ADVANCED ANALYSIS OF THE RESPONSES OF COTTON GENOTYPES GROWING UNDER WATER STRESS

A Thesis

by

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ABSTRACT

The ever-growing world population raises the concern and necessity of rational use and distribution of limited water resources. Water deficit is the single most dominant abiotic factor limiting cotton (*Gossypium hirsutum L.)* yield in drought-prone Texas croplands. Characterizing plant traits conferring drought tolerance to cotton genotypes and then transferring this information back to breeders and geneticists have the potential of significantly increasing and stabilizing production statewide. Although a plethora of physiological studies have been conducted and have demonstrated that drought tolerance in plants is likely to be conferred by a combination of plant traits rather than a single trait, this knowledge has not translated into improved breeding lines. Experiments were conducted in 2010 and 2011 in the Drought Tolerance Laboratory (Texas AgriLife Research and Extension Center in Corpus Christi, TX) to analyze the responses of cotton genotypes to different levels of water stress. This facility is equipped with computerized systems capable of continuously monitoring whole-plant water use as well as several environmental parameters. Sixteen cotton genotypes were provided by Monsanto Co. and the Texas AgriLife Cotton Improvement Programs at College Station and Lubbock. Seeds were pre-germinated in wet paper towels and then hand planted in large pots previously filled with fritted clay. A total of 3 and 8 (2010 and 2011, respectively) pots containing plants of each genotype were permanently placed on micro-lysimeters for continuous measurement of water use. Water regimes were imposed in 2010 (well-watered and water-stressed), and 2011 (water-stressed) when plants reached the early-flowering stage and were carried until plants reached maturity (100% open bolls).

Data collected showed that genotypes have very distinct water use patterns. The water stress treatment imposed on the test plants negatively affected plant growth that was indicated by a lower plant height, total number of leaves, and main-stem nodes of stressed plants when contrasted to their well-watered counterparts. Stomatal density was remarkably different among genotypes and a higher density was found on the abaxial (lower) leaf surface for all genotypes studied. Root dry mass production had different responses depending upon the severity of the water stress. Highest root dry mass was observed when plants were exposed to a mild stress and lowest when a more severe water restriction was imposed.

DEDICATION

To my family

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CHAPTER I

INTRODUCTION

Plants are more often than not, unable to express their full genetic potential that is constrained by unfavorable environmental conditions (Boyer, 1982). Drought is the major abiotic factor limiting crop productivity, and the increase in world population and food demand raises the concern of rational use of limited water resources for human consumption as well as for agricultural purposes. Global models predict that rainfall is shifting towards fewer, but more intense events, and predictions are backed up by empirical evidence that such change is occurring (Heisler-White et al., 2009). Alteration in rainfall patterns is also likely to be coupled with higher temperatures and increased evaporative demand; how plants in general will adapt to such changes is still largely unknown.

Drought tolerance may be defined as a plant's ability to grow, flower and display economic yield under suboptimal water supply where various morphological, biochemical and physiological processes are involved (Farooq et al., 2009). Cotton (*Gossypium hirsutum* L.) is not classified as a drought-tolerant crop. It is also known not to be a very efficient crop in the amount of water it requires to produce a unit of dry matter (Ray et al., 1974). Insufficient water supply is widely known to negatively affect plant growth, especially in early stages of vegetative development, which may happen because of the intimate dependency of growth on cell expansion (Hsiao et al., 1976).

In simple terms, growth can be described as an increase in dry mass, volume, length, or area that results from cell division, expansion and differentiation (Lambers et al., 2008a). According to Mutsaers (1983), even though plant growth and development may be significantly affected by external conditions, these parameters always follow a general and genetically determined pattern, typical for the species. Among other factors, leaf growth inhibition is among the earliest responses of plants to drought (Chaves et al., 2003). Ball et al. (1994) reported a significant reduction in leaf expansion for cotton plants grown in the field four days into water-stress, and a decreased rate of leaf expansion was noticeable as early as two days for chamber-grown cotton. Similar results have also been reported elsewhere (Fernandez et al., 1996). It was also suggested that although leaf expansion rates returned to that of the control plants 5d after rewatering, total leaf area was lower at the end of the experiment. This is an indication that after water supply is reestablished the plants may resume growth at a normal rate, but the growth of individual plant parts curtailed during the stress is not recovered. Reduced crop leaf canopy may reduce the amount of intercepted solar radiation (Singh et al., 2006) and, therefore, transpiration and photosynthetic rates and, ultimately water economy and yield. Fernandez et al. (1996) demonstrated that water stress decreased whole-plant cumulative leaf area by about 50%, through decreased production of main-stem and branch leaves.

In the leaves, stomates are a key structure. Stomatal aperture controls the exchange of CO_2 between the leaf interior and the surrounding air and also plant water use efficiency (WUE) (Woodward and Kelly, 1995; Xu and Zhou, 2008). CO_2 is a substrate for the photosynthetic process inside the leaf. The exchange balance between these two components is known as gaseous WUE. The aperture of stomata is reduced when the hydration state of the leaf epidermis deteriorates. Stomata are also widely known to respond to limited water availability (e.g. drying soil) through increases in density (Gindel, 1969) and decreased stomatal conductance (Davies and Zhang, 1991). However, water economy does not come without a tradeoff; by decreasing conductance and therefore reducing water loss to the atmosphere, carbon assimilation and ultimately dry matter production rates are also reduced (Atkinson et al., 2000). Differences in stomatal density are likely among cotton genotypes, and this may influence their water economies under a wide range of soil water regimes. The soil-plant-atmosphere continuum system is complex, with numerous factors influencing its various interactions. Water moves passively from soil to atmosphere through the plant in response to water potential gradients. Since stomata on the leaves need to be open for carbon (CO_2) uptake, water loss through transpiration is clearly an inevitable consequence of photosynthesis. Stomates allow CO_2 to enter the leaf, but at the same time also offers a pathway for water loss to the atmosphere (Lambers et al., 2008c). Among other factors, WUE is inherently low in plants because the diffusion coefficient of water (H_2O) and carbon dioxide (CO_2) are different; in air, the H_2O/ CO_2 diffusion ratio is approximately 1.6 and it changes when molecules are diffusing through the boundary layer, where the ratio is approximately 1.37 (Lambers et al., 2008b). Although H_2O and CO_2 molecules diffuse through the same pathway (in opposite directions), H_2O pathway resistances are largely composed of the boundary layer resistance and the stomatal resistance, for CO2; on the other hand, the mesophyll resistance should also be considered. (Lambers et al., 2008b; Taiz and Zeiger, 2002a). Until recently, the mesophyll conductance was previously assumed to be large, and its resistance was often ignored; however, recent reports have shown that this may not be the case (Flexas et al., 2008; Warren, 2008). While increased plant transpiration (water loss) coupled with a steady or even decreased rate of photosynthesis may diminish WUE, this phenomenon can also be a valuable plant strategy to dissipate excess heat (Saranga et al., 2009).

The plant's root system plays an important role not only in providing structural support but also supplies chemical signals, nutrients and water to mediate shoot physiological processes (Dodd, 2005), and is thus obviously a vital structure. In cotton, several factors such as soil temperature, soil aeration, soil strength and soil water are known to affect root growth (McMichael et al., 2010). Cotton plants grown under water stress will alter their root growth pattern. As a result of death of older roots in layers closer to the soil surface and sustained growth at lower horizons, rooting density will increase with depth as the drought progresses (Klepper et al., 1973). It has been documented that an increased root-to-shoot ratio is one of the many long-term responses of plants to periods of drought stress (Chaves et al., 2003). In coffee (*Coffea canephora*), root depth of drought-tolerant clones has been reported to be higher than the drought-sensitive ones (Pinheiro et al., 2005). In cotton seedlings, a brief (6 days) period of drought stress reduced root elongation and root volume, although leaf expansion was curtailed just 2 days after the stress started and was found to be more sensitive to drought than root elongation (Ball et al., 1994). Root characteristics have also been reported to be important information in understanding the basis of drought tolerance and water use efficiency (WUE) in various other plants such as rice (*Oriza sativa* L.) (Henry et al., 2011), turfgrasses (*Cynodon dactylon* L., *Eremochloa ophiuroides* Munro, *Paspalum vaginatum* Swartz, and *Zoysia japonica* Steudel) (Huang et al., 1997), perennial grasses (*Poa pratensis* L. and *Festuca arundinaceae* Schreb.) (Huang and Fu, 2000), wheat (*Triticum aestivum* L.) (Manschadi et al., 2010), and peanut (*Arachis hypogaea* L.) (Songsri et al., 2008). Because roots are the main channel for water uptake, their ability to readily access water will play a key role in the plant water use.

Several years of selection and indirect improvements have enabled cotton to be grown in areas where insufficient rainfall prevails, but the amount of water necessary to maintain a profitable crop production often has to be supplemented by irrigation. Even though water is the most abundant molecule on Earth, its availability to plant growth is the strongest factor limiting crop productivity, as well as determining geographical distribution.

Understanding how plants adapt to water shortages while maintaining a reasonable yield could significantly increase and stabilize crop production worldwide, help accelerate development of drought tolerant cultivars and perhaps also enhance land utilization, by enabling marginal areas to be used for agriculture where insufficient rainfall prevails.

CHAPTER II

WHOLE-PLANT WATER USE

OVERVIEW

To investigate water use economy in a set of cotton genotypes, experiments were conducted in the 2010 and 2011 cotton growing seasons in the Drought Tolerance Laboratory in Corpus Christi, TX. Data collected at 10-min. intervals permitted the removal of almost all interference of plant growth in the measurements of daily plant water use. Additional correction to plant water use measurements were made by removing the leaf mass effect of leafiness (leaf dry mass) particular to each genotype by fitting regression lines. Daily water use decreased substantially after the initiation of the water stress treatment on both testing years, and variation between days was observed to be lower in stressed plants when contrasted to well-watered ones. Average daily plant water use per leaf dry mass (DWM), expressed in mL g^{-1} d^{-1} ranged from 24.7 to 36.6, 19.8 to 33.7, and 20.8 to 31.8 for well-watered and water-stressed plants in 2010 and water-stressed plants in 2011, respectively.

INTRODUCTION

Each plant species will need different amounts of water to germinate, develop (grow), flower, and generate seeds. Cotton (*Gossypium hirsutum* L.) is not classified as a drought-tolerant crop and it is also known not to be a very efficient crop in the amount of water it requires to produce a unit of dry matter (Ray et al., 1974). Whole-plant water use is a major factor limiting plant productivity in general, and is usually very complex due to its dependency on various other factors (environment, leaf area, leaf conductance, root system, stomatal density). In cropping systems, a good understanding of whole-plant water use and improved water-use efficiency presents opportunities for increased yields where water is limiting (Richards et al., 2002). Although several years of selection and indirect improvements have enabled cotton to be grown in areas where insufficient rainfall prevails, such as arid and semi-arid environments, the water necessary to maintain a profitable crop production often has to be supplemented by irrigation. In the year of 2011, the State of Texas had one of the worst droughts on record to date. According to Texas AgriLife Extension Service economists, agricultural losses due to the 2011 drought totaled an impressive $7.62 billion, of which $2.2 billion were attributed to the negative impact of the drought on the cotton industry alone (detailed article available at http://today.agrilife.org/2012/03/21/updated-2011-texas-agricultural-drought-losses-total-7-62-billion/). With the changes in rainfall and weather patterns predicted to continue over the following years, recently considerable attention has been given to understanding and quantifying crop water use. Attempts have been made to improve the efficiency of water usage in agricultural settings (e.g. crop production), not only by increasing technology applied to irrigation systems, but also by trying to understand and improve crop water use efficiency (WUE). While increased efficiency in crop water use may be a useful trait in any climate condition, it would most definitely be a very desirable trait for arid and semi-arid regions if coupled with maintenance of yield. This could potentially increase the utilization of marginal areas where insufficient rainfall prevails. Additionally, improved crop water use efficiency could help farmers maintain a profitable operation in environments where periods of drought within the rain season often limit productivity.

With the provided information, experiments were conducted in 2010 and 2011 at the Texas AgriLife in Corpus Christi with the objective of evaluating water-use response of 22 unique cotton genotypes growing under water-stress conditions in the Drought Tolerance Laboratory.

MATERIALS AND METHODS

Plants of 16 cotton genotypes were grown in the Drought Tolerance Laboratory (DTL) at the Texas AgriLife Research and Extension Center in Corpus Christi, Texas during the 2010 and 2011 cotton growing seasons. This facility is equipped with a computerized system and 128 micro-lysimeters capable of continuously monitoring plant water use. The facility consists of two joined modified greenhouses to serve as a rain shelter. Six genotypes were unique for each of the growing years, while 10 were common for both years. Genotypes were provided by Monsanto Co. and the Texas AgriLife Cotton Improvement Programs at College Station and Lubbock. Seeds were pre-germinated in wet paper towels until a healthy 3.81cm (1 ½ in.) radicle was present and then hand planted in large 13.5-L (3.578 gallon) pots. Pots were uniformly filled with fritted clay, wetted, and covered with aluminum foil with tens of tiny perforations made with medium size sewing needles to allow for irrigation water infiltration and minimize water loss through soil evaporation. A central cut was made to allow seedling emergence and growth. Seedlings were planted at the rate of two per pot in 2010 and four per pot in 2011. This fritted clay soil medium was chosen because of its high water holding capacity (~ 45% of volume) and excellent water relations properties for plant growth purposes (VanBavel et al., 1978). After seedling establishment, pots were thinned to only one seedling per pot. Pots were then spatially arranged to conform to a randomized complete block design (RCB) totaling 3 and 8 replications per water treatment (2010 and 2011, respectively). Six plants in 2010 and eight plants in 2011 of each genotype were permanently suspended from the micro-lisymeters for continuous measurement of plant water use. In 2010, two water regimes were tested, namely well-watered (1-WW) and water-stressed (1-WS), while in 2011 only the water-stressed (2-WS) treatment was imposed. Pots were irrigated daily in excess (~ 4L/d) until plants reached the early bloom (early flowering) stage, on day of the year (DOY) 169 and 161 for 2010 and 2011, respectively. At these times, the water regime treatments were initiated and carried throughout the season until plants reached full maturity. Dates corresponding to days of the year are shown in Appendix II.A. In 2010, the 1-WS treatment started with a 2L/d irrigation cycle and at about mid-flowering stage the water stress was intensified by reducing the daily irrigation to 1L/d. In 2011, due to the severity of the 1-WS treatment imposed in 2010 the 2-WS treatment was modified and consisted of a mild and constant water-stress regime (2L/d). Plants grown under the 1-WW treatment in 2010 continued to receive daily excess irrigation throughout the season. Irrigation water was city water purified through a reverse osmosis system. All plants received the same irrigation water dosed with a modified Hoagland solution from Fernandez' PhD research project, shown on table II.1 (Fernandez, 1989).

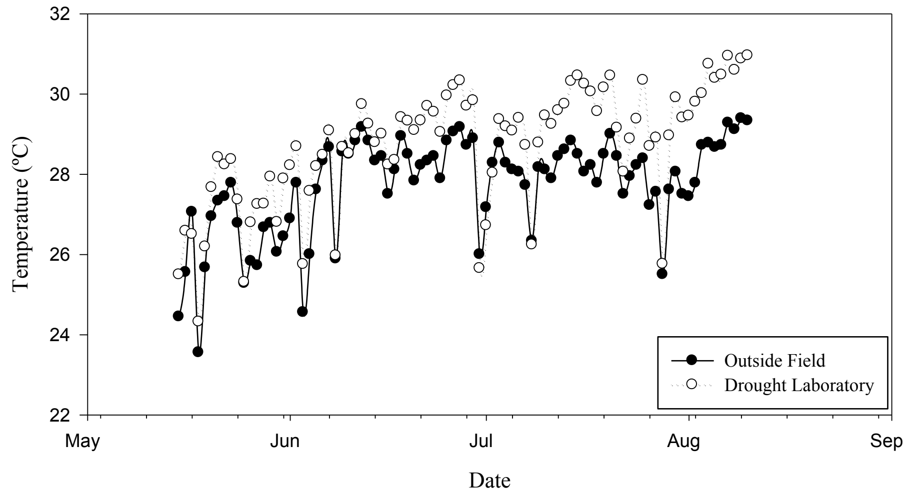
Table II.1. Modified Hoagland's nutrient solution (Fernandez, 1989).

	Macro Nutrients	**g/L**
1	$NH_4H_2PO_4$	46
2	KNO_3	121
3	$Ca(NO_3)_2 \cdot 4H_2O$	189
4	$MgSO_4 \cdot 7H_2O$	99
	Micro Nutrients	**g/L**
5	H_3BO_3	0.62
6	$MnCl_2 \cdot 4H_2O$	0.4
7	$ZnSO_4 \cdot 7\ H_2O$	0.046
8	$CuSO_4 \cdot 5\ H_2O$	0.02
9	$Na_2MoO_4 \cdot 2H_2O$	0.02
10	NaCl	1.17
	Iron Solution	**g/L**
11	Na_2-EDTA	6.7
12	$FeSO_4 \cdot 7H_2O$	5
13	KOH	4

Injection rate 0.50%.

Daily plant water use (plant transpiration) was calculated as the 24-hr sum of the differences in pot weight between consecutive hours, which allowed the removal of almost all interference of plant growth in the calculation of plant transpiration. Environmental conditions such as air temperature (°C), relative humidity (%), solar radiation (kJ m^{-2} day^{-1}), and wind speed (km h^{-1}) were measured continuously at 10-min. intervals, from which daily averages were calculated.

Weather conditions inside the Drought Tolerance Laboratory during the 2010 cotton-growing season were similar to outdoors as measured by a weather station installed about 60 m apart in a cotton field. From 05/15/10 through 08/10/10 daily average temperature was 28.7 ºC with 12 days reaching temperatures over 37.8 °C. A rapid and continuous increase trend in temperature was evident within the specified dates (~7 °C). For the same period, average daily values for relative humidity, solar radiation and wind speed were 78.6%, 1604.8 kJ m^{-2} day^{-1}, and 0.72 km h^{-1}, respectively. Figures II.3 and II.4 depict weather conditions inside the DTL in 2011. Average values for environmental conditions in 2010 and 2011 were similar, but the latter was a much drier and hotter year with record high temperatures.



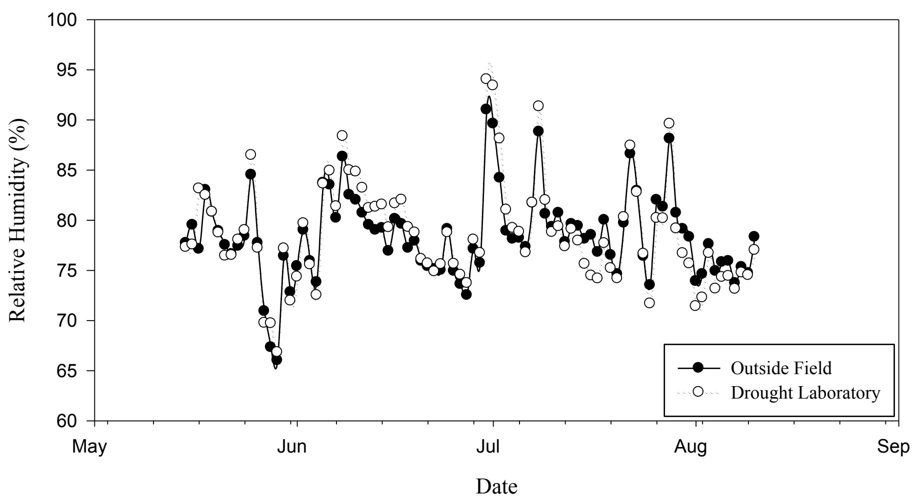
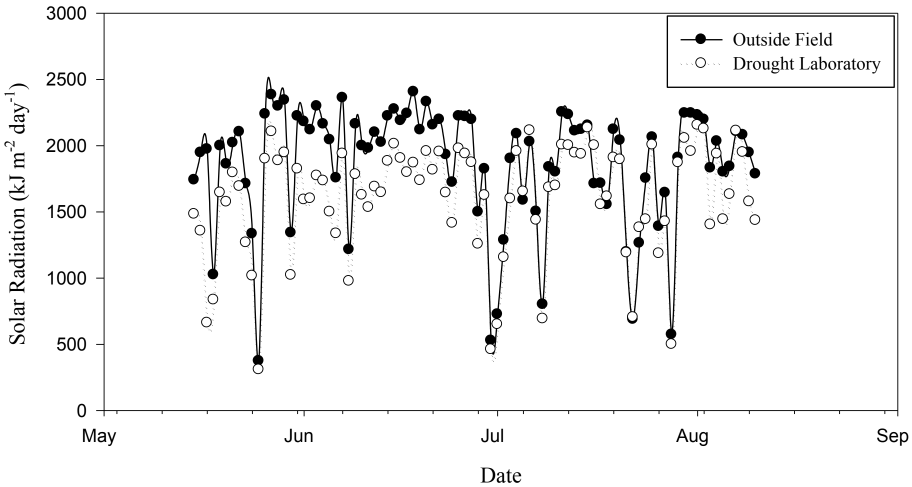


Fig. II.1. 2010 temperature (°C) and relative humidity (%) as measured inside the Drought Tolerance Laboratory in Corpus Christi, TX. Graphs illustrate data collected from 05/15/10 through 08/10/10. Values are daily averages calculated from data collected at 10-min. intervals.



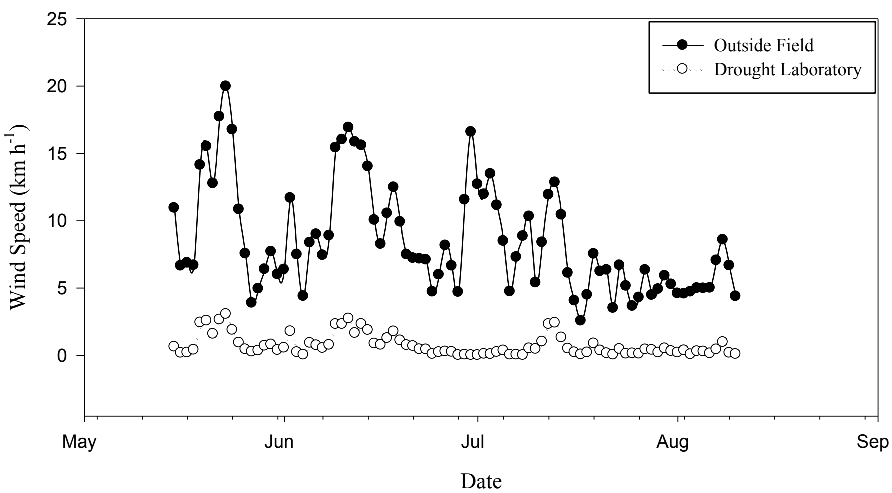
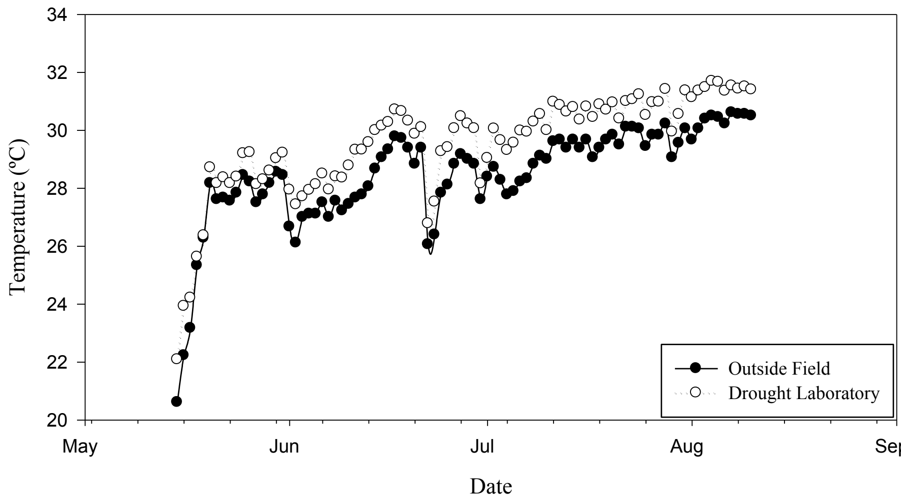


Fig. II.2. 2010 solar radiation (kJ m^{-2} day^{-1}), and wind speed (km h^{-1}) as measured inside the Drought Tolerance Laboratory in Corpus Christi, TX. Graphs illustrate data collected from 05/15/10 through 08/10/10. Values are daily averages calculated from data collected at 10-min. intervals.

The average daily temperature value was 29.6 °C, and for 29 days within 05/15/11 and 08/10/11, temperatures went above 37.8 °C. In a six-day time frame, from 05/15/11 through 05/20/11, a sharp increase in temperature occurred (over 7 °C), after which it kept increasing at a slow but steady rate over the summer months. At the beginning of July through the end of the first week of August, variations in average daily temperatures were small. For the same time frame, average daily values for relative humidity, solar radiation and wind speed were 72.4 %, 1474.9 kJ m^{-2} day^{-1}, and 1.46 km h^{-1}, respectively. Environmental data collected from the nuec1 weather station at the Texas AgriLife in Corpus Christi (data obtained from the Crop Weather Program, http://cwp.tamu.edu/) showed that solar radiation and relative humidity were comparable for inside and outside the DTL for both years of the study (Figs. II.1 to II.4), but temperatures inside the DTL were higher and wind speed values were lower in both years. Wind speed is widely known to decrease the leaf boundary layer resistance to diffusion. Therefore, daily plant transpiration is expected to be higher for the same set of genotypes growing in a field setting. The boundary layer resistance is a layer of unstirred air surrounding the leaf surface, through which water molecules must diffuse in order to reach the atmosphere (Taiz and Zeiger, 2002b).



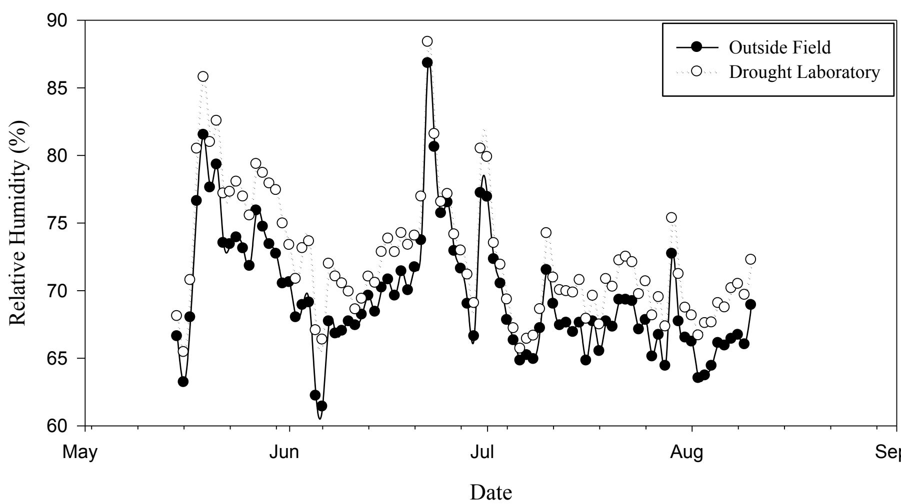
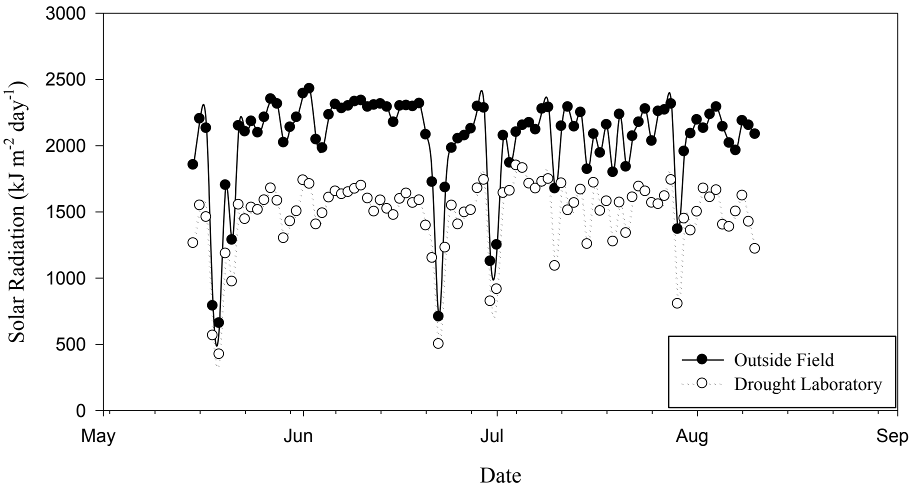


Fig. II.3. 2011 temperature (°C) and relative humidity (%) as measured inside the Drought Tolerance Laboratory in Corpus Christi, TX. Graphs illustrate data collected from 05/15/11 through 08/10/11. Values are daily averages calculated from data collected at 10-min. intervals.



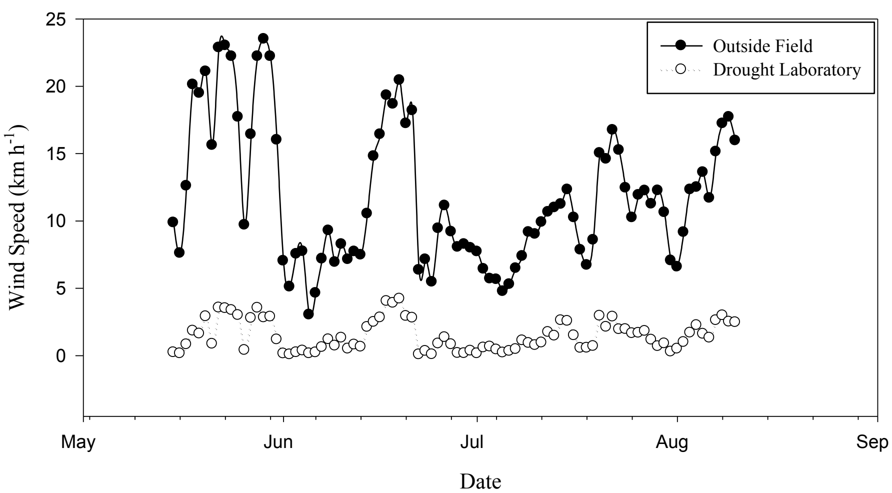


Fig. II.4. 2011 solar radiation (kJ m^{-2} day^{-1}), and wind speed (km h^{-1}) as measured inside the Drought Tolerance Laboratory in Corpus Christi, TX. Graphs illustrate data collected from 05/15/11 through 08/10/11. Values are daily averages calculated from data collected at 10-min. intervals.

When comparing weather parameters inside the Drought Tolerance Lab (DTL) across years (at the 5% level of probability), temperature and RH were significantly different with 0.81ºC and 6.21% mean difference, respectively, while wind speed and solar radiation values were not significantly different (Table II.2). Due to the fact that all weather parameters analyzed play an important role in changing not only evaporative demand (e.g. plant transpiration), but also other morphological characteristics, 50% of the weather parameters are here acknowledged as a confounding factor, together with the water treatments imposed, across years, for all experiments conducted for this manuscript.

Table II.2. Weather parameters mean comparisons between Drought Tolerance Lab (DTL) and outside field (TAMUCC) across years from DOY 135 trough DOY 222. a. (Temperature in ºC), b. (Relative Humidity in %), c. (Wind Speed in km h^{-1}), and d. (Solar Radiation in kJ m^{-2} day^{-1}). Means not connected by the same letter are significantly different at the 5% level of probability.

a. Temperature

Level				Mean
2011-DTL	A			29.53
2010-DTL		B		28.72
2011-TAMUCC		B		28.47
2010-TAMUCC			C	27.73

b. RH

Level				Mean
2010-DTL	A			78.62
2010-TAMUCC	A			78.43
2011-DTL		B		72.41
2011-TAMUCC			C	69.61

c. Wind Speed

Level				Mean
2011-TAMUCC	A			11.78
2010-TAMUCC		B		8.53
2011-DTL			C	1.46
2010-DTL			C	0.72

d. Solar Radiation

Level				Mean
2011-TAMUCC	A			2050.67
2010-TAMUCC		B		1862.27
2010-DTL			C	1604.50
2011-DTL			C	1474.10

RESULTS AND DISCUSSION

In 2010, the initial average daily plant water use at the start of the experimental period was similar for both water regime treatments. Figure II.5 shows the average response of the 16 genotypes used in the experiment. A large decrease in daily plant water use of 1-WS treatment plants was observed on DOY 170, when the water stress regime was initiated. The amount of daily irrigation was reduced by half (from 4 to 2L/d). Another significant decrease in average daily water use occurred on DOY 193, when the amount of daily irrigation was reduced from 2 to 1L/d.

Stomatal closure is among the known short-term responses of plants to drought (Chaves et al., 2003). As leaves dehydrate, stomata close in response to a low (negative) water potential, the leaf diffusive resistance increases (Hsiao and Acevedo, 1974) and, consequently, the amount of water lost to the atmosphere is reduced accordingly. Therefore, the significant reductions in plant water use observed on DOY 170 and 193 may be partially explained by the low soil water availability, decreased plant water uptake, and leaf dehydration leading to stomatal closure. Variation between consecutive days within the same water regime may be attributed to changes in the daily evaporative demand (e.g. humid/dry, cloudy/sunny). The amplitude of variation in daily plant water use within water regimes, although occurring at the same time, was significantly smaller in genotypes growing under water stress. This response was most notable after DOY 193, and may be attributed to the already low water status of those plants.

Cumulative plant water use from DOY 166 to 222 is shown on Fig. II.6. As expected, plants growing under limited water availability used less water than their well-watered counterparts (roughly 54%). Average cumulative water use values for plants growing under the 1-WW and 1-WS water regimes were 106.3L and 58.3L, respectively, for the period. The impact of intensifying the water stress on DOY 193 is clearly noted by the immediate further decline of plant water use as shown in Fig.II.6.

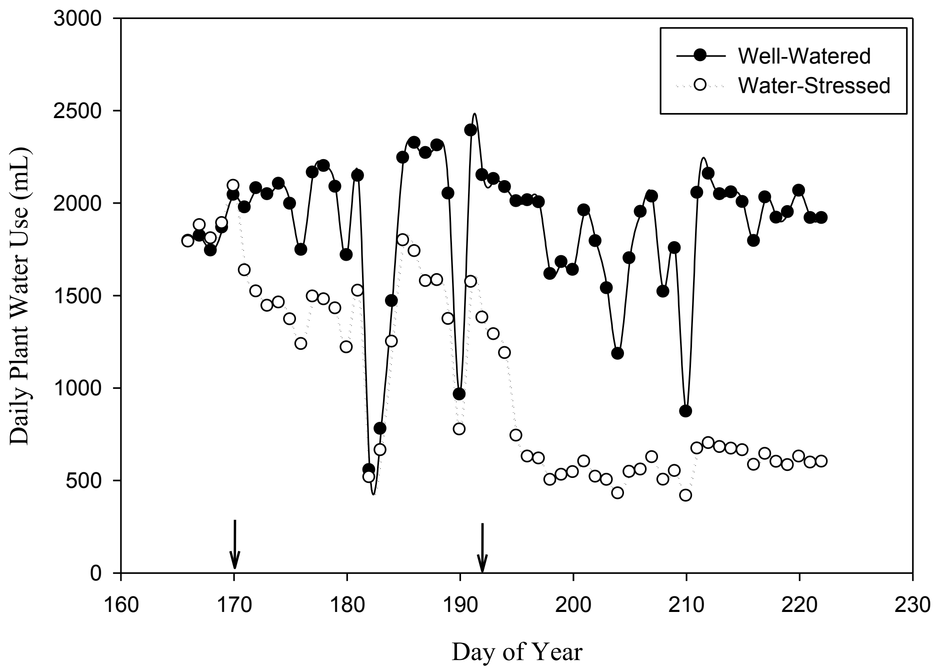


Figure II.5. Daily plant water use of cotton genotypes growing under well-watered (1-WW) and water-stressed (1-WS) conditions in 2010 and shown from DOY 166 to 222. Values are means of all 16 genotypes and 3 replications for each of the water treatments. Down-pointing arrows indicate day of the year 170 and 193 and represent dates when the water stress treatment (1-WS) was imposed and then increased, respectively.

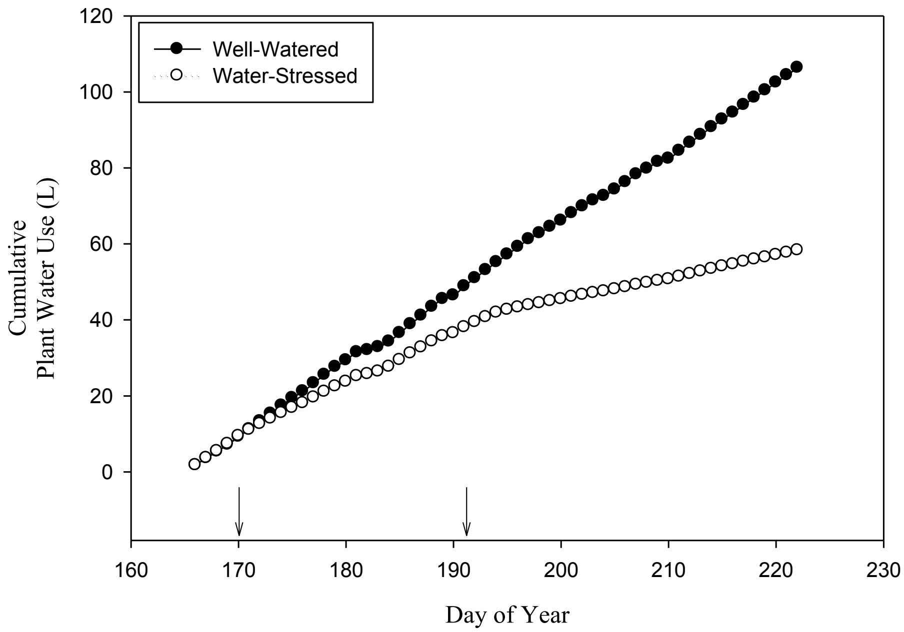


Figure II.6. Cumulative plant water use of cotton genotypes growing under well-watered (1-WW) and water-stressed (1-WS) conditions in 2010. Values are means of all 16 genotypes and 3 replications for each of the water treatments and shown from DOY 166 to 222. Down-pointing arrows indicate day of the year 170 and 193 and represent dates when the water stress treatment (1-WS) was imposed and then increased, respectively.

Plant water use in the 2011 experiment showed a very similar trend to that in 2010. As shown on Fig. II.7, a sharp decrease in plant water use was noticeable following the initiation of the 2-WS treatment on DOY 161. Unlike what happened in 2010, daily plant water use did not fall below 1L (1000 mL) consistently, as the soil water deficit was not further intensified. The 2-WS regime imposed in 2011 was moderate (2L/d from flowering to maturity), therefore resulting in a higher amount of plant available water throughout the water stress period as compared to the 2010 experiment.

Variation in daily plant water use can also be attributed to changes in daily evaporative demand. The average cumulative plant water use between DOY 157 and 223 for all genotypes growing under the 2-WS treatment in 2011 was 85.6L (Fig. II.8).

In an attempt to remove part of the effects of differences in leaf area production among genotypes, plant water use was divided by the plant's total leaf biomass, resulting in the new state variable plant water use per unit leaf mass presented as mL of water used per g of leaf dry mass per day (mL g^{-1} d^{-1}).

