IRRIGATION FREQUENCY, DRIP TAPE FLOW RATE, AND ONION PERFORMANCE

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Introduction

Onion production with subsurface drip irrigation has proven at the Malheur Experiment Station to be highly productive on sites that are difficult to irrigate. In 1997 and 1998 onions were submitted to five soil water potential treatments using an automated, high frequency irrigation system (Shock et al. 2000a). The soil water potential was maintained relatively constant by applying 0.06 inch of water up to eight times a day, depending on soil water potential readings. The soil water potential at 8-inch depth that resulted in maximum onion yield, grade, and quality after storage was determined to be -20 kPa. An irrigation frequency of up to eight times a day in small increments is not feasible on a commercial scale. Would reducing the irrigation frequency result in lower water use efficiencies and lower onion yield and quality?

The drip tape that has been used at the Malheur Experiment Station has a flow rate of 0.22 gal/min/100 ft of tape. A reduced flow rate could theoretically result in an improved soil wetting pattern and less water lost to deep percolation. An improved soil wetting pattern could result in the onions on the outside row of a double row receiving more uniform soil moisture. New "ultra low flow" drip irrigation tapes with reduced emitter flow rates are being introduced by drip tape manufacturers. This trial tested four irrigation frequencies and two drip tape flow rates for their effect on onion yield and quality.

Materials and Methods

The onions were grown at the Malheur Experiment Station, Ontario, Oregon on an Owyhee silt loam previously planted to wheat. Onion (cv. 'Vaquero', Sunseeds, Morgan Hill, CA) was planted in two double rows, spaced 22 inches apart (center of double row to center of double row) on 44-inch beds on March 17, 2003. The rows in the "double row" were spaced 3 inches apart. Onion was planted at 150,000 seeds/acre. Drip tape (T-tape, T-systems International, San Diego, CA) was laid at 4-inch depth between the two double onion rows on March 28. The distance between the tape and the double row was 11 inches. The drip tape had emitters spaced 12 inches apart and either of two flow rates: low flow (0.22 gal/min/100 ft) and ultra low flow (0.11 gal/min/100 ft).

Immediately after planting the onion rows received 3.7 oz of Lorsban 15G per 1,000 ft of row (0.82 lb ai/acre), and the soil surface was rolled. Onion emergence started on April 7. The trial was irrigated on April 14 with a minisprinkler system (R10 Turbo

Rotator, Nelson Irrigation Corp., Walla Walla, WA) for even stand establishment. Risers were spaced 25 ft apart along the flexible polyethylene hose laterals, which were spaced 30 ft apart.

Onion tissue was sampled for nutrient content on June 19. The roots from 25 onion plants taken from plot border rows representative of the field were washed with deionized water and analyzed for nutrient content by Western Labs, Parma, Idaho. The onions in all treatments were fertilized according to the nutrient analyses (Table 1). Fertilizer was applied through the drip tape: ammonium sulfate at 25 lb N/acre on May 30, urea ammonium nitrate solution at 25 lb N/acre on June 5, 16, and 25, and zinc chelate at 0.25 lb Zn/acre and copper chelate at 0.2 lb Cu/acre on June 25.

Roundup at 24 oz/acre was sprayed on March 28. The field had Prowl (1lb ai/acre) broadcast on April 21 for postemergence weed control. Approximately 0.4 inch of water was applied through the minisprinkler system on April 21 to incorporate the Prowl. The field had Buctril at 0.12 lb ai/acre and Poast at 0.4 lb ai/acre applied on April 28. Thrips were controlled with one aerial application of Warrior on June 5 and two aerial applications of Warrior (0.03 lb ai/acre) plus Lannate (0.4 lb ai/acre) on July 16 and August 4.

The experimental design was a randomized complete block with four replicates. The onions were submitted to eight treatments consisting of a combination of two drip tape flow rates and four daily irrigation frequency/duration treatments (Table 2). The onions in each plot (four double rows by 50 ft) were submitted to one irrigation frequency and one tape flow rate. The irrigation frequencies were the daily time interval by which the datalogger (CR10, Campbell Scientific, Logan, UT) checked the sensors and made irrigation decisions. Each plot was irrigated independently when the average soil water potential at 8-inch depth in the plot reached -20 kPa. The irrigation durations for each treatment were adjusted so that when irrigated the maximum number of times, all treatments had the capacity to deliver a maximum of 0.48 inch of water per day.

