Variable-Rate Irrigation Management for Peanut in the Eastern Coastal Plains

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Variable rate irrigation systems provide a tool to spatially allocate limited water resources while potentially increasing profits. The reasons for spatial water application were local site-specific problems that included the following: spatial variability in topography, soil type, soil water availability, landscape features, cropping systems, and more recently water conservation. Although technology for spatial water application is available and it has high grower interest, farmers that have retrofitted their center pivot systems to be able to make precision applications are basing the application rates on their past experience and knowledge of variability in their fields. Science-based information is needed on how to precision-apply water with these systems. Sadler et al. (2005) identified critical needs for site-specific irrigation research that included decision support systems for spatial water application and improved real time monitoring of field conditions with feedback to irrigation systems.

Some researchers are working with growers to use soil electrical conductivity (EC) maps of fields together with historic yield maps to develop management zones (Lund, et al. 2001). Soil EC measurements in non-saline soils are driven primarily by soil texture and soil moisture. Those same factors correlate highly to the soil's water-holding capacity. Thus, an EC map can serve as a proxy for soil water-holding capacity, resulting in soil EC and yield maps that frequently exhibit similar spatial patterns. A few researchers are developing wireless communication systems to provide feedback to irrigation system controllers and for remote real time monitoring of soil and plant conditions (Kim and Evans, 2005, and Vellidis et al., 2005). In fields that are highly variable many sensors would be required to provide useful site-specific soil water monitoring. This can be very expensive.

Another approach to site-specific management would be using decision support systems to assist with spatial irrigation application. Currently there are no readily identified decision support systems for site-specific water management. However, the USDA-ARS National Peanut Laboratory in Dawson, Georgia has developed and distributed an expert system for peanut management (Irrigation Pro). Irrigator Pro assists producers with irrigation management by integrating several factors including soil type, yield potential, previous crop, cultivar, and planting date. During the growing season, the expert system requires inputs of rainfall, soil temperature, percent chance of rain, canopy size, and date of fruit initiation, among others, to recommend a decision on when and how much to irrigate. Irrigator Pro has typically been used for uniform (whole field) applications. In this research we will evaluate the potential of using Irrigator Pro to spatially manage irrigation under a site-specific variable rate irrigation system. Our specific objective will be to compare spatial irrigation management using both Irrigator Pro and traditional soil water potential measurements.

Methods

Experiments were conducted under the variable rate irrigation system located at the USDA-ARS Coastal Plains Soil, Water, and Plant Research Center in Florence, South Carolina. The system was developed in 1995 and consisted of a center pivot irrigation system that had been modified to permit variable applications to individual areas 9.1 by 9.1m in size (Omary et al., 1997; Camp et al., 1998). The center pivot length was divided into 13 segments, each 9.1 m in length. Variable-rate water applications were accomplished by using three manifolds in each segment, each with nozzles sized to deliver 1x, 2x, or 4x of a base application depth at that location along the center pivot length. All combinations of the three manifolds provided application depths of 0 through 7x of the base rate. When the outer tower was operated at 50% duty cycle, the 7x depth was 12.7 mm. The variable-rate water delivery system solenoid valves were controlled by a computer and programmable logic controller (PLC) that obtained positional (angular) data from the C:A:M:S management system (Valmont Industries, Inc., Valley, Neb.). A program written in Visual Basic controlled the PLC with user-supplied positional data, and angular position from the center pivot management system. A more detailed description of the water delivery system may be found in Omary et al. (1997) and, of the control system in Camp et al. (1998).

