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ECONOMICS AND MARKETING

Irrigation Termination of Cotton: An Economic Analysis of Yield, Quality, and Market Factors

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ABSTRACT

The decision to terminate the irrigation of cotton (*Gossypium hirsutum* L.) is complicated by interactions and uncertainties related to lint yield and quality, water costs, and market factors. High, medium, and low values for the cost of water, lint price, and quality discount/premium schedule for High Volume Instrument (HVI) quality factors were applied to lint yield and quality differentials realized from irrigation termination experiments conducted in central Arizona for the crop years of 1991 and 1992, 1994 through 1997, and 2000. Deviations in lint yield and quality for the first irrigation termination treatment versus the subsequent second and third irrigation termination treatments are the agronomic basis of this study. Irrigation termination dates were defined by heat units after planting (31/12.8º C or 86/55º F) to place the crop progression of different experimental sites and years on a more equal basis than using calendar dates. Classification and regression tree analysis was used to quantify the data. The relative ranking of results from this procedure in which the most important variable is normalized on 100 were as follows: cultivar (100), additional heat units after the first irrigation termination treatment (94), yield of first irrigation termination treatment trial (93), year of the field experiment or crop year (83), micronaire associated with the first irrigation termination treatment (68), heat units after planting for the first irrigation termination treatment (67), lint price (5), water cost (2), and the quality discount/premium year (0.09). In general, the season needs to be extended at least 330 to 360 heat units Centigrade (600 to 650 heat units Fahrenheit) to yield a profitable return for cultivars with potential to produce a top-crop. Also, a crop that has a yield less than 1533 kg ha^{-1} (1368 lb ac^{-1}) at the first irrigation termination treatment is more likely to have the potential for producing a profitable top-crop than a crop that has already set a fruit boll load greater than this level.

A profit function for the producer of an agricultural commodity is commonly derived assuming that the level of factor inputs applied does not impact the output price received (e.g., Bontems and Thomas, 2000; Cochran et al., 2001; Dai et al., 1993; Debertin, 1986; Isik et al., 2001; Larson et al., 2001; Moffitt et al., 1984; and Kumbhakar, 2001). While this assumption may be reasonable for commodities like feed grains, this framework has serious limitations for analyzing the irrigation termination decision for cotton (*Gossypium hirsutum* L.). Cotton is priced according to fiber length, strength, micronaire, uniformity, trash, and color as measured by High Volume Instrument (HVI). Micronaire or fiber diameter, which is also related to fiber maturity, is of particular interest in the decision to terminate irrigation. That is, extending the season to produce a "top-crop" through a second fruiting cycle has the potential to lower the overall micronaire average of a plant since these top bolls will be relatively fine or low in micronaire compared with the more mature bottom bolls. Extending the season can also exacerbate the problem of high micronaire if a significant reduction in fruit retention occurs late in the season. It is reasoned that unless plants gain a significant boll load, carbohydrates will be loaded into existing bolls and increase the micronaire level of the crop. Prior irrigation termination studies (Moffitt et al., 1984; Silvertooth et al., 2001, and Unruh and Silvertooth, 1997) have not accounted for lint quality effects in analyzing the profitability of the irrigation termination decision for cotton.

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Average micronaire of cotton has been increasing for the U.S. Cotton Belt over the last 25 years (Figure 1). From 1975 to 2000, the trend has been for average micronaire to increase by 0.0092 and 0.0113 each year for the United States and Arizona, respectively. Since breeders and producers continue to select for higher yields, it is not surprising that micronaire has increased, because one way to obtain higher yields is to produce a fiber with a structurally thicker cell wall that weighs more. Because high day and night temperatures combined with abundant sunlight and ample soil moisture are conducive for producing high micronaire cotton, Arizona has a higher overall micronaire level than the rest of the USA (Figure 1).