Soil water potential was measured in each plot with four granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) installed at 8-inch depth in the center of the double row. Sensors were calibrated to SWP (Shock et al. 1998a). The GMS were connected to the datalogger via five multiplexers (AM 410 multiplexer, Campbell Scientific, Logan, UT). The datalogger read the sensors and recorded the soil water potential every 3 hours. The irrigations were controlled by the datalogger using a controller (SDM CD16AC controller, Campbell Scientific, Logan, UT) connected to solenoid valves in each plot. The pressure in the drip lines was maintained at 10 psi by pressure regulators in each plot. The amount of water applied to each plot was recorded daily at 8:00 a.m. from a water meter installed between the solenoid valve and the drip tape. The automated drip irrigation system was started on May 22. Irrigations were terminated on September 2.

Onion evapotranspiration (Et_c) was calculated with a modified Penman equation (Wright 1982) using data collected at the Malheur Experiment Station by an AgriMet weather station. Onion Et_c was estimated and recorded from crop emergence on April 7 until the final irrigation.

On September 11 the onions were lifted to field cure. On September 17, onions in the central 40 ft of the middle two double rows in each subplot were topped and bagged. The bags were placed into storage on September 29. The storage shed was managed to maintain an air temperature of approximately 34°F. Onions were graded on December 11.

During grading bulbs, were separated according to quality: bulbs without blemishes (No. 1s), split bulbs (No. 2s), neck rot (bulbs infected with the fungus *Botrytis allii* in the neck or side), plate rot (bulbs infected with the fungus *Fusarium* oxysporum), and black mold (bulbs infected with the fungus *Aspergillus niger*). The No. 1 bulbs were graded according to diameter: small (<2¼ inches), medium (2¼-3 inches), jumbo (3-4 inches), colossal (4-4¼ inches), and supercolossal (>4¼ inches). Bulb counts per 50 lb of supercolossal onions were determined for each plot of every variety by weighing and counting all supercolossal bulbs during grading.

Results

In the analysis of variance, the year effect was significant for total marketable and jumbo onion yields, both being higher in 2002. The yield of the larger bulb size classes was limited in these trials by the high plant population (Shock et al. 2004). While the yields are above the county average, they are in the range achieved by growers using drip irrigation.

There was no interaction between emitter type or irrigation frequency and year, so the results are analyzed and discussed as the average over the 2 years. Averaged over irrigation frequencies, the drip tape with 0.13 gal/hour emitters had significantly higher total yield, marketable yield, and colossal onion yield than the tape with 0.07 gal/hour emitters (Table 2). Averaged over emitter type, the once per day irrigation frequency (0.48 inch of water applied per irrigation) had among the highest total and marketable onion yields. Averaged over emitter type, the once per day irrigation frequency resulted in the highest colossal onion yield.

There was no significant difference in average soil water potential between treatments (Table 2). The standard deviation of the soil water potential increased with decreasing irrigation frequency, reflecting the higher amplitude of soil water potential oscillation around the criteria of -20 kPa (Table 2, Figs. 1 and 2). There was no significant difference in total water applied between treatments, with, on average, 32 and 28 inches applied in 2002 and 2003, respectively. Onion Et_c from emergence to the last irrigation totaled 30.2 and 32 inches in 2002 and 2003, respectively. The total amount of water applied includes 2 and 0.52 inches of water applied with the minisprinkler system after emergence, and 0.84 and 1.28 inches of precipitation, in 2002 and 2003, respectively. Water applications to all treatments closely followed Et_c during the season (Figs. 3 and 4).

Discussion

An explanation for the increased bulb size with the lowest irrigation frequency could be that, since the lowest irrigation frequencies had the highest amplitude of soil water potential oscillation, the onions might have responded to the soil becoming wetter during irrigations than with the lower irrigation frequencies. Our past research has shown that onions will respond to irrigation criteria higher than -20 kPa with increased bulb size (Shock et al. 1998b, Shock et al. 2000b). An irrigation criteria higher than -20 kPa is not recommended on silt loam soils, because of the unpredictability of onion storage quality, which in some years can be low with irrigation criteria higher than -20 kPa.

The results of this study suggest that the drip tape with 0.066 gal/hour emitters should not be recommended for onion production in the Treasure Valley, since onion yield and size were lower and there were no apparent irrigation benefits.

References

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Table 1. Onion root nutrient concentrations on June 19, 2003. Malheur Experiment Station, Oregon State University, Ontario, OR.