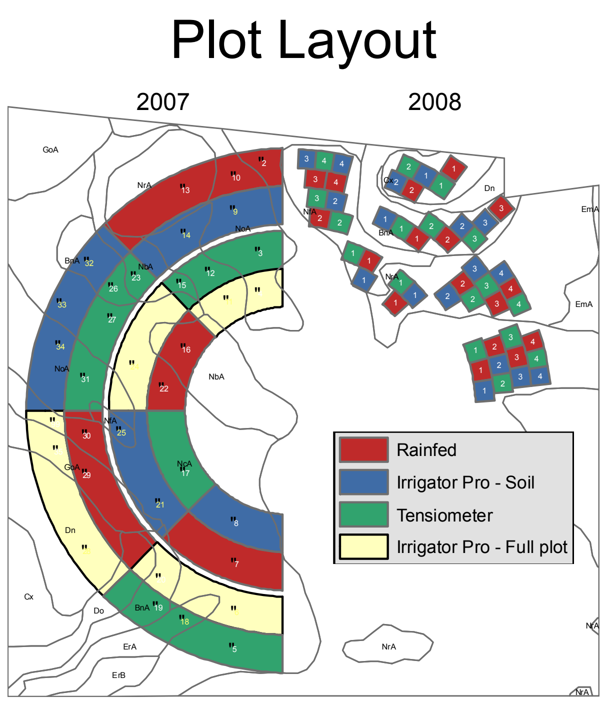

Figure 1. Plot layout for irrigated and non-irrigated treatments for 2007 and 2008.

Irrigation experiments were conducted using peanut to evaluate three spatial irrigation scheduling methods (Figure 1). Peanuts (variety NC-V11) were planted in May of 2007 and 2008 under one half (~3 ha) of the variable rate irrigation system. Soils under the center pivot system are highly variable and have been extensively spatially monitored with various field crops since the mid 1980's. Four irrigation treatments were used in the study: 1) using Irrigator Pro to spatially manage irrigation based on the predominate soil in a management zone; 2) using Irrigator Pro to spatially manage irrigation based on individual soils in a management zone; 3) using soil water potential measurements in management zones to maintain acceptable soil water potentials (<30 kPa) in the surface 30 cm of each soil; and 4) a non-irrigated treatment. Figure 1 details the plot layout for both 2007 and 2008.

The peanut crop was managed for planting, tillage, and disease and pest control using Clemson University Extension recommendations for profitable peanut production (http://virtual.clemson.edu/groups/peanuts/mmaker06.PDF , Chapin et al., 2006).

Results

Peanut yields among the treatments differed for the two years of the study (Table 1). The yield differences in 2007 were mainly attributed to the weather conditions that saw an extended drought condition for the latter part of the growing season. Rainfall was adequate for the first part of the 2007 growing season. Cumulative rainfall was approximately 125 mm for the first eight weeks of the growing season (Figure 2). The total rainfall for the growing season was 186 mm. In 2007, the non-irrigated treatment had approximately half the yield (2.4 Mg/ha) of the irrigation treatments (5 Mg/ha). The irrigated treatment yields were not significantly different from each other. Irrigator Pro called for irrigation to begin immediately as the rainfall began to subside (~8 weeks after planting). The soil water potential controlled treatments did not call for irrigation until about 2-3 weeks later (figure 3). Similarly near the end of the growing season, Irrigator Pro began to reduce irrigation application amount/times whereas the soil water potential controlled treatments did not. Total water applied (rainfall +irrigation) was significantly higher for the Irrigator Pro treatments than for the soil water potential controlled treatment (Table 2). In 2007, no significant differences were observed between the two Irrigator Pro treatments (whole plot management vs. each soil in a plot management). However, both Irrigator Pro treatments applied significantly more water than the treatment controlled by soil water potential measurements.

Table 1. Irrigated and non-irrigated peanut yields using Irrigator Pro and soil water potentials to schedule irrigations.

	2007		2008	
Treatment	Yield (kg/ha)	Std	Yield (kg/ha)	Std
Non-Irrigated	2448 a	277	5793 a	766
Irrigator Pro	5050 b	563	5841 a	767
Irrigator Pro by soil	4722 b	622		
Tensiometer (soil water potential)	5216 b	935	6035 a	954

Table 2. Total water for irrigated and non-irrigated peanuts.

