PEANUT WATER USE UNDER OPTIMUM CONDITIONS OF GROWTH AND DEVELOPMENT: A SIMULATION APPROACH

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REFERENCE: *Proceedings of the 2007 Georgia Water Resources Conference*, held March 27-29, 2007, at The University of Georgia.

Abstract. Soil and weather conditions are not always favorable for optimal growth and development of plants and experiments must be repeated over time and space in order to obtain results that can reflect the average conditions of a specific area. Crop models and Decision Support Systems are useful tools as a complement to research, such as their ability to simulate a crop's response to different management scenarios under various environmental conditions. The objective of this study was to determine the water use of peanut grown under optimum conditions of soil and weather. Our analysis revealed that peanut requires around 22 inches of water from sowing to harvest. No significant differences on water use were found between early and medium maturity varieties; however, significant differences were found between medium and late maturity varieties and between early and late maturity varieties.

INTRODUCTION

Soil and weather conditions are not always favorable for optimal growth and development of plants; therefore, experiments must be repeated over time and space in order to obtain results that can reflect the average conditions of a specific area. Crop models and Decision Support Systems (DSS) are useful tools as a complement to research, such as their ability to simulate a crop's response to different management scenarios under various environmental conditions. As crop's water demand is a function of plant type, the stage of development, local soil characteristics and atmospheric conditions, the total amount of water used by a crop can be estimated through the use of simulation models and DDS.

The Decision Support System for Agrotechnology Transfer (DSSAT) v4.0 (Hoogenboom et al., 2004) is a computer-based program that predicts yield and water use as a function of crop management and soil and weather conditions. The DSSAT soil water balance module, a one-dimensional model, computes the daily changes in soil water content by soil layer due to infiltration of rainfall and irrigation, vertical drainage, unsaturated flow, soil evaporation, and root water uptake; as described by Ritchie (1998). Irrigation can be applied on specific dates with specified irrigation amount or can be controlled by plant available water. If plant available water drops below a specific fraction of water holding capacity in the irrigation management depth, an irrigation event is triggered. The irrigation amount applied can be either a fixed amount or it can refill the profile to the management depth. When irrigation is applied, the amount applied is added to the amount of rainfall for that day in order to compute infiltration and runoff. The drainage of water through the profile is first calculated based on an overall soil drainage parameter assumed to be constant with depth.

The objective of this study was to determine the water use of peanut grown under optimum conditions of soil and weather.

MATERIALS AND METHODS

The model CSM-CROPGRO-Peanut, that is part of the Decision Support System for Agrotechnology Transfer (DSSAT) version 4 (Hoogenboom et al., 2004), was used to simulate water use, yield and associated parameters for three varieties of different maturity for three selected locations in southwest Georgia. The varieties Georgia Green (135 to 140 days to harvest), C99-R (145 to 152 days to harvest), and Virugard (120-125 days to harvest) (Carter, 2005), were used. Three planting dates were used; April 16, May 12, and June 12. The irrigation threshold and irrigation management were set to avoid water stress.

The soil profile information was obtained from the National Resources Conservation Service (NRCS; http://www.nrcs.usda.gov). Daily maximum and minimum air temperatures and precipitation from 1911 to 1999 for Sumter and Tift counties and from 1957 to 1999 for Burke county, were obtained from the Cooperative Observer Program (COOP) network and compiled by the Center for Ocean-Atmospheric Prediction Studies (COAPS, www.coaps.fsu.edu), through the Southeast Climate Consortium (SECC). Missing data were estimated with WeatherMan (Pickering et al., 1994), a weather utility program that is part of the Decision Support System for Agrotechnology Transfer (DSSAT) version 4 (Hoogenboom et al., 2004). Daily solar radiation was generated using the program WGENR, a solar radiation generator based on the approach of Hodges et al. (1985), with adjustment factors obtained for the southeastern U.S. (Garcia y Garcia and Hoogenboom, 2005).

Weekly and seasonal water use by peanut were obtained from the simulations and then compared with extension recommendations (Beasley, 2006) of water use for the same periods. The extension recommendations are generic; i.e., is one recommendation for the whole Georgia peanut belt. Thus, a simple difference between simulated total amounts and extension recommendations was determined. Additionally, differences between means from the simulations were determined through the Student's *t* test at a probability level (*p*).of 0.05. The statistical analyses were performed using the Data Analysis package of Microsoft® Office Excel (Microsoft, 2003).

RESULTS AND DISCUSSION

Average air temperature and solar radiation were similar for the three locations. The high air temperature and solar radiation were observed for the cropping season that started on April 16. However, the higher average air temperature was observed for the cropping season that started on May 12. Temperatures were as low as 62°F at the end of the cropping season that started on June 12 and as high as 80.5°F at 105, 77, and 49 days after planting for April 16, May 12, and June 12 planting dates, respectively. On the other hand, solar radiation was as low as 13.3 MJ m^{-2} d^{-1} at the end of the cropping season that started on April 16 to as high as 23.4 MJ m^{-2} d^{-1} at 77, 28, and 14 days after planting for April 16, May 12, and June 12 planting dates, respectively (Figure 1). Since irrigation management was set to avoid water stress, rainfall was considered not relevant and its distribution during the cropping season is not presented.

