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Minimizing Farm-to-Mill Cotton Cleaning Cost

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ABSTRACT

This study focuses on least-cost farm-to-mill cotton cleaning configurations employing survey, regression, and simulation techniques. The resulting least-cost cotton cleaning configurations, employing standard textile technology, included the use of one lint cleaning in the ginning stage. The use of a field cleaner in the harvesting stage was also found to be optimal with some variation based on the desired yarn quality. Results of the study indicated that the optimal cleaning configurations were distinctly different from currently used practices, such that appropriate changes could save the cotton industry between $0.30 and $0.60 per bale of cotton, depending on the desired yarn quality.

Key Words: cotton cleaning, least-cost configurations, yarn quality.

Machine harvesting of cotton removes extraneous materials along with the seed cotton. Therefore, seed cotton must be thoroughly cleaned and extraneous materials removed before cotton lint is used by textile mills. Cotton cleaning is a multistage process which involves successive stages of production, harvesting, ginning, and textile processing. Within each of the stages, there can be a significant variation in cleaning practices, including the time of harvest, the use of a field cleaner on a stripper during the harvesting stage, and a combination of one to three stages of lint cleaning at the gin plant. Alternate processes of opening, carding, and drawing at the textile mill can also affect cotton cleanliness.

Production practices employed and the mix of cotton cleaning activities during harvesting, at the gin plant, and at the textile mill determine both cotton cleanliness and fiber quality. A determination of cotton cleaning costs must include costs of owning and operating cleaning equipment in all three stages as well as the effects of cleaning practices on cotton quality. The debate surrounding cotton cleaning to date has been limited to a consideration of the operational efficiency of the processing operations in a typical gin plant and the impact of cleaning on lint quality. For example, the U.S. Department of Agriculture (USDA) recommends two lint cleanings at the gin plant regardless of the cleaning practices used in the production stage and regardless of the yarn quality desired by textile mills. This procedure achieves satisfactory bale value and reduces damage to the inherent quality of the fiber, but it may not maximize the net cash value for each individual bale (Anthony).

It is important from an overall industry perspective to know the optimal (least-cost) mix of cotton cleaning activities across the various stages of cotton handling. The optimal cotton

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cleaning configuration for the cotton industry, assuming a specific production practice, should include a sequence of cleaning processes in the field, at the gin, and at the textile mill which can be accomplished at minimum cost. Textile mills, however, usually target a desired quality of yarn. Thus, the issue for the industry is one of selecting the least-cost cleaning configuration across harvesting, ginning, and textile mill stages to achieve the desired yarn quality.

To date, there is no published research addressing the issue of cotton cleaning across the various segments of the industry. The lack of cost estimates and of quality effects for alternative cleaning configurations makes it difficult to identify those combinations of cleaning practices that will minimize costs for the industry. The general objective of this study is to identify least-cost cleaning configurations across various stages of cotton handling without sacrificing the desired quality characteristics.

Theoretical Framework

The empirical issue is one of multistage constrained cost minimization. The total cost for any specific cleaning configuration can be determined simply by the summation of those costs associated with cleaning practices employed in the harvesting, ginning, and textile mill stages. Let TCC_i be the total cleaning cost for the ith cleaning configuration, and CC_{ji} the cleaning cost associated with the jth stage in the ith configuration:

$$(1) \qquad TCC_i = \sum_{j=1}^{3} (CC)_{ji}, \qquad i = 1, \ldots, n.$$

Then, the cleaning cost for each individual stage is a function of the specific cleaning practices employed. Therefore, let CCP_{kj} be the cost of the kth cleaning practice (CP) used in the jth stage:

$$(2) \qquad CC_j = \sum_{k=1}^{m} (CCP)_{kj}, \qquad j = 1, 2, 3.$$

Equation (1) can thus be rewritten as

$$(3) \qquad TCC_i = \sum_{j=1}^{3} \sum_{k=1}^{m} (CCP)_{kji}, \qquad i = 1, \ldots, n.$$

Clearly, TCC_i would differ for alternative cleaning configurations.

