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INNOVATIVE IRRIGATION SCHEDULING FOR PEANUTS VIA THE USE OF ADVANCED TECHNOLOGY IN ALABAMA, FLORIDA, AND GEORGIA

FUNDING YEAR: 2016, **PRINCIPAL INVESTIGATOR:** WESLEY M PORTER
PROJECT PARTICIPANTS: UGA: GEORGE VELLIDIS, GLEN C. RAINS W. SCOTT MONFORT, CALVIN PERRY, **AUBURN/ACES:** KRIS BALKCOM, **UFL:** DIANE ROWLAND, BARRY TILLMAN

TOTAL FUNDS REQUESTED: $99,000: ALABAMA: $20,000, FLORIDA: $39,000, GEORGIA: $40,000

LOCATION FOR RESEARCH:

ALABAMA: WIREGRASS REC (HEADLAND, AL), GEORGIA: STRIPLING IRRIGATION RESEARCH PARK (CAMILLA, GA), AND ONE PRODUCTION FIELDS NEAR THIS REGION, FLORIDA: North FL Research and Extension Center - Suwannee Valley (Live Oak, FL)

NEW OR CONTINUING PROJECT: **CONTINUING, THIS IS A RENEWAL OF A 2 YEAR PROJECT.**

RATIONALE: Irrigation management is becoming increasingly important for peanut production with more than 50% of the peanut acreage in Georgia and Florida now irrigated. In Alabama, the irrigated acreage is smaller but increasing rapidly as the state is providing incentives for producers to adopt irrigation. With the resulting increase in demand for water resources, it is imperative that we develop and adopt technologies and strategies which maximize water use efficiency. Technology is changing at a rapid pace and needs to be adopted by agricultural production. Recent research in peanut growing states indicates that several "advanced" irrigation scheduling methods including soil moisture sensing or canopy temperature sensing can be an effective and efficient way to irrigate peanuts. The development of a crop water stress index (CWSI) for peanuts by Porter et al. (2015) has provided the beginning basis to use thermal sensors to determine irrigation thresholds for peanuts. In addition, there are web-based tools that use estimated crop evapotranspiration to schedule irrigation. Precision irrigation is a tool that can be used to implement all of these practices and is defined as varying the application rate of irrigation water across the field to meet the crop's measured demand or to manipulate physiology to improve crop water-use efficiency. Precision irrigation is made possible by two key technologies. The first is variable rate irrigation (VRI) for center pivot irrigation systems. The water conservation potential of the technology has been recognized by USDA-NRCS which provides 100% cost-share in Alabama and 75% cost-share in Georgia for VRI systems. The second critical technology is a cheap, rapid way to determine irrigation scheduling, whether by using irrigation trigger points for peanut based on plant or soil sensors or by ET based mobile irrigation scheduling tools to provide us with the data we need to calculate when and how much water to apply with our VRI systems. UGA has developed the UGA Smart Sensor Array (UGA SSA) and UF has developed PeanutFARM and Primed Acclimation, all of which meet these criteria. With NPB funding in 2015, these tools have been tested under VRI enabled pivots in Georgia and Florida. Continuing the partnership in 2016 among Georgia, Florida and Alabama, will provide us with multiple field and research locations to gather at least two years of validation data on the aforementioned technologies. We will concentrate efforts in 2016 on ground (sensor platforms) and aerial based (UAS) systems to collect NDVI (vegetative index) and other vegetation indices as well as thermal imaging for determining irrigation requirements.

OBJECTIVES: The main goal of this project is to utilize advanced technologies to determine optimum irrigation thresholds and amounts for peanut:

The secondary objectives are as follows:

Alabama, Georgia, and Florida:

- To evaluate advanced irrigation scheduling methods and determine water use requirements for commonly planted peanut varieties in Alabama, Florida, and Georgia.
- Assess the yield and water conservation benefits of utilizing VRI in combination with the UGA SSA, UF PeanutFARM, and PA to schedule irrigation on peanuts in Georgia and Florida on production fields in combination with a farmer as well as research trials.
- To further refine and utilize a thermal imaging method for implementing a CWSI strategy for scheduling irrigation on peanuts in Georgia.
- To investigate other imagery techniques for determining moisture stress and irrigation trigger points on peanut.

