I. **Identification**

**Title:** Expanding the PeanutFARM tools to offer a Smartphone app to peanut growers  
**Funding Year:** January 1, 2015 – June 1, 2016  
**Investigators:** Diane Rowland, Barry Tillman, Elena Toro, University of Florida, (dirowland@ufl.edu; 229-869-2952); Wilson Faircloth, Syngenta, Inc., (wilson.faircloth@gmail.com; 229-854-0278); Kris Balkom, Auburn Univ., (balkckb@auburn.edu; 334-693-2010); Scott Monfort, Scott Tubbs, George Vellidis, Univ. of Georgia, (tubbs@uga.edu; 229-386-3360)  
**Total Funds Requested:** $72,978  
**Locations:** Florida, Georgia, Alabama  
**Continued Project:** Three years of previous support have been received; it is anticipated that a minimum of 1-2 additional years of support is needed to continue to validate tools and launch them on a Smartphone App platform. Continued minimal support for maintenance of the website is also anticipated.

II. **Layman’s Summary:** To remain both economically and environmentally sustainable, peanut growers require access to new technologies and tools that can maximize production through improved agronomic management of their peanut crop, including in-season and harvest decisions. With the release of the web based tool, Peanut FARM (Field Agronomic Resource Manager) funded in part by the NPB/SPRI program in 2012-2014, growers now have access to a suite of tools on a web platform. **TOOL #1: Peanut maturity predictor.** An adjusted growing degree day (aGDD) model for predicting peanut maturity has been incorporated into a web platform and was launched for the 2013 growing season. **TOOL #2: Irrigation Scheduling System.** Launched with the aGDD tool in 2013, this tool utilizes cumulative aGDD’s and ET to estimate crop water use and provides daily irrigation recommendations. **TOOL #3: Digital imaging model (DIM).** Our team has finalized the development of DIM to assess peanut maturity and have successfully translated the digital analysis of mesocarp color into a digging date prediction. We are currently developing a web platform for the tool on the PeanutFARM site. We now propose to launch the tools available on PeanutFARM on a Smartphone App to increase the platform options to growers and make these tools more accessible to growers while working in the field.

III. **Project Purpose:** Both the aGDD and DIM methods have been rigorously tested in GA, FL, and AL over the last three years and analysis of their harvest prediction is indicating at least equal performance with the widely accepted maturity profile board (Williams and Drexler 1981), but with less analysis time and subjectivity. Accumulated aGDD values can be used to predict crop developmental stage in-season and have been incorporated into an irrigation scheduling model. The launching of these tools on a web platform has now made them freely accessible to growers across the tri-state area and there have been over 150 growers and researchers registered as users to date. Anecdotal reports from growers and data from research trials indicates that the irrigation scheduling and harvest predictions work well. Further validation testing will help us identify any problems with these models and continue to refine and perfect them. In this current request, we propose
to expand the platform delivery for these tools to a Smartphone App. This would allow growers to access the PeanutFARM recommendations while in the field and to reach a set of growers that prefer Smartphone App platforms over web delivery. This is a multi-year project.

IV. Hypothesis and Objectives: We hypothesize that growers can manage peanut irrigation scheduling and maturity predictions effectively through a set of weather-based algorithms centered on the calculation of aGDDs using either a web based system or a Smartphone App. We propose continued testing and refining of these tools that will be used on both platforms along with the development of a Smartphone App that incorporates these tools with some added features. The specific objectives are: 1) continued testing and validation of the PeanutFARM tools including the aGDD maturity model, the irrigation scheduling model, and the DIM model for peanut pod color analysis via web upload; and 2) develop a Smartphone App platform that will deliver these tools on a Smartphone platform in the field. Objective 1: We expect to continue testing the aGDD model and DIM with samples collected from grower cooperator fields in GA, AL, and FL and on research plots at UF, UGA, and Auburn. Objective 2: We will work with our established web designer to develop the Smartphone App, enabling growers to access their field data and the tools from the App platform.

