IRRIGATION TERMINATION AND FIBER QUALITY, SUBSURFACE DRIP IRRIGATION VERSUS OVERHEAD

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Abstract

The standard practice is to terminate irrigation on cotton sometime between the first cracked boll and ten percent open boll. This practice is typical to aid in the preservation of fiber quality. However, the bolls are typically still developing on the upper part of the plant. The availability of subsurface drip irrigation (SDI) and the adoption of SDI by producers has opened possibilities for continued irrigation after cotton bolls have begun to open without introducing moisture straight to the cotton fibers in the open bolls. This was a two year study that investigated irrigating cotton throughout the production season with SDI until the cotton reached open boll. Once the cotton reached open boll overhead and continued SDI irrigation treatments were implemented. Half of the field was irrigated using an overhead center pivot system and the other half of the field was irrigated using SDI. This process continued until the cotton was ready to harvest. Initial data analysis shows a significant difference between almost all HVI fiber parameters for year, but very little difference within each year. Color grade was slightly higher treatments, reflectance (Rd) was much lower, and uniformity was lower for the overhead treatments. Yield did not show a significant difference for either overhead or SDI irrigation treatments. This analysis did not explore varietal differences however, upon inspection there are varietal differences present suggesting that certain varieties will respond better to SDI irrigation post standard irrigation termination.

Introduction

The standard practice for irrigated cotton is to terminate irrigation sometime between the first cracked boll and ten percent open boll. In some cases this can also be estimated by monitoring the node above white flower (NAWF), once NAWF is less than five irrigation termination should be considered (Vories et. al 2002 and Multer and Sansone 2007). Multer and Sansone (2007) conducted a study that used NAWF reaching the five node stage as a trigger point to record accumulated heat units to determine if heat units were a valid method to determine optimum irrigation termination timing. They stated that previous studies indicated that irrigation should be terminated once 400-500 heat units are accumulated after the cotton reaches five NAWF. Studies have shown that additional irrigation after open boll will help to promote boll filling and increase yield over that of crops without the additional irrigation treatments. However, in most cases, in the Southeast the type of irrigation being used on the cotton plants is an overhead sprinkler type of irrigation. Additional water introduced in to the open boll directly on the cotton fiber either via rainfall or via overhead irrigation can promote the degradation of fiber quality. In many cases the plant can still be developing bolls higher on the plant when termination is deemed necessary, and these bolls will typically not develop as fully as those with ample irrigation throughout the season. Preliminary work done by Multer and Sansone (2007) in 2002 indicated that yield loses can be substantial (up to 200 lbs of lint/acre) if irrigation is ended too soon and that water costs can increase with no yield benefit if irrigation is extended too long. However, in a study by Vories et al. (2002) only two of eight studies exhibited significant differences in lint yield for extended irrigation. Very little difference was observed in fiber quality for the different irrigation termination treatments in the Vories et al. (2002) study. However, in the same study furrow irrigation was the most common type of irrigation used, thus the extra moisture was not introduced into the open cotton bolls via irrigation and should not have had a negative effect on fiber quality. The availability to and adoption of Subsurface Drip Irrigation (SDI) by producers has provided them with the potential to continue irrigation after the crop has reach the first cracked boll or ten percent open boll.

Even though the irrigation method was not stated, Silvertooth et al. (2006) noted that lint yield and micronaire values consistently increased with later irrigation termination dates. This study was performed the University of Arizona Maricopa Agricultural Center. Thus, rainfall is very limited and typically irrigation is the only way to produce a crop, and growing conditions are drastically different than in the Southeastern US. It was noted by Silvertooth et al. (2006) that an irrigation treatment imposed just after cutout, which is the recommended irrigation practice in this region was found to be optimal. This irrigation treatment produced the optimal yield and micronaire relationship and saved 12 inches of water in one year and 19 inches in the next year over the extended irrigation treatment, which was terminated late enough to allow for a second cycle fruit cycle, this irrigation treatment was extended until late September each year.

Most of the previous studies that have been performed on irrigation termination and fiber quality have either been under a different irrigation regime such as furrow irrigation, or have occurred in a more dry and arid environment than is present in the southeast. This study did not focus so much on the exact timing of irrigation termination, but on the effects of additional irrigation added to a crop after the deemed optimal or culturally accepted irrigation termination time for the humid southeast on yield and fiber quality.

