A DECISION TOOL TO DETERMINE THE OPTIMAL LEVEL OF LINT CLEANINGS FOR IRRIGATED AND DRYLAND COTTON

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Abstract

This study analyzes the level of lint cleanings in the gin plant that would maximize producer net revenues for a range of cotton prices. Results indicate that no generalized prescription should be made. The optimal level of lint cleaning was found to depend on prices, price premiums resulting from additional lint cleaning, turnout percentage, and time of harvest.

Introduction and Objectives

A persisting question with cotton cleaning is the determination of the level of lint cleaning in the gin plant that would maximize producer net revenues. Several studies have addressed the issue of the optimal level of lint cleaning with an objective to maximize the price per pound of lint (Baker et al., 1977). A problem with this approach is that it ignores important factors such as the cost of lint cleaning and lint loss due to sequential stages of lint cleaning. Ethridge et al. (1995) addressed the consequences of successive stages of lint cleaning with an objective to maximize net revenue. In analyzing the effects on prices, lint loss, and cost of lint cleaning, they found two lint cleanings to be the optimal decision rule for the 1995 crop year. Ethridge et al. (1995), however, estimated price per pound of lint based on pre-HVI measurements of fiber attributes and only considered the energy cost of lint cleanings in their cost estimates. A recent study by Bennett et al. (1997), however, found one lint cleaning to maximize producer net revenues for the average price structure that existed in 1996. Bennett et al. (1997) hypothesized in their study that the change in the pricing structure (with the inception of the HVI measurement) may be primarily responsible for redefining the optimal level of lint cleaning at the gin plant. In addition, they were of the opinion that any further change in the pricing structure may alter the findings of their study.

This study, motivated by Bennett et al.'s hypothesis, examines the optimal number of lint cleanings in the gin plant for dryland and irrigated cotton cultivars for a range of prices and premiums. It further develops a predictive equation to determine the optimal level of lint cleaning for a range of prices and premiums, considering the total cost of ginning activities associated with different levels of lint cleaning, the cost of lint loss in the gin plant, and the price received for cotton.

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Methods

For purposes of this analysis, three groups of irrigated and dryland cotton cultivars were chosen based on their turnout percentages. Irrigated cotton groups were high turnout cultivars (Paymaster HS-26, Paymaster 145, and All-Tex Excess), medium turnout cultivars (Tamcot CAB-CS, Southland M-1, and Paymaster HS200), and low turnout cultivars (Lankart LX-571, Lankart PR-75, and Cencot). The three dryland turnout groups chosen were high turnout cultivars (All-Tex Atlas, Southland M-1, and Paymaster HS-26), medium turnout cultivars (GSC 25, Deltapine 50, and Tamcot CAB-CS), and low turnout cultivars (Lankart LX-571, Cencot, and GP 3755). The high turnout categories represent cultivars of cotton with high turnout ratios (24.53 percent for irrigated and 23.83 percent for dryland cotton), the medium turnout categories represent cultivars with medium turnout ratios (23.37 percent for irrigated and 20.33 percent for dryland cotton), and the low turnout categories represent cultivars with low turnout ratios (18.10 percent for irrigated and 16.87 percent for dryland cotton).

Cotton Lint Loss

A ginning simulation model, GINQUAL (Barker et al., 1991), was used to determine the effects of lint cleaning on cotton lint losses. The GINQUAL model simulated the processing of stripper harvested cotton at a rate of 15 bales per hour through a single 96 in. wide overhead cleaning stream consisting of: (1) an airline cleaner, (2) first tower dryer, (3) first incline cleaner, (4) first stick machine, (5) second tower dryer, (6) second incline cleaner, (7) second stick machine, and (8) extractor feeder. Cotton was processed using zero to three (88 inch wide) sequential lint cleaners. The simulated lint cleaners used a combing ratio of 30:1 with 16 inch diameter saws operating at 1000 rpm. The first and second tower dryers' drying temperatures were held constant at 300 and 150 degrees Fahrenheit, respectively, and the atmospheric temperature and relative humidity at 60 degrees Fahrenheit and 30 percent humidity, respectively. Initial estimates of micronaire, length, strength, and uniformity ratio provided by the GINQUAL model were used in the simulation.

