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Summary NPB Report for 2017 Project, Wesley Porter, Vasileios Liakos, George Vellidis

Irrigation is applied to crops when precipitation is not sufficient in a specific time period. However, the amount and the time of an irrigation event depends on many factors and several calculations should be carried out; this requires time and effort with the possibility of making mistakes. Hence the University of Georgia developed the University of Georgia Smart Sensor Array system (UGA SSA) which records soil moisture data utilizing inexpensive soil water tension sensors (Watermarks®) and combined it to work with any Variable Rate Irrigation (VRI) system. In addition the UGA SSA also consists of a website which presents the recorded soil moisture data within a field and also works as Decision Support Tool (DST) as it recommends water allocations based on the soil moisture data to increase irrigation water efficiency. The objective of this project was to evaluate the performance of VRI and the UGA SSA in Georgia. The irrigation experiment was carried out during the 2017 growing season in a peanut field located at Leary, Ga. The center pivot of the field was equipped with VRI technology. Before planting the VRI system was tested for uniformity to ensure it was evenly and adequately applying irrigation. After realizing that the pivot and the VRI system were working properly the field was divided into Irrigation Management Zones (IMZs) by using field properties such as soil electric conductivity, elevation data, hydrology data, historical aerial images of the field and satellite images. The IMZs were delineated by using UGA's EZZone software. After IMZ delineation, the field was divided into eight alternating conventional irrigation and dynamic VRI strips. In four of the eight strips, irrigation scheduling was based on the Irrigator Pro soil temperature scheduling recommendations and the irrigation water applied uniformly. The other four strips were irrigated individually based on UGA SSA recommendations. After planting, UGA SSA sensors were installed in each of the IMZs. Additionally, we installed several tipping bucket rain gages close to the nodes to evaluate the VRI system performance and understand how fast the UGA SSA nodes respond. During the 2017 growing season the UGA SSA website was checked every morning to create prescription maps. The field was harvested on approximately 10/18/17. The yield recorded by weighting trailers with the yield of each strip. Additionally, extra data such as peanut moisture and foreign material were taken into account for the yield calculation of each strip. The strip by strip data analysis (Table 1) showed that the UGA SSA/VRI treatment had a 3.6% higher yield than the strips which were irrigated based on the Irrigator Pro recommendations. Furthermore the soil water tension at the strips where the UGA SSA irrigation recommendations were applied was 2.14 % less (more wet soil) than at the control strips. On the other hand, the strips which were irrigated conventionally received 25% more irrigation than the strips which were irrigated with the VRI system. Moreover the Irrigation Water Use Efficiency (IWUE) which shows how many pounds per acres of yield were produced per inch of water was always higher in the UGASSA/VRI strips than in the Irrigator Pro strips. This means that in addition to the higher yield in the strips which were irrigated based on the UGA SSA method the IWUE of these strips was 38.2 % higher than the Irrigator Pro method showing that the UGA SSA in combination with a VRI control system on a pivot can increase the IWUE of the crop.

Table 1. Total irrigation, yield, IWUE, and weighted average of the three soil moisture sensors (SWT) for each strip.

Treatment	Irrigation (mm)	Irrigation Difference (mm)	Yield (lbs/ac)	Yield Difference (lbs/ac)	IWUE (lbs/ac/in)	IWUE Difference (lbs/ac/in)	SWT- Weighted Average (kPa)	SWT Difference (%)
VRI 1	3.0	-1.8	3830	-1632	1277	139	41.34	-16.34
Uni 1	4.8		5462		1138		49.42	
VRI 2	3.3	-1.5	6077	689	1841	719	63.6	-26.6
Uni 2	4.8		5388		1123		86.76	
VRI 3	4.1	-0.7	6518	1477	1590	539	44.78	59.3
Uni 3	4.8		5042		1051		28.11	
VRI 4	4.0	-0.8	4526	206	1132	231	36.23	40.75
Uni 4	4.8		4320		900		25.74	
VRI avg	3.6	-1.2	5238	185	1456	403	46.48	-2.14
Uni avg	4.8		5053		1053		47.5	

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Final Report for 2017 NPB Project