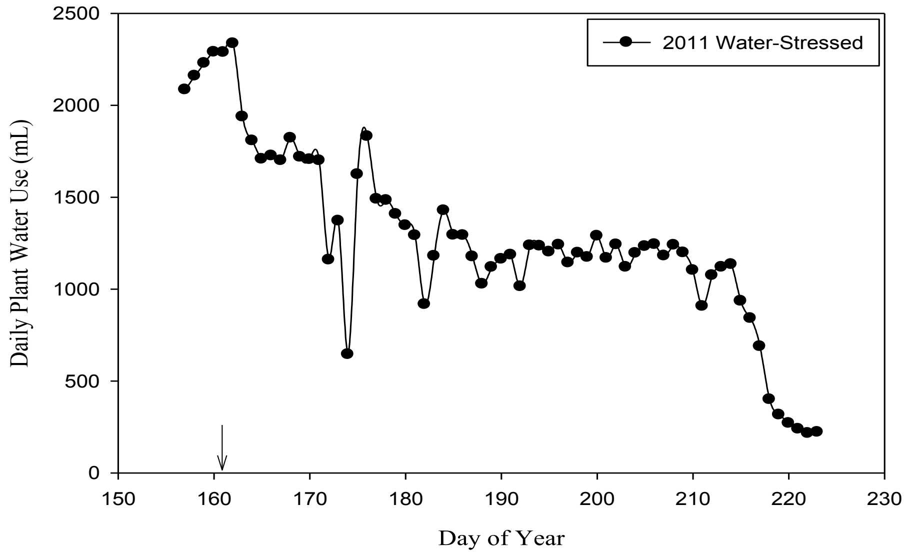


Figure II.7. Daily plant water use of cotton genotypes growing under water-stressed (2-WS) conditions in 2011 and shown from DOY 157 to 223. Values are means of all 16 genotypes and 8 replications. The down-pointing arrow indicates day of the year 161 and represents the date when the water stress treatment (2-WS) was imposed.

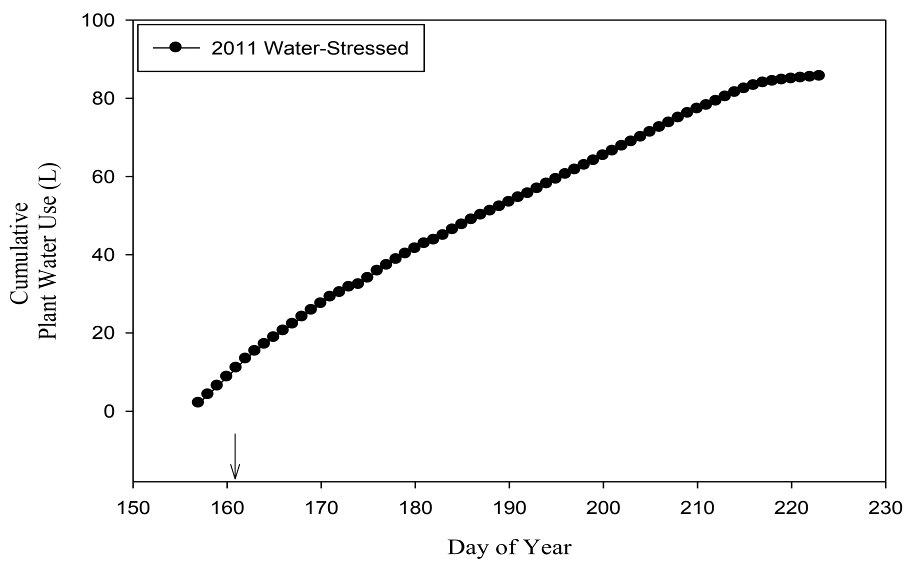


Figure II.8. Cumulative plant water use of cotton genotypes growing under water-stressed (2-WS) conditions in 2011. Values are means of all 16 genotypes and 8 replications shown from DOY 157 to 223. The down-pointing arrow indicates day of the year 161 and represents the date when the water stress treatment (2-WS) was imposed.

Because whole-plant leaf mass measurements throughout the experimental period were discrete, the daily values were estimated using regression equations of whole-plant dry mass on day of the year for each genotype. Equations used for the genotypes on the water regimes 1-WW and 1-WS in 2010, and 2-WS in 2011 were developed using discrete measurements taken on DOY 167, 179, 202, and 223 with 3 plants (on each DOY), and DOY 159, and 217 with 5 plants (on each DOY) in 2010 and 2011, respectively. These equations and other details can be found in Appendix II.B. Mean comparisons between genotypes growing under 1-WW conditions showed that plant water use per unit leaf mass ranged from 24.7 mL g^{-1} d^{-1} for DP1028 B2RF to 36.6 mL g^{-1} d^{-1} for DP1048 B2RF when grown under well-watered conditions (Table II.3). DP1028 B2RF was the only genotype to present a significantly lower plant water use per unit leaf mass when compared to the average value for all 16 genotypes (WW AVERAGE). Plant water use per unit leaf mass for genotypes growing under the 1-WS treatment during 2010 ranged from 19.8 mL g^{-1} d^{-1} for DP0935 B2RF to 33.7 mL g^{-1} d^{-1} for DP1048 B2RF (Table II.4). DP1048 B2RF was the only genotype significantly different from the average (WS AVERAGE), displaying the highest water use per unit leaf mass among the tested genotypes.

Table II.3. Estimated daily plant water use per unit leaf mass (mL g^{-1} d^{-1}) mean comparisons between genotypes grown in 2010 under the well-watered (1-WW) treatment. Values were computed from DOY 169 through 222. WW AVERAGE is the average value for all 16 genotypes for each DOY. Levels not connected by the same letter are significantly different at the 5% level of probability.

2010 Well-Watered								
Level								Mean
DP1048 B2RF	A							36.58
02-WK-11L	A	B						35.92
DP0912 B2RF	A	B	C					34.49
L-23	A	B	C	D				34.00
CS-50	A	B	C	D	E			32.63
05-47-802	A	B	C	D	E	F		32.31
06-46-153		B	C	D	E	F		31.89
TAM B-182-33		B	C	D	E	F		31.48
WW AVERAGE			C	D	E	F		31.01
DP0935 B2RF			C	D	E	F		30.86
DP0949 B2RF				D	E	F		29.50
DP0141 B2RF					E	F	G	28.99
08-1-1325					E	F	G	28.95
DP1044 B2RF					E	F	G	28.05
03-WZ-37						F	G	27.95
04-22-405						F	G	27.86
DP1028 B2RF							G	24.71

Table II.4. Estimated daily plant water use per unit leaf mass (mL g^{-1} d^{-1}) mean comparisons between genotypes grown in 2010 under the water-stressed (1-WS) treatment. Values were computed from DOY 169 through 222. WS AVERAGE is the average value for all 16 genotypes for each DOY. Levels not connected by the same letter are significantly different at the 5% level of probability.

2010 Water-Stressed				
Level				Mean
DP1048 B2RF	A			33.73
L-23		B		26.64
DP0949 B2RF		B		25.01
CS-50		B	C	23.83
DP1028 B2RF		B	C	23.81
WS AVERAGE		B	C	23.55
04-22-405		B	C	23.37
TAM B-182-33		B	C	23.15
03-WZ-37		B	C	23.06
02-WK-11L		B	C	22.77
06-46-153		B	C	22.59
08-1-1325		B	C	22.19
DP1044 B2RF		B	C	22.04
DP0141 B2RF		B	C	21.76
05-47-802		B	C	21.68
DP0912 B2RF		B	C	21.48
DP0935 B2RF			C	19.79

The plant water use per unit leaf mass values in 2011 were similar to those of 2010, even though six out of sixteen genotypes were unique for that particular year. With increased available water in 2011 contrasted to the lower availability in 2010 due to less intense water deficit treatment, the average daily plant water use per leaf dry mass increased. Values ranged from 20.8 mL g^{-1} d^{-1} for 11R136 B2R2 to 31.8 mL g^{-1} d^{-1} for L-23 (Table II.5). A "water-wise" plant should conserve water when exposed to soil water deficits thus maximizing the probability of growth and/or survival under stress. On the other hand, when water is abundant, a "water-wise" plant should be able to capitalize on the non-stressful condition and maximize growth and, hence, productivity (Nicotra and Davidson, 2010). Therefore, when plants are growing in an environment with a higher amount of available water such as a mild stress imposed by the 2-WS treatment contrasted to the more severe stress imposed by the 1-WS in 2010, one could expect the plants to make use of the available water by increasing transpiration rates. Interestingly though, out of the 10 genotypes in common for both years, DP1048 B2RF actually demonstrated a decrease in daily water use per unit leaf mass (DWM) while all others increased, and may indicate that this particular genotype was not able to capitalize on the increased water availability.

Table II.5. Daily plant water use per unit leaf mass (mL g^{-1} d^{-1}) mean comparisons between genotypes grown in 2011 under the water-stressed (2-WS) treatment. Values were computed from DOY 161 through 223. WS AVERAGE is the average value for all 16 genotypes for each DOY. Levels not connected by the same letter are significantly different at the 5% level of probability.

2011 Water-Stressed						
Level						Mean
L-23	A					31.81
DP1032 B2RF		B				28.31
06-46-153		B				27.90
10R013 B2R2		B	C			26.10
10R011 B2R2		B	C			25.97
WS AVERAGE			C	D		25.00
08-1-1325			C	D		24.94
CS-50			C	D		24.44
DP0935 B2RF			C	D		24.43
04-22-405			C	D		24.15
05-47-802			C	D		24.13
11R159 B2R2			C	D		23.75
DP1044 B2RF			C	D		23.70
10R052 B2R2			C	D	E	23.43
DP1048 B2RF				D	E	23.06
DP0912 B2RF				D	E	23.05
11R136 B2R2					E	20.76

In 2010, 7 out of 16 genotypes showed a decreased plant water use per unit leaf mass when growing under water stress (Table II.6), while the other 9 genotypes increased their water use per unit leaf mass under water deficit. Since the plant water use (transpiration) is being presented as the amount of water transpired per amount of leaf dry mass, some of this variation is attributed to the effects of drought on plant growth; not only does it curtail the initiation of new leaves, but it also causes a premature leaf abscission. Other factors such as stomatal density and conductance, leaf conductance, osmotic adjustment, and changes in cellular ultrastructure are also important when interpreting these differences. McDaniel (2000) reported that cotton plants with apparent normal morphological characteristics, but presenting lower stomatal density on the adaxial (upper) leaf surface, showed out-standing tolerance to abiotic stresses (water and temperature stresses) and also mentioned the potential for such a characteristic in breeding programs. Bakker (1991) found in a glasshouse study that in the range 0.2 to 1.6 kPa of vapor pressure, stomatal density as affected by humidity did not influence leaf conductance in cucumber (*Cucumis sativus* L.), tomato (*Lycopersicon esculentum* Mill.), sweet pepper (*Capsicum anuum* L.) and eggplant (*Solanum melongena* L.). In peach (*Prunus persica* L.) trees, Garnier and Berger (1987) showed that leaf water potential and the vapor pressure of the air explained 49% of the stomatal conductance variance, but they were not able to confirm if the influence of the drying soil on stomatal conductance was direct. In cotton, the drought effects on stomatal conductance are not consistent (Pettigrew and Gerik, 2007). Ackerson and Hebert (1981) reported that cotton plants subjected to a series of water stresses demonstrated adaptation in the form of osmoregulation (osmotic adjustment), where leaf water potentials differed between adapted and control plants. The same authors also indicated that stress-adapted plants had modified cellular ultrastructure when contrasted to the control plants, and showed chloroplasts containing large starch granules and smaller vacuoles. When plant water use data is available for well-watered and water-stressed conditions, contrasting changes between water regimes as a percentage of the average may be a simplistic way to summarize plant responses. This would be true not only with regards to water use but also for their growth response (leaf mass production) to the water limitation. Greatest differences in water use between water regimes (WW – WS) among genotypes were observed for DP1048 B2RF and DP0912 B2RF, respectively, with a 25.2% increase and a 20.0% decrease compared to the average of all genotypes within each treatment. It is clear from table II.6 that genotypes have very distinct responses to drought stress. Some are able to decrease their plant water use per unit leaf mass when growing under limited availability of water, while others will increase plant water use per unit leaf mass perhaps due to the negative impact of water stress on plant growth.

Table II.6. Summary of daily plant transpiration of cotton genotypes per leaf dry mass (% of the average) grown in 2010 under well-watered and water-stressed conditions. Status indicates whether a particular genotype increased or decreased daily transpiration when contrasting well-watered and water-stressed conditions.

Genotype	% 1-WW Average	% 1-WS Average	WW - WS	Status
02-WK-11L	115.83	96.68	19.15	Decrease
03 WZ-37	90.14	97.88	-7.74	Increase
04-22-405	89.85	99.22	-9.37	Increase
05-47-802	104.21	92.06	12.15	Decrease
06-46-153	102.83	95.89	6.94	Decrease
08-1-1325	93.35	94.20	-0.85	Increase
CS-50	105.23	101.15	4.08	Increase
DP0912 B2RF	111.24	91.19	20.05	Decrease
DP0949 B2RF	95.12	106.20	-11.08	Increase
DP1028 B2RF	79.67	101.08	-21.41	Increase
DP1044 B2RF	90.44	93.55	-3.11	Increase
DP1048 B2RF	117.96	143.19	-25.23	Increase
DP141 B2RF	93.47	92.36	1.11	Decrease
DP935 B2RF	99.51	84.02	15.49	Decrease
L-23	109.64	113.09	-3.45	Increase
TAM B-182-33	101.50	98.26	3.24	Decrease
1-WW AVERAGE	100	-	-	-
1-WS AVERAGE	-	100	-	-

CONCLUSIONS

Data collected showed that genotypes have very distinct water use patterns and that their response to drought also differs. In 2010 a sharp decrease in plant water use was observed when the water stress treatment was initiated and also when the intensity of the stress was increased, which was attributed to the decrease in plant water status that triggered stomatal closure. Variation in plant water use between days was also smaller in plants under water stress than in plants growing in an environment free of water stress, likely due to the already low plant water status and decreased stomatal conductivity. While plants were well-watered, DWM values ranged from 24.7 mL g^{-1} d^{-1} for DP1028 B2RF to 36.6 mL g^{-1} d^{-1} for DP1048 B2RF, and the only genotype to have a significantly lower than average DWM was DP1028 B2RF. While plants were under water-stress, DWM ranged from 19.8 mL g^{-1} d^{-1} for DP0935 B2RF to 33.7 mL g^{-1} d^{-1} for DP1048 B2RF, and DP1048 B2RF was the only genotype to be significantly different (higher than average). In 2011 plant water use decreased sharply soon after the water stress regime was imposed, after which variation between days was small and within 1 to 1.5L throughout most of the season. DWM values ranged from 20.8 mL g^{-1} d^{-1} for 11R136 B2R2 to 31.8 mL g^{-1} d^{-1} for L-23, and although 6 genotypes were unique for that test, the average value showed a very similar trend to the one observed in 2010. It is possible that if both well-watered and water-stressed DWM data is available, presenting values as a percent of the average may be a simplistic and integrated way to summarize genotypes' water use and growth responses to drought. The experiments demonstrated the potential for the method used; not only does it allow for a clear discrimination of water economy among the genotypes and their distinct water use patterns, but it also provides the capability to track water use in different stages of plant growth.

CHAPTER III

GROWTH AND LEAF EXPANSION OF GENOTYPES IN RESPONSE TO DROUGHT

OVERVIEW

Twenty-two upland cotton genotypes were grown in 2010 and 2011 in the Drought Tolerance Laboratory at the Texas AgriLife Research and Extension Center (Corpus Christi, TX) to evaluate their growth responses to drought. Water stress (WS) treatments were initiated at the early flowering stage and terminated at maturity, in this case defined as 100% open bolls. In 2010 the WS treatment consisted of an increased water deficit (water provided decreased from 2L/day at early flowering to 1L/day by final harvest), while in 2011 the WS treatment was constant throughout the season (2L/day). Data collected indicated that the WS treatment imposed in 2010 negatively affected plant growth as noted by decreased plant height, number of main-stem nodes and total number of leaves. Within the first 10 days after starting the water stress, initiation of new leaves was negatively affected. Leaf dry mass of water stressed plants reached a plateau around 33 days after the water restriction was initiated and then started to decrease thereafter. No such trend was visible on the well-watered plants, which were still increasing leaf dry mass at the time of final harvest. In 2011 the largest main-stem leaf was determined to be between nodes 7 to 12 for all genotypes, even while growing with sub-optimal water availability. The equation (Constable and Rawson, 1980a) used to estimate the leaf area based on the length of the leaf midrib was found to be inappropriate for okra leaf type cotton, due to an overestimation of the final leaf area values.

INTRODUCTION

Plants are, more often than not, unable to express their full genetic potential when constrained by unfavorable environmental conditions (Boyer, 1982). Insufficient water supply is widely known to negatively affect plant growth, especially in early stages of vegetative development, which may happen because of the intimate dependency of growth on cell expansion (Hsiao et al., 1976). In simple terms, growth can be described as an increase in dry mass, volume, length, or area that results from cell division, expansion and differentiation (Lambers et al., 2008a). According to Mutsaers (1983), even though plant growth and development may be significantly affected by external conditions, these parameters always follow a general and genetically determined pattern, typical for the species. Among other factors, leaf growth inhibition is among the earliest responses of plants to drought (Chaves et al., 2003). Ball et al. (1994) reported a significant reduction in leaf expansion for cotton plants grown in the field four days into water-stress, and a decreased rate of leaf expansion was noticeable as early as two days for chamber-grown cotton. Similar results have also been reported elsewhere (Fernandez et al., 1996). It was also suggested that although leaf expansion rates returned to that of the control plants 5d after rewatering, total leaf area was lower at the end of the experiment. This is an indication that after water supply is reestablished the plants may resume growth at a normal rate, but the growth of individual plant parts curtailed during the stress is not recovered. Reduced crop leaf canopy may reduce the amount of intercepted solar radiation (Singh et al., 2006) and, therefore, transpiration, photosynthetic rates, and ultimately water economy and yield. While cotton is a perennial woody shrub with an indeterminate growth habit (Cothren and Oosterhuis, 2010), plant height will, however, be determined by the genotype-environment interaction (Wells and Stewart, 2010). Fernandez et al. (1996) demonstrated that water stress decreased whole-plant cumulative leaf area by about 50%, through decreased production of main-stem and branch leaves. Cotton genotypes differ in the amount of leaf production, leaf characteristics like hairiness and shape, and spatial distribution. How much of these morphological variations affect the plant's water economy has not been sufficiently characterized

MATERIALS AND METHODS

Plants of 16 unique cotton genotypes were grown in the Drought Tolerance Laboratory at the Texas AgriLife Research and Extension Center (Corpus Christi, TX) in 2010 and 2011 cotton growing seasons, and subjected to different intensities of drought-stress. Growing conditions were the same as previously described in the Whole-Plant Water Use chapter. Destructive plant harvests for leaf sampling were conducted June 15th and June 9th (prior to the water restrictions) and August 10th and August 8th (final harvest) for 2010 and 2011, respectively. Also, in 2010 two additional destructive samplings for leaf data were conducted between the first and final harvests, on June 28th and July 21st. Data is presented for 3 replications in 2010 and 8 replications in 2011. Total number of leaves and their dry weight were recorded for both sampling dates in 2010 while in 2011 those measurements were taken only on the first sampling date. In

2011, data regarding the ratio between main-stem leaves and all other leaves and their dry weights at final harvest were estimated based upon data collected at the first sampling date and calculated on a per genotype basis. Samples were hand harvested and placed at 71 ± 2°C for 96 hours in a P0M7-806F drier (Blue M., Garland, TX) until dry weights were constant. Dry weights were collected using a high precision Sartorius scale (Brinkmann Instruments, Inc., Westbury, NY), and measurements were taken within an hour of removing the samples from the drier. In 2011, midrib leaf length was measured for all main-stem leaves present for each of the genotypes at approximate two-week intervals. Their leaf area was estimated using the following equation: $R^2 = 0.98$, (Constable and Rawson, 1980a), where A (Leaf Area in cm^2) and L (Midrib Length in cm):

$$A = 1.0526L^2 - 1.96L$$

All statistical analysis was performed using JMP 9.0 (SAS Institute Inc., Cary, NC) and graphics used were compiled using SigmaPlot version 10.0 (Systat Software Inc., San Jose, CA).

RESULTS AND DISCUSSION

In 2010, no statistically significant differences were noted for plant height, number of main-stem nodes, and total number of leaves at the first sampling date (June 15th) prior to the initiation of the water restrictions between water regimes, indicating homogeneity of the growing conditions (Table III.1). Table III.2, on the other hand, clearly shows the effects of water stress on the cotton plants at the second sampling date (final harvest). Overall, the water stress induced by an insufficient amount of water provided by the 1-WS treatment (2L/d at early flowering and 1L/d by the sampling date) negatively affected plant growth, as can be noted by the significantly ($P < 0.0001$) lower values for the water-stressed plants compared to their well-watered counterparts, on all traits analyzed.

Table III.1. Mean comparisons of plant height, number of main-stem (MS) nodes, and total number of leaves between water regimes of cotton grown in 2010 on the first sampling date (June 15th), prior to the initiation of water restrictions. 2010 Well-Watered (1-WW), 2010 Water-Stressed (1-WS).

Treatment	Plant Height	Number of MS Nodes	Total Number of Leaves
	cm		
1-WW	109.84	18.29	73.54
1-WS	106.49	18.37	76.85
p-value	0.3056	0.8146	0.4564

Table III.2. Mean comparisons of plant height, number of main-stem (MS) nodes, and total number of leaves between water regimes of cotton plants grown in 2010 on the final sampling date (August 10th), after the initiation of water restrictions. 2010 Well-Watered (1-WW), 2010 Water-Stressed (1-WS).

Treatment	Plant Height	Number of MS Nodes	Total Number of Leaves
	cm		
1-WW	149.62	23.42	199.50
1-WS	127.06	20.04	94.83
p-value	< 0.0001	< 0.0001	< 0.0001

When analyzing average leaf laminae dry mass production of the genotypes, it was also evident that initiation of new leaves was immediately curtailed by the water stress treatment, as can be seen by the sharp diversion of the 1-WW and 1-WS curves soon after the initiation of the 1-WS treatment on June 18th (Fig. III.1). Leaf dry mass production reached a plateau around July 21st for the plants subjected to water restriction (1-WS); after this time leaf dry mass started to decrease. For plants growing under well-watered conditions, however, leaf mass production continued to increase until final harvest on August 10th.

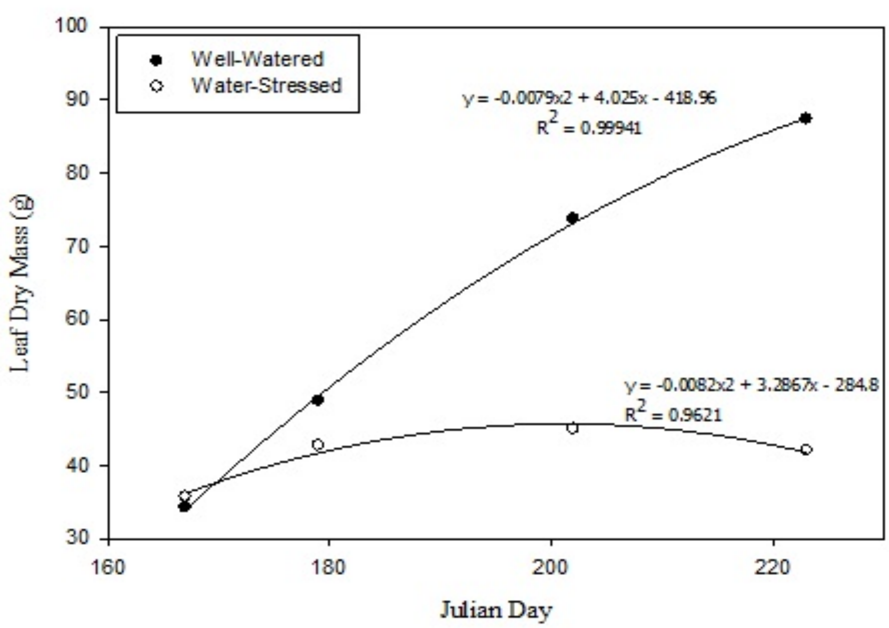


Figure III.1. Average leaf laminae dry mass production of cotton genotypes grown in 2010 from the beginning of water restrictions to final harvest. Julian days 167 (06/16/10), 179 (06/28/10), 202 (07/21/10), and 223 (08/11/10) are sampling dates when leaves were harvested.

While Table III.2 gives a general overview of the plants response to the onset of drought, more detailed information on the genotype x water regime interaction is provided on Table III.3. Out of the 16 genotypes included in 2010, three genotypes (06-46-153, DP1028 B2RF, and DP1044 B2RF) did not show any significant decrease (at the 5% level of probability) in growth when subjected to water stress. This observation may indicate an ability of these particular genotypes to maintain growth in water-limited environments, which can then be translated into higher water use efficiency (WUE). In five genotypes (CS-50, DP0141 B2RF, DP0949 B2RF, L-23, and TAM B-182-33), total number of leaves was the only trait significantly reduced (roughly 47% decrease) when plants were subjected to the 1-WS treatment. Only in two of the genotypes (02-WK-11L and DP1048 B2RF) tested where all traits analyzed were significantly affected by the limited availability of water. Average total leaf dry mass (g) was significantly different between 1-WW x 1-WS and 1-WW x 2-WS; however, no significant difference was found in total leaf dry mass between 1-WS x 2-WS water regimes (Fig. III.2). In terms of plant height, values were significantly different (at the 5% level of probability) between all water treatments, with average plant height values of 127.0 cm, 149.6 cm, and 135.4 cm for 1-WW, 1-WS, and 2-WS, respectively (Fig. III.3).

Table III.3. Mean comparisons of growth traits between water regimes for each cotton genotype grown in 2010 and their respective p-value at final harvest. 1-WS (Well-Watered), 1-WS (Water-Stressed).

Genotype	Water Regime	Plant Height (cm)	p-value	Number of MS Nodes	p-value	Total Number of Leaves	p-value
02-WK-11L	1-WS	136.00	0.0346*	21.33	0.0285*	100.67	0.0107*
02-WK-11L	1-WW	178.33		26.33		288.33	
03-WZ-37	1-WS	104.00	0.0217*	20.67	0.1000	94.33	0.2776
03-WZ-37	1-WW	129.33		24.00		132.33	
04-22-405	1-WS	122.67	0.0371*	22.33	0.2417	95.00	0.0025*
04-22-405	1-WW	149.33		24.67		248.67	
05-47-802	1-WS	127.67	0.2876	19.67	0.0201*	70.67	0.0168*
05-47-802	1-WW	137.33		24.33		177.67	
06-46-153	1-WS	115.33	0.1695	20.33	0.1145	78.33	0.3115
06-46-153	1-WW	134.33		23.33		120.67	
08-1-1325	1-WS	127.67	0.1028	21.00	0.0114*	92.67	0.0003*
08-1-1325	1-WW	153.67		25.67		272.67	
CS-50	1-WS	137.33	0.1421	20.67	0.0686	93.33	0.0021*
CS-50	1-WW	154.00		25.33		240.00	
DP0141 B2RF	1-WS	134.67	0.1833	20.67	0.0668	102.67	0.0125*
DP0141 B2RF	1-WW	160.00		24.00		208.00	
DP0912 B2RF	1-WS	123.33	0.0261*	19.33	0.0890	89.33	0.0386*
DP0912 B2RF	1-WW	153.00		22.67		191.67	
DP0935 B2RF	1-WS	129.33	0.0156*	21.00	0.0257*	72.33	0.0633
DP0935 B2RF	1-WW	168.00		25.00		141.00	
DP0949 B2RF	1-WS	120.33	0.1307	19.00	0.2879	111.67	0.0165*
DP0949 B2RF	1-WW	145.00		21.00		222.67	
DP1028 B2RF	1-WS	140.00	0.8072	17.67	0.1933	119.33	0.0599
DP1028 B2RF	1-WW	145.00		21.67		210.00	
DP1044 B2RF	1-WS	127.33	0.8485	19.00	0.4918	102.67	0.4518
DP1044 B2RF	1-WW	125.00		19.67		158.67	
DP1048 B2RF	1-WS	138.00	0.0276*	17.00	0.0114*	107.67	0.0295*
DP1048 B2RF	1-WW	167.00		21.67		188.33	
L-23	1-WS	136.00	0.1837	22.33	0.7376	103.67	0.0032*
L-23	1-WW	162.33		23.00		233.00	
TAM B-182-33	1-WS	113.33	0.1437	18.67	0.0559	83.00	0.0044*
TAM B-182-33	1-WW	132.33		22.33		158.33	

* = values are significantly different at the 5% level of probability

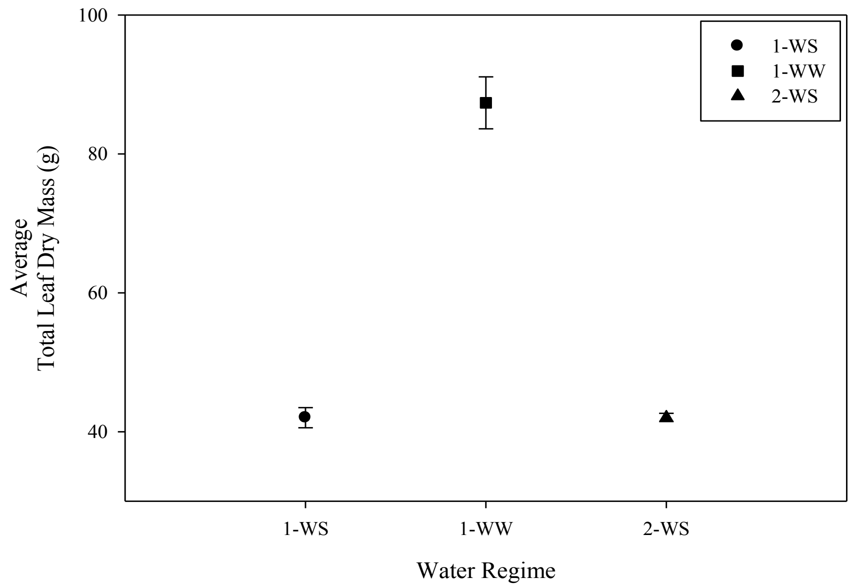


Figure III.2. Average total leaf dry mass (g) at final harvest between water regimes of cotton genotypes grown in 2010 and 2011. Values are means and bars represent ± SE. 2010 Water-Stressed (1-WS), 2010 Well-Watered (1-WW), and 2011 Water-Stressed (2-WS).

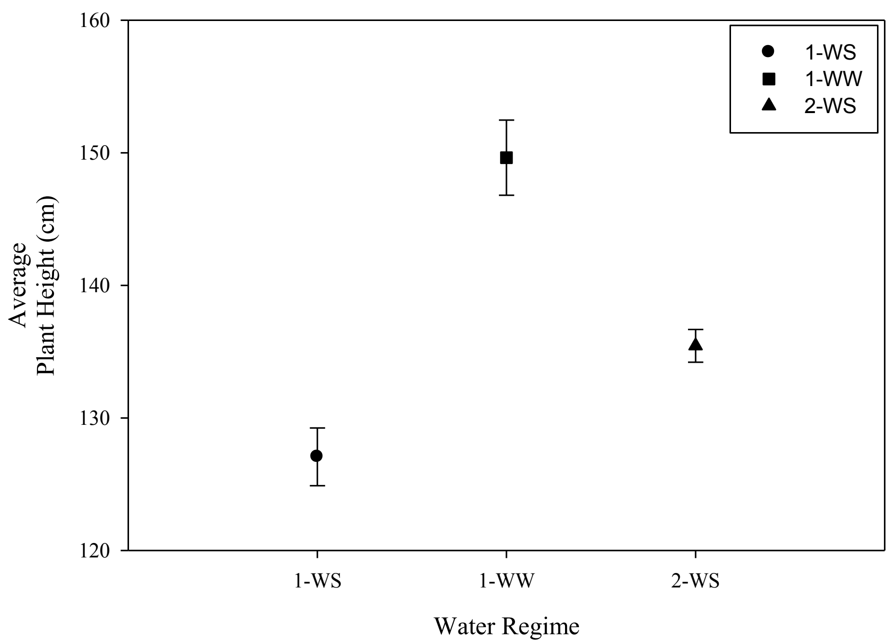


Figure III.3. Average plant height (cm) at final harvest between water regimes of cotton genotypes grown in 2010 and 2011. Values are means and bars represent ± SE. 2010 Water-Stressed (1-WS), 2010 Well-Watered (1-WW), and 2011 Water-Stressed (2-WS).

Table III.4. Comparisons of total number of leaf means among cotton genotypes grown in 2011 based on measured data. First sampling date (a. – prior to water-stress), Final harvest (b. – after water-stress). Levels not connected by the same letter are significantly different at the 5% level of probability.

a. First Sampling							b. Final Harvest				
Level						Mean	Level				Mean
DP1044 B2RF	A					133.25	DP1044 B2RF	A			75.49
L-23	A	B				130.50	11R159 B2R2	A	B		72.31
11R136 B2R2	A	B	C			122.50	10R013 B2R2	A	B		72.31
10R013 B2R2	A	B	C	D		121.00	10R011 B2R2	A	B		72.13
04-22-405	A	B	C	D		120.87	CS-50	A	B		68.27
CS-50	A	B	C	D	E	117.75	DP0912 B2RF	A	B		67.96
08-1-1325	A	B	C	D	E	117.12	10R052 B2R2	A	B	C	67.05
DP0912 B2RF		B	C	D	E	112.50	11R136 B2R2	A	B	C	65.22
11R159 B2R2		B	C	D	E	112.12	DP1032 B2RF	A	B	C	64.23
10R011 B2R2			C	D	E	106.87	05-47-802	A	B	C	63.98
DP1048 B2RF			C	D	E	106.87	L-23	A	B	C	63.58
06-46-153			C	D	E	105.87	DP1048 B2RF	A	B	C	62.77
DP1032 B2RF				D	E	101.87	04-22-405		B	C	59.71
05-47-802					E	101.12	DP0935 B2RF		B	C	59.54
10R052 B2R2					E	99.75	06-46-153		B	C	57.94
DP0935 B2RF					E	98.75	08-1-1325			C	53.03

Table III.5. Comparisons of total leaf dry mass means among cotton genotypes grown in 2011 based on estimated data. First sampling date (a. - prior to water-stress), Final harvest (b. – after water-stress). Levels not connected by the same letter are significantly different at the 5% level of probability.

a. First Sampling							b. Final Harvest					
Level						Mean	Level					Mean
11R136 B2R2	A					66.71	10R011 B2R2	A				47.71
04-22-405	A	B				63.81	10R052 B2R2	A	B			45.32
08-1-1325	A	B	C			60.48	05-47-802	A	B			44.77
11R159 B2R2	A	B	C			60.18	DP1044 B2RF	A	B	C		44.70
CS-50	A	B	C			60.08	11R159 B2R2	A	B	C		44.67
DP0935 B2RF	A	B	C			59.99	DP0935 B2RF	A	B	C		44.61
10R013 B2R2		B	C	D		57.55	DP0912 B2RF	A	B	C		43.43
DP1048 B2RF		B	C	D		57.52	10R013 B2R2		B	C		41.53
05-47-802			C	D		55.51	DP1048 B2RF		B	C		41.46
DP1044 B2RF			C	D		54.86	CS-50		B	C		41.43
10R011 B2R2			C	D		54.48	11R136 B2R2		B	C		41.35
10R052 B2R2			C	D		53.97	DP1032 B2RF		B	C		40.95
06-46-153			C	D		53.45	04-22-405		B	C	D	39.70
L-23				D	E	51.66	08-1-1325			C	D	38.64
DP0912 B2RF				D	E	50.84	06-46-153			C	D	38.63
DP1032 B2RF					E	44.75	L-23				D	34.02

In 2011, average total number of leaves at the first sampling date and at final harvest is shown in Table III.4. Mean comparisons among genotypes show that prior to the initiation of water stress, various genotypes were significantly different in total number of leaves. However, at the end of the season (final harvest) there were fewer differences among genotypes. The same trend appeared when comparing total leaf dry mass. At the last sampling date (final harvest), a lower number of significant differences among genotypes were detected (Tables III.5a and III.5b). At the first sampling date, prior to water stress, the average dry weight (g) per leaf was calculated and ranged from 1.65 g/leaf for DP0935 B2RF to 2.53 g/leaf for L-23. After the plants were subjected to water stress from early flowering to harvest, average dry weight per leaf ranged from 1.33 g/leaf to 1.87 g/leaf to for DP0935 B2RF and L-23, respectively. All genotypes presented a decrease in average dry weight per leaf after they were subjected to stress. In cotton, the largest leaves are known to be in the middle part of the plant, around nodes 7 to 13, and will usually decrease in size as you move to lower or higher nodal positions (Constable and Rawson, 1980b; Constable, 1986; Mutsaers, 1983). This was also the case for all genotypes included in the test growing under water-stress, where the positions of the largest leaf ranged from node 7 to node 12 (Table III.6). The maintenance of this pattern may indicate that cotton growing in a water deficient environment will not deviate from the pre-determined (genetic) growth and physiological processes. In a thorough study of growth of cotton leaves, Mutsaers (1983) reasoned that larger leaves will be in the middle of the plant because of the assimilate competition occurring during plant development. As a young seedling, leaves will be competing for assimilates when branches start developing and later in the season, competition will occur with developing bolls (fruits). Leaves on the sympodia (fruiting branches) are smaller and for the first three positions have values of 0.55, 0.4, and 0.3 respectively, the size of the main-stem leaf at the same node position (Constable and Oosterhuis, 2010). For example, the first, second, and third leaves on a fruiting branch will have, respectively 0.55, 0.4, and 0.3 the leaf area of the main-stem leaf on the same nodal position as said fruiting branch.

Table III.6. Position of largest leaf and its respective area as determined by the equation $A = 1.0526L^2 - 1.96L$ for each cotton genotype grown in 2010 under water stress. Values are means for 8 plants per genotype.

Genotype	Node of Largest Leaf	Largest Leaf Area (cm^2)
04-22-405	12	258.34
05-47-802	12	270.88
06-46-153	8	248.12
08-1-1325	12	296.84
10R011B2R2	11	283.71
10R013B2R2	7	236.13
10R052B2R2	10	340.37
11R136B2R2	10	305.76
11R159B2R2	12	252.19
CS 50	12	236.13
DP0912B2RF	12	258.34
DP0935B2RF	11	303.52
DP1032B2RF	11	273.00
DP1044B2RF	12	250.15
DP1048B2RF	7	349.92
L23*	12	707.58

* L23 is an okra leaf genotype.