The upward trend in micronaire has caused a sharp increase in the amount of cotton classed in the high micronaire discount range for regions like Arizona. The Phoenix classing office classified 38.6% of the 1999 crop for Arizona with a micronaire reading of 5.0 or greater that was discounted due to high micronaire (Figure 2). In 1991, about half of this cotton or 19.4% of Arizona's crop was discounted for having undesirably high micronaire readings. Given that high temperature and arid production regimes generally coincide with irrigated production, high micronaire is likely to be an issue for other irrigated cotton regions around the world. It is estimated by the International Cotton Advisory Committee (2001) that 55% of world cotton production comes from irrigated land and even some of the rest relies on partial irrigation.

Table 1 describes the discount/premium schedule that has been received for different micronaire

Figure 1. Average micronaire and trend for the U.S. and Arizona, 1975-2000. Source: AMS/USDA Classing Offices

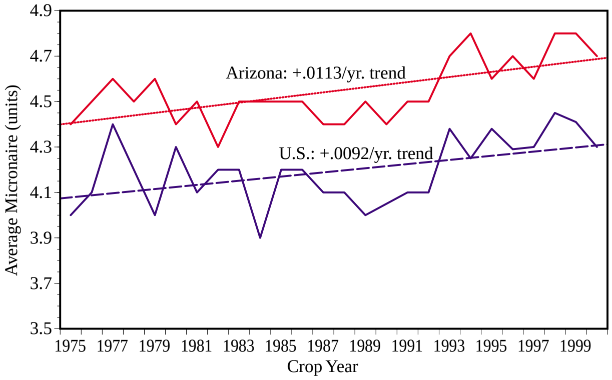


Figure 2. Micronaire distribution for the 1999 cotton crop from selected U.S. classing offices. Source: AMS/USDA Classing Offices

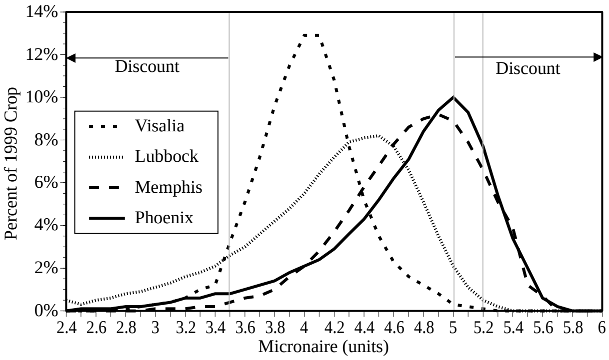


Table 1. Prices and the accompanying micronaire discount/premium schedule, 1990-2001

Year	Discount/premium for micronaire ranges (¢/kg)										
	31-3/35[z]	<2.4	2.5-2.6	2.7-2.9	3.0-3.2	3.3-3.4	3.5-3.6	3.7-4.2	4.3-4.9	5.0-5.2	>5.3
1990	167.6		-46.3	-30.9	-17.6	-7.7	0.0	0.0	0.0	-2.2	-3.3
1991	124.8	-37.5	-30.9	-22.1	-9.9	-4.4	0.0	0.6	0.0	-2.2	-4.4
1992	113.1	-35.3	-28.7	-24.3	-11.0	-5.5	0.0	0.6	0.0	-4.4	-6.6
1993	122.8	-30.9	-24.3	-19.8	-8.8	-3.3	0.0	0.6	0.0	-7.7	-9.9
1994	165.4	-30.9	-24.3	-19.8	-8.8	-3.3	0.0	0.6	0.0	-3.3	-5.0
1995	188.2	-30.9	-24.3	-19.8	-8.8	-3.3	0.0	0.6	0.0	-7.7	-11.0
1996	159.5	-35.3	-30.9	-27.6	-15.4	-3.3	0.0	0.6	0.0	-7.7	-15.4
1997	153.2	-35.3	-30.9	-27.6	-15.4	-3.3	0.0	0.6	0.0	-4.4	-8.8
1998	141.1	-35.3	-30.9	-27.6	-15.4	-3.3	0.0	0.6	0.0	-4.4	-8.8
1999	104.8	-35.3	-30.9	-27.6	-15.4	-3.3	0.0	0.6	0.0	-17.6	-22.1
2000	128.0	-35.3	-30.9	-27.6	-15.4	-3.3	0.0	0.6	0.0	-15.4	-19.8
2001	77.6	-26.5	-22.1	-17.6	-6.6	-3.3	0.0	0.6	0.0	-6.6	-11.0