Objectives

The main objective of this study was to determine the effects of extending irrigation after first open boll on final yield and fiber quality. The secondary objectives were to:

- Quantify the treatment effects of overhead irrigation versus SDI on cotton yield.
- Determine if there are fiber quality differences that could lead to discounts on cotton with extended irrigation beyond the regional culturally accepted irrigation termination point.
- Gather information that could help producers to decide if it is worth the investment to either use SDI to continue irrigation or if the added yield increase will offset the fiber quality discounts for continued overhead irrigation.

Materials and Methods

A two year study was performed at the Stripling Irrigation Research Park (SIRP) just outside of Camilla, GA. Two varieties were planted in 2013 (Phytogen 499 and FiberMax 1944) and three varieties (Phytogen 499, FiberMax 1944, and DeltaPine 1252) in 2014, all commonly planted in Georgia. The treatments and varieties were planted in randomized strips under half of a three acre center pivot irrigation system. In coordination with the pivot irrigation, SDI was previously installed throughout the entire field. The crop was irrigated throughout the season following the University of Georgia (UGA) Modified Checkbook Method via SDI. Once ten percent open boll was reached irrigation treatments were implemented. The pivot was divided in half (Figure 1), SDI irrigation was stopped in half of the field and overhead irrigation began and continued at a split applied rate of one inch per week until the crop was ready for defoliation. In the other half of the field SDI continued at split applied weekly rates of one inch until the crop was ready for defoliation. Both irrigation treatments either via overhead sprinkler or SDI were applied on the same day.

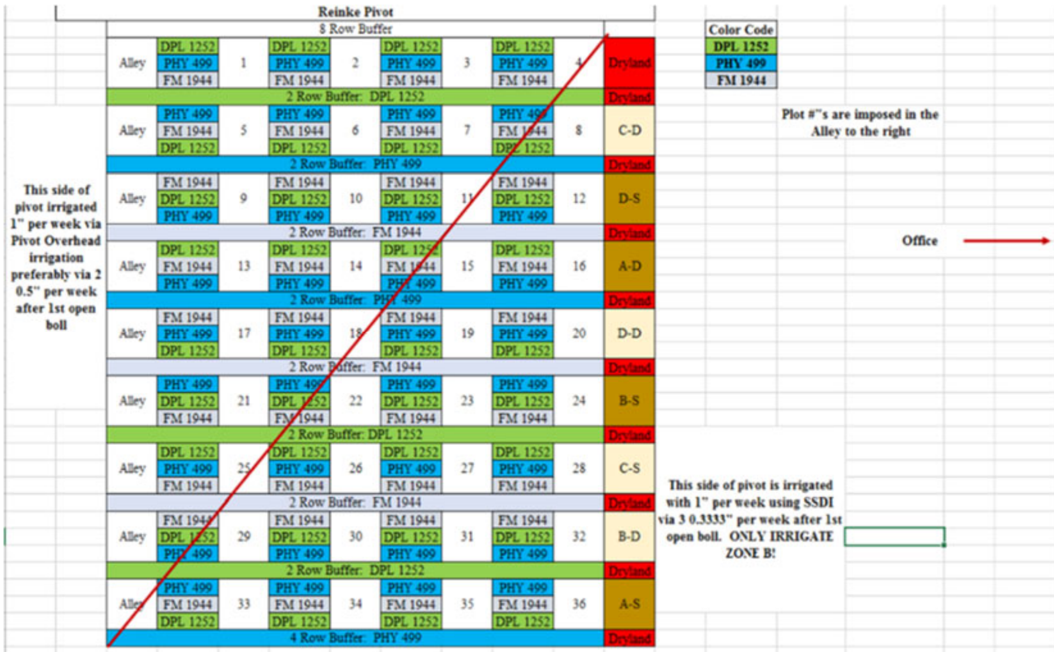

Figure 1. An example of the randomized strips in the split field for the Overhead and SDI irrigation treatments.

Each of the irrigation treatments were irrigated for an additional four weeks and received an additional four inches of irrigation beyond standard irrigation termination.

Plots were harvested using a four row cotton picker with a bagging attachment in the basket of the picker. All of the seed cotton from harvest plots was collected, weighed, ginned at the UGA Microgin, and the fiber quality samples were sent to the USDA-AMS Macon, GA classing office for analysis. SAS JMP was used to run Tukey's LSD's (alpha = 0.05) on the data to determine differences in yield and fiber quality parameters.