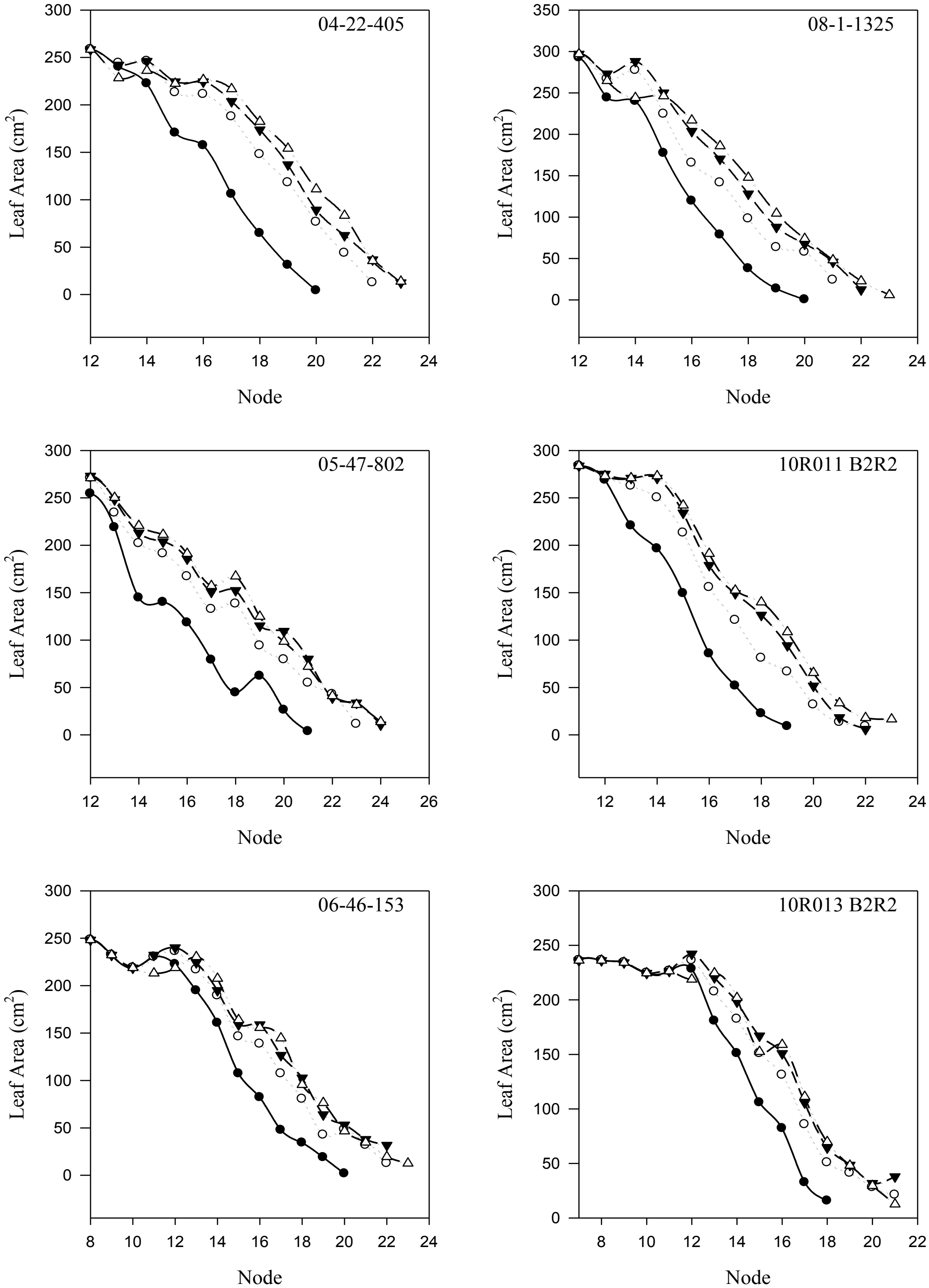


Figure III.4. Average main-stem leaf area expansion for all 16 cotton genotypes grown in 2011 under water stress. Values are averages of 8 plants and shown for each of the four sampling dates starting from whichever node had the largest area for that particular genotype (ranges from node 7 to 12). The same legend applies for all graphs in this figure.

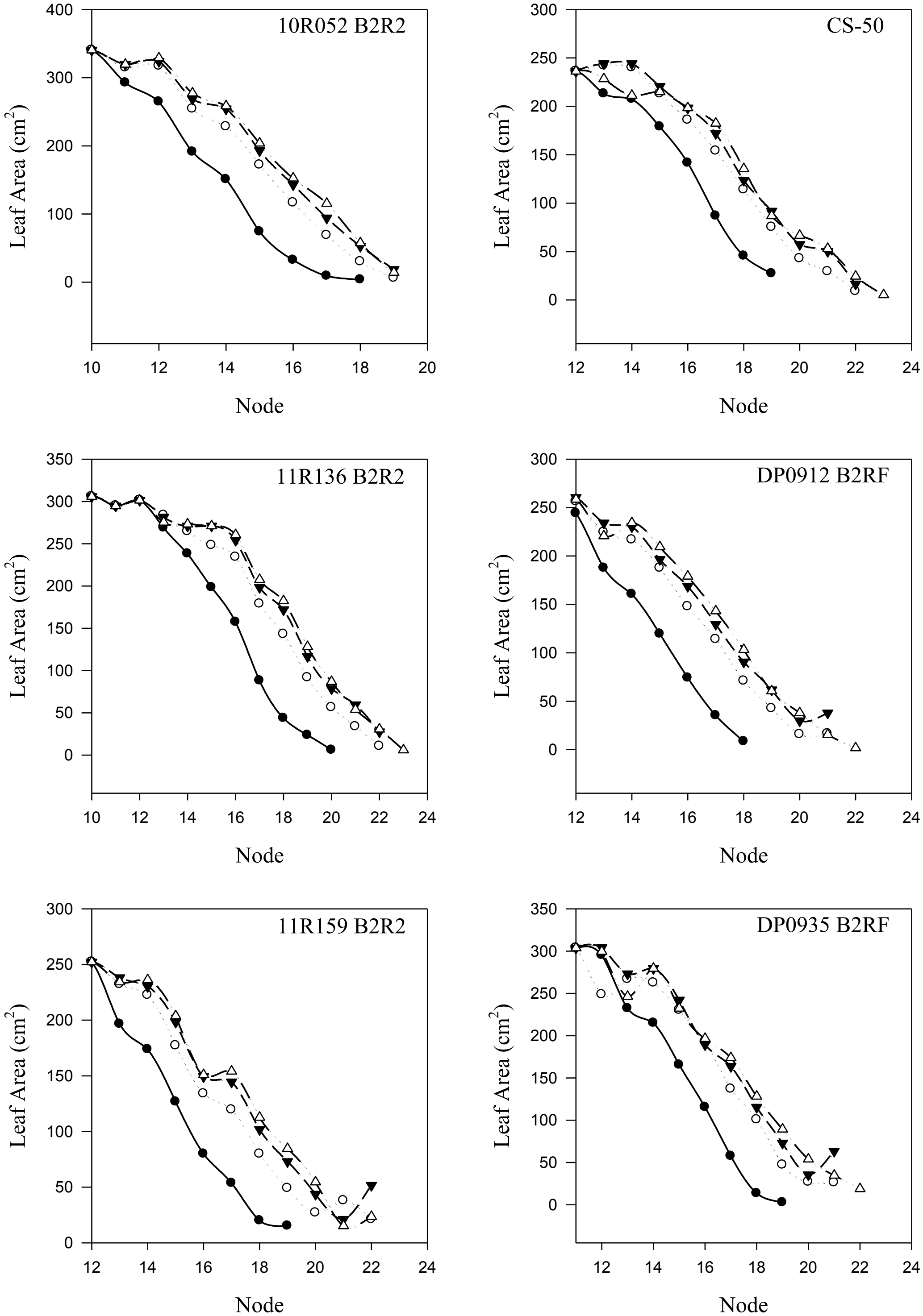


Figure III.4. Continued.

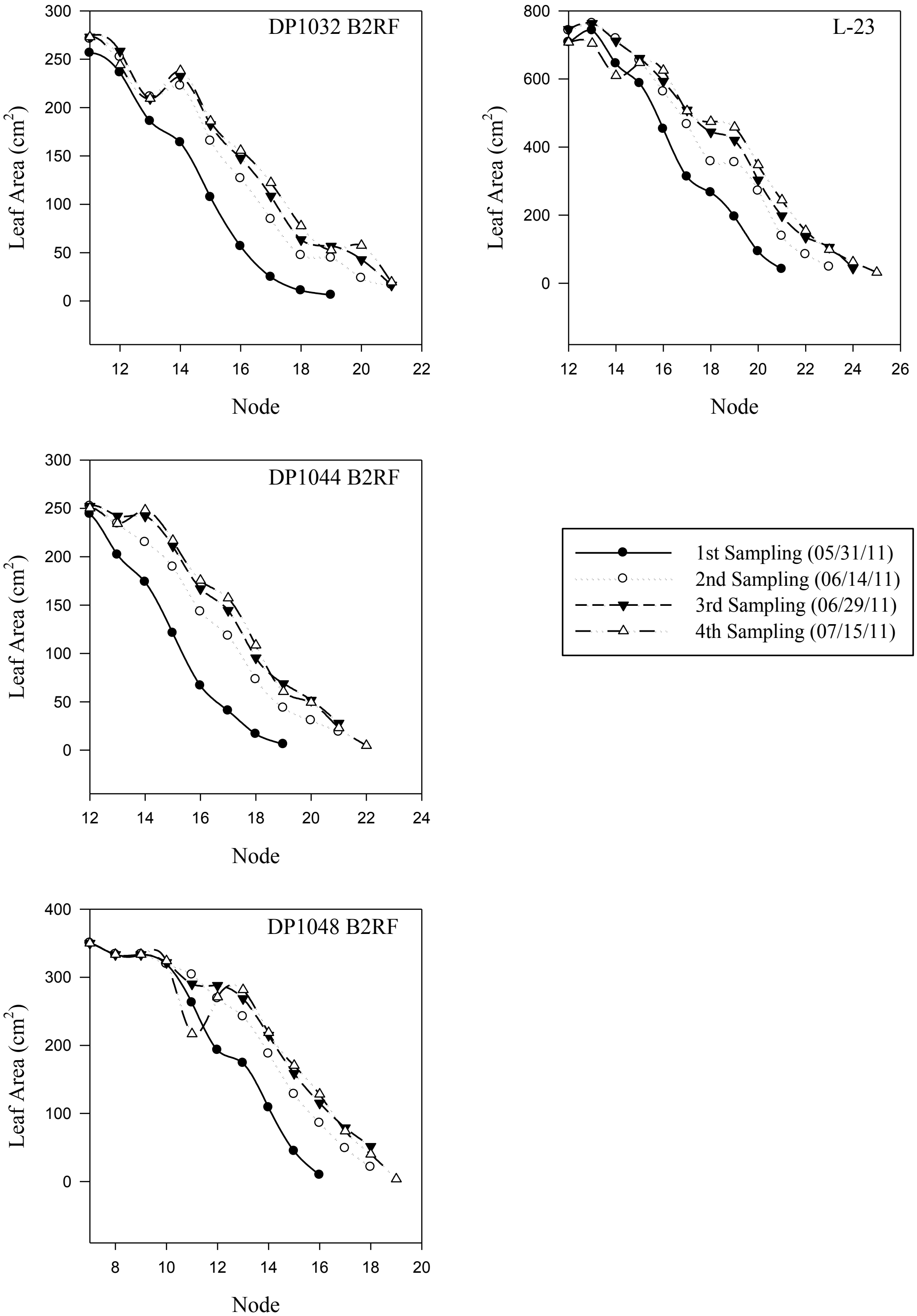


Figure III.4. Continued.

Constable and Rawson (1980b) reported that leaf growth starts at leaf unfolding and continues for approximately 17.7 days; leaf area expansion will occur at a rate of 9 cm^2 day^{-1} (averages for leaves at nodes 5 and 9) for plants growing during the winter. Interestingly, plants cultivated during the spring/summer months displayed a slight increase in the duration of leaf growth (average of 18.45 days) and a slower rate of leaf area expansion (average of 6.25 cm^2 day^{-1}). Leaf area expansion usually achieves highest expansion rate around 30 to 38% of the maximum leaf area (Constable and Rawson, 1980a; Constable and Rawson, 1980b). Figure III.4 shows leaf area expansion for all 16 genotypes grown in 2011 under water stress. Higher leaf area expansion occurred between the first and second sampling dates (05/31/11 and 06/14/11, respectively), after which the rate of leaf area expansion decreased significantly. This was evidenced by the reduction in the distance between points from second to third and third to fourth sampling dates. Table III.7 shows that a total of 54 significant differences were found among genotypes when comparing the total maximum main-stem leaf area (cm^2) achieved. The genotype L-23 had the largest total leaf area, and was also significantly higher (at the 5% level of probability) than all others. It is important though to note that this particular genotype (L-23) is an okra leaf type cotton that had very lengthy leaves. Okra cotton is known to have a lower leaf area (Meredith and Wells, 1986) and also a very distinct leaf shape (deeply cleft with narrow lobes) compared to normal broad leaf cottons (Wells and Meredith, 1986). Since the equation used to estimate the leaf area uses midrib leaf length to estimate the area and was not specifically developed for okra leaf genotypes, one can assume that the values for this genotype may have been overestimated and should in fact be lower than the others.

Table III.7. Total maximum main-stem leaf area (cm^2) mean comparisons among cotton genotypes grown in 2011 under water stress at the last sampling date (07/15/11) prior to the final harvest. Values are means of 8 plants per genotype. Levels not connected by the same letter are significantly different at the 5% level of probability.

Level								Mean
L23	A							10584.82
11R136B2R2		B						4193.36
DP1048B2RF		B						4038.18
10R052B2R2		B	C					4003.25
DP0935B2RF		B	C	D				3945.61
05-47-802		B	C	D				3873.75
04-22-405		B	C	D				3846.63
10R011B2R2		B	C	D	E			3757.26
08-1-1325		B	C	D	E	F		3750.16
11R159B2R2			C	D	E	F	G	3468.75
DP1044B2RF				D	E	F	G	3421.36
06-46-153					E	F	G	3272.27
DP1032B2RF					E	F	G	3245.13
DP0912B2RF						F	G	3212.52
CS 50						F	G	3211.24
10R013B2R2							G	3171.32

* L23 is an okra leaf genotype.

CONCLUSIONS

Plant growth and leaf expansion/initiation were significantly affected by the water deficit imposed in 2010. Comparisons between treatments prior to the initiation of water restrictions treatment showed no significant difference in any parameters measured, also indicating homogeneity of the growing conditions. At the end of the season, however, data indicated that plant height, number of main-stem nodes, and total number of leaves were all significantly lower in plants growing in water deficient conditions. For the same traits, three genotypes (06-46-153, DP1028 B2RF, and DP1044 B2RF) grown under 1-WS treatment did not show any significant decrease when compared to their well-watered (1-WW) counterparts. A numerical decrease was noted, however, for all genotypes/traits analyzed, except for DP1044 B2RF, which presented a small increase in plant height. Average leaf dry mass collected at 4 different occasions, about two weeks apart from each other, illustrated that initiation of new leaves was promptly curtailed upon initiation of water restrictions; water-stressed plants reached a plateau around July 21st, after which leaf dry mass started to decrease. No such trend was visible in plants growing with plenty of available water. In 2011, mean comparisons of total number of leaves and total leaf dry mass among genotypes taken at final harvest (predicted values) showed that after the stress was imposed there were a lower number of significant differences at the 5% level of probability among genotypes. Main-stem leaf area measurements taken every two weeks indicated that the main-stem leaf with the largest area was located between nodes 7 to 12, even when plants were growing under water-stress. The greatest rate of leaf area expansion occurred between the first two measurements taken on 05/31/11 and 06/14/11, prior to the initiation of the water stress treatments (also coinciding with the pre-flowering growth stage), at which point the rate of expansion significantly decreased. A total of 54 significant differences were found among genotypes regarding the final main-stem leaf area at the end of the season, where it was also noted that the equation ($A = 1.0526L^2 - 1.96L$, R2 = 0.98) used to estimate leaf area based on leaf midrib length was not suitable for okra leaf type cotton, as it disproportionally overestimated the final leaf area.

CHAPTER IV

STOMATAL DENSITY CHARACTERIZATION OF GENOTYPES

OVERVIEW

Stomatal density may be a valuable characteristic to consider when searching for traits conferring drought tolerance in cotton (*Gossypium hirsutum* L.). This is especially true for the adaxial leaf surface, where lower stomatal density has been reported to enhance the plants ability to withstand water and temperature stresses (McDaniel, 2000). Stomatal imprints were collected from 22 unique cotton genotypes grown in the Drought Tolerance Laboratory at the Texas AgriLife Research and Extension Center in Corpus Christi, Texas during the 2010 and 2011 growing seasons. Data showed that a higher stomatal density was present on the abaxial leaf surface, for all genotypes tested. Abaxial/adaxial ratios ranged from 1.53 to 3.68. Compared to the average, 03-WZ037 and 05-47-802 had the lowest densities for both surfaces while 11R159 B2R2 had the highest value. Although genotypes have remarkably different stomatal densities on both surfaces, a higher number of significant differences among genotypes were found on the abaxial leaf surface.

INTRODUCTION

Stomata play an important role in plant water economy by controlling the exchange of water vapor between the leaf interior and the air surrounding the leaf (Woodward and Kelly, 1995; Xu and Zhou, 2008). Water vapor lost from the leaf surface is called leaf transpiration. Stomatal aperture also controls the exchange of CO_2 between the leaf interior and the surrounding air. CO_2 is a substrate for the photosynthetic process inside the leaf. The exchange balance between these two components is known as gaseous water use efficiency. The aperture of stomata is reduced when the hydration state of the leaf epidermis deteriorates. Stomata are also widely known to respond to limited water availability (e.g. drying soil) through increases in density (Gindel, 1969) and decreased stomatal conductance (Davies and Zhang, 1991). However, water economy does not come without a tradeoff; by decreasing conductance and therefore reducing water loss to the atmosphere, carbon assimilation and ultimately dry matter production rates are also reduced (Atkinson et al., 2000). Differences in stomatal density are likely among cotton genotypes, and this may influence their water economies under a wide range of soil water regimes.

The soil-plant-atmosphere continuum system is complex, with numerous factors influencing its various interactions. Water moves passively from soil to atmosphere through the plant in response to water potential gradients. Since stomata on the leaves need to be open for carbon (C) uptake, water loss through transpiration is clearly an inevitable consequence of photosynthesis. Stomates allow CO_2 to enter the leaf, but at the same time also offer a pathway for water loss to the atmosphere (Lambers et al., 2008c). Among other factors, water use efficiency (WUE) is inherently low in plants because the diffusion coefficient of water (H_2O) and carbon dioxide (CO_2) are different; in air, the H_2O/ CO_2 diffusion ratio is approximately 1.6 and it changes when molecules are diffusing through the boundary layer, where the ratio is approximately 1.37 (Lambers et al., 2008b). Although H_2O and CO_2 molecules diffuse through the same pathway (in opposite directions), H_2O pathway resistances are largely composed of the boundary layer resistance and the stomatal resistance. For CO2 on the other hand, the mesophyll resistance should also be considered. (Lambers et al., 2008b; Taiz and Zeiger, 2002a). Until recently, the mesophyll conductance was previously assumed to be large, and its resistance was often ignored, but recent reports have shown that this may not be the case (Flexas et al., 2008; Warren, 2008). While increased plant transpiration (water loss) coupled with a steady or even decreased rate of photosynthesis may diminish WUE, this phenomenon can also be a valuable plant strategy to dissipate excess heat (Saranga et al., 2009).

MATERIALS AND METHODS

Plants of 22 cotton genotypes were grown in the Drought Tolerance Laboratory at the Texas AgriLife Research and Extension Center (Corpus Christi, TX) in large pots (3.578 gallon / 13.5 L) and arranged in a randomized complete block design (RCB). Stomatal imprints were taken from a single leaf per genotype (6^{th} main-stem leaf down from the plant's terminal) on June 18^{th} and June 10^{th} for 2010 and 2011, respectively. A thin layer of clear nail polish was applied to both adaxial and abaxial leaf surfaces on opposite sides of the leaf vein at three different areas for each surface, such that samples from both of the surfaces were not overlapping. The recently applied clear nail polish imprint (approximately 15 mm x 15mm) was allowed to dry for 45 to 60 minutes and then gently peeled from the leaf with fine point tweezers, properly identified, and stored for posterior analysis. Stomatal imprints were assembled using 76.2 mm x 25.4 mm, 1mm micro slides and 25mm x 25mm micro covers (VWR International, West Chester, PA) in distilled water. Slides were photographed using a National DC5-163 Digital

Microscope (National Optical & Scientific Instruments Inc., San Antonio, TX) with 20X magnification and images were captured at a resolution of 1600x1200 pixels. Each pixel was calculated to have an area of 7.56×10^{-7} mm^2 at the specified settings. Stomatal quantity was manually counted from the image displayed on a computer monitor; density was then calculated and expressed as number of stomata per unit leaf area for each sample. All statistical analysis was performed using JMP 9.0 (SAS Institute Inc., Cary, NC) and graphics compiled using SigmaPlot version 10.0 (Systat Software Inc., San Jose, CA).

RESULTS AND DISCUSSION

Higher stomatal density on the abaxial leaf surface has been previously reported for various plants, including cotton (Gay and Hurd, 1975; Gindel, 1969; Gitz et al., 2005; Pallas et al., 1967; Romeroaranda et al., 1994). Data collected during experiments conducted in both 2010 and 2011 are in agreement, as shown by the average stomatal density of all 22 unique genotypes (Fig. IV.1). Differences in densities could perhaps be explained by the fact that stomata in the abaxial and adaxial leaf surfaces will develop and function in significantly different environments (Lu et al., 1993), with varying degrees of sunlight quality and intensity and wind exposure. While stomata on the adaxial leaf surface may be in the direct trajectory of solar radiation, stomata on the abaxial side will be somewhat protected, and only reached indirectly. The same will also apply to wind, which is widely known to decrease the boundary layer resistance to water diffusion from the leaf to the atmosphere.

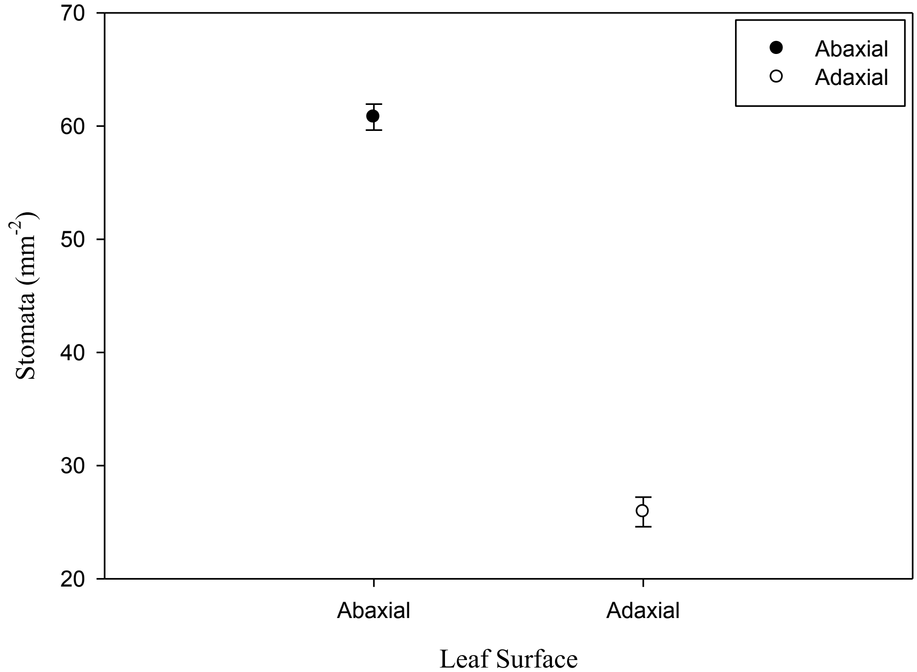


Figure IV.1. Stomatal density on abaxial and adaxial cotton leaf surfaces. Values are means for all 22 genotypes included in 2010 and 2011 studies. Bars represent ± SE.

Average stomatal density among 22 genotypes for the abaxial and adaxial leaf surfaces were 60.78 mm^{-2} and 25.90 mm^{-2}, respectively, which were significantly different at the 5% level of probability. Table IV.1 shows average stomatal density values for each of the genotypes used in the study in both years and their p-values when compared to the average. Genotypes 03-WZ-37, 05-47-802, DP0935 B2RF, and L-23 had significantly ($P<5\%$) lower abaxial stomatal density than the average, while 10R013 B2R2, 11R136 B2R2, 11R159 B2R2 had the highest abaxial densities when compared to the average of all 22 genotypes involved. Regarding adaxial stomatal density, genotypes 03-WZ-37, 05-47-802 also had significantly lower densities and 11R159 B2R2 higher density than the average. Stomatal density ratios between abaxial and adaxial leaf surfaces range from 1.53 for DP1044 B2RF to 3.68 for 10R013 B2R2. Although several complex factors and interactions influence the plant water use, stomata have been reported to strongly influence water use efficiency (Mansfield et al., 1990; Woodward, 1987; Woodward and Kelly, 1995; Xu and Zhou, 2008).

Table IV.1. Cotton genotypes average stomatal density for both leaf surfaces in 2010 and 2011 experiments. Ratio is for abaxial/adaxial surfaces. P-values are shown for each genotype in comparison with the average of the 22 genotypes.

Genotype	Abaxial Surface		Adaxial Surface		Ratio
	Mean	p-value	Mean	p-value	
	mm^{-2}		mm^{-2}		
02-WK-11L	45.33	0.0569	21.14	0.1136	2.14
03-WZ-37	41.73	0.0268*	19.81	0.0451*	2.11
04-22-405	55.12	0.5093	25.70	0.9479	2.14
05-47-802	42.77	0.0264*	15.27	0.0005*	2.80
06-46-153	46.79	0.0846	20.82	0.0946	2.25
08-1-1325	47.14	0.0763	28.32	0.4770	1.66
10R011 B2R2	70.46	0.1190	39.07	< 0.0001*	1.80
10R013 B2R2	78.39	0.0010*	21.30	0.0766	3.68
10R052 B2R2	62.58	0.7225	26.56	0.8014	2.36
11R136 B2R2	88.61	< 0.0001*	29.84	0.1178	2.97
11R159 B2R2	80.24	0.0001*	34.79	0.0008*	2.31
CS-50	46.75	0.0832	22.15	0.2113	2.11
DP0141 B2RF	46.85	0.0855	28.99	0.3555	1.62
DP0912 B2RF	47.62	0.1040	26.08	0.9513	1.83
DP0935 B2RF	38.79	0.0070*	20.86	0.0950	1.86
DP0949 B2RF	47.72	0.1070	21.70	0.1631	2.20
DP1028 B2RF	49.20	0.1780	24.74	0.7171	1.99
DP1032 B2RF	70.07	0.0535	32.27	0.0122*	2.17
DP1044 B2RF	50.61	0.4019	33.05	0.0533	1.53
DP1048 B2RF	46.17	0.0717	24.35	0.6115	1.90
L-23	44.89	0.0500*	21.50	0.1466	2.09
TAM B-182-33	50.09	0.1493	25.30	0.8252	1.98
MEAN†	60.78	-	25.90	-	2.35

* Significantly different at the 5% level of probability

† Mean for the 22 genotypes included in both years

According to McDaniel (2000), cotton plants with lower stomatal density on the adaxial leaf surface displayed an enhanced ability to withstand water and temperature stresses in trials conducted in southern Arizona and should be better able to control their water loss through transpiration while still maintaining adequate levels of evaporative cooling and CO_2 uptake for photosynthesis. Considering that no single trait is likely to confer drought tolerance to cotton, it is important to note that decisions in cotton improvement programs seeking cultivars with better adaptation to water deficits should be made at the whole-plant level, also accounting for desirable agronomic traits such as yield, fiber quality, and length of the plant's developmental cycle.

Genotypes tested are remarkably different with respect to stomatal density on both leaf surfaces (Fig. IV.2 and IV.3). Means separation of stomatal density on abaxial and adaxial leaf surfaces at the 5% level of probability are shown on tables IV.2 and IV.3, respectively. Although very close, a higher number of significant differences (at the 5% level of probability) among genotypes were found on the abaxial surface, when comparing mean differences (Appendix IV.A and IV.B).

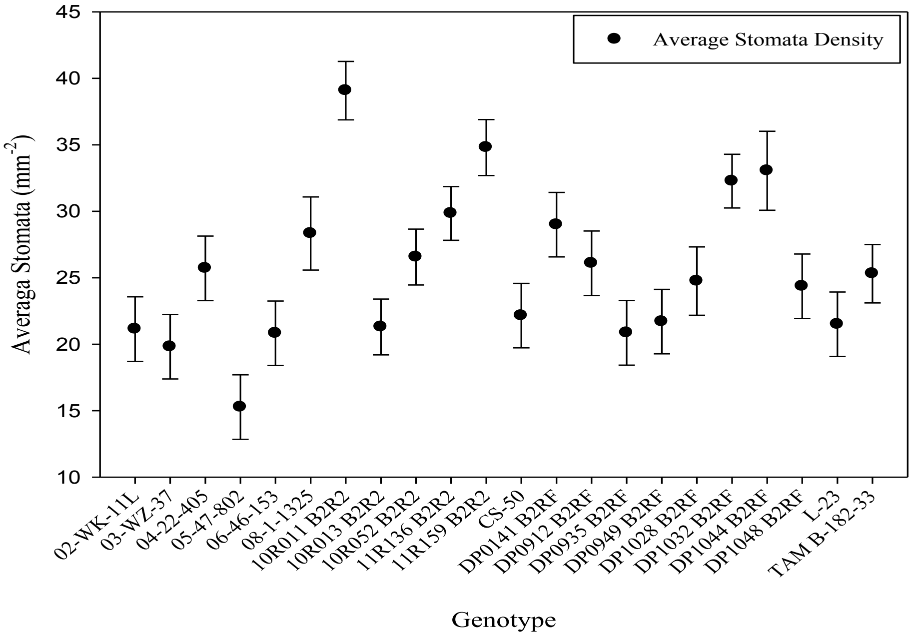


Figure IV.2. Stomatal density on adaxial leaf surface of cotton genotypes in 2010 and 2011. Values are means and bars represent ± SE.

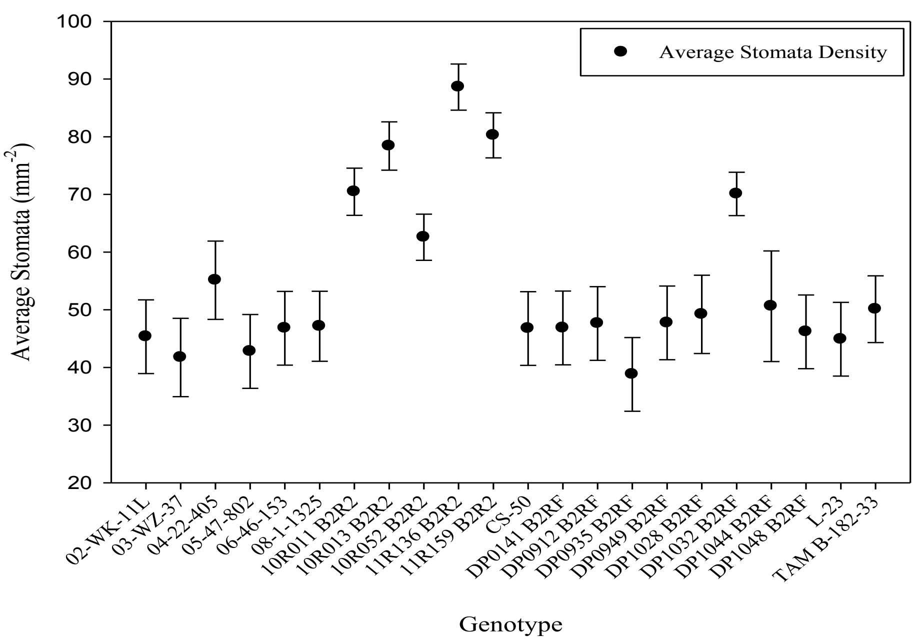


Figure IV.3. Stomatal density on abaxial leaf surface of cotton genotypes in 2010 and 2011. Values are means and bars represent ± SE.

Table IV.2. Fisher's LSD means separation on stomatal density (abaxial leaf surface) for cotton genotypes used in 2010 and 2011. Levels not connected by the same letter are significantly different at the 5% level of probability.

Genotype						Mean
11R136 B2R2	A					88.61
11R159 B2R2	A	B				80.24
10R013 B2R2	A	B				78.39
10R011 B2R2		B	C			70.46
DP1032 B2RF		B	C			70.07
10R052 B2R2			C	D		62.58
04-22-405			C	D	E	55.12
DP1044 B2RF			C	D	E	50.61
TAM B-182-33				D	E	50.09
DP1028 B2RF				D	E	49.20
DP0949 B2RF					E	47.72
DP0912 B2RF					E	47.62
08-1-1325					E	47.14
DP0141 B2RF					E	46.85
06-46-153					E	46.79
CS-50					E	46.74
DP1048 B2RF					E	46.17
02-WK-11L					E	45.33
L-23					E	44.89
05-47-802					E	42.77
03-WZ-37					E	41.73
DP0935 B2RF					E	38.79

Table IV.3. Fisher's LSD means separation on stomatal density (adaxial leaf surface) for cotton genotypes used in 2010 and 2011. Levels not connected by the same letter are significantly different at the 5% level of probability.

Genotype										Mean
10R011 B2R2	A									39.07
11R159 B2R2	A	B								34.79
DP1044 B2RF	A	B	C	D						33.05
DP1032 B2RF		B	C							32.27
11R136 B2R2		B	C	D	E					29.84
DP0141 B2RF		B	C	D	E					28.99
08-1-1325		B	C	D	E	F				28.32
10R052 B2R2			C	D	E	F	G			26.56
DP0912 B2RF			C	D	E	F	G	H		26.08
04-22-405				D	E	F	G	H		25.70
TAM B-182-33					E	F	G	H		25.30
DP1028 B2RF					E	F	G	H		24.74
DP1048 B2RF					E	F	G	H		24.35
CS-50						F	G	H		22.15
DP0949 B2RF						F	G	H	I	21.70
L-23						F	G	H	I	21.50
10R013 B2R2							G	H	I	21.29
02-WK-11L						F	G	H	I	21.13
DP0935 B2RF							G	H	I	20.85
06-46-153							G	H	I	20.82
03-WZ-37								H	I	19.81
05-47-802									I	15.27

CONCLUSIONS

The analysis of stomatal density in 22 unique cotton genotypes sampled in 2010 and 2011 indicated that a higher density was found on the abaxial leaf surface, with ratios for abaxial/adaxial ranging from 1.53 for DP1044 B2RF to 3.68 for 10R013 B2R2. Average stomatal density for all genotypes varied from 15.27 to 39.07 and 38.79 to 88.61 for the adaxial and abaxial surfaces, respectively. When comparing average stomatal density for each of the genotypes against the average of all genotypes, 03-WZ-37 and 05-47-802 had the lowest significantly different densities for both leaf surfaces while 11R159 B2R2 had the highest significantly different values for both surfaces. Also, although genotypes are remarkably different in respect to stomatal density on both leaf surfaces, a higher number of significant differences at the 5% level of probability were found on the abaxial side. McDaniel (2000) reported that cotton plants with a lower stomatal density on the adaxial (upper) leaf surface showed out-standing tolerance for abiotic stresses (water and temperature). Stomatal density may be an important trait when developing lines for drought tolerance, and although time consuming, its inclusion in breeding programs should be considered.

CHAPTER V

ROOT DRY MASS RESPONSE OF COTTON GENOTYPES TO DIFFERENT WATER REGIMES

OVERVIEW

Water deficit is the major single abiotic factor limiting crop yields throughout the world. The limitation in crop yield is usually caused by decreased photosynthetic rates and limited carbon assimilation, a consequence of stomatal closure due to a decline in leaf water potential. Experiments were conducted in the 2010 and 2011 cotton growing seasons at the Texas AgriLife Research and Extension Center Drought Tolerance Laboratory in Corpus Christi, TX to evaluate the root dry matter production responses of 22 unique genotypes to drought stress. Data suggests that the greatest separation in root biomass responses among genotypes occurred when they were exposed to water stress and that root growth was likely to be closely related to duration and intensity of the stress. Highest root dry mass production was observed when genotypes were exposed to a mild stress while severe water deprivation caused the lowest values. The genotype DP0935 B2RF consistently had the highest root dry mass production in both 2010 and 2011 when exposed to drought stress.

INTRODUCTION

The plant’s root system plays an important role not only in providing structural support, but it also supplies chemical signals, nutrients and water to mediate shoot physiological processes (Dodd, 2005). Thus the root system is obviously a vital structure to the plant. In cotton, several factors such as soil temperature, soil aeration, soil strength and soil water are known to affect root growth (McMichael et al., 2010). Cotton plants grown under water stress will alter their root growth pattern. As a result of death of older roots in layers closer to the soil surface and sustained growth at lower horizons, rooting density will increase with depth as the drought progresses (Klepper et al., 1973). It has been documented that an increased root-to-shoot ratio is one of the many long-term responses of plants to periods of drought stress (Chaves et al., 2003). In coffee (*Coffea canephora*), root depth of drought-tolerant clones has been reported to be higher than the drought-sensitive ones (Pinheiro et al., 2005). In cotton seedlings, a brief (6 days) period of drought stress reduced root elongation and root volume, although leaf expansion was curtailed just 2 days after the stress started and was found to be more sensitive to drought than root elongation (Ball et al., 1994). Since the increased root:shoot ratio is an expected long-term response to drought, the reduction in root elongation and volume observed by Ball et al. (1994) may be partially attributed to the fact that in their study, the water stress was imposed when plants were 55 to 65 days old. However, the water deficit treatment and measurements were not carried until the plants reached maturity. Basal et al. (2005) and Condon et al. (2004) have suggested that among other traits, root parameters may be reliably used as a selection criteria for drought tolerance in cotton improvement programs. Root characteristics have also been reported to be important information in understanding the basis of drought tolerance and water use efficiency (WUE) in various other plants such as rice (Henry et al., 2011), turfgrasses (Huang et al., 1997), perennial grasses (Huang and Fu, 2000), wheat (Manschadi et al., 2010), and peanut (Songsri et al., 2008). A study conducted by Quisenberry et al. (1996) with seventy-seven cotton genotypes indicated significant differences in root growth potential across entries. The plant's ability to change root growth patterns to explore larger volumes of soil and access deeper stored water may be an important mechanism to avoid drought (Songsri et al., 2008). Because roots are the main channel for water uptake, their ability to readily access water will play a key role in the plant water use.

With the objective of analyzing the root dry mass (root growth) response of 22 unique cotton genotypes subjected to water stress, experiments were carried in 2010 and 2011 in the Drought Tolerance Laboratory (Corpus Christi, TX) to examine the possible differential responses among genotypes.

MATERIALS AND METHODS

Experiments were conducted in 2010 and 2011 cotton growing seasons in the Drought Tolerance Laboratory at Texas AgriLife Research and Extension Center in Corpus Christi, TX. Growing conditions were exactly the same as previously described in the Whole-Plant Water Use chapter. Root samples were collected June 15, 2010 before the start of the WS regime and at final harvest, on August 10, 2010 and August 8, 2011. Samples consisted of all below soil surface plant matter, manually washed using a #20 (0.85 mm) sieve to remove any soil accumulated, and then dried at 71 ± 2°C for 96 hours in a P0M7-806F drier (Blue M., Garland, TX). Dry mass measurements were made with a high precision Sartorius scale (Brinkmann Instruments, Inc., Westbury, NY) within an hour of removing the samples from the drier. All statistical analysis was performed using JMP 9.0 (SAS Institute Inc., Cary, NC) and graphics used were compiled using either JMP or SigmaPlot version 10.0 (Systat Software Inc., San Jose, CA).