[z] **Desert Southwest prices for the last week in November for 31-3/35 cotton in uncompressed bales (source: AMS/USDA).**

readings in the last week of November from 1990 to 2001. Micronaire readings of 5.0 to 5.2 received just a 2 to 8¢ kg^{-1} (1 to 3.5¢ lb^{-1}) discount prior to 1999. Since then, the discount associated with 5.0 to 5.2 micronaire has increased to 18¢ kg^{-1} (8¢ lb^{-1}). This discount reduces the net market price received by a grower by 10 to 15%. Micronaire readings of 5.3 or greater accounted for 11.6% of Arizona's crop in 1999. The 22¢ kg^{-1} (10¢ lb^{-1}) discount associated with this high level of micronaire in 1999 reduced the net price received by almost 20% compared with the more desirable micronaire readings in the 3.5 to 4.9 range. Some cotton marketing professionals believe that high micronaire has cost Arizona producers \$20 to \$25 million per year in recent years (Silvertooth et al., 2001).

Changes in lint quality from extending the season can have a dramatic impact on profit since both the "base yield" and any additional yield are affected. For example, if the initial yield is 1345 kg ha^{-1} (1200 lb ac^{-1}) and 23 kg (50 lb) of additional lint are obtained from extending the season, a 9¢ kg^{-1} (4¢ lb^{-1}) quality enhancement would increase revenues by \$124 ha^{-1} (\$50 ac^{-1}). This is more than double the \$62 ha^{-1} (\$25 ac^{-1}) that would be received from the extra 23 kg (50 lb) of lint from extending the season, assuming a base price near the loan rate at 110¢ kg^{-1} (50¢ lb^{-1}). The primary objective of this paper is to identify both agronomic and economic combinations that are profitable or not conducive to extending the season for cotton, considering both yield and quality components.

MATERIALS AND METHODS

Irrigation termination studies conducted in central Arizona for the seven years of 1991 and 1992, 1994 to 1997, and 2000 are the basis for this analysis. To quantify the progression of each crop among different years on a relatively equal basis, heat units after planting (31/12.8° C or 86/55° F) accumulated by the irrigation termination dates of each study were obtained from the nearest University of Arizona Meteorological weather station. A total of 198 irrigation termination experiments were available with lint quality measures that included at least micronaire. These 198 observations comprise 67 experiments that are used to determine the first or baseline irrigation termination treatment. Another 67 experiments consist of the second irrigation termination treatment, while 64 experiments had a third irrigation termination treatment. The deviations in lint yield, quality, and production costs for the second and third termination treatments compared with first termination treatment are the basis for this analysis.

In evaluating the timing of irrigation termination and ceasing other crop inputs, both agronomic and economic factors need to be considered. Crop maturity, cultivar, existing boll load, and micronaire readings of base cotton bolls can provide signals on the potential for additional yield and for changes in micronaire associated with extending the season. Genetics, environment, and management all influence fiber properties like micronaire. Economic factors such as the price of lint, micronaire discount/premium schedule, harvest and interest costs, plus the cost of crop inputs like water, insecticides, fertilizer, and labor will also impact the profitability of extending the season.

The onset of cutout occurs when the number of nodes above the uppermost, first-position, fresh white flower equal five (Bourland et al., 2001). The first irrigation termination date was predicated on having sufficient moisture to carry these final blooms to complete fiber length development or full-sized hard green bolls. Therefore, factors like evapotranspiration, water holding capacity of the soil, and the amount of water applied at each irrigation also influenced the first irrigation termination date. The first irrigation termination date for field experiments in 2000 was identified using final blooms tagged when the number of nodes above the uppermost, first-position, fresh white flower equaled five or six rather than five. This slightly earlier termination date or essentially dropping an irrigation from the other protocol was made to explore whether returns would be robust with potentially lower micronaire readings and lower water costs in spite of fewer bolls harvested.

