AUTOMATION OF SUBSURFACE DRIP IRRIGATION FOR ONION PRODUCTION

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Summary

Information on soil water potential was used to automatically control a subsurface-drip irrigation system for onion production. Granular matrix sensors provided the soil water potential data. A datalogger was programmed to maintain soil water potential at constant levels by high frequency irrigations (up to 8 times/day) using controllers connected to solenoid valves. Soil water potential was maintained constant at -10, -20, -30 or -40 kPa minimizing oscillations. Irrigation at -10 kPa resulted in water applications in excess of crop evapotranspiration and continuously wet soil at the 20 inch depth. Irrigation at -20 kPa or drier resulted in water applications close to or less than crop evapotranspiration, and slow soil drying at the 20 inch depth below the onions and drip tape.

Introduction

Subsurface drip irrigation allows for the application of small amounts of water at a high frequency close to the crop root zone. Soil water potential measurements can provide the feedback necessary to automatically schedule high frequency drip irrigations. The feedback allows the maintenance of nearly constant soil water potential in the crop root zone. Maintenance of constant soil water potential in the crop root zone could result in optimum crop growth with a low leaching potential. Onions have a shallow root system and need to be grown in wet soil for optimum yield (Dragland, 1974). In general, onions receive substantial inputs of N fertilizer (Voss, 1979). Onion crop requirements for wet soil, combined with high N fertilizer inputs, result in a substantial nitrate leaching risk under this crop.

Where rainfall is minimal, irrigating onions for optimum yield with little leaching of nutrients could be possible with an automated, high frequency, subsurface drip irrigation system.

Materials and methods

Sweet Spanish onions (CV. "Vision," Petoseed) were grown on 64-inch beds (88-inch centers) with nine single onion rows per bed on an Owyhee silt loam (coarse-silty, mixed, mesic, Xerollic Camborthid) at the Malheur Experiment Station, Oregon State University, Ontario, Oregon. Three drip tapes (Turbulent Twin-Wall, Chapin Watermatics, Watertown, NY) with 0.3 gal/min/100 ft flow rate and 12-inch emitter spacing, were laid 4 inches deep and spaced 8 inches apart prior to planting in each bed. Plots were three beds wide and 40 feet long, and arranged in a randomized complete block design with five replicates.

The treatments consisted of four target soil water potentials (-10, -20, -30, and -40 kPa) as irrigation criteria. Soil water potential was monitored in each plot by five granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200 SS, Irrometer Co., Riverside, CA). Four of the five GMS in each plot were installed at 8-inch depths, and one GMS was installed at a 20-inch depth. All GMS were installed below one of the onion rows that was 0.2 m to the side of a drip tape. All GMS were connected via multiplexers (AM 410 multiplexer, Campbell Scientific, Logan, UT) to the datalogger (CR 10 datalogger, Campbell Scientific, Logan, UT). All GMS were calibrated to soil water potential (Barnum and Shock, 1992).

The datalogger was programmed to make irrigation decisions at a frequency of eight times per day for each plot individually using the average soil water potential at the 8-inch depth in that plot as the criterion. If the soil water potential for a plot was drier than the irrigation criterion, the datalogger would irrigate the plot for 30 minutes (0.06 inch of water) using a solenoid valve (DV Series electric remote control valve, Rainbird Mfg. Corp.) wired to a controller (SDM CD16AC controller, Campbell Scientific, Logan, UT). With the capacity for eight irrigations, each at 0.06 inch, a total of 0.48 inches could theoretically be applied in a 24 hour period. Consequently, the system had the capacity to replace the highest historical daily evapotranspiration (Et_c) for onions of 0.35 inches.

Crop evapotranspiration was measured at the Malheur Experiment Station using an AgriMet weather station and a modified Penman equation (Wright, 1982). The amount of water applied in each plot was recorded daily by reading the water meter installed at the inlet of each plot. The pressure in the drip lines in each plot was maintained at 10 PSI by pressure regulators installed before each solenoid valve.

Nitrogen fertilizer as URAN (Urea ammonium nitrate solution) was injected in the drip lines using venturi injectors (Mazzei injector Model 1087, Mazzei Injector Corp., Bakersfield, CA). A total of 150 lb N/ac was applied as six split applications of 25 lb N/ac from May 11 through July 19.

Onions from a 30-foot section in the middle bed of each plot were topped and put in storage in late September. The onions were graded out of storage in mid-December. Gross economic returns were calculated by crediting medium onions with US $2.50/cwt, jumbo onions with US $5.00/cwt, and colossal onions with US $10.00/cwt.

Differences between treatments were compared using ANOVA and protected least significant differences at the 5 percent level, LSD (0.05).

Results and Discussion

The amount of water applied (including rainfall) to maintain the soil water potential at the 8-inch depth at -10 kPa was substantially higher than Et_c (Figure 1). The amount of water applied to the -20 kPa treatment was slightly higher (29 inches) than Et_c (27 inches) and the amount of water applied to the -30 kPa treatment was slightly lower (26 inches) than Et_c.

The automated, subsurface drip irrigation system maintained soil water potential at the 8-inch depth fairly constant for the different criteria (Figure 2). The irrigation system used in this study avoided the large oscillations in soil water potential common with furrow irrigation (Figure 3; Shock et al., 1994). Large oscillations in soil water potential can result in plant stress and conditions favorable to insect and disease development. Large oscillations in soil water potential where the soil is alternately saturated, then dried, will result in nitrate leaching below the crop root zone.

Soil water potential at the 20-inch depth remained wetter than at the 8-inch depth for the -10 kPa treatment suggesting a high leaching potential (Figure 4). For the -20 and -30 kPa treatments, soil water potential at the 20-inch depth remained drier than at the 8-inch depth suggesting a low leaching potential.

Onion total yield and yield by size class were not significantly responsive to the treatments in this trial at harvest (Table 1). When the gross return at harvest is calculated from the different treatments the optimal irrigation criterion is -20 kPa (Table 1). This is in accordance with previous research at the Malheur Experiment Station that demonstrated that the optimum target soil water potential for onions on silt loam soils is -12.5 to -37.5 kPa depending on the site and year (Shock et al., 1994).

There was a trend for a significant increase in storage rot with the increasing wetness (higher soil water potential) of the irrigation criteria. As a result there was a trend for a decrease in marketable onion yield out of storage with the increasing wetness of the irrigation criteria.

Conclusions

It is feasible to use soil water potential measurements at 8-inch depth to automatically control drip irrigations for optimum onion production with a low leaching potential.

Literature cited

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Table 1. Effect of irrigation criteria on onion yield, quality, and gross economic return. Malheur Experiment Station, Oregon State University, Ontario, OR.

Soil water potential criteria	Yield by market grade							Onion quality out of storage	
	#2	Small	Medium	Jumbo	Colossal	Total yield	Gross return	Rot	Marketable (med-col)
kPa	------------------- cwt/ac -------------------						US $/ac	------ cwt/ac ------	
-10	22.3	25.0	137.4	750.5	42.8	978.1	8,254.5	412.3	538.1
-20	17.9	23.2	113.3	773.7	41.1	969.1	8,361.5	394.4	550.6
-30	17.0	29.4	126.7	717.5	26.8	916.5	7,882.0	209.7	671.1
-40	4.5	33.0	169.6	722.0	25.9	954.0	8,150.5	158.0	764.8
LSD (0.05)	ns	ns	ns	ns	ns	ns		194.5	149

Fig. 1. Water applied (includes precip.) for drip irrigated onions, Ontario, OR, 1995.

