IRRIGATION TERMINATION AND FIBER QUALITY: SUBSURFACE DRIP IRRIGATION VERSUS OVERHEAD

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Introduction

The standard practice for irrigated cotton is to terminate irrigation sometime between the first cracked boll and 10 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; 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 to 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 cotton 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 increase with no yield benefit if irrigation is extended too long. In a study by Vories et al. (2002), only two of eight studies exhibited significant differences in lint yield for extended irrigation. Further, very little difference was observed in fiber quality for the different irrigation termination treatments in the Vories et al. (2002) study. In that study, however, 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 10 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 at 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 that 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 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 in the Southeast. This study did not focus so much on the exact timing of irrigation termination, but the effects on yield and fiber quality of additional irrigation added to a crop after the deemed optimal or culturally accepted irrigation termination time for the humid Southeast.

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) near Camilla, GA. Two varieties (Phytogen 499 and FiberMax 1944) were planted in 2013 and three varieties (Phytogen 499, FiberMax 1944, and DeltaPine 1252) were planted in 2014, all commonly planted in Georgia. The treatments and varieties were planted in randomized strips under half of a 3-acre center pivot irrigation system. In coordination with the pivot irrigation, SDI was previously installed throughout the entire field. The crop was irrigated via SDI throughout the season following the University of Georgia (UGA) Modified Checkbook Method. Once 10 percent open boll was reached, the various 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 1 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 1 inch until the crop was ready for defoliation. Both irrigation treatments, either via overhead sprinkler or SDI, were applied on the same day. Each of the irrigation treatments were irrigated for an additional four weeks and received an additional 4 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 sent to the USDA-AMS classing office in Macon, GA, 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 had very poor emergence issues in this trial (Figure 2).

Eventhough the plant population for the DP 1252 was statistically lower, conversations with agronomists provided information that 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 shows lint turnout (lint weight as a percentage of total seedcotton weight). Across all treatments and averaged for all varieties, turnout ranged from roughly 38% to 42%. In 2013, turnout was highest for dryland. In 2014, turnout was lowest for dryland. For the irrigated treatments in 2013, SDI had slightly higher turnout than overhead (OVH). In 2014, OVD had slightly higher turnout than SDI.

The 2013 dryland turnout was not only higher than both irrigated treatments that year, but also similar to the irrigated treatments in 2014. This is likely due to high rainfall in 2013 compared to 2014. Lint turnout typically should not be affected by extended irrigation unless there are major fiber quality issues or other differences.

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

There were no statistical differences in lint yield between the irrigation treatments (Figure 4). The only statistical difference 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.

In both years there was a slight yield advantage for using SDI versus overhead irrigation after termination. This advantage was not statistically significant, however. In 2013 it appears that the overhead irrigation actually reduced the yield when compared to the dryland treatment. In a very wet year, 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.

Major factors impacting Color grade include weather (specifically rainfall/water on open cotton) and defoliation and harvest timing. Over the two years of the study, extended OVD irrigation resulted in the worse Color grades (Figure 5). SDI resulted in the best Color grades. Color grade was not statistically different among the treatments, however.

HVI Color Grade is a combination of the degree of whiteness in the fiber (+b) and the degree of brightness or reflectance (Rd) in the fiber. Higher +b values (increasing yellowness) and lower Rd (decreasing brightness) values result in a less desirable Color grade. The lower the +b and higher the Rd, the better the Color grade. The lowest +b values were observed with SDI in 2013 and OVD in 2014 (Figure 6). The highest Rd values were observed with SDI in 2013 and OVD in 2013 (Figure 7). For +b, there was a statistical difference between years but no difference among the treatments within a year.

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

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. For 2014, micronaire was lower for the two irrigated treatments with a mean of 4.75 and the dryland treatment at 4.5. These are all still within the acceptable range. Based on the data from the two years, there was a year effect but no effect on micronaire from irrigation type.