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VRI Evaluation in Georgia for 2017: The experiment was carried out during the 2017 growing season on a 91 ac commercial peanut field located near Leary of Georgia, USA. Initially the field was divided into Irrigation Management Zones (IMZs) by using field properties such as soil electric conductivity, elevation data, hydrology data which simulate how the water flows within the field, historical aerial images of the field and satellite images as well. The IMZs were delineated by using UGA's EZZone software (https://ezzone.pythonanywhere.com/). This software is a free online resource for delineating Agricultural Management Zones from univariate georeferenced data. After IMZ delineation, the field was divided into alternating conventional irrigation and dynamic VRI strips. There were 8 total strips and the width of each strip was 120 rows (Figure 1). In four of the eight strips, irrigation scheduling was based on the IrrigatorPro soil temperature scheduling recommendations and the irrigation water applied uniformly. IrrigatorPro is a computerized expert system designed to manage peanut irrigation and pest management decisions. The version of IrrigatorPro used in this study uses precipitation and soil and ambient temperature to make irrigation decisions. It is widely used in the southeastern USA by consultants and some farmers to schedule irrigation. It is used regularly by the grower who cooperated with us in this study as well. The other four strips were divided into IMZs which were irrigated individually based on UGA SSA recommendations.

Figure 1. The eight strips where the two different irrigation treatments were applied. The yellow areas show the buffer zones of each strip.

After planting, University of Georgia Smart Sensor Array (UGA SSA) sensors were installed in each of the IMZs. The UGA SSA control system which was installed in the field consists of a wireless soil moisture sensing array with thirty sensor nodes and a web-based user interface (Figure 2). A detailed description of the UGA SSA system was presented from Liakos *et al.* (2015). Additionally, we installed several tipping bucket rain gages close to the nodes to evaluate the VRI system performance and understand how fast the UGA SSA nodes respond. The readings from the rain gages proved to be helpful for analyzing the performance of each treatment and calculating the irrigation water use efficiency.

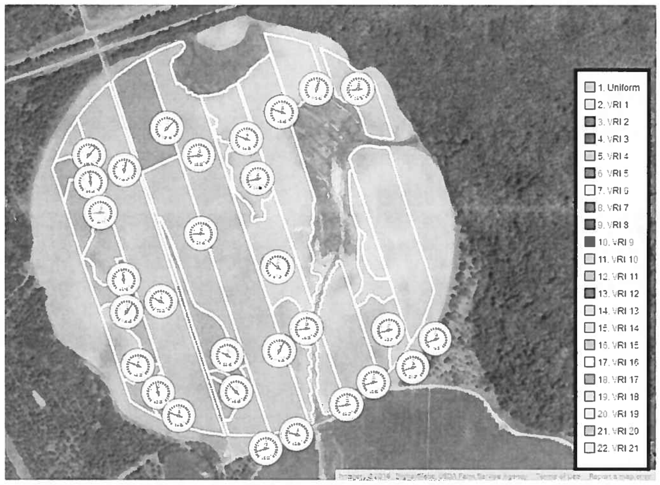

Figure 2. Each gage shows the exact location of each node within the field and the weighted average of the three soil moisture sensors.

During the 2017 growing season the UGA SSA website was checked every morning to create prescription maps (Figure 3). The UGA SSA website in addition to presenting the soil moisture data also works as a Decision Support Tool (DST) because it recommends water allocations based on the latest soil moisture readings.

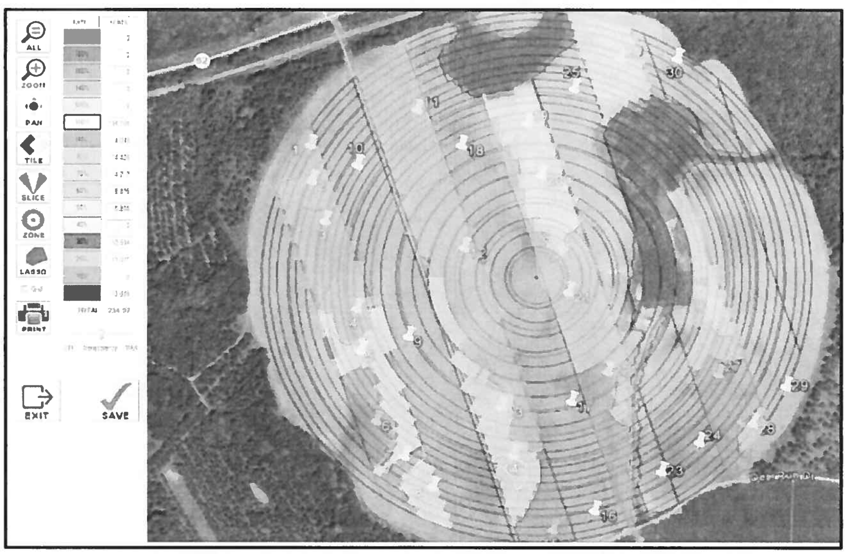

Figure 3. An example of a prescription map.