The lint loss in the gin plant due to precleaning and successive levels of lint cleaning were estimated from the GINQUAL output for irrigated and dryland cotton, for different cultivars, and for different harvest dates, and for different levels of lint cleaning. Lint loss at each level of lint cleaning was calculated by subtracting the current level of turnout in percent from the previous stage lint turnout in percent. The resulting lint turnout difference was multiplied by 2,300 lbs. of initial seed cotton entering the gin plant and was further adjusted to a lint loss weight per bale.

Cost and Revenue Estimation

A survey of local ginners was taken and the survey results were used in the ginning cost simulator, GINMODEL (Childers, 1995), to determine the cost of ginning for successive stages of lint cleanings. GINMODEL calculates fixed and variable ginning costs for simulated gins at various processing utilization rates and gin capacities. Output from GINMODEL consists of total and per bale ginning costs separated into fixed and variable components. These costs are calculated for processing utilization levels ranging from one-hundred percent to ten percent. The per bale ginning cost, for the purposes of this analysis, was used for those gins operating at one-hundred percent utilization. Ninety to fifty percent utilizations are not reported in this study because no differences were observed from the results found with one-hundred percent utilization.

GINMODEL does not, however, account for increases in costs attributed to lint loss and higher levels of lint cleaning. This cost was determined by multiplying the hypothetical prices of cotton, discussed later, after being subjected to one, two, and three lint cleanings and the pounds of lint losses corresponding to the respective sequential stages of lint cleaning calculated from the GINQUAL outputs. The total costs of ginning were determined by adding the costs of ginning calculated from GINMODEL and the costs of lint loss. Revenues were then determined by multiplying the prices of cotton after being subjected to one, two, and three lint cleanings and 480 lbs. (1 bale). Finally, net revenues were determined by subtracting the total costs of ginning, including the costs of lint loss, from the revenues for sequential stages of lint cleaning.

Price and Price Premium Determination

Initial prices were examined on $0.05 per pound intervals between the ranges of $0.50 per pound and $1.10 per pound. Each of these twelve initial prices was assigned to cotton after being subjected to one lint cleaning in the gin plant. Lint loss costs and revenues from the sale of processed cotton lint were determined by utilizing these initial prices in the lint loss and revenue determination discussed above.

Prices required to justify two lint cleanings over one lint cleaning were determined by increasing price premiums over the initial prices until net revenues for two lint cleanings were just greater than net revenues associated with one lint cleaning. It should be noted that for the purpose of this study, price premiums refers to the total premium for cotton (total premium = premiums - discounts). These adjusted prices (initial prices plus price premiums) were used in the cost and revenue calculations for cotton subjected to two lint cleanings. The differences between the initial and adjusted prices represent the premiums required to justify two lint cleanings, over one lint cleaning, in the gin plant. A similar approach was used in determining the premiums required to justify three lint cleanings, over two lint cleanings, in the gin plant. This was done by further increasing price premiums over the initial prices until net revenues for three lint cleaned cotton were just greater than net revenues associated with two lint cleanings.

Predictive Equation

To establish an equation that could be used to predict the price premium required to move to a higher level of lint cleaning in the gin plant, the simulated price premiums were regressed against the prices of cotton at the current level of lint cleaning, the methods of production, the turnout characteristics, and the times of harvest (equation 1),

$$\text{Premium} = f\,(\text{Price, ProdM, Turnout, Time}) \qquad (1)$$

where Premium is the price premium required to move to the next level of lint cleaning in the gin plant, Price represents the price of cotton at the current level of lint cleaning, ProdM represents the method of cotton production, Turnout is the characteristics of the cotton with regard to turnout, and Time represents the time of harvest.

Results

Revenues, costs, and net returns were standardized to yield per bale revenues, costs, and net returns. The optimal number of lint cleanings for both irrigated and dryland cotton were found to depend on price at the current level of lint cleaning, time of harvest, and cotton turnout percentage. Specifically, for a given price level, one lint cleaning was found to be optimal for irrigated and dryland cotton for a relatively lower price premium, two lint cleanings for a moderate price premium, and three lint cleanings for a relatively high price premium. However, as the price increased, the magnitude of required price premiums increased to make higher levels of lint cleanings optimal.

