IMPACT OF LOCAL WEATHER VARIABILITY ON IRRIGATION WATER USE IN GEORGIA

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Abstract. Irrigation is often used to offset the impact of rainfall variability on crop yield and to reduce the risk associated with weather variability. However, especially for the state of Georgia, how much water is required and how much water is actually being used for irrigation is largely unknown. The objective of this study was to determine the relationship between farmers' irrigation applications, crop types, and local weather conditions. Farmers' monthly irrigation applications for three major crops in Georgia, i.e., cotton, peanut and maize, were obtained from selected sites of the Agricultural Water Pumping program. Significant relationships between monthly irrigation depth and monthly water deficit were obtained for only two of seven months for cotton, five of seven months for peanut, and only one of six months for maize. Individual differences among farmers on how much water they applied contributed to the lack of correlation between monthly irrigation depth and monthly water deficit. Future efforts should focus on a better understanding of the factors that contribute to the farmer's decisions related to when to irrigate and how much water to apply.

INTRODUCTION

Irrigation management is a complex problem in the southeastern USA because of the high variability in local weather conditions, especially rainfall. While annual rainfall is adequate for most agricultural crops, the distribution of rainfall is highly unpredictable. During the growing season, crops may receive either frequent and excessive rainfall or sporadic and moderate rainfall, and can also be exposed to long periods of drought. Thus, irrigation is used to offset the impact of rainfall variability on crop yield and to reduce the risk associated with weather variability.

A practical decision on when to irrigate and how much water to apply is based on the farmer's previous knowledge of soil characteristics, actual conditions of the crop, and the amount of rainfall (personal communication with several farmers in Mitchell and Baker counties, 2003). However, the farmer's irrigation applications are largely unknown for the state of Georgia. The objective of this study was to determine the relationships between farmers' irrigation applications, crop types, and local weather conditions.

METHODS

Crop and Site Selection

Farmers in Georgia irrigate a wide variety of crops. However, cotton, peanut, and maize constitute the major crops. In 2002, these crops accounted for about 68% of the total irrigated acreage in the state of Georgia (www.usda.gov/nass/census/census2002/volume1/ga).

The Agricultural Water Pumping (AWP) program was initiated in 1998 to estimate agricultural water use across the entire state of Georgia (Thomas et al., 1999; 2001; 2003; Hook et al., 2004). Starting in 1999, hour meters were installed at the water withdrawal (i.e., pumping) sites selected under the AWP program. The number of sites increased for each subsequent year as the installation of hour meters progressed. In 2003, the AWP program was monitoring over 600 permitted withdrawal sites for irrigation. For farmers that withdraw from surface water resources, reduced flows in rivers and streams during drought periods put constraints on the timing and amount of water applied. To minimize the effect of this lack of available water on the analysis of the relationships between irrigation applications and local weather conditions, only sites with groundwater source were selected for this study. We selected farmers' fields that were located near the weather stations of the Georgia Automated Environmental Monitoring Network (www.GeorgiaWeather.net). The selected sites were located in the three Coastal Plain regions of Georgia (i.e., Flint, Central and Coastal). These regions comprise about 95% of crop production and irrigated acreage in the state. Planting dates and monthly depth of irrigation for individual fields during the 2002 growing season were obtained from the AWP program (www.AgWaterPumping.net) database.

Weather Data

Weather data from stations located nearest the individual sites were used in the analysis of relationships between irrigation applications, crop types, rainfall, and atmospheric demand. Daily solar radiation, maximum and minimum air temperature, and precipitation for 2002 were obtained from weather records of the Georgia Automated Environmental Monitoring Network (Hoogenboom et al., 2003). The Priestley-Taylor method was used to calculate potential evapotranspiration. Monthly water deficit was calculated as monthly potential evapotranspiration minus monthly rainfall.