The cost-minimization problem is constrained by the desired yarn quality in that textile mills are assumed to target a desired quality of yarn (measured by yarn strength). The desired yarn quality can be affected by the cleaning practices used in each stage. In other words, yarn quality in the harvesting stage will be influenced by the cleaning practices used in the harvesting stage. The effect on yarn quality in the ginning stage, however, is affected by cleaning practices used in both the harvesting and ginning stages. Therefore, the quality of yarn produced by the mill is a function of those cleaning practices used across various stages of cotton. Mathematically, the functional relationships for the desired yarn quality (Q^*) can be specified as follows:

$$(4) \qquad \begin{aligned} Q^* &= f(CP_k)_{j=3}, \\ f(CP_k)_{j=3} &= g(CP_k)_{j=2}, \\ g(CP_k)_{j=2} &= h(CP_k)_{j=1}, \end{aligned}$$

where $\{j = 1, 2, 3\}$ corresponds to the harvesting, ginning, and textile mill stages, respectively. Alternatively, equation (4) can be written as a composite functional constraint for the specified model:

$$(5) \qquad Q^* \geq f\{g[h(CP_k)_{j=1}]\}.$$

A mathematical solution to the proposed model does not exist since the cost and quality functions in the model are necessarily discrete in nature (i.e., in violation of the axiom of differentiability). However, given a finite, relatively small number of cleaning configurations and practices, reliable solutions can be obtained without any loss of theoretical refinement by simply comparing results from the alternative configurations.

Methods and Procedures

This analysis focuses on irrigated, stripper harvested (mid-season) cotton from an average 1,000-acre farm on the Southern High Plains of Texas. Alternative cleaning configurations were selected considering three cotton variety groups, two methods of cotton cleaning in the harvesting stage, three variations of cotton cleaning in the gin plant, and a typical cleaning process at the textile mill.

Average cotton yields per acre were calculated by averaging agronomic yield data for 1988 through 1992 reported by Gannaway et al. for high trash-producing varieties (Lankart LX-571 and Cencot), medium trash-producing varieties (Tamcot CAB-CS, Deltapine SR-383, and Deltapine 50), and low trash-producing varieties (Paymaster HS-26, Paymaster 145, and all-Tex Atlas). Cotton varieties were categorized as follows: low trash cotton with high yields (1.56 bales/acre), medium trash cotton with moderate yields (1.26 bales/acre), and high trash cotton with low yields (0.81 bales/acre).

The only factor allowed to change in the harvesting stage was the use of a field cleaner. The impact of field cleaning on the cleanliness and quality of seed cotton was determined by collecting primary cotton sample data from the Agricultural Research Service office of the USDA in Lubbock, Texas. The samples were taken from irrigated Paymaster HS-26 variety of cotton, some of which were stripper harvested with the use of a field cleaner and some without. All samples were ginned within two days of harvest, and trash attributes (burs, sticks, and fine trash) and seed cotton yields were measured. The samples were sent to the USDA classing office in Lubbock, Texas, where the quality attributes (strength, length, micronaire, uniformity ratio, reflectance, +b, color grade, composite grade, trash grade, moisture percent, and non-lint percent) were measured. (A detailed explanation of these quality attributes can be found in the USDA's 1993 agricultural handbook, *The Classification of Cotton.*)

Trash and quality attribute data were used to estimate the effects of a field cleaner. Each of the trash and quality attributes was specified as a function of the field cleaner (*FC*). The general specification of the regression model was

$$(6) \qquad (Attr)_l = \beta_0 + \beta_1(FC) + \mu_i,$$

where $(Attr)_l$ represents each of the trash and quality attributes, and *FC* is a dummy variable equal to one if the field cleaner was used in harvesting and zero otherwise.

Cleaning costs for the six alternative cleaning configurations (three categories of cotton times two types of harvesting) in the harvesting stage were determined from a survey of several area producers in Lubbock and from information provided by an area implement company. Annual ownership costs of the field cleaner were determined (using straight-line depreciation) assuming a 10-year life. Costs were then adjusted to arrive at total ownership and operating costs per bale per year of a field cleaner. The cost of hauling cotton in modules (a compressed form of seed cotton) to the gin plant was determined from the average number of bales per module and the hauling charge per module.