Results and Discussion

It should be noted that there were year differences observed in all of the data collected. Most of this can be attributed to weather conditions. 2013 was much cooler and wetter than 2014. Plots at SIRP received 27.3 inches of rainfall during the 2013 season and only received 12.3 inches during the 2014 season. 2014 was wet early but then it turned hot and dry and the crop did not receive an effective and significant rainfall from mid-June until mid-September.

It was decided to plant three common varieties to Georgia in 2014 to introduce more diversity into the data and provide a better opportunity to delineate varietal effects, however, for a reason that could not be diagnosed the DeltaPine 1252 variety have very poor emergence issues in this trial (Figure 2).

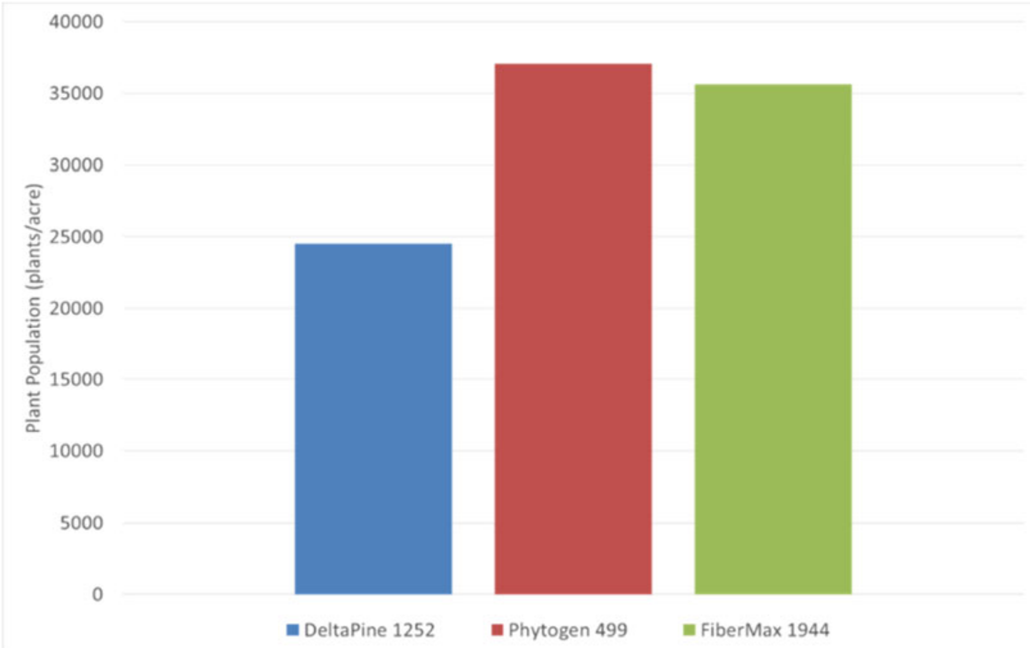

Figure 2. Plant population randomly collected and averaged from plots within the irrigation termination study.

Even though the plant population for the DP 1252 was statistically lower, conversations with agronomists provided information that the no differences in yield were prevalent between cotton plant populations of 25,000 plants per acre and 36,000 plants per acre. This is due to the ability of cotton plants to compensate for lack of competition or empty space in the rows, thus the data collected from the DP 1252 plots was kept and compiled with the other two varieties.

Figure 3 represents lint turnout, which typically should not be affected by extended irrigation unless there are major fiber quality issues or differences. In this case the 2013 dryland actually had a higher turnout than the irrigated treatments, and was very similar to the turnout for the irrigated treatments during 2014. This is likely due to the high volume of rainfall received during the 2013 production season. In other studies during 2013, over-irrigation actually reduced yields, and in this study the dryland crop had the statistically simlar yields to the irrigated treatments. The dryland treatment from 2014 had the lowest lint turnout.

In the case of lint turnout it does not seem that irrigation type or termination has a significant effect, more so the difference presented is between year effect and the irrigated versus dryland crop. Thus, additional irrigation added into the cotton bolls by overhead sprinklers does not have an effect on ginning performance of the cotton.