METHODS:

Advanced Irrigation Scheduling for Peanuts: We will use the Stripling Irrigation Research Park (SIRP) (Camilla, GA), North FL Research and Extension Center - Suwannee Valley (Live Oak, FL) and the Wiregrass REC (Headland, AL) to implement irrigation scheduling trials. The Georgia and Florida locations will be used to evaluate advanced sensing techniques for determining irrigation scheduling thresholds for peanut. Four irrigation treatment levels will be implemented utilizing a variety of technologies including soil moisture sensors. The four treatments will encompass a range of application levels, from water conservative to applications exceeding crop demand. Rainfed and a schedule based on CWSI treatment will be incorporated specifically in GA. For imaging purposes, data will be collected from each of these treatments using either a ground based sensor platform or an Unmanned Aerial System (UAS) equipped with two different sensors, one to determine NDVI and one thermal sensor. The range of treatments will be used to develop relationships of crop moisture stress to remote sensing techniques.

A sensor-based irrigation scheduling method, the PeanutFARM online scheduling tool, the UGA Checkbook method and rainfed (dryland) treatments will be evaluated in AL. The treatments will include grower based irrigation levels, rainfed, soil moisture sensor based scheduling, and scheduling using full PeanutFARM recommendations and PeanutFARM modified with Primed Acclimation. Treatments will be planted in randomized complete block design with at least three replicates at Wiregrass. Irrigation will be scheduled based on individual treatment thresholds. Water application will be done using VRI-enabled overhead irrigation. In all treatments, soil moisture conditions will be monitored. Either the UGA Checkbook method or the AL grower utilized schedule will be used as the standard to compare water conservation potential of the other treatments.

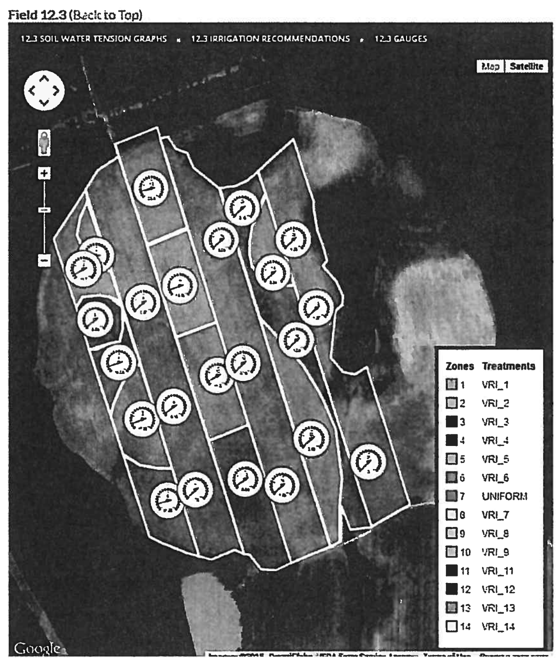

Figure 1. VRI Zones and field used for the 2015 on-farm VRI evaluation of dynamic VRI. The gages indicate the location of UGA SSA sensors.