Cotton samples for the six alternative cleaning configurations entering the gin were subjected to one, two, and three lint cleanings using the GINQUAL model (Barker, Baker, and Laird). GINQUAL is a ginning simulation model which simulates the effect of successive stages of lint cleaning on cotton weight, lint quality, and lint turnout, and has been used successfully in previous research (Ethridge, Barker, and Bergan; Baker). The simulation generated a total of 18 alternative cleaning configurations. The default initial trash content values given by the GINQUAL model for seed cotton entering the gin were used as a proxy for non-field cleaned cotton. These values for field cleaned cotton were adjusted using the statistical estimates of the effects of the field cleaner derived from primary data. Potential variations in the effect of field cleaning arising from differences in variety were ignored due to lack of data. Simulation results were then analyzed to measure the impact of alternative cleaning configurations in the gin on the cleanliness and quality of cotton.

Local ginners were consulted and survey results were used in the GINMODEL (Childers) to estimate total cleaning cost in the gin. The GINMODEL, a ginning cost simulator, calculates fixed and variable ginning costs at various processing efficiencies and gin capacities, and has been used by Gillis et al. to estimate costs for simulated gins. Waste disposal cost per bale was calculated from survey responses and added to the estimated cleaning cost per bale since the GINMODEL does not account for the disposal cost of waste produced by the gin plant.

The amount of cleaning in the textile mill required to obtain a desired yarn quality is dependent on the quality of cotton delivered to the mill. A typical cleaning configuration at the textile mill was established with the aid of Trutzschler GMBH & Co. (a noted German textile machinery manufacturing company) and the International Textile Center at Texas Tech University. These experts, by analyzing GINQUAL outputs, determined that cotton from all of the 18 configurations should go through the same cleaning process at the textile mill, confirming that a single cleaning configuration for the textile mill (Bennett) was appropriate. The suggested method of yarn production specified open-end spinning with the use of an opening roller.

Resulting yarn qualities for the 18 alternative cotton cleaning configurations were predicted from a mathematical relationship provided by the International Textile Center, Lubbock, Texas, as follows:

$$\text{(7)} \quad \begin{aligned} CSP &= 382.5 + (52.26 \times \mathit{Strength}) \\ &\quad + (792.2 \times \mathit{Length}) \\ &\quad - \Big((44.47 - ((23.96 \times \mathit{Length}) \\ &\qquad + (1.918 \times \mathit{Micronaire}))) \times N_{ec}\Big), \end{aligned}$$

where CSP is the yarn strength prediction and N_{ec} is the yarn size held constant at 16. The strength, length, and micronaire are lint quality characteristics and were obtained for each configuration from the GINQUAL model; the yarn strength (a measure of yarn quality) for each configuration was predicted using equation (7).

Cleaning configurations were then grouped into three different quality categories based on the following range of quality values for yarn strength: 2,350 and above for the best quality yarn, 2,200 and above for the second best quality yarn, and 2,000 and above for the third best quality of yarn.

The only differences in cleaning costs at the mill among the alternative configurations were the revenue loss due to lint loss and the disposal cost for waste produced at the textile mill since a single cleaning configuration was chosen for the textile mill. To obtain the revenue loss per bale, an econometric relationship reported by Chen was first used to determine prices paid by textile mills for cotton from each configuration. The textile mill pricing equation was specified as

$$\text{(8)} \quad \begin{aligned} TPRICE &= 8.5640(9 - G1)^{0\,1726} \\ &\quad \times (8 - G2)^{0\,2444}(L)^{0\,1674} \\ &\quad \times e^{0\,3706M - 0\,522MM}, \end{aligned}$$

where $TPRICE$ is the price paid by textile mills per pound for cotton lint, $G1$ is the first digit of the color grade, $G2$ is the second digit of the color grade, L is the length measurement of the cotton lint, M is the micronaire measurement, and MM is the micronaire measurement squared.

According to Smith, 5% of the cotton lint per bale is lost during textile processing. The total revenue loss per bale for each configuration can thus be determined from the product of the revenue loss per pound and 24 pounds (5% of 480 pounds). However, the revenue loss per pound of lint is not equal to the estimated price paid by textile mills for a pound of cotton lint, because textile mills usually sell the lint waste and receive a marginal compensation. The average compensation received by the textile mill for lint waste was obtained by surveying several textile mills; this amount was subtracted from the estimated price paid by textile mills for cotton lint to arrive at the revenue loss per pound of cotton for each configuration.