RESULTS AND DISCUSSION

Monthly rainfall and irrigation applications during the 2002 growing season for cotton, peanut, and maize fields are shown in Figure 1. On average farmers applied 8.2 inches for cotton, 8.8 inches for peanut, and 12.1 inches for maize during the 2002 growing season. Rainfall was generally low in May for all sites and the irrigation application for maize was highest during this month. In May, maize is normally at a stage when growth and ultimately yield are sensitive to water deficit, so it would be expected that irrigation for maize should be higher during this month with low rainfall. The total amount of irrigation for this month ranged from 1.2 inches to 9.5 inches, with an average of 4.4 inches for the 26 maize fields. For some cotton and peanut fields, irrigation in May was needed to establish good crop stand. There was generally a higher variability in irrigation applications among maize fields compared with the cotton and peanut fields. For cotton and peanut, peak water use period was from June through August. For cotton, irrigation applications in June, July, and August were similar, despite large differences in rainfall during these months. For peanut, the distribution of monthly irrigation amounts was similar to that of cotton. For both crops, irrigation applications were high for July despite very high rainfall during this month. One to three days with heavy rainfall contributed largely to cumulative rainfall during this month. The period of heavy rainfall was preceded and/or followed by up to six consecutive days with no rainfall, which required irrigation applications because the soils were sandy and had a low water holding capacity.

Results of the correlation analysis to determine relationships between monthly water deficit, i.e., potential evapotranspiration minus rainfall, and monthly depth of irrigation are shown in Table 1. For cotton, the correlation coefficient was significantly different from zero only for August and September. For September, however, monthly depth of irrigation was negatively correlated with monthly water deficit, which was not expected. In general, the amount of irrigation would increase with an increase in water deficit. The unexpected result could be attributed to very high rainfall on September 14 and 15, which was not effectively stored in the sandy soils. When data from these dates were excluded from the analysis, monthly depth of irrigation became positively correlated with monthly water deficit. For peanut, the correlation coefficient was significantly different from zero for April, May, August, and October. Similarly, when data for September 14 and 15 were excluded from the analysis, monthly depth of irrigation became positively correlated with monthly water deficit for September. For maize, the correlation coefficient was only significantly different from zero for August.

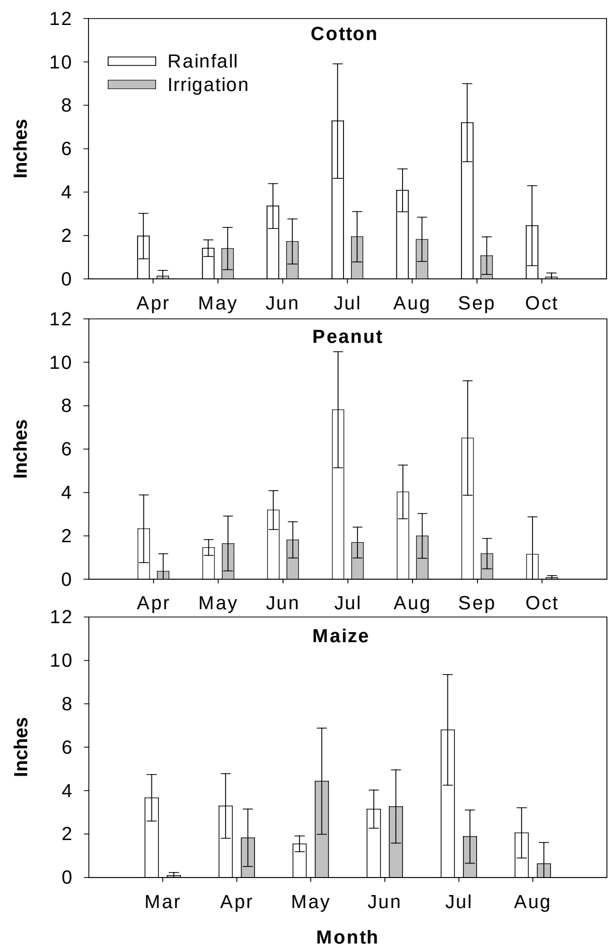

Figure 1. Monthly mean and standard deviation (±1-SD) for rainfall and depth of irrigation for cotton, peanut, and maize fields.

Table 1. Pearson correlation coefficients for the relationship between monthly water deficit (potential evapotranspiration minus rainfall) and monthly depth of irrigation in 2002

	Number of Fields	Correlation coefficient r
Cotton	67	
April		0.20
May		0.14
June		0.19
July		0.15
August		0.27[a]
September		-0.26[a] (0.36[a])
October		0.09
Peanut	39	
April		0.34[a]
May		0.55[a]
June		-0.05
July		-0.12
August		0.39[a]
September		-0.24 (0.56[a])
October		0.39[a]
Maize	26	
Mar		0.03
April		0.04
May		0.23
June		0.03
July		0.18
August		0.70[a]

[a] Significantly different from zero at $\alpha = 0.05$
Values in parentheses are the correlation coefficients when data for September 14 and 15 were excluded from the analysis.