Figure 1 represents the price premiums required to justify two lint cleanings over one lint cleaning in the gin plant for irrigated and dryland cotton for a range of prices. The price on the horizontal axis refers to the price ginners expect to receive for cotton that is lint cleaned once in the gin plant. The required price premium on the vertical axis refers to the total premium required to justify two lint cleanings over one lint cleaning in the gin plant. For example, if a ginner estimates that a lot of irrigated, mid-season harvested cotton with medium turnout, lint cleaned once in the gin plant will command a price of $0.67/lb., then a price premium of at least $0.01687/lb. will be required to justify cleaning the lot twice in the gin plant. With regard to irrigated cotton, any combination of price and price premium resulting in a point in the area below the irrigated cotton line indicates one lint cleaning being optimal. Any combination resulting in a point on or above the irrigated cotton line indicates a situation where two lint cleanings are optimal.

Similar results were derived for dryland cotton. It was found, however, that dryland cotton cultivars required a higher price premium than irrigated cultivars to justify more cleaning in the gin plant. For example, if a ginner estimates that a lot of dryland, mid-season harvested cotton with medium turnout, lint cleaned once will command a price of \$0.67/lb., then a price premium of at least \$0.017001/lb. will be required to justify two lint cleanings in the gin plant.

Results regarding price premiums required to justify three lint cleanings over two lint cleanings in the gin plant were found to be similar to those found above (Figure 2). In this case, price on the horizontal axis refers to the price ginners expect to receive for cotton that is lint cleaned twice in the gin plant. The required price premium on the vertical axis refers to the total premium required to justify three lint cleanings over two lint cleanings in the gin plant.

It was also found that as turnout percentages increased, lower price premiums were required to justify more lint cleaning in the gin plant (Figures 3 and 4). Specifically, low-turnout cotton cultivars required the highest price premiums, followed by medium turnout cotton cultivars, and finally, high-turnout cotton cultivars required the lowest price premium to justify more cleaning in the gin plant. For example, holding the price of irrigated, mid-season harvested cotton after one lint cleaning constant at \$0.67/lb., low, medium, and high turnout cultivars were found to require price premiums of \$0.01768/lb., \$0.01687/lb., and \$0.01645/lb. to justify two lint cleanings in the gin plant, respectively.

Results showed that cotton harvested later in the season required higher price premiums to justify two lint cleanings over one lint cleaning than cotton harvested earlier in the season (Figure 5). For example, holding the price of irrigated, medium turnout cotton after one lint cleaning constant at \$0.67/lb., early and mid/late harvested cotton were found to require price premiums of \$0.01674/lb. and \$0.01687/lb. to justify two lint cleanings in the gin plant, respectively. However, there does not appear to be any difference between time of harvest and price premium required to justify three lint cleanings over two lint cleanings in the gin plant (Figure 6).

Equations 2 and 3 represent the predictive equations that can be used to predict the price premium required to justify two lint cleanings over one lint cleaning and three lint cleanings over two in the gin plant with the standard errors in parenthesis below the coefficients.

$$Pre_{12} = \underset{(0.000095)}{0.424E\text{-}3} + \underset{(0.000035)}{0.024547P_1} + \underset{(0.000043)}{0.131E\text{-}3D} - 0.42E\text{-}3HT + \underset{(0.000043)}{0.81E\text{-}3LT} - \underset{(0.000038)}{0.13E\text{-}3EH} \quad (2)$$

where: Pre_{12} = the estimated price premium required to justify two lint cleanings over one lint cleaning in the gin plant,
P_1 = the price cotton cleaned with one lint cleaning can acquire,
D = a binary variable representing the method of production (D = if dryland cotton, 0 otherwise),
HT = a binary variable representing high turnout cotton (HT = 1 if cotton has high turnout, 0 otherwise),
LT= binary variable representing low turnout cotton (LT = 1 if cotton has low turnout, 0 otherwise), and
EH = a binary variable representing cotton that is harvested early (EH = 1 if cotton is harvested early, 0 otherwise).