Fiber uniformity (Figure 9) was affected by both weather (year) and irrigation treatment. The highest/best fiber uniformity was in the 2013 dryland treatment. Uniformity in the SDI treatments was similar in both years and slightly higher than the OVD treatments. The 2014 dryland treatment had the lowest fiber uniformity.

The data were examined for any differences due to variety. Some fiber quality parameters exhibited varietal differences and some did not (Figure 10). Fiber strength, leaf grade, +b, HVI Length, HVI Trash, and uniformity were all found to have significant differences by variety.

Based on the differences shown in Figure 10, it might be advantageous to explore the data more in-depth to determine if one variety had a better response than another to extended end of season irrigation type. FiberMax 1944, for example, had a much longer fiber length and Phytogen 499 had a much higher uniformity. Such an analysis was not performed for this paper. However, an optimization of variety versus fiber quality parameters 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 10 percent open boll. The two extended irrigation treatments that were tested were subsurface drip irrigation (SDI) and overhead sprinkler irrigation (OVD). Two varieties were planted and evaluated in 2013 and three in 2014. The main differences observed were due to year (weather) effect. It was much more rainy and cooler in 2013 with 27.3 inches of rainfall, compared to the hotter drier year of 2014 when only 12.3 inches of rainfall were received during the entire production season.

There were year differences only for lint yield. Neither variety nor SDI versus overhead irrigation statistically had an effect on lint yield. Differences were observed in some of the fiber quality parameters but only a few of them were significant independent of variety. Even though some of the fiber quality parameters were not statistically different among treatments, SDI typically did have numerically better fiber quality ratings. This suggests that additional overhead sprinkler irrigation on the crop after there are open bolls can lead to reduction or further degradation of fiber quality.

Statistical analysis of any variety effects showed that strength, leaf grade, +b, length, trash, and uniformity all had significant differences by variety. This would suggest that a more in-depth analysis and potentially an optimization analysis could reveal the best variety to select for each irrigation termination strategy. To fully complete this analysis, however, lint yield and fiber quality data are needed from a treatment where irrigation was fully terminated at the traditional 10 percent open boll period. 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 or SDI, or help them to decide if additional overhead irrigation is worth applying for the additional yield.

