DRIP IRRIGATION OF PROCESSING TOMATOUNDER SALINE, SHALLOW GROUNDWATER CONDITIONS: Progress Report 2000

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Introduction

During the past three years, a project has been conducted in the Westlands Water District to evaluate using drip irrigation of processing tomato in fine-textured soil underlain by saline, shallow groundwater. The objective of this project is to determine the effect of drip irrigation on yield and yield quality, soil salinity, and depth to the water table. In 1999, drip irrigation systems were installed at two locations in the district. Results from these systems were compared with adjacent sprinkler irrigated fields. Westlands irrigation water was used for these fields. In 2000, drip irrigation was installed in a third site irrigated with well water containing about 3 times more salt compared with the district water. Measurements made at these sites were yield, yield quality, depth to the water table, and applied water.

At each site, an experiment consisting of different irrigation amounts was conducted to determine how little irrigation water could be applied without reducing yield. Target amounts of applied water were 90, 75, 60, 45, and 30 percent of the potential crop evapotranspiration. At Site DP, three varieties were grown last summer for the differential irrigation treatments. Measurements made during these experiments were yield, fruit quality, soil salinity, soil moisture content, and tomato canopy development.

Summary of Results

Yield Characteristics

Table 1 shows applied water, yield, solids, and color for both 1999 and 2000. 1999 yields of the drip irrigated fields were 6 to 10 tons/acre more compared with the sprinkler irrigated fields. Applied water of the sprinkler systems was available for only Site BR, similar for both irrigation methods. After the 1999 crop, the adjacent sprinkler-irrigated fields at Sites BR and DI were converted to drip irrigation.

In 2000, yield of the drip irrigated field at Site DP was about 10 tons/acre more compared with the sprinkler field. About 6 inches more water were applied to the drip field, which was irrigated about two weeks longer compared with the sprinkler field. The yield at Site BR was relatively low, the result of a late replanting due to hail damage in late April.

For both years, the solids content was acceptable for all sites. However, the lowest solids occurred at Site DI in 2000, the site with the lowest soil salinity. The higher solids contents occurred on those fields with higher levels of soil salinity.

At all sites, we were unable to attain the desired irrigation amounts for the differential irrigation treatments. Also, the yields of the differential treatments of Site DI (not reported) were considerably less compared with the field-wide yield due to the late harvest of these treatments caused excessively wet soil from a leak.

The results of the differential treatments at Site DP are shown in Table 2 for the three varieties. Interestingly, although the applied water amounts differed only by about 4 inches among the treatments, a significant decrease in yield with decreasing applied water was found. Yields of H8892 were significantly less than those of the other varieties. Little differences were found in both solids content and color.

These results coupled with that at Site BR (not shown) suggests that for relatively high levels of soil salinity, a slight decrease in applied water can affect yield, whereas for soils with relatively low salt levels (Site DI), reductions in applied water did not significantly reduce yield where shallow groundwater exists.

Table 1. Yields and quality characteristics for 1999 and 2000.

Irrigation System	**Variety**	**Applied Water (inches)**	**Yield (tons/ac)**	**Soluble Solids (^{o}Brix)**	**Color**
		Site BR (1999)			
Sprinkler	H8892	16.8	36.47	5.3	24.2
Drip	H8892	16.0	46.26	6.0	21.1
		Site DI (1999)			
Sprinkler	H9557	**	35.26	5.2	24.8
Drip	H9557	22.2	40.60	5.0	22.8
		Site BR (2000)			
Drip	Halley 3551	16.8	34.97	5.4	23.4
		Site DI (2000)			
Drip	H9492	29.0	46.38	4.8	21.0
		Site DP (2000)			
Sprinkler	H9557	22.8	28.53	5.5	23.9
Drip	H9557	28.0	38.61	5.6	23.7

Table 2. Yield results of the differential irrigation treatments at Site DP.