Based on information provided by Trutzschler GMBH & Co., about 99% of the trash per bale is extracted from cotton in pre-cleaning and carding at the textile mill. Eighty percent of the remaining trash in the cotton is then removed during open-end spinning using a rotor machine (Smith). The amount of trash extracted from the cotton lint before it reaches the rotor machine was determined for this study by taking 99% of the initial trash levels entering the textile mill

Table 1. Cost of Field Cleaner and Hauling Stripper Harvested Cotton ($/bale) for Alternative Module Hauling Charges, With and Without the Use of a Field Cleaner

	Hauling Cost per Module			
	$70		$60	
Variety	With Field Cleaner (Field Clean)	Without Field Cleaner	With Field Cleaner (Field Clean)	Without Field Cleaner
	($/bale)			
High Trash	8.64	7.78	7.75	6.67
Medium Trash	7.76	7.78	6.88	6.67
Low Trash	7.45	7.78	6.57	6.67

(obtained from the GINQUAL simulation runs). The remaining trash levels were then multiplied by 0.8 to determine the amount of trash removed by the rotor machine. The two trash levels were then added to arrive at the total amount of trash removed in the textile mill. From a survey of textile mills, it was calculated that the average cost of disposing non-lint waste in a landfill is about $0.015 per pound of waste material. Total waste disposal cost was then computed by multiplying the number of pounds of trash extracted at the textile mill for each configuration by the unit waste disposal cost.

Least-cost cleaning configurations were determined by combining the total costs of each alternative cleaning configuration which met the yarn quality specifications. Various cost components (e.g., owning and operating costs of a stripper, pre-cleaning and operating costs of the gin, textile mill costs following the rotor machine, etc.) were excluded from the analysis because they did not differ across configurations, and thus should not have any impact on the determination of optimal cleaning configurations.

Results

Harvesting Stage

The estimated regression for the effects of field cleaners on trash and quality attributes failed to suggest a statistically significant relationship between the use of field cleaners and quality attributes of cotton lint. It was observed, however, that field cleaners did have a statistically significant effect on the level of trash entering the gin plant. Specifically, the field cleaner was found to be most effective in reducing the percentage of bur and stick in seed cotton by 69.878% and 29.367%, respectively.[1]

The only differences in cleaning costs in the harvesting stage among the alternative cleaning configurations were the cost of owning and operating a field cleaner and the hauling cost. The ownership and maintenance cost of a field cleaner was estimated at $1,990 per year. Cleaning costs were calculated assuming hauling charges of $70 and $60 per module[2] containing 11.33 bales and nine bales of field cleaned and non-field cleaned cotton, respectively. The cleaning cost was estimated at $7.78 per bale of non-field cleaned cotton regardless of the variety, assuming an average lint yield for high trash varieties (0.81 bales), medium trash varieties (1.26 bales), and low trash varieties (1.56 bales) for a 1,000-acre cotton farm and a $70 per module hauling charge (table 1). Field cleaned cotton, in contrast, had an estimated cleaning cost of $8.64 per bale for high trash varieties, $7.76 per bale for medium trash varieties, and $7.45 per bale for low trash varieties, representing a cost savings of $0.33 to $0.02 per bale for field cleaned low and medium trash varieties, respectively.

The cleaning cost for non-field cleaned cotton was $6.67 per bale for all three varieties assuming a hauling charge of $60 per module. Costs associated with field cleaned cotton were estimated at $7.75 per bale for high trash

[1] The estimated equations are: Bur Percent = 21.698 − 15.157*FC*, and Stick Percent = 6.048 − 1.776*FC*.

[2] A survey of several producers revealed that a hauling charge of between $60 and $70 per module is common in the study area.

varieties, $6.88 per bale for medium trash varieties, and $6.57 per bale for low trash varieties (table 1). These findings provided an initial indication that the use of field cleaner was not cost effective for high or medium trash varieties at the reduced hauling charge of $60 per module.