<u>VRI Evaluation in Georgia:</u> – Precision Irrigation: During 2015, we identified a producer who has five fields equipped with VRI in southwestern Georgia. We used the 230 ac field shown in Figure 1 to conduct our study. The field was divided into alternating conventional irrigation and precision irrigation strips with each strip 72 rows wide (Figure 1). We used aerial photographs, soil maps, soil electrical conductivity, topography, yield history, producers' knowledge of the fields and geostatistical software to develop irrigation management zones (IMZs) in the precision irrigation strips. After planting and stand establishment we installed UGA SSA sensors in each of the IMZs. The data from the sensors is being used to dynamically develop irrigation scheduling recommendations for each IMZ. At each irrigation event, the sensor data from each IMZ are automatically converted into irrigation recommendations and then into a prescription map which is downloaded remotely to the pivot VRI controller. UGA SSA sensors were also installed in the conventional irrigation strips to monitor soil moisture conditions. The conventional strips are being irrigated uniformly based on the producer's recommendations. During 2015, the producer used Irrigator Pro to generate his recommendations. To date, the soil in the uniform strips is being maintained much wetter than in the VRI strips. At the end of the growing season we will harvest the field using two combines equipped with yield monitors. The parallel strips will allow us to directly compare yields between precision-irrigated and uniformly irrigated areas with similar soil and topographic properties and assess the benefits of dynamic VRI.

During 2016, the producer will rotate peanuts to an adjacent field which is also equipped with a VRI-enabled center pivot irrigation system. We propose to repeat the experiment in the adjacent field to determine if our findings from 2015 can be validated on a different field and in a different cropping year.

MEASURABLE OUTCOMES AND POTENTIAL IMPACT: We will provide an unbiased assessment of the advanced irrigation scheduling tools used in the study. We will report on the water use requirements for commonly planted varieties and make irrigation scheduling recommendations for them. We will also calculate total volumes of water used and water use efficiencies of each method. Finally, we will draw conclusions on the efficacy of using precision irrigation in peanuts. We will work towards developing relationships between rapid high frequency (UAS) remote sensing relationships to moisture stress and irrigation trigger levels for peanut. This data will provide information for persons interested in utilizing UASs in irrigation management decisions. Our results will be used by researchers, extension specialists, and extension agents to provide recommendations to producers in Alabama, Georgia, Florida, and other southeastern states. This information can help growers with timeliness in their farming operations. For years, growers planted peanuts in April to take advantage of soil moisture and to ensure that all of the peanut crop would be planted timely.

Potential Pitfalls: As with any on-the-farm project there are associated issues. We have tried to ensure that our methods prevent any opportunities for errors to occur. However, research schedules and production schedules do not always match, there could be instances where to producer does not feel comfortable following one of our recommendations and makes an independent decision. This could cause the data to not fully align with our research plots, but at the same time we want to have field level results, thus we are prepared to deal with these types of issues.

Progress to Date (03/17/17)

Two experiments were conducted in Florida in support of the project and were established under Variable Rate Irrigation Systems at: 1) Plant Science Research and Education Unit (PSREU) in Citra, FL; and 2) at the Suwannee Valley Agricultural Extension Center (SVAEC) in Live Oak, FL.

Project 1: PSREU

Experimental design: The field study was initiated in 2016 at the University of Florida's Plant Science Research and Education Unit in North Central Florida (29° 24' 38" N, 82° 10' 12" W). The soil is classified as an Arredondo sand (Loamy, siliceous, semiactive, hyperthermic Grossarenic Paleudults). Daily meteorological data is being recorded using an automated weather station located within 1500 m of the experiment. Rainfall is also being collected using a rain gauge placed within 200 m of the experiment (Spectrum Technologies, Inc., Aurora, IL).

Irrigation and peanut genotypes treatments were randomized in a split plot arrangement within a randomized complete block design. Irrigation treatments are the whole plots and peanut genotype is the sub-plot. Irrigation was applied using a lateral move system equipped with variable rate irrigation (VRI) (Lindsey Corporation, Omaha, NE). The irrigation treatments included: 1) irrigation scheduled using the University of Florida's PeanutFARM (PF) soil water mass balance scheduling tool with applications at a 1.9 cm amount for the entire season; 2) irrigation scheduled with tensiometers at an optimum application amount of 1.9 cm (100%) for the entire season; 3) managed using the treatment #2 to trigger irrigation but with an application of 1.1 cm until mid-bloom and 1.9cm following mid-bloom (PA); 4) irrigation triggered using #2 but with 1.1 cm application amount for the entire season (DI); and 5) a rainfed control. Irrigation in treatments 2, 3, and 4 are being triggered when tensiometers reach 25-35 kPa in the optimum irrigation treatment (100%) using tensiometers placed at 30 cm. (Irrometer Company, Inc., Riverside, CA) . Sub-plots were planted to four rows (7.6 meters in length with 0.91 meter between rows) of runner (*Arachis hypogaea*) type peanuts FloRun '107'™ and TUFRunner '511'™, and valencia (*Arachis fastigiata*) type peanuts New Mexico Valencia C and COC 041.