Equation 2 indicates that as the price of cotton that is lint cleaned once increases, the premiums required to justify two lint cleanings over one lint cleaning increases. Further, high turnout cultivars of cotton require lower and low turnout cultivars of cotton require higher price premiums than medium turnout cultivars to justify two lint cleanings over one lint cleaning in the gin plant. Finally, early harvested cotton was found to require a lower premium to justify two lint cleanings in the gin plant than mid-season and late season harvested cotton.

Equation 3 represents the predictive equation that can be used to predict the price premium required to justify three lint cleanings over two lint cleanings in the gin plant with the standard errors in parenthesis below the coefficients.

$$Pre_{23} = 0.635E\text{-}3 + \underset{(0.000285)}{0.9417E\text{-}2P_2} + \underset{(0.000113)}{0.279E\text{-}3D} - \underset{(0.000138)}{0.18E\text{-}3HT} + \underset{(0.000138)}{0.315E\text{-}3LT} + \underset{(0.000119)}{0.18E\text{-}5EH} \quad (3)$$

where: Pre_{23} = the estimated price premium required to justify two lint cleanings over one lint cleaning in the gin plant, and
P_2 = the price cotton cleaned with two lint cleanings can acquire.

As with equation 2, equation 3 indicates higher price premiums are required to justify three lint cleanings over two lint cleanings in the gin plant as the price of cotton lint cleaned twice increases. Further, high turnout cultivars require a lower and low turnout cultivars require a greater price premium than medium turnout cultivars to justify three lint cleanings over two lint cleanings in the gin plant. Finally, early harvested cotton was found to require a greater premium to justify three lint cleanings in the gin plant than mid-season and late season harvested cotton, but was not statistically significant supporting the findings in Figure 6. This suggests that time of harvest does not significantly affect the premium required to justify three lint cleanings over two lint cleanings in the gin plant.

Practical Illustration

Suppose a ginner is faced with the decision of how many times to lint clean a given lot of cotton, assuming that the ginner wishes to maximize the producer's net revenue. To determine method of cleaning (using one, two, or three lint cleanings) the lot of cotton, equation 1 and equation 2 can be used. The ginner must input the required information into the equations to determine the price premiums that must be attained for an additional lint cleaning to be profitable. For example, let us assume the ginner estimates that a lot of dryland, early harvested cotton with low turnout cleaned with one lint cleaner will command a price of \$0.72/lb.. To determine the price premium that must be attained to make two lint cleanings return a greater net revenue than one lint cleaning, equation 2 must be used.

$$Pre_{12} = 0.424E\text{-}3 + 0.024547*(P_1{=}0.72) + 0.131E\text{-}3*(D{=}1) - 0.42E\text{-}3*(HT{=}0) + 0.81E\text{-}3*(LT{=}1) - 0.13E\text{-}3*(EH{=}1) \quad (2)$$

Pre_{12} = \$0.018909/lb.

Thus, the lot of cotton will require a total premium of at least \$0.018909/lb. in order to justify cleaning the cotton with two lint cleanings in the gin plant. Any premium less than \$0.018909/lb. suggests that one lint cleaning will maximize the producer's net revenue. Any premium greater than or equal to \$0.018909/lb. suggests two lint cleanings will maximize the producer's net revenue.

Now let us assume another lot of irrigated, late-season harvested cotton with medium turnout is to be ginned, and the ginner expects that this lot will command a price of \$0.77/lb. after two lint cleanings. To determine whether or not to clean the cotton with three lint cleanings, the ginner must input the necessary information into equation 3.

$$Pre_{23} = 0.635E\text{-}3 + 0.9417E\text{-}2*(P_2{=}0.77) + 0.279E\text{-}3*(D{=}0) - 0.18E\text{-}3*(HT{=}0) + 0.315E\text{-}3*(LT{=}0) + 0.18E\text{-}5*(EH{=}0) \quad (3)$$

Pre_{23} = \$0.007881/lb.