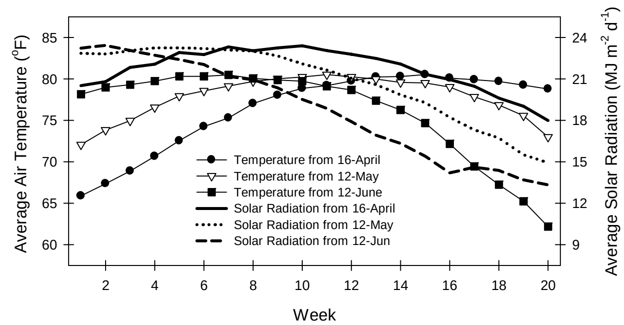

Figure 1. Average air temperature and solar radiation observed at the three locations.

For the three varieties at the three locations, total water use by peanut tended to decrease as the planting date was delayed. Total water use as low as 19.0, 20.3, and 18.4 inches for the cropping season that started on June 12 in Burke County and as high as 23.2, 25.5, and 22.1 inches for the cropping season that started on April 16 in Tift, were observed for the varieties Georgia Green (medium maturity), C99-R (late maturity), and Virugard (early maturity) (Table 1).

Differences between simulated total amount of water used by each one of the three varieties and the extension recommendations for total water used by peanut (Beasley, 2006) were consistently lower for the cropping system that started on June 12 (Figure 2). This is because the extension recommendations of total amount of water use by peanut represents the average of the Georgia peanut belt conditions and our estimates are specific for each county. In fact, and as observed in Figure 1, weather conditions for the cropping season that started on June 12, resulted in lower atmospheric demand and, consequently, the lower water used by the crop.

Table 1. Amount of water requirements (in), from planting to harvest, for each variety at different planting dates and different locations obtained with the crop simulation model.

Variety	Sumter			Tift			Burke			Average	Deviation
	16-Apr	12-May	12-Jun	16-Apr	12-May	12-Jun	16-Apr	12-May	12-Jun		
GA Green	22.8	22.3	20.0	23.2	22.7	20.5	21.7	21.6	19.0	21.5a	1.4
C99-R	25.1	24.2	21.4	25.5	24.6	21.9	24.0	23.4	20.3	23.4b	1.8
Virugard	21.7	21.5	19.3	22.1	21.9	19.8	20.8	20.8	18.4	20.7a	1.3
Average	23.2	22.6	20.2	23.6	23.1	20.7	22.2	21.9	19.2	**21.9**	1.5
Average water use obtained from research conducted by UGA scientist from Tifton Campus (Beasley, 2006)										**22.4**	

Values followed by the same letter are not statistically significant at $p < 0.05$.

We also observed that a consistent higher amount of water was used by the variety C99-R for the cropping seasons that started on April 16 and May 12 when compared with the other two varieties. The main reason for this is because C99-R is a late maturity variety (Carter, 2005). From our simulations, it took 155 days for C-99R to reach maturity; which was at least 14 days longer than the medium maturity Georgia Green. Conversely, when compared with the observed data, we observed a consistent lower amount of water used by the variety Virugard, an early maturing variety, at the three locations and for the three planting dates. Indeed, the total amount of water used by the variety Georgia Green, differed the least with the extension recommendation for total water used by peanut; from slightly higher for the cropping season that started on April 16 in Sumter and Tift counties as well as on May 12 in Tift county to slightly lower for the cropping seasons that started on April 16 and May 12 in Burke.

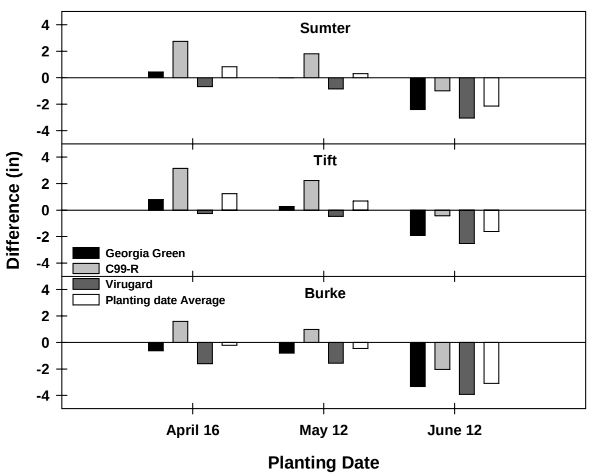

Figure 2. Difference (in) between observed and simulated water use amounts required by three peanut varieties from different maturity at different planting dates and different locations.

The results from this study showed the importance of using crop simulation models and Decision Support Systems as complementary tools for applied research in order to obtain insights on the optimization of the resources. While several years of research have demonstrated that water used by peanut for Georgia conditions is around 22 in, crop models can facilitate our comprehension on the spatial and temporal optimization of that resource. As an example, and as observed on Figure 2, a generic recommendation for water use by peanut for late planting dates or for farmers planting an early maturity variety will imply over applications that could impact negatively the maximization of profits by farmers. On the other hand, a generic recommendation of water use for farmers planting a late maturity variety could also affect negatively, mainly during drought seasons.

CONCLUSION

No significant differences on water use were found between early and medium maturity varieties; however, significant differences were found between medium and late maturity varieties and between early and late maturity varieties. The potential of using crop simulation models and Decision Support Systems as tools for resolving practical issues on water use was demonstrated. We plan to extend the methodology to the Georgia peanut belt with the objective of determining the spatial variability of peanut water use that can help in making decisions on water use for specific-location.

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