Calibrations were made to the 2015 PeanutFARM model and this adjusted model was used for irrigation scheduling in 2016. These calibrations were determined by adjusting the Kc values and durations (Figure 1) to simulate the models irrigation recommendation to the 2015 soil tension based irrigation scheduling.

Irrigation Treatments: Overall, the 2016 growing season has been relatively dry with only 3.0 cm of rainfall occurring in the month of July (Figure 2). A total of ten irrigation treatments were applied using the soil tension irrigation scheduling and nine irrigation treatments were applied using the PF model. Of the ten irrigation treatments scheduled, three of them were applied prior to mid-bloom.

Field Measurements: Volumetric water content has been recorded weekly since initiating irrigation treatments at depths of 10, 20, 30, 40, 60, and 100 cm using a Profiler Probe (Delta-T Devices Ltd, Cambridge, UK).

Maturity has been assessed by pod blasting and determined by the percentage of pods which are characterized by a brown/black pod exocarp. Mechanical digging of the two center rows of each plot occurred for the Valencia genotypes on 18 August. Plants were allowed to dry in the field and pods were separated from the peanut vines using a hand thrasher on 22 August. Peanut pods were then dried to approximately 10.5% water content. Valencia peanut genotypes yield the greatest in both the PeanutFARM (PF) and 100% irrigation treatment (Figure 3). No statistical differences in pod yield were observed between the PF and 100% irrigation treatment. The runner type peanut genotypes will be harvest on 19 September. Following the harvest and processing of all peanut genotypes, peanut pod grades will be quantified by determining total sound mature kernels (TSMK).