To help quantify the impact of key economic factors associated with base lint price, discount/premium schedule for micronaire, and cost of water, the profitability of each experiment was determined assuming a low, medium, and high value scenario for each of these components. That is, the profitability of extending the season on each of the 131 experiments was solved for using the following possible combinations: 1) a base lint price of 110, 132, and 154¢ kg^{-1} (50, 60, and 70¢ lb^{-1}), 2) a discount/premium schedule for micronaire and lint quality that existed in November of 1994, 1996, or 1999, and 3) a water cost of either \$81, \$284, or \$487 per hectare-meter (\$10, \$35, or \$60 per acre-foot). Applying these 27 different possible price and cost combinations to the 131 termination experiments resulted in 3537 possible return combinations that were utilized in the data analysis.

Other assumptions used to calculate the return for each possible combination were as follows: harvest and ginning costs occur at 22¢ kg^{-1} (10¢ lb^{-1}), cottonseed equals 175% of lint weight (turnout of 36.36%) and is valued at 14.3¢ kg^{-1} (6.5¢ lb^{-1}), an irrigation requires 0.74 h ha^{-1} (0.3 h ac^{-1}) of labor and this labor costs \$5.75 h^{-1}, the opportunity cost of foregone revenues from extending the season were charged at 10%/365 day^{-1} (conversion of annual 10% interest rate to a daily interest rate) for the days between harvest of the first irrigation termination treatment and the extended treatment, and insecticide, fertilizer, defoliation, and any other remaining costs were added at \$0.75 day^{-1}. This value of \$0.75 day^{-1} is on the low end of that actually experienced for most of the crop years considered, to reflect the recent widespread adoption of Bollgard or *Bacillus thuringiensis* Berliner var. *kurstaki* (Bt) cotton and the accompanying reduced insecticide spray requirements for pink bollworm [*Pectinophora gossypiella* (Saunders)] late in the season (Agnew and Baker, 2001; Ellsworth and Jones, 2001). In addition, acreage currently not planted with Bollgard is primarily where the threat of pests controlled by Bollgard is perceived to be low, so it would be inappropriate to apply a high insecticide cost to non-Bollgard cultivars. Irrespective, returns presented in this analysis could be adjusted to provide insights on irrigation termination decisions where costs differ from the values utilized.

Profitable agronomic and economic combinations for extending the season were identified using the non-parametric procedure of classification and regression trees. This is a computationally intensive statistical algorithm that was also used to determine the relative importance of factors for influencing the profitability of extending the season. Independent variables used to explain the return of extending the season were as follows: 14 cultivars, heat units after planting for the first irrigation termination date, heat units accumulated after the first irrigation termination treatment, year of the field experiment or crop year, yield and micronaire of first irrigation termination treatment experiments, base lint price, price year for quality discounts/premiums (last week in November for 1994, 1996, or 1999), and water cost.

To better understand the classification and regression tree algorithm, envision a jar full of marbles where each marble is identified with a return from irrigation termination. Each marble or return is also labeled with the value of each independent variable. The first question the classification and regression tree algorithm addresses is what variable and accompanying magnitude can be used to divide the marbles into two jars so that the returns in each jar are as close to one another as possible. For this analysis, closeness refers to the total sum of squared errors for all marbles and the predictor value for each jar is simply the average of all marbles in the jar. Subsequent divisions occur until all returns are placed into terminal categories or nodes of the same value or less than a minimum number of observations (five for our analysis). Although a variable may not give the best split for a node, it may give the second or third best split. This concept of surrogate splits is used by classification and regression tree analysis to determine the relative importance of different variables. A surrogate split is essentially how well each variable predicts the action of the best linear split. The classification and regression tree algorithm keeps track of the performance of each variable for all splits and normalizes all variables so that the most important variable has a ranking of 100. This procedure was used to quantify the relative importance of agronomic and economic factors for the irrigation termination decision.