RESULTS AND DISCUSSION

In 2010, experimental data showed WS plants had a significantly lower root dry mass when compared to their WW counterparts (Fig. V.1). This behavior could be partially explained by reductions in photosynthetic rates and expansive growth of aboveground components (Jones, 1973; Pallas et al., 1967) induced by soil water deficits. These responses led to decreased carbon assimilation due to stomatal closure, consequently reducing the availability of carbon substrate and energy for sustaining growth rates (McCree et al., 1984). However, under severe water stress, nonstomatal effects at the chloroplast level may also trigger downregulation or inhibition of photosynthesis (Ennahli and Earl, 2005). Downregulation of the photosynthetic process, also known as photosynthetic acclimation (usually a response to elevated levels of CO_2), will occur if the capacity for carbohydrate export and utilization is exceeded, thereby generating an increase in leaf carbohydrate content and a source-sink imbalance. Plants will fail to maintain the maximal initial rate of CO_2 uptake, a behavior documented for plants grown in chambers and exposed to elevated levels of CO_2 (Drake et al., 1997). The diminished rate (downregulation) of photosynthesis has been attributed almost entirely to the decreased activity of Rubisco (ribulose-1,5-bisphosphate carboxylase/oxygenase) enzyme (Rogers and Humphries, 2000).

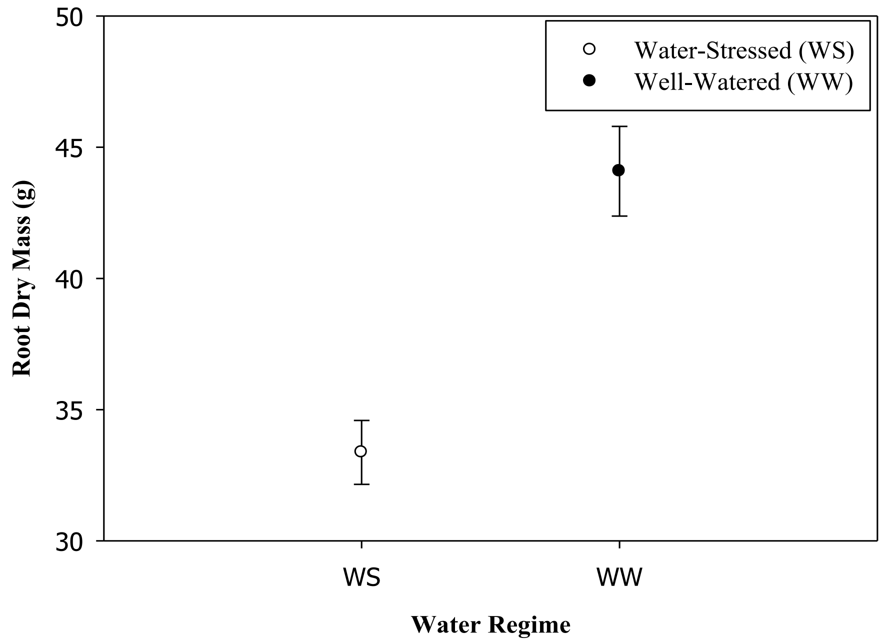


Fig. V.1. Root dry mass (g) in 2010 for 16 genotypes x 2 replications used in each treatment in 2010. Values are averages within treatments and bars represent ± SE.

Comparisons among genotypes within water treatments showed significant differences in root dry mass at the 5% level of probability (Table V.1). Apart from 08-1-1325 and 04-22-405, no other significant differences in root dry mass were found among genotypes in the WW treatment (Table V.1a), but several significant means separations were found on the WS treatment (Table V.1b). The only genotype to present a significant difference between water regimes was DP0912 B2RF (Table V.2), but it is worth noting an increase in root dry mass for 04-22-405 when exposed to water deficit.

This particular genotype was the only one to display an increased root mass and may have the ability to allocate a higher fraction of assimilated carbon towards root growth and development even under water stress. Although an increase in root dry mass has been found for this genotype at this point, this information does not take into account any particular root characteristics such as root density and/or length. Plants in the WS treatment displayed a premature and accentuated leaf abscission when supplied with only 1L/d of irrigation water due to the severe water stress towards the end of the season. The WS plants reached the final harvest date with approximately half the number of leaves as those in the WW treatment.

Plant growth was also curtailed as demonstrated by the reduced shoot and root dry mass and significantly lower plant height, leading to a significant increase in the root-to-shoot ratio (Tables V.3 and V.4). Several researchers have previously reported the increased root-to-shoot ratio in cotton subjected to water stress (Ball et al., 1994; Malik et al., 1979), including expressions of genetic variability (McMichael and Quisenberry, 1991). All genotypes responded to water stress with a significant increase in root-to-shoot ratio, except DP1044 B2RF (Table V.5).

Table V.1. Fisher's LSD root dry mass mean comparisons among cotton genotypes in 2010. Levels not connected by the same letter are significantly different at the 0.05 level of probability.

a. Well-Watered Level			Mean	b. Water-Stressed Level					Mean
08-1-1325	A		54.31	DP935 B2RF	A				42.18
DP0949 B2RF	A	B	49.99	DP0949 B2RF	A	B			41.38
L-23	A	B	49.22	CS-50	A	B	C		39.04
DP141 B2RF	A	B	48.26	02-WK-11L	A	B	C		38.51
02-WK-11L	A	B	48.25	L-23	A	B	C	D	36.65
DP1044 B2RF	A	B	47.61	08-1-1325	A	B	C	D	35.95
TAM B-182-33	A	B	45.80	DP141 B2RF	A	B	C	D	35.66
DP935 B2RF	A	B	44.93	04-22-405	A	B	C	D	34.61
CS-50	A	B	43.57	TAM B-182-33	A	B	C	D	32.88
05-47-802	A	B	41.95	03 WZ-37	A	B	C	D	31.85
DP1048 B2RF	A	B	41.62	DP1028 B2RF	A	B	C	D	30.13
DP1028 B2RF	A	B	40.93	DP1048 B2RF		B	C	D	29.08
DP0912 B2RF	A	B	40.92	05-47-802		B	C	D	28.81
06-46-153	A	B	39.72	DP1044 B2RF			C	D	26.60
03 WZ-37	A	B	39.05	DP0912 B2RF				D	25.67
04-22-405		B	29.19	06-46-153				D	24.90

Table V.2. Cotton genotypes root dry mass mean comparisons between water regimes in 2010.

Genotype	Water Regime	Root Mass Average	Difference (WW - WS)	Std. Error	P-value
02-WK-11L	WS	38.51	9.74	8.65	0.5093
02-WK-11L	WW	48.25			
03 WZ-37	WS	31.85	7.20	1.61	0.0873
03 WZ-37	WW	39.05			
04-22-405	WS	34.61	-5.41	1.70	0.1910
04-22-405	WW	29.19			
05-47-802	WS	28.81	13.13	4.43	0.1709
05-47-802	WW	41.95			
06-46-153	WS	24.90	14.82	3.87	0.1139
06-46-153	WW	39.72			
08-1-1325	WS	35.95	18.35	7.79	0.2377
08-1-1325	WW	54.31			
CS-50	WS	39.04	4.53	5.92	0.6428
CS-50	WW	43.57			
DP0912 B2RF	WS	25.67	15.25	0.29	0.0007*
DP0912 B2RF	WW	40.92			
DP0949 B2RF	WS	41.38	8.61	6.52	0.4493
DP0949 B2RF	WW	49.99			
DP1028 B2RF	WS	30.13	10.80	1.95	0.0592
DP1028 B2RF	WW	40.93			
DP1044 B2RF	WS	26.60	21.01	7.07	0.1705
DP1044 B2RF	WW	47.61			
DP1048 B2RF	WS	29.08	12.55	2.91	0.0931
DP1048 B2RF	WW	41.6240			
DP0141 B2RF	WS	35.6600	12.60	4.87	0.2091
DP0141 B2RF	WW	48.2620			
DP0935 B2RF	WS	42.1840	2.75	8.07	0.8321
DP0935 B2RF	WW	44.9325			
L-23	WS	36.6530	12.57	12.07	0.5384
L-23	WW	49.2190			
TAM B-182-33	WS	32.8820	12.92	7.43	0.3437
TAM B-182-33	WW	45.8025			

* = Significant at the 0.05 level of probability.

Table V.3. Root and shoot growth in 2010, WS and WW treatments.

Water Regime	Plant Height	Number of Leaves	Shoot Dry Mass	Root Dry Mass	Root:Shoot Ratio
	cm		g	g	
WS	123.6	94.8	121.38	33.37	0.28
WW	146.9	199.5	209.83	44.08	0.21
p-value	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*

* = Significant at the 0.05 level of probability.

Table V.4. Fisher's LSD root:shoot ratio mean comparisons between cotton genotypes in 2010. Levels not connected by the same letter are significantly different at the 0.05 level of probability.

a. Well-Watered Level			Mean	b. Water-Stressed Level				Mean
DP1044 B2RF	A		0.29	02-WK-11L	A			0.41
TAM B-182-33	A	B	0.25	TAM B-182-33	A	B		0.33
DP1028 B2RF	A	B	0.24	DP0949 B2RF	A	B	C	0.31
08-1-1325	A	B	0.24	03 WZ-37	A	B	C	0.30
DP0949 B2RF	A	B	0.23	06-46-153	A	B	C	0.30
L-23	A	B	0.23	L-23		B	C	0.28
CS-50	A	B	0.22	CS-50		B	C	0.28
DP141 B2RF	A	B	0.21	DP935 B2RF		B	C	0.27
03 WZ-37	A	B	0.21	DP1028 B2RF		B	C	0.27
DP0912 B2RF	A	B	0.21	04-22-405		B	C	0.27
05-47-802	A	B	0.20	08-1-1325		B	C	0.27
02-WK-11L	A	B	0.20	DP0912 B2RF		B	C	0.26
06-46-153	A	B	0.18	05-47-802		B	C	0.26
DP935 B2RF	A	B	0.18	DP141 B2RF		B	C	0.24
DP1048 B2RF		B	0.17	DP1048 B2RF		B	C	0.24
04-22-405		B	0.15	DP1044 B2RF			C	0.19

Table V.5. Cotton genotypes root:shoot ratio mean comparisons between water regimes in 2010.

Genotype	Water Regime	Average Root:Shoot Ratio	Difference (WW - WS)	Std. Error	P-value
02-WK-11L	WS	0.41	-0.21	0.0142	0.0089*
02-WK-11L	WW	0.20			
03 WZ-37	WS	0.30	-0.09	0.0204	0.0828
03 WZ-37	WW	0.21			
04-22-405	WS	0.27	-0.11	0.0114	0.0194*
04-22-405	WW	0.15			
05-47-802	WS	0.26	-0.05	0.0485	0.5234
05-47-802	WW	0.20			
06-46-153	WS	0.39	-0.12	0.0305	0.1110
06-46-153	WW	0.18			
08-1-1325	WS	0.27	-0.03	0.0200	0.3915
08-1-1325	WW	0.24			
CS-50	WS	0.28	-0.06	0.0576	0.5325
CS-50	WW	0.22			
DP0912 B2RF	WS	0.26	-0.06	0.0194	0.1649
DP0912 B2RF	WW	0.21			
DP0949 B2RF	WS	0.31	-0.08	0.0589	0.4397
DP0949 B2RF	WW	0.23			
DP1028 B2RF	WS	0.27	-0.02	0.0201	0.4671
DP1028 B2RF	WW	0.24			
DP1044 B2RF	WS	0.19	0.10	0.0544	0.3221
DP1044 B2RF	WW	0.29			
DP1048 B2RF	WS	0.24	-0.07	0.0060	0.0160*
DP1048 B2RF	WW	0.17			
DP141 B2RF	WS	0.24	-0.03	0.0203	0.3790
DP141 B2RF	WW	0.21			
DP935 B2RF	WS	0.27	-0.09	0.0517	0.3274
DP935 B2RF	WW	0.18			
L-23	WS	0.28	-0.05	0.0342	0.3998
L-23	WW	0.23			
TAM B-182-33	WS	0.33	-0.08	0.0802	0.5561
TAM B-182-33	WW	0.25			

* = Significant at the 0.05 level of probability.

Data in 2011 also showed mean separation between genotypes within the treatment, with DP0935 B2RF and 05-47-802 being at the two extremes, and averaging 59.05g and 50.35g root dry mass, respectively (Table V.6). As previously mentioned, the WS treatment imposed in 2011 was mild and constant from early bloom to harvest, which may have led to an increased assimilated carbon partitioning towards root growth. Mean comparisons between 2010 WW and 2011 WS treatments for the genotypes in common for both (10 varieties) showed WS plants in 2011 as having a significantly higher root dry mass at the 5% level of probability (Fig. V.2). Across both years, DP0935 B2RF consistently had the highest root dry mass among genotypes when exposed to water stress. Because data collected in 2011 was not sufficient to determine shoot weight, it is assumed that root-to-shoot ratio was also increased by the increase in root dry weight, based on information in the literature already mentioned in this chapter (Ball et al., 1994; Chaves et al., 2003), among others. For this particular scenario, means for all water regimes between years show that severe water deprivation, like the one imposed on the 2010 WS treatment, will curtail plant root growth, causing root dry matter production to be lower than that of well-watered plants. On the other hand, a mild constant stress like the 2011 WS treatment will cause an enhanced root growth, averaging higher root mass when compared to that of plants growing in an environment where water is a non-limiting factor (Table V.7 and Fig. V.3). Because plant root mass was not significantly different in 2010 between water regimes at the start of water restrictions, and all the plants were grown in the same environmental conditions, it is assumed that the different responses to root growth is related to the intensity of the stress.

Table V.6. Fisher's LSD root dry mass mean comparisons between genotypes in 2011. Alpha = 0.05. Levels not connected by the same letter are significantly different.

Level				Mean
DP0935 B2RF	A			59.05
11R159 B2R2	A	B		57.31
10R011 B2R2	A	B		57.13
L-23	A	B	C	56.53
11R136 B2R2	A	B	C	56.40
CS-50	A	B	C	55.57
DP1044 B2RF	A	B	C	55.52
08-1-1325	A	B	C	55.41
DP0912 B2RF	A	B	C	54.66
DP1048 B2RF	A	B	C	54.50
10R052 B2R2	A	B	C	54.27
06-46-153		B	C	52.11
DP1032 B2RF		B	C	52.00
04-22-405		B	C	51.33
10R013 B2R2			C	50.58
05-47-802			C	50.35

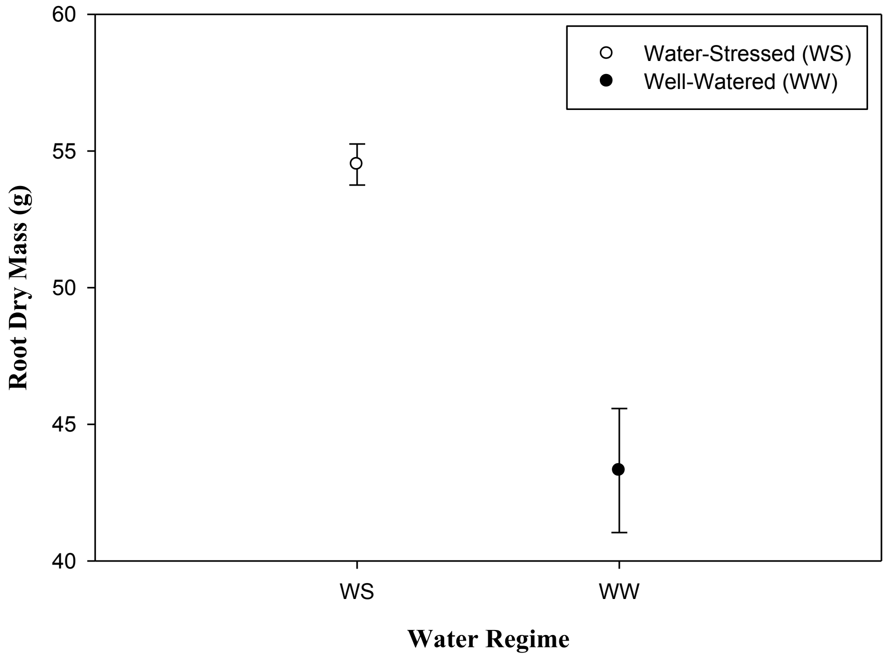


Figure V.2. Average root dry mass between water regimes for 10 genotypes in common for both years. WS (2011), WW (2010). Values are averages within treatments and bars represent ± SE.

Table V.7. Fisher's LSD root dry mass mean comparisons between water regimes. 2010 Water-Stressed 1st sampling (1-WS); 2010 Well-Watered 1st sampling (1-WW); 2010 Water-Stressed 2nd sampling (2-WS); 2010 Well-Watered 2nd sampling (2-WW); 2011 Water-Stressed 2nd sampling (3-WS). Alpha = 0.05. Levels not connected by same letter are significantly different.

Level					Mean
3-WS	A				54.55
2-WW		B			44.08
2-WS			C		33.37
1-WS				D	16.35
1-WW				D	15.35

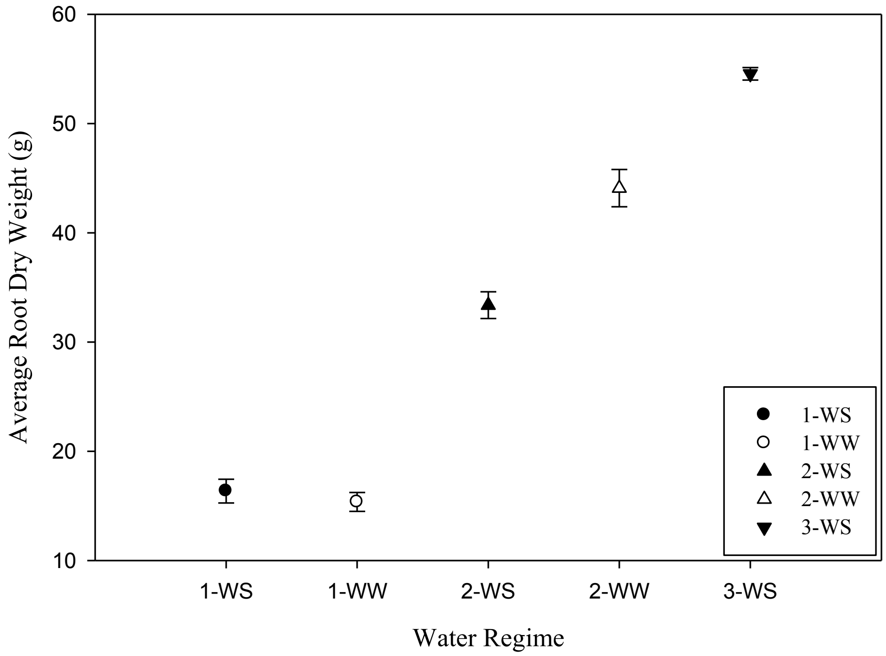


Figure V.3. Root dry mass between water regimes. 2010 Water-Stressed 1st sampling (1-WS); 2010 Well-Watered 1st sampling (1-WW); 2010 Water-Stressed 2nd sampling (2-WS); 2010 Well-Watered 2nd sampling (2-WW); 2011 Water-Stressed 2nd sampling (3-WS). Values are means and bars represent ± SE.

CONCLUSIONS

Both studies in 2010 and 2011 show that genotypes respond differently in terms of carbon allocation to root growth when subjected to distinct levels of water stress. Root mass was highest when plants were exposed to a mild water stress and lowest when a more severe water restriction was imposed. DP0935 B2RF consistently had the higher root dry mass in both 2010 and 2011 tests within WS treatments. In 2010, data showed that the severe WS treatment decreased total number of leaves and shoot and root dry mass, but the root-to-shoot ratio was increased indicating that plants were allocating a higher amount of available resources towards root development.

CHAPTER VI

CONLUSIONS

Data collected showed that genotypes have very distinct water use patterns and that their response to drought also differs. In 2010 a sharp decrease in plant water use was observed when the water stress treatment was initiated and also when the intensity of the stress was increased, which were attributed to the decrease in plant water status that triggered stomatal closure. Variation in plant water use between days was also smaller in plants under water stress than on plants growing in an environment free of water stress, likely due to the already low plant water status and decreased stomatal conductivity. While plants were well-watered, the only genotype to have a significantly different (lower than average) daily plant water use per unit leaf mass was DP1028 B2RF. While plants were under water-stress, DP1048 B2RF was the only genotype to be significantly different (higher than average). In 2011 plant water use decreased sharply right after the water stress regime was imposed, after which variation between days was small and within 1 to 1.5L throughout most of the season. Although 6 genotypes were unique for that test, the average value showed a very similar trend to the one observed in 2010. The experiments demonstrated the potential for the method used; not only does it allow for a clear discrimination of water economy among the genotypes and their distinct water use patterns, but it also provides the capability to track water use in different stages of plant growth.

Plant growth and leaf expansion/initiation were significantly affected by the water deficit imposed in 2010. Comparisons between treatments prior to the initiation of water restrictions treatment showed no significant difference in any parameters measured, also indicating homogeneity of the growing conditions. At the end of the season, however, data indicated that plant height, number of main-stem nodes, and total number of leaves were all significantly lower in plants growing in water deficient conditions. For the same traits, three genotypes (06-46-153, DP1028 B2RF, and DP1044 B2RF) grown under 1-WS treatment did not show any significant decrease when compared to their well-watered (1-WW) counterparts. Average leaf dry mass collected at 4 different occasions, about two weeks apart from each other, illustrated that initiation of new leaves was promptly curtailed upon initiation of water restrictions; water-stressed plants reached a plateau around July 21st, after which leaf dry mass started to decrease. No such trend was visible in plants growing with plenty of available water. In 2011, mean comparisons of total number of leaves and total leaf dry mass among genotypes taken at final harvest (predicted values) showed that after the stress was imposed there were a lower number of significant differences at the 5% level of probability among genotypes. Main-stem leaf area measurements taken every two weeks indicated that the main-stem leaf with the largest area was located between nodes 7 to 12, even when plants were growing under water-stress. The greatest rate of leaf area expansion occurred between the first two measurements taken on 05/31/11 and 06/14/11, coinciding with the pre-flowering growth stage, at which point the rate of expansion significantly decreased. A total of 54 significant differences were found among genotypes regarding the final main-stem leaf area at the end of the season, where it was also noted that the equation ($A = 1.0526L^2 - 1.96L$, $R^2 = 0.98$) used to estimate leaf area based on leaf midrib length was not suitable for okra leaf type cotton, as it disproportionally overestimated the final leaf area.

The analysis of stomatal density in 2010 and 2011 indicated a higher density on the abaxial leaf surface, with ratios for abaxial/adaxial ranging from 1.53 for DP1044 B2RF to 3.68 for 10R013 B2R2. Average stomatal density for all genotypes varied from 15.27 to 39.07 and 38.79 to 88.61 for the adaxial and abaxial surfaces respectively. When comparing average stomatal density for each of the genotypes against the average of all genotypes, 03-WZ-37 and 05-47-802 had the lowest significantly different densities for both leaf surfaces while 11R159 B2R2 had the highest significantly different values for both surfaces. Also, although genotypes are remarkably different in respect to stomatal density on both leaf surfaces, a higher number of significant differences at the 5% level of probability were found on the abaxial side. While very time consuming, stomatal density may be a very important trait for breeding programs, and its inclusion should be considered.

Studies in 2010 and 2011 showed that genotypes respond differently in terms of carbon allocation to root growth when subjected to distinct levels of water stress. Root mass was highest when plants were exposed to a mild water stress and lowest when a more severe water restriction was imposed. DP0935 B2RF consistently had the higher root dry mass in both years within WS treatments. In 2010, data showed that the severe water stress treatment decreased total number of leaves, shoot and root dry mass, but the root-to-shoot ratio was increased.

The studies conducted in the Drought Tolerance Lab, demonstrates that cotton genotypes are very diverse and a range of responses were found depending on the water stress regime imposed to the test plants. Plant water use, growth patterns, stomatal densities, and root growth responses to water limitation all vary by genotype. The methodology used to conduct this study may be used to characterize genotypes and traits conferring drought tolerance and increased water use efficiency to cotton and other crops. The information collected during this, and other trials, should aid breeding efforts, and help accelerate the development of improved drought tolerant lines.

For all experiments described in this manuscript, there was a replication problem with DP 1044 B2RF and thus data presented for this particular genotype should be disregarded.

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APPENDIX II.A

DAY OF THE YEAR CALENDAR

MONTH

DAY OF THE MONTH

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1	32	60	91	121	152	182	213	244	274	305	335
2	2	33	61	92	122	153	183	214	245	275	306	336
3	3	34	62	93	123	154	184	215	246	276	307	337
4	4	35	63	94	124	155	185	216	247	277	308	338
5	5	36	64	95	125	156	186	217	248	278	309	339
6	6	37	65	96	126	157	187	218	249	279	310	340
7	7	38	66	97	127	158	188	219	250	280	311	341
8	8	39	67	98	128	159	189	220	251	281	312	342
9	9	40	68	99	129	160	190	221	252	282	313	343
10	10	41	69	100	130	161	191	222	253	283	314	344
11	11	42	70	101	131	162	192	223	254	284	315	345
12	12	43	71	102	132	163	193	224	255	285	316	346
13	13	44	72	103	133	164	194	225	256	286	317	347
14	14	45	73	104	134	165	195	226	257	287	318	348
15	15	46	74	105	135	166	196	227	258	288	319	349
16	16	47	75	106	136	167	197	228	259	289	320	350
17	17	48	76	107	137	168	198	229	260	290	321	351
18	18	49	77	108	138	169	199	230	261	291	322	352
19	19	50	78	109	139	170	200	231	262	292	323	353
20	20	51	79	110	140	171	201	232	263	293	324	354
21	21	52	80	111	141	172	202	233	264	294	325	355
22	22	53	81	112	142	173	203	234	265	295	326	356
23	23	54	82	113	143	174	204	235	266	296	327	357
24	24	55	83	114	144	175	205	236	267	297	328	358
25	25	56	84	115	145	176	206	237	268	298	329	359
26	26	57	85	116	146	177	207	238	269	299	330	360
27	27	58	86	117	147	178	208	239	270	300	331	361
28	28	59	87	118	148	179	209	240	271	301	332	362
29	29	60	88	119	149	180	210	241	272	302	333	363
30	30		89	120	150	181	211	242	273	303	334	364
31	31		90		151		212	243		304		365

APPENDIX II.B

2010 AND 2011 - REGRESSION EQUATIONS UTILIZED TO ESTIMATE LEAF DRY MASS ON DAY OF THE YEAR FOR COTTON GENOTYPES

Year	Water Regime	Genotype	Regression Equation	Type	R^2
2010	Well-Watered	02-WK-11L	$y = -0.0027x^2 + 2.2411x - 268.86$	Poly.	0.8847
2010	Water-Stressed	02-WK-11L	$y = -0.0124x^2 + 4.9002x - 440.7$	Poly.	0.4087
2010	Well-Watered	03-WZ-37	$y = -0.0279x^2 + 11.434x - 1091.3$	Poly.	0.5618
2010	Water-Stressed	03-WZ-37	$y = -0.0197x^2 + 7.7091x - 705.58$	Poly.	0.2597
2010	Well-Watered	04-22-405	$y = -0.0227x^2 + 9.7221x - 954.88$	Poly.	0.8146
2010	Water-Stressed	04-22-405	$y = -0.0109x^2 + 4.4858x - 413.78$	Poly.	0.3396
2010	Well-Watered	05-47-802	$y = 0.0055x^2 - 1.2674x + 94.343$	Poly.	0.7402
2010	Water-Stressed	05-47-802	$y = -0.0078x^2 + 3.0895x - 258.53$	Poly.	0.0832
2010	Well-Watered	06-46-153	$y = -0.031x^2 + 12.777x - 1237$	Poly.	0.3329
2010	Water-Stressed	06-46-153	$y = -0.0166x^2 + 6.4359x - 576.62$	Poly.	0.4144
2010	Well-Watered	08-1-1325	$y = -0.008x^2 + 4.4996x - 492.84$	Poly.	0.8765
2010	Water-Stressed	08-1-1325	$y = -0.0156x^2 + 6.3233x - 587.56$	Poly.	0.5079
2010	Well-Watered	CS-50	$y = 0.0066x^2 - 1.5887x + 123.97$	Poly.	0.6721
2010	Water-Stressed	CS-50	$y = 0.0018x^2 - 0.692x + 111.21$	Poly.	0.0046
2010	Well-Watered	DP0912 B2RF	$y = -0.0073x^2 + 3.9786x - 441.49$	Poly.	0.9121
2010	Water-Stressed	DP0912 B2RF	$y = -0.0132x^2 + 5.2913x - 481.32$	Poly.	0.1835
2010	Well-Watered	DP0949 B2RF	$y = 0.0019x^2 + 0.5729x - 123.43$	Poly.	0.8120
2010	Water-Stressed	DP0949 B2RF	$y = -0.0056x^2 + 2.528x - 237.7$	Poly.	0.4269
2010	Well-Watered	DP1028 B2RF	$y = -0.0239x^2 + 10.392x - 1046.2$	Poly.	0.8240
2010	Water-Stressed	DP1028 B2RF	$y = -0.0098x^2 + 3.7484x - 314.69$	Poly.	0.0751
2010	Well-Watered	DP1044 B2RF	$y = -0.0312x^2 + 12.552x - 1200.7$	Poly.	0.3176
2010	Water-Stressed	DP1044 B2RF	$y = -0.0249x^2 + 10.055x - 960.97$	Poly.	0.5274
2010	Well-Watered	DP1048 B2RF	$y = 0.0078x^2 - 1.8555x + 124.58$	Poly.	0.8712
2010	Water-Stressed	DP1048 B2RF	$y = -0.0053x^2 + 2.48x - 246.78$	Poly.	0.7828
2010	Well-Watered	DP0141 B2RF	$y = -0.0078x^2 + 4.3895x - 484.18$	Poly.	0.8408
2010	Water-Stressed	DP0141 B2RF	$y = -0.0167x^2 + 6.7984x - 637.22$	Poly.	0.7065
2010	Well-Watered	DP0935 B2RF	$y = -0.0112x^2 + 5.6652x - 599.38$	Poly.	0.9077
2010	Water-Stressed	DP0935 B2RF	$y = -0.022x^2 + 8.6203x - 791.29$	Poly.	0.2340
2010	Well-Watered	L-23	$y = -0.0073x^2 + 3.759x - 392.31$	Poly.	0.7920
2010	Water-Stressed	L-23	$y = -0.0118x^2 + 4.7283x - 433.23$	Poly.	0.2825
2010	Well-Watered	TAM B-182-33	$y = -0.0123x^2 + 5.4912x - 546.75$	Poly.	0.7007
2010	Water-Stressed	TAM B-182-33	$y = 0.0138x^2 - 5.4871x + 584.04$	Poly.	0.1136
2011	Water-Stressed	04-22-405	$y = -0.423x + 129.51$	Linear	0.8093
2011	Water-Stressed	05-47-802	$y = -0.2782x + 103.81$	Linear	0.7005
2011	Water-Stressed	06-46-153	$y = -0.3109x + 108.04$	Linear	0.8096
2011	Water-Stressed	08-1-1325	$y = -0.39x + 120.46$	Linear	0.6842
2011	Water-Stressed	10R011 B2R2	$y = -0.1339x + 72.645$	Linear	0.1707
2011	Water-Stressed	10R013 B2R2	$y = -0.3806x + 121.26$	Linear	0.7867
2011	Water-Stressed	10R052 B2R2	$y = -0.09x + 67.214$	Linear	0.1857
2011	Water-Stressed	11R136 B2R2	$y = -0.4553x + 141.27$	Linear	0.8745

Year	Water Regime	Genotype	Regression Equation	Type	R^2
2011	Water-Stressed	11R159 B2R2	y = -0.2691x + 101.13	Linear	0.4044
2011	Water-Stressed	CS-50	y = -0.3132x + 108.74	Linear	0.7418
2011	Water-Stressed	DP0912 B2RF	y = -0.1622x + 77.599	Linear	0.3491
2011	Water-Stressed	DP0935 B2RF	y = -0.283x + 104.08	Linear	0.5718
2011	Water-Stressed	DP1032 B2RF	y = -0.1533x + 73.46	Linear	0.2628
2011	Water-Stressed	DP1044 B2RF	y = -0.2026x + 87.356	Linear	0.4700
2011	Water-Stressed	DP1048 B2RF	y = -0.2411x + 93.755	Linear	0.7342
2011	Water-Stressed	L-23	y = -0.3001x + 100.66	Linear	0.5153

APPENDIX II.C

2010 – DAILY PLANT WATER USE PER UNIT LEAF DRY MASS MEANS COMPARISONS BETWEEN COTTON GENOTYPES GROWN UNDER WELL WATERED CONDITIONS

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP1048 B2RF	DP1028 B2RF	11.8719	2.365478	7.22942	16.51439	<.0001
02-WK-11L	DP1028 B2RF	11.21103	2.365478	6.56854	15.85352	<.0001
DP0912 B2RF	DP1028 B2RF	9.7889	2.365478	5.14641	14.43138	<.0001
L-23	DP1028 B2RF	9.29412	2.365478	4.65163	13.9366	<.0001
DP1048 B2RF	04-22-405	8.71482	2.365478	4.07233	13.3573	0.0002
DP1048 B2RF	03-WZ-37	8.62749	2.365478	3.985	13.26998	0.0003
DP1048 B2RF	DP1044 B2RF	8.53171	2.365478	3.88922	13.17419	0.0003
02-WK-11L	04-22-405	8.05394	2.365478	3.41146	12.69643	0.0007
02-WK-11L	03-WZ-37	7.96662	2.365478	3.32413	12.60911	0.0008
CS-50	DP1028 B2RF	7.92443	2.365478	3.28194	12.56692	0.0008
02-WK-11L	DP1044 B2RF	7.87083	2.365478	3.22834	12.51332	0.0009
DP1048 B2RF	08-1-1325	7.63109	2.365478	2.98861	12.27358	0.0013
05-47-802	DP1028 B2RF	7.60855	2.365478	2.96606	12.25104	0.0013
DP1048 B2RF	DP0141 B2RF	7.59205	2.365478	2.94956	12.23454	0.0014
06-46-153	DP1028 B2RF	7.18152	2.365478	2.53903	11.82401	0.0025
DP1048 B2RF	DP0949 B2RF	7.0808	2.365478	2.43831	11.72329	0.0028
02-WK-11L	08-1-1325	6.97022	2.365478	2.32773	11.61271	0.0033
02-WK-11L	DP0141 B2RF	6.93118	2.365478	2.28869	11.57367	0.0035
TAM B-182-33	DP1028 B2RF	6.76957	2.365478	2.12708	11.41206	0.0043
DP0912 B2RF	04-22-405	6.63181	2.365478	1.98932	11.2743	0.0052
DP0912 B2RF	03-WZ-37	6.54448	2.365478	1.90199	11.18697	0.0058
DP0912 B2RF	DP1044 B2RF	6.4487	2.365478	1.80621	11.09118	0.0065
02-WK-11L	DP0949 B2RF	6.41993	2.365478	1.77744	11.06241	0.0068
WW AVERAGE	DP1028 B2RF	6.30346	2.365478	1.66098	10.94595	0.0078
DP0935 B2RF	DP1028 B2RF	6.15193	2.365478	1.50944	10.79442	0.0095
L-23	04-22-405	6.13703	2.365478	1.49454	10.77952	0.0096
L-23	03-WZ-37	6.0497	2.365478	1.40721	10.69219	0.0107
L-23	DP1044 B2RF	5.95392	2.365478	1.31143	10.59641	0.012
DP1048 B2RF	DP0935 B2RF	5.71997	2.365478	1.07749	10.36246	0.0158
DP1048 B2RF	WW AVERAGE	5.56844	2.365478	0.92595	10.21093	0.0188
DP0912 B2RF	08-1-1325	5.54809	2.365478	0.9056	10.19057	0.0192
DP0912 B2RF	DP0141 B2RF	5.50904	2.365478	0.86655	10.15153	0.0201
DP1048 B2RF	TAM B-182-33	5.10234	2.365478	0.45985	9.74483	0.0313
02-WK-11L	DP0935 B2RF	5.0591	2.365478	0.41661	9.70159	0.0327
L-23	08-1-1325	5.05331	2.365478	0.41082	9.69579	0.0329
L-23	DP0141 B2RF	5.01426	2.365478	0.37177	9.65675	0.0343
DP0912 B2RF	DP0949 B2RF	4.99779	2.365478	0.3553	9.64028	0.0349

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
02-WK-11L	WW AVERAGE	4.90757	2.365478	0.26508	9.55006	0.0383
DP0949 B2RF	DP1028 B2RF	4.79111	2.365478	0.14862	9.4336	0.0431
CS-50	04-22-405	4.76734	2.365478	0.12485	9.40983	0.0442
DP1048 B2RF	06-46-153	4.69039	2.365478	0.0479	9.33287	0.0477
CS-50	03-WZ-37	4.68001	2.365478	0.03753	9.3225	0.0482
CS-50	DP1044 B2RF	4.58423	2.365478	-0.05826	9.22672	0.0529
L-23	DP0949 B2RF	4.50301	2.365478	-0.13948	9.1455	0.0573
05-47-802	04-22-405	4.45147	2.365478	-0.19102	9.09395	0.0602
02-WK-11L	TAM B-182-33	4.44147	2.365478	-0.20102	9.08395	0.0608
05-47-802	03-WZ-37	4.36414	2.365478	-0.27835	9.00663	0.0654
DP0141 B2RF	DP1028 B2RF	4.27985	2.365478	-0.36263	8.92234	0.0707
05-47-802	DP1044 B2RF	4.26835	2.365478	-0.37413	8.91084	0.0715
DP1048 B2RF	05-47-802	4.26335	2.365478	-0.37914	8.90584	0.0718
08-1-1325	DP1028 B2RF	4.24081	2.365478	-0.40168	8.8833	0.0733
02-WK-11L	06-46-153	4.02951	2.365478	-0.61298	8.672	0.0888
06-46-153	04-22-405	4.02443	2.365478	-0.61806	8.66692	0.0892
DP1048 B2RF	CS-50	3.94748	2.365478	-0.69501	8.58996	0.0955
06-46-153	03-WZ-37	3.93711	2.365478	-0.70538	8.57959	0.0964
06-46-153	DP1044 B2RF	3.84132	2.365478	-0.80117	8.48381	0.1047
CS-50	08-1-1325	3.68362	2.365478	-0.95887	8.32611	0.1198
CS-50	DP0141 B2RF	3.64458	2.365478	-0.99791	8.28706	0.1237
DP0912 B2RF	DP0935 B2RF	3.63696	2.365478	-1.00552	8.27945	0.1245
TAM B-182-33	04-22-405	3.61248	2.365478	-1.03001	8.25497	0.1271
02-WK-11L	05-47-802	3.60248	2.365478	-1.04001	8.24497	0.1281
TAM B-182-33	03-WZ-37	3.52515	2.365478	-1.11734	8.16764	0.1365
DP0912 B2RF	WW AVERAGE	3.48543	2.365478	-1.15706	8.12792	0.141
TAM B-182-33	DP1044 B2RF	3.42937	2.365478	-1.21312	8.07186	0.1475
05-47-802	08-1-1325	3.36774	2.365478	-1.27475	8.01023	0.1549
DP1044 B2RF	DP1028 B2RF	3.3402	2.365478	-1.30229	7.98269	0.1583
05-47-802	DP0141 B2RF	3.3287	2.365478	-1.31379	7.97119	0.1597
02-WK-11L	CS-50	3.2866	2.365478	-1.35588	7.92909	0.1651
03-WZ-37	DP1028 B2RF	3.24441	2.365478	-1.39807	7.8869	0.1705
04-22-405	DP1028 B2RF	3.15709	2.365478	-1.4854	7.79958	0.1823
WW AVERAGE	04-22-405	3.14638	2.365478	-1.49611	7.78886	0.1838
L-23	DP0935 B2RF	3.14219	2.365478	-1.5003	7.78467	0.1844
CS-50	DP0949 B2RF	3.13332	2.365478	-1.50917	7.77581	0.1856
WW AVERAGE	03-WZ-37	3.05905	2.365478	-1.58344	7.70154	0.1963
DP0912 B2RF	TAM B-182-33	3.01933	2.365478	-1.62316	7.66182	0.2021
DP0935 B2RF	04-22-405	2.99484	2.365478	-1.64765	7.63733	0.2058
L-23	WW AVERAGE	2.99065	2.365478	-1.65184	7.63314	0.2065
WW AVERAGE	DP1044 B2RF	2.96326	2.365478	-1.67922	7.60575	0.2106
06-46-153	08-1-1325	2.94071	2.365478	-1.70178	7.5832	0.2141
DP0935 B2RF	03-WZ-37	2.90752	2.365478	-1.73497	7.55	0.2193
06-46-153	DP0141 B2RF	2.90167	2.365478	-1.74082	7.54415	0.2203
05-47-802	DP0949 B2RF	2.81745	2.365478	-1.82504	7.45993	0.2339
DP0935 B2RF	DP1044 B2RF	2.81173	2.365478	-1.83076	7.45422	0.2349