Nutrient	Sufficiency range*	Analysis
NO_3 (ppm)	6,200	4,251
P (%)	0.32 - 0.70	0.59
K (%)	2.7 - 7.0	4.95
S (%)	0.24 - 1.4	0.61
Ca (%)	0.4 - 1.6	1.69
Mg (%)	0.3 - 0.6	0.41
Zn (ppm)	32 - 100	27
Mn (ppm)	35 - 100	91
Cu (ppm)	8 - 30	8
Fe (ppm)	60 - 250	448
B (ppm)	19 - 80	27

*supplied by Western Labs, Parma, ID.

Table 2. Effect of irrigation frequency and drip tape emitter flow rate on onion yield and size, Malheur Experiment Station, Oregon State University, Ontario, OR.

Emitter flow rate	Irrigation frequency	Irrigation duration	Water applied		Avg soil water potential	Total yield	Marketable yield				
gal/h	h	h	Per irrigation (inch)	Total (inch)	(kPa)	(cwt/acre)	Total (cwt/acre)	Super colossal (cwt/acre)	Colossal (cwt/acre)	Jumbo (cwt/acre)	Medium (cwt/acre)
2002											
0.13	3	1	0.06	32.7	-20.3 ± 3.1	1,042	1,028	6	239	764	20
0.13	6	2	0.12	32.2	-19.9 ± 3.4	985	970	11	192	738	30
0.13	12	4	0.24	32.6	-20.3 ± 3.5	1,041	1,028	9	192	800	28
0.13	24	8	0.48	31.5	-18.8 ± 4.1	1,052	1,028	16	287	708	16
Avg				32.3	-19.8	1,030	1,014	10	227	753	24
0.066	3	2	0.06	32.6	-19.8 ± 2.9	969	952	13	185	736	18
0.066	6	4	0.12	31.2	-21.2 ± 3.9	994	972	3	190	751	28
0.066	12	8	0.24	32.9	-19.8 ± 4.2	977	958	10	178	746	24
0.066	24	16	0.48	31.5	-19.9 ± 5.4	1,041	1,025	11	213	778	23
Avg				32.0	-20.2	995	977	9	192	753	23
Avg over tape types	3		0.06	32.7	-20.0	1,005	990	9	212	750	19
	6		0.12	31.8	-20.4	989	971	8	191	744	29
	12		0.24	32.7	-20.1	1,009	993	10	185	773	26
	24		0.48	31.5	-19.4	1,047	1,027	14	256	738	19
2003											
0.13	3	1	0.06	28.5	-18.0 ± 2.7	861	846	17	164	649	17
0.13	6	2	0.12	28.0	-19.4 ± 3.0	880	846	9	211	610	16
0.13	12	4	0.24	27.7	-18.9 ± 3.3	902	894	6	194	677	18
0.13	24	8	0.48	29.2	-17.4 ± 4.5	947	925	26	269	615	15
Avg				28.4	-18.4	897	878	14	209	637	17
0.066	3	2	0.06	26.9	-18.9 ± 2.8	849	834	2	138	673	20
0.066	6	4	0.12	28.8	-18.9 ± 2.4	805	786	16	150	599	22
0.066	12	8	0.24	24.9	-19.6 ± 3.3	940	901	5	186	692	18
0.066	24	16	0.48	31.1	-18.7 ± 4.1	882	859	13	197	630	19
Avg				27.9	-19.0	869	845	9	168	649	20
Avg over tape types	3		0.06	28.0	-18.5	855	840	10	151	661	18
	6		0.12	28.3	-19.2	842	816	12	180	605	19
	12		0.24	26.8	-19.2	921	897	6	190	684	18
	24		0.48	29.9	-18.1	914	892	19	233	622	17
2002-2003											
0.13	3	1	0.06	29.9	-18.8	952	937	11	201	706	18
0.13	6	2	0.12	29.8	-19.6	932	908	10	201	674	23
0.13	12	4	0.24	29.8	-19.5	972	961	7	193	738	23
0.13	24	8	0.48	30.0	-17.9	1,000	976	21	278	662	16
Avg				29.9	-18.9	964	946	12	218	695	20
0.066	3	2	0.06	29.8	-19.2	909	893	8	162	705	19
0.066	6	4	0.12	30.0	-19.6	886	866	10	167	664	24
0.066	12	8	0.24	28.9	-19.7	958	930	8	182	719	21
0.066	24	16	0.48	31.3	-19.1	950	930	12	204	693	21
Avg				30.0	-19.4	926	905	9	179	695	21
Avg over tape types	3		0.06	29.8	-19.0	930	915	9	181	705	19
	6		0.12	29.9	-19.6	911	889	10	185	669	24
	12		0.24	29.5	-19.6	965	945	8	187	729	22
	24		0.48	30.5	-18.5	976	955	17	244	676	18
LSD (0.05) Emitter				NS	NS	36	34	NS	4	NS	NS
LSD (0.05) Water applied				NS	NS	50	48	9	50	44	1
LSD (0.05) Emitter X Water applied				NS	NS	NS	NS	NS	NS	NS	NS
LSD (0.05) Emitter X Water appl. X Year				NS	NS	NS	NS	NS	NS	NS	NS