A tree with one node for every observation would have no node impurity but would likely produce spurious results from a test sample, whereas a very small sized tree would inadequately represent the relationships embodied in the data. The accuracy or “standard error” associated with trees of different sizes was determined using the *v*-fold (*v* equal to 10 for our results) cross-validation procedure. The cross-validation procedure has been referred to as the “leave-one-out” estimate. First, the entire data are randomly divided into *v* different subsets, $L_1, \ldots, L_v$, that are equal or nearly equal in size. A classification tree with a specified number of terminal nodes is computed *V* times, each time leaving out one of the L_v subsamples to serve as a test sample. Misclassification costs for each L_v test sample are then averaged over each of the different sized trees to determine their respective cross-validation error.

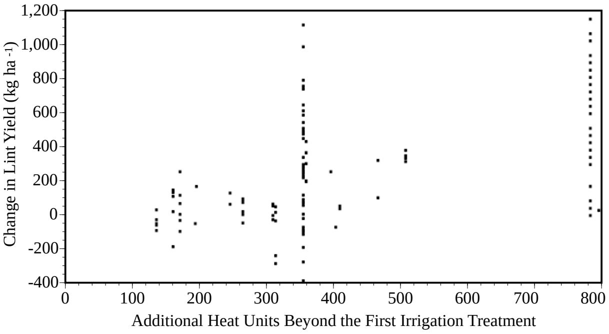
As described by Sorensen et al. (2000), advantages associated with classification and regression tree analysis include, 1) intuition provided by the hierarchy of the estimated binary tree, 2) accounting for non-linearities in the data, and 3) accounting for dependencies among variables. Advantages to classification and regression tree analysis over grouping methods like cluster analysis are that it does not need any data normalization or recoding/elimination of extreme values that is often required for cluster analysis (Cunningham and Maloney, 2001) and it provides a relative importance ranking for all variables. Additional information regarding the procedures and properties of estimates obtained from classification and regression tree analysis are discussed in Breiman et al. (1984), Efron and Tibshirani (1991), Horowitz and Carson (1991), Lim et al. (1997), and Tronstad (1995).

RESULTS

Agronomic indicators for extending the season profitably are cultivar, heat units accumulated during the extended season, yield, micronaire, and heat units after planting associated with the first irrigation termination date. Applying the classification and regression tree algorithm to the 3537 possible combinations of return revealed that agronomic factors are better signals for predicting the profitability of extending the season than the economic factors of lint price, HVI quality discount/premium schedule, and water cost. The relative ranking criteria of the classification and regression tree analysis was cultivar (100), additional heat units after the first irrigation termination treatment (94), yield of the first irrigation termination treatment (93), year of the field experiment or crop year (83), micronaire associated with the first irrigation termination treatment (68), heat units after planting for the first irrigation termination treatment (67), lint price (5), water cost (2), and the quality discount/premium year (0.09). Cultivar influences both the yield potential for a top-crop and the propensity of the genetics of the crop for producing high micronaire cotton. Both base yield and micronaire associated with the first irrigation termination date provide signals on the potential of the crop to produce a significant top-crop and to increase micronaire without moving into the discount range. The heat units after planting for the first irrigation termination treatment provide a signal of the developmental stage of the crop in relation to its fruiting cycle.