In this case the lot of cotton must receive a total premium of at least \$0.007881/lb. in order to justify cleaning the cotton with three lint cleanings in the gin plant. Any premium less than \$0.007881/lb. suggests that two lint cleanings will maximize the producer's net revenue. Any premium greater than or equal to \$0.007881/lb. suggests three lint cleanings will maximize the producer's net revenue.

Conclusions

Results of this study suggest that the premium required to justify increased lint cleanings in the gin plant is dependent on the price at the current level of lint cleaning, time of harvest, and cotton turnout percentage. It was determined that higher price premiums were required to justify more lint cleaning in the gin plant as the price received at the current level of lint cleaning increased. Dryland cotton was found to require a higher price premium than irrigated cotton to justify more lint cleaning in the gin plant. Further, as the turnout percentage cotton increased, the price premium required to justify more lint cleaning in the gin plant decreased. Finally, cotton harvested earlier in the season required less of a price premium than cotton harvested later in the season to justify two lint cleanings in the gin plant.

Currently the existing practice in the cotton industry is to lint clean cotton twice in the gin plant. Previous research on machine-stripped cotton also have suggested two lint cleanings to be the best general rule. This generalization may not be accurate at various levels of cotton prices, premiums, discounts, turnout percentages, and times of harvest. This general rule may be accurate when prices are relatively low. However, when prices increase, this study has found that higher premiums are required to justify more lint cleaning in the gin plant. Thus, the cotton industry requires additional information about factors such as current price levels, factors of production (dryland or irrigated), turnout percentages, and times of harvest to make an informed decision concerning the optimal number of lint cleanings.

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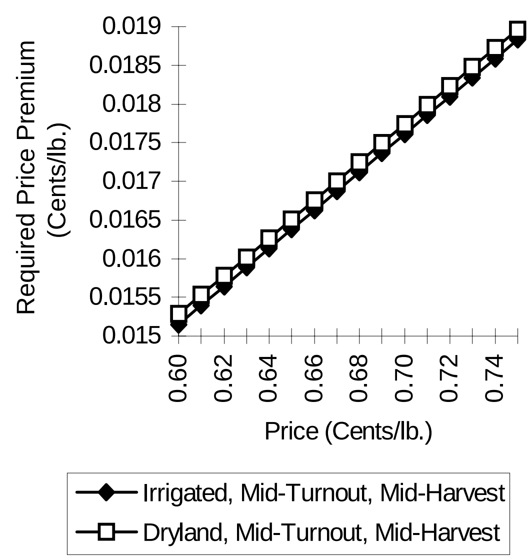

Figure 1. Price premium required to justify two lint cleanings over one lint cleaning in the gin plant for irrigated and dryland cotton.

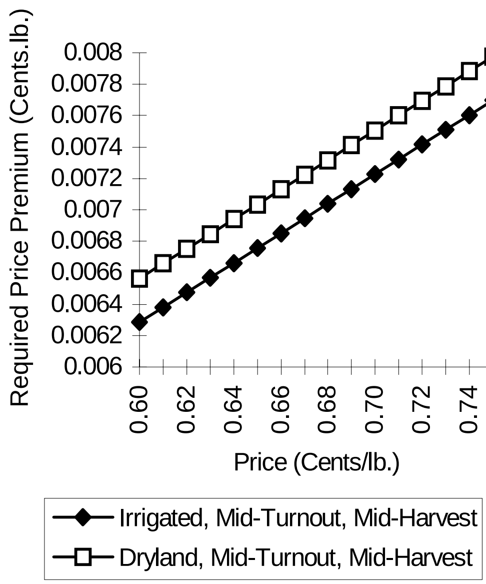

Figure 2. Price premium required to justify three lint cleanings over two lint cleanings in the gin plant for irrigated and dryland cotton.