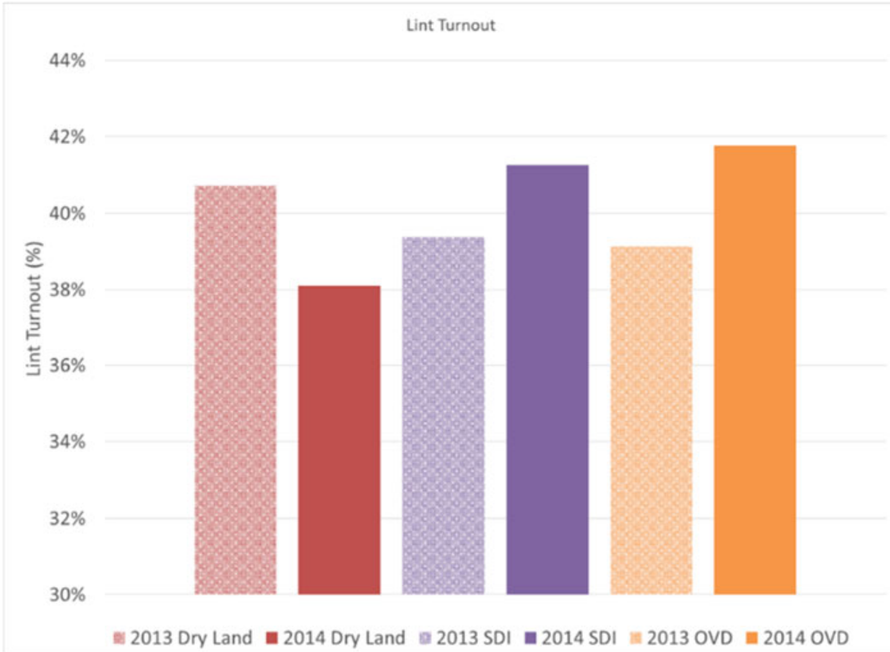

Figure 3. Lint turnout for each of the irrigation termination treatments.

There were no statistical differences in lint yield between the irrigation treatments (Figure 4), the only statistical differences between the treatments was between the dryland crop and the irrigated treatments when the data was averaged over both years (individual data shown in Figure 4). When the data was analyzed individually by treatment independent of year the only statistical difference was between the 2014 dryland and the rest of the treatments.

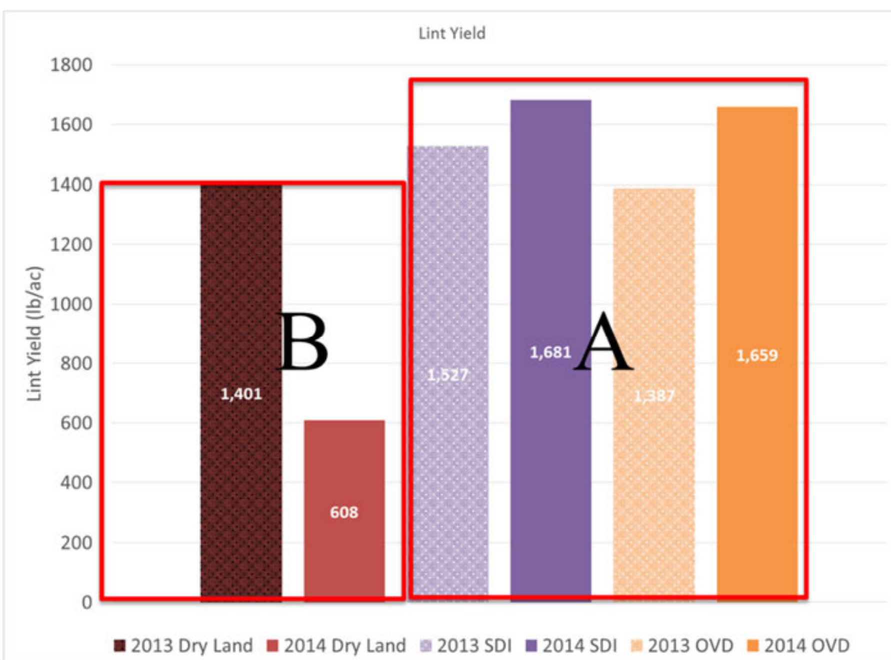

Figure 4. Lint yield for each of the treatments, the only statistical difference was between irrigated and dryland.

In both years there was a slight advantage for using SDI versus overhead irrigation after termination, however, this advantage was not statistically significant, and was trivial in 2014. As stated earlier, in 2013 it appears that the overhead irrigation actually reduced the yield when compared to the dryland treatment. In a very wet year, when over 20 inches of rainfall is received during a season it is highly recommened that careful consideration be paid to irrigation scheduling and amount applied. Over-watering can cause as much of a yield penalty as underwatering.