Factors that contributed to the lack of correlation between monthly depth of irrigation and monthly water deficit were individual differences among farmers on how much water they applied during specific stages of crop growth. As an example, two neighboring fields with the same soil type, weather, crop, and planting date had large differences in the amount of water applied during the 2002 growing season (Figure 2). All fields were located in the Flint region; the two cotton fields were located in Early County, the two peanut fields in Sumter County, and the two maize fields in Baker County. For cotton, monthly irrigation applications were generally higher in Field 2, with more than twice the amount in June and July, than in Field 1. For peanut, the amount of irrigation for Field 1 was more than twice that of Field 2 for August and seven times more for September. For maize, Field 1 and Field 2 had large differences in the amount of water applied during the months of June and July. In June, the amount of irrigation in Field 1 was nearly twice that of Field 2; however, in July, the amount of irrigation in Field 2 was more than twice that of Field 1. Differences among individual farmers could be attributed to many factors which include reliability and capacity of water source, capacity and type of irrigation system, scheduling approaches, and economic viability.

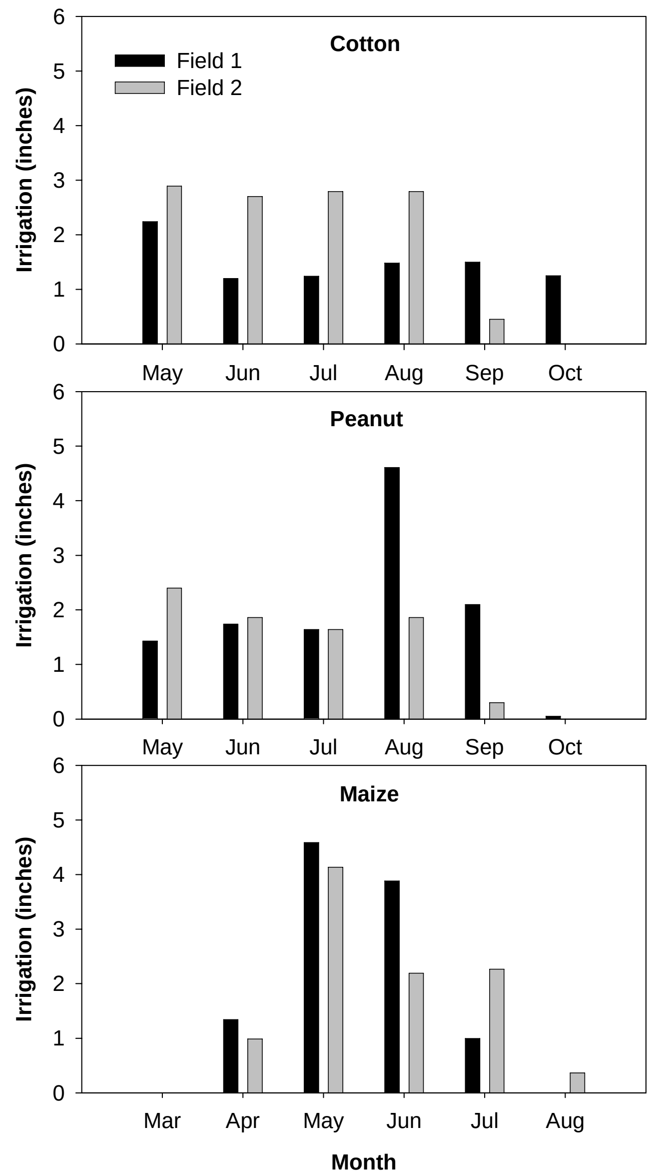

Figure 2. Total monthly irrigation in 2002 for two neighboring fields with the same soil type, weather, crop, and planting date.

CONCLUSIONS

Significant relationships between monthly depth of irrigation and monthly water deficit were found for only two of seven months for cotton, five of seven months for peanut, and only one of six months for maize. Individual differences among farmers on how much water they applied during specific stages of crop growth contributed to the lack of correlation between monthly depth of irrigation and monthly water deficit. A better understanding of the factors that contribute to the farmer's decisions related to when to irrigate and how much water to apply is needed before an irrigation decision tool that promotes water savings is successfully adopted by farmers.

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