	Applied Water (in)	Yield (tons/ac)	Brix (%)	Color	Red Fruit (%)	Green Fruit (%)	Nonmar-ketable (%)
				Halley			
90	24.0	42.96	6.3	22.6	87.6	2.4	10.0
75	24.1	42.48	6.1	22.8	88.8	2.6	8.6
60	22.8	36.16	6.4	22.3	86.4	4.4	9.2
45	21.9	37.55	6.3	23.2	86.0	2.0	12.0
30	20.9	33.67	6.5	23.4	90.4	2.0	7.6
Average		38.55a	6.3a	22.8a	87.8a	2.7a	9.5ab
				H9665			
90	24.0	47.42	5.4	23.4	9.02	2.4	7.4
75	24.1	43.91	5.6	23.4	92.4	3.6	4.0
60	22.8	38.88	5.9	23.2	90.2	3.6	6.2
45	21.9	39.39	5.6	24.2	91.2	2.6	6.2
30	20.9	35.85	6.3	22.8	85.2	2.8	12.0
Average		41.09a	5.8a	23.4a	89.7a	3.0a	7.2b
				H8892			
90	24.0	40.07	5.45	23.0	85.6	3.6	10.8
75	24.1	37.04	6.1	20.8	83.6	4.8	12.8
60	22.8	31.22	5.5	21.2	88.4	2.8	8.8
45	21.9	39.39	5.8	21.4	82.8	2.4	14.8
30	20.9	30.57	6.3	21.0	83.8	1.8	14.5
Average		33.89b	5.8a	21.5b	85.1b	3.1a	11.9a

Water Quality

The water quality for both 1999 and 2000, listed in Table 3, shows low salinity irrigation water at Sites BR and DI, with values electrical conductivity of about 0.34 dS/m. However, at Site DP, the electrical conductivity of the irrigation water was about 1.06 dS/m, about three times higher compared with the other sites. The electrical conductivity of the shallow groundwater was the least of Site BR and the highest for Site DP.

Soil Salinity

Soil salinity measurements of the treatment receiving the most irrigation water, in Figure 1, revealed salinity to be the least at Site DI with levels less than the threshold value of

Table 3. Water quality of the irrigation water and groundwater for all sites.

Irrigation Water	Ground Water
Site BR (1999)	
0.34-0.46	6.9
Site DI (1999)	
0.34-0.46	9.8-11.1
Site BR (2000)	
0.34	4.7-7.4
Site DI (2000)	
0.34	7.9-10.8
Site DP (2000)	
1.06	13.6-16.4

soil salinity for tomato (2.5 dS/m). The threshold value is the maximum soil salinity at which yield reductions will not occur, based on data provided by the US Salinity Laboratory. A slight increase in soil salinity occurred with time for depths less than about 2 feet. At the other sites, however, salinity levels were much higher that the threshold salinity, with values ranging from about 2.5 to 7 at Site BR and about 3.5 to 7 at Site DP. At both of these sites, soil salinity increased with time for depths less than about 1 to 1.5 feet and decreased with time for the deeper depths. Soil salinity profiles of the treatment receiving the least amount of irrigation water (not shown) showed an increase in soil salinity with time at nearly all depths for all sites.

In spite of the higher levels of soil salinity at Sites BR and DP, crop yields were similar to those of Site DI except for the 2000 yield of Site BR which was affected by a late planting, even though soil salinity at Sites BR and DP was much higher that that at

Site DI. This behavior indicates that drip irrigation has the potential for large yields, even under conditions of excessive soil salinity.

Patterns of soil salinity about the dripline are shown in Figures 2, 3, and 4 for the three locations. At Site DI (Figure 2), low values of soil salinity occurred throughout the soil profile. A slight increase in salinity occurred as the surface was approached. At Site BR (Figure 3), salinity was the least near the dripline with values less than about 1 dS/m. Salinity increased with distance and depth from the dripline to values of about 7 dS/m. Salinity also increased as the soil surface was approached. The area of relatively low soil salinity (less than the threshold value of 2.5 dS/m) extended to about 16 inches horizontally from the dripline and to about 22 inches deep below the drip line. This pattern shows that most of the root zone probably consisted of low salinity soil.

A much different pattern of soil salinity was found at Site DP (Figure 4). Soil salinity was the highest near the dripline and decreased with horizontal distance. Values near the dripline were about 3 to 4 dS/m. At distances beyond about 8 to 16 inches, soil salinity was less than 2.5 dS/m. The high salinity near the dripline reflects the salinity of the irrigation water. The low levels of salinity near the edge of the pattern, however, suggest that for depths less than about 16 inches, considerable leaching of salt had occurred, reasons for which are not clear because the preplant irrigation was applied with a sprinkler system using the well water (EC = 1.06 dS/m). The only possible explanation for this behavior is that during the spring, the storm that destroyed the crop at Site BR caused much ponding of water at Site DI, which probably leached much of the salt near the ground surface.