Averaged color grade (Figure 5) did not have statistical differences but it did have practical differences. The SDI treatments had the lowest color grades of all of the treatments for both years. Since 2014 was such a dry year the color grade for the dryland treatment was similar to that of the SDI treatment. In this case a lower color grade is better and the overhead irrigation system caused an increase in color grade, thus a worse rating.

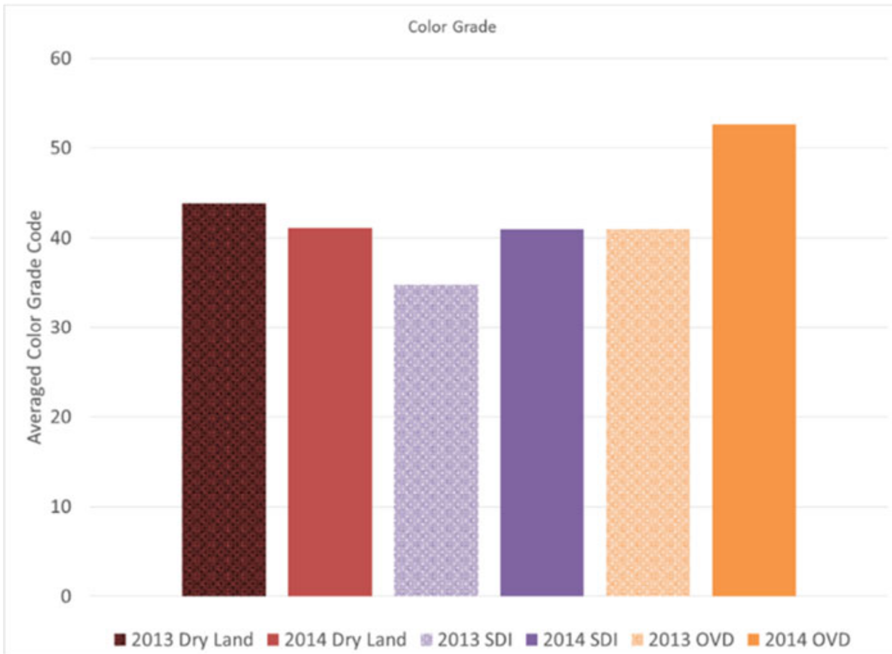

Figure 5. Averaged color grade, with the SDI having the lowest value.

To obtain the color grade a combination of yellowness (+b) (Figure 6) and reflectance (Rd) (Figure 7) must be considered. The +b had year effects prevalent, and they are the opposite of what would be expected. 2013 had a much lower yellowness value than 2014. However, there were a few high intensity rainfall events during mid- to late- September of 2014, which could have caused a higher +b value. There were not statistical or practical differences for +b within each year. The overhead treatment had the lowest values in 2013 while the SDI treatment had the lowest values in 2014. However, these differences were very slight and are not practical.

The overhead treatment had a statistically lower value for Rd in 2014, but all other treatments were statistically similar. It is hard to explain this difference but it did lead to a worse overall color grade. The SDI treatments in both years were higher than the corresponding overhead treatments, but not by a statistically significant amount.

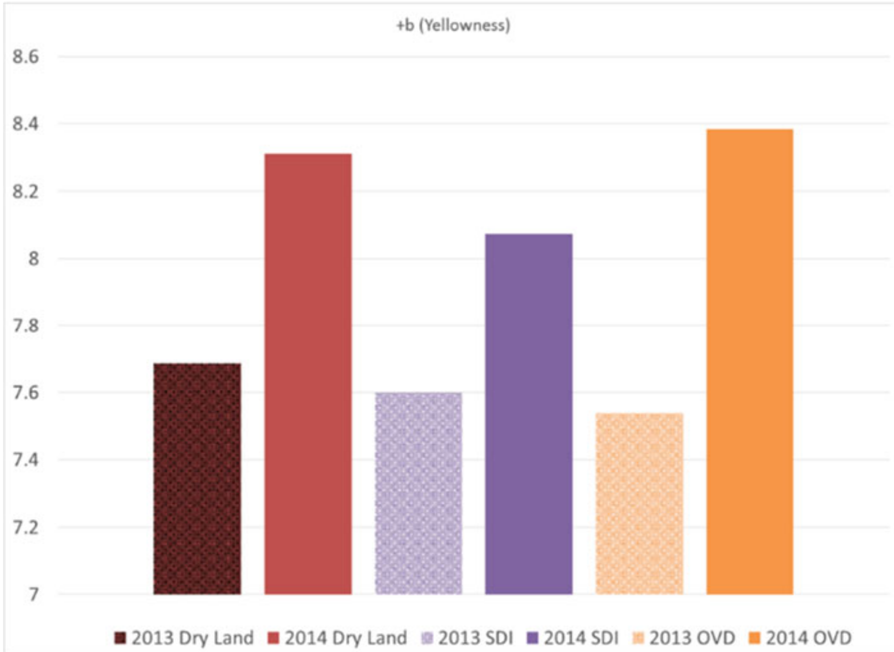

Figure 6. Yellowness data, which only exhibited significant differences for year.