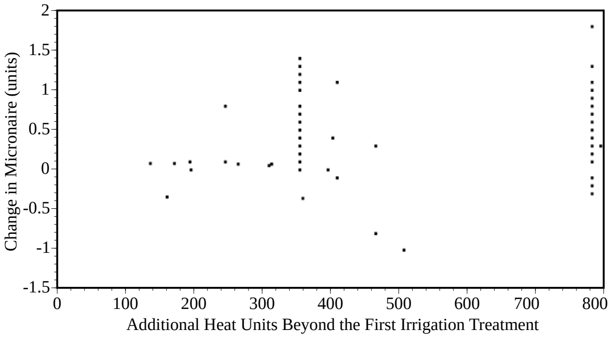
While economic factors of lint price and water cost influence profitability, their impact is relatively small compared to agronomic factors. For example, extending the season from the first to second termination date or anywhere from 137 to 467 heat units Centigrade (247 to 840 heat units Fahrenheit) resulted in a yield change that ranged anywhere from -384 to 1120 kg ha^{-1} (-343 to 999 lb ac^{-1}) and averaged 192 kg ha^{-1} (171 lb ac^{-1}) (Figure 3). Extending the season for studies with three termination dates or anywhere from 266 to 796 heat units Centigrade (478 to 1432 heat units Fahrenheit) also resulted in significant yield variation. Yield changes for these experiments averaged 387 kg ha^{-1} (345 lb ac^{-1}) and ranged from -282 to 1153 kg ha^{-1} (-252 to 1029 lb ac^{-1}). Given the range in yields associated with these experiments, it is not surprising that lint price is a relatively small component. That is, the maximum range in lint price is only 44¢ kg^{-1} (20¢ lb^{-1}) or 33% of the value of its average, whereas yield changes range from -384 to 1153 kg ha^{-1} (-343 to 1029 lb ac^{-1}) or by 536% of the average yield change associated with all field plots. Given that the additional water applied ranged from 0.094 to 0.610 meters ha^{-1} (0.31 to 2.0 feet ac^{-1}) and water costs varied from \$81.10 to \$486.62 per hectare-meter (\$10 to \$60 per acre-foot), the range in cost associated with water and irrigation labor was anywhere from \$11.93 to \$313.57 ha^{-1} (\$4.83 to \$126.90 ac^{-1}). While this range of \$301.65 ha^{-1} (\$122.07 ac^{-1}) is quite large, it is relatively small compared with the \$1695.11 (\$686.00) range in lint revenues realized from different yield changes with only 110¢ kg^{-1} (50¢ lb^{-1}) lint prices.

Figure 3. Change in lint yield (kg ha^{-1}) from extending the season beyond the first irrigation termination treatment, 31/12.8º Centigrade heat units.



The market discount/premium associated with lint quality was also relatively small compared to agronomic factors for explaining profitability. Figure 4 illustrates the change in micronaire realized for the experiments from their respective first irrigation termination treatment levels. Because some experiments were replications where each plot was weighed separately in trailers, but combined into a module from which sub-samples were taken to determine lint quality, the number of individual data points is less for quality than quantity. An increase in micronaire is not necessarily an issue until it exceeds a threshold value (Table 1). Being able to predict whether a crop will exceed a specified micronaire level appears to be more important for explaining profitability than knowing whether the discount associated with high micronaire is relatively low or high (i.e., 1994 versus 1999 prices).

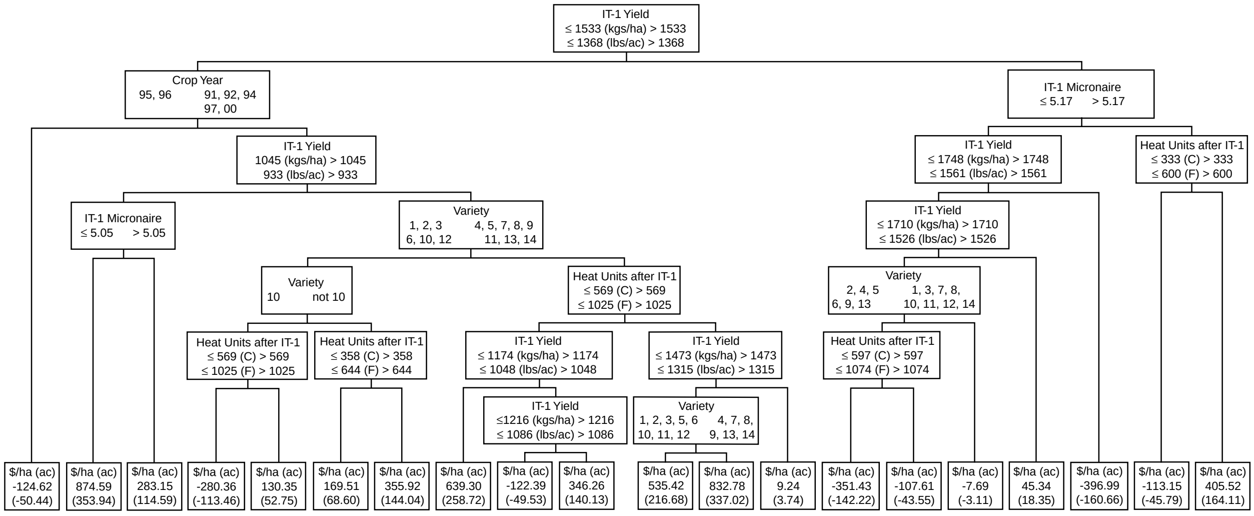
Figure 4. Change in micronaire from extending the season beyond the first irrigation termination treatment, 31/12.8º Centigrade heat units.