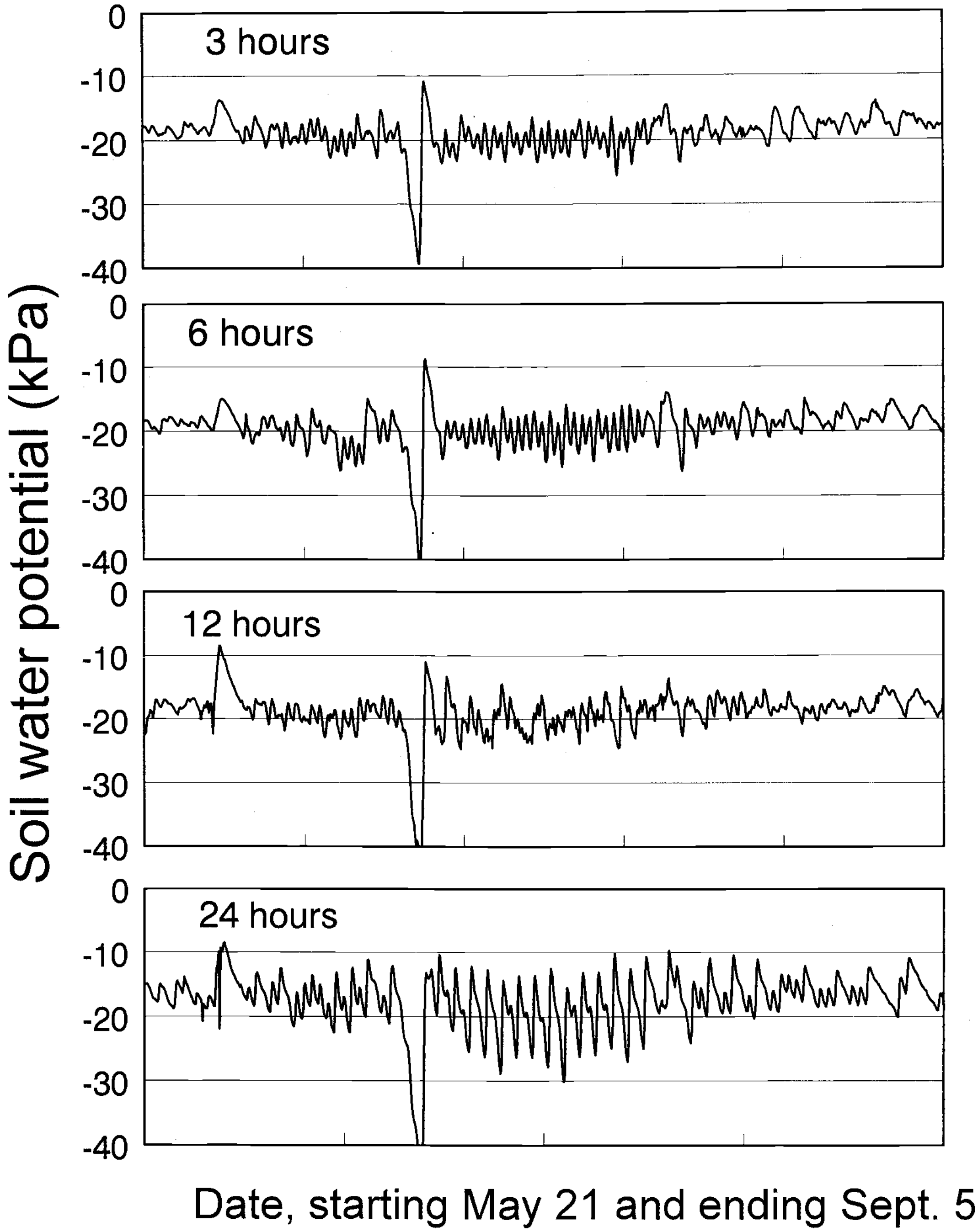

Figure 1. Soil water potential over time for drip-irrigated onion using a tape flow rate of 0.22 gal/min/100 ft and four irrigation frequencies (time interval used by datalogger for checking sensors and making irrigation decisions). Soil water potential is the average of 16 sensors. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