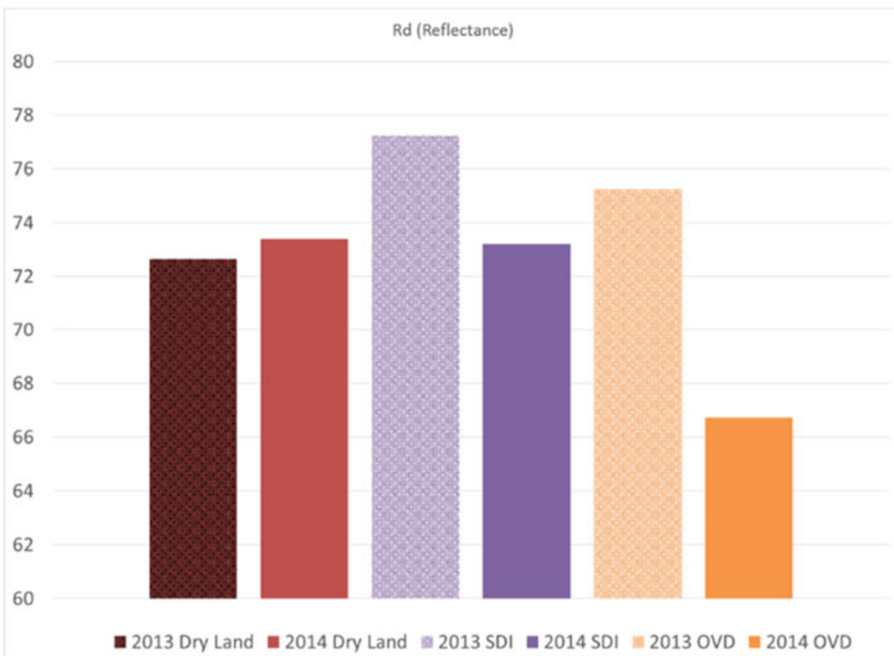

Figure 7. Reflectance data, which only exhibited significant differences for the 2014 OVD treatment.

The only differences seen in micronaire (Figure 8) can be attributed to year and climatic effects. The mean micronaire for 2013 was 4.95 for all treatments, however, for the 2014 it was lower for the two irrigated treatments with the mean falling to 4.75 and the dryland treatment at 4.5. These are all still within an acceptable range. Based on the data from the two years independent of year effect there is no effect on micronaire from irrigation type.

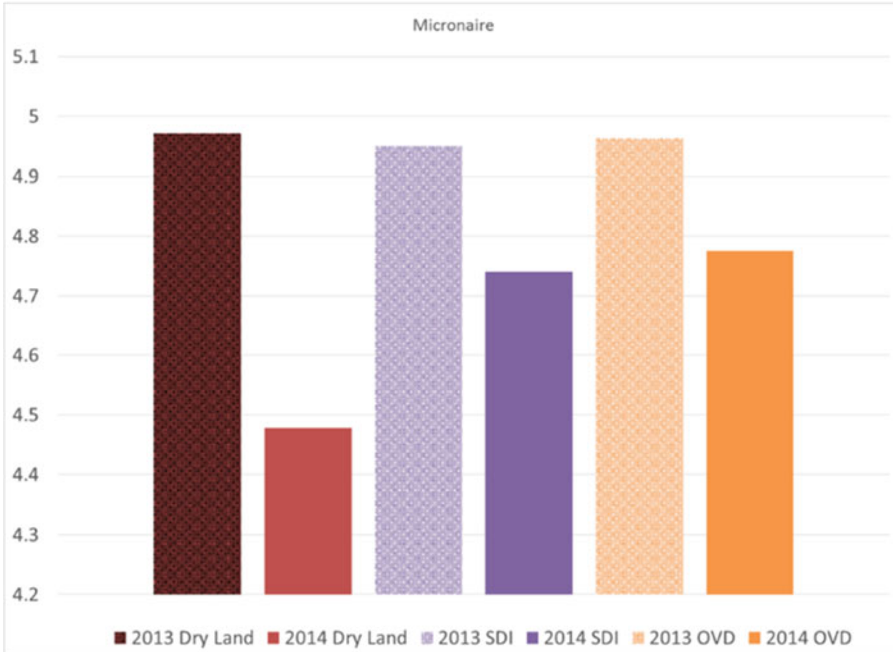

Figure 8. Micronaire data, with no difference independent of year and climatic effect.