	2007		2008	
Treatment	Total Water (mm)	Std	Yield	Std
Non-Irrigated	186	-	605	-
Irrigator Pro	509 a	47	651 a	34
Irrigator Pro by soil	503 a	53		
Tensiometer (soil water potential)	452 b	35	668 a	33

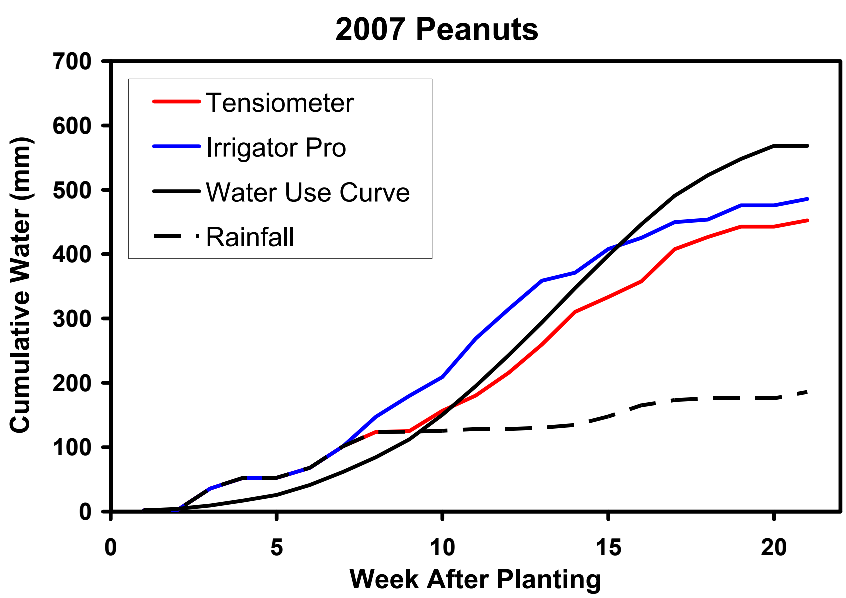

Figure 2. Total cumulative water for both non-irrigated and irrigated peanuts in 2007.

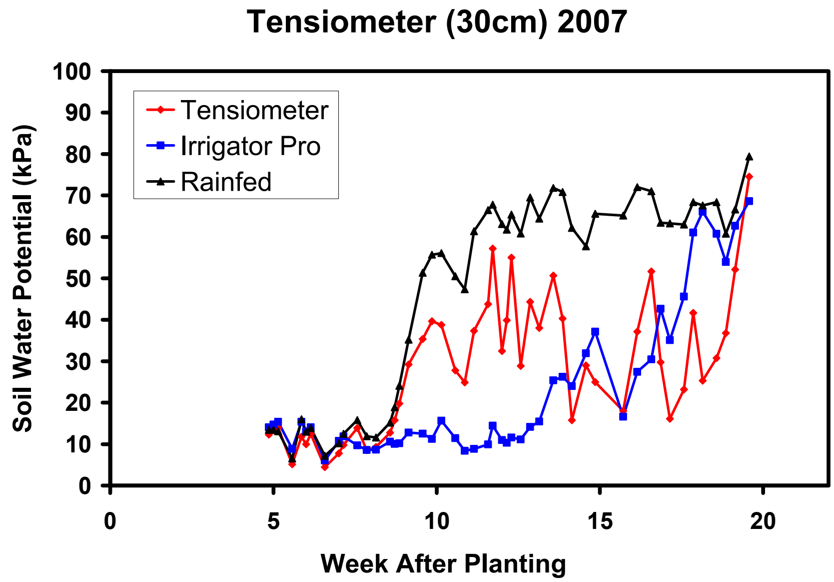

Figure 3. Soil water potentials for non-irrigated and irrigated peanut treatments in 2007.