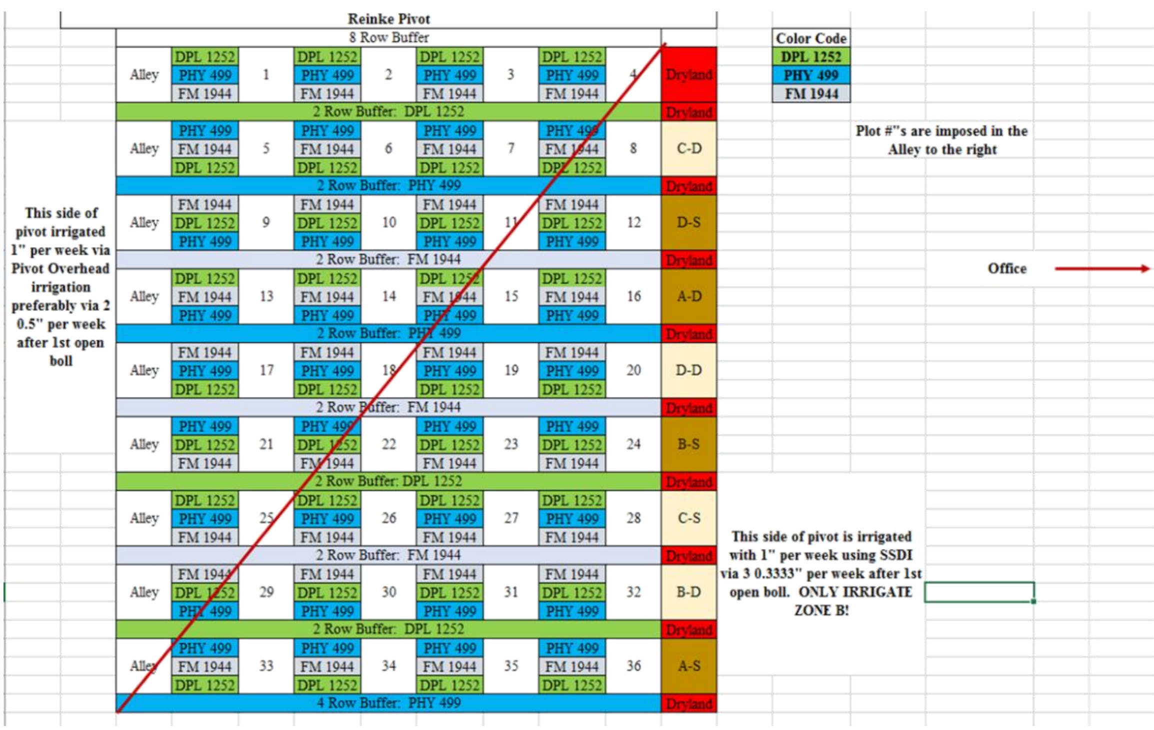

Figure 1. Randomized strips in the split field for the overhead and SDI irrigation treatments.

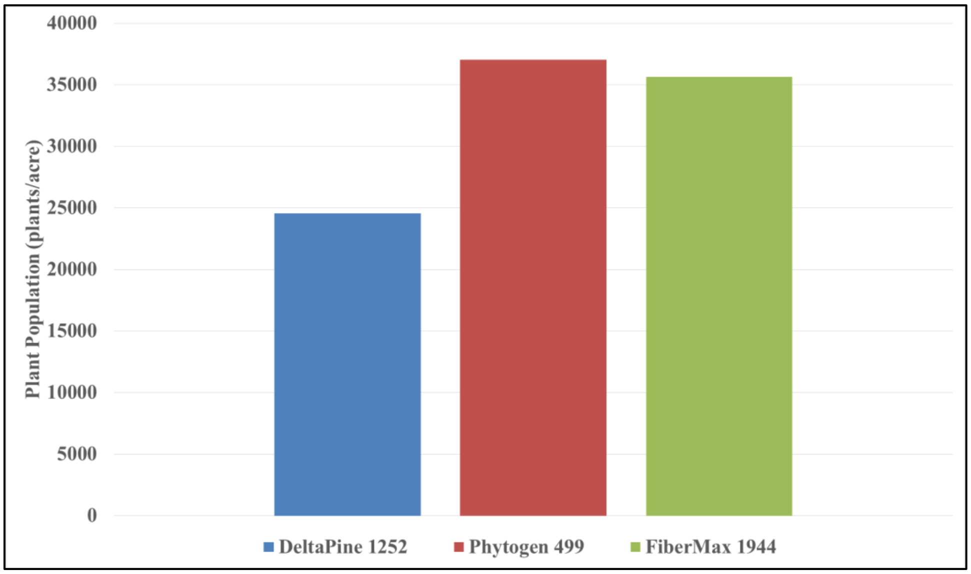

Figure 2. Plant population randomly collected and averaged from plots within the irrigation termination study.