Fiber uniformity (Figure 9) was affected by both weather and irrigation treatment. The highest fiber uniformity was in the 2013 dryland treatment. Both SDI treatments were very similar and slightly higher than their corresponding overhead treatments. The 2014 dryland treatment had the lowest fiber uniformity. Thus, based on fiber uniformity it would be beneficial to irrigation using SDI.

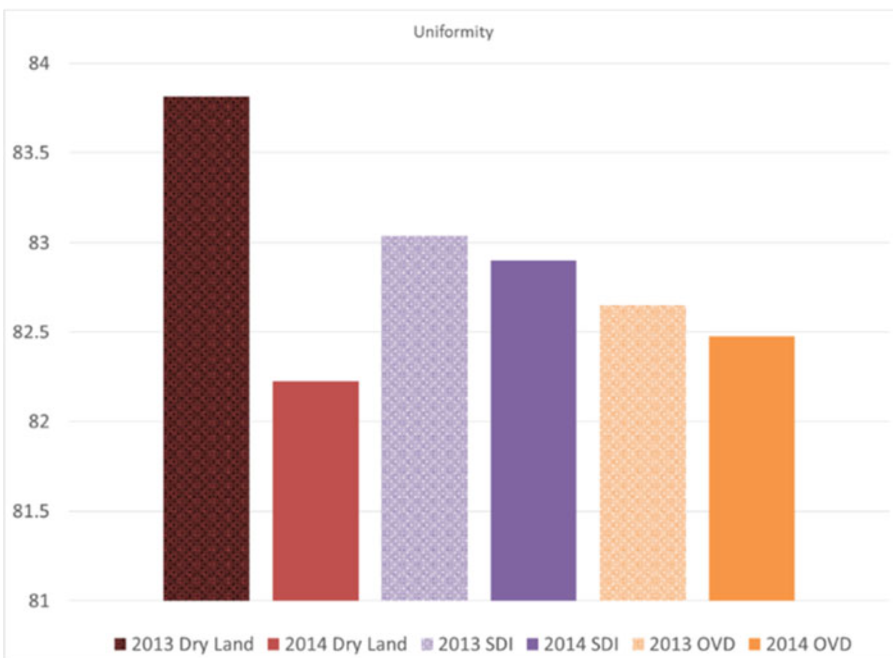

Figure 9. Fiber uniformity, the 2013 dryland had the highest uniformity and the 2014 dryland had the lowest.

There were some of the fiber quality parameters that did not exhibit varietal differences and there were some that varietal differences were very prominent (Figure 10). Figure 10 is a compilation of the fiber quality parameters that were found to be statistically different at the alpha = 0.05 level. Fiber strength, leaf grade, +b, HVI Length, HVI Trash, and uniformity were all found to have significant variety differences.

