harvested acres a producer must have for a bur extractor to be cost effective. Results indicate that the bur extractor has a significant effect in reducing bur percent, stick percent, and in increasing seed cotton percent and lint turnout, while it showed no statistically significant effect on any of the quality attributes. Results also suggest that investment in bur extractors is profitable for both irrigated and dryland cotton production situations with an operation of at least 750 acres. This study provides a simple method that can be employed by producers of stripper-harvested cotton to determine the cost effectiveness of a bur extractor given individualized production scenarios.*

Key Words and Phrases: *Stripper harvesting, bur extractors, cotton, cost-benefit analysis.*

Currently, 24 percent of the cotton produced in the United States is stripper harvested and the other 76 percent is machine picked (Glade et al.). The greatest concentration of stripper harvesting is centered in New Mexico, Oklahoma and Texas. Stripper harvesting is faster than picker harvesting, but removes more extraneous matter with the cotton lint and seed. Most of this extraneous matter (non-lint and non-seed) is composed of plant material such as burs, stems, leaves and hulls, but could also contain non-plant materials that include sand and rocks. If these extraneous materials are not removed from cotton lint, it may not be usable for certain purposes. The presence of foreign material in cotton lint may also compromise the quality of the products coming out of the textile mills.

Research was initiated as early as 1927 to develop a bur extractor that could be used on stripper harvesters for removing some extraneous material at the time of harvesting (Kirk et al.). Currently, bur extractors are commercially available to producers. Producers have a choice of buying a new stripper with a bur extractor already attached or adding a bur extractor to their existing stripper harvesters.

Cotton producers may need to know the effect of a bur extractor on extraneous materials (fractionation attributes) in harvested cotton, on quality attributes of lint (e.g., strength, color grade, trash grade and micronaire), and on lint turnout. Further, producers may also like to know the cost effectiveness of bur extractors. Previous studies have addressed the effect of bur extractors and have found that lint turnout can be improved if a bur extractor is used (Richman et al., p. 55). However, no published research has focused on the cost effectiveness of a bur extractor by incorporating effects of bur extractors on lint turnout. The objectives of this study were to estimate the effects of a bur extractor on extraneous material, on quality attributes of stripper-harvested cotton, on lint turnout, and to determine the minimum harvested acres a producer must have for a bur extractor to be cost effective. The study provides a simple method that can be employed by producers to determine the cost effectiveness of a field cleaner given their individualized production scenarios.

Data and Methods

The data for analyzing the effects of a bur extractor on extraneous material, quality characteristics and lint turnout were collected from the U.S. Department of Agriculture (USDA)Agricultural Research Service (ARS) office in Lubbock, Texas. The cotton samples used for this analysis were of one cotton variety, Paymaster HS-26, and were all stripper harvested (some with the use of a bur extractor and some without). Once harvested and dumped into trailers, samples were taken at random to obtain the trailer samples. During the ginning process, samples were taken at the feeder apron above the gin stand. For each of these samples, 200 grams of seed cotton were weighed and the burs and sticks were removed by hand. These 200-gram samples were then placed in a pneumatic fractionator that separated the fine trash. Each foreign matter fraction and the seed cotton was then weighed. The cotton was then ginned using the standard sequence used for stripper-harvested cotton, which included: airline cleaner, inclined cleaner, combination bur and stick machine, second incline cleaner, stick machine, 178 saw gin and two saw-type lint cleaners. Lint samples collected after the second lint cleaning were used to measure the lint turnout. Samples were then sent to the USDA classing office in Lubbock where the quality attributes were measured. The data were compiled for all samples and an average was taken of the samples with similar treatments.

Effects of Bur Extractors on Extraneous Material, Quality Attributes and Lint Turnout. To analyze the effects of bur extractors on extraneous material, quality attributes of cotton, and lint turnout, several regression models were run. Each of the attributes was specified as a function of the bur extractor. The bur extractor (BE) variable was specified as a dummy variable; BE = 1 if the field cleaner was used in harvesting and BE = 0, if otherwise. Due to a lack of data, it was assumed the effects of a bur extractor on extraneous material and quality attributes of other cotton varieties would possess the same properties as results found using Paymaster HS-26. It should be further noted that the bur extractors could potentially increase the loss of lint during harvesting. However, it is not perceived by producers to be substantial, and due to lack of experimental data, it was not incorporated into this analysis.

