SITE-SPECIFIC IRRIGATION OF PEANUTS ON A COASTAL PLAIN FIELD

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ABSTRACT

Irrigator-Pro is an expert system that prescribes irrigation for corn (*Zea mays* L.), cotton (*Gossypium hirsutum* L.) and peanut (*Arachis hypogaea*). We conducted an experiment in 2007 to evaluate Irrigator-Pro as a tool for variable rate irrigation of peanut using a site-specific center pivot irrigation system. Treatments were irrigation of whole plots based on the expert system, irrigation of individual soils within plots based on the expert system, irrigation of individual soils within plots based on tensiometers, and rainfed. Treatments were assigned to large plots with lengths that were 45° along the travel distance of the pivot and widths of 18.3 m along its span. Experimental design was randomized complete block and there were four replicates of each treatment. In-season data collection from all plots included normalized difference vegetative index (NDVI), canopy temperature, soil water potential, and cumulative water applied. Peanut yield was determined with a yield monitor. Irrigation applications began earlier in the season for plots managed with the expert system than for plots managed with tensiometers on all soils and total water applied was generally higher for both treatments using Irrigator Pro than for the tensiometer treatment. Rainfed yields were approximately 50% of irrigated yields. There were no differences between the three irrigation scheduling methods treatments for NDVI, canopy temperature, or yield. Using Irrigator Pro to prescribe water on a by-soil map unit basis did not reduce variability compared to using the model to prescribe irrigation on a whole plot basis.

Keywords: Variable rate irrigation, Peanut, Expert system

INTRODUCTION

Technology has been developed for site-specific irrigation and has been installed on 35 center pivots on grower fields in the southeast USA (Milton and Perry, 2006). Variable rate irrigation can provide substantial water savings and because of this USDA-NRCS in some southern states provide cost-sharing for retrofitting an existing center pivot through the Environmental Quality Incentive Program (EQIP). Sadler et al. (2007) reviewed current research and presented a state-of-the-art of precision irrigation. They concluded that more basic research is needed to validate the economic viability of the practice. There is a need to find methodologies to precision-apply water for maximum agronomic and economic utility. Khalilian et al. (2007) reported that using soil water sensors and tensiometers were superior to using evaporation pan and evapotranspiration (ET) models for scheduling spatial irrigation applications in cotton (*Gossypium hirsutum* L.) because the latter two did not take into account soil spatial variability.

Site-specific monitoring of soil water is expensive and time consuming, especially if a field is highly variable and would need many sensors. Irrigator Pro is an expert system designed to manage irrigation decisions based crop variety, previous crop, soil texture, irrigation capacity of the soil, expected yield potential, growing region, crop planting date, current days after planting, rain, irrigation, maximum and minimum soil temperature at 5-cm depth, and soil map unit (Davidson et al., 1998). Our objective was to evaluate Irrigator-Pro as a tool for variable rate irrigation of peanut using a site-specific center pivot irrigation system.

MATERIALS AND METHODS

The experiment was conducted in 2007 at the USDA-ARS Coastal Plains Soil, Water, and Plant Research Center near Florence, SC. The study was conducted under a site-specific center pivot irrigation machine that was constructed in 1995 (Camp and Sadler, 1994; Sadler et al., 1996; Omary et al., 1997). Treatments in the study were irrigation based on Irrigator Pro for the predominant soil in a plot (Model-Full Plot), irrigation based on Irrigator Pro for individual soils within a plot (Model-by-Soil), irrigation based on tensiometers, and rainfed,. Treatments were assigned to large plots with lengths that were 45° along the travel distance of the pivot and widths of 18.3 m along its span. Figure 1 shows a layout of the plots in the experiment.