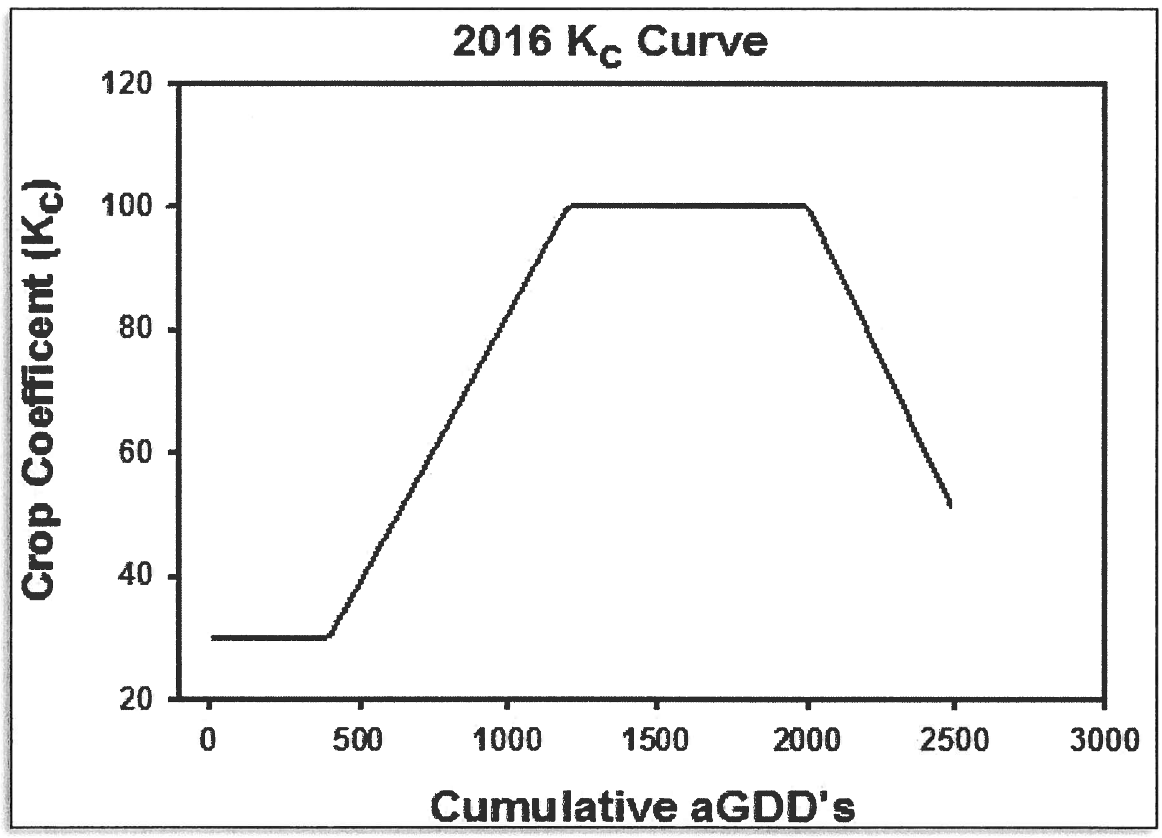

Figure 1: The 2016 PeanutFARM irrigation model crop coefficient curve (Abbreviations: aGDD, adjusted growing degree days).