Determination of the Minimum Harvested Acres for a Bur Extractor to Be Cost Effective. For the purpose of cost analysis, secondary data for average yield and ginning cost, and survey data for bur extractor ownership cost were used. Average yield per acre for high-yielding varieties (Paymaster HS-26, Paymaster 145, and All-Tex Atlas), medium-yielding varieties (Tamcot CAB-CS, Deltapine SR-383, and Deltapine 50), and low-yielding varieties (Lankart LX-571 and Cencot) of cotton were calculated by averaging agronomic yield data for 1988 through 1992 reported by Gannaway et al. Average yield per acre for high-, medium-, and low-yielding varieties of cotton were calculated to be 1.5, 1.3 and 0.8 bales for irrigated cotton and 0.7, 0.5 and 0.3 bales for dryland cotton, respectively.

Lint turnout for the three different groupings of non-bur-extracted (stripper-harvested without using a bur extractor) irrigated and dryland cotton was also taken from Gannaway et al. Gannaway et al. reported lint turnout for non-bur-extracted dryland cotton to be 23.4, 21.3 and 17.1 percent for high-, medium-, and low-yielding varieties, respectively. Similarly, lint turnout for irrigated non-bur-extracted cotton has been reported to be 24.5, 21.6 and 16.7 percent for high-, medium- and low-yielding varieties, respectively. Lint turnout for bur-extracted cotton was calculated by adjusting the reported lint turnouts by the estimated effect of bur extraction on lint turnout provided by the regression model.

To determine the cost of owning and operating a bur extractor over a ten-year life, a present value of the maintenance cost (PV_M) associated with a field cleaner was determined by using the following equation:

$$PV_M = \sum_{t=1}^{n} \frac{CM_t}{(1+i)^t} \tag{1}$$

where CM_t is the cost of maintenance and repairs on the bur extractor in time t, and I is the interest rate, assumed to be 10.5 percent (Norwest Bank Texas), for a farm loan. This present value was then divided by 10 to obtain an average maintenance cost per year of operating a bur extractor. This average maintenance cost was then added to the average per-year cost of a bur extractor (total cost of a bur extractor divided by 10) to obtain the per-year average cost of owning and operating a bur extractor (ADC_{BE}).

To determine the ginning cost savings (GCS) per bale of lint due to the use of a bur extractor, the ginning charges (dollars per hundred weight (cwt.) of seed cotton assessed by the gin) were adjusted for bur-extracted cotton by accounting for the difference in lint turnout between bur-extracted and non-bur-extracted cotton. The ginning cost savings in time t was calculated by the following equation:

$$GCS_t = \frac{480 * GCCWT * (LTBE - LTNBE)}{LTBE * LTNBE} \tag{2}$$

where GCCWT is ginning charges in dollars per cwt of material entering the gin plant, LTBE is lint turnout (lbs. of lint cotton/cwt. of seed cotton) for bur-extracted cotton, and LTNBE is lint turnout (lbs. of lint cotton/cwt. of seed cotton) for non-bur-extracted cotton.

This ginning cost savings was then discounted to obtain a present value of ginning cost savings (PV_{GC}) associated with owning and operating a bur extractor using the following equation:

$$PV_{GC} = \sum_{t=1}^{n} \frac{GCS_t}{(1+i)^t} \tag{3}$$

where GCS_t is the ginning cost savings associated with using a bur extractor in time t, and i is the interest rate, assumed to be 10.5 percent (Norwest Bank Texas), for a farm loan. This present value was then divided by 10 to obtain an average ginning cost savings per year of operating a bur extractor (APV_{GC}).

To obtain the break-even number of acres for a bur extractor, over a ten-year period (assumed life of a bur extractor), the following equation was used:

$$\text{Acres} = \frac{ADC_{BE}}{Y * (APV_{GC})} \tag{4}$$

where ADC_{BE} is the average discounted ownership and maintenance cost of a bur extractor per year, APV_{GC} is the average discounted ginning cost savings per bale determined from equation 3, and Y is the lint yield per acre.