V. Experimental Plan and Methods: We will accomplish the objectives through the following tasks:
Task 1: Continued testing of PeanutFARM harvest and irrigation tools as well as the new DIM upload capability on the website with extension agents and growers in 2015 on 2-3 farms or research plots each in FL, and AL. Continued validation of the tools on PeanutFARM for current and future cultivars and regions is important for insuring the model’s performance under varying climatic and regional conditions.
Task 2: Develop a Smartphone App that will either initiate a new PeanutFARM account when utilized by a grower or make an existing account accessible on the Smartphone platform. Other options that we propose for the Smartphone App platform: 1) an option to have the GPS locator capability of the Smartphone App automatically locate and associate the closest weather station from the PeanutFARM database when initiating a new field; 2) use of a hand scanner or phone camera to image pods in the field and upload from a Smartphone to utilize the DIM tool of PeanutFARM; and 3) automated text messages indicating irrigation scheduled events from PeanutFARM.

VI. Measurable Outcomes and Potential Impacts: The PeanutFARM website was launched during the 2013 growing season and currently has over 150 registered grower and researcher users across GA, FL, and AL. Distribution via the internet of these tools has and will continue to make widespread adoption both fast and simple. Refinement of existing tools and further development of additional platforms, such as the Smartphone App, will increase user adoption and add beneficial economic impacts for southeastern peanut growers. The importance of peanut maturity is becoming even more clear through other NPB sponsored projects, and we already know that a 1-point average grade increase through improved harvest prediction on as few as 1% of US acres could easily pay for 2-3 years of this study. Providing an efficient irrigation scheduling tool easily delivered via the web or Smartphone App could decrease irrigation costs and demonstrate grower stewardship of water resources.

VII. Potential Pitfalls: None.

VIII. Budget: Please see attached.

IX. Proposed Percentage of Any Revenue Generated by the Project to be Reinvested in Peanut Research (after payment of costs): 100%
Final Report

Task 1: Continued testing of PeanutFARM harvest and irrigation tools as well as the new DIM upload capability on the website with extension agents and growers in 2015 on 2-3 farms or research plots each in FL, and AL. Continued validation of the tools on PeanutFARM for current and future cultivars and regions is important for insuring the model’s performance under varying climatic and regional conditions.

This task was accomplished through validation of harvest and irrigation tools in plots at the Plant Science Research and Education Unit in Citra, FL; a research trial at the Suwannee Valley Agricultural Extension Center (SVAEC) in Live Oak, FL; and harvest clinics held at SVAEC.

PSREU Site - 2015

Materials and Methods:

Site characteristics and experimental design

The field study was initiated in 2015 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 will be recorded using an automated weather station located within 1500 m of the experiment. Rainfall was collected using a data logging rain gauge placed within 200 m of the experiment (Spectrum Technologies, Inc., Aurora, IL).

Irrigation and peanut genotypes treatments were randomized in complete block with a split plot arrangement with irrigation as the whole plot and peanut genotype as 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 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) PA managed using the treatment #2 to trigger irrigation but with an application of 1.1 cm until mid-bloom and 1.9 cm following mic-bloom; 4) irrigation triggered using #2 but with 1.1 cm application amount for the entire season; and 5) a rainfed control. The tensiometer treatment had sensors installed at 0.31, 0.70, and 0.91 m (Irrrometer Company, Inc., Riverside, CA). Irrigation in treatments 2, 3, and 4 were triggered when the tensiometers reach 25-35 kPa in the optimum irrigation treatment (100%) using tensiometers placed at 30 cm. 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 ‘S11™’, and valencia (Arachis fastigiate) type peanuts New Mexico Valencia C and C0C 041.

Field Measurements:

Ten composite soil cores were collected per rep prior to planting and analyzed to a depth of 0-40 cm for macro and micro nutrients. Volumetric soil moisture was record prior to an irrigation treatment at depths of 10, 20, 30, 40, 60, and 100 cm using a Profiler Probe (Delta-T Devices Ltd, Cambridge, UK). Volumetric soil water content was also measured 2 and 4 days after an irrigation treatment.

Mini-Rhizotron tubes were installed centered and parallel to the row immediately after peanut emergence at a 45° angle to a target depth of 1.0 m. Images were recorded every 1.3 cm using a BTC 100X camera (Bartz Technology Corporation, Carpinteria, CA). Root imaging occurred on a weekly basis during early crop development. As root growth slows later in the season, root imaging occurred every 2-4 weeks. These images were analyzed using Win RHIZOTRON software for root length, diameter, area and volume (Reagent Instruments INC., Quebec, Canada).