Future ginning technology will likely place more importance on fiber uniformity than current ginning technology and the imputed range in premium/discount schedules reported by the Agricultural Marketing Service. The price premium/discount range for uniformity is generally less than 2¢ kg^{-1}, but the premium/discount for high micronaire can reach 22¢ kg^{-1} (Table 1). Even though uniformity will most likely become a more important quality-price component in the future, it was not a noticeable factor for the production and price data utilized. Uniformity remained rather constant within the 78% to 82% range irrespective of the irrigation termination treatment and in some cases uniformity actually improved with a later irrigation termination date. Uniformity premiums/discounts were applied to experiments with uniformity data using the Nov. 1994, 1996, and 1999 price schedules of the Agricultural Marketing Service.

A classification and regression predictor or decision tree was generated that summarizes the profitability of extending the season for all 3537 combinations of experimental plots, base lint prices, cost of water, and price discount/premium year schedules (Figure 5). This tree was pruned using a standard error rule of 30 to highlight only the most important variables and their respective levels. A lower standard error pruning rule would still yield the same "base tree" described in Figure 5, but would have additional binary splits below those presented. To interpret the binary tree, consider a situation with Deltapine 33B in which yield associated with the first irrigation termination treatment is estimated at 1400 to 1450 kg ha^{-1} (1250 to 1300 lb ac^{-1}), and samples from the first irrigation termination treatment indicate that micronaire will be about 5.0. Yield

Figure 5. Irrigation termination guidelines generated by the classification and regression tree analysis.



Variety Legend:
1 = Deltapine 90
6 = Stoneville BXN 47
11 = Deltapine 428 B
2 = Deltapine 5415
7 = Stoneville 491 B
12 = Deltapine 388
3 = Deltapine 33 B
8 = Deltapine 20 B
13 = Sure-Grow 125 BR
4 = Sure-Grow 747
9 = Deltapine 422 BR
14 = Deltapine 655 BR
5 = Deltapine 451 BR
10 = Stoneville 474

Abbreviations: IT-1 indicates the first irrigation termination treatment. C and F indicate Centigrade (31/12.8°) and Fahrenheit (86/55°) heat units.

is less than 1533 kg ha^{-1} (1362 lb ac^{-1}), so proceed left down the decision tree. If the crop year is similar to 1995 or 1996 the decision tree categorizes the return from extending the season at -$124.62 ha^{-1} (-$50.43 ac^{-1}). This value represents the average of all returns that fall into this category. If the crop year is comparable to 5 out of the 7 years considered, move right below the crop year node, proceed right at the yield node of 1045 kg ha^{-1} (933 lb ac^{-1}), and then left and right at the subsequent cultivar nodes. If the season is extended less than 358 heat units Centigrade (644 heat units Fahrenheit) after the first irrigation termination treatment, an expected return of $169.51 ha^{-1} ($68.60 ac^{-1}) is realized. Extending the season beyond this level of heat units results in more than twice the level of return at $355.92 ha^{-1} ($144.04 ac^{-1}). On average, 358 heat units Centigrade (644 heat units Fahrenheit) equaled 24 days for all the experiments considered.