Soil Moisture Content

Little trend in soil moisture content with time was found for Sites DI and DP (not shown). Soil moisture content increased with depth. However, at Site BR, relatively high soil moisture contents were found in July compared with August and September, as shown in Figure 5. This behavior was evident for depths down to about 3 feet. In August and September, soil moisture contents were much smaller, particularly for the shallower depths. This behavior was caused by early water applications with the drip system in excess of the crop evapotranspiration in an attempt to control soil salinity. These water applications had a considerable impact on the water table (discussed later). When this impact became evident, irrigation amounts were reduced to about 80 percent of the potential crop evapotranspiration about mid-July.

Water Table Depth

Figures 6 and 7 show the depth to the water table at Sites BR and DI. Similar data were not collected at Site DP because of the difficulty in installing observations wells in that soil. At Site BR, the spikes from about June 28 to about July 15 are a water table response to the drip irrigations. For example, between July 10 and July 11, the water table rose by about 1.7 feet, to a depth of 1.4 feet below the ground surface as a result of the irrigation on July 10. In the later part of July, irrigation amounts were decreased to less than the potential crop evapotranspiration, and as a result, the depth to the water table increased with time. A slight response of the water table to irrigations still could be found between mid July and into August. At Site DI, the depth to the water table was relatively constant with time throughout the irrigation season. However, a slight response of the water table to drip irrigation could be found with changes in the water table depth of a few inches during an irrigation. At Site DP, periodic measurements showed the depth to the water table to be about 5 feet.

Crop Evapotranspiration

Crop evapotranspiration was determined using measurements of canopy coverage with time and a computer simulation model. Figure 8 shows the total crop evapotranspiration with time after planting. Note that crop evapotranspiration changed little with time until about 50 days after planting. There after, cumulative crop ET increased rapidly with time. The rate of increase was similar for all sites. Also shown in Figure 8 is the total amount of applied water at each site. Applied water and cumulative crop ET was about the same for Site BR, but for the other sited, the applied water exceeded the cumulative crop ET. Table 4 shows the amounts of cumulative crop ET and applied water.

Table 4. Total amount of applied water and cumulative crop ET for 2000.

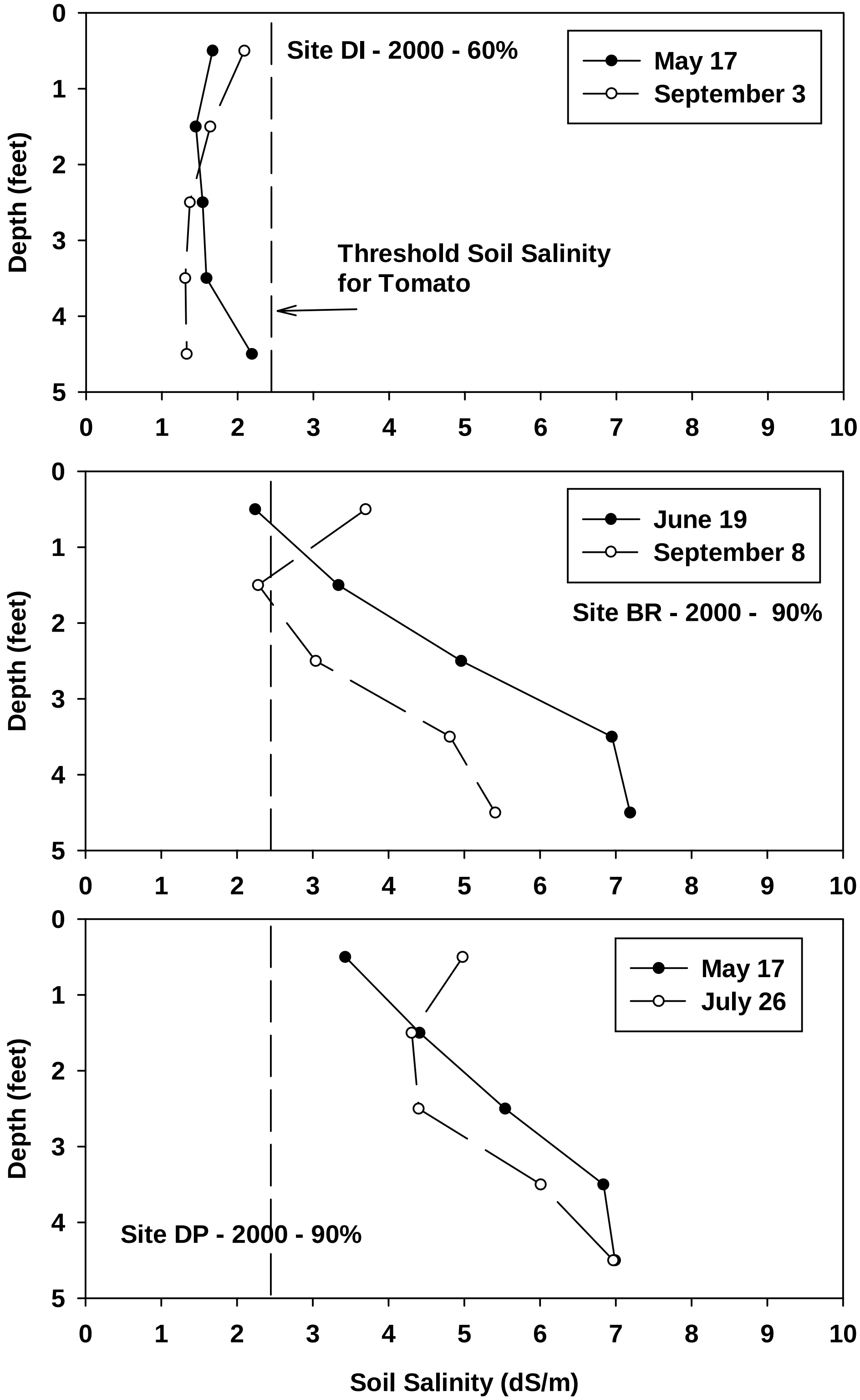
Site	**Applied Water (inches)**	**Cumulative Crop ET (inches)**
BR	16.8	16.7
DP	27.9	24.2
DI	29.0	23.8