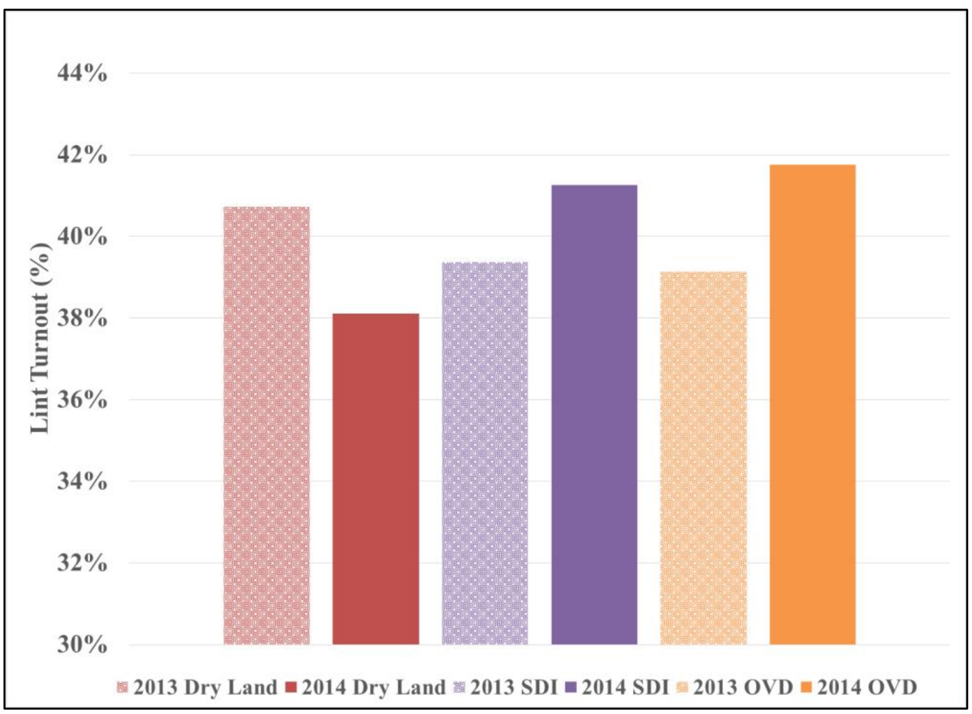

Figure 3. Lint turnout for each of the irrigation termination treatments.

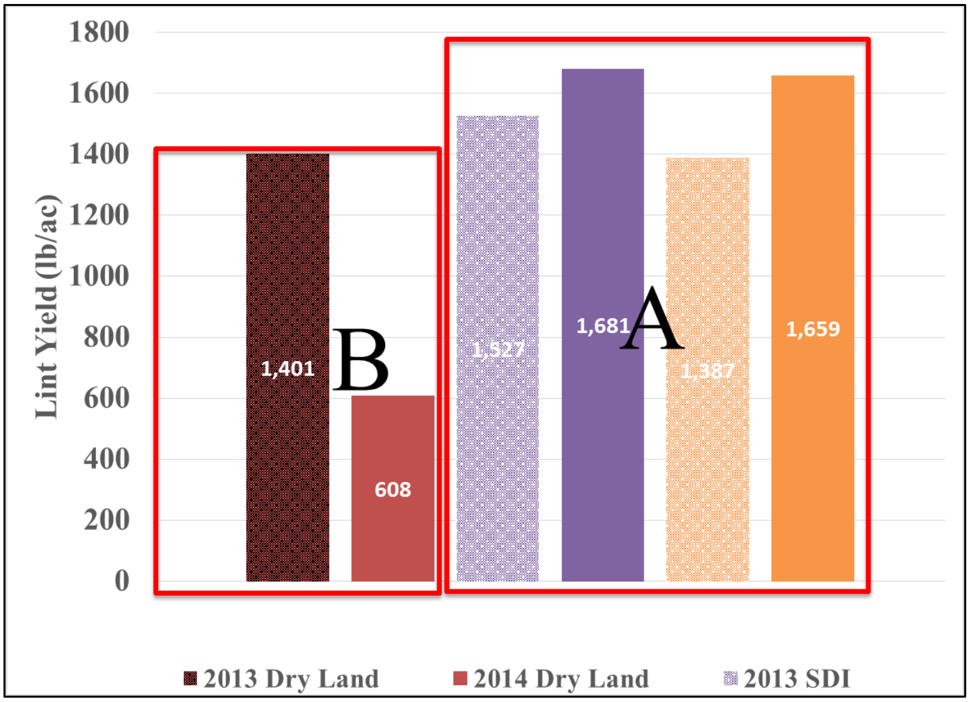

Figure 4. Lint yield for each of the treatments; the only statistical difference was between irrigated and dryland.