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP0912 B2RF	06-46-153	2.60738	2.365478	-2.03511	7.24986	0.2706
DP1048 B2RF	L-23	2.57779	2.365478	-2.0647	7.22028	0.2761
TAM B-182-33	08-1-1325	2.52876	2.365478	-2.11373	7.17125	0.2853
L-23	TAM B-182-33	2.52455	2.365478	-2.11794	7.16704	0.2861
TAM B-182-33	DP0141 B2RF	2.48971	2.365478	-2.15278	7.1322	0.2928
06-46-153	DP0949 B2RF	2.39041	2.365478	-2.25208	7.0329	0.3125
DP0912 B2RF	05-47-802	2.18034	2.365478	-2.46215	6.82283	0.3569
L-23	06-46-153	2.1126	2.365478	-2.52989	6.75509	0.372
DP1048 B2RF	DP0912 B2RF	2.08301	2.365478	-2.55948	6.7255	0.3788
WW AVERAGE	08-1-1325	2.06265	2.365478	-2.57983	6.70514	0.3835
WW AVERAGE	DP0141 B2RF	2.02361	2.365478	-2.61888	6.6661	0.3925
TAM B-182-33	DP0949 B2RF	1.97846	2.365478	-2.66403	6.62095	0.4032
02-WK-11L	L-23	1.91692	2.365478	-2.72557	6.5594	0.4179
DP0935 B2RF	08-1-1325	1.91112	2.365478	-2.73137	6.55361	0.4193
DP0935 B2RF	DP0141 B2RF	1.87208	2.365478	-2.77041	6.51456	0.4289
DP0912 B2RF	CS-50	1.86447	2.365478	-2.77802	6.50695	0.4308
CS-50	DP0935 B2RF	1.7725	2.365478	-2.86999	6.41499	0.4539
L-23	05-47-802	1.68556	2.365478	-2.95693	6.32805	0.4763
DP0949 B2RF	04-22-405	1.63402	2.365478	-3.00847	6.27651	0.4899
CS-50	WW AVERAGE	1.62097	2.365478	-3.02152	6.26345	0.4934
DP0949 B2RF	03-WZ-37	1.54669	2.365478	-3.0958	6.18918	0.5134
WW AVERAGE	DP0949 B2RF	1.51236	2.365478	-3.13013	6.15485	0.5228
05-47-802	DP0935 B2RF	1.45662	2.365478	-3.18587	6.09911	0.5382
DP0949 B2RF	DP1044 B2RF	1.45091	2.365478	-3.19158	6.0934	0.5398
02-WK-11L	DP0912 B2RF	1.42214	2.365478	-3.22035	6.06463	0.5479
L-23	CS-50	1.36969	2.365478	-3.2728	6.01218	0.5627
DP0935 B2RF	DP0949 B2RF	1.36082	2.365478	-3.28167	6.00331	0.5652
05-47-802	WW AVERAGE	1.30509	2.365478	-3.3374	5.94758	0.5813
CS-50	TAM B-182-33	1.15486	2.365478	-3.48763	5.79735	0.6255
DP0141 B2RF	04-22-405	1.12277	2.365478	-3.51972	5.76525	0.6352
08-1-1325	04-22-405	1.08372	2.365478	-3.55877	5.72621	0.647
DP0141 B2RF	03-WZ-37	1.03544	2.365478	-3.60705	5.67793	0.6617
06-46-153	DP0935 B2RF	1.02959	2.365478	-3.6129	5.67208	0.6635
08-1-1325	03-WZ-37	0.9964	2.365478	-3.64609	5.63888	0.6737
DP0141 B2RF	DP1044 B2RF	0.93965	2.365478	-3.70283	5.58214	0.6913
08-1-1325	DP1044 B2RF	0.90061	2.365478	-3.74188	5.5431	0.7035
06-46-153	WW AVERAGE	0.87806	2.365478	-3.76443	5.52054	0.7106
05-47-802	TAM B-182-33	0.83899	2.365478	-3.8035	5.48147	0.7229
CS-50	06-46-153	0.74291	2.365478	-3.89958	5.3854	0.7535
DP1048 B2RF	02-WK-11L	0.66087	2.365478	-3.98162	5.30336	0.78
TAM B-182-33	DP0935 B2RF	0.61764	2.365478	-4.02485	5.26013	0.7941
DP0949 B2RF	08-1-1325	0.5503	2.365478	-4.09219	5.19279	0.8161
DP0949 B2RF	DP0141 B2RF	0.51125	2.365478	-4.13124	5.15374	0.8289
DP0912 B2RF	L-23	0.49478	2.365478	-4.14771	5.13727	0.8344
TAM B-182-33	WW AVERAGE	0.4661	2.365478	-4.17639	5.10859	0.8438
05-47-802	06-46-153	0.42703	2.365478	-4.21545	5.06952	0.8568

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
06-46-153	TAM B-182-33	0.41195	2.365478	-4.23054	5.05444	0.8618
CS-50	05-47-802	0.31588	2.365478	-4.32661	4.95836	0.8938
DP1044 B2RF	04-22-405	0.18311	2.365478	-4.45938	4.8256	0.9383
WW AVERAGE	DP0935 B2RF	0.15153	2.365478	-4.49095	4.79402	0.9489
DP1044 B2RF	03-WZ-37	0.09579	2.365478	-4.5467	4.73827	0.9677
03-WZ-37	04-22-405	0.08733	2.365478	-4.55516	4.72981	0.9706
DP0141 B2RF	08-1-1325	0.03904	2.365478	-4.60344	4.68153	0.9868

Difference = (Genotype – Genotype). Std Err Dif = Standard Error of Difference, Lower CL = Lower Confidence Level, Upper CL = Upper Confidence Level, p=Value – Probability Value

APPENDIX II.D

2010 – DAILY PLANT WATER USE PER UNIT LEAF DRY MASS MEANS COMPARISONS BETWEEN COTTON GENOTYPES GROWN UNDER WATER STRESS CONDITIONS

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP1048 B2RF	DP0935 B2RF	13.93707	2.655429	8.72553	19.14862	<.0001
DP1048 B2RF	DP0912 B2RF	12.24703	2.655429	7.03549	17.45858	<.0001
DP1048 B2RF	05-47-802	12.04376	2.655429	6.83221	17.25531	<.0001
DP1048 B2RF	DP0141 B2RF	11.97218	2.655429	6.76063	17.18372	<.0001
DP1048 B2RF	DP1044 B2RF	11.6912	2.655429	6.47965	16.90275	<.0001
DP1048 B2RF	08-1-1325	11.5396	2.655429	6.32806	16.75115	<.0001
DP1048 B2RF	06-46-153	11.14135	2.655429	5.9298	16.35289	<.0001
DP1048 B2RF	02-WK-11L	10.95452	2.655429	5.74297	16.16606	<.0001
DP1048 B2RF	03-WZ-37	10.67185	2.655429	5.4603	15.88339	<.0001
DP1048 B2RF	TAM B-182-33	10.58225	2.655429	5.37071	15.7938	<.0001
DP1048 B2RF	04-22-405	10.35677	2.655429	5.14522	15.56831	0.0001
DP1048 B2RF	WS AVERAGE	10.17255	2.655429	4.961	15.38409	0.0001
DP1048 B2RF	DP1028 B2RF	9.91907	2.655429	4.70752	15.13061	0.0002
DP1048 B2RF	CS-50	9.90222	2.655429	4.69068	15.11377	0.0002
DP1048 B2RF	DP0949 B2RF	8.71327	2.655429	3.50173	13.92482	0.0011
DP1048 B2RF	L-23	7.08863	2.655429	1.87708	12.30017	0.0077
L-23	DP0935 B2RF	6.84845	2.655429	1.6369	12.05999	0.0101
DP0949 B2RF	DP0935 B2RF	5.2238	2.655429	0.01226	10.43535	0.0495
L-23	DP0912 B2RF	5.15841	2.655429	-0.05314	10.36995	0.0524
L-23	05-47-802	4.95513	2.655429	-0.25641	10.16668	0.0624
L-23	DP0141 B2RF	4.88355	2.655429	-0.328	10.0951	0.0662
L-23	DP1044 B2RF	4.60257	2.655429	-0.60897	9.81412	0.0834
L-23	08-1-1325	4.45098	2.655429	-0.76057	9.66252	0.094
L-23	06-46-153	4.05272	2.655429	-1.15883	9.26427	0.1273
CS-50	DP0935 B2RF	4.03485	2.655429	-1.17669	9.2464	0.129
DP1028 B2RF	DP0935 B2RF	4.018	2.655429	-1.19354	9.22955	0.1306
L-23	02-WK-11L	3.86589	2.655429	-1.34566	9.07744	0.1458
WS AVERAGE	DP0935 B2RF	3.76453	2.655429	-1.44702	8.97607	0.1566
L-23	03-WZ-37	3.58322	2.655429	-1.62833	8.79477	0.1775
04-22-405	DP0935 B2RF	3.5803	2.655429	-1.63124	8.79185	0.1779
DP0949 B2RF	DP0912 B2RF	3.53376	2.655429	-1.67778	8.74531	0.1836
L-23	TAM B-182-33	3.49363	2.655429	-1.71792	8.70517	0.1886
TAM B-182-33	DP0935 B2RF	3.35482	2.655429	-1.85673	8.56637	0.2068
DP0949 B2RF	05-47-802	3.33049	2.655429	-1.88106	8.54203	0.2101
L-23	04-22-405	3.26814	2.655429	-1.9434	8.47969	0.2187
03-WZ-37	DP0935 B2RF	3.26523	2.655429	-1.94632	8.47677	0.2192
DP0949 B2RF	DP0141 B2RF	3.2589	2.655429	-1.95264	8.47045	0.22
L-23	WS AVERAGE	3.08392	2.655429	-2.12762	8.29547	0.2458

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
02-WK-11L	DP0935 B2RF	2.98256	2.655429	-2.22899	8.1941	0.2617
DP0949 B2RF	DP1044 B2RF	2.97793	2.655429	-2.23362	8.18947	0.2624
L-23	DP1028 B2RF	2.83044	2.655429	-2.3811	8.04199	0.2868
DP0949 B2RF	08-1-1325	2.82633	2.655429	-2.38521	8.03788	0.2875
L-23	CS-50	2.81359	2.655429	-2.39795	8.02514	0.2896
06-46-153	DP0935 B2RF	2.79573	2.655429	-2.41582	8.00727	0.2927
DP0949 B2RF	06-46-153	2.42807	2.655429	-2.78347	7.63962	0.3608
08-1-1325	DP0935 B2RF	2.39747	2.655429	-2.81408	7.60902	0.3668
CS-50	DP0912 B2RF	2.34481	2.655429	-2.86673	7.55636	0.3775
DP1028 B2RF	DP0912 B2RF	2.32796	2.655429	-2.88358	7.53951	0.3809
DP1044 B2RF	DP0935 B2RF	2.24587	2.655429	-2.96567	7.45742	0.3979
DP0949 B2RF	02-WK-11L	2.24125	2.655429	-2.9703	7.45279	0.3989
CS-50	05-47-802	2.14154	2.655429	-3.07001	7.35309	0.4202
DP1028 B2RF	05-47-802	2.12469	2.655429	-3.08685	7.33624	0.4238
WS AVERAGE	DP0912 B2RF	2.07449	2.655429	-3.13706	7.28603	0.4349
CS-50	DP0141 B2RF	2.06996	2.655429	-3.14159	7.2815	0.4359
DP1028 B2RF	DP0141 B2RF	2.05311	2.655429	-3.15844	7.26465	0.4396
DP0141 B2RF	DP0935 B2RF	1.9649	2.655429	-3.24665	7.17644	0.4595
DP0949 B2RF	03-WZ-37	1.95857	2.655429	-3.25297	7.17012	0.461
05-47-802	DP0935 B2RF	1.89331	2.655429	-3.31823	7.10486	0.476
04-22-405	DP0912 B2RF	1.89027	2.655429	-3.32128	7.10181	0.4767
WS AVERAGE	05-47-802	1.87121	2.655429	-3.34033	7.08276	0.4812
DP0949 B2RF	TAM B-182-33	1.86898	2.655429	-3.34256	7.08053	0.4817
WS AVERAGE	DP0141 B2RF	1.79963	2.655429	-3.41192	7.01117	0.4981
CS-50	DP1044 B2RF	1.78898	2.655429	-3.42257	7.00053	0.5007
DP1028 B2RF	DP1044 B2RF	1.77213	2.655429	-3.43941	6.98368	0.5047
DP0912 B2RF	DP0935 B2RF	1.69004	2.655429	-3.52151	6.90159	0.5246
04-22-405	05-47-802	1.68699	2.655429	-3.52455	6.89854	0.5254
TAM B-182-33	DP0912 B2RF	1.66478	2.655429	-3.54677	6.87633	0.5309
DP0949 B2RF	04-22-405	1.6435	2.655429	-3.56805	6.85504	0.5361
CS-50	08-1-1325	1.63738	2.655429	-3.57416	6.84893	0.5376
L-23	DP0949 B2RF	1.62464	2.655429	-3.5869	6.83619	0.5408
DP1028 B2RF	08-1-1325	1.62053	2.655429	-3.59101	6.83208	0.5418
04-22-405	DP0141 B2RF	1.61541	2.655429	-3.59614	6.82695	0.5431
03-WZ-37	DP0912 B2RF	1.57519	2.655429	-3.63636	6.78673	0.5532
WS AVERAGE	DP1044 B2RF	1.51865	2.655429	-3.69289	6.7302	0.5675
TAM B-182-33	05-47-802	1.46151	2.655429	-3.75004	6.67305	0.5822
DP0949 B2RF	WS AVERAGE	1.45928	2.655429	-3.75227	6.67082	0.5828
TAM B-182-33	DP0141 B2RF	1.38992	2.655429	-3.82162	6.60147	0.6008
03-WZ-37	05-47-802	1.37191	2.655429	-3.83963	6.58346	0.6055
WS AVERAGE	08-1-1325	1.36706	2.655429	-3.84449	6.5786	0.6068
04-22-405	DP1044 B2RF	1.33443	2.655429	-3.87711	6.54598	0.6154
03-WZ-37	DP0141 B2RF	1.30033	2.655429	-3.91122	6.51188	0.6245
02-WK-11L	DP0912 B2RF	1.29252	2.655429	-3.91903	6.50406	0.6266
CS-50	06-46-153	1.23913	2.655429	-3.97242	6.45067	0.6409
DP1028 B2RF	06-46-153	1.22228	2.655429	-3.98927	6.43382	0.6454

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP0949 B2RF	DP1028 B2RF	1.2058	2.655429	-4.00575	6.41734	0.6499
DP0949 B2RF	CS-50	1.18895	2.655429	-4.0226	6.4005	0.6544
04-22-405	08-1-1325	1.18284	2.655429	-4.02871	6.39438	0.6561
TAM B-182-33	DP1044 B2RF	1.10895	2.655429	-4.1026	6.32049	0.6763
06-46-153	DP0912 B2RF	1.10569	2.655429	-4.10586	6.31723	0.6772
02-WK-11L	05-47-802	1.08924	2.655429	-4.1223	6.30079	0.6818
CS-50	02-WK-11L	1.0523	2.655429	-4.15925	6.26384	0.692
DP1028 B2RF	02-WK-11L	1.03545	2.655429	-4.1761	6.24699	0.6967
03-WZ-37	DP1044 B2RF	1.01935	2.655429	-4.19219	6.2309	0.7012
02-WK-11L	DP0141 B2RF	1.01766	2.655429	-4.19389	6.22921	0.7016
WS AVERAGE	06-46-153	0.9688	2.655429	-4.24275	6.18034	0.7153
TAM B-182-33	08-1-1325	0.95735	2.655429	-4.2542	6.1689	0.7185
06-46-153	05-47-802	0.90241	2.655429	-4.30913	6.11396	0.7341
03-WZ-37	08-1-1325	0.86776	2.655429	-4.34379	6.0793	0.7439
06-46-153	DP0141 B2RF	0.83083	2.655429	-4.38072	6.04238	0.7544
04-22-405	06-46-153	0.78458	2.655429	-4.42697	5.99612	0.7677
WS AVERAGE	02-WK-11L	0.78197	2.655429	-4.42958	5.99352	0.7685
CS-50	03-WZ-37	0.76962	2.655429	-4.44192	5.98117	0.772
DP1028 B2RF	03-WZ-37	0.75278	2.655429	-4.45877	5.96432	0.7769
02-WK-11L	DP1044 B2RF	0.73668	2.655429	-4.47486	5.94823	0.7815
08-1-1325	DP0912 B2RF	0.70743	2.655429	-4.50412	5.91898	0.79
CS-50	TAM B-182-33	0.68003	2.655429	-4.53151	5.89158	0.7979
DP1028 B2RF	TAM B-182-33	0.66318	2.655429	-4.54836	5.87473	0.8028
04-22-405	02-WK-11L	0.59775	2.655429	-4.6138	5.80929	0.8219
02-WK-11L	08-1-1325	0.58509	2.655429	-4.62646	5.79663	0.8257
TAM B-182-33	06-46-153	0.55909	2.655429	-4.65245	5.77064	0.8333
DP1044 B2RF	DP0912 B2RF	0.55583	2.655429	-4.65571	5.76738	0.8342
06-46-153	DP1044 B2RF	0.54985	2.655429	-4.66169	5.7614	0.836
08-1-1325	05-47-802	0.50416	2.655429	-4.70739	5.7157	0.8495
WS AVERAGE	03-WZ-37	0.4993	2.655429	-4.71225	5.71084	0.8509
03-WZ-37	06-46-153	0.4695	2.655429	-4.74205	5.68105	0.8597
CS-50	04-22-405	0.45455	2.655429	-4.757	5.66609	0.8641
DP1028 B2RF	04-22-405	0.4377	2.655429	-4.77385	5.64925	0.8691
08-1-1325	DP0141 B2RF	0.43257	2.655429	-4.77897	5.64412	0.8706
WS AVERAGE	TAM B-182-33	0.40971	2.655429	-4.80184	5.62125	0.8774
06-46-153	08-1-1325	0.39826	2.655429	-4.81329	5.6098	0.8808
TAM B-182-33	02-WK-11L	0.37226	2.655429	-4.83928	5.58381	0.8885
DP1044 B2RF	05-47-802	0.35256	2.655429	-4.85899	5.56411	0.8944
04-22-405	03-WZ-37	0.31508	2.655429	-4.89647	5.52662	0.9056
03-WZ-37	02-WK-11L	0.28267	2.655429	-4.92887	5.49422	0.9152
DP1044 B2RF	DP0141 B2RF	0.28098	2.655429	-4.93057	5.49252	0.9158
DP0141 B2RF	DP0912 B2RF	0.27486	2.655429	-4.93669	5.4864	0.9176
CS-50	WS AVERAGE	0.27033	2.655429	-4.94122	5.48187	0.9189
DP1028 B2RF	WS AVERAGE	0.25348	2.655429	-4.95807	5.46503	0.924
04-22-405	TAM B-182-33	0.22549	2.655429	-4.98606	5.43703	0.9323
05-47-802	DP0912 B2RF	0.20327	2.655429	-5.00827	5.41482	0.939

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
02-WK-11L	06-46-153	0.18683	2.655429	-5.02472	5.39837	0.9439
WS AVERAGE	04-22-405	0.18422	2.655429	-5.02733	5.39577	0.9447
08-1-1325	DP1044 B2RF	0.1516	2.655429	-5.05995	5.36314	0.9545
TAM B-182-33	03-WZ-37	0.08959	2.655429	-5.12195	5.30114	0.9731
DP0141 B2RF	05-47-802	0.07158	2.655429	-5.13996	5.28313	0.9785
CS-50	DP1028 B2RF	0.01685	2.655429	-5.1947	5.22839	0.9949

Difference = (Genotype – Genotype). Std Err Dif = Standard Error of Difference, Lower CL = Lower Confidence Level, Upper CL = Upper Confidence Level, p=Value – Probability Value

APPENDIX II.E

2011 – DAILY PLANT WATER USE PER UNIT LEAF DRY MASS MEANS COMPARISONS BETWEEN COTTON GENOTYPES GROWN UNDER WATER STRESS CONDITIONS

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
L-23	11R136B2R2	11.04746	1.410446	8.27986	13.81506	<.0001
L-23	DP0912B2RF	8.75412	1.410446	5.98652	11.52172	<.0001
L-23	DP1048B2RF	8.74384	1.410446	5.97624	11.51144	<.0001
L-23	10R052B2R2	8.38071	1.410446	5.6131	11.14831	<.0001
L-23	DP1044B2RF	8.10416	1.410446	5.33656	10.87177	<.0001
L-23	11R159B2R2	8.05462	1.410446	5.28702	10.82222	<.0001
L-23	05-47-802	7.67422	1.410446	4.90662	10.44182	<.0001
L-23	04-22-405	7.65363	1.410446	4.88603	10.42123	<.0001
DP1032B2RF	11R136B2R2	7.54921	1.410446	4.78161	10.31681	<.0001
L-23	DP0935B2RF	7.37632	1.410446	4.60872	10.14392	<.0001
L-23	CS-50	7.36698	1.410446	4.59938	10.13458	<.0001
06-46-153	11R136B2R2	7.13602	1.410446	4.36842	9.90363	<.0001
L-23	08-1-1325	6.86573	1.410446	4.09813	9.63334	<.0001
L-23	WS AVERAGE	6.81108	1.410446	4.04348	9.57868	<.0001
L-23	10R011B2R2	5.84315	1.410446	3.07554	8.61075	<.0001
L-23	10R013B2R2	5.70262	1.410446	2.93502	8.47022	<.0001
10R013B2R2	11R136B2R2	5.34484	1.410446	2.57724	8.11245	0.0002
DP1032B2RF	DP0912B2RF	5.25587	1.410446	2.48827	8.02347	0.0002
DP1032B2RF	DP1048B2RF	5.24559	1.410446	2.47799	8.01319	0.0002
10R011B2R2	11R136B2R2	5.20432	1.410446	2.43672	7.97192	0.0002
DP1032B2RF	10R052B2R2	4.88245	1.410446	2.11485	7.65005	0.0006
06-46-153	DP0912B2RF	4.84268	1.410446	2.07508	7.61028	0.0006
06-46-153	DP1048B2RF	4.8324	1.410446	2.0648	7.60001	0.0006
DP1032B2RF	DP1044B2RF	4.60591	1.410446	1.83831	7.37351	0.0011
DP1032B2RF	11R159B2R2	4.55637	1.410446	1.78877	7.32397	0.0013
06-46-153	10R052B2R2	4.46927	1.410446	1.70167	7.23687	0.0016
WS AVERAGE	11R136B2R2	4.23638	1.410446	1.46878	7.00399	0.0027
06-46-153	DP1044B2RF	4.19273	1.410446	1.42512	6.96033	0.003
08-1-1325	11R136B2R2	4.18173	1.410446	1.41413	6.94933	0.0031
DP1032B2RF	05-47-802	4.17597	1.410446	1.40837	6.94357	0.0031
DP1032B2RF	04-22-405	4.15538	1.410446	1.38778	6.92298	0.0033
06-46-153	11R159B2R2	4.14318	1.410446	1.37558	6.91079	0.0034
L-23	06-46-153	3.91144	1.410446	1.14384	6.67904	0.0056
DP1032B2RF	DP0935B2RF	3.87807	1.410446	1.11046	6.64567	0.0061
DP1032B2RF	CS-50	3.86873	1.410446	1.10113	6.63633	0.0062
06-46-153	05-47-802	3.76278	1.410446	0.99518	6.53038	0.0078
06-46-153	04-22-405	3.74219	1.410446	0.97459	6.50979	0.0081
CS-50	11R136B2R2	3.68048	1.410446	0.91288	6.44808	0.0092

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP0935B2RF	11R136B2R2	3.67115	1.410446	0.90354	6.43875	0.0094
L-23	DP1032B2RF	3.49825	1.410446	0.73065	6.26585	0.0133
06-46-153	DP0935B2RF	3.46488	1.410446	0.69728	6.23248	0.0142
06-46-153	CS-50	3.45554	1.410446	0.68794	6.22315	0.0144
04-22-405	11R136B2R2	3.39383	1.410446	0.62623	6.16143	0.0163
05-47-802	11R136B2R2	3.37324	1.410446	0.60564	6.14084	0.0169
DP1032B2RF	08-1-1325	3.36748	1.410446	0.59988	6.13508	0.0171
DP1032B2RF	WS AVERAGE	3.31283	1.410446	0.54523	6.08043	0.019
10R013B2R2	DP0912B2RF	3.0515	1.410446	0.2839	5.8191	0.0307
10R013B2R2	DP1048B2RF	3.04122	1.410446	0.27362	5.80883	0.0313
11R159B2R2	11R136B2R2	2.99284	1.410446	0.22524	5.76044	0.0341
06-46-153	08-1-1325	2.9543	1.410446	0.18669	5.7219	0.0364
DP1044B2RF	11R136B2R2	2.9433	1.410446	0.1757	5.7109	0.0371
10R011B2R2	DP0912B2RF	2.91098	1.410446	0.14338	5.67858	0.0393
10R011B2R2	DP1048B2RF	2.9007	1.410446	0.1331	5.6683	0.04
06-46-153	WS AVERAGE	2.89964	1.410446	0.13204	5.66724	0.04
10R013B2R2	10R052B2R2	2.67809	1.410446	-0.08952	5.44569	0.0579
10R052B2R2	11R136B2R2	2.66676	1.410446	-0.10084	5.43436	0.0589
10R011B2R2	10R052B2R2	2.53756	1.410446	-0.23004	5.30516	0.0723
10R013B2R2	DP1044B2RF	2.40155	1.410446	-0.36606	5.16915	0.0889
10R013B2R2	11R159B2R2	2.352	1.410446	-0.4156	5.11961	0.0957
DP1032B2RF	10R011B2R2	2.34489	1.410446	-0.42271	5.11249	0.0967
DP1048B2RF	11R136B2R2	2.30362	1.410446	-0.46398	5.07122	0.1027
DP0912B2RF	11R136B2R2	2.29334	1.410446	-0.47426	5.06094	0.1043
10R011B2R2	DP1044B2RF	2.26102	1.410446	-0.50658	5.02862	0.1092
10R011B2R2	11R159B2R2	2.21148	1.410446	-0.55612	4.97908	0.1172
DP1032B2RF	10R013B2R2	2.20437	1.410446	-0.56323	4.97197	0.1184
10R013B2R2	05-47-802	1.9716	1.410446	-0.796	4.7392	0.1625
10R013B2R2	04-22-405	1.95101	1.410446	-0.81659	4.71861	0.1669
WS AVERAGE	DP0912B2RF	1.94304	1.410446	-0.82456	4.71064	0.1686
WS AVERAGE	DP1048B2RF	1.93276	1.410446	-0.83484	4.70037	0.1709
06-46-153	10R011B2R2	1.93171	1.410446	-0.83589	4.69931	0.1711
08-1-1325	DP0912B2RF	1.88839	1.410446	-0.87921	4.65599	0.1809
08-1-1325	DP1048B2RF	1.87811	1.410446	-0.88949	4.64571	0.1833
10R011B2R2	05-47-802	1.83107	1.410446	-0.93653	4.59868	0.1945
10R011B2R2	04-22-405	1.81049	1.410446	-0.95711	4.57809	0.1996
06-46-153	10R013B2R2	1.79118	1.410446	-0.97642	4.55878	0.2044
10R013B2R2	DP0935B2RF	1.6737	1.410446	-1.0939	4.4413	0.2356
10R013B2R2	CS-50	1.66436	1.410446	-1.10324	4.43197	0.2383
WS AVERAGE	10R052B2R2	1.56963	1.410446	-1.19798	4.33723	0.266
10R011B2R2	DP0935B2RF	1.53317	1.410446	-1.23443	4.30077	0.2773
10R011B2R2	CS-50	1.52384	1.410446	-1.24376	4.29144	0.2802
08-1-1325	10R052B2R2	1.51497	1.410446	-1.25263	4.28257	0.283
CS-50	DP0912B2RF	1.38714	1.410446	-1.38046	4.15474	0.3256
DP0935B2RF	DP0912B2RF	1.3778	1.410446	-1.3898	4.14541	0.3289
CS-50	DP1048B2RF	1.37686	1.410446	-1.39074	4.14446	0.3292

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP0935B2RF	DP1048B2RF	1.36752	1.410446	-1.40008	4.13513	0.3325
WS AVERAGE	DP1044B2RF	1.29308	1.410446	-1.47452	4.06069	0.3595
WS AVERAGE	11R159B2R2	1.24354	1.410446	-1.52406	4.01115	0.3782
08-1-1325	DP1044B2RF	1.23843	1.410446	-1.52917	4.00603	0.3801
08-1-1325	11R159B2R2	1.18889	1.410446	-1.57871	3.95649	0.3995
10R013B2R2	08-1-1325	1.16312	1.410446	-1.60449	3.93072	0.4098
10R013B2R2	WS AVERAGE	1.10846	1.410446	-1.65914	3.87606	0.4321
04-22-405	DP0912B2RF	1.10049	1.410446	-1.66711	3.86809	0.4354
04-22-405	DP1048B2RF	1.09021	1.410446	-1.67739	3.85781	0.4397
05-47-802	DP0912B2RF	1.0799	1.410446	-1.6877	3.8475	0.4441
05-47-802	DP1048B2RF	1.06962	1.410446	-1.69798	3.83722	0.4484
10R011B2R2	08-1-1325	1.02259	1.410446	-1.74501	3.79019	0.4686
CS-50	10R052B2R2	1.01372	1.410446	-1.75388	3.78132	0.4725
DP0935B2RF	10R052B2R2	1.00439	1.410446	-1.76321	3.77199	0.4766
10R011B2R2	WS AVERAGE	0.96793	1.410446	-1.79967	3.73553	0.4927
WS AVERAGE	05-47-802	0.86314	1.410446	-1.90446	3.63074	0.5407
WS AVERAGE	04-22-405	0.84255	1.410446	-1.92505	3.61015	0.5504
08-1-1325	05-47-802	0.80849	1.410446	-1.95912	3.57609	0.5666
08-1-1325	04-22-405	0.7879	1.410446	-1.9797	3.5555	0.5765
CS-50	DP1044B2RF	0.73718	1.410446	-2.03042	3.50478	0.6013
DP0935B2RF	DP1044B2RF	0.72785	1.410446	-2.03976	3.49545	0.6059
04-22-405	10R052B2R2	0.72707	1.410446	-2.04053	3.49467	0.6063
05-47-802	10R052B2R2	0.70649	1.410446	-2.06112	3.47409	0.6165
11R159B2R2	DP0912B2RF	0.6995	1.410446	-2.0681	3.4671	0.62
11R159B2R2	DP1048B2RF	0.68922	1.410446	-2.07838	3.45682	0.6252
CS-50	11R159B2R2	0.68764	1.410446	-2.07996	3.45524	0.626
DP0935B2RF	11R159B2R2	0.6783	1.410446	-2.0893	3.44591	0.6307
DP1044B2RF	DP0912B2RF	0.64996	1.410446	-2.11764	3.41756	0.645
DP1044B2RF	DP1048B2RF	0.63968	1.410446	-2.12792	3.40728	0.6503
WS AVERAGE	DP0935B2RF	0.56524	1.410446	-2.20236	3.33284	0.6887
WS AVERAGE	CS-50	0.5559	1.410446	-2.2117	3.32351	0.6936
08-1-1325	DP0935B2RF	0.51058	1.410446	-2.25702	3.27818	0.7174
08-1-1325	CS-50	0.50125	1.410446	-2.26635	3.26885	0.7224
04-22-405	DP1044B2RF	0.45053	1.410446	-2.31707	3.21813	0.7495
05-47-802	DP1044B2RF	0.42994	1.410446	-2.33766	3.19755	0.7606
DP1032B2RF	06-46-153	0.41319	1.410446	-2.35441	3.18079	0.7696
04-22-405	11R159B2R2	0.40099	1.410446	-2.36661	3.16859	0.7762
05-47-802	11R159B2R2	0.3804	1.410446	-2.3872	3.148	0.7874
10R052B2R2	DP0912B2RF	0.37342	1.410446	-2.39418	3.14102	0.7913
10R052B2R2	DP1048B2RF	0.36314	1.410446	-2.40446	3.13074	0.7969
11R159B2R2	10R052B2R2	0.32608	1.410446	-2.44152	3.09368	0.8172
CS-50	05-47-802	0.30724	1.410446	-2.46036	3.07484	0.8276
DP0935B2RF	05-47-802	0.2979	1.410446	-2.4697	3.0655	0.8328
CS-50	04-22-405	0.28665	1.410446	-2.48095	3.05425	0.839
DP0935B2RF	04-22-405	0.27731	1.410446	-2.49029	3.04492	0.8442
DP1044B2RF	10R052B2R2	0.27654	1.410446	-2.49106	3.04414	0.8446

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
10R013B2R2	10R011B2R2	0.14053	1.410446	-2.62707	2.90813	0.9207
WS AVERAGE	08-1-1325	0.05466	1.410446	-2.71295	2.82226	0.9691
11R159B2R2	DP1044B2RF	0.04954	1.410446	-2.71806	2.81714	0.972
04-22-405	05-47-802	0.02059	1.410446	-2.74701	2.78819	0.9884
DP1048B2RF	DP0912B2RF	0.01028	1.410446	-2.75732	2.77788	0.9942
CS-50	DP0935B2RF	0.00934	1.410446	-2.75827	2.77694	0.9947

Difference = (Genotype – Genotype). Std Err Dif = Standard Error of Difference, Lower CL = Lower Confidence Level, Upper CL = Upper Confidence Level, p=Value – Probability Value

APPENDIX III.A

2011 - MAXIMUM MAIN-STEM LEAF AREA (CM^2) MEANS COMPARISONS BETWEEN COTTON GENOTYPES GROWN UNDER WATER STRESS

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
L23	10R013B2R2	7413.498	273.5234	6871.55	7955.45	<.0001
L23	CS 50	7373.58	273.5234	6831.63	7915.531	<.0001
L23	DP0912B2RF	7372.296	273.5234	6830.34	7914.247	<.0001
L23	DP1032B2RF	7339.687	273.5234	6797.74	7881.638	<.0001
L23	06-46-153	7312.551	273.5234	6770.6	7854.502	<.0001
L23	DP1044B2RF	7163.453	273.5234	6621.5	7705.405	<.0001
L23	11R159B2R2	7116.067	273.5234	6574.12	7658.019	<.0001
L23	08-1-1325	6834.659	273.5234	6292.71	7376.61	<.0001
L23	10R011B2R2	6827.551	273.5234	6285.6	7369.503	<.0001
L23	04-22-405	6738.181	273.5234	6196.23	7280.133	<.0001
L23	05-47-802	6711.07	273.5234	6169.12	7253.021	<.0001
L23	DP0935B2RF	6639.207	273.5234	6097.26	7181.158	<.0001
L23	10R052B2R2	6581.571	273.5234	6039.62	7123.522	<.0001
L23	DP1048B2RF	6546.636	273.5234	6004.68	7088.588	<.0001
L23	11R136B2R2	6391.455	273.5234	5849.5	6933.406	<.0001
11R136B2R2	10R013B2R2	1022.043	273.5234	480.09	1563.995	0.0003
11R136B2R2	CS 50	982.125	273.5234	440.17	1524.077	0.0005
11R136B2R2	DP0912B2RF	980.841	273.5234	438.89	1522.793	0.0005
11R136B2R2	DP1032B2RF	948.232	273.5234	406.28	1490.184	0.0007
11R136B2R2	06-46-153	921.096	273.5234	379.14	1463.047	0.001
DP1048B2RF	10R013B2R2	866.862	273.5234	324.91	1408.813	0.002
10R052B2R2	10R013B2R2	831.927	273.5234	289.98	1373.879	0.0029
DP1048B2RF	CS 50	826.943	273.5234	284.99	1368.895	0.0031
DP1048B2RF	DP0912B2RF	825.659	273.5234	283.71	1367.611	0.0031
DP1048B2RF	DP1032B2RF	793.05	273.5234	251.1	1335.002	0.0045
10R052B2R2	CS 50	792.009	273.5234	250.06	1333.961	0.0046
10R052B2R2	DP0912B2RF	790.725	273.5234	248.77	1332.677	0.0046
DP0935B2RF	10R013B2R2	774.291	273.5234	232.34	1316.243	0.0055
11R136B2R2	DP1044B2RF	771.999	273.5234	230.05	1313.95	0.0056
DP1048B2RF	06-46-153	765.914	273.5234	223.96	1307.866	0.006
10R052B2R2	DP1032B2RF	758.116	273.5234	216.16	1300.068	0.0065
DP0935B2RF	CS 50	734.373	273.5234	192.42	1276.324	0.0084
DP0935B2RF	DP0912B2RF	733.089	273.5234	191.14	1275.041	0.0085
10R052B2R2	06-46-153	730.98	273.5234	189.03	1272.931	0.0087