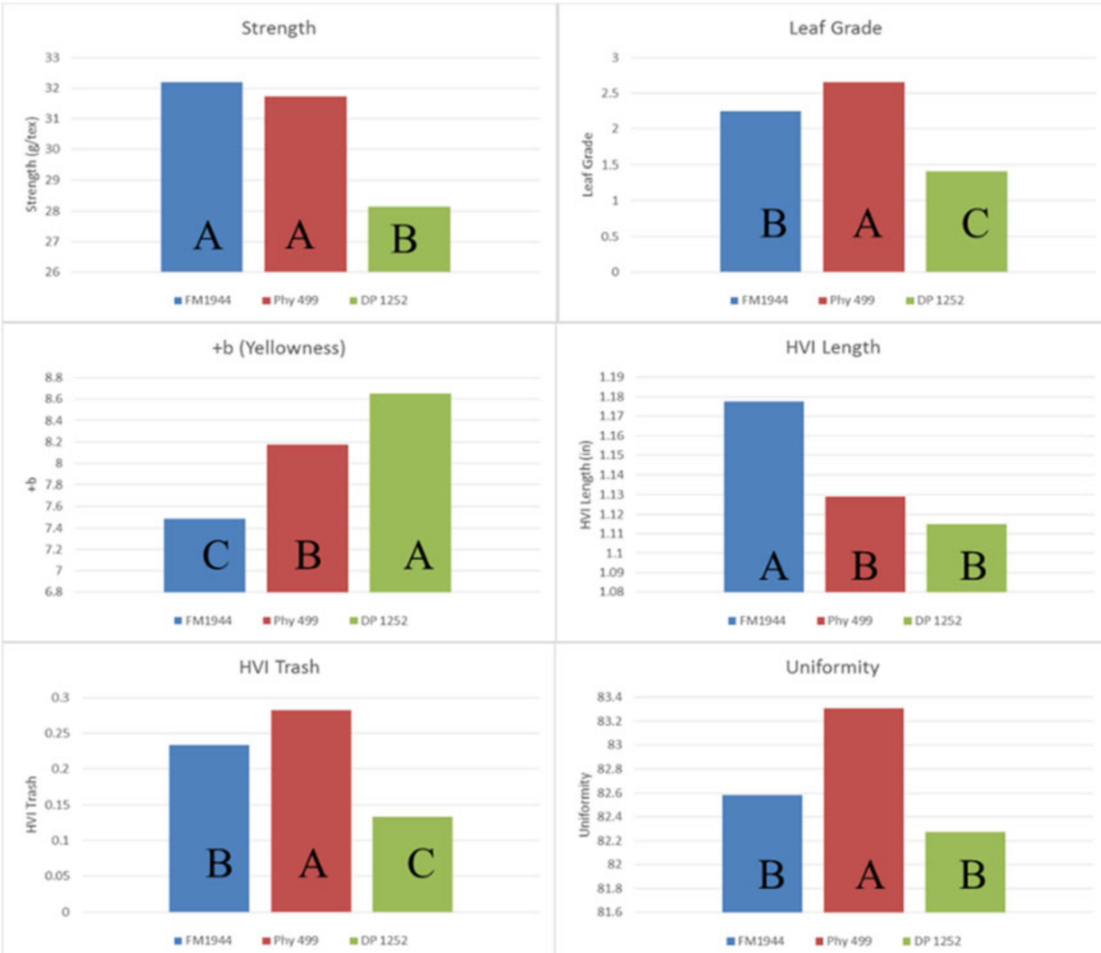

Figure 10. Fiber quality parameters that were found to be statistically different by variety.

Based on the differences exhibited in figure 10 it would be advantageous to explore the data more in-depth to determine if one variety had a better response than another to the end of season irrigation type. For example, FiberMax 1944 had a much longer length, and Phytogen 499 had a much higher uniformity. This analysis was not performed for this paper, however, an optimization of variety versus fiber quality parameter versus end of season irrigation type could provide producers with an insight as to which variety to select if they plan to extend irrigation beyond standard termination.

Summary and Conclusions

Irrigation was extended beyond the standard practice in Georgia of terminating somewhere between first cracked boll and ten percent open boll. The two extended irrigation treatments that were tested were SDI and overhead sprinkler irrigation. Two varieties were planted and evaluated in 2013 and three in 2014. The main differences observed initially were due to year effect. It was much more rainy and cooler in 2013 with 27.3 inches of rainfall when compared to the hotter drier year of 2014 when only 12.3 inches of rainfall were received during the entire production season. There were only year differences for lint yield, neither variety nor SDI versus overhead irrigation had an effect on the final lint yield. Differences were observed in some of the fiber quality parameters but only a few of them were significant independent of variety. However, even though some of the fiber quality parameters did not have statistical differences SDI did typically have practically better fiber quality ratings for each

of the fiber quality parameters discussed in this paper. This suggests that additional overhead sprinkler irrigation on to the crop once there are open bolls can lead to the reduction or further degradation of fiber quality.
Statistical analysis of variety effect revealed that strength, leaf grade, +b, length, trash, and uniformity all had significant variety differences. This would suggest that a more in-depth analysis and potentially an optimization analysis would reveal the best variety to select for each irrigation termination strategy. However, to fully complete this analysis lint yield and fiber quality data is needed from a treatment where irrigation was fully terminated at ten percent open boll. This would provide a baseline for both yield and fiber quality. The addition of this data set would provide a decision aid tool for producers to aid them in varietal selection for either overhead, SDI, or help them to decide if it additional overhead irrigation is worth applying for the additional yield.

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