Conclusions

These results indicate that processing tomato can be successfully grown with drip irrigation on salt affected soils in areas with saline, shallow groundwater. Yields under drip irrigation have been 6 to 10 tons/acre more compared with sprinkler irrigation. In two of the fields, soil salinity greatly exceeded the threshold soil salinity for tomato. At the same time, the solids content of the drip-irrigated fields have been acceptable.

Water table depths can be controlled with properly managed drip systems. However, if drip system applications are excessive, substantial decreases in the depth to the groundwater can occur.

Figure 1. Soil salinity with depth from ground surface for the three sites.



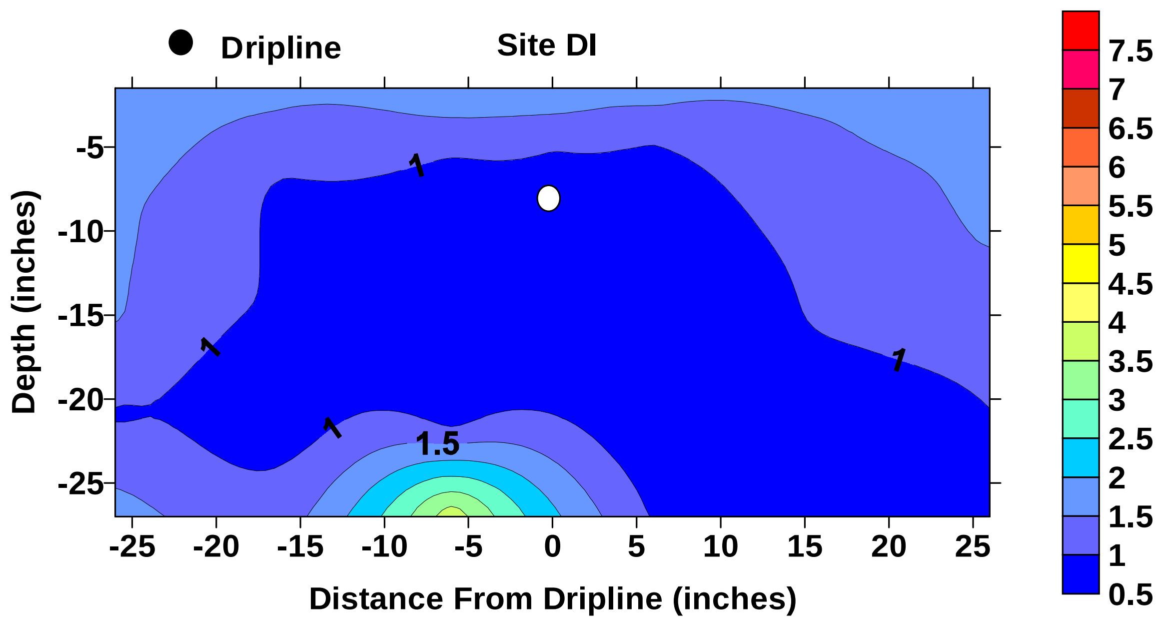


Figure 2. Pattern of soil salinity about the drip line for Site DI.