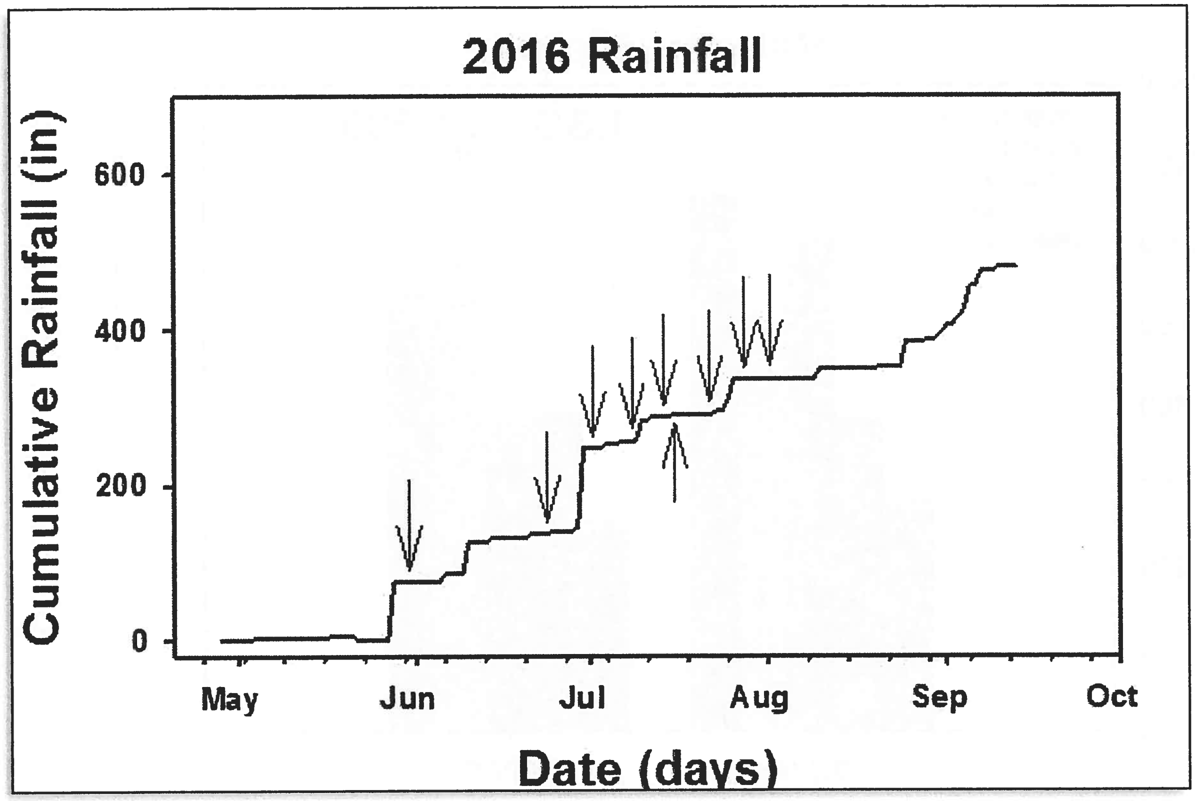

Figure 2: The 2016 cumulative rainfall. Arrows on the figure represent when a PeanutFARM scheduled irrigation treatment was applied.

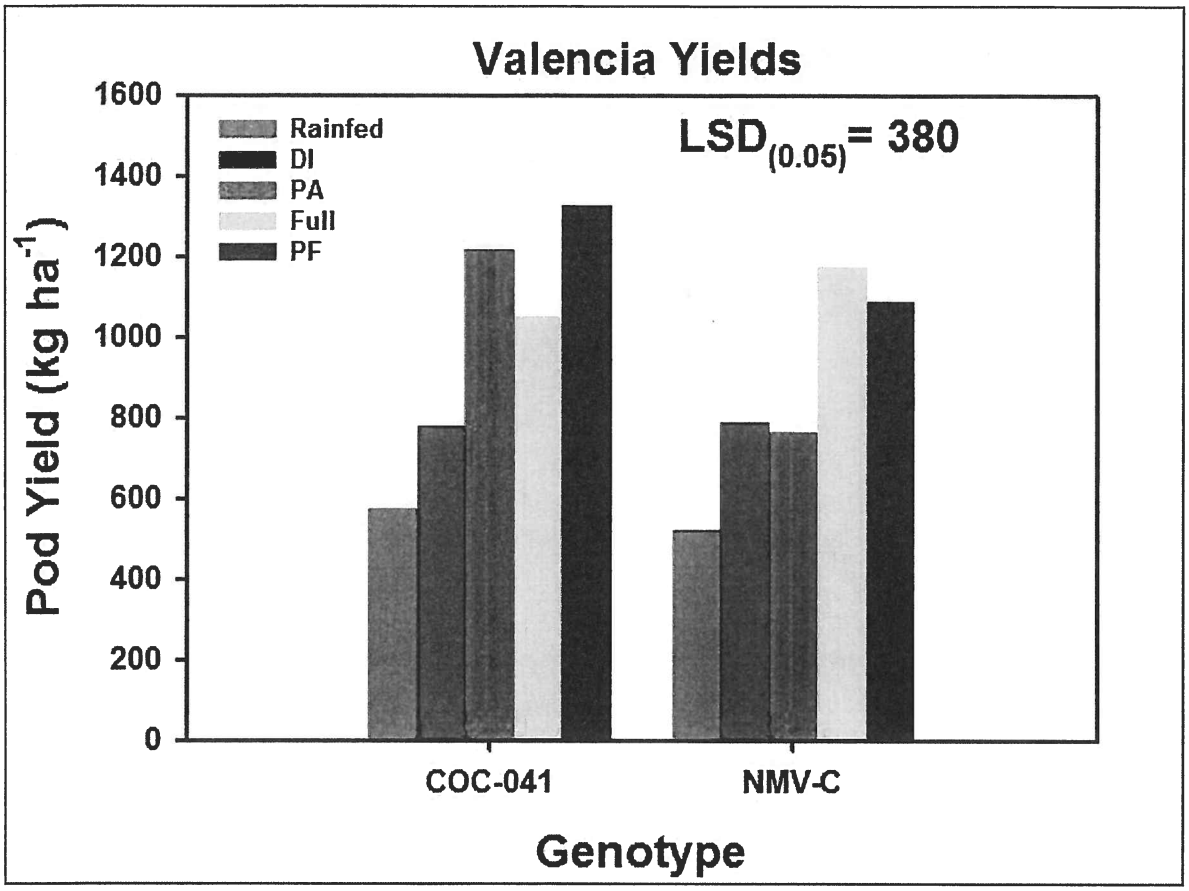

Figure 3: The 2016 valencia pod yields (Abbreviations: DI, Deficit; PA, primed acclimation; LSD, Fischer's protected least significant difference).