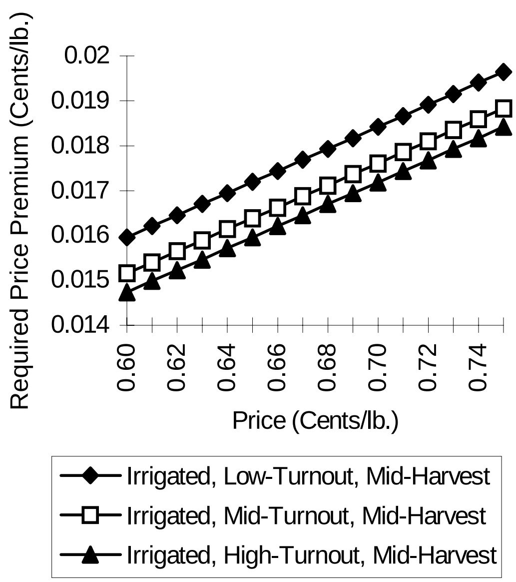

Figure 3. Price premium required to justify two lint cleanings over one lint cleaning in the gin plant for irrigated, low, medium, and high turnout cotton cultivars.

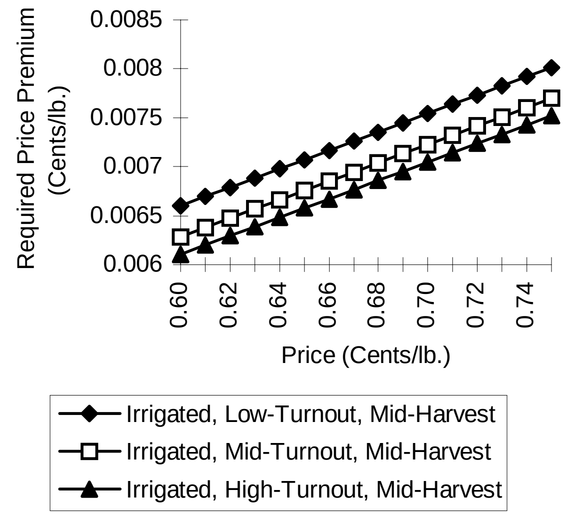

Figure 4. Price premium required to justify three lint cleanings over two lint cleanings in the gin plant for irrigated, low, medium, and high turnout cotton cultivars.

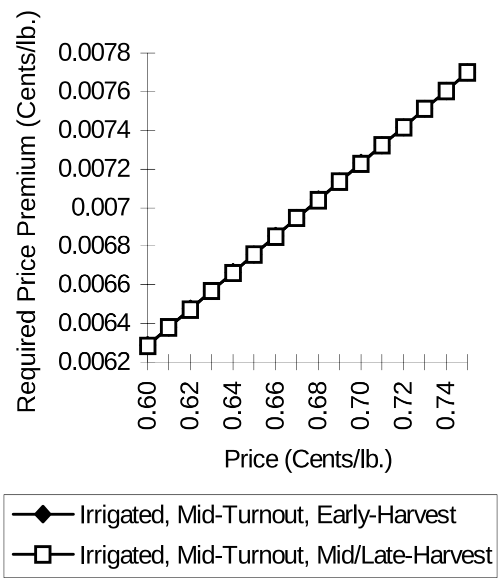

Figure 5. Price premium required to justify two lint cleanings over one lint cleaning in the gin plant for irrigated, early-harvested, and mid/late-harvested cotton.

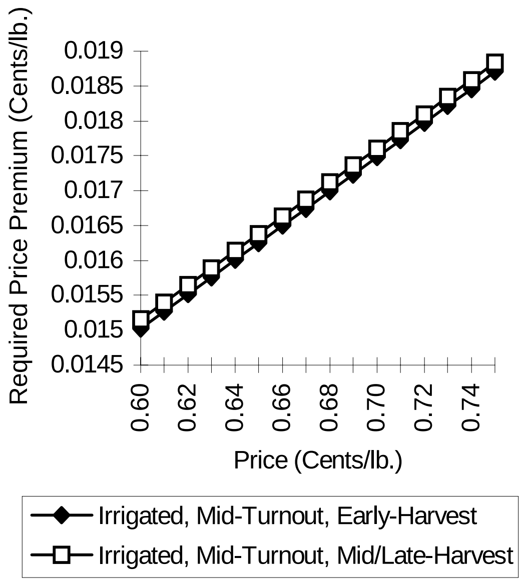

Figure 6. Price premium required to justify three lint cleanings over two lint cleanings in the gin plant for irrigated, early-harvested, and mid/late-harvested cotton.