Canopy assessment of leaf area index (LAI) was initiated at approximately 30 DAP (LI-COR, Lincoln, Nebraska). Measurement intervals for leaf area index (LAI) occurred weekly early in the growing season, and subsequently every 2-4 weeks later in the growing season (LI-COR, Lincoln, Nebraska). Infrared temperature
(IRT) sensors were installed to monitor peanut canopy temperatures from about 45 DAP to harvest (SmartCrop, Lubbock, TX).

At optimum maturity, mechanical digging of the two center rows occurred and pods were separated from the vines using a mechanical thresher. Pod yield were determined at target moisture of 10.5%. Peanut grade was also measured as total sound mature kernels (TSMK).

Results:

Figure 1 shows the measured differences in soil moisture among treatments by depth. Both canopy and root development varied among the peanut genotypes over the growing season. Measurements of leaf area index (LAI) after 48 days after planting (DAP) showed an increased amount of leaf area index when comparing the runner (TUFRunner™ '511' and FloRun™ '107') to the valencia (New Mexico Valencia C and COC 041) peanuts (Figure 2). The opposite trend was observed with the total amount of measured root length over the growing season. This trend was increased amounts of total root length following 35 DAP when comparing valencia to runner peanuts.

Pod yield of particular peanut genotypes did vary among the irrigation treatments (Table 1). These differences were an increase in pod yield when comparing the 100% irrigation treatment to both the PeanutFARM scheduling and rainfed control irrigation treatments for peanut genotypes of COC 041 and FloRun™'511'. No differences in pod yield occurred among the irrigation treatments with peanut genotypes of New Mexico Valencia C and TUFRunner™ '511'. The 100% treatment had similar yields to the 60% and 60PA irrigation treatments for all genotypes. Irrigation treatments were also averaged across genotypes for an overall impact of the irrigation effect on pod yield of all genotypes. These results indicate the 60% and 60%PA to be the optimum water treatments since they had similar pod yields to the 100% treatment (Figure 3 for valencia yields).

The overall findings of this research suggest that the two valencia peanuts partition more assimilates for root growth versus canopy growth when compared to the two runner genotypes in this study. Furthermore, the root growth continues to increase in the valencia's later into the growing season when reproductive growth is occurring. As a result of increased growth partitioning to roots, and decreased canopy growth later into the growing season/reproductive growth, the valencia peanuts have significantly less yield potential than the runner peanuts.

Model Calibration

Prior to the growing season, the PeanutFARM irrigation scheduling tool was modified based on field validation from the 2014 growing season. These modifications included decreasing the Kc values for the early and late portions of the growing season. The late season modifications proved to be successful in the fact that PeanutFARM did not call for irrigation when adequate amounts of rainfall were received post 50 DAP during the 2015 growing season. However, the early season adjustment was conservative in its water application resulting in pod yield decreases in comparison to the 100% irrigation treatment. Therefore, adjustments were made to the initial Kc to match the 100% irrigation treatment. This calibrated model is currently being validated in the 2016 field trial (Figure 4).
Table 1. Average pod yield for each genotype and irrigation treatment. Treatments with different letters indicate statistical difference using the Tukey-Kramer pairwise comparisons test at P < 0.05 (Abbreviations: NMVC, New Mexico Valencia C; 100%, full irrigation; 60%, Water application of 60% of the full treatment for the entire season; 60%PA; 60%PA, Water application of 60% of the full treatment for first 50 DAP; PF, PeanutFARM irrigation scheduling; RF, Rain-fed control).

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>NMVC</th>
<th>COC 041</th>
<th>TUFRunner™ '511'</th>
<th>FloRun™ '107'</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>2836 a</td>
<td>2782 a</td>
<td>4550 a</td>
<td>5440 a</td>
</tr>
<tr>
<td>60%</td>
<td>2618 a</td>
<td>2245 ab</td>
<td>4467 a</td>
<td>4810 ab</td>
</tr>
<tr>
<td>60%PA</td>
<td>2708 a</td>
<td>2221 ab</td>
<td>4384 a</td>
<td>4411 ab</td>
</tr>
<tr>
<td>PF</td>
<td>2527 a</td>
<td>1728 b</td>
<td>4444 a</td>
<td>4373 b</td>
</tr>
<tr>
<td>RF</td>
<td>1964 a</td>
<td>1659 b</td>
<td>4091 a</td>
<td>4209 b</td>
</tr>
</tbody>
</table>

Figure 1. Volumetric water content for each irrigation treatment at soil depths of 10, 20, 30, 40, and 60 cm. Arrows indicate the soil moisture measurement prior to an irrigation application. Daily rainfall is also reported for this time period.
Figure 2. Leaf area index averaged across each irrigation treatment for all genotypes.