Ginning Stage

GINQUAL results (table 2) revealed similar cotton lint quality characteristics between field cleaned and non-field cleaned cotton. However, some differences were observed among varieties and the number of lint cleanings. The low trash variety possessed the highest strength, length, micronaire, reflectance, and uniformity, followed in succession by the medium trash and high trash varieties. The medium trash varieties had the highest +b of the three varieties for non-field cleaned cotton, followed in succession by the low and high trash varieties. For field cleaned cotton, the high trash varieties had the highest +b. Non-lint content was highest with cotton lint cleaned one time and lowest with cotton lint cleaned three times in the gin plant.

The analysis of cleaning costs for the gin plant (table 3) showed that a gin plant operating at 19 bales per hour and at 100% utilization had a total cleaning cost of $0.41 per bale for one lint cleaning, $0.79 per bale for two lint cleanings, and $1.11 per bale for three lint cleanings (all other costs held constant). The cleaning cost for one lint cleaning increased less than proportionately than for two and three lint cleanings as the gin utilization rate was reduced. Thus, variations in gin utilization rates were not considered appropriate for further analysis.

Textile Mill Stage

The analysis of the effects of field cleaning, cotton variety, and number of lint cleanings on yarn quality indicated that low trash cotton varieties produced the best quality yarn with a yarn strength of 2,350 and above. The medium trash and low trash varieties both produced yarns with a strength of 2,200 and above. All three varieties of cotton were found suitable for yarn with a strength of 2,000 and above.

The results of the analysis of cleaning costs in the textile mill are presented in table 4. Textile mills, as might be expected, experienced lower non-lint disposal costs as the number of lint cleanings in the gin plant increased. In most cases, textile mills experienced larger revenue losses when cotton was cleaned less aggressively in the gin plant. However, field cleaning did not affect revenue losses in the textile mill except for high trash-producing varieties. For high trash varieties, field cleaned cotton generated higher revenue losses because prices paid by textile mills for field cleaned cotton were higher than for non-field cleaned cotton. Total cleaning costs in the textile mill were generally less for field cleaned cotton that had been subjected to additional lint cleaning in the gin plant.

Determination of the Least-Cost Cleaning Configuration

Cotton cleaning costs for the cotton sector as whole, for a $70 module hauling charge and for 100% utilization of the gin plant, are presented in table 5. These results indicate that for the best quality yarn (strength of 2,350 and above) and the second best quality yarn (strength of 2,200 and above), the least-cost cleaning configuration requires the use of field cleaned, low trash varieties and one lint cleaning in the gin plant (configuration 16). Configuration 1, the use of non-field cleaned, high trash cotton varieties with one lint cleaning, was found to be the most cost effective for the third best quality of yarn (strength of 2,000 and above). The same cleaning configurations for all trash varieties and yarn qualities remained optimal when the hauling charge was reduced to $60 per module.

These results clearly suggest that one lint cleaning in the ginning stage is optimal for a broad range of trash varieties and yarn qualities. The use of a field cleaner in the harvesting stage was also found to effectively reduce total cleaning costs for high and medium qualities of yarn. Field cleaners were not cost effective, however, for low qualities of yarn.

Table 2. Effects of a Field Cleaner and One, Two, and Three Lint Cleanings on Quality Parameters of Cotton Exiting the Gin Plant