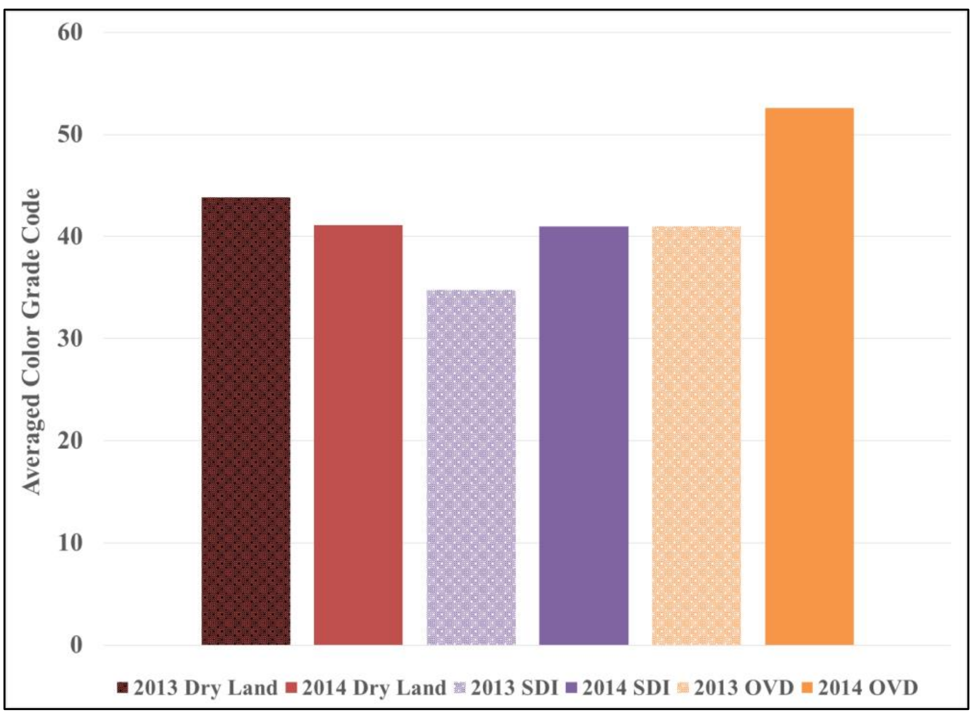

Figure 5. Average Color grade with the SDI having the lowest value.

