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Effects of Soil Surfactant IrrigAid Gold on Water Management for Tomato Production in Florida Spodosols

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A field study was conducted in west-central Florida to determine the effects of a soil surfactant application on soil moisture and tomato growth and yield. Six treatments resulted from the combination of 100%, 80%, and 60% of the potential evapotranspiration (ETo)-based standard irrigation with and without the application of the soil surfactant IrrigAid Gold (0.5 gal/acre and applied at 0, 3, and 6 weeks after transplanting). There was a significant effect of IrrigAid Gold on soil moisture at 5 inches deep, nitrate-nitrogen (NO_3-N) concentration in petiole sap, and early fruit yield. There was no significant difference between 100% of standard irrigation and 80% of the standard irrigation plus IrrigAid Gold on soil moisture, NO_3-N concentration in petiole sap, and early fruit yield. The results indicated that using IrrigAid Gold increased soil moisture in planting beds and allowed water use to be reduced for tomato production in sandy soils.

Florida is the second largest tomato producer in the U.S. with more than 32,000 acres of open field production and an estimated value of $564 million (U.S. Department of Agriculture, 2012). Most of the tomato production in Florida occurs in sandy soils. These soils are characterized by limited water retention, rapid infiltration, and low nutrient holding capacity, mainly due to the small specific surface area of sand, and low organic matter and clay content (Brady and Well, 2007). Ground water contamination by soluble fertilizer and pesticide leaching is a serious problem where these soils are used for crop production, especially because 90% of Florida drinking water comes from groundwater (Florida Department of Environmental Protection, 2009). These conditions require cautious management of crop irrigation programs to support plant development and obtain high yields, while avoiding water waste and nutrient leaching (Ramirez-Sanchez et al., 2009).

Soil surfactants have been available for agricultural uses since 1950 (Sunderman, 1983). These complex molecules increase the interfacial free energy of water. When present in low concentration in a system, like the soil solution, they are adsorbed onto the interface of the liquid and alter the surface tension of the solution (Rosen and Kunjappu, 2012). The surface tension is a property of liquids that allows them to resist an external force, including gravity. This property is caused by the cohesion of similar molecules with different charges or polar nature. The action of capillarity is due to the combined forces of attraction of water to the solid (adhesion) and the attraction of water molecules for each other (cohesion) (Brady and Well, 2007). The reduction of energy required to break the surface tension allows the potential energy of water to increase, so the molecules can spread out. Soil surfactants can improve the ability of water to penetrate the soil surface and thus decrease soil hydrophobicity (Sloan and Mackay, 2004).

However, it is unclear how much water usage could be reduced with the addition of soil surfactants to sandy soils, especially for a crop like tomato that has a high water requirement. The objective of this study was to assess the effects of soil surfactant applications on soil moisture, NO_3-N concentration in petiole sap, and tomato growth and yield.

Materials and Methods

A field study was conducted in Spring 2008 at the Gulf Coast Research and Education Center of the University of Florida, located at Balm, FL. The soil at the experimental site is classified as a Myakka fine sand siliceous hyperthermic Oxyaquic Alorthod. Planting beds were 27 inches wide at the base, 24 inches wide at the top, 10 inches high, and spaced 5 ft apart on centers. In early February, pressed beds were fumigated with methyl bromide plus chloropicrin (67:33, v/v) at a rate of 350 lb/acre to eliminate soilborne diseases, nematodes, and weeds in the soil. A standard fumigation rig with three knives per bed delivering the fumigant 8 inches deep was used. A single line of drip irrigation tubing (0.45 gal/100 ft row per min; T-Tape Systems, San Diego, CA) was buried 1 inch deep on bed center and, within 1 min of fumigation, beds were covered with black high-density polyethylene mulch (0.7-mil thick).