				Cotton Quality Parameters									
Variety	Config. No.	Field Clean	No. of Lint Clean-ings	Strength	Micron-aire	Length	Uni-formity Ratio	Reflec-tance	+b	Color Grade	Com-posite Color Grade	Trash Grade	Moisture % (Wet Basis)	Non-lint %
High Trash	1	No	1	21.89	2.44	30.5	80.92	69.06	7.49	51	61	7	6.61	6.97
	2	No	2	22.22	2.44	30.4	80.13	69.96	7.67	51	60	6	6.50	5.79
	3	No	3	22.54	2.44	30.1	79.93	70.60	7.70	51	60	6	6.22	5.57
	4	Yes	1	21.89	2.45	30.5	80.74	69.37	7.84	51	61	7	6.52	6.66
	5	Yes	2	22.22	2.45	30.4	80.00	70.27	8.02	41	51	6	6.40	5.48
	6	Yes	3	22.54	2.45	30.1	79.79	70.90	8.05	41	51	6	6.13	5.26
Medium Trash	7	No	1	25.06	3.39	32.5	81.43	69.37	7.75	51	60	6	6.50	5.74
	8	No	2	25.59	3.39	32.3	80.73	70.28	7.93	51	51	5	6.38	4.56
	9	No	3	26.11	3.39	32.1	80.52	70.91	7.96	41	50	5	6.11	4.34
	10	Yes	1	25.06	3.39	32.5	81.41	69.37	7.77	51	60	6	6.44	5.68
	11	Yes	2	25.59	3.39	32.3	80.70	70.27	7.94	51	51	5	6.32	4.50
	12	Yes	3	26.11	3.39	32.1	80.49	70.90	7.98	41	50	5	6.05	4.28
Low Trash	13	No	1	26.47	3.68	33.0	82.24	69.38	7.74	51	60	6	6.47	5.47
	14	No	2	27.09	3.68	32.9	81.55	70.28	7.92	51	51	5	6.36	4.29
	15	No	3	27.70	3.68	32.6	81.34	70.91	7.95	41	50	5	6.08	4.08
	16	Yes	1	26.47	3.68	33.0	82.19	69.38	7.76	51	60	6	6.42	5.41
	17	Yes	2	27.09	3.68	32.9	81.49	70.28	7.93	51	51	5	6.30	4.23
	18	Yes	3	27.70	3.68	32.6	81.28	70.91	7.97	41	50	5	6.04	4.01

Table 3. Lint Cleaning Cost ($/bale) of Cotton in the Ginning Stage for Alternative Utilization Rates

	100% Utilization		90% Utilization		80% Utilization	
No. of Lint Cleanings	Total Cost	Cost Difference	Total Cost	Cost Difference	Total Cost	Cost Difference
	($/bale)					
0	40.97		42.38		44.28	
		0.41		0.42		0.45
1	41.38		42.8		44.73	
		0.79		0.81		0.86
2	41.76		43.19		45.14	
		1.11		1.15		1.22
3	42.08		43.53		45.50	

Note: Cost difference figures represent differentials between zero and the number of lint cleanings, i.e., between 0 and 1, 0 and 2, etc.

Table 4. Revenue Loss, Non-lint Disposal Cost, and Total Lint Cleaning Costs in Cotton Textile Processing

Variety	Config. No.	Field Clean	No. of Lint Cleanings	Revenue Loss	Non-lint Disposal Cost	Textile Mill Total Cleaning Cost
				($/bale)		
High Trash	1	No	1	13.45	0.50	13.95
	2	No	2	13.44	0.42	13.85
	3	No	3	13.42	0.40	13.82
	4	Yes	1	13.44	0.48	13.92
	5	Yes	2	13.90	0.39	14.29
	6	Yes	3	13.96	0.38	14.34
Medium Trash	7	No	1	14.47	0.41	14.88
	8	No	2	14.46	0.33	14.79
	9	No	3	15.01	0.31	15.32
	10	Yes	1	14.47	0.41	14.88
	11	Yes	2	14.46	0.32	14.78
	12	Yes	3	15.01	0.31	15.32
Low Trash	13	No	1	14.52	0.39	14.91
	14	No	2	14.51	0.31	14.82
	15	No	3	15.06	0.29	15.35
	16	Yes	1	14.52	0.39	14.91
	17	Yes	2	14.51	0.30	14.81
	18	Yes	3	15.06	0.29	15.35

Very few producers in Texas currently use field cleaners in the harvesting stage. Furthermore, it is currently a standard practice in the cotton industry to employ two lint cleanings in the gin plant. This study estimates that the industry incurs a cleaning cost (excluding owning and operating costs of stripper, pre-cleaning and operating costs of the gin, and textile mill costs following the rotor machine) of $23.39 per bale for the best quality yarn (configuration 14),

Table 5. Total Cleaning Cost for the Harvesting, Ginning, and Textile Mill Stages, and for the Industry