Excluding observations for 2000, average heat units after planting for the first irrigation termination date were 1821 heat units Centigrade (3278 heat units Fahrenheit) or roughly equal to the 1778 heat units Centigrade (3200 heat units Fahrenheit) after planting recommended by University of Arizona Cooperative Extension for the optimal timing for irrigation termination of a mid-season cultivar. The range in heat units after planting for all first irrigation termination treatment plots is from 1281 to 1941 heat units Centigrade (2305 to 3494 heat units Fahrenheit), and averages 1591 heat units Centigrade (2863 heat units Fahrenheit). The somewhat earlier first irrigation termination treatment for 2000 occurred at 1423 heat units Centigrade (2561 heat units Fahrenheit), within the range of prior years. Because the 2000 crop year did not rise to the forefront as a significant item for categorizing the data, returns appear to be fairly robust in identifying final blooms when the number of nodes above the uppermost, first-position, white flower equal five, or five to six. That is, being a few days early in the timing of the first irrigation termination date is not as crucial as correctly quantifying the yield and micronaire associated with the crop when the tagged final blooms turn to full-sized hard green bolls.

In general, results indicate that the season needs to be extended at least 330 to 360 heat units Centigrade (600 to 650 heat units Fahrenheit) or 22 to 24 days for this data if one is going to pursue a top-crop. Extending the season one or two weeks is not likely to produce beneficial returns. This result also coincides with the work by Brown and Silvertooth (1994) that 333 heat units Centigrade (600 heat units Fahrenheit) are needed to mature a fresh flower to a hard green boll for full fiber development. A crop with a relatively modest yield associated with the first irrigation termination treatment (i.e., less than 1533 kg ha^{-1} or 1,368 lb ac^{-1}) is also more likely to have the potential for producing a profitable top-crop than a crop that has already set a high fruit boll load.

The results indicate that cultivar differences also play a role in conjunction with the first irrigation termination treatment yield and micronaire for influencing the profitability of extending the season. If a crop already has an estimated yield associated with the first irrigation termination treatment greater than 1533 kg ha^{-1} (1368 lb ac^{-1}) and micronaire is just below the threshold of the steepest micronaire discount of 5.2, extending the season is not likely to be profitable. But if micronaire associated with the first irrigation termination treatment has already entered the steepest discount range and its yield is above 1533 kg ha^{-1} (1368 lb ac^{-1}), extending the season more than 333 heat units Centigrade (600 heat units Fahrenheit) is generally profitable. There is no risk of further discounting the price received for yield established for the first irrigation termination treatment through a higher micronaire reading, while there is a possibility that average micronaire can be lowered through producing immature top-crop fibers.

CONCLUSIONS

The return associated with different irrigation termination protocols was analyzed in a heat unit framework considering both fiber quality and lint yield factors. Deviations in lint yield and quality for first irrigation termination trials in central Arizona were compared with subsequent second and third irrigation termination treatments. In general, results indicated that agronomic factors relating to cultivar, additional heat units, and yield associated with first irrigation termination treatments were more important signals than economic factors of water cost, base lint price, and quality discount/premium year. In addition, crop year was near the top of importance for determining whether extending the season was profitable or not, suggesting that there is a significant weather risk in going for a top-crop.

While insecticide costs were expensed relatively low compared to historical values to reflect the recent widespread adoption of Bt cotton, non-Bt cotton is still being grown and this could possibly alter some of the marginally profitable scenarios for extending the season into a loss. Adjustments could be made to the returns presented for extending the season if costs differ for a region or producer from the values utilized in this analysis to provide insights into going for a top-crop. Furthermore, while water costs were the only input cost that varied in the analysis, it was found to have a relatively minor impact on the irrigation termination decision.

Yield and micronaire of a crop at the first irrigation termination treatment date are not known with certainty as analyzed, but must be estimated from boll counts and micronaire readings of lower bolls. Because many inputs have already been committed to the crop prior to the first irrigation termination date, economic factors are relatively small in relation to the yield and quality changes associated with extending the season. Thus, this research suggests that crop scouting and developing better techniques for predicting micronaire and yield of the first irrigation termination treatment is more important for identifying the most profitable irrigation termination date than scouting the latest market report.

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