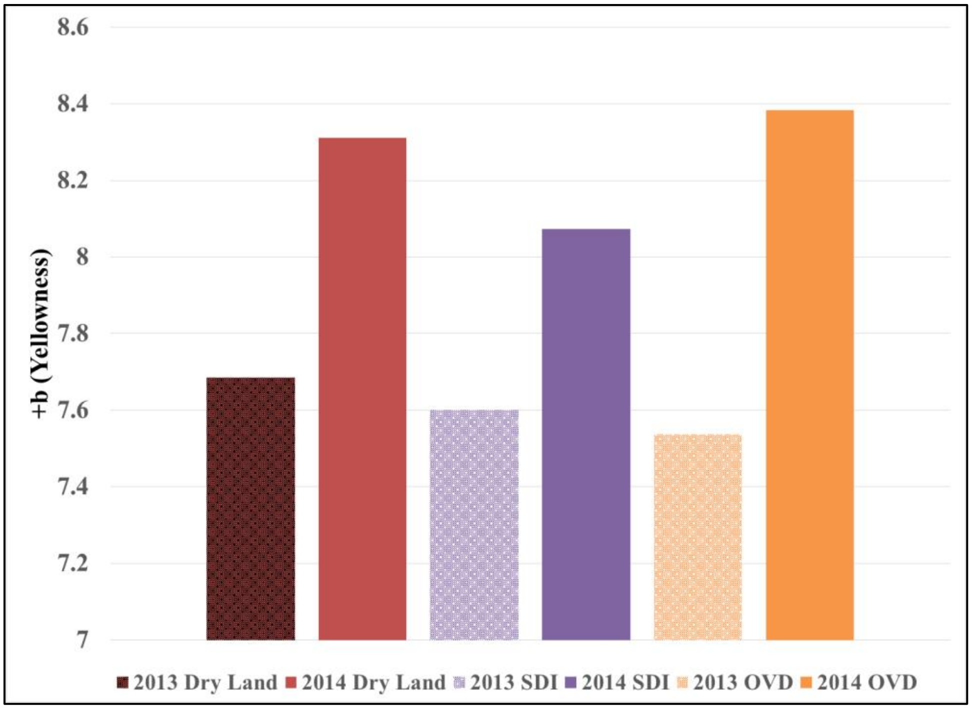

Figure 6. Yellowness data, which only exhibited significant differences for year.

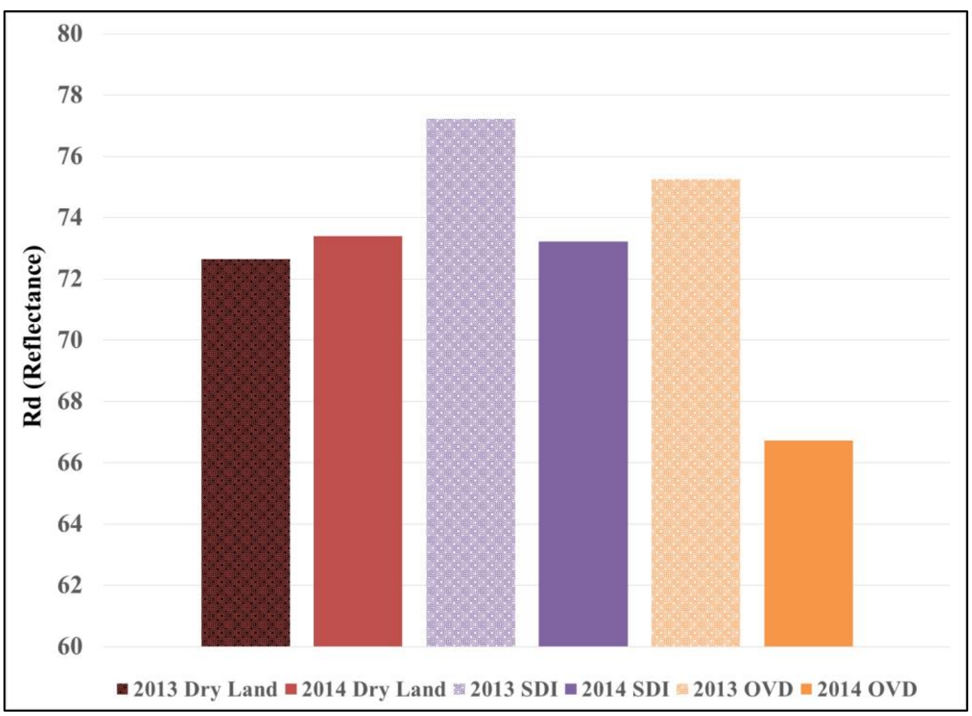

Figure 7. Reflectance data, which only exhibited significant differences for the 2014 OVD treatment.

