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Cotton Root Research

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# A Look at Young Cotton Plant's Roots in Drought and Low Temperature Situations

## Introduction and Hypothesis

The objective of this experiment is to determine if there is any difference in cotton plants' roots that are 20 days old that come from different breeding programs across the United States Cotton Belt, and that have temperature stresses of 22/14 degrees Celsius versus 30/22 degrees Celsius, and water stress of well watered versus drought stress. It's hypothesized that if the cotton breeding programs from which these were collected are furthering the adaptation of cotton to their area then the cultivars will show it. For example, there are cultivars being used from programs in New Mexico and Arizona, therefore, it is expected that these cultivars would do better in the drought stressed units than the cultivars from other areas.

## Materials

### SPAR Units

The experiment was conducted in the ten SPAR units on North Farm Research Center at Mississippi State University. SPAR stands for Soil-Plant-Atmosphere-Research. These units can control air temperature, atmospheric carbon dioxide, and water availability. Each chamber has a pot-holding area that is one meter deep by two meters long by half a meter wide. Each chamber also has a Plexiglas covering that measure two and a half meters tall by two meters long by one and a half meters wide. In order to maintain the temperature constraints and air-flow the units have a heating and cooling system each. Evapotranspiration can also be read by the units by capturing the condensation in the return air duct from the plants (Lokhande 2014).

**Structure Support**

The pots that the cotton plants are growing in are made out of a PVC material with a bottom glued in it. The soil media put in the pots is fine sand. Pea gravel was also put in the bottom 1\8 of the pots to allow drainage.

**Plant Material**

The cotton seed that is used comes from nine cultivars of a line known as 13RBTN. Each cultivar comes from a separate breeding program in a separate state. They are: 0504-4 pedigree Arkot 9608ne/Arkot 9314HG from Arkansas, PD05064 pedigree PD94042/FM989 from South Carolina, GA 2009100 pedigree GA 2002167/DeltaPEARL from Georgia, MD25-26ne pedigree MD 25 from Mississippi, LA09309116 pedigree LA00405034/DP393 from Louisiana, OA-33 pedigree OA44/OA-87 from Arizona, PX06520-42-2-1 pedigree SG 747/NM49//AGC85/4364-43 from Texas, AU10090 pedigree DES227/SG747 from Alabama, and Acala 1517-99 pedigree B7636 x LA 887 from New Mexico.

### Fertilizer

The fertilizer used is a nutrient solution known as Hogland Solution. This solution consists of macronutrients and micronutrients: calcium nitrate tetrahydrate, potassium nitrate, magnesium sulfate, monopotassium phosphate, ferric sodium salt, sodium chloride, manganese chloride tetrahydrate, boric acid, copper (II) sulfate, zinc sulfate heptahydrate, and ammonium molybdate tetrahydrate. The solution is mixed in and held in a 6000 liter tank.

## Method

### Getting Ready

The several weeks before the experiment began, clean (meaning that large debris was clean out of them); non-broken pots were set out in rows on the concrete pad in front of the SPAR units. This made it easier to fill the pots 1/8 of the way full with pea gravel. Starting on April 8, 2014 pots were beginning to be put in the SPAR units. Once all the 33 pots for each chamber were put into place they were filled 2/3 of the way full with sand. An approach of waiting to fill the pots while they were in the units was due to the fact that they would be heavier to lift if sand was placed in them before. While waiting for word of seed sources the pots were leisurely filled with sand three times before planting. The first time was to fill the pots 2/3 of the way full. The second time was to fill the up to within an inch of the top. The third was to complete fill the pots to the top and level them off. After every filling the sand was packed down by watering it in. During the second filling the moisture sensors were placed it in certain pot; one in the back column of pots, one in the middle column of pots, and one in the front column of pots. The three moisture sensors were placed in a loose pattern in every chamber. The first, back column sensor was placed in the third pot from the left (pot #9), the second, middle column sensor was placed three pots over and one pot forward of the first sensor (pot #17), and the third, front column sensor was placed three pots over and one pot forward of the second sensor, or the third pot from the right (pot #25). The sensors, themselves, were placed in the middle of the pots, away from the side of the PVC pots which could cause a mis-reading. On April 28 it was discovered that the soil moisture readings were not working properly, so readings were taken with a Theta Probe. Also during filling the pots, maintenance and cleanup was done on the SPAR units. Old debris from the last experiment was vacuumed up, mold was washed off of the surface areas, and sand was vacuumed up from the marginal areas of the chambers.