<u>Project 2: Live Oak</u>

Design

The experimental design included four replicate plots for each treatment. A total of 60 plots per crop (5 irrigation treatments x 3 fertility levels x 4 replicates) were monitored. Peanut was planted on 19 May, 2015.

Treatment structure

1. 5 irrigation treatments
   a. I1 (Rationale): irrigation mimicked peanut grower's irrigation practices.
   a. I2 (PeanutFARM): irrigation was determined using the PeanutFARM app. As part of the inputs, rainfall data was obtained from the FAWN weather station located in Live Oak, FL.
   b. I3 (SMS): using the SENTEK probes, moisture content of the soil was monitored and irrigation was determined using the maximum allowable depletion (MAD) and field capacity (FC) points to refill the soil profile with irrigation accordingly.
   c. I4 (60% I1- Reduced): it corresponded to the 60% irrigation of I1 (60% of peanut grower's irrigation practices). This represented a low irrigation treatment.
   d. I5 (NO): non-irrigated plots.

Field Management

On 15 March, the peanut field was harrowed and again on 11 May 2016 a few days before planting. No plowing was performed due to potential damage to lysimeter hoses. Peanut (Georgia 06G) was planted on 13 May 2016 at a row spacing of 30" and 5-6 seed/ft. for a total plant population approximately 90,000 seed/acre. At planting, a fungicide and an inoculant (i.e. Macho + Lift Inoculant) were applied through the planter directly in the furrow. A 500 lb/ac granular application of 3-7-28 was performed at 42 DAP and a gypsum application of 2000 lb/ac (i.e. GypsuMax) was performed at 41 DAP. Both products were broadcast with a Tag-Along spreader.

At harvest, Maturity level tests utilizing the hull scrape and profile board were performed to determine the harvest time. Digging was performed on 30 September 2016 at 140 after planting (DAP). Peanuts were dug using a digger KMC 236 DSI converted to 230 DSI. Peanuts were dried four days before harvest. Pods were harvested on 4 October 2016 using a KMC 3300 peanut combine.Yield determination was performed on the 7th and the 8th planting rows starting ten feet inside each plot to avoid border effects. A total length of 20 feet in each row were harvested for data analysis. The parameters measured per plot were: peanut weight and percentage of moisture (wet basis). All samples were taken to a drying facility located in PSREU, near Citra, FL. When average moisture reached 10.5%, the samples were removed from the driers and moisture content was taken (dry basis) on each sample.