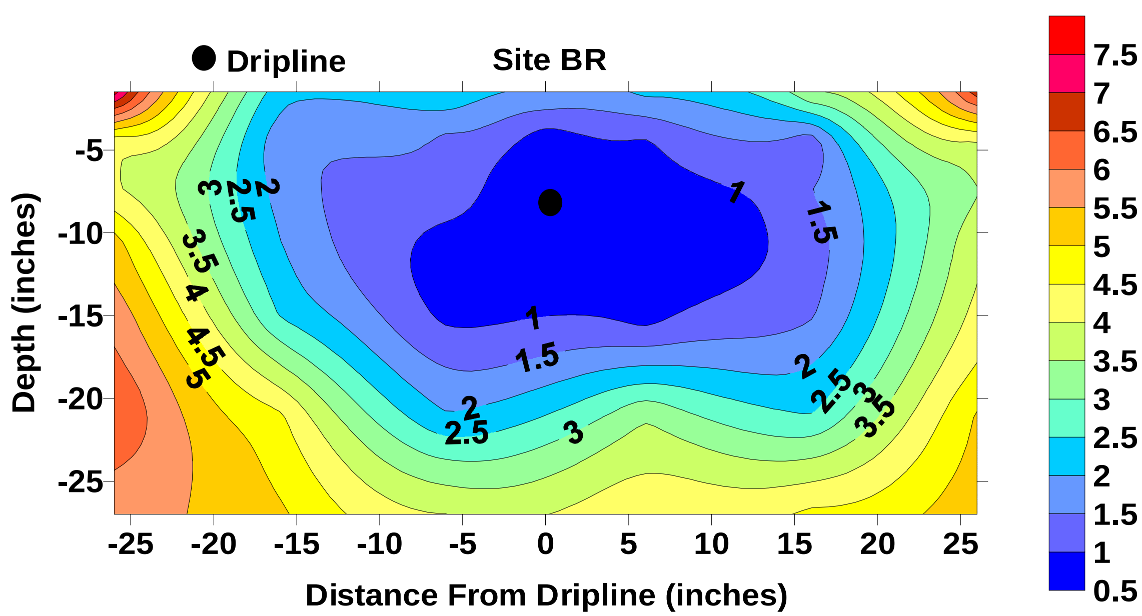


Figure 3. Pattern of soil salinity about the drip line for Site BR.