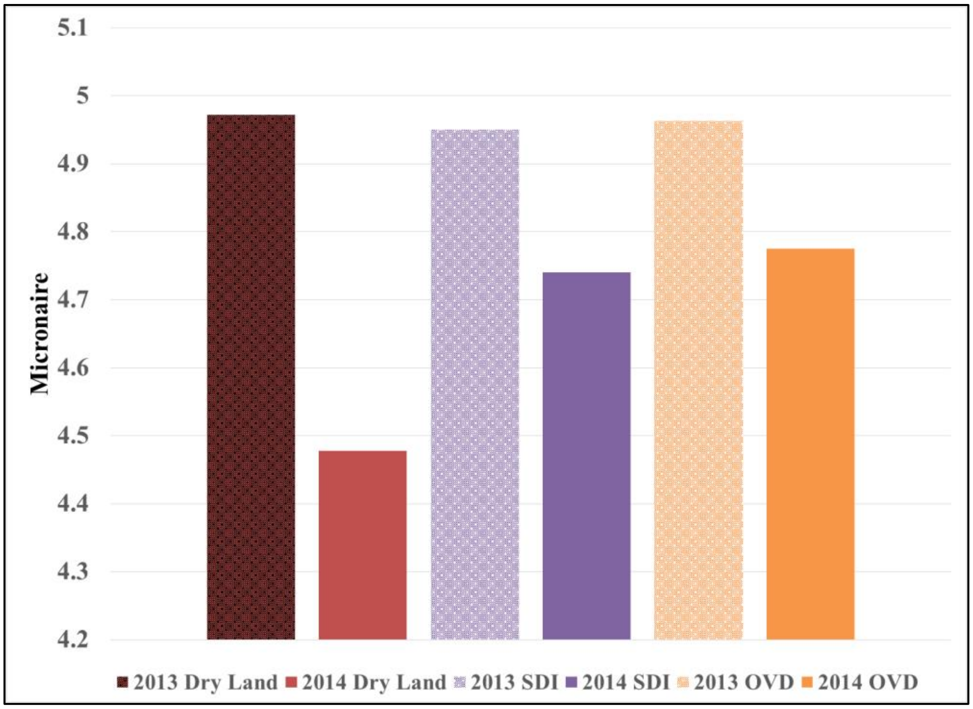

Figure 8. Micronaire data with no difference independent of year and climatic effect.

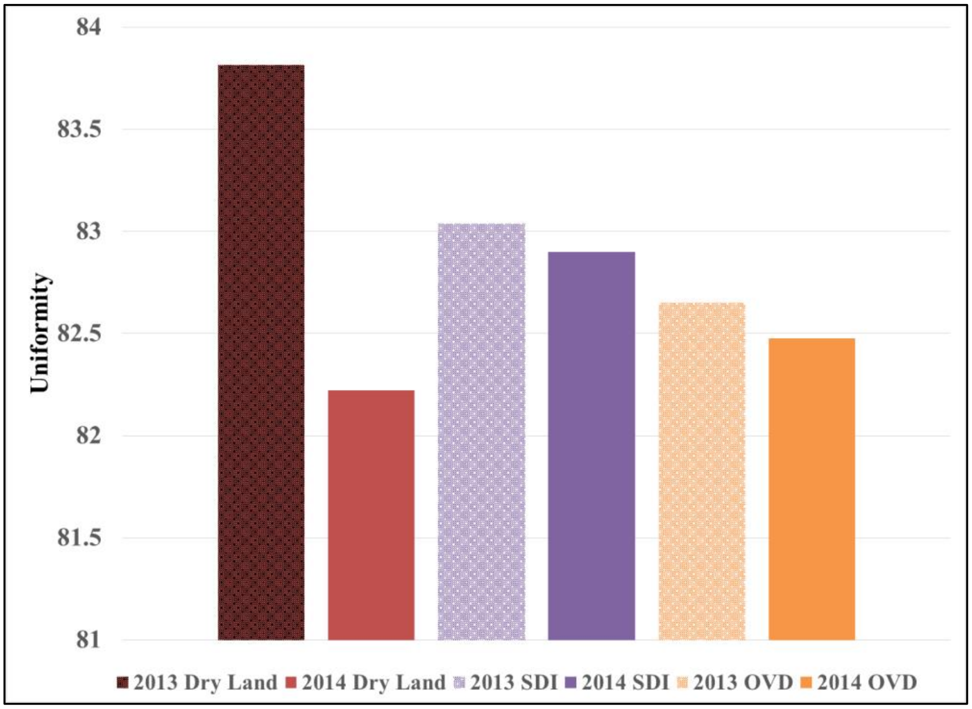

Figure 9. Fiber uniformity; the 2013 dryland had the highest uniformity, and the 2014 dryland had the lowest.