Figure 3. Average pod yield of Valencia genotypes for each irrigation treatment.
Figure 4: The 2016 PeanutFARM irrigation model crop coefficient curve (Abbreviations: aGDD, adjusted growing degree days).

SVAEC 2015

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.
   b. 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.
   c. 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.
   d. 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.
   e. I5 (NO): non-irrigated plots.

Table 1. Treatment irrigation applied based on programmed ARs in VR.

<table>
<thead>
<tr>
<th>Date</th>
<th>I1</th>
<th>I2</th>
<th>I3</th>
<th>I4</th>
<th>I5</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/10/2015</td>
<td>0.5</td>
<td>-</td>
<td>-</td>
<td>0.3</td>
<td>-</td>
</tr>
<tr>
<td>7/13/2015</td>
<td>-</td>
<td>-</td>
<td>0.6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7/15/2015</td>
<td>0.5</td>
<td>0.5</td>
<td>-</td>
<td>0.3</td>
<td>-</td>
</tr>
</tbody>
</table>
7/24/2015  0.7  -   0.4  0.4  -
7/31/2015  0.7  -   -   0.4  -
8/14/2015  0.7  -   -   0.4  -
8/21/2015  0.7  -   -   0.4  -
8/31/2015  0.7  -   -   0.4  -
9/4/2015   0.7  -   -   0.4  -

Cumulative water applied to each treatment

a. I1 (Rationale): 5.2 in
e. I2 (SWB): 0.5 in
f. I3 (SMS): 1 in
g. I4 (60% I1- Reduced): 3 in
h. I5 (NO): 0 in

Total Rainfall (5/19 – 10/8) = 25.52 in
Total Rainfall (5/19 – 10/8) = 21.05 in

Cumulative Irrigation: (see Figure 5)

Figure 5. Treatment cumulative irrigation (in) applied based on programmed ARs in VRI.

Types of data collected
1. Soil moisture: a total of 27 SENTEK probes were installed at each crop. Each probe contains nine sensors which take readings of:
   a. Soil moisture content (SMC)
   b. Electric conductivity (EC)
   c. Temperature
   Sensors are installed at 2, 6, 10, 14, 18, 22, 26, 30, 34 inches depth within the probes. Probes were installed in the I3 treatments only.

2. Biomass data
Plant tissue sampling was conducted 4 times over the cropping season (including at harvest) to measure N uptake of the crop over time (see below).

Results – 2015
The peanut crop season started on 19 May (planting day) and ended on 16 October 2015 (digging day). During the crop season, cumulative rainfall and calculated ET, summed up to 26.9 and 20.4 inches, respectively. The first irrigation event occurred on 10 July (52 DAP), when irrigation treatments started. Cumulative irrigation applied per treatment was: 5.2, 0.5, 1.0, 3.0 and 0.0 inches for I1, I2, I3, I4 and I5, respectively (Figure 5). Therefore, irrigation treatments applied about 90%, 81%, 42% and 100% less water than I1, which is intended to simulate peanut grower’s irrigation practices. Due to the consistent rainfall patterns, peanut required relatively little irrigation throughout the season.

Average dry weight, dry matter and percent of N in stem, pod and root obtained from all tissue samplings performed at I3 treatment is shown in Table 2. Average stem dry weight increased during the second sampling and reached its highest level. Afterwards, stem decreased gradually in the season. Average root dry weight increased during the second sampling and reached its highest level. Afterwards, root DW decreased gradually until harvest. From the results obtained in September 1, the highest percent N was obtained in the pod; whereas the leaf and root show similar N % (2.7 and 2.6, respectively).

Table 2. Average dry weight (g), dry matter (%) and N (%) per plant sections (stem, pod and root) from all tissue samplings performed at I3 treatment in peanut.