The peanut growing season covered from 13 May to 30 September 2016 (planting and digging dates, respectively). During the crop season, cumulative rainfall and calculated ET_c summed up to 25.9 and 22.4 inches, respectively. A flat irrigation rate of 0.5" and 0.7" were applied across all plots the day before planting and on 15 May to apply herbicide. Irrigation treatments started on 1 June (19 DAP). Cumulative irrigation applied per treatment was: 21.7, 8.4, 8.1, 13.2 and 1.2 inches for I1, I2, I3, I4 and I5, respectively. Therefore, irrigation treatments applied about 61%, 63%, 39% and 94% less water than I1, which is intended to simulate peanut grower's irrigation practices. For the initial stages of the crop (May-July), monthly average rainfall was 13%, 58% and 45% below the historical average (Cum average May-July: 8.06" rainfall). And by contrast, excessive rainfall events occurred in August (monthly average 12.4") and September (5.52") resulting in a cumulative monthly average 49% and 9% above historical average (7" and 3.5", respectively). Due to the low water holding capacity characteristic of sandy soils, most of the rainfall was not used by the crop and thus, it was lost through drainage. VWC was evaluated at: I1, I3 and I5 irrigation treatments in the peanut experimental field. VWC ranges obtained at I1, I3 and I5 were: 0.05-0.11 in^3/in^3, 0.03-0.11 in^3/in^3 and 0.03-0.11 in^3/in^3, respectively. Similar VWC trends were found at each irrigation treatment across the year. VWC in I1 was higher in all soil layers throughout the season compared to the I3 and I5 VWC soil layers. However, I1 applied 43% and 95% more irrigation than I3 and I5, respectively. The first soil sampling in the peanut season was performed on May 11 (pre-planting); however, irrigation was not applied until May 12, to provide well-moisture conditions for planting. Hence, all treatments show low VWC during this sampling date. I1 kept constant high VWC across all peanut season averaging 0.09 in^3/in^3 (Figure 14). The I3 treatment fell below FC of the deepest layers during three sampling dates (20 June, 6 July and 25 July, Figure 15). However, after 20 June, VWC in I3 quickly increased in most of the soil layers. I5 prevailed below FC from 6 July until 19 September mostly on the deepest soil layers (Figure 16). Heavy rainfall events occurred on 8, 11 and 14 August (Cum. rainfall = 8.27"), helping increase moisture in all treatments, but especially in I5 treatment; however, most of that rainfall was ineffective for crop uptake and it was lost through leaching.

Final peanut yield means per irrigation treatment were: 7,201, 6,656, 6,695, 7,117, and 4,577 lb/ac for I1 through 5, respectively. I5 was significantly lower than the other four irrigation treatments (Figure 4).

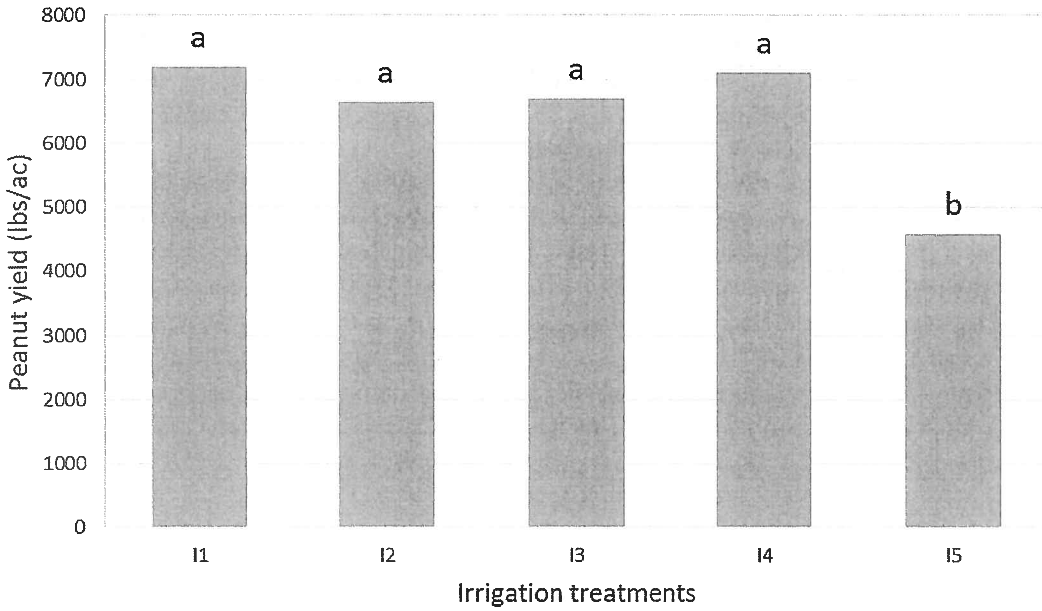

Figure 4. Average peanut yield data across irrigation treatments. Data standardized for 10.5% moisture. Different letters indicate differences at the 95% CI for irrigation treatment means.