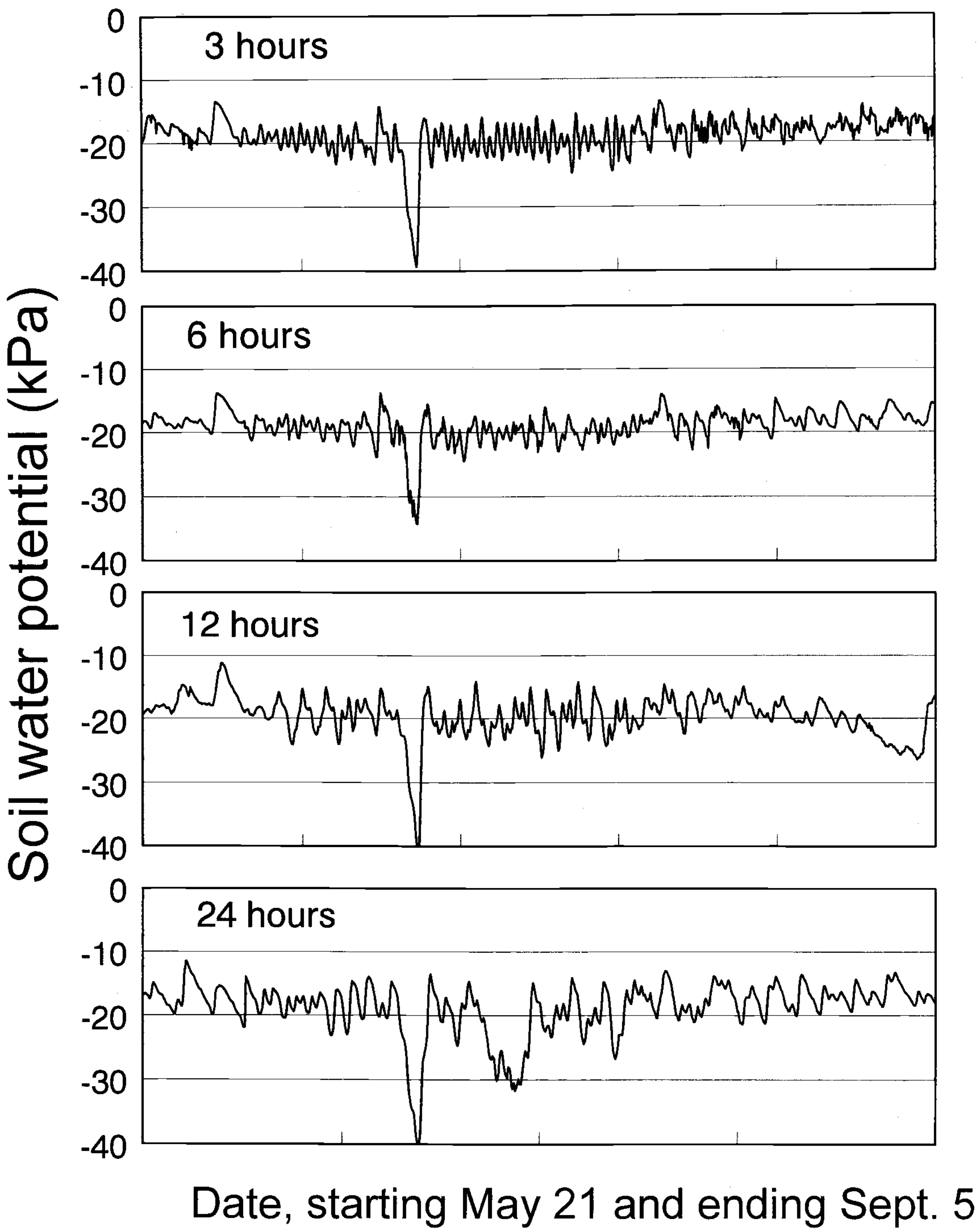

Figure 2. Soil water potential over time for drip-irrigated onion using a tape flow rate of 0.11 gal/min/100 ft and four irrigation frequencies (time interval used by datalogger for checking sensors and making irrigation decisions). Soil water potential is the average of 16 sensors. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