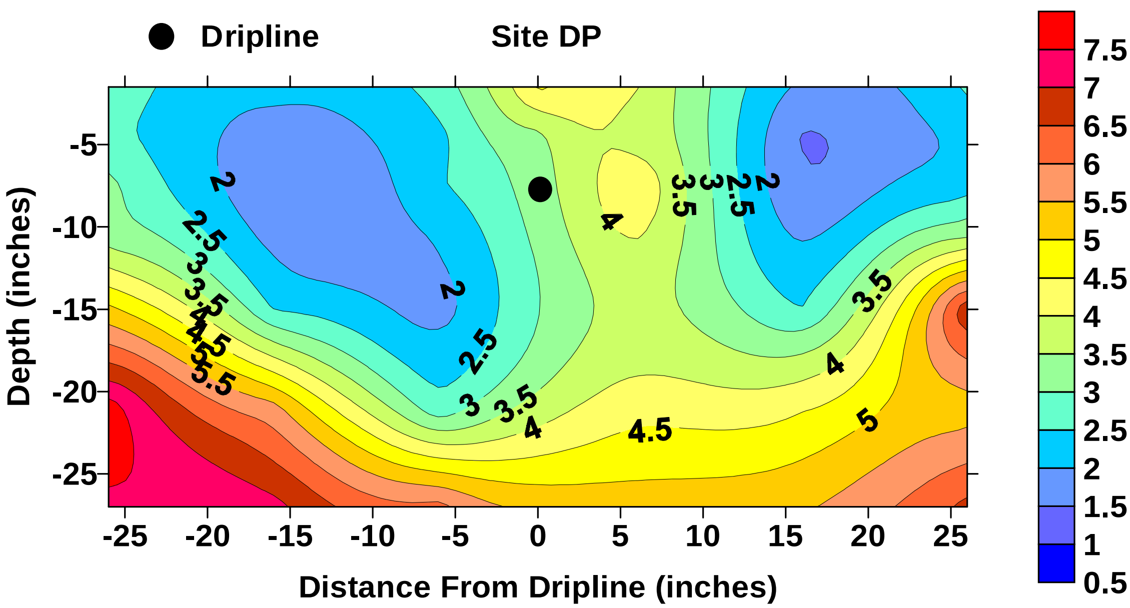


Figure 4. Pattern of soil salinity about the drip line for Site DP.

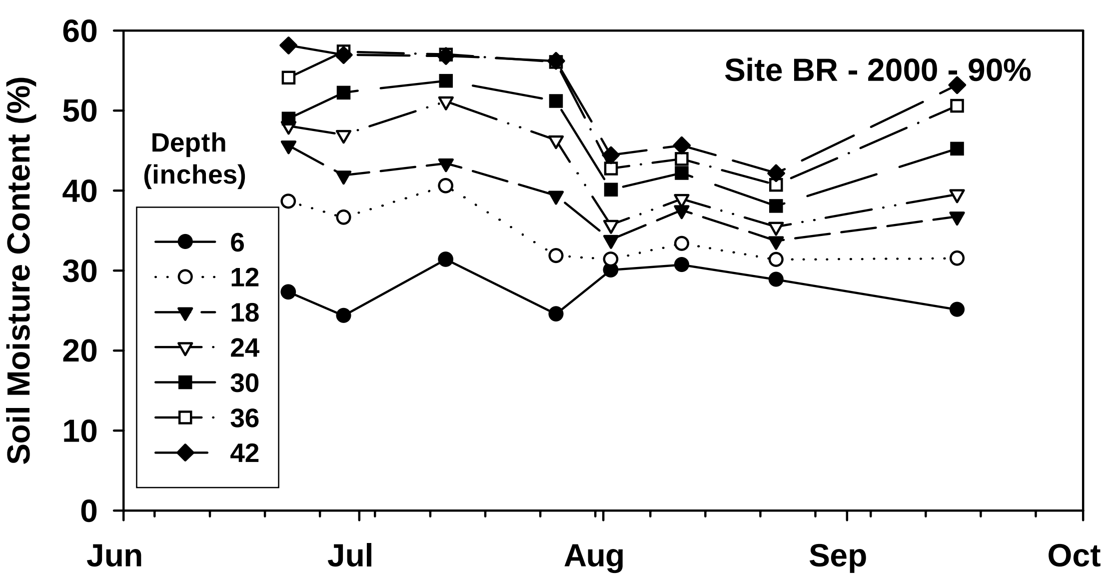


Figure 5. Soil moisture content with time for Site BR.

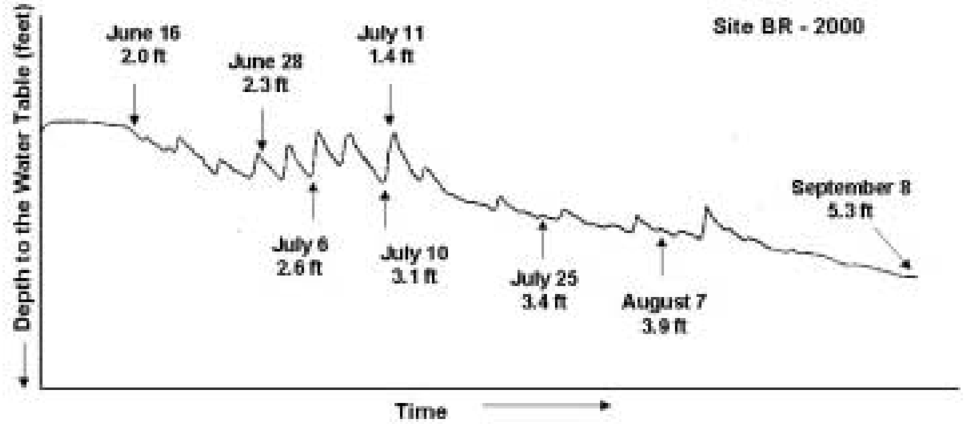


Figure 6. Depth to the water table for Site BR.