Six treatments resulted from the combination of 100%, 80%, and 60% of the ETo-based standard irrigation with and without the application of the soil surfactant IrrigAid Gold (Aquatrols, Paulsboro, NJ) at a rate of 0.5 gal/acre and applied at 0, 3, and 6 weeks after transplant (WAT). Three weeks after fumigation, 'Tygress' tomato transplants were set 2 ft apart in single rows on bed center. Treatments were established in a randomized complete-block design with four replications. Experimental units were 30 ft long (15 plants/plot). Seepage irrigation was used 8 h/d for 7 d until the establishment of the seedlings. After establishment, ETo values used were 4344 gal/acre per day in August, 3801 gal/acre per day in September, 2987 gal/acre per day in October, and 2172 gal/acre per day in November. These values were adjusted for each treatment and crop stage. Plants received approximately 300 lb/acre of nitrogen (N) through the drip line during the season in a

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Table 1. Effect of soil surfactant IrrigAid Gold on soil moisture, nitrate-nitrogen (NO_3-N) concentration in petiole sap, and yield. Spring 2008 at Balm, FL.

Irrigation program	Soil moisture	NO_3-N petiole sap	1st harvest	2nd harvest	Total yield
	------(%)-----	-------(ppm)-------		----------------------(ton/acre)----------------------	
100% SI[z] + IrrigAid Gold	14.7 a[y]	750 a	11.0 a	18.4 a	29.4 a
100% SI	14.2 ab	723 a	10.4 a	19.3 a	29.7 a
80% SI + IrrigAid Gold	14.8 a	778 a	9.9 a	17.0 a	26.9 b
80% SI	13.8 b	588 b	7.4 b	15.4 ab	22.8 c
60% SI + IrrigAid Gold	13.9 b	623 b	7.0 b	12.1 b	19.1 d
60% SI	12.7 c	545 b	7.1 b	11.0 b	18.1 d
Significance ($P < 0.05$)	*	*	*	*	*

[y]SI = Potential evapotranspiration based on standard irrigation.
[z]Values followed by the same letters do not differ at the 5% significance level, according to Fisher's least significant difference test.
*Significant at $P < 0.05$.

daily injection with the last irrigation cycle. Soil moisture (v/v) was measured daily before the beginning of the first irrigation cycle using a time domain reflectometer (TDR) at 5 inches deep and the values were averaged for the season. Concentration of NO_3-N in the petiole sap was measured at 8 WAT with a cardy twin nitrate (NO_3) sensor (Spectrum Technologies, Plainfield, IL). Early and total marketable fruit weights were collected starting at 10 WAT. Early marketable fruit weight was defined as the cumulative marketable weight of the first harvest, whereas total marketable fruit yield consisted of two harvests. A marketable fruit was defined as a fruit at physiological maturity, green stage, without visible damage. Soil surfactant and irrigation effects were examined for significant differences ($P < 0.05$) with the general linear model (Statistix Analitical Software, Tallahasee, FL). Means were compared with a Fisher's-protected least significance difference test at the 5% significance level.

Results and Discussion

There was a significant effect of the treatments on soil moisture at 5 inches deep and NO_3-N concentration in petiole sap. There was no significant difference between 100% of ETo with or without the application of IrrigAid Gold and 80% of ETo plus IrrigAid Gold for soil moisture and NO_3-N concentration, which were higher than for the other treatments (Table 1). The application of IrrigAid Gold significantly influenced early marketable fruit yield but not total marketable yield. The highest early marketable fruit yield values were found in plots treated with 100% of ETo with and without the application of the soil surfactant and 80% of ETo with IrrigAid Gold (Table 1). There was no effect of the soil surfactant on total marketable fruit yield.

These results show that the use of IrrigAid Gold increases soil moisture retention in planting beds. Nitrogen concentration in tomato leaves increased with the application of IrrigAid Gold, possibly due to an improvement in water use efficiency and therefore the nutrient uptake efficiency (Morgan and Hanlon, 2011). Sloan and Mackay (2004) reported that the addition of soil surfactants helped retain water within the soil profile, which allowed the time between irrigations to be increased. Similar results were found by Boatright et al. (1995), who reported that leached water decreased by 17% with the application of a hydrophilic polymer in petunia (*Petunia* ×*hybrida*) production. Bres and Weston (1993) indicated that two hydrophilic polymers evaluated increased water retention and NO_3-N concentration in tomato leaves. The results of this research may lead to water savings for Florida growers but further studies are needed to assess the interaction of soil surfactants with molecules like ammonium and nitrate in the soil.

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