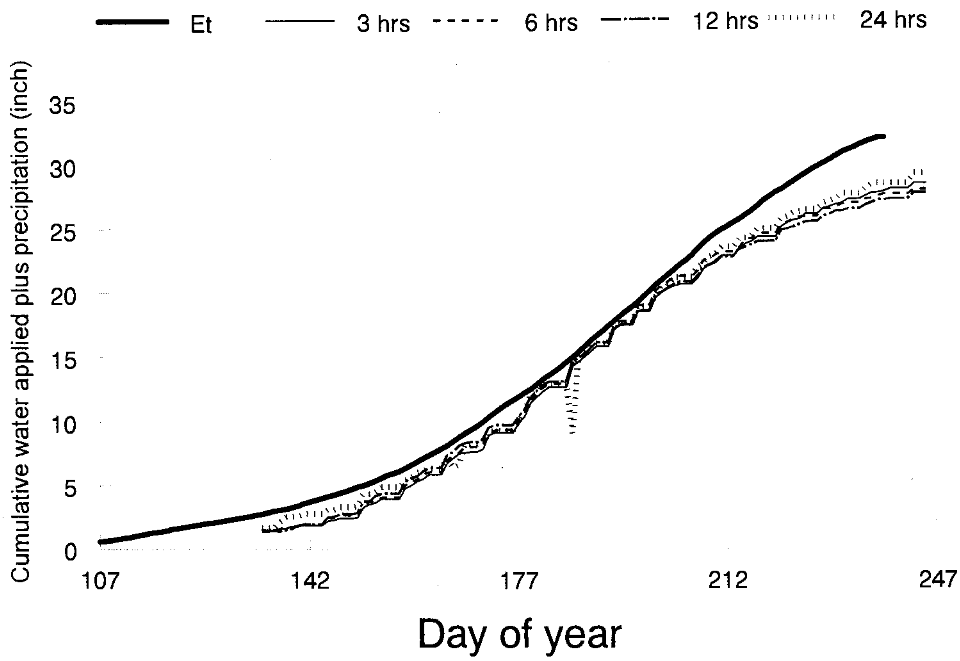

Figure 3. Cumulative water applied and Et_c over time for drip-irrigated onion using a tape flow rate of 0.22 gal/min/100 ft and four irrigation frequencies. Water applied is the average of four plots. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

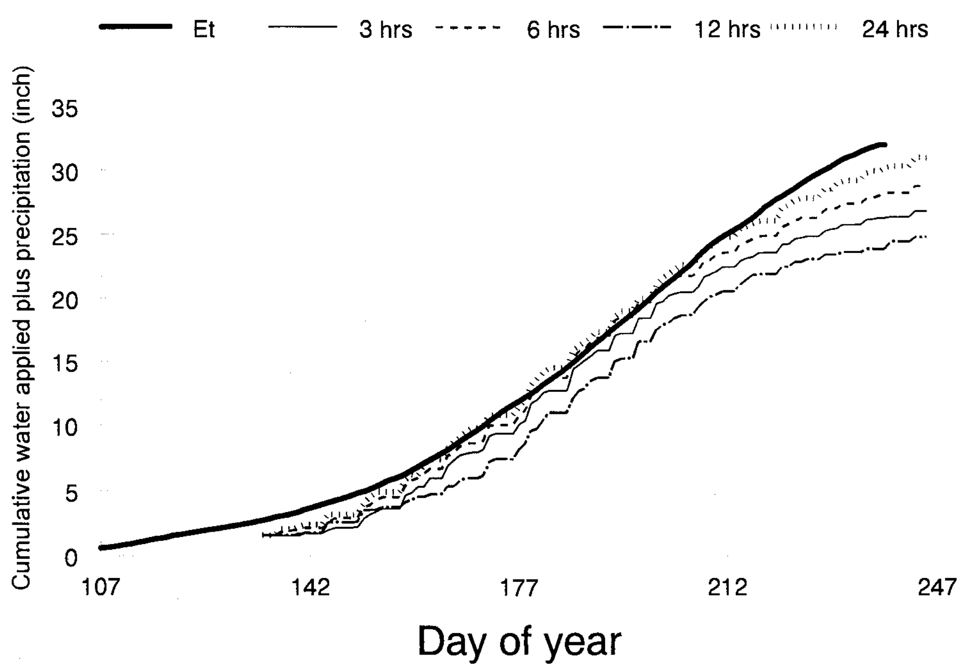

Figure 4. Cumulative water applied and Et_c over time for drip-irrigated onion using a tape flow rate of 0.11 gal/min/100 ft and four irrigation frequencies. Water applied is the average of four plots. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.