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
11R136B2R2	11R159B2R2	724.612	273.5234	182.66	1266.564	0.0092
05-47-802	10R013B2R2	702.428	273.5234	160.48	1244.38	0.0115
DP0935B2RF	DP1032B2RF	700.48	273.5234	158.53	1242.432	0.0118
04-22-405	10R013B2R2	675.317	273.5234	133.37	1217.269	0.0151
DP0935B2RF	06-46-153	673.344	273.5234	131.39	1215.295	0.0154
05-47-802	CS 50	662.51	273.5234	120.56	1204.462	0.017
05-47-802	DP0912B2RF	661.226	273.5234	119.27	1203.178	0.0172
04-22-405	CS 50	635.399	273.5234	93.45	1177.35	0.022
04-22-405	DP0912B2RF	634.115	273.5234	92.16	1176.066	0.0222
05-47-802	DP1032B2RF	628.617	273.5234	86.67	1170.569	0.0234
DP1048B2RF	DP1044B2RF	616.817	273.5234	74.87	1158.768	0.0261
04-22-405	DP1032B2RF	601.506	273.5234	59.55	1143.457	0.0299
05-47-802	06-46-153	601.481	273.5234	59.53	1143.432	0.0299
10R011B2R2	10R013B2R2	585.947	273.5234	44	1127.899	0.0343
10R052B2R2	DP1044B2RF	581.883	273.5234	39.93	1123.834	0.0356
08-1-1325	10R013B2R2	578.84	273.5234	36.89	1120.791	0.0365
04-22-405	06-46-153	574.37	273.5234	32.42	1116.321	0.038
DP1048B2RF	11R159B2R2	569.43	273.5234	27.48	1111.382	0.0396
10R011B2R2	CS 50	546.029	273.5234	4.08	1087.98	0.0483
10R011B2R2	DP0912B2RF	544.745	273.5234	2.79	1086.696	0.0489
08-1-1325	CS 50	538.921	273.5234	-3.03	1080.873	0.0513
08-1-1325	DP0912B2RF	537.637	273.5234	-4.31	1079.589	0.0518
10R052B2R2	11R159B2R2	534.496	273.5234	-7.46	1076.448	0.0532
DP0935B2RF	DP1044B2RF	524.246	273.5234	-17.71	1066.198	0.0578
10R011B2R2	DP1032B2RF	512.136	273.5234	-29.82	1054.087	0.0638
08-1-1325	DP1032B2RF	505.028	273.5234	-36.92	1046.98	0.0675
10R011B2R2	06-46-153	484.999	273.5234	-56.95	1026.951	0.0789
08-1-1325	06-46-153	477.892	273.5234	-64.06	1019.844	0.0833
DP0935B2RF	11R159B2R2	476.86	273.5234	-65.09	1018.812	0.084
05-47-802	DP1044B2RF	452.384	273.5234	-89.57	994.335	0.1009
11R136B2R2	08-1-1325	443.204	273.5234	-98.75	985.155	0.108
11R136B2R2	10R011B2R2	436.096	273.5234	-105.86	978.048	0.1137
04-22-405	DP1044B2RF	425.272	273.5234	-116.68	967.224	0.1228
05-47-802	11R159B2R2	404.997	273.5234	-136.95	946.949	0.1415
04-22-405	11R159B2R2	377.886	273.5234	-164.07	919.838	0.1699
11R136B2R2	04-22-405	346.726	273.5234	-195.23	888.678	0.2076
10R011B2R2	DP1044B2RF	335.902	273.5234	-206.05	877.854	0.222
08-1-1325	DP1044B2RF	328.795	273.5234	-213.16	870.746	0.2319
11R136B2R2	05-47-802	319.615	273.5234	-222.34	861.567	0.2451
11R159B2R2	10R013B2R2	297.431	273.5234	-244.52	839.383	0.2792
10R011B2R2	11R159B2R2	288.516	273.5234	-253.44	830.467	0.2938
DP1048B2RF	08-1-1325	288.022	273.5234	-253.93	829.974	0.2946

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
08-1-1325	11R159B2R2	281.408	273.5234	-260.54	823.36	0.3058
DP1048B2RF	10R011B2R2	280.915	273.5234	-261.04	822.866	0.3066
11R159B2R2	CS 50	257.513	273.5234	-284.44	799.464	0.3485
11R159B2R2	DP0912B2RF	256.229	273.5234	-285.72	798.18	0.3509
10R052B2R2	08-1-1325	253.088	273.5234	-288.86	795.039	0.3568
DP1044B2RF	10R013B2R2	250.045	273.5234	-291.91	791.996	0.3626
11R136B2R2	DP0935B2RF	247.752	273.5234	-294.2	789.704	0.367
10R052B2R2	10R011B2R2	245.98	273.5234	-295.97	787.932	0.3704
11R159B2R2	DP1032B2RF	223.62	273.5234	-318.33	765.571	0.4153
DP1044B2RF	CS 50	210.126	273.5234	-331.83	752.078	0.444
DP1044B2RF	DP0912B2RF	208.843	273.5234	-333.11	750.794	0.4468
11R159B2R2	06-46-153	196.484	273.5234	-345.47	738.435	0.474
DP0935B2RF	08-1-1325	195.452	273.5234	-346.5	737.403	0.4764
DP1048B2RF	04-22-405	191.545	273.5234	-350.41	733.496	0.4852
11R136B2R2	10R052B2R2	190.116	273.5234	-351.84	732.068	0.4885
DP0935B2RF	10R011B2R2	188.344	273.5234	-353.61	730.296	0.4925
DP1044B2RF	DP1032B2RF	176.234	273.5234	-365.72	718.185	0.5207
DP1048B2RF	05-47-802	164.433	273.5234	-377.52	706.385	0.5489
10R052B2R2	04-22-405	156.61	273.5234	-385.34	698.562	0.5681
11R136B2R2	DP1048B2RF	155.182	273.5234	-386.77	697.133	0.5716
DP1044B2RF	06-46-153	149.097	273.5234	-392.85	691.049	0.5868
10R052B2R2	05-47-802	129.499	273.5234	-412.45	671.451	0.6368
05-47-802	08-1-1325	123.589	273.5234	-418.36	665.54	0.6523
05-47-802	10R011B2R2	116.481	273.5234	-425.47	658.433	0.671
06-46-153	10R013B2R2	100.948	273.5234	-441	642.899	0.7128
DP0935B2RF	04-22-405	98.974	273.5234	-442.98	640.926	0.7181
04-22-405	08-1-1325	96.478	273.5234	-445.47	638.429	0.725
DP1048B2RF	DP0935B2RF	92.57	273.5234	-449.38	634.522	0.7357
04-22-405	10R011B2R2	89.37	273.5234	-452.58	631.322	0.7445
DP1032B2RF	10R013B2R2	73.811	273.5234	-468.14	615.763	0.7878
DP0935B2RF	05-47-802	71.863	273.5234	-470.09	613.814	0.7932
06-46-153	CS 50	61.029	273.5234	-480.92	602.981	0.8238
06-46-153	DP0912B2RF	59.745	273.5234	-482.21	601.697	0.8275
10R052B2R2	DP0935B2RF	57.636	273.5234	-484.32	599.588	0.8335
11R159B2R2	DP1044B2RF	47.386	273.5234	-494.57	589.338	0.8628
DP0912B2RF	10R013B2R2	41.202	273.5234	-500.75	583.154	0.8805
CS 50	10R013B2R2	39.918	273.5234	-502.03	581.87	0.8842
DP1048B2RF	10R052B2R2	34.934	273.5234	-507.02	576.886	0.8986
DP1032B2RF	CS 50	33.893	273.5234	-508.06	575.844	0.9016
DP1032B2RF	DP0912B2RF	32.609	273.5234	-509.34	574.56	0.9053
06-46-153	DP1032B2RF	27.136	273.5234	-514.82	569.088	0.9211
05-47-802	04-22-405	27.111	273.5234	-514.84	569.063	0.9212

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
10R011B2R2	08-1-1325	7.107	273.5234	-534.84	549.059	0.9793
DP0912B2RF	CS 50	1.284	273.5234	-540.67	543.235	0.9963

Difference = (Genotype – Genotype). Std Err Dif = Standard Error of Difference, Lower CL = Lower Confidence Level, Upper CL = Upper Confidence Level, p=Value – Probability Value

APPENDIX IV.A

2010 AND 2011 – ABAXIAL STOMATAL DENSITY (MM^2) MEAN COMPARISONS BETWEEN GENOTYPES

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
11R136 B2R2	DP0935 B2RF	49.8136	7.5409	34.9635	64.6637	<.0001
11R136 B2R2	03-WZ-37	46.8826	7.8724	31.3798	62.3854	<.0001
11R136 B2R2	05-47-802	45.8349	7.5409	30.9848	60.6850	<.0001
11R136 B2R2	L-23	43.7212	7.5409	28.8711	58.5712	<.0001
11R136 B2R2	02-WK-11L	43.2788	7.5409	28.4287	58.1288	<.0001
11R136 B2R2	DP1048 B2RF	42.4359	7.5409	27.5858	57.2860	<.0001
11R136 B2R2	CS-50	41.8628	7.5409	27.0127	56.7129	<.0001
11R136 B2R2	06-46-153	41.8169	7.5409	26.9668	56.6670	<.0001
11R136 B2R2	DP0141 B2RF	41.7586	7.5409	26.9085	56.6086	<.0001
11R136 B2R2	08-1-1325	41.4710	7.2648	27.1645	55.7774	<.0001
11R159 B2R2	DP0935 B2RF	41.4474	7.4966	26.6846	56.2102	<.0001
11R136 B2R2	DP0912 B2RF	40.9914	7.5409	26.1414	55.8415	<.0001
11R136 B2R2	DP0949 B2RF	40.8894	7.5409	26.0393	55.7395	<.0001
10R013 B2R2	DP0935 B2RF	39.5912	7.6412	24.5436	54.6389	<.0001
11R136 B2R2	DP1028 B2RF	39.4063	7.8724	23.9035	54.9092	<.0001
11R159 B2R2	03-WZ-37	38.5164	7.8299	23.0972	53.9357	<.0001
11R136 B2R2	TAM B-182-33	38.5155	7.0309	24.6697	52.3613	<.0001
11R136 B2R2	DP1044 B2RF	37.9943	10.3901	17.5333	58.4553	0.0003
11R159 B2R2	05-47-802	37.4687	7.4966	22.7059	52.2315	<.0001
10R013 B2R2	03-WZ-37	36.6602	7.9685	20.9681	52.3524	<.0001
10R013 B2R2	05-47-802	35.6125	7.6412	20.5649	50.6602	<.0001
11R159 B2R2	L-23	35.3550	7.4966	20.5922	50.1178	<.0001
11R159 B2R2	02-WK-11L	34.9126	7.4966	20.1498	49.6754	<.0001
11R159 B2R2	DP1048 B2RF	34.0697	7.4966	19.3069	48.8325	<.0001
10R013 B2R2	L-23	33.4988	7.6412	18.4511	48.5464	<.0001
11R159 B2R2	CS-50	33.4966	7.4966	18.7338	48.2594	<.0001
11R136 B2R2	04-22-405	33.4887	7.8724	17.9859	48.9916	<.0001
11R159 B2R2	06-46-153	33.4507	7.4966	18.6879	48.2135	<.0001
11R159 B2R2	DP0141 B2RF	33.3924	7.4966	18.6296	48.1552	<.0001
11R159 B2R2	08-1-1325	33.1048	7.2188	18.8889	47.3206	<.0001
10R013 B2R2	02-WK-11L	33.0564	7.6412	18.0087	48.1040	<.0001
11R159 B2R2	DP0912 B2RF	32.6253	7.4966	17.8624	47.3881	<.0001
11R159 B2R2	DP0949 B2RF	32.5232	7.4966	17.7604	47.2860	<.0001
10R013 B2R2	DP1048 B2RF	32.2135	7.6412	17.1659	47.2612	<.0001
10R011 B2R2	DP0935 B2RF	31.6678	7.5889	16.7231	46.6125	<.0001

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
10R013 B2R2	CS-50	31.6404	7.6412	16.5928	46.6881	<.0001
10R013 B2R2	06-46-153	31.5945	7.6412	16.5469	46.6422	<.0001
10R013 B2R2	DP0141 B2RF	31.5362	7.6412	16.4885	46.5838	<.0001
DP1032 B2RF	DP0935 B2RF	31.2753	7.4175	16.6682	45.8824	<.0001
10R013 B2R2	08-1-1325	31.2486	7.3689	16.7372	45.7600	<.0001
11R159 B2R2	DP1028 B2RF	31.0402	7.8299	15.6209	46.4594	<.0001
10R013 B2R2	DP0912 B2RF	30.7691	7.6412	15.7214	45.8167	<.0001
10R013 B2R2	DP0949 B2RF	30.6670	7.6412	15.6194	45.7147	<.0001
11R159 B2R2	TAM B-182-33	30.1493	6.9834	16.3971	43.9014	<.0001
11R159 B2R2	DP1044 B2RF	29.6281	10.3580	9.2303	50.0258	0.0046
10R013 B2R2	DP1028 B2RF	29.1840	7.9685	13.4918	44.8761	0.0003
10R011 B2R2	03-WZ-37	28.7368	7.9184	13.1433	44.3303	0.0003
DP1032 B2RF	03-WZ-37	28.3443	7.7543	13.0740	43.6146	0.0003
10R013 B2R2	TAM B-182-33	28.2931	7.1384	14.2356	42.3506	<.0001
10R013 B2R2	DP1044 B2RF	27.7719	10.4632	7.1671	48.3767	0.0084
10R011 B2R2	05-47-802	27.6891	7.5889	12.7443	42.6337	0.0003
DP1032 B2RF	05-47-802	27.2966	7.4175	12.6894	41.9037	0.0003
11R136 B2R2	10R052 B2R2	26.0274	5.6557	14.8898	37.1649	<.0001
10R011 B2R2	L-23	25.5753	7.5889	10.6306	40.5200	0.0009
DP1032 B2RF	L-23	25.1828	7.4175	10.5757	39.7900	0.0008
10R011 B2R2	02-WK-11L	25.1329	7.5889	10.1882	40.0776	0.0011
11R159 B2R2	04-22-405	25.1225	7.8299	9.7033	40.5418	0.0015
DP1032 B2RF	02-WK-11L	24.7404	7.4175	10.1333	39.3476	0.001
10R011 B2R2	DP1048 B2RF	24.2900	7.5889	9.3453	39.2347	0.0015
DP1032 B2RF	DP1048 B2RF	23.8976	7.4175	9.2904	38.5047	0.0014
10R052 B2R2	DP0935 B2RF	23.7863	7.5409	8.9362	38.6363	0.0018
10R011 B2R2	CS-50	23.7170	7.5889	8.7723	38.6617	0.002
10R011 B2R2	06-46-153	23.6711	7.5889	8.7264	38.6158	0.002
10R011 B2R2	DP0141 B2RF	23.6127	7.5889	8.6680	38.5574	0.0021
10R011 B2R2	08-1-1325	23.3251	7.3147	8.9205	37.7298	0.0016
DP1032 B2RF	CS-50	23.3245	7.4175	8.7173	37.9316	0.0019
DP1032 B2RF	06-46-153	23.2786	7.4175	8.6714	37.8857	0.0019
10R013 B2R2	04-22-405	23.2664	7.9685	7.5742	38.9585	0.0038
DP1032 B2RF	DP0141 B2RF	23.2202	7.4175	8.6131	37.8274	0.0019
DP1032 B2RF	08-1-1325	22.9326	7.1367	8.8785	36.9868	0.0015
10R011 B2R2	DP0912 B2RF	22.8456	7.5889	7.9009	37.7903	0.0029
10R011 B2R2	DP0949 B2RF	22.7436	7.5889	7.7989	37.6883	0.003
DP1032 B2RF	DP0912 B2RF	22.4531	7.4175	7.8460	37.0603	0.0027
DP1032 B2RF	DP0949 B2RF	22.3511	7.4175	7.7439	36.9582	0.0028
10R011 B2R2	DP1028 B2RF	21.2605	7.9184	5.6670	36.8540	0.0077
DP1032 B2RF	DP1028 B2RF	20.8680	7.7543	5.5977	36.1383	0.0076
10R052 B2R2	03-WZ-37	20.8553	7.8724	5.3524	36.3581	0.0086

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
10R011 B2R2	TAM B-182-33	20.3696	7.0824	6.4224	34.3169	0.0044
DP1032 B2RF	TAM B-182-33	19.9771	6.8984	6.3922	33.5621	0.0041
10R011 B2R2	DP1044 B2RF	19.8484	10.4251	-0.6813	40.3782	0.058
10R052 B2R2	05-47-802	19.8075	7.5409	4.9574	34.6576	0.0091
DP1032 B2RF	DP1044 B2RF	19.4560	10.3009	-0.8294	39.7413	0.0601
11R136 B2R2	DP1032 B2RF	18.5383	5.4901	7.7268	29.3498	0.0008
11R136 B2R2	10R011 B2R2	18.1458	5.7196	6.8824	29.4092	0.0017
10R052 B2R2	L-23	17.6938	7.5409	2.8437	32.5439	0.0197
11R159 B2R2	10R052 B2R2	17.6612	5.5964	6.6402	28.6821	0.0018
10R052 B2R2	02-WK-11L	17.2514	7.5409	2.4013	32.1015	0.023
10R052 B2R2	DP1048 B2RF	16.4085	7.5409	1.5584	31.2586	0.0305
04-22-405	DP0935 B2RF	16.3249	9.3195	-2.0277	34.6775	0.081
10R052 B2R2	CS-50	15.8354	7.5409	0.9854	30.6855	0.0367
10R013 B2R2	10R052 B2R2	15.8050	5.7888	4.4053	27.2046	0.0068
10R052 B2R2	06-46-153	15.7895	7.5409	0.9395	30.6396	0.0373
10R052 B2R2	DP0141 B2RF	15.7312	7.5409	0.8811	30.5813	0.038
10R052 B2R2	08-1-1325	15.4436	7.2648	1.1371	29.7500	0.0345
10R011 B2R2	04-22-405	15.3429	7.9184	-0.2506	30.9364	0.0538
10R052 B2R2	DP0912 B2RF	14.9641	7.5409	0.1140	29.8142	0.0483
DP1032 B2RF	04-22-405	14.9504	7.7543	-0.3199	30.2207	0.055
10R052 B2R2	DP0949 B2RF	14.8620	7.5409	0.0120	29.7121	0.0498
04-22-405	03-WZ-37	13.3939	9.5897	-5.4908	32.2785	0.1637
10R052 B2R2	DP1028 B2RF	13.3790	7.8724	-2.1239	28.8818	0.0904
10R052 B2R2	TAM B-182-33	12.4881	7.0309	-1.3577	26.3339	0.0769
04-22-405	05-47-802	12.3462	9.3195	-6.0064	30.6987	0.1864
10R052 B2R2	DP1044 B2RF	11.9669	10.3901	-8.4941	32.4279	0.2505
DP1044 B2RF	DP0935 B2RF	11.8194	11.5253	-10.8772	34.5159	0.3061
TAM B-182-33	DP0935 B2RF	11.2982	8.6205	-5.6779	28.2742	0.1912
DP1028 B2RF	DP0935 B2RF	10.4073	9.3195	-7.9453	28.7599	0.2652
04-22-405	L-23	10.2324	9.3195	-8.1201	28.5850	0.2733
11R136 B2R2	10R013 B2R2	10.2224	5.7888	-1.1773	21.6220	0.0786
11R159 B2R2	DP1032 B2RF	10.1721	5.4291	-0.5192	20.8635	0.0621
04-22-405	02-WK-11L	9.7900	9.3195	-8.5626	28.1426	0.2945
11R159 B2R2	10R011 B2R2	9.7797	5.6610	-1.3684	20.9278	0.0853
04-22-405	DP1048 B2RF	8.9472	9.3195	-9.4054	27.2997	0.3379
DP0949 B2RF	DP0935 B2RF	8.9242	9.0412	-8.8804	26.7288	0.3245
DP1044 B2RF	03-WZ-37	8.8883	11.7449	-14.2405	32.0172	0.4499
DP0912 B2RF	DP0935 B2RF	8.8222	9.0412	-8.9824	26.6268	0.3301
04-22-405	CS-50	8.3741	9.3195	-9.9785	26.7267	0.3697
TAM B-182-33	03-WZ-37	8.3672	8.9119	-9.1827	25.9170	0.3487
11R136 B2R2	11R159 B2R2	8.3662	5.5964	-2.6547	19.3871	0.1362
08-1-1325	DP0935 B2RF	8.3427	8.8123	-9.0111	25.6965	0.3447

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
04-22-405	06-46-153	8.3282	9.3195	-10.0244	26.6807	0.3724
10R013 B2R2	DP1032 B2RF	8.3160	5.6271	-2.7654	19.3973	0.1407
04-22-405	DP0141 B2RF	8.2698	9.3195	-10.0828	26.6224	0.3757
DP0141 B2RF	DP0935 B2RF	8.0551	9.0412	-9.7495	25.8597	0.3738
06-46-153	DP0935 B2RF	7.9967	9.0412	-9.8079	25.8013	0.3773
04-22-405	08-1-1325	7.9822	9.0975	-9.9333	25.8978	0.3811
CS-50	DP0935 B2RF	7.9508	9.0412	-9.8538	25.7554	0.38
10R013 B2R2	10R011 B2R2	7.9235	5.8512	-3.5992	19.4461	0.1769
10R011 B2R2	10R052 B2R2	7.8815	5.7196	-3.3819	19.1449	0.1694
DP1044 B2RF	05-47-802	7.8406	11.5253	-14.8559	30.5371	0.4969
04-22-405	DP0912 B2RF	7.5027	9.3195	-10.8499	25.8553	0.4215
DP1032 B2RF	10R052 B2R2	7.4890	5.4901	-3.3225	18.3006	0.1737
DP1028 B2RF	03-WZ-37	7.4763	9.5897	-11.4084	26.3609	0.4363
10R052 B2R2	04-22-405	7.4614	7.8724	-8.0415	22.9642	0.3441
04-22-405	DP0949 B2RF	7.4007	9.3195	-10.9519	25.7532	0.4279
DP1048 B2RF	DP0935 B2RF	7.3777	9.0412	-10.4269	25.1824	0.4153
TAM B-182-33	05-47-802	7.3194	8.6205	-9.6566	24.2955	0.3966
02-WK-11L	DP0935 B2RF	6.5349	9.0412	-11.2698	24.3395	0.4705
DP1028 B2RF	05-47-802	6.4286	9.3195	-11.9240	24.7811	0.4909
L-23	DP0935 B2RF	6.0925	9.0412	-11.7122	23.8971	0.501
DP0949 B2RF	03-WZ-37	5.9932	9.3195	-12.3594	24.3458	0.5207
04-22-405	DP1028 B2RF	5.9176	9.5897	-12.9670	24.8023	0.5377
DP0912 B2RF	03-WZ-37	5.8912	9.3195	-12.4614	24.2437	0.5279
DP1044 B2RF	L-23	5.7269	11.5253	-16.9696	28.4234	0.6197
08-1-1325	03-WZ-37	5.4117	9.0975	-12.5039	23.3272	0.5525
DP1044 B2RF	02-WK-11L	5.2845	11.5253	-17.4120	27.9810	0.647
TAM B-182-33	L-23	5.2057	8.6205	-11.7703	22.1817	0.5465
DP0141 B2RF	03-WZ-37	5.1241	9.3195	-13.2285	23.4766	0.5829
06-46-153	03-WZ-37	5.0657	9.3195	-13.2869	23.4183	0.5872
04-22-405	TAM B-182-33	5.0267	8.9119	-12.5232	22.5766	0.5732
CS-50	03-WZ-37	5.0198	9.3195	-13.3328	23.3724	0.5906
DP0949 B2RF	05-47-802	4.9455	9.0412	-12.8591	22.7501	0.5849
DP0912 B2RF	05-47-802	4.8434	9.0412	-12.9612	22.6481	0.5926
TAM B-182-33	02-WK-11L	4.7633	8.6205	-12.2127	21.7393	0.581
04-22-405	DP1044 B2RF	4.5055	11.7449	-18.6233	27.6344	0.7016
DP1048 B2RF	03-WZ-37	4.4467	9.3195	-13.9058	22.7993	0.6337
DP1044 B2RF	DP1048 B2RF	4.4416	11.5253	-18.2549	27.1381	0.7003
08-1-1325	05-47-802	4.3639	8.8123	-12.9899	21.7177	0.6209
DP1028 B2RF	L-23	4.3148	9.3195	-14.0377	22.6674	0.6438
DP0141 B2RF	05-47-802	4.0763	9.0412	-13.7283	21.8810	0.6525
06-46-153	05-47-802	4.0180	9.0412	-13.7866	21.8226	0.6571
05-47-802	DP0935 B2RF	3.9787	9.0412	-13.8259	21.7834	0.6603

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
CS-50	05-47-802	3.9721	9.0412	-13.8325	21.7767	0.6608
TAM B-182-33	DP1048 B2RF	3.9204	8.6205	-13.0556	20.8965	0.6497
DP1028 B2RF	02-WK-11L	3.8724	9.3195	-14.4802	22.2250	0.6781
DP1044 B2RF	CS-50	3.8685	11.5253	-18.8280	26.5651	0.7374
DP1044 B2RF	06-46-153	3.8226	11.5253	-18.8739	26.5192	0.7404
DP1044 B2RF	DP0141 B2RF	3.7643	11.5253	-18.9322	26.4608	0.7442
02-WK-11L	03-WZ-37	3.6039	9.3195	-14.7487	21.9564	0.6993
DP1044 B2RF	08-1-1325	3.4767	11.3466	-18.8679	25.8213	0.7595
DP1048 B2RF	05-47-802	3.3990	9.0412	-14.4056	21.2036	0.7073
TAM B-182-33	CS-50	3.3473	8.6205	-13.6287	20.3234	0.6981
TAM B-182-33	06-46-153	3.3014	8.6205	-13.6746	20.2775	0.7021
TAM B-182-33	DP0141 B2RF	3.2431	8.6205	-13.7329	20.2191	0.7071
L-23	03-WZ-37	3.1615	9.3195	-15.1911	21.5140	0.7347
DP1028 B2RF	DP1048 B2RF	3.0295	9.3195	-15.3230	21.3821	0.7454
DP1044 B2RF	DP0912 B2RF	2.9972	11.5253	-19.6993	25.6937	0.795
TAM B-182-33	08-1-1325	2.9555	8.3800	-13.5471	19.4581	0.7246
03-WZ-37	DP0935 B2RF	2.9310	9.3195	-15.4216	21.2836	0.7534
DP1044 B2RF	DP0949 B2RF	2.8951	11.5253	-19.8014	25.5916	0.8019
DP0949 B2RF	L-23	2.8318	9.0412	-14.9728	20.6364	0.7544
DP0912 B2RF	L-23	2.7297	9.0412	-15.0749	20.5343	0.763
02-WK-11L	05-47-802	2.5561	9.0412	-15.2485	20.3608	0.7776
TAM B-182-33	DP0912 B2RF	2.4760	8.6205	-14.5001	19.4520	0.7742
DP1028 B2RF	CS-50	2.4565	9.3195	-15.8961	20.8091	0.7923
DP1028 B2RF	06-46-153	2.4106	9.3195	-15.9420	20.7631	0.7961
DP0949 B2RF	02-WK-11L	2.3894	9.0412	-15.4153	20.1940	0.7918
TAM B-182-33	DP0949 B2RF	2.3739	8.6205	-14.6021	19.3500	0.7832
DP1028 B2RF	DP0141 B2RF	2.3522	9.3195	-16.0004	20.7048	0.8009
DP0912 B2RF	02-WK-11L	2.2873	9.0412	-15.5173	20.0919	0.8005
08-1-1325	L-23	2.2502	8.8123	-15.1036	19.6040	0.7987
L-23	05-47-802	2.1137	9.0412	-15.6909	19.9183	0.8153
DP1028 B2RF	08-1-1325	2.0646	9.0975	-15.8509	19.9802	0.8206
DP0141 B2RF	L-23	1.9626	9.0412	-15.8420	19.7672	0.8283
06-46-153	L-23	1.9043	9.0412	-15.9004	19.7089	0.8334
CS-50	L-23	1.8584	9.0412	-15.9463	19.6630	0.8373
11R159 B2R2	10R013 B2R2	1.8562	5.7309	-9.4295	13.1419	0.7463
08-1-1325	02-WK-11L	1.8078	8.8123	-15.5460	19.1616	0.8376
DP1028 B2RF	DP0912 B2RF	1.5851	9.3195	-16.7675	19.9377	0.8651
DP0949 B2RF	DP1048 B2RF	1.5465	9.0412	-16.2581	19.3511	0.8643
DP0141 B2RF	02-WK-11L	1.5202	9.0412	-16.2844	19.3248	0.8666
DP1028 B2RF	DP0949 B2RF	1.4831	9.3195	-16.8695	19.8356	0.8737
06-46-153	02-WK-11L	1.4619	9.0412	-16.3428	19.2665	0.8717
DP0912 B2RF	DP1048 B2RF	1.4444	9.0412	-16.3602	19.2491	0.8732

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
CS-50	02-WK-11L	1.4160	9.0412	-16.3887	19.2206	0.8757
DP1044 B2RF	DP1028 B2RF	1.4121	11.7449	-21.7168	24.5409	0.9044
DP1048 B2RF	L-23	1.2853	9.0412	-16.5193	19.0899	0.8871
05-47-802	03-WZ-37	1.0477	9.3195	-17.3049	19.4003	0.9106
DP0949 B2RF	CS-50	0.9734	9.0412	-16.8312	18.7780	0.9143
08-1-1325	DP1048 B2RF	0.9649	8.8123	-16.3889	18.3187	0.9129
DP0949 B2RF	06-46-153	0.9275	9.0412	-16.8771	18.7321	0.9184
TAM B-182-33	DP1028 B2RF	0.8909	8.9119	-16.6590	18.4408	0.9205
DP0912 B2RF	CS-50	0.8714	9.0412	-16.9333	18.6760	0.9233
DP0949 B2RF	DP0141 B2RF	0.8692	9.0412	-16.9355	18.6738	0.9235
DP1048 B2RF	02-WK-11L	0.8429	9.0412	-16.9617	18.6475	0.9258
DP0912 B2RF	06-46-153	0.8255	9.0412	-16.9792	18.6301	0.9273
DP0912 B2RF	DP0141 B2RF	0.7671	9.0412	-17.0375	18.5717	0.9325
DP0141 B2RF	DP1048 B2RF	0.6773	9.0412	-17.1273	18.4819	0.9403
06-46-153	DP1048 B2RF	0.6190	9.0412	-17.1856	18.4236	0.9455
DP0949 B2RF	08-1-1325	0.5816	8.8123	-16.7722	17.9354	0.9474
CS-50	DP1048 B2RF	0.5731	9.0412	-17.2315	18.3777	0.9495
DP1044 B2RF	TAM B-182-33	0.5212	11.1983	-21.5313	22.5737	0.9629
DP0912 B2RF	08-1-1325	0.4795	8.8123	-16.8743	17.8333	0.9566
02-WK-11L	L-23	0.4424	9.0412	-17.3622	18.2470	0.961
10R011 B2R2	DP1032 B2RF	0.3925	5.5559	-10.5486	11.3336	0.9437
08-1-1325	CS-50	0.3919	8.8123	-16.9619	17.7456	0.9646
08-1-1325	06-46-153	0.3459	8.8123	-17.0078	17.6997	0.9687
08-1-1325	DP0141 B2RF	0.2876	8.8123	-17.0662	17.6414	0.974
DP0141 B2RF	CS-50	0.1043	9.0412	-17.7004	17.9089	0.9908
DP0949 B2RF	DP0912 B2RF	0.1021	9.0412	-17.7026	17.9067	0.991
DP0141 B2RF	06-46-153	0.0584	9.0412	-17.7463	17.8630	0.9949
06-46-153	CS-50	0.0459	9.0412	-17.7587	17.8505	0.996

Difference = (Genotype – Genotype). Std Err Dif = Standard Error of Difference, Lower CL = Lower Confidence Level, Upper CL = Upper Confidence Level, p=Value – Probability Value

APPENDIX IV.B

2010 AND 2011 – ADAXIAL STOMATAL DENSITY (MM^2) MEANS

COMPARISONS BETWEEN GENOTYPES

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
10R011 B2R2	05-47-802	23.8073	3.2713	17.3547	30.2599	<.0001
11R159 B2R2	05-47-802	19.5240	3.2094	13.1935	25.8545	<.0001
10R011 B2R2	03-WZ-37	19.2665	3.2713	12.8139	25.7191	<.0001
10R011 B2R2	06-46-153	18.2511	3.2713	11.7985	24.7037	<.0001
10R011 B2R2	DP0935 B2RF	18.2184	3.2713	11.7657	24.6710	<.0001
10R011 B2R2	02-WK-11L	17.9386	3.2713	11.4860	24.3912	<.0001
DP1044 B2RF	05-47-802	17.7819	3.8360	10.2155	25.3482	<.0001
10R011 B2R2	10R013 B2R2	17.7784	3.0381	11.7858	23.7710	<.0001
10R011 B2R2	L-23	17.5751	3.2713	11.1225	24.0277	<.0001
10R011 B2R2	DP0949 B2RF	17.3758	3.2713	10.9232	23.8284	<.0001
DP1032 B2RF	05-47-802	17.0012	3.1561	10.7759	23.2264	<.0001
10R011 B2R2	CS-50	16.9264	3.2713	10.4738	23.3790	<.0001
11R159 B2R2	03-WZ-37	14.9832	3.2094	8.6527	21.3136	<.0001
10R011 B2R2	DP1048 B2RF	14.7198	3.2713	8.2672	21.1724	<.0001
11R136 B2R2	05-47-802	14.5694	3.1561	8.3442	20.7947	<.0001
10R011 B2R2	DP1028 B2RF	14.3297	3.3819	7.6589	21.0004	<.0001
11R159 B2R2	06-46-153	13.9678	3.2094	7.6374	20.2983	<.0001
11R159 B2R2	DP0935 B2RF	13.9350	3.2094	7.6046	20.2655	<.0001
10R011 B2R2	TAM B-182-33	13.7726	3.1035	7.6512	19.8941	<.0001
DP0141 B2RF	05-47-802	13.7223	3.4310	6.9547	20.4898	<.0001
11R159 B2R2	02-WK-11L	13.6553	3.2094	7.3248	19.9858	<.0001
11R159 B2R2	10R013 B2R2	13.4951	2.9713	7.6342	19.3560	<.0001
10R011 B2R2	04-22-405	13.3697	3.2713	6.9171	19.8223	<.0001
11R159 B2R2	L-23	13.2918	3.2094	6.9613	19.6222	<.0001
DP1044 B2RF	03-WZ-37	13.2410	3.8360	5.6747	20.8074	0.0007
11R159 B2R2	DP0949 B2RF	13.0925	3.2094	6.7621	19.4230	<.0001
08-1-1325	05-47-802	13.0569	3.6679	5.8221	20.2917	0.0005
10R011 B2R2	DP0912 B2RF	12.9895	3.2713	6.5369	19.4421	0.0001
11R159 B2R2	CS-50	12.6431	3.2094	6.3126	18.9735	0.0001
10R011 B2R2	10R052 B2R2	12.5171	3.0381	6.5245	18.5096	<.0001
DP1032 B2RF	03-WZ-37	12.4603	3.1561	6.2351	18.6856	0.0001
DP1044 B2RF	06-46-153	12.2257	3.8360	4.6593	19.7920	0.0017
DP1044 B2RF	DP0935 B2RF	12.1929	3.8360	4.6265	19.7592	0.0017
DP1044 B2RF	02-WK-11L	11.9132	3.8360	4.3468	19.4795	0.0022
DP1044 B2RF	10R013 B2R2	11.7529	3.6391	4.5749	18.9310	0.0015

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP1044 B2RF	L-23	11.5496	3.8360	3.9833	19.1160	0.003
DP1032 B2RF	06-46-153	11.4450	3.1561	5.2198	17.6702	0.0004
DP1032 B2RF	DP0935 B2RF	11.4122	3.1561	5.1870	17.6375	0.0004
DP1044 B2RF	DP0949 B2RF	11.3504	3.8360	3.7840	18.9167	0.0035
10R052 B2R2	05-47-802	11.2903	3.2094	4.9598	17.6207	0.0005
DP1032 B2RF	02-WK-11L	11.1325	3.1561	4.9072	17.3577	0.0005
DP1032 B2RF	10R013 B2R2	10.9723	2.9136	5.2252	16.7193	0.0002
DP1044 B2RF	CS-50	10.9009	3.8360	3.3346	18.4673	0.005
DP0912 B2RF	05-47-802	10.8178	3.4310	4.0503	17.5854	0.0019
DP1032 B2RF	L-23	10.7690	3.1561	4.5437	16.9942	0.0008
10R011 B2R2	08-1-1325	10.7505	3.5190	3.8093	17.6916	0.0026
DP1032 B2RF	DP0949 B2RF	10.5697	3.1561	4.3445	16.7949	0.001
04-22-405	05-47-802	10.4376	3.4310	3.6700	17.2051	0.0027
11R159 B2R2	DP1048 B2RF	10.4365	3.2094	4.1061	16.7670	0.0014
DP1032 B2RF	CS-50	10.1203	3.1561	3.8950	16.3455	0.0016
10R011 B2R2	DP0141 B2RF	10.0850	3.2713	3.6324	16.5376	0.0024
11R159 B2R2	DP1028 B2RF	10.0464	3.3221	3.4937	16.5990	0.0028
TAM B-182-33	05-47-802	10.0347	3.2713	3.5821	16.4873	0.0025
11R136 B2R2	03-WZ-37	10.0286	3.1561	3.8034	16.2538	0.0017
11R159 B2R2	TAM B-182-33	9.4893	3.0381	3.4967	15.4819	0.0021
DP1028 B2RF	05-47-802	9.4776	3.5366	2.5018	16.4535	0.008
10R011 B2R2	11R136 B2R2	9.2379	2.9817	3.3566	15.1192	0.0022
DP0141 B2RF	03-WZ-37	9.1815	3.4310	2.4139	15.9490	0.0081
DP1048 B2RF	05-47-802	9.0875	3.4310	2.3199	15.8550	0.0088
11R159 B2R2	04-22-405	9.0864	3.2094	2.7560	15.4169	0.0051
11R136 B2R2	06-46-153	9.0133	3.1561	2.7880	15.2385	0.0048
11R136 B2R2	DP0935 B2RF	8.9805	3.1561	2.7552	15.2057	0.0049
11R159 B2R2	DP0912 B2RF	8.7062	3.2094	2.3757	15.0366	0.0073
11R136 B2R2	02-WK-11L	8.7007	3.1561	2.4755	14.9260	0.0064
DP1044 B2RF	DP1048 B2RF	8.6944	3.8360	1.1280	16.2607	0.0245
11R136 B2R2	10R013 B2R2	8.5405	2.9136	2.7935	14.2876	0.0038
08-1-1325	03-WZ-37	8.5160	3.6679	1.2812	15.7508	0.0213
11R136 B2R2	L-23	8.3372	3.1561	2.1120	14.5625	0.0089
DP1044 B2RF	DP1028 B2RF	8.3042	3.9307	0.5510	16.0574	0.0359
11R159 B2R2	10R052 B2R2	8.2337	2.9713	2.3729	14.0946	0.0061
DP0141 B2RF	06-46-153	8.1661	3.4310	1.3986	14.9337	0.0183
11R136 B2R2	DP0949 B2RF	8.1380	3.1561	1.9127	14.3632	0.0107
DP0141 B2RF	DP0935 B2RF	8.1333	3.4310	1.3658	14.9009	0.0188
DP1032 B2RF	DP1048 B2RF	7.9137	3.1561	1.6885	14.1389	0.013
DP0141 B2RF	02-WK-11L	7.8536	3.4310	1.0861	14.6211	0.0232
DP1044 B2RF	TAM B-182-33	7.7472	3.6939	0.4612	15.0332	0.0373
DP0141 B2RF	10R013 B2R2	7.6934	3.2094	1.3629	14.0238	0.0175