The analysis was further modified to determine how long it would take to recover the cost of a bur extractor for alternative farm sizes. This was accomplished by rewriting equation 2 in the following manner:

$$\text{Years} = \frac{TC_{BED}}{\text{Size} * Y * APV_{GC}} \tag{5}$$

where TC_{BED} is the discounted total ownership and maintenance cost of a bur extractor over a ten-year period, Size is the farm size (number of acres under production), Y is the yield per acre, and APV_{GC} is the average discounted ginning cost savings per bale determined from equation 3.

Results and Implications

Effects of Bur Extractors on Trash, Quality Attributes and Lint Turnout. The effects of the bur extractor on fractionation and quality attributes of cotton were

Table 1.
Regression Results of the Effects of a Bur Extractor on Fractionation Attributes[a]

	Constant	BE	R^2
Bur Percent	21.70* (0.66)[c]	-15.16* (0.93)	0.87[b]
Stick Percent	6.05* (0.32)	-1.78* (0.46)	0.27
Fine Trash	7.33* (0.38)	-0.09 (0.54)	0.00
Seed Cotton Percent	64.02* (0.84)	17.04* (1.19)	0.84
Turnout	21.70* (0.32)	4.56* (0.46)	0.61

[a]This table may also be expressed in equation form. An example would be:

Bur Percent = 21.70 - 15.16*BE,

with the effect of the bur extractor being represented by the BE coefficient. All other regression results presented in table 1 can be expressed in the same manner.

[b]R^2 represents the coefficient of determination (goodness of fit). The numbers appearing in this column can be interpreted as the proportion of the total variation of the dependant variable that is explained by the independent variable.

[c]Numbers in parenthesis are standard errors.

*Significance level less than 0.05.

analyzed with regression procedures. The regression results presented in Table 1 indicate that the bur extractor has a statistically significant effect (significance level of 0.05 or less) in reducing bur percent, stick percent and in increasing seed cotton percent and lint turnout. These models tended to fit the data reasonably well as indicated by the R^2 values.

Specifically, results (Table 1) indicated that bur percent in cotton can be reduced from 21.70 percent to about 6.54 percent (21.70 - 15.16) when a bur extractor is used, representing a decrease of about 70 percent. Similarly, a bur extractor was found to decrease stick percent in harvested cotton by about 29 percent and increase seed cotton percent by approximately 27 percent. Further, it was observed that the bur extractor increased the lint turnout by approximately 21 percent (from 21.70 to 26.26), and the relationship was statistically significant.

Regression results, presented in Table 2, however, did not reveal any statistically significant relationship between bur extractor and any of the quality attributes (cotton

Table 2.
Regression Results of the Effects of a Bur Extractors on Quality Attributes[a]

	Constant	BE	R^2
Strength	23.48* (0.20)[c]	0.43 (0.29)	0.05[b]
Composite Color	39.48* (0.95)	-0.90 (1.35)	0.01
RD	3.71* (0.10)	0.00 (0.14)	0.00
+b	1.76* (0.13)	-0.10 (0.19)	0.01
Trash	4.67* (0.15)	-0.05 (0.22)	0.00
Length	101.71* (0.48)	9.38 (6.85)	0.04
Uniformity	80.43* (0.22)	-0.048 (0.32)	0.00
Micronaire	35.43* (0.33)	-0.48 (0.47)	0.03

[a]This table may also be expressed in equation form. An example would be:

Strength = 23.48 + 0.43*BE,

with the effect of the bur extractor being represented by the BE coefficient. All other regression results presented in Table 2 can also be expressed in the same manner.
[b]R^2 represents the coefficient of determination (goodness of fit). The numbers appearing in this column can be interpreted as the proportion of the total variation of the dependant variable that is explained by the independent variable.
[c]Numbers in parenthesis are standard errors.
*Significance level of less than 0.05.

that was bur-extracted possessed the same quality attributes as cotton that was not bur-extracted). This implies that the effects of the bur extraction are offset as the cotton is further cleaned in the gin plant.

Cost Effectiveness of Bur Extractors. Survey results indicate the cost of operating a bur extractor is comprised of an initial cost of $11,000.00 for a new bur extractor with a ten-year expected life. Assuming that the bur extractor will have no salvage value at the end of the ten-year time period, the straight-line depreciation cost

Table 3.
Ginning Cost Savings and the Number of Acres Required to Cover the Ownership and Maintenance Costs of a Bur Extractor

	Ginning Cost Savings Per Bale[a]		Acres Required to Break-Even	
Yield[b]	Dryland	Irrigated	Dryland	Irrigated
Low	6.47	6.63	809.51	296.24
Medium	5.20	5.12	604.33	236.07
High	4.73	4.52	474.56	231.75

[a]Average yield levels were assumed to be 1.5, 1.3, and 0.8 bales/acre for high, medium, and low yielding irrigated cotton, and 0.7, 0.5, and 0.3 bales/acre for high, medium, and low yielding dryland cotton, respectively.
[b]Lint turnouts for non-bur extracted cotton were assumed to be 23.4, 21.3, and 17.1% for high, medium, and low yielding dryland varieties, and 26.5, 21.6, and 16.7% for high, medium, and low yielding irrigated varieties, respectively. For bur-extracted cotton, turnouts were adjusted up by 21 % and were calculated to be 28.3, 25.8, and 20.7% for dryland and 29.7, 26.1, and 20.2% for irrigated high, medium, and low yielding cotton, respectively.

per year of the bur extractor is $1,100.00. The repairs to the bur extractor include: replacing all top saws at a cost of $500.00 every two years; replacing all bottom saws at a cost of $500.00 every four years; replacing one and one-half of all brushes each year at a cost of $180.00; replacing two belts per year at a cost of $100.00; replacing four bearings per year at a cost of $160.00; and replacing one and one-half reclaimer brushes every year at a cost of $75.00.

The summation of the initial investment expense and the present value for maintenance on a bur extractor yields a total cost ($15,712.62) for using and maintaining a bur extractor during harvest. The straight-line depreciation cost per year of owning and operating a bur extractor is $1,571.26.

Ginning charges, including transportation of modules from the field to the gin, were assumed to be $2.00 per hundred weight (cwt.) of material entering the gin (U.S. Department of Agriculture). The average discounted ginning cost savings per bale of lint was calculated by using equation 3. Lint turnout for each of the three variety groups, for both dryland and irrigated varieties, were adjusted up by 21 percent to account for the effect of a bur extractor in harvesting.

Ginning cost savings per bale ranged between $4.73 and $6.47 for dryland cotton and between $4.52 and $6.63 for irrigated cotton (Table 3). It is interesting to observe that lower-yielding varieties of cotton (with lower lint turnouts) save relatively more in ginning costs per bale than higher-yielding varieties. Given the assumption that the effect of a field cleaner on lint turnout is constant among varieties, as might be

Table 4.
Number of Years Required to Cover the Ownership and Maintenance Costs of a Bur Extractor, by Farm Size, for Irrigated and Dryland Cotton

	Cotton Acres					
	500 Acres		750 Acres		1,000 Acres	
Yield[a]	Dryland	Irrigated	Dryland	Irrigated	Dryland	Irrigated
	Years To Pay-Back					
Low	16.19	5.92	10.79	3.95	8.10	2.96
Medium	12.09	4.72	8.06	3.15	6.04	2.36
High	9.49	4.63	6.33	3.09	4.75	2.32

[a]Average yield levels were assumed to be 1.5, 1.3, and 0.8 bales/acre for high, medium, and low yielding irrigated cotton, and 0.7, 0.5, and 0.3 bales/acre for high, medium, and low yielding dryland cotton, respectively.

expected, lower-yielding varieties with a higher initial ginning cost per bale stand to save more (in absolute terms) than varieties with a lower initial ginning cost per bale.

The analysis of the number of acres required to recover the cost of a bur extractor for dryland and irrigated cotton for three different yield categories was accomplished by using equation 4. Results (Table 3) suggest that a producer with an average yield of 1.5 bales/acre of (high-yielding irrigated) cotton must harvest at least 231.75 acres of cotton per year for ten years to recover the cost of a bur extractor. For medium- (1.3 bales/acre) and low- (0.8 bales/acre) yielding irrigated cotton, a producer would be required to harvest 236.07 and 296.24 acres, respectively, of cotton per year for ten years to recover the bur extractor cost. Likewise, a producer must harvest at least 474.56, 604.33 and 809.51 acres of dryland cotton per year for a ten-year time period to recover the costs of a bur extractor when using high-yielding, medium-yielding and low-yielding cotton, respectively.

The alternative analysis examined how long it would take to recover the cost of a bur extractor for various farm sizes by using equation 5. Table 4 presents the results of this analysis. For example, a producer with 1,000 acres of high-yielding (1.5 bales/acre) irrigated cotton will take just over 2.32 years to recover the cost of purchasing and maintaining a bur extractor and 4.75 years for dryland cotton producing 0.7 bales/acre on the same size farm. Likewise, a producer using irrigated cotton with medium yield on 1,000 acres will again take 2.36 years versus 6.04 years for dryland cotton to recover the costs associated with a bur extractor. Finally, an irrigated, low-yielding, 1,000-acre cotton farm will take just under 3 years while the dryland cotton will take 8.10 years to recover the costs of owning and operating a bur extractor.

Summary and Conclusions

Experimental data on cotton attributes, with and without the use of a bur extractor, were collected and analyzed to assess the effects of a bur extractor on extraneous material, quality attributes and on lint turnout. The analysis suggests that bur percent and stick percent in cotton can be reduced by about 70 percent and 29 percent, respectively, with the use of a bur extractor. Seed cotton percent was found to increase by about 27 percent when a bur extractor is used during harvesting. The analysis also suggested that the use of a bur extractor in harvesting increases lint turnout by about 21 percent. However, bur extractors did not appear to have any statistically significant effect on the quality attributes of cotton.

The findings of this study suggest that investment in bur extractors was profitable for Texas producers in all irrigated and most dryland cotton production situations with an operation of at least 750 acres. The 500-acre farm, with low- and medium-yield dryland cotton and the 750-acre farm with low-yield dryland cotton, were the only instances rendering a payback period which exceeded the life of the bur extractor. In all cases of irrigated cotton, the farm recovered the cost of the bur extractor in about 6 or fewer years. In dryland cropping practices, the cost of the bur extractor can be recovered in just under 9.5 years or less, with the exception of the low- and medium-yield varieties on the 500-acre farm and the low yield varieties on the 750-acre farm. The most profitable alternative (irrigated, high-yielding cotton on a 1,000-acre farm) yielded a recovery period of 2.32 years. Producing beyond these levels of yields, acreages and break-even time periods would provide additional returns to capital.

Although the adoption of bur extractors was found to be cost effective for the representative Texas producers considered in this study, different producers in different regions may incur different costs. Thus, this study provides a simple method that can be employed by producers of stripper-harvested cotton in various parts of the United States to determine the cost effectiveness of a field cleaner given individualized production scenarios.

Some policy ramifications emerge from this study. Given that producers using bur extractors save between $4.52 and $6.63 in ginning charges per bale of cotton lint (Table 3), ginners must absorb this loss. The net loss for ginners, however, is not equal to the producers' savings. Since ginners, in most cases, include the cost of module hauling in ginning charges, ginners can save in module transportation costs when a bur extractor is used (Misra et al.). Further, with less trash being taken to the gin plant when bur extractors are used, ginners may experience lower trash disposal costs because of further adoption of bur extractors. Finally, there is some evidence suggesting that ginners can also save on gin machinery maintenance and repair costs if a bur extractor is used in the harvesting stage. If ginners do not make up for the loss in ginning charges by cost savings, then the ginning pricing structure may be expected to change. Further research is thus needed to evaluate the net effect of increased adoption of bur extractors on ginners's revenue.

Notes:

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