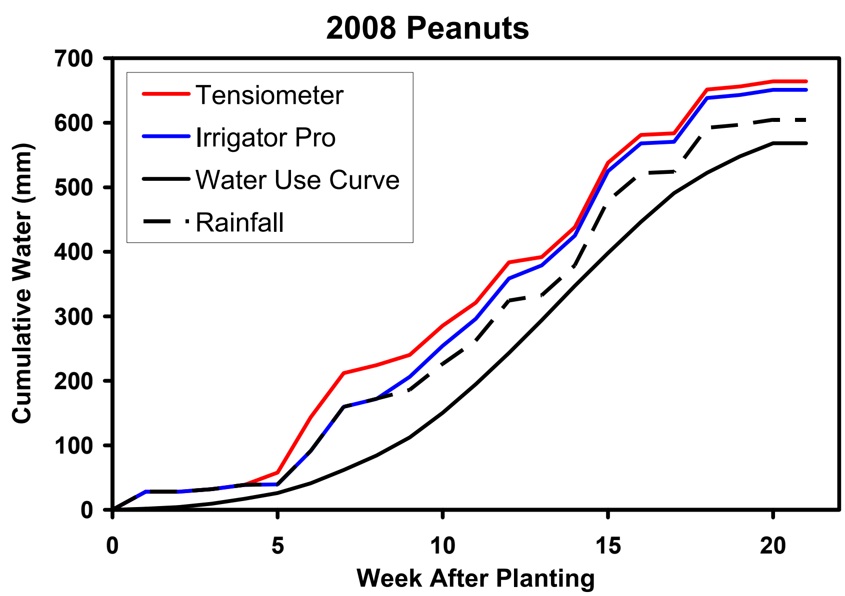

Figure 4. Total cumulative water for both non-irrigated and irrigated peanuts in 2008.

In 2008, there was much more rainfall than in 2007 and it was well distributed throughout the growing season. Total rainfall was 605 mm compared to 186 in 2007 (Table 2 and figure 4). Consequently, the soil water potential measurements under all treatments seldom exceeded -30 kPa irrigation trigger. The peanut yields reflected the favorable rainfall and distribution. Yields averaged approximately 5.9 Mg/ha across all treatments (Table 1). There were no significant differences in peanut yields among the treatments. Initial observation on using Irrigator Pro for scheduling irrigation using a variable rate system shows promise but further evaluation on refining its application for spatial application is needed.

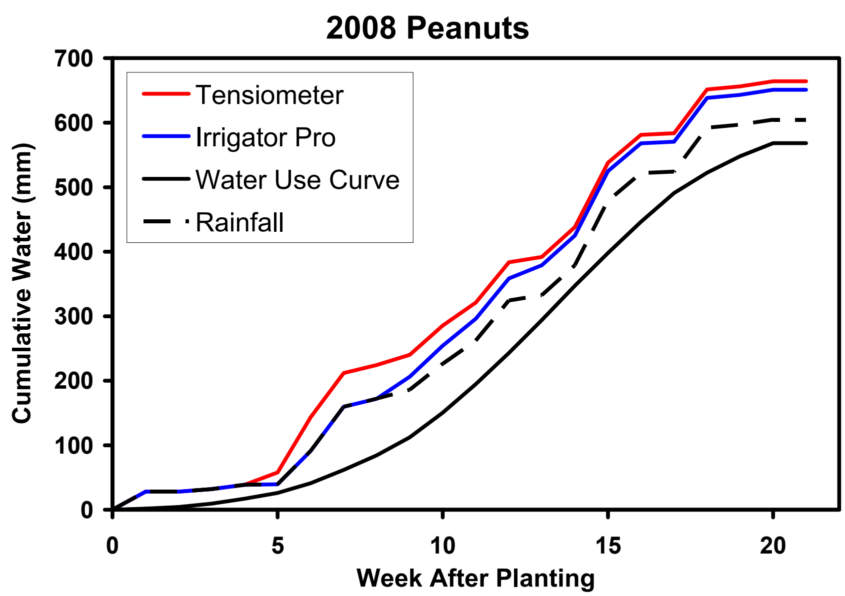

Figure 5. Cumulative water for both non-irrigated and irrigated peanuts in 2008.

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