Impact of Weather Variability and Soil Moisture Deficit on Water Use and Water Use Efficiency of Sweet Corn

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Introduction

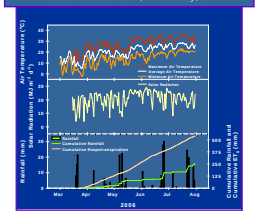
- Water use (WU) and water use efficiency (WUE) of crops are affected by weather conditions and available soil water (ASW) (Tanner and Sinclair, 1987). Weather conditions determine the extent of the potential evapotranspiration (PET), whereas ASW acts as the reservoir to respond to that demand.
- ASW is depleted due to the crop's uptake at a rate determined by PET (Stone et al., 2001) until the soil reaches a state of moisture deficit and growth stops. Beyond that point, crops are exposed to stresses that have cumulative effects and ultimately can reduce final biomass (Jamieson et al., 1995).
- The objectives of this study were to determine the impact of weather variability and maximum soil moisture deficit on WU and WUE of sweet corn.

Materials and Methods

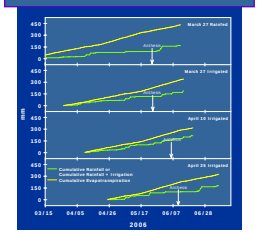
- An experiment was conducted in 2006 at the Bledsoe Research Farm of The University of Georgia in Pike County, Georgia, USA, in a Cecil sandy clay loam soil.
- Sweet corn (*sh2* type) was planted using a simple one-way randomized complete block design and four replicates of three planting dates; including March 27 (one rainfed and one irrigated) and April 10 and April 25, both irrigated. Irrigation was applied with a linear sprinkler irrigation system.
- The soil moisture was monitored in each replicate twice per week using a PR2 at six fixed depths (10, 20, 30, 40, 60, and 100 cm). The PR2 uses electromagnetic signals to measure the permittivity of the soil (dominated by the water)
- Rainfall and irrigation were recorded with rain gauges installed in the experimental area; other weather variables were recorded with an automatic weather station located near the experiment.
- Growth analysis data were collected every two weeks. At harvest, yield and yield components were obtained in 3-m row length from each replicate.
- A water balance equation was used to determine the crop's daily evapotranspiration using the PR2's soil moisture readings. Water use was calculated as the sum of the crop's daily evapotranspiration (ETa). WUE was determined for aboveground biomass and fresh and dry matter as their ration with ETa.
- As a measure of the crop's moisture stress, potential soil moisture deficit was calculated as the accumulated difference between daily PET and irrigation amount for each treatment. The maximum soil moisture deficit reached during the crop's growth was used.
- An analysis of variance was conducted for aboveground biomass, fresh and dry matter ears yield as well as for WUE. Orthogonal contrasts were also performed for WUE between treatments.

Results

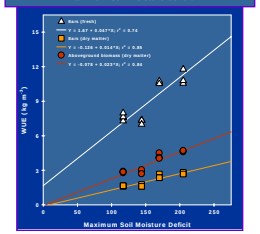
Weather conditions during the 2006 cropping season at Bledsoe Research Farm, Pike County, GA.



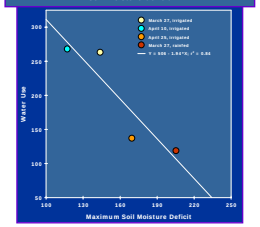
Cumulative rainfall and irrigation for each treatment



Water use efficiency of sweet corn as a function of the maximum soil moisture deficit



Water use of sweet corn as a function of the maximum soil moisture deficit



- The growing season was dry and hot. March was exceptionally warm and early April was exceptionally cool. These conditions resulted in temporary stress of the crop from the March 27 planting date for irrigated conditions and in an early stressed crop for the rainfed conditions.
- A marked difference was observed between cumulative rainfall and cumulative potential evapotranspiration (ET_0) during the growing season. The cumulative rainfall / ET_0 were 86/330, 75/300, 130/279 for March 27, April 10, and April25 growing seasons, respectively.
- Water use was reduced from 268 mm to 119 mm, while the maximum soil moisture deficit varied from 117 mm to 205 mm.
- A significant difference was found between WUE of irrigated and rainfed conditions for both, total aboveground biomass and ears. However, no significant differences were found for WUE of the sweet corn plant on April 25 under irrigated conditions and the rainfed experiment.

Mean comparison for aboveground biomass, fresh and dry matter of ears, and WUE

Treatment	Yield (t ha^{-1})			WUE (kg m^{-3})		
	Aboveground biomass	Ears		Aboveground biomass	Ears	
		Fresh	Dry matter		Fresh	Dry matter
March 27 rainfed	5.5a	13.1a	3.8a	4.70a	11.40a	2.8a
March 27 irrigated	7.4b	19.1b	4.7b	2.83b	7.30b	1.7b
April 10 irrigated	7.6b	20.4c	4.4b	2.85b	7.60b	1.65b
April 25 irrigated	5.7a	14.5d	3.3a	4.2c	10.60a	2.44c
LSD	0.70	0.43	0.32	0.36	0.47	0.27

Within columns, means with the same letter are not significantly different at $p < 0.05$.
LSD = Least Significant Difference

Orthogonal contrasts for WUE of sweet corn total aboveground biomass and fresh and dry matter ears

Contrast	Water Use Efficiency		
	Total Aboveground biomass	Ears	
		Fresh	Dry matter
March 27 irrigated vs. March 27 rainfed	< 0.0001*	< 0.0001*	< 0.0001*
April 10 vs. March 27 rainfed	< 0.0001*	< 0.0001*	< 0.0001*
April 25 irrigated vs. March 27 rainfed	0.26ns	0.18ns	0.55ns
March 27 irrigated vs. April 10 irrigated	0.32ns	0.20ns	0.76ns
March 27 irrigated vs. April 25 irrigated	< 0.0001*	< 0.0001*	< 0.0001*
April 10 irrigated vs. April 25 irrigated	< 0.0001*	< 0.0001*	< 0.0001*
Irrigated vs. Rainfed	< 0.0001*	< 0.0001*	0.0002*

* Contrasts are significantly different at $p < 0.05$; ns = no significant difference between contrasts

Conclusions

- Sweet corn water use was markedly affected by the soil moisture deficit.
- The higher the soil moisture deficit, the smaller the amount of water used by the sweet corn.
- Water use efficiency of sweet corn differed significantly between planting dates and between both rainfed and irrigated conditions.
- The higher the soil moisture deficit, the higher the WUE for total aboveground biomass and for yield of fresh and dry matter ears.

- Biomass of fresh ears was more sensitive to soil moisture deficit than for both total aboveground biomass and ears, as the relationship WUE of fresh ears and soil moisture deficit had a higher slope.
- Further work will study the potential impact of timing of soil moisture deficit on yield of sweet corn.

Acknowledgements

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