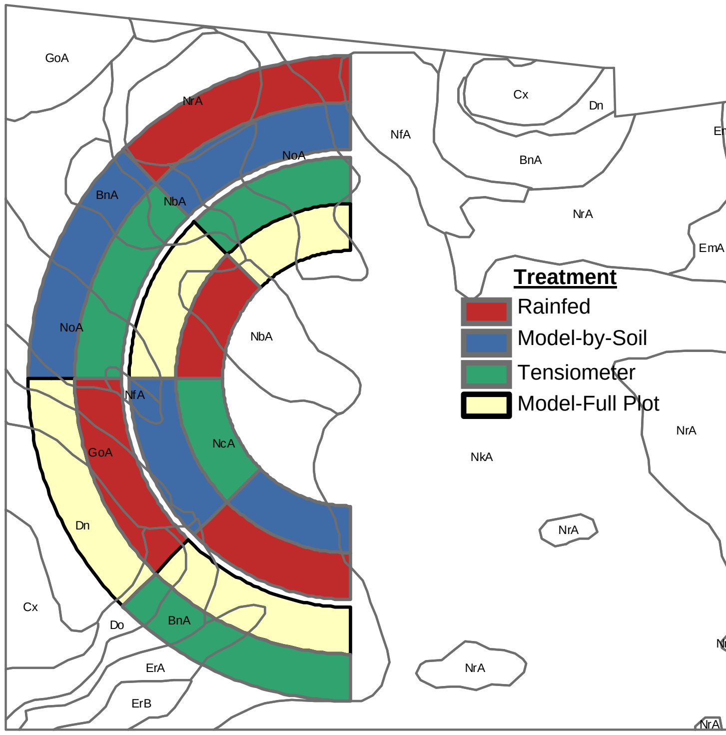

Figure 1. Experimental plan of four irrigation treatments overlaid on 1:1200 soil map.

Peanuts (cultivar NC-11) were planted on 18 May in 1-m wide rows. Clemson University recommendations were used for managing the crop including soil fertility, pest and disease management, and digging and harvesting the crop. Soil map units in the field were Bonneau loamy fine sand (BnA), Dunbar loamy fine sand (Dn), Dunbar loamy fine sand, overwash (Do), Emporia fine sandy loam (ErA), Goldsboro loamy fine sand (GoA), Noboco loamy fine sand, moderately thick surface (NbA), Noboco fine sandy loam, thick surface (NcA), Noboco fine sandy loam (NfA), Norfolk loamy fine sand, moderately thick surface (NkA), Norfolk loamy fine sand, thick surface (NoA), and Norfolk fine sandy loam (NrA).

Shortly after planting, tensiometers were inserted to a depth of 30 cm directly in a row within each soil map unit within each plot. Soil tension data were collected three times per wk and irrigation applications (either 1.2 or 2.5 cm, depending on level of stress and time of week) were made to individual soils within the tensiometer treatment when soils were at -0.3 MPa. Soil thermometers were placed in the plots where irrigation was managed by Irrigator Pro. These were placed in the predominant soil map unit for the Model-Full Plot irrigation treatment and in each soil map unit in the Model-by Soil irrigation treatment. The model was run 2-3 times per wk (depending on rainfall) and irrigation (either 1.2 or 2.5 cm) was applied to these plots when prescribed by the model. Irrigator Pro provides recommendations for only three distinct soil categories. The model was run using the medium/heavy soil category for the Norfolk series and as sandy for the other soils in the experiment.

Within-season measurements of canopy temperature and normalized difference vegetative index (NDVI) were made frequently throughout the year after crop emergence. Four infrared thermometers (IRT) were mounted on a bar at the front of a tractor and used to measure the canopy temperature of two rows (two IRT's per row). Also mounted on the bar was a Crop Circle model ACS 210 canopy analyzer for measuring NDVI. All sensors were placed approximately 75 cm above the top of the canopy. A global positioning system unit was also mounted on the tractor to allow for the data to be geo-referenced. When collecting data, the tractor was driven through the field at a speed of 3.2 km hr^{-1}.