The pivot used at the experiment was well maintained with VRI system installed on it. The VRI system consisted of solenoid valves which allowed different water flow within each pivot zone. The Farmscan 7000 (Farm Scan Ag, Australia) was the solenoid controller. The Farmscan used was an upgraded version of the 7000 series which allowed both the upload of prescription maps by using a USB memory stick or remotely through the internet.

The field was harvested on approximately 10/18/17. Yield monitors were not used in 2017. To compare the productivity and efficiency of the irrigation treatments we recorded the yield of each strip. To eliminate yield errors every truck with full trailer with the yield of each strip was sent to a professional scale which was near the field and the truck drivers reported the empty and the full weight of their trailers. Additionally, extra data such as peanut moisture and foreign material were taken into account for the yield calculation of each strip.

Table 1 summarizes the yield and irrigation results from the 2017 growing season. By looking at the column with the yield and the water allocations used in each strip it becomes clear that the strips which received irrigation according to the UGA SSA treatment had a 3.6% higher yield than the strips which were irrigated based on the IrrigatorPro recommendations. The average irrigated peanut yield in Georgia in 2017 was 4380 lb/ac - so the yield from both treatments can be considered high and above average. However, the strips which irrigated conventionally received 25% more irrigation than the strips which irrigated with the VRI system. Furthermore, we divided the yield from each strip by the amount of irrigation which was applied to calculate the Irrigation Water Use Efficiency (IWUE) index. This index shows how many pounds per acres of yield were produced per inch of water. As it was expected, the IWUE index was always higher in the precision irrigation strips than the IrrigatorPro strips. This means that in addition to the higher yield in the strips which were irrigated based on the UGA SSA method the IWUE of the UGA SSA method was 38.2 % higher than the IrrigatorPro method meaning that the UGA SSA method can produce more yield with less water.

Table 1. Total irrigation, yield and irrigation water use efficiency, and weighted average of the three soil moisture sensors (SWT) for every strip.

Treatment	Irrigation (mm)	Irrigation Difference (mm)	Yield (lbs/ac)	Yield Difference (lbs/ac)	IWUE (lbs/ac/in)	IWUE Difference (lbs/ac/in)	SWT-Weighted Average (kPa)	SWT Difference (%)
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A more detailed analysis of the yield and the soil moisture conditions in each strip through the growing season revealed that the yield had positive strong correlation with the IWUE (p=0.664) while irrigation had negative strong correlation with the IWUE (p=-0.661; Table 2). Table 1 presents the weighted average of the three different sensors for each strip. The weighted average was calculated using the function (1). The comparison of the weighted average of the soil water tension in the VRI strips and the Uniform strips showed that there were no significant differences between the two. Specifically, the weighted average of the soil water tension in the VRI strips was 46.4 kPa while in the Uniform strips it was 47.5. In the reality a 1.1 kPa difference is not a significant difference in soil moisture and would not cause yield differences. The 1.1 kPa difference is probably under sensor tolerance. Furthermore, according to Table 1 the Uni 1 strip was drier than the VRI 1 strip but the yield was lower in the VRI 1 strip than in the Uni 1 strip. This means that there were other factors which affected the yield. However, there was positive correlation (p=0.444) between the weighted average of the soil moisture sensors and the yield (Table 2).

(1) Weighted Average = (0.5×SWT at 4 in) + (0.3×SWT at 8 in) + (0.2×SWT at 16 in)

where SWT: Soil Water Tension

Table 2. Correlation matrix for the studied properties.

	Irrigation	Yield	IWUE	SWT
Irrigation	1	0.109	-0.661	-0.044
Yield	0.109	1	0.664	0.444
IWUE	-0.661	0.664	1	0.368
SWT	-0.044	0.444	0.368	1

To sum up, at the current work we applied irrigation in a peanut field using the UGA SSA scheduling tool and the Irrigator Pro method. The yield comparison between these two treatments revealed that 25% less water was used at the UGA SSA treatment than at the Irrigator Pro. On the other hand the soil water tension at the strips where the UGA SSA irrigation recommendations were applied was 2.14 % less (wetter soil) than at the rest strips. The higher the soil water tension the drier the soil is. Furthermore the yield and the IWUE were 3.6% and 38.2% higher at the UGA SSA strips than at the strips where the Irrigator Pro recommendations applied. The strip by strip comparison showed also that the irrigation was not the only one factor which affected the yield ($p=0.44$; Table 2.). Additionally, previous researches with the same concept resulted in similar results for IWUE and irrigation but yield was reduced at the UGA SSA strips. Therefore, more years of research are required to have a better understanding of the main factors which affect yield and profitability in peanuts.