**Growing the Plants**

In the meantime, connections were made to obtain seed from several breeding programs across the United States Cotton Belt. When the seeds arrived, the order in which they would be placed in the chamber pots was randomized; however there was a pattern for which pots in each chamber were used for the nine cultivars. Units 1, 4, and 7 are in the same pot pattern; units 2, 5, and 8 are in the same pot pattern; and units 3, 6, and 9 are in the same pattern. The seeds were planted by hand. The holes that the seed were sown in were made by a homemade wooden hand tool that is made to fit down on the rim of the pots. On the bottom of the tool are four evenly spaced prongs that are about two to three inches apart, and about two inches long. Theoretically, one seed was placed in each hole; however it was evident that more than one was accidentally put in some of the holes when the seed sprouted. Another error that could have occurred with sowing the seed is that a planting hole could have been missed. When looking at the pots with less than four planting holes sprouting a seed, therefore, it could have been from missing the hole during planting or due to bad seed. The seeds were planted Thursday April 17, 2014. The first signs of sprouting were noticed on Saturday April 19. These first seedlings were from units 4 through 10; the optimal temperature units. As seeds sprouted and seedling appeared seedling counts were taken starting on April 22 and ending at April 26 for the optimal temperature units, and starting April 24 and ending April 27 for the low temperature units. In order to take seedling counts a definition of what a seedling is had to be determined. For this experiment, it was determined that a seedling is a sprouted seed that is standing erect out of the soil with both of its cotyledons fully opened. Water was gently sprayed over the seedlings at this time in order to remove any soil that may be holding the cotyledons together or keeping the seedlings from fully emerging, and to pack the soil around the base of the seedlings. This was not done starting on April 24 and afterward because the drought stress variable was implemented on units 7 through 9. On April 28 all but two seedlings were pulled out of each pot in the optimal temperature units.

**Unit Organization**

For this experiment nine pots per unit will be analyzed. Units 1 through 3 have a low temperature stress (22/14 Celsius), are well watered, and have 400 ppm carbon dioxide. Units 4 through 6 have an optimal temperature stress (30/22 Celsius), are well watered, and have 400 ppm carbon dioxide. Units 7 through 9 have an optimal temperature stress (30/22 Celsius), a drought stress, and 400 ppm carbon dioxide. Unit 10 is an extra chamber. It has an optimal temperature stress (30/22 Celsius), is well watered, and has 750 ppm carbon dioxide. The tenth chamber will be used as a guide for when the cotton plants should be pulled up. Since the plants in chamber 10 have an optimal growing environment they will grow faster and larger than the plants in the other chambers. This will give an estimate of where the plants in chambers 1 through 9 will be before they actually reach that point.

### Harvesting

The plants will be allowed to grow 20 days and then will be harvested. This will be done so that the roots of the plants will be small enough to take from the soil, and because they will be small enough to fit in the root scanner. Taking the roots from the soil will consist of dumping the contents of each pot on a sift and then running water over the root balls to clear any soil and debris. Once there is just plant material left and no soil the roots will be cut off in order to be scanned.

### Scanning

It is projected they the roots will be harvested and scanned around April 8 or 9. The scanner that will be used is a Regent Instruments machine; specifically an Epson Expression 11000XL along with a WinRHIZO software. Each root will be individually scanned and analyzed by the software to give in-depth measurements such as length, girth, etc.

## Results

### Seedling Counts and Temperature

The seedling counts show a direct relation to the temperature of the units. The seedlings in the optimal temperature units were up before the seedlings of the low temperature units. It could even be seen as the seedling got older; when the optimal temperature plants were showing signs of their mature leaves, three or four seedlings per pot in the low temperature units were beginning to be seen, whereas before only one or two seedlings were being seen in each pot and those were scattered around the units. In other studies it has been shown that that cotton grows and produces bolls in a particular range of temperature (Reddy 2008). Therefore, it is possible that this could be applied to young cotton plants' roots.

### Water Stress

The expected outcome in terms of water stress is that initially the plants in the drought stressed units will be smaller than the ones in the well watered units. However, this is somewhat dependent on the cultivar. It is believed that due to the local breeding programs of each state that the seeds were collected from that the seeds will have an adaption to that area. Therefore, the cultivars that come from Arizona and New Mexico would be expected to handle drought stress better than the other cultivars. Other studies have shown that when cotton is in a drought stress situation its tap root will be longer and thinner than that of well watered cotton (Pace 1999).

## Conclusion

The objective of this experiment is to determine if water availability and temperature affects the roots of twenty day old cotton plants. Halfway through the experiment the young plants have shown expected reactions to its specific environments; the plants under low temperature stress are much smaller than those in optimal temperatures. It is expected that at the end of the twenty days that the water availability stresses will be more evident, as well as the different reactions of each nine cultivars.

**References**


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