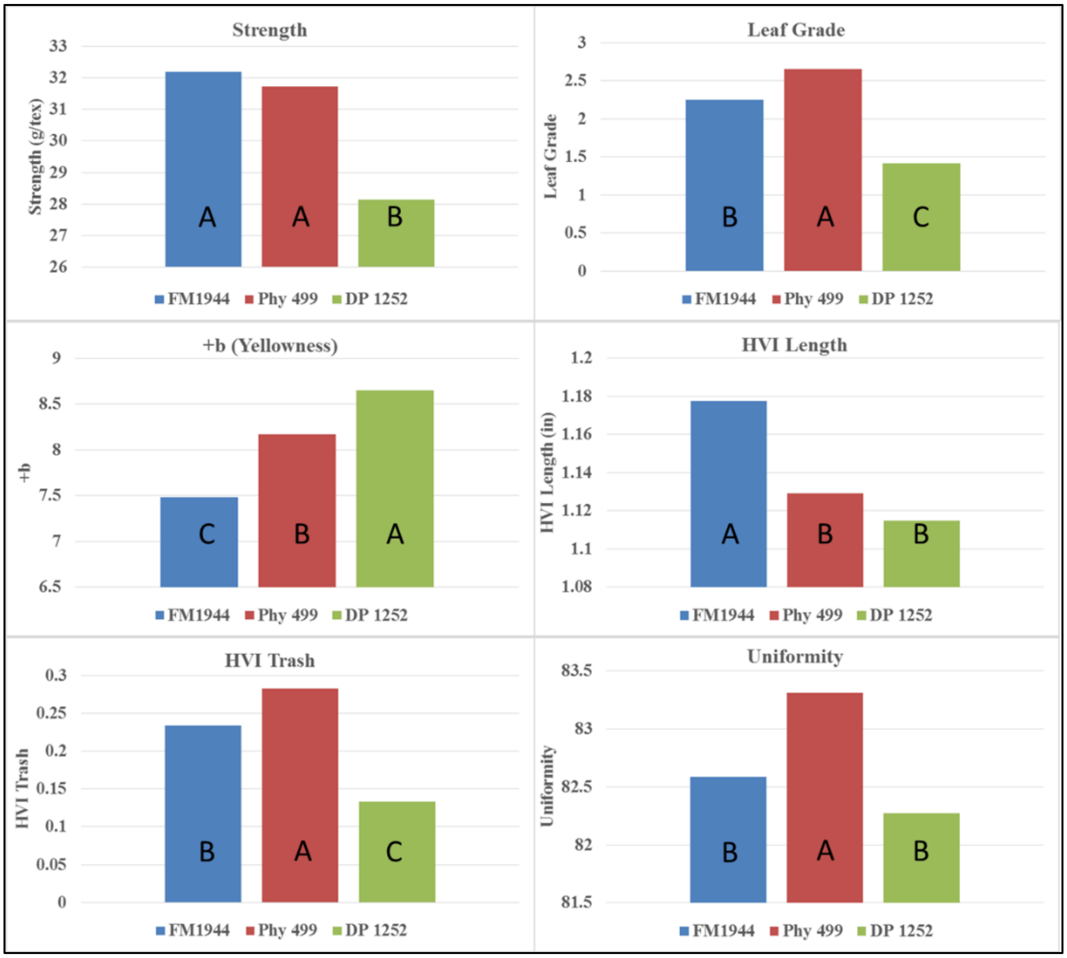

Figure 10. Fiber quality parameters that were found to be statistically different by variety.

References

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