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
11R136 B2R2	CS-50	7.6885	3.1561	1.4633	13.9138	0.0158
DP1032 B2RF	DP1028 B2RF	7.5235	3.2706	1.0725	13.9746	0.0225
08-1-1325	06-46-153	7.5007	3.6679	0.2659	14.7355	0.0422
DP0141 B2RF	L-23	7.4901	3.4310	0.7225	14.2576	0.0303
08-1-1325	DP0935 B2RF	7.4679	3.6679	0.2331	14.7027	0.0431
DP1044 B2RF	04-22-405	7.3443	3.8360	-0.2221	14.9106	0.057
DP0141 B2RF	DP0949 B2RF	7.2908	3.4310	0.5233	14.0584	0.0349
08-1-1325	02-WK-11L	7.1882	3.6679	-0.0466	14.4230	0.0515
08-1-1325	10R013 B2R2	7.0280	3.4615	0.2003	13.8557	0.0437
DP1032 B2RF	TAM B-182-33	6.9665	2.9817	1.0852	12.8478	0.0205
DP1044 B2RF	DP0912 B2RF	6.9640	3.8360	-0.6023	14.5304	0.071
CS-50	05-47-802	6.8809	3.4310	0.1134	13.6485	0.0463
DP0141 B2RF	CS-50	6.8414	3.4310	0.0738	13.6089	0.0476
08-1-1325	L-23	6.8247	3.6679	-0.4102	14.0595	0.0643
10R011 B2R2	DP1032 B2RF	6.8061	2.9817	0.9248	12.6875	0.0236
10R052 B2R2	03-WZ-37	6.7494	3.2094	0.4190	13.0799	0.0368
08-1-1325	DP0949 B2RF	6.6254	3.6679	-0.6094	13.8602	0.0724
DP1032 B2RF	04-22-405	6.5636	3.1561	0.3384	12.7888	0.0389
DP1044 B2RF	10R052 B2R2	6.4916	3.6391	-0.6865	13.6697	0.076
11R159 B2R2	08-1-1325	6.4671	3.4615	-0.3606	13.2948	0.0633
DP0949 B2RF	05-47-802	6.4315	3.4310	-0.3361	13.1990	0.0624
DP0912 B2RF	03-WZ-37	6.2770	3.4310	-0.4906	13.0445	0.0689
L-23	05-47-802	6.2322	3.4310	-0.5353	12.9998	0.0709
DP1032 B2RF	DP0912 B2RF	6.1834	3.1561	-0.0419	12.4086	0.0515
08-1-1325	CS-50	6.1760	3.6679	-1.0589	13.4108	0.0939
10R013 B2R2	05-47-802	6.0289	3.2094	-0.3015	12.3594	0.0618
10R011 B2R2	DP1044 B2RF	6.0255	3.6939	-1.2605	13.3115	0.1045
04-22-405	03-WZ-37	5.8967	3.4310	-0.8708	12.6643	0.0873
02-WK-11L	05-47-802	5.8687	3.4310	-0.8989	12.6362	0.0888
11R159 B2R2	DP0141 B2RF	5.8017	3.2094	-0.5288	12.1322	0.0722
10R052 B2R2	06-46-153	5.7341	3.2094	-0.5964	12.0646	0.0756
DP1032 B2RF	10R052 B2R2	5.7109	2.9136	-0.0361	11.4580	0.0514
10R052 B2R2	DP0935 B2RF	5.7013	3.2094	-0.6292	12.0318	0.0773
DP0935 B2RF	05-47-802	5.5890	3.4310	-1.1786	12.3565	0.105
06-46-153	05-47-802	5.5562	3.4310	-1.2114	12.3237	0.107
TAM B-182-33	03-WZ-37	5.4938	3.2713	-0.9588	11.9464	0.0947
11R136 B2R2	DP1048 B2RF	5.4820	3.1561	-0.7433	11.7072	0.084
10R052 B2R2	02-WK-11L	5.4216	3.2094	-0.9089	11.7520	0.0928
DP0912 B2RF	06-46-153	5.2617	3.4310	-1.5059	12.0292	0.1268
10R052 B2R2	10R013 B2R2	5.2614	2.9713	-0.5995	11.1222	0.0782
DP0912 B2RF	DP0935 B2RF	5.2289	3.4310	-1.5387	11.9964	0.1292
11R136 B2R2	DP1028 B2RF	5.0918	3.2706	-1.3593	11.5429	0.1212

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
10R052 B2R2	L-23	5.0581	3.2094	-1.2724	11.3885	0.1167
11R159 B2R2	11R136 B2R2	4.9546	2.9136	-0.7925	10.7016	0.0907
DP0912 B2RF	02-WK-11L	4.9491	3.4310	-1.8184	11.7167	0.1508
DP1028 B2RF	03-WZ-37	4.9368	3.5366	-2.0390	11.9126	0.1644
04-22-405	06-46-153	4.8814	3.4310	-1.8861	11.6490	0.1564
10R052 B2R2	DP0949 B2RF	4.8588	3.2094	-1.4717	11.1892	0.1317
04-22-405	DP0935 B2RF	4.8486	3.4310	-1.9189	11.6162	0.1592
DP0912 B2RF	10R013 B2R2	4.7889	3.2094	-1.5415	11.1194	0.1373
DP1044 B2RF	08-1-1325	4.7250	4.0493	-3.2620	12.7120	0.2447
DP0141 B2RF	DP1048 B2RF	4.6348	3.4310	-2.1327	11.4024	0.1783
DP0912 B2RF	L-23	4.5856	3.4310	-2.1819	11.3532	0.183
04-22-405	02-WK-11L	4.5689	3.4310	-2.1987	11.3364	0.1846
DP1048 B2RF	03-WZ-37	4.5466	3.4310	-2.2209	11.3142	0.1867
03-WZ-37	05-47-802	4.5408	3.4310	-2.2267	11.3084	0.1873
11R136 B2R2	TAM B-182-33	4.5348	2.9817	-1.3466	10.4161	0.1299
TAM B-182-33	06-46-153	4.4785	3.2713	-1.9741	10.9311	0.1726
TAM B-182-33	DP0935 B2RF	4.4457	3.2713	-2.0069	10.8983	0.1758
10R052 B2R2	CS-50	4.4093	3.2094	-1.9211	10.7398	0.1711
04-22-405	10R013 B2R2	4.4087	3.2094	-1.9218	10.7391	0.1712
DP0912 B2RF	DP0949 B2RF	4.3863	3.4310	-2.3812	11.1539	0.2026
10R011 B2R2	11R159 B2R2	4.2833	3.0381	-1.7093	10.2759	0.1602
DP0141 B2RF	DP1028 B2RF	4.2447	3.5366	-2.7312	11.2205	0.2315
04-22-405	L-23	4.2054	3.4310	-2.5622	10.9729	0.2218
TAM B-182-33	02-WK-11L	4.1660	3.2713	-2.2866	10.6186	0.2044
11R136 B2R2	04-22-405	4.1319	3.1561	-2.0934	10.3571	0.192
DP1044 B2RF	DP0141 B2RF	4.0596	3.8360	-3.5068	11.6259	0.2913
04-22-405	DP0949 B2RF	4.0061	3.4310	-2.7614	10.7736	0.2444
TAM B-182-33	10R013 B2R2	4.0058	3.0381	-1.9868	9.9984	0.1889
08-1-1325	DP1048 B2RF	3.9694	3.6679	-3.2654	11.2042	0.2805
DP1032 B2RF	08-1-1325	3.9443	3.4121	-2.7859	10.6746	0.2491
DP0912 B2RF	CS-50	3.9369	3.4310	-2.8306	10.7045	0.2526
DP1028 B2RF	06-46-153	3.9215	3.5366	-3.0544	10.8973	0.2689
DP1028 B2RF	DP0935 B2RF	3.8887	3.5366	-3.0871	10.8645	0.2729
TAM B-182-33	L-23	3.8025	3.2713	-2.6501	10.2551	0.2465
11R136 B2R2	DP0912 B2RF	3.7516	3.1561	-2.4736	9.9768	0.236
DP0141 B2RF	TAM B-182-33	3.6876	3.2713	-2.7650	10.1402	0.2611
DP1028 B2RF	02-WK-11L	3.6089	3.5366	-3.3669	10.5848	0.3088
TAM B-182-33	DP0949 B2RF	3.6032	3.2713	-2.8494	10.0558	0.2721
08-1-1325	DP1028 B2RF	3.5792	3.7669	-3.8508	11.0092	0.3432
04-22-405	CS-50	3.5567	3.4310	-3.2109	10.3242	0.3012
DP1048 B2RF	06-46-153	3.5313	3.4310	-3.2362	10.2989	0.3047
DP1048 B2RF	DP0935 B2RF	3.4985	3.4310	-3.2690	10.2661	0.3092

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP1028 B2RF	10R013 B2R2	3.4487	3.3221	-3.1039	10.0014	0.3005
DP0141 B2RF	04-22-405	3.2847	3.4310	-3.4828	10.0523	0.3396
11R136 B2R2	10R052 B2R2	3.2792	2.9136	-2.4679	9.0262	0.2618
DP1032 B2RF	DP0141 B2RF	3.2789	3.1561	-2.9464	9.5041	0.3002
DP1028 B2RF	L-23	3.2454	3.5366	-3.7304	10.2213	0.36
DP1048 B2RF	02-WK-11L	3.2188	3.4310	-3.5488	9.9863	0.3494
DP1044 B2RF	11R136 B2R2	3.2124	3.5922	-3.8730	10.2979	0.3723
TAM B-182-33	CS-50	3.1538	3.2713	-3.2988	9.6064	0.3362
DP1048 B2RF	10R013 B2R2	3.0586	3.2094	-3.2719	9.3890	0.3418
DP1028 B2RF	DP0949 B2RF	3.0462	3.5366	-3.9297	10.0220	0.3901
08-1-1325	TAM B-182-33	3.0222	3.5190	-3.9189	9.9633	0.3915
DP0141 B2RF	DP0912 B2RF	2.9045	3.4310	-3.8631	9.6720	0.3983
DP1048 B2RF	L-23	2.8553	3.4310	-3.9123	9.6228	0.4063
DP1048 B2RF	DP0949 B2RF	2.6560	3.4310	-4.1116	9.4235	0.4398
08-1-1325	04-22-405	2.6193	3.6679	-4.6155	9.8541	0.476
DP1028 B2RF	CS-50	2.5967	3.5366	-4.3791	9.5726	0.4637
11R159 B2R2	DP1032 B2RF	2.5228	2.9136	-3.2242	8.2699	0.3877
DP0141 B2RF	10R052 B2R2	2.4320	3.2094	-3.8984	8.7625	0.4495
DP1032 B2RF	11R136 B2R2	2.4317	2.8548	-3.1992	8.0627	0.3954
CS-50	03-WZ-37	2.3401	3.4310	-4.4275	9.1076	0.496
08-1-1325	DP0912 B2RF	2.2390	3.6679	-4.9958	9.4738	0.5423
DP1048 B2RF	CS-50	2.2066	3.4310	-4.5610	8.9741	0.5209
10R052 B2R2	DP1048 B2RF	2.2028	3.2094	-4.1277	8.5332	0.4933
DP0949 B2RF	03-WZ-37	1.8907	3.4310	-4.8769	8.6582	0.5822
10R052 B2R2	DP1028 B2RF	1.8126	3.3221	-4.7400	8.3653	0.586
08-1-1325	10R052 B2R2	1.7666	3.4615	-5.0611	8.5943	0.6104
11R159 B2R2	DP1044 B2RF	1.7422	3.6391	-5.4359	8.9202	0.6327
DP0912 B2RF	DP1048 B2RF	1.7304	3.4310	-5.0372	8.4979	0.6146
L-23	03-WZ-37	1.6914	3.4310	-5.0762	8.4589	0.6226
11R136 B2R2	08-1-1325	1.5126	3.4121	-5.2177	8.2428	0.6581
10R013 B2R2	03-WZ-37	1.4881	3.2094	-4.8424	7.8185	0.6434
04-22-405	DP1048 B2RF	1.3501	3.4310	-5.4174	8.1177	0.6944
DP0912 B2RF	DP1028 B2RF	1.3402	3.5366	-5.6356	8.3160	0.7051
02-WK-11L	03-WZ-37	1.3279	3.4310	-5.4397	8.0954	0.6992
CS-50	06-46-153	1.3248	3.4310	-5.4428	8.0923	0.6998
CS-50	DP0935 B2RF	1.2920	3.4310	-5.4756	8.0595	0.7069
10R052 B2R2	TAM B-182-33	1.2556	3.0381	-4.7370	7.2482	0.6799
DP0935 B2RF	03-WZ-37	1.0481	3.4310	-5.7194	7.8157	0.7603
06-46-153	03-WZ-37	1.0153	3.4310	-5.7522	7.7829	0.7676
CS-50	02-WK-11L	1.0122	3.4310	-5.7553	7.7798	0.7683
04-22-405	DP1028 B2RF	0.9599	3.5366	-6.0159	7.9358	0.7864
TAM B-182-33	DP1048 B2RF	0.9472	3.2713	-5.5054	7.3998	0.7725

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP0949 B2RF	06-46-153	0.8753	3.4310	-5.8922	7.6429	0.7989
10R052 B2R2	04-22-405	0.8527	3.2094	-5.4778	7.1831	0.7908
CS-50	10R013 B2R2	0.8520	3.2094	-5.4785	7.1825	0.7909
11R136 B2R2	DP0141 B2RF	0.8471	3.1561	-5.3781	7.0724	0.7887
DP0949 B2RF	DP0935 B2RF	0.8425	3.4310	-5.9250	7.6101	0.8063
DP0912 B2RF	TAM B-182-33	0.7832	3.2713	-5.6694	7.2358	0.8111
DP1044 B2RF	DP1032 B2RF	0.7807	3.5922	-6.3048	7.8661	0.8282
L-23	06-46-153	0.6761	3.4310	-6.0915	7.4436	0.844
DP0141 B2RF	08-1-1325	0.6654	3.6679	-6.5694	7.9002	0.8562
CS-50	L-23	0.6487	3.4310	-6.1188	7.4163	0.8502
L-23	DP0935 B2RF	0.6433	3.4310	-6.1243	7.4108	0.8515
DP0949 B2RF	02-WK-11L	0.5628	3.4310	-6.2048	7.3303	0.8699
TAM B-182-33	DP1028 B2RF	0.5570	3.3819	-6.1137	7.2278	0.8693
10R013 B2R2	06-46-153	0.4727	3.2094	-5.8577	6.8032	0.8831
10R052 B2R2	DP0912 B2RF	0.4724	3.2094	-5.8580	6.8029	0.8831
CS-50	DP0949 B2RF	0.4494	3.4310	-6.3181	7.2170	0.8959
10R013 B2R2	DP0935 B2RF	0.4400	3.2094	-5.8905	6.7704	0.8911
04-22-405	TAM B-182-33	0.4029	3.2713	-6.0497	6.8555	0.9021
DP0949 B2RF	10R013 B2R2	0.4026	3.2094	-5.9279	6.7330	0.9003
DP1028 B2RF	DP1048 B2RF	0.3902	3.5366	-6.5857	7.3660	0.9123
DP0912 B2RF	04-22-405	0.3803	3.4310	-6.3873	7.1478	0.9119
L-23	02-WK-11L	0.3635	3.4310	-6.4040	7.1311	0.9157
02-WK-11L	06-46-153	0.3125	3.4310	-6.4550	7.0801	0.9275
02-WK-11L	DP0935 B2RF	0.2797	3.4310	-6.4878	7.0473	0.9351
L-23	10R013 B2R2	0.2033	3.2094	-6.1272	6.5338	0.9496
DP0949 B2RF	L-23	0.1993	3.4310	-6.5683	6.9668	0.9537
10R013 B2R2	02-WK-11L	0.1602	3.2094	-6.1702	6.4907	0.9602
DP0935 B2RF	06-46-153	0.0328	3.4310	-6.7348	6.8003	0.9924

Difference = (Genotype – Genotype). Std Err Dif = Standard Error of Difference, Lower CL = Lower Confidence Level, Upper CL = Upper Confidence Level, p=Value – Probability Value

APPENDIX V.A

2010 WW TREATMENT – ROOT DRY MASS MEANS COMPARISONS BETWEEN GENOTYPES

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
08-1-1325	04-22-405	25.1160	10.7892	2.2439	47.9881	0.0334
DP0949 B2RF	04-22-405	20.7955	10.7892	-2.0766	43.6676	0.0719
L-23	04-22-405	20.0245	10.7892	-2.8476	42.8966	0.0820
DP141 B2RF	04-22-405	19.0675	10.7892	-3.8046	41.9396	0.0962
02-WK-11L	04-22-405	19.0535	10.7892	-3.8186	41.9256	0.0965
DP1044 B2RF	04-22-405	18.4145	10.7892	-4.4576	41.2866	0.1072
TAM B-182-33	04-22-405	16.6080	10.7892	-6.2641	39.4801	0.1433
DP935 B2RF	04-22-405	15.7380	10.7892	-7.1341	38.6101	0.1640
08-1-1325	03 WZ-37	15.2610	10.7892	-7.6111	38.1331	0.1764
08-1-1325	06-46-153	14.5915	10.7892	-8.2806	37.4636	0.1950
CS-50	04-22-405	14.3715	10.7892	-8.5006	37.2436	0.2015
08-1-1325	DP0912 B2RF	13.3895	10.7892	-9.4826	36.2616	0.2325
08-1-1325	DP1028 B2RF	13.3795	10.7892	-9.4926	36.2516	0.2328
05-47-802	04-22-405	12.7515	10.7892	-10.1206	35.6236	0.2545
08-1-1325	DP1048 B2RF	12.6865	10.7892	-10.1856	35.5586	0.2569
DP1048 B2RF	04-22-405	12.4295	10.7892	-10.4426	35.3016	0.2662
08-1-1325	05-47-802	12.3645	10.7892	-10.5076	35.2366	0.2686
DP1028 B2RF	04-22-405	11.7365	10.7892	-11.1356	34.6086	0.2928
DP0912 B2RF	04-22-405	11.7265	10.7892	-11.1456	34.5986	0.2932
DP0949 B2RF	03 WZ-37	10.9405	10.7892	-11.9316	33.8126	0.3257
08-1-1325	CS-50	10.7445	10.7892	-12.1276	33.6166	0.3341
06-46-153	04-22-405	10.5245	10.7892	-12.3476	33.3966	0.3438
DP0949 B2RF	06-46-153	10.2710	10.7892	-12.6011	33.1431	0.3553
L-23	03 WZ-37	10.1695	10.7892	-12.7026	33.0416	0.3599
03 WZ-37	04-22-405	9.8550	10.7892	-13.0171	32.7271	0.3746
L-23	06-46-153	9.5000	10.7892	-13.3721	32.3721	0.3916
08-1-1325	DP935 B2RF	9.3780	10.7892	-13.4941	32.2501	0.3976
DP141 B2RF	03 WZ-37	9.2125	10.7892	-13.6596	32.0846	0.4058
02-WK-11L	03 WZ-37	9.1985	10.7892	-13.6736	32.0706	0.4065
DP0949 B2RF	DP0912 B2RF	9.0690	10.7892	-13.8031	31.9411	0.4130
DP0949 B2RF	DP1028 B2RF	9.0590	10.7892	-13.8131	31.9311	0.4135
DP1044 B2RF	03 WZ-37	8.5595	10.7892	-14.3126	31.4316	0.4392

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP141 B2RF	06-46-153	8.5430	10.7892	-14.3291	31.4151	0.4401
02-WK-11L	06-46-153	8.5290	10.7892	-14.3431	31.4011	0.4408
08-1-1325	TAM B-182-33	8.5080	10.7892	-14.3641	31.3801	0.4419
DP0949 B2RF	DP1048 B2RF	8.3660	10.7892	-14.5061	31.2381	0.4494
L-23	DP0912 B2RF	8.2980	10.7892	-14.5741	31.1701	0.4530
L-23	DP1028 B2RF	8.2880	10.7892	-14.5841	31.1601	0.4536
DP0949 B2RF	05-47-802	8.0440	10.7892	-14.8281	30.9161	0.4667
DP1044 B2RF	06-46-153	7.8900	10.7892	-14.9821	30.7621	0.4752
L-23	DP1048 B2RF	7.5950	10.7892	-15.2771	30.4671	0.4916
DP141 B2RF	DP0912 B2RF	7.3410	10.7892	-15.5311	30.2131	0.5060
DP141 B2RF	DP1028 B2RF	7.3310	10.7892	-15.5411	30.2031	0.5065
02-WK-11L	DP0912 B2RF	7.3270	10.7892	-15.5451	30.1991	0.5068
02-WK-11L	DP1028 B2RF	7.3170	10.7892	-15.5551	30.1891	0.5073
L-23	05-47-802	7.2730	10.7892	-15.5991	30.1451	0.5099
TAM B-182-33	03 WZ-37	6.7530	10.7892	-16.1191	29.6251	0.5402
08-1-1325	DP1044 B2RF	6.7015	10.7892	-16.1706	29.5736	0.5433
DP1044 B2RF	DP0912 B2RF	6.6880	10.7892	-16.1841	29.5601	0.5441
DP1044 B2RF	DP1028 B2RF	6.6780	10.7892	-16.1941	29.5501	0.5447
DP141 B2RF	DP1048 B2RF	6.6380	10.7892	-16.2341	29.5101	0.5470
02-WK-11L	DP1048 B2RF	6.6240	10.7892	-16.2481	29.4961	0.5479
DP0949 B2RF	CS-50	6.4240	10.7892	-16.4481	29.2961	0.5599
DP141 B2RF	05-47-802	6.3160	10.7892	-16.5561	29.1881	0.5664
02-WK-11L	05-47-802	6.3020	10.7892	-16.5701	29.1741	0.5673
TAM B-182-33	06-46-153	6.0835	10.7892	-16.7886	28.9556	0.5807
08-1-1325	02-WK-11L	6.0625	10.7892	-16.8096	28.9346	0.5820
08-1-1325	DP141 B2RF	6.0485	10.7892	-16.8236	28.9206	0.5828
DP1044 B2RF	DP1048 B2RF	5.9850	10.7892	-16.8871	28.8571	0.5868
DP935 B2RF	03 WZ-37	5.8830	10.7892	-16.9891	28.7551	0.5931
DP1044 B2RF	05-47-802	5.6630	10.7892	-17.2091	28.5351	0.6069
L-23	CS-50	5.6530	10.7892	-17.2191	28.5251	0.6075
DP935 B2RF	06-46-153	5.2135	10.7892	-17.6586	28.0856	0.6355
08-1-1325	L-23	5.0915	10.7892	-17.7806	27.9636	0.6434
DP0949 B2RF	DP935 B2RF	5.0575	10.7892	-17.8146	27.9296	0.6456
TAM B-182-33	DP0912 B2RF	4.8815	10.7892	-17.9906	27.7536	0.6570
TAM B-182-33	DP1028 B2RF	4.8715	10.7892	-18.0006	27.7436	0.6577
DP141 B2RF	CS-50	4.6960	10.7892	-18.1761	27.5681	0.6692
02-WK-11L	CS-50	4.6820	10.7892	-18.1901	27.5541	0.6701

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
CS-50	03 WZ-37	4.5165	10.7892	-18.3556	27.3886	0.6811
08-1-1325	DP0949 B2RF	4.3205	10.7892	-18.5516	27.1926	0.6941
L-23	DP935 B2RF	4.2865	10.7892	-18.5856	27.1586	0.6964
DP0949 B2RF	TAM B-182-33	4.1875	10.7892	-18.6846	27.0596	0.7030
TAM B-182-33	DP1048 B2RF	4.1785	10.7892	-18.6936	27.0506	0.7036
DP1044 B2RF	CS-50	4.0430	10.7892	-18.8291	26.9151	0.7128
DP935 B2RF	DP0912 B2RF	4.0115	10.7892	-18.8606	26.8836	0.7149
DP935 B2RF	DP1028 B2RF	4.0015	10.7892	-18.8706	26.8736	0.7156
TAM B-182-33	05-47-802	3.8565	10.7892	-19.0156	26.7286	0.7254
CS-50	06-46-153	3.8470	10.7892	-19.0251	26.7191	0.7261
L-23	TAM B-182-33	3.4165	10.7892	-19.4556	26.2886	0.7556
DP141 B2RF	DP935 B2RF	3.3295	10.7892	-19.5426	26.2016	0.7616
02-WK-11L	DP935 B2RF	3.3155	10.7892	-19.5566	26.1876	0.7626
DP935 B2RF	DP1048 B2RF	3.3085	10.7892	-19.5636	26.1806	0.7631
DP935 B2RF	05-47-802	2.9865	10.7892	-19.8856	25.8586	0.7855
05-47-802	03 WZ-37	2.8965	10.7892	-19.9756	25.7686	0.7918
DP1044 B2RF	DP935 B2RF	2.6765	10.7892	-20.1956	25.5486	0.8072
CS-50	DP0912 B2RF	2.6450	10.7892	-20.2271	25.5171	0.8095
CS-50	DP1028 B2RF	2.6350	10.7892	-20.2371	25.5071	0.8102
DP1048 B2RF	03 WZ-37	2.5745	10.7892	-20.2976	25.4466	0.8144
DP141 B2RF	TAM B-182-33	2.4595	10.7892	-20.4126	25.3316	0.8226
02-WK-11L	TAM B-182-33	2.4455	10.7892	-20.4266	25.3176	0.8236
DP0949 B2RF	DP1044 B2RF	2.3810	10.7892	-20.4911	25.2531	0.8281
TAM B-182-33	CS-50	2.2365	10.7892	-20.6356	25.1086	0.8384
05-47-802	06-46-153	2.2270	10.7892	-20.6451	25.0991	0.8391
CS-50	DP1048 B2RF	1.9420	10.7892	-20.9301	24.8141	0.8594
DP1048 B2RF	06-46-153	1.9050	10.7892	-20.9671	24.7771	0.8621
DP1028 B2RF	03 WZ-37	1.8815	10.7892	-20.9906	24.7536	0.8637
DP0912 B2RF	03 WZ-37	1.8715	10.7892	-21.0006	24.7436	0.8645
DP1044 B2RF	TAM B-182-33	1.8065	10.7892	-21.0656	24.6786	0.8691
DP0949 B2RF	02-WK-11L	1.7420	10.7892	-21.1301	24.6141	0.8738
DP0949 B2RF	DP141 B2RF	1.7280	10.7892	-21.1441	24.6001	0.8748
CS-50	05-47-802	1.6200	10.7892	-21.2521	24.4921	0.8825
L-23	DP1044 B2RF	1.6100	10.7892	-21.2621	24.4821	0.8832
DP935 B2RF	CS-50	1.3665	10.7892	-21.5056	24.2386	0.9008
DP1028 B2RF	06-46-153	1.2120	10.7892	-21.6601	24.0841	0.9120
DP0912 B2RF	06-46-153	1.2020	10.7892	-21.6701	24.0741	0.9127

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
05-47-802	DP0912 B2RF	1.0250	10.7892	-21.8471	23.8971	0.9255
05-47-802	DP1028 B2RF	1.0150	10.7892	-21.8571	23.8871	0.9262
L-23	02-WK-11L	0.9710	10.7892	-21.9011	23.8431	0.9294
L-23	DP141 B2RF	0.9570	10.7892	-21.9151	23.8291	0.9304
TAM B-182-33	DP935 B2RF	0.8700	10.7892	-22.0021	23.7421	0.9367
DP0949 B2RF	L-23	0.7710	10.7892	-22.1011	23.6431	0.9439
DP1048 B2RF	DP0912 B2RF	0.7030	10.7892	-22.1691	23.5751	0.9489
DP1048 B2RF	DP1028 B2RF	0.6930	10.7892	-22.1791	23.5651	0.9496
06-46-153	03 WZ-37	0.6695	10.7892	-22.2026	23.5416	0.9513
DP141 B2RF	DP1044 B2RF	0.6530	10.7892	-22.2191	23.5251	0.9525
02-WK-11L	DP1044 B2RF	0.6390	10.7892	-22.2331	23.5111	0.9535
05-47-802	DP1048 B2RF	0.3220	10.7892	-22.5501	23.1941	0.9766
DP141 B2RF	02-WK-11L	0.0140	10.7892	-22.8581	22.8861	0.9990
DP1028 B2RF	DP0912 B2RF	0.0100	10.7892	-22.8621	22.8821	0.9993

Difference = (Genotype – Genotype). Std Err Dif = Standard Error of Difference, Lower CL = Lower Confidence Level, Upper CL = Upper Confidence Level, p=Value – Probability Value

APPENDIX V.B

2010 WS TREATMENT – ROOT DRY MASS MEANS COMPARISONS BETWEEN GENOTYPES

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP935 B2RF	06-46-153	17.2815	5.9329	4.7042	29.8588	0.0102
DP935 B2RF	DP0912 B2RF	16.5165	5.9329	3.9392	29.0938	0.0133
DP0949 B2RF	06-46-153	16.4775	5.9329	3.9002	29.0548	0.0135
DP0949 B2RF	DP0912 B2RF	15.7125	5.9329	3.1352	28.2898	0.0175
DP935 B2RF	DP1044 B2RF	15.5820	5.9329	3.0047	28.1593	0.0183
DP0949 B2RF	DP1044 B2RF	14.7780	5.9329	2.2007	27.3553	0.0241
CS-50	06-46-153	14.1355	5.9329	1.5582	26.7128	0.0299
02-WK-11L	06-46-153	13.6050	5.9329	1.0277	26.1823	0.0357
CS-50	DP0912 B2RF	13.3705	5.9329	0.7932	25.9478	0.0386
DP935 B2RF	05-47-802	13.3685	5.9329	0.7912	25.9458	0.0386
DP935 B2RF	DP1048 B2RF	13.1075	5.9329	0.5302	25.6848	0.0421
02-WK-11L	DP0912 B2RF	12.8400	5.9329	0.2627	25.4173	0.0459
DP0949 B2RF	05-47-802	12.5645	5.9329	-0.0128	25.1418	0.0502
CS-50	DP1044 B2RF	12.4360	5.9329	-0.1413	25.0133	0.0523
DP0949 B2RF	DP1048 B2RF	12.3035	5.9329	-0.2738	24.8808	0.0546
DP935 B2RF	DP1028 B2RF	12.0545	5.9329	-0.5228	24.6318	0.0591
02-WK-11L	DP1044 B2RF	11.9055	5.9329	-0.6718	24.4828	0.0620
L-23	06-46-153	11.7505	5.9329	-0.8268	24.3278	0.0651
DP0949 B2RF	DP1028 B2RF	11.2505	5.9329	-1.3268	23.8278	0.0761
08-1-1325	06-46-153	11.0530	5.9329	-1.5243	23.6303	0.0809
L-23	DP0912 B2RF	10.9855	5.9329	-1.5918	23.5628	0.0826
DP141 B2RF	06-46-153	10.7575	5.9329	-1.8198	23.3348	0.0886
DP935 B2RF	03 WZ-37	10.3350	5.9329	-2.2423	22.9123	0.1007
08-1-1325	DP0912 B2RF	10.2880	5.9329	-2.2893	22.8653	0.1021
CS-50	05-47-802	10.2225	5.9329	-2.3548	22.7998	0.1042
L-23	DP1044 B2RF	10.0510	5.9329	-2.5263	22.6283	0.1096
DP141 B2RF	DP0912 B2RF	9.9925	5.9329	-2.5848	22.5698	0.1115
CS-50	DP1048 B2RF	9.9615	5.9329	-2.6158	22.5388	0.1126
04-22-405	06-46-153	9.7070	5.9329	-2.8703	22.2843	0.1213
02-WK-11L	05-47-802	9.6920	5.9329	-2.8853	22.2693	0.1219
DP0949 B2RF	03 WZ-37	9.5310	5.9329	-3.0463	22.1083	0.1277

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
02-WK-11L	DP1048 B2RF	9.4310	5.9329	-3.1463	22.0083	0.1315
08-1-1325	DP1044 B2RF	9.3535	5.9329	-3.2238	21.9308	0.1345
DP935 B2RF	TAM B-182-33	9.3020	5.9329	-3.2753	21.8793	0.1365
DP141 B2RF	DP1044 B2RF	9.0580	5.9329	-3.5193	21.6353	0.1464
04-22-405	DP0912 B2RF	8.9420	5.9329	-3.6353	21.5193	0.1513
CS-50	DP1028 B2RF	8.9085	5.9329	-3.6688	21.4858	0.1527
DP0949 B2RF	TAM B-182-33	8.4980	5.9329	-4.0793	21.0753	0.1713
02-WK-11L	DP1028 B2RF	8.3780	5.9329	-4.1993	20.9553	0.1771
04-22-405	DP1044 B2RF	8.0075	5.9329	-4.5698	20.5848	0.1959
TAM B-182-33	06-46-153	7.9795	5.9329	-4.5978	20.5568	0.1974
L-23	05-47-802	7.8375	5.9329	-4.7398	20.4148	0.2051
L-23	DP1048 B2RF	7.5765	5.9329	-5.0008	20.1538	0.2198
DP935 B2RF	04-22-405	7.5745	5.9329	-5.0028	20.1518	0.2199
TAM B-182-33	DP0912 B2RF	7.2145	5.9329	-5.3628	19.7918	0.2416
CS-50	03 WZ-37	7.1890	5.9329	-5.3883	19.7663	0.2432
08-1-1325	05-47-802	7.1400	5.9329	-5.4373	19.7173	0.2463
03 WZ-37	06-46-153	6.9465	5.9329	-5.6308	19.5238	0.2588
08-1-1325	DP1048 B2RF	6.8790	5.9329	-5.6983	19.4563	0.2633
DP141 B2RF	05-47-802	6.8445	5.9329	-5.7328	19.4218	0.2656
DP0949 B2RF	04-22-405	6.7705	5.9329	-5.8068	19.3478	0.2706
02-WK-11L	03 WZ-37	6.6585	5.9329	-5.9188	19.2358	0.2783
DP141 B2RF	DP1048 B2RF	6.5835	5.9329	-5.9938	19.1608	0.2835
DP935 B2RF	DP141 B2RF	6.5240	5.9329	-6.0533	19.1013	0.2878
L-23	DP1028 B2RF	6.5235	5.9329	-6.0538	19.1008	0.2878
TAM B-182-33	DP1044 B2RF	6.2800	5.9329	-6.2973	18.8573	0.3055
DP935 B2RF	08-1-1325	6.2285	5.9329	-6.3488	18.8058	0.3094
03 WZ-37	DP0912 B2RF	6.1815	5.9329	-6.3958	18.7588	0.3129
CS-50	TAM B-182-33	6.1560	5.9329	-6.4213	18.7333	0.3149
08-1-1325	DP1028 B2RF	5.8260	5.9329	-6.7513	18.4033	0.3407
04-22-405	05-47-802	5.7940	5.9329	-6.7833	18.3713	0.3433
DP0949 B2RF	DP141 B2RF	5.7200	5.9329	-6.8573	18.2973	0.3493
02-WK-11L	TAM B-182-33	5.6255	5.9329	-6.9518	18.2028	0.3571
04-22-405	DP1048 B2RF	5.5330	5.9329	-7.0443	18.1103	0.3649
DP935 B2RF	L-23	5.5310	5.9329	-7.0463	18.1083	0.3651
DP141 B2RF	DP1028 B2RF	5.5305	5.9329	-7.0468	18.1078	0.3651
DP0949 B2RF	08-1-1325	5.4245	5.9329	-7.1528	18.0018	0.3741
03 WZ-37	DP1044 B2RF	5.2470	5.9329	-7.3303	17.8243	0.3896

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP1028 B2RF	06-46-153	5.2270	5.9329	-7.3503	17.8043	0.3914
L-23	03 WZ-37	4.8040	5.9329	-7.7733	17.3813	0.4300
DP0949 B2RF	L-23	4.7270	5.9329	-7.8503	17.3043	0.4373
04-22-405	DP1028 B2RF	4.4800	5.9329	-8.0973	17.0573	0.4612
DP1028 B2RF	DP0912 B2RF	4.4620	5.9329	-8.1153	17.0393	0.4629
CS-50	04-22-405	4.4285	5.9329	-8.1488	17.0058	0.4662
DP1048 B2RF	06-46-153	4.1740	5.9329	-8.4033	16.7513	0.4918
08-1-1325	03 WZ-37	4.1065	5.9329	-8.4708	16.6838	0.4988
TAM B-182-33	05-47-802	4.0665	5.9329	-8.5108	16.6438	0.5029
05-47-802	06-46-153	3.9130	5.9329	-8.6643	16.4903	0.5189
02-WK-11L	04-22-405	3.8980	5.9329	-8.6793	16.4753	0.5205
DP141 B2RF	03 WZ-37	3.8110	5.9329	-8.7663	16.3883	0.5297
TAM B-182-33	DP1048 B2RF	3.8055	5.9329	-8.7718	16.3828	0.5303
L-23	TAM B-182-33	3.7710	5.9329	-8.8063	16.3483	0.5340
DP935 B2RF	02-WK-11L	3.6765	5.9329	-8.9008	16.2538	0.5442
DP1028 B2RF	DP1044 B2RF	3.5275	5.9329	-9.0498	16.1048	0.5605
DP1048 B2RF	DP0912 B2RF	3.4090	5.9329	-9.1683	15.9863	0.5736
CS-50	DP141 B2RF	3.3780	5.9329	-9.1993	15.9553	0.5770
05-47-802	DP0912 B2RF	3.1480	5.9329	-9.4293	15.7253	0.6030
DP935 B2RF	CS-50	3.1460	5.9329	-9.4313	15.7233	0.6032
CS-50	08-1-1325	3.0825	5.9329	-9.4948	15.6598	0.6105
08-1-1325	TAM B-182-33	3.0735	5.9329	-9.5038	15.6508	0.6115
03 WZ-37	05-47-802	3.0335	5.9329	-9.5438	15.6108	0.6161
DP0949 B2RF	02-WK-11L	2.8725	5.9329	-9.7048	15.4498	0.6348
02-WK-11L	DP141 B2RF	2.8475	5.9329	-9.7298	15.4248	0.6378
DP141 B2RF	TAM B-182-33	2.7780	5.9329	-9.7993	15.3553	0.6459
03 WZ-37	DP1048 B2RF	2.7725	5.9329	-9.8048	15.3498	0.6466
04-22-405	03 WZ-37	2.7605	5.9329	-9.8168	15.3378	0.6480
TAM B-182-33	DP1028 B2RF	2.7525	5.9329	-9.8248	15.3298	0.6489
02-WK-11L	08-1-1325	2.5520	5.9329	-10.0253	15.1293	0.6728
DP1048 B2RF	DP1044 B2RF	2.4745	5.9329	-10.1028	15.0518	0.6822
CS-50	L-23	2.3850	5.9329	-10.1923	14.9623	0.6930
DP0949 B2RF	CS-50	2.3420	5.9329	-10.2353	14.9193	0.6982
05-47-802	DP1044 B2RF	2.2135	5.9329	-10.3638	14.7908	0.7140
L-23	04-22-405	2.0435	5.9329	-10.5338	14.6208	0.7350
02-WK-11L	L-23	1.8545	5.9329	-10.7228	14.4318	0.7586
04-22-405	TAM B-182-33	1.7275	5.9329	-10.8498	14.3048	0.7747