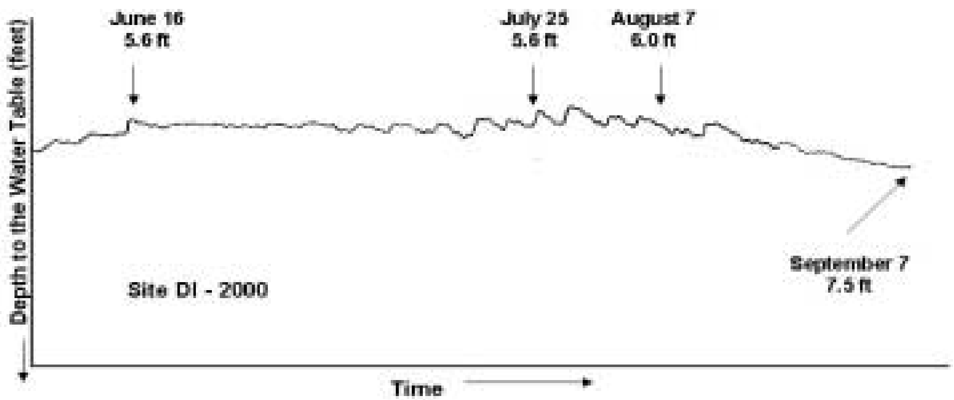


Figure 7. Depth to the water table for Site DI.

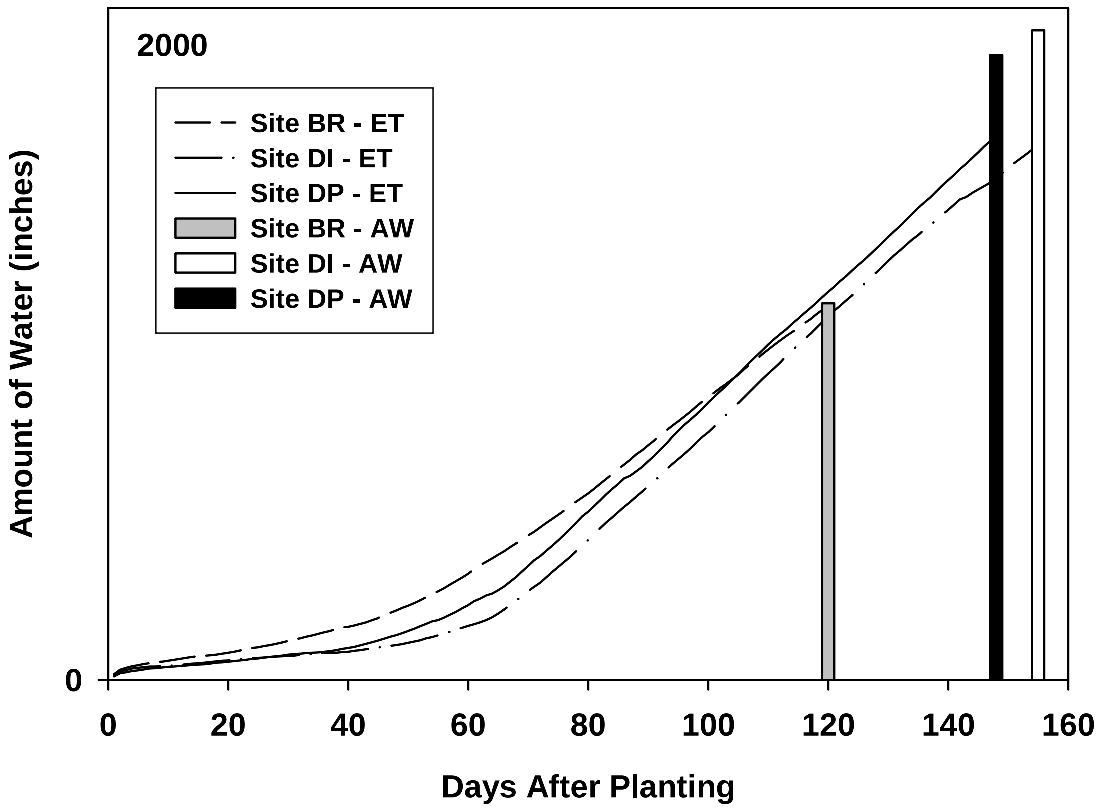


Figure 8. Cumulative crop evapotranspiration (ET) and total applied water (AW) for the three 2000 sites.