Peanuts were dug on 10 October and harvested with a combine on 17 October. Yield was determined from each soil map unit within each plot by harvesting a 15-m long section of two rows and weighing the harvested peanuts. A subsample of the peanuts from each plot was collected at harvest and dried at 60 °C for three days. Peanut yields were corrected for moisture content. Data were subjected to analysis of variance. Coefficients of variation were calculated for yield and NDVI means of treatments across replications in an effort to assess treatment effects on within-field variability

RESULTS AND DISCUSSION

The 2007 growing season had good early season rainfall that was followed by a prolonged dry period that lasted through the end of season. Approximately 13 cm of rainfall occurred during the first eight wks after planting, but only 5 cm of rainfall occurred throughout the rest of the 21-wk season. The Irrigator Pro model prescribed irrigation beginning between 7 and 8 wks after planting for all soils. Soil tensiometers, on the other hand, did not reach low enough levels to prescribe irrigation until between 9 and 10 weeks after planting.

With irrigation applications beginning earlier in the season in plots managed with Irrigator Pro, the plots managed with the model were generally prescribed more total water for the entire season than application prescriptions for plots in the tensiometer treatment. Total irrigation prescribed for the peanuts in the tensiometer treatment ranged from about 20 cm to 36 cm. Most (8 of 11 soils) application prescriptions for the tensiometer treatments were between 25 cm and 28 cm. Irrigator Pro prescribed irrigation amounts ranged from 25 cm to 36 cm with most (5 of 8 soils) of those being about 36 cm in the Model-by-Soil treatment and the Model-Full Plot treatment (also 5 of 8 soils).

Table 1 shows the NDVI means for the four irrigation treatments at four different times during the season. The three irrigation scheduling methods (tensiometers, Model-Full Plot, and Model-by-Soil) did not differ for NDVI at any time during the season. Within treatment variability was also similar at these four dates. Within treatment variability declined as the canopy grew. By 16 wks after planting, there was complete canopy closure and very little variability for this measurement in any of the peanuts that were irrigated. Mean NDVI was lower and variability for NDVI was greater in the rainfed plots than the three irrigated plots at 14 and 16 wks after planting. These measurements were taken mid-day, and the severe dry weather caused considerable leaf wilting and leaflet folding in the rainfed plots. That is probably the reason for the lower NDVI values and the higher variability at 14 and 16 wks after planting than at 10 wks after planting.

Table 1. Peanut NDVI and coefficient of variation at four dates in 2007.

Weeks After Planting	Treatment	NDVI	CV
			%
6	Rainfed	0.521a†	15.0
	Model-by-Soil	0.522a	15.8
	Model-Full Plot	0.518a	15.4
	Tensiometer	0.523a	15.5
10	Rainfed	0.747a	8.2
	Model-by-Soil	0.754a	6.7
	Model-Full Plot	0.740a	7.9
	Tensiometer	0.747a	10.2
14	Rainfed	0.648b	13.1
	Model-by-Soil	0.789a	3.5
	Model-Full Plot	0.778a	7.2
	Tensiometer	0.793a	6.7
16	Rainfed	0.728b	12.2
	Model-by-Soil	0.791a	2.2
	Model-Full Plot	0.797a	2.5
	Tensiometer	0.796a	3.8

† Means followed by the same letter within a date are not significantly different based on Duncan's New Multiple Range Test.

Canopy temperature of the peanuts on different soil map units at two dates in August is shown in Figures 2 and 3. As occurred for NDVI, there was no significant difference among the three irrigation scheduling methods for canopy temperature at either date. Also, variation among soils for the three irrigation methods was small at both dates. For the rainfed peanuts, variation among soils was quite large on August 10. This is similar to the findings by Sadler et al. (2000) for corn on these soils. By August 21, the drought had intensified substantially and at that date there was little difference among soils in canopy temperature in the rainfed plots.