<table>
<thead>
<tr>
<th>Plant section</th>
<th>17-Jul</th>
<th>1-Sep</th>
<th>2-Oct</th>
<th>12-Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf</td>
<td>-</td>
<td>756.5</td>
<td>727.1</td>
<td>607.9</td>
</tr>
<tr>
<td>Pod</td>
<td>15.9</td>
<td>356.4</td>
<td>484.6</td>
<td>571.9</td>
</tr>
<tr>
<td>Root</td>
<td>8.6</td>
<td>30.4</td>
<td>23.8</td>
<td>20.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plant section</th>
<th>17-Jul</th>
<th>1-Sep</th>
<th>2-Oct</th>
<th>12-Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf</td>
<td>-</td>
<td>92.5</td>
<td>94.3</td>
<td>-</td>
</tr>
<tr>
<td>Pod</td>
<td>-</td>
<td>97.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Root</td>
<td>-</td>
<td>94.4</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plant section</th>
<th>17-Jul</th>
<th>1-Sep</th>
<th>2-Oct</th>
<th>12-Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf</td>
<td>-</td>
<td>3.9</td>
<td>2.7</td>
<td>-</td>
</tr>
<tr>
<td>Pod</td>
<td>-</td>
<td>4.1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Root</td>
<td>-</td>
<td>2.6</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

(-) indicates plant section not sampled or results not analyzed yet. N (%) obtained from TKN analysis at each plant section.

Table 3 shows the average dry weight in stem, pod and root obtained at all irrigation treatments at harvest (final sampling). Also, a summary of plant number, canopy width and total peanut per irrigation treatment is presented in Table 8. Similar patterns were found in all irrigation treatments at each of these parameters.

Table 3. Average dry weight (g) per plant sections (stem, pod and root), plant number, canopy width and total peanuts obtained at the irrigation treatments during final sampling (pre-harvest).

<table>
<thead>
<tr>
<th>Irrigation Treatment</th>
<th>Dry Weight (g)</th>
<th>Plant #</th>
<th>Canopy width (cm)</th>
<th>Total Peanut #</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1</td>
<td>Stem 630.2</td>
<td>Pod 574.6</td>
<td>Root 17.4</td>
<td>40.0</td>
</tr>
<tr>
<td>I2</td>
<td>Stem 580.9</td>
<td>Pod 535.8</td>
<td>Root 18.2</td>
<td>41.9</td>
</tr>
</tbody>
</table>
I3  607.9  571.9  20.5  12.9  39.1  466.3
I4  597.0  533.7  18.5  11.5  39.8  427.6
I5  646.4  587.0  18.3  12.9  38.5  510.3

Overall Avg.  612.5  560.6  18.6  12.3  39.9  485.6
STD              26.1  24.3  1.1  0.6  1.3  38.4

Final peanut yield per irrigation treatment were: 6068, 6502, 6687, 5938 and 6244 lb/ac for I1 through I5, respectively. No significant differences among the treatments were found (Figure 6).

![Figure 6. 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.](image)

**Task 2:** Develop a Smartphone App that will either initiate a new PeanutFARM account when utilized by a grower or make an existing account accessible on the Smartphone platform. Other options that we proposed for the Smartphone App platform: 1) an option to have the GPS locator capability of the Smartphone App automatically locate and associate the closest weather station from the PeanutFARM database when initiating a new field; 2) use of a hand scanner or phone camera to image pods in the field and upload from a Smartphone to utilize the DIM tool of PeanutFARM; and 3) automated text messages indicating irrigation scheduled events from PeanutFARM.

The smartphone app was developed and delivered during this period (Figure 7). It includes a GPS locator option and other mapping techniques for growers. This platform is identical to the desktop layout and data access if maintained, allowing growers to move seamlessly between the desktop and smartphone platform. Development of the beta version of the app is complete. The version will be ready to test for the 2016 growing season. Continued discussion with the web designer is ongoing to refinement and tool accessibility. The opening screen of the app is shown in Figure 7.
PeanutPROFILE was refined during this period. The Peanut Profile Project established auto analyzing in the Fall of 2015 for uploaded digital images. The website allows users to fill out a form (Figure 8), upload an image and receive results within 24 hours that will provide harvesting details for the farm that the sample was taken from on the main webpage for PeanutPROFILE (Figure 9). The automated script takes place on a secure server and will send the results back to the email that was submitted with the form. Additional tests are being run to compare images taken with smartphone cameras as opposed to the scanning using a flatbed copier/printer. We have not been able to successfully achieve images in a repeatable manner utilizing this technique, but tests will continue.
Figure 9: Opening screenshot showing PeanutPROFILE tool.