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
03 WZ-37	DP1028 B2RF	1.7195	5.9329	-10.8578	14.2968	0.7757
DP1044 B2RF	06-46-153	1.6995	5.9329	-10.8778	14.2768	0.7782
08-1-1325	04-22-405	1.3460	5.9329	-11.2313	13.9233	0.8234
DP1028 B2RF	05-47-802	1.3140	5.9329	-11.2633	13.8913	0.8275
DP1028 B2RF	DP1048 B2RF	1.0530	5.9329	-11.5243	13.6303	0.8614
DP141 B2RF	04-22-405	1.0505	5.9329	-11.5268	13.6278	0.8617
TAM B-182-33	03 WZ-37	1.0330	5.9329	-11.5443	13.6103	0.8640
L-23	DP141 B2RF	0.9930	5.9329	-11.5843	13.5703	0.8692
DP1044 B2RF	DP0912 B2RF	0.9345	5.9329	-11.6428	13.5118	0.8768
DP935 B2RF	DP0949 B2RF	0.8040	5.9329	-11.7733	13.3813	0.8939
DP0912 B2RF	06-46-153	0.7650	5.9329	-11.8123	13.3423	0.8990
L-23	08-1-1325	0.6975	5.9329	-11.8798	13.2748	0.9079
CS-50	02-WK-11L	0.5305	5.9329	-12.0468	13.1078	0.9299
08-1-1325	DP141 B2RF	0.2955	5.9329	-12.2818	12.8728	0.9609
DP1048 B2RF	05-47-802	0.2610	5.9329	-12.3163	12.8383	0.9655

Difference = (Genotype – Genotype). Std Err Dif = Standard Error of Difference, Lower CL = Lower Confidence Level, Upper CL = Upper Confidence Level, p=Value – Probability Value

APPENDIX V.C

2011 WS TREATMENT – ROOT DRY MASS MEANS COMPARISONS BETWEEN GENOTYPES

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP0935 B2RF	05-47-802	8.6956	3.1895	2.3760	15.0152	0.0074
DP0935 B2RF	10R013 B2R2	8.4674	3.1895	2.1478	14.7870	0.0091
DP0935 B2RF	04-22-405	7.7205	3.1895	1.4009	14.0401	0.0171
DP0935 B2RF	DP1032 B2RF	7.0431	3.1895	0.7235	13.3627	0.0293
11R159 B2R2	05-47-802	6.9563	3.1895	0.6367	13.2758	0.0313
DP0935 B2RF	06-46-153	6.9370	3.1895	0.6174	13.2566	0.0317
10R011 B2R2	05-47-802	6.7760	3.1895	0.4564	13.0956	0.0358
11R159 B2R2	10R013 B2R2	6.7280	3.1895	0.4084	13.0476	0.0371
10R011 B2R2	10R013 B2R2	6.5478	3.1895	0.2282	12.8673	0.0424
L-23	05-47-802	6.1823	3.1895	-0.1373	12.5018	0.0551
11R136 B2R2	05-47-802	6.0508	3.1895	-0.2688	12.3703	0.0604
11R159 B2R2	04-22-405	5.9811	3.1895	-0.3385	12.3007	0.0634
L-23	10R013 B2R2	5.9540	3.1895	-0.3656	12.2736	0.0646
11R136 B2R2	10R013 B2R2	5.8225	3.1895	-0.4971	12.1421	0.0706
10R011 B2R2	04-22-405	5.8009	3.1895	-0.5187	12.1205	0.0716
11R159 B2R2	DP1032 B2RF	5.3038	3.1895	-1.0158	11.6233	0.0991
CS-50	05-47-802	5.2201	3.1895	-1.0995	11.5397	0.1045
L-23	04-22-405	5.2071	3.1895	-1.1125	11.5267	0.1054
11R159 B2R2	06-46-153	5.1976	3.1895	-1.1220	11.5172	0.1060
DP1044 B2RF	05-47-802	5.1639	3.1895	-1.1557	11.4835	0.1083
10R011 B2R2	DP1032 B2RF	5.1235	3.1895	-1.1961	11.4431	0.1110
11R136 B2R2	04-22-405	5.0756	3.1895	-1.2440	11.3952	0.1143
08-1-1325	05-47-802	5.0595	3.1895	-1.2601	11.3791	0.1155
10R011 B2R2	06-46-153	5.0174	3.1895	-1.3022	11.3370	0.1185
CS-50	10R013 B2R2	4.9919	3.1895	-1.3277	11.3115	0.1204
DP1044 B2RF	10R013 B2R2	4.9356	3.1895	-1.3840	11.2552	0.1246
08-1-1325	10R013 B2R2	4.8313	3.1895	-1.4883	11.1508	0.1327
DP0935 B2RF	10R052 B2R2	4.7785	3.1895	-1.5411	11.0981	0.1369
DP0935 B2RF	DP1048 B2RF	4.5471	3.1895	-1.7725	10.8667	0.1567
L-23	DP1032 B2RF	4.5298	3.1895	-1.7898	10.8493	0.1583
L-23	06-46-153	4.4236	3.1895	-1.8960	10.7432	0.1682
11R136 B2R2	DP1032 B2RF	4.3983	3.1895	-1.9213	10.7178	0.1706
DP0935 B2RF	DP0912 B2RF	4.3909	3.1895	-1.9287	10.7105	0.1714
DP0912 B2RF	05-47-802	4.3048	3.1895	-2.0148	10.6243	0.1798
11R136 B2R2	06-46-153	4.2921	3.1895	-2.0275	10.6117	0.1811
CS-50	04-22-405	4.2450	3.1895	-2.0746	10.5646	0.1859
DP1044 B2RF	04-22-405	4.1888	3.1895	-2.1308	10.5083	0.1918
DP1048 B2RF	05-47-802	4.1485	3.1895	-2.1711	10.4681	0.1960
08-1-1325	04-22-405	4.0844	3.1895	-2.2352	10.4040	0.2030

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP0912 B2RF	10R013 B2R2	4.0765	3.1895	-2.2431	10.3961	0.2039
DP1048 B2RF	10R013 B2R2	3.9203	3.1895	-2.3993	10.2398	0.2216
10R052 B2R2	05-47-802	3.9171	3.1895	-2.4025	10.2367	0.2220
10R052 B2R2	10R013 B2R2	3.6889	3.1895	-2.6307	10.0085	0.2499
DP0935 B2RF	08-1-1325	3.6361	3.1895	-2.6835	9.9557	0.2567
CS-50	DP1032 B2RF	3.5676	3.1895	-2.7520	9.8872	0.2657
DP0935 B2RF	DP1044 B2RF	3.5318	3.1895	-2.7878	9.8513	0.2705
DP1044 B2RF	DP1032 B2RF	3.5114	3.1895	-2.8082	9.8310	0.2733
DP0935 B2RF	CS-50	3.4755	3.1895	-2.8441	9.7951	0.2782
CS-50	06-46-153	3.4615	3.1895	-2.8581	9.7811	0.2801
08-1-1325	DP1032 B2RF	3.4070	3.1895	-2.9126	9.7266	0.2877
DP1044 B2RF	06-46-153	3.4053	3.1895	-2.9143	9.7248	0.2880
DP0912 B2RF	04-22-405	3.3296	3.1895	-2.9900	9.6492	0.2988
08-1-1325	06-46-153	3.3009	3.1895	-3.0187	9.6205	0.3029
DP1048 B2RF	04-22-405	3.1734	3.1895	-3.1462	9.4930	0.3219
11R159 B2R2	10R052 B2R2	3.0391	3.1895	-3.2805	9.3587	0.3427
10R052 B2R2	04-22-405	2.9420	3.1895	-3.3776	9.2616	0.3583
10R011 B2R2	10R052 B2R2	2.8589	3.1895	-3.4607	9.1785	0.3720
11R159 B2R2	DP1048 B2RF	2.8078	3.1895	-3.5118	9.1273	0.3806
DP0912 B2RF	DP1032 B2RF	2.6523	3.1895	-3.6673	8.9718	0.4074
11R159 B2R2	DP0912 B2RF	2.6515	3.1895	-3.6681	8.9711	0.4076
DP0935 B2RF	11R136 B2R2	2.6449	3.1895	-3.6747	8.9645	0.4087
10R011 B2R2	DP1048 B2RF	2.6275	3.1895	-3.6921	8.9471	0.4118
DP0912 B2RF	06-46-153	2.5461	3.1895	-3.7735	8.8657	0.4264
DP0935 B2RF	L-23	2.5134	3.1895	-3.8062	8.8330	0.4324
DP1048 B2RF	DP1032 B2RF	2.4960	3.1895	-3.8236	8.8156	0.4355
10R011 B2R2	DP0912 B2RF	2.4713	3.1895	-3.8483	8.7908	0.4401
DP1048 B2RF	06-46-153	2.3899	3.1895	-3.9297	8.7095	0.4553
L-23	10R052 B2R2	2.2651	3.1895	-4.0545	8.5847	0.4791
10R052 B2R2	DP1032 B2RF	2.2646	3.1895	-4.0550	8.5842	0.4792
10R052 B2R2	06-46-153	2.1585	3.1895	-4.1611	8.4781	0.5000
11R136 B2R2	10R052 B2R2	2.1336	3.1895	-4.1860	8.4532	0.5049
L-23	DP1048 B2RF	2.0338	3.1895	-4.2858	8.3533	0.5250
DP0935 B2RF	10R011 B2R2	1.9196	3.1895	-4.4000	8.2392	0.5485
11R136 B2R2	DP1048 B2RF	1.9023	3.1895	-4.4173	8.2218	0.5521
11R159 B2R2	08-1-1325	1.8968	3.1895	-4.4228	8.2163	0.5533
L-23	DP0912 B2RF	1.8775	3.1895	-4.4421	8.1971	0.5573
11R159 B2R2	DP1044 B2RF	1.7924	3.1895	-4.5272	8.1120	0.5753
06-46-153	05-47-802	1.7586	3.1895	-4.5610	8.0782	0.5825
11R136 B2R2	DP0912 B2RF	1.7460	3.1895	-4.5736	8.0656	0.5852
DP0935 B2RF	11R159 B2R2	1.7394	3.1895	-4.5802	8.0590	0.5866
11R159 B2R2	CS-50	1.7361	3.1895	-4.5835	8.0557	0.5873
10R011 B2R2	08-1-1325	1.7165	3.1895	-4.6031	8.0361	0.5915
DP1032 B2RF	05-47-802	1.6525	3.1895	-4.6671	7.9721	0.6054
10R011 B2R2	DP1044 B2RF	1.6121	3.1895	-4.7075	7.9317	0.6142
10R011 B2R2	CS-50	1.5559	3.1895	-4.7637	7.8755	0.6266

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
06-46-153	10R013 B2R2	1.5304	3.1895	-4.7892	7.8500	0.6323
DP1032 B2RF	10R013 B2R2	1.4243	3.1895	-4.8953	7.7438	0.6561
CS-50	10R052 B2R2	1.3030	3.1895	-5.0166	7.6226	0.6837
DP1044 B2RF	10R052 B2R2	1.2468	3.1895	-5.0728	7.5663	0.6966
08-1-1325	10R052 B2R2	1.1424	3.1895	-5.1772	7.4620	0.7209
L-23	08-1-1325	1.1228	3.1895	-5.1968	7.4423	0.7255
CS-50	DP1048 B2RF	1.0716	3.1895	-5.2480	7.3912	0.7375
L-23	DP1044 B2RF	1.0184	3.1895	-5.3012	7.3380	0.7501
DP1044 B2RF	DP1048 B2RF	1.0154	3.1895	-5.3042	7.3350	0.7508
11R136 B2R2	08-1-1325	0.9913	3.1895	-5.3283	7.3108	0.7565
04-22-405	05-47-802	0.9751	3.1895	-5.3445	7.2947	0.7604
L-23	CS-50	0.9621	3.1895	-5.3575	7.2817	0.7635
CS-50	DP0912 B2RF	0.9154	3.1895	-5.4042	7.2350	0.7746
08-1-1325	DP1048 B2RF	0.9110	3.1895	-5.4086	7.2306	0.7757
11R159 B2R2	11R136 B2R2	0.9055	3.1895	-5.4141	7.2251	0.7770
11R136 B2R2	DP1044 B2RF	0.8869	3.1895	-5.4327	7.2065	0.7815
DP1044 B2RF	DP0912 B2RF	0.8591	3.1895	-5.4605	7.1787	0.7881
11R136 B2R2	CS-50	0.8306	3.1895	-5.4890	7.1502	0.7950
06-46-153	04-22-405	0.7835	3.1895	-5.5361	7.1031	0.8064
11R159 B2R2	L-23	0.7740	3.1895	-5.5456	7.0936	0.8087
08-1-1325	DP0912 B2RF	0.7548	3.1895	-5.5648	7.0743	0.8134
04-22-405	10R013 B2R2	0.7469	3.1895	-5.5727	7.0665	0.8153
10R011 B2R2	11R136 B2R2	0.7253	3.1895	-5.5943	7.0448	0.8205
DP1032 B2RF	04-22-405	0.6774	3.1895	-5.6422	6.9970	0.8322
10R011 B2R2	L-23	0.5938	3.1895	-5.7258	6.9133	0.8527
DP0912 B2RF	10R052 B2R2	0.3876	3.1895	-5.9320	6.7072	0.9035
DP1048 B2RF	10R052 B2R2	0.2314	3.1895	-6.0882	6.5510	0.9423
10R013 B2R2	05-47-802	0.2283	3.1895	-6.0913	6.5478	0.9431
11R159 B2R2	10R011 B2R2	0.1803	3.1895	-6.1393	6.4998	0.9550
CS-50	08-1-1325	0.1606	3.1895	-6.1590	6.4802	0.9599
DP0912 B2RF	DP1048 B2RF	0.1563	3.1895	-6.1633	6.4758	0.9610
L-23	11R136 B2R2	0.1315	3.1895	-6.1881	6.4511	0.9672
06-46-153	DP1032 B2RF	0.1061	3.1895	-6.2135	6.4257	0.9735
DP1044 B2RF	08-1-1325	0.1044	3.1895	-6.2152	6.4240	0.9740
CS-50	DP1044 B2RF	0.0563	3.1895	-6.2633	6.3758	0.9860

Difference = (Genotype – Genotype). Std Err Dif = Standard Error of Difference, Lower CL = Lower Confidence Level, Upper CL = Upper Confidence Level, p=Value – Probability Value

APPENDIX V.D

2010 WW TREATMENT – ROOT:SHOOT RATIO MEANS COMPARISONS BETWEEN GENOTYPES

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP1044 B2RF	04-22-405	0.1398	0.0562	0.0206	0.2589	0.0243
DP1044 B2RF	DP1048 B2RF	0.1230	0.0562	0.0038	0.2421	0.0438
DP1044 B2RF	DP935 B2RF	0.1142	0.0562	-0.0049	0.2334	0.0590
DP1044 B2RF	06-46-153	0.1134	0.0562	-0.0057	0.2325	0.0607
TAM B-182-33	04-22-405	0.1013	0.0562	-0.0178	0.2204	0.0904
DP1044 B2RF	02-WK-11L	0.0965	0.0562	-0.0226	0.2156	0.1052
DP1044 B2RF	05-47-802	0.0902	0.0562	-0.0290	0.2093	0.1281
DP1028 B2RF	04-22-405	0.0891	0.0562	-0.0301	0.2082	0.1326
DP1044 B2RF	DP0912 B2RF	0.0876	0.0562	-0.0315	0.2068	0.1385
DP1044 B2RF	03 WZ-37	0.0875	0.0562	-0.0317	0.2066	0.1392
TAM B-182-33	DP1048 B2RF	0.0845	0.0562	-0.0346	0.2036	0.1521
DP1044 B2RF	DP141 B2RF	0.0827	0.0562	-0.0365	0.2018	0.1607
08-1-1325	04-22-405	0.0815	0.0562	-0.0377	0.2006	0.1664
DP0949 B2RF	04-22-405	0.0792	0.0562	-0.0399	0.1984	0.1776
L-23	04-22-405	0.0789	0.0562	-0.0402	0.1981	0.1793
DP1044 B2RF	CS-50	0.0767	0.0562	-0.0424	0.1958	0.1913
TAM B-182-33	DP935 B2RF	0.0758	0.0562	-0.0434	0.1949	0.1964
TAM B-182-33	06-46-153	0.0749	0.0562	-0.0442	0.1941	0.2010
DP1028 B2RF	DP1048 B2RF	0.0723	0.0562	-0.0469	0.1914	0.2167
08-1-1325	DP1048 B2RF	0.0647	0.0562	-0.0544	0.1838	0.2665
DP1028 B2RF	DP935 B2RF	0.0635	0.0562	-0.0556	0.1827	0.2750
CS-50	04-22-405	0.0631	0.0562	-0.0561	0.1822	0.2783
DP1028 B2RF	06-46-153	0.0627	0.0562	-0.0564	0.1818	0.2810
DP0949 B2RF	DP1048 B2RF	0.0625	0.0562	-0.0567	0.1816	0.2828
L-23	DP1048 B2RF	0.0621	0.0562	-0.0570	0.1813	0.2851
DP1044 B2RF	L-23	0.0608	0.0562	-0.0583	0.1800	0.2951
DP1044 B2RF	DP0949 B2RF	0.0605	0.0562	-0.0586	0.1796	0.2976
DP1044 B2RF	08-1-1325	0.0583	0.0562	-0.0609	0.1774	0.3152
TAM B-182-33	02-WK-11L	0.0580	0.0562	-0.0611	0.1772	0.3171
DP141 B2RF	04-22-405	0.0571	0.0562	-0.0620	0.1762	0.3248
08-1-1325	DP935 B2RF	0.0559	0.0562	-0.0632	0.1751	0.3343

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
08-1-1325	06-46-153	0.0551	0.0562	-0.0640	0.1743	0.3412
DP0949 B2RF	DP935 B2RF	0.0537	0.0562	-0.0654	0.1728	0.3534
L-23	DP935 B2RF	0.0534	0.0562	-0.0657	0.1725	0.3562
DP0949 B2RF	06-46-153	0.0529	0.0562	-0.0662	0.1720	0.3605
L-23	06-46-153	0.0526	0.0562	-0.0666	0.1717	0.3634
03 WZ-37	04-22-405	0.0523	0.0562	-0.0668	0.1714	0.3659
DP0912 B2RF	04-22-405	0.0521	0.0562	-0.0670	0.1713	0.3673
TAM B-182-33	05-47-802	0.0517	0.0562	-0.0674	0.1708	0.3712
DP1044 B2RF	DP1028 B2RF	0.0507	0.0562	-0.0684	0.1698	0.3803
05-47-802	04-22-405	0.0496	0.0562	-0.0695	0.1687	0.3906
TAM B-182-33	DP0912 B2RF	0.0492	0.0562	-0.0700	0.1683	0.3947
TAM B-182-33	03 WZ-37	0.0490	0.0562	-0.0701	0.1681	0.3962
CS-50	DP1048 B2RF	0.0463	0.0562	-0.0728	0.1654	0.4222
DP1028 B2RF	02-WK-11L	0.0458	0.0562	-0.0733	0.1649	0.4271
TAM B-182-33	DP141 B2RF	0.0442	0.0562	-0.0749	0.1633	0.4431
02-WK-11L	04-22-405	0.0433	0.0562	-0.0759	0.1624	0.4526
DP141 B2RF	DP1048 B2RF	0.0403	0.0562	-0.0788	0.1594	0.4835
DP1028 B2RF	05-47-802	0.0395	0.0562	-0.0797	0.1586	0.4926
DP1044 B2RF	TAM B-182-33	0.0385	0.0562	-0.0807	0.1576	0.5034
08-1-1325	02-WK-11L	0.0382	0.0562	-0.0809	0.1574	0.5061
TAM B-182-33	CS-50	0.0382	0.0562	-0.0809	0.1574	0.5062
CS-50	DP935 B2RF	0.0375	0.0562	-0.0816	0.1567	0.5137
DP1028 B2RF	DP0912 B2RF	0.0369	0.0562	-0.0822	0.1561	0.5206
DP1028 B2RF	03 WZ-37	0.0368	0.0562	-0.0824	0.1559	0.5224
CS-50	06-46-153	0.0367	0.0562	-0.0824	0.1559	0.5228
DP0949 B2RF	02-WK-11L	0.0360	0.0562	-0.0831	0.1551	0.5310
L-23	02-WK-11L	0.0357	0.0562	-0.0835	0.1548	0.5346
03 WZ-37	DP1048 B2RF	0.0355	0.0562	-0.0836	0.1547	0.5363
DP0912 B2RF	DP1048 B2RF	0.0354	0.0562	-0.0838	0.1545	0.5381
05-47-802	DP1048 B2RF	0.0328	0.0562	-0.0863	0.1519	0.5675
DP1028 B2RF	DP141 B2RF	0.0320	0.0562	-0.0872	0.1511	0.5774
08-1-1325	05-47-802	0.0319	0.0562	-0.0872	0.1510	0.5782
DP141 B2RF	DP935 B2RF	0.0316	0.0562	-0.0876	0.1507	0.5822
DP141 B2RF	06-46-153	0.0307	0.0562	-0.0884	0.1499	0.5919
DP0949 B2RF	05-47-802	0.0297	0.0562	-0.0895	0.1488	0.6049
08-1-1325	DP0912 B2RF	0.0293	0.0562	-0.0898	0.1485	0.6087
L-23	05-47-802	0.0293	0.0562	-0.0898	0.1485	0.6087

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
08-1-1325	03 WZ-37	0.0292	0.0562	-0.0900	0.1483	0.6107
DP0949 B2RF	DP0912 B2RF	0.0271	0.0562	-0.0920	0.1462	0.6360
DP0949 B2RF	03 WZ-37	0.0269	0.0562	-0.0922	0.1461	0.6380
L-23	DP0912 B2RF	0.0268	0.0562	-0.0923	0.1459	0.6400
03 WZ-37	DP935 B2RF	0.0268	0.0562	-0.0924	0.1459	0.6403
L-23	03 WZ-37	0.0266	0.0562	-0.0925	0.1458	0.6420
DP0912 B2RF	DP935 B2RF	0.0266	0.0562	-0.0925	0.1457	0.6423
02-WK-11L	DP1048 B2RF	0.0265	0.0562	-0.0927	0.1456	0.6439
06-46-153	04-22-405	0.0264	0.0562	-0.0928	0.1455	0.6455
DP1028 B2RF	CS-50	0.0260	0.0562	-0.0932	0.1451	0.6500
03 WZ-37	06-46-153	0.0259	0.0562	-0.0932	0.1451	0.6505
DP0912 B2RF	06-46-153	0.0258	0.0562	-0.0933	0.1449	0.6525
DP935 B2RF	04-22-405	0.0255	0.0562	-0.0936	0.1447	0.6556
08-1-1325	DP141 B2RF	0.0244	0.0562	-0.0947	0.1435	0.6701
05-47-802	DP935 B2RF	0.0241	0.0562	-0.0951	0.1432	0.6744
05-47-802	06-46-153	0.0232	0.0562	-0.0959	0.1424	0.6847
TAM B-182-33	L-23	0.0224	0.0562	-0.0968	0.1415	0.6960
DP0949 B2RF	DP141 B2RF	0.0222	0.0562	-0.0970	0.1413	0.6986
TAM B-182-33	DP0949 B2RF	0.0220	0.0562	-0.0971	0.1412	0.7001
L-23	DP141 B2RF	0.0218	0.0562	-0.0973	0.1410	0.7027
CS-50	02-WK-11L	0.0198	0.0562	-0.0993	0.1389	0.7290
TAM B-182-33	08-1-1325	0.0198	0.0562	-0.0993	0.1389	0.7291
08-1-1325	CS-50	0.0184	0.0562	-0.1007	0.1375	0.7474
02-WK-11L	DP935 B2RF	0.0177	0.0562	-0.1014	0.1369	0.7565
02-WK-11L	06-46-153	0.0169	0.0562	-0.1022	0.1360	0.7674
DP1048 B2RF	04-22-405	0.0168	0.0562	-0.1024	0.1359	0.7691
DP0949 B2RF	CS-50	0.0162	0.0562	-0.1030	0.1353	0.7771
L-23	CS-50	0.0159	0.0562	-0.1033	0.1350	0.7814
DP141 B2RF	02-WK-11L	0.0138	0.0562	-0.1053	0.1330	0.8087
CS-50	05-47-802	0.0135	0.0562	-0.1056	0.1326	0.8134
TAM B-182-33	DP1028 B2RF	0.0122	0.0562	-0.1069	0.1314	0.8304
CS-50	DP0912 B2RF	0.0109	0.0562	-0.1082	0.1301	0.8482
CS-50	03 WZ-37	0.0108	0.0562	-0.1084	0.1299	0.8504
DP1028 B2RF	L-23	0.0101	0.0562	-0.1090	0.1293	0.8593
DP1028 B2RF	DP0949 B2RF	0.0098	0.0562	-0.1093	0.1289	0.8637
06-46-153	DP1048 B2RF	0.0096	0.0562	-0.1096	0.1287	0.8670
03 WZ-37	02-WK-11L	0.0090	0.0562	-0.1101	0.1282	0.8742

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP0912 B2RF	02-WK-11L	0.0089	0.0562	-0.1103	0.1280	0.8764
DP935 B2RF	DP1048 B2RF	0.0088	0.0562	-0.1104	0.1279	0.8782
DP1028 B2RF	08-1-1325	0.0076	0.0562	-0.1116	0.1267	0.8945
DP141 B2RF	05-47-802	0.0075	0.0562	-0.1116	0.1266	0.8954
05-47-802	02-WK-11L	0.0063	0.0562	-0.1128	0.1255	0.9118
CS-50	DP141 B2RF	0.0060	0.0562	-0.1132	0.1251	0.9166
DP141 B2RF	DP0912 B2RF	0.0050	0.0562	-0.1142	0.1241	0.9308
DP141 B2RF	03 WZ-37	0.0048	0.0562	-0.1143	0.1239	0.9331
03 WZ-37	05-47-802	0.0027	0.0562	-0.1164	0.1218	0.9621
08-1-1325	L-23	0.0026	0.0562	-0.1166	0.1217	0.9643
DP0912 B2RF	05-47-802	0.0026	0.0562	-0.1166	0.1217	0.9644
08-1-1325	DP0949 B2RF	0.0022	0.0562	-0.1169	0.1214	0.9688
06-46-153	DP935 B2RF	0.0008	0.0562	-0.1183	0.1199	0.9886
DP0949 B2RF	L-23	0.0003	0.0562	-0.1188	0.1195	0.9955
03 WZ-37	DP0912 B2RF	0.0002	0.0562	-0.1190	0.1193	0.9977

Difference = (Genotype – Genotype). Std Err Dif = Standard Error of Difference, Lower CL = Lower Confidence Level, Upper CL = Upper Confidence Level, p=Value – Probability Value

APPENDIX V.E

2010 WS TREATMENT – ROOT:SHOOT RATIO MEANS COMPARISONS BETWEEN GENOTYPES

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
02-WK-11L	DP1044 B2RF	0.2143	0.0571	0.0932	0.3354	0.0017
02-WK-11L	DP1048 B2RF	0.1702	0.0571	0.0491	0.2913	0.0089
02-WK-11L	DP141 B2RF	0.1645	0.0571	0.0434	0.2855	0.0109
02-WK-11L	05-47-802	0.1516	0.0571	0.0305	0.2727	0.0173
02-WK-11L	DP0912 B2RF	0.1426	0.0571	0.0215	0.2637	0.0239
02-WK-11L	08-1-1325	0.1415	0.0571	0.0204	0.2626	0.0247
TAM B-182-33	DP1044 B2RF	0.1414	0.0571	0.0203	0.2625	0.0249
02-WK-11L	04-22-405	0.1399	0.0571	0.0188	0.2610	0.0262
02-WK-11L	DP1028 B2RF	0.1394	0.0571	0.0183	0.2605	0.0267
02-WK-11L	DP935 B2RF	0.1342	0.0571	0.0131	0.2553	0.0319
02-WK-11L	CS-50	0.1298	0.0571	0.0087	0.2509	0.0373
02-WK-11L	L-23	0.1234	0.0571	0.0023	0.2445	0.0462
DP0949 B2RF	DP1044 B2RF	0.1196	0.0571	-0.0015	0.2406	0.0526
02-WK-11L	06-46-153	0.1090	0.0571	-0.0121	0.2301	0.0745
02-WK-11L	03 WZ-37	0.1074	0.0571	-0.0137	0.2285	0.0785
03 WZ-37	DP1044 B2RF	0.1069	0.0571	-0.0141	0.2280	0.0795
06-46-153	DP1044 B2RF	0.1054	0.0571	-0.0157	0.2265	0.0837
TAM B-182-33	DP1048 B2RF	0.0972	0.0571	-0.0239	0.2183	0.1081
02-WK-11L	DP0949 B2RF	0.0948	0.0571	-0.0263	0.2159	0.1165
TAM B-182-33	DP141 B2RF	0.0915	0.0571	-0.0296	0.2126	0.1287
L-23	DP1044 B2RF	0.0909	0.0571	-0.0302	0.2120	0.1311
CS-50	DP1044 B2RF	0.0846	0.0571	-0.0365	0.2057	0.1582
DP935 B2RF	DP1044 B2RF	0.0801	0.0571	-0.0410	0.2012	0.1799
TAM B-182-33	05-47-802	0.0787	0.0571	-0.0424	0.1998	0.1874
DP0949 B2RF	DP1048 B2RF	0.0754	0.0571	-0.0457	0.1965	0.2054
DP1028 B2RF	DP1044 B2RF	0.0750	0.0571	-0.0461	0.1960	0.2080
04-22-405	DP1044 B2RF	0.0744	0.0571	-0.0467	0.1955	0.2110
02-WK-11L	TAM B-182-33	0.0729	0.0571	-0.0482	0.1940	0.2199
08-1-1325	DP1044 B2RF	0.0728	0.0571	-0.0483	0.1939	0.2207
DP0912 B2RF	DP1044 B2RF	0.0718	0.0571	-0.0493	0.1928	0.2271
DP0949 B2RF	DP141 B2RF	0.0697	0.0571	-0.0514	0.1908	0.2402

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
TAM B-182-33	DP0912 B2RF	0.0696	0.0571	-0.0515	0.1907	0.2405
TAM B-182-33	08-1-1325	0.0686	0.0571	-0.0525	0.1897	0.2472
TAM B-182-33	04-22-405	0.0670	0.0571	-0.0541	0.1881	0.2582
TAM B-182-33	DP1028 B2RF	0.0664	0.0571	-0.0547	0.1875	0.2618
03 WZ-37	DP1048 B2RF	0.0628	0.0571	-0.0583	0.1839	0.2879
05-47-802	DP1044 B2RF	0.0627	0.0571	-0.0584	0.1838	0.2884
TAM B-182-33	DP935 B2RF	0.0613	0.0571	-0.0598	0.1824	0.2992
06-46-153	DP1048 B2RF	0.0612	0.0571	-0.0599	0.1823	0.2999
03 WZ-37	DP141 B2RF	0.0571	0.0571	-0.0640	0.1782	0.3326
TAM B-182-33	CS-50	0.0568	0.0571	-0.0643	0.1779	0.3346
DP0949 B2RF	05-47-802	0.0568	0.0571	-0.0643	0.1779	0.3346
06-46-153	DP141 B2RF	0.0555	0.0571	-0.0656	0.1766	0.3458
TAM B-182-33	L-23	0.0505	0.0571	-0.0706	0.1716	0.3898
DP141 B2RF	DP1044 B2RF	0.0499	0.0571	-0.0712	0.1710	0.3955
DP0949 B2RF	DP0912 B2RF	0.0478	0.0571	-0.0733	0.1689	0.4151
DP0949 B2RF	08-1-1325	0.0468	0.0571	-0.0743	0.1678	0.4250
L-23	DP1048 B2RF	0.0467	0.0571	-0.0743	0.1678	0.4252
DP0949 B2RF	04-22-405	0.0451	0.0571	-0.0760	0.1662	0.4411
DP0949 B2RF	DP1028 B2RF	0.0446	0.0571	-0.0765	0.1657	0.4463
03 WZ-37	05-47-802	0.0442	0.0571	-0.0769	0.1653	0.4501
DP1048 B2RF	DP1044 B2RF	0.0442	0.0571	-0.0769	0.1653	0.4507
06-46-153	05-47-802	0.0426	0.0571	-0.0785	0.1637	0.4663
L-23	DP141 B2RF	0.0410	0.0571	-0.0801	0.1621	0.4830
CS-50	DP1048 B2RF	0.0404	0.0571	-0.0807	0.1615	0.4895
DP0949 B2RF	DP935 B2RF	0.0395	0.0571	-0.0816	0.1605	0.4997
TAM B-182-33	06-46-153	0.0360	0.0571	-0.0851	0.1571	0.5371
DP935 B2RF	DP1048 B2RF	0.0359	0.0571	-0.0851	0.1570	0.5381
03 WZ-37	DP0912 B2RF	0.0352	0.0571	-0.0859	0.1563	0.5465
DP0949 B2RF	CS-50	0.0350	0.0571	-0.0861	0.1561	0.5488
CS-50	DP141 B2RF	0.0347	0.0571	-0.0864	0.1558	0.5522
TAM B-182-33	03 WZ-37	0.0344	0.0571	-0.0866	0.1555	0.5550
03 WZ-37	08-1-1325	0.0342	0.0571	-0.0869	0.1552	0.5582
06-46-153	DP0912 B2RF	0.0336	0.0571	-0.0875	0.1547	0.5645
06-46-153	08-1-1325	0.0326	0.0571	-0.0885	0.1537	0.5765
03 WZ-37	04-22-405	0.0325	0.0571	-0.0886	0.1536	0.5770
03 WZ-37	DP1028 B2RF	0.0320	0.0571	-0.0891	0.1531	0.5831
06-46-153	04-22-405	0.0309	0.0571	-0.0902	0.1520	0.5956

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP1028 B2RF	DP1048 B2RF	0.0308	0.0571	-0.0903	0.1519	0.5972
06-46-153	DP1028 B2RF	0.0304	0.0571	-0.0907	0.1515	0.6018
04-22-405	DP1048 B2RF	0.0303	0.0571	-0.0908	0.1514	0.6034
DP935 B2RF	DP141 B2RF	0.0302	0.0571	-0.0909	0.1513	0.6040
DP0949 B2RF	L-23	0.0287	0.0571	-0.0924	0.1497	0.6228
08-1-1325	DP1048 B2RF	0.0286	0.0571	-0.0925	0.1497	0.6230
L-23	05-47-802	0.0282	0.0571	-0.0929	0.1493	0.6286
DP0912 B2RF	DP1048 B2RF	0.0276	0.0571	-0.0935	0.1487	0.6355
03 WZ-37	DP935 B2RF	0.0268	0.0571	-0.0942	0.1479	0.6447
06-46-153	DP935 B2RF	0.0253	0.0571	-0.0958	0.1463	0.6642
DP1028 B2RF	DP141 B2RF	0.0251	0.0571	-0.0960	0.1462	0.6665
04-22-405	DP141 B2RF	0.0246	0.0571	-0.0965	0.1456	0.6730
08-1-1325	DP141 B2RF	0.0229	0.0571	-0.0982	0.1440	0.6936
03 WZ-37	CS-50	0.0224	0.0571	-0.0987	0.1435	0.7003
DP0912 B2RF	DP141 B2RF	0.0219	0.0571	-0.0992	0.1430	0.7067
TAM B-182-33	DP0949 B2RF	0.0218	0.0571	-0.0993	0.1429	0.7072
CS-50	05-47-802	0.0218	0.0571	-0.0993	0.1429	0.7073
06-46-153	CS-50	0.0208	0.0571	-0.1003	0.1419	0.7206
L-23	DP0912 B2RF	0.0191	0.0571	-0.1019	0.1402	0.7419
05-47-802	DP1048 B2RF	0.0186	0.0571	-0.1025	0.1397	0.7493
L-23	08-1-1325	0.0181	0.0571	-0.1030	0.1392	0.7553
DP935 B2RF	05-47-802	0.0174	0.0571	-0.1037	0.1385	0.7650
L-23	04-22-405	0.0165	0.0571	-0.1046	0.1376	0.7768
03 WZ-37	L-23	0.0160	0.0571	-0.1050	0.1371	0.7824
L-23	DP1028 B2RF	0.0159	0.0571	-0.1051	0.1370	0.7837
06-46-153	L-23	0.0145	0.0571	-0.1066	0.1355	0.8034
DP0949 B2RF	06-46-153	0.0142	0.0571	-0.1069	0.1353	0.8069
05-47-802	DP141 B2RF	0.0129	0.0571	-0.1082	0.1339	0.8248
CS-50	DP0912 B2RF	0.0128	0.0571	-0.1083	0.1339	0.8254
DP0949 B2RF	03 WZ-37	0.0126	0.0571	-0.1085	0.1337	0.8282
DP1028 B2RF	05-47-802	0.0122	0.0571	-0.1089	0.1333	0.8332
CS-50	08-1-1325	0.0118	0.0571	-0.1093	0.1329	0.8393
04-22-405	05-47-802	0.0117	0.0571	-0.1094	0.1328	0.8403
L-23	DP935 B2RF	0.0108	0.0571	-0.1103	0.1319	0.8524
CS-50	04-22-405	0.0101	0.0571	-0.1110	0.1312	0.8614
08-1-1325	05-47-802	0.0101	0.0571	-0.1110	0.1312	0.8624
CS-50	DP1028 B2RF	0.0096	0.0571	-0.1115	0.1307	0.8685

Genotype	- Genotype	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
DP0912 B2RF	05-47-802	0.0090	0.0571	-0.1121	0.1301	0.8764
DP935 B2RF	DP0912 B2RF	0.0083	0.0571	-0.1127	0.1294	0.8857
DP935 B2RF	08-1-1325	0.0073	0.0571	-0.1138	0.1284	0.8998
L-23	CS-50	0.0063	0.0571	-0.1148	0.1274	0.9130
DP141 B2RF	DP1048 B2RF	0.0057	0.0571	-0.1154	0.1268	0.9215
DP935 B2RF	04-22-405	0.0057	0.0571	-0.1154	0.1268	0.9222
DP935 B2RF	DP1028 B2RF	0.0051	0.0571	-0.1159	0.1262	0.9293
CS-50	DP935 B2RF	0.0045	0.0571	-0.1166	0.1256	0.9387
DP1028 B2RF	DP0912 B2RF	0.0032	0.0571	-0.1179	0.1243	0.9561
04-22-405	DP0912 B2RF	0.0027	0.0571	-0.1184	0.1238	0.9633
DP1028 B2RF	08-1-1325	0.0022	0.0571	-0.1189	0.1233	0.9703
04-22-405	08-1-1325	0.0016	0.0571	-0.1195	0.1227	0.9775
03 WZ-37	06-46-153	0.0016	0.0571	-0.1195	0.1227	0.9782
08-1-1325	DP0912 B2RF	0.0010	0.0571	-0.1201	0.1221	0.9858
DP1028 B2RF	04-22-405	0.0005	0.0571	-0.1206	0.1216	0.9928

Difference = (Genotype – Genotype). Std Err Dif = Standard Error of Difference, Lower CL = Lower Confidence Level, Upper CL = Upper Confidence Level, p=Value – Probability Value