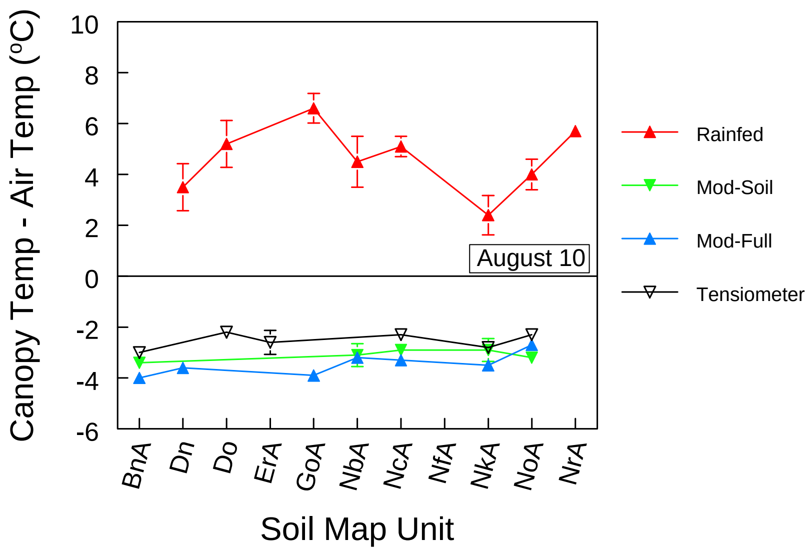

Figure 2. Canopy temperature on 10 August for the soil map units within the study for the four irrigation treatments.

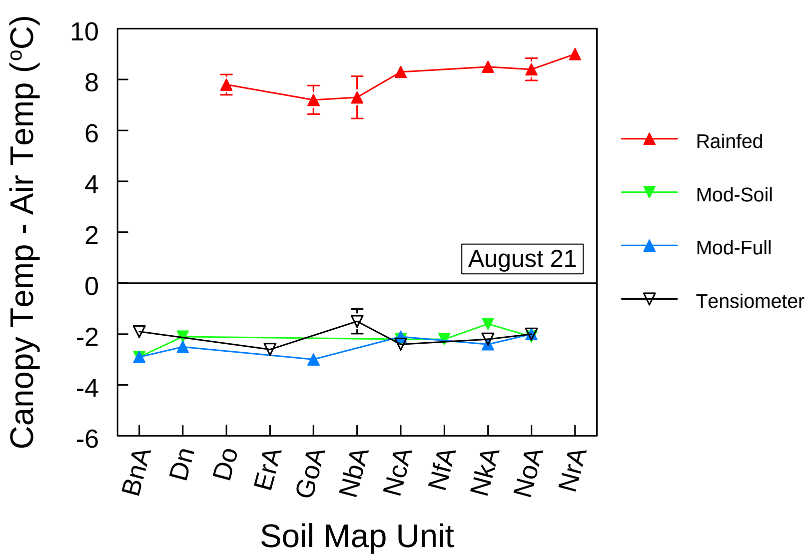

Figure 3. Canopy temperature on 21 August for the soil map units within the study for the four irrigation treatments.

Crop yields followed the same trends as the NDVI and canopy temperature data (Table 2). Rainfed yields were approximately one-half of irrigated yields, but there was no difference among irrigation scheduling methods for yield. Variation for yield was somewhat higher with the tensiometer method than with either method that employed Irrigator Pro.

Table 2. Peanut Yield and Coefficient of Variation from Plot Harvest

Treatment	Yield	CV
	kg ha^{-1}	%
Rainfed	2448a†	11.3
Model-by-Soil	4722b	13.2
Model-Full Plot	5049b	11.1
Tensiometer	5216b	17.9

† Means followed by the same letter are not significantly different based on Duncan’s New Multiple Range Test.

SUMMARY

In this first year of the study, irrigation (by any scheduling method) increased yield. Irrigation also increased NDVI at sampling dates later in the season. Variability among the different soil map units for canopy temperature was lower for all irrigated treatments than for the rainfed treatment at the beginning of a long rain-free period, but not when water deficit stress was severe later in the season. There was no benefit to using Irrigator Pro on a by-soil basis in this experiment (compared to using the model on the predominant soil map unit in the plot). Both treatments that used the model prescribed more irrigation water than the tensiometer method. Further evaluation of the expert system in the Carolina’s growing region appears warranted.

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