Variety	Config. No.	Field Clean	No. of Lint Cleanings	Total Cleaning Cost ($/bale) Harvesting Stage	Ginning Stage	Textile Mill Stage	Industry	Yarn Strength
High Trash	1	No	1	7.78	0.41	13.95	22.14	2,009
	2	No	2	7.78	0.79	13.85	22.42	2,024
	3	No	3	7.78	1.11	13.82	22.71	2,030
	4	Yes	1	8.64	0.41	13.92	22.97	2,009
	5	Yes	2	8.64	0.79	14.29	23.72	2,024
	6	Yes	3	8.64	1.11	14.34	24.09	2,030
Medium Trash	7	No	1	7.78	0.41	14.88	23.07	2,281
	8	No	2	7.78	0.79	14.79	23.36	2,299
	9	No	3	7.78	1.11	15.32	24.21	2,317
	10	Yes	1	7.76	0.41	14.88	23.05	2,281
	11	Yes	2	7.76	0.79	14.78	23.33	2,299
	12	Yes	3	7.76	1.11	15.32	24.19	2,317
Low Trash	13	No	1	7.78	0.41	14.91	23.10	2,378
	14	No	2	7.78	0.79	14.82	23.39	2,410
	15	No	3	7.78	1.11	15.35	24.24	2,431
	16	Yes	1	7.45	0.41	14.91	22.77	2,378
	17	Yes	2	7.45	0.79	14.81	23.05	2,410
	18	Yes	3	7.45	1.11	15.35	23.91	2,431

$23.36 per bale for second best quality yarn (configuration 8), and $22.42 per bale for the third best quality yarn (configuration 2), given current cleaning practices (table 5). The least-cost cleaning configurations (configuration 16 for the best and the second best, and configuration 1 for the third best quality of yarn) suggest that the cleaning practices currently used are not optimal. Results of this study indicate that if least-cost cleaning configurations are employed, the cotton industry would save about $0.62 per bale when producing the best quality yarn, $0.59 per bale for the second best quality yarn, and $0.28 per bale when producing the third best quality yarn.

Conclusions

Texas farmers produce about 5 million bales of cotton per year. Based on this production figure, the Texas cotton industry would save about $2.5 million per year in cleaning costs if it is conservatively assumed that the recommended optimal cleaning configurations would save approximately $0.50 per bale. This represents a significant cost savings for the cotton industry.

Why is it a general practice to lint clean cotton twice in the gin plant? It is perhaps based on the perception that additional lint cleanings result in higher cotton quality, which in turn results in higher prices (Ethridge, Barker, and Bergan). In fact, prices estimated by the GINQUAL model based on the Commodity Credit Corporation (CCC) loan schedule clearly indicate that additional lint cleanings result in higher prices for producers. Since producers and ginners primarily utilize CCC loan schedule data to make production and ginning decisions, it is likely that gins choose to use multiple lint cleanings in expectation of higher prices. However, there is some evidence to suggest that the loan schedule may not be accurately reporting prices, premiums, and discounts in the Southwest region (Hudson, Ethridge, and Brown). This implies that the existing price reporting system may be encouraging multiple lint cleanings and, perhaps, is responsible for a cleaning practice that is suboptimal for the cotton industry. If price quotes can be made to accurately reflect the market, it could encourage more cleaning in the harvesting stage and less lint cleaning in the gin plant—a change that would reduce farm-to-mill cleaning costs.

Several other factors may be influencing excessive farm-to-mill cleaning costs in the cotton industry. Currently, a lack of reliable information about the effect of field cleaning on economic returns and quality characteristics of cotton lint has limited the adoption rate for field cleaning on the Southern High Plains of Texas. There also may be a perception that cotton quality characteristics may be compromised as a result of damage that may occur when field cleaners are used. Results of this study show, however, that cotton harvested with the use of a field cleaner possesses virtually the same quality parameters as cotton harvested without a field cleaner. In addition, the industry may be unaware of module transportation cost savings when cotton is harvested with the use of a field cleaner.

While this study is the first analytical attempt to determine optimal farm-to-mill cotton cleaning configurations, it has a number of limitations. Conclusions and implications drawn from this study are limited by the geographical focus (Texas High Plains) and the assumed crop practices (size of farm operation, irrigation, and stripper harvesting). Because of the absence of published data on cost estimates and quality effects for alternative cleaning configurations across the harvesting, ginning, and textile mill stages, it was necessary to use survey data and simulation results for the analysis. Further, potential variations in the effect of field cleaning arising from differences in variety were ignored due to lack of data. Therefore, attempts to apply the results of this study to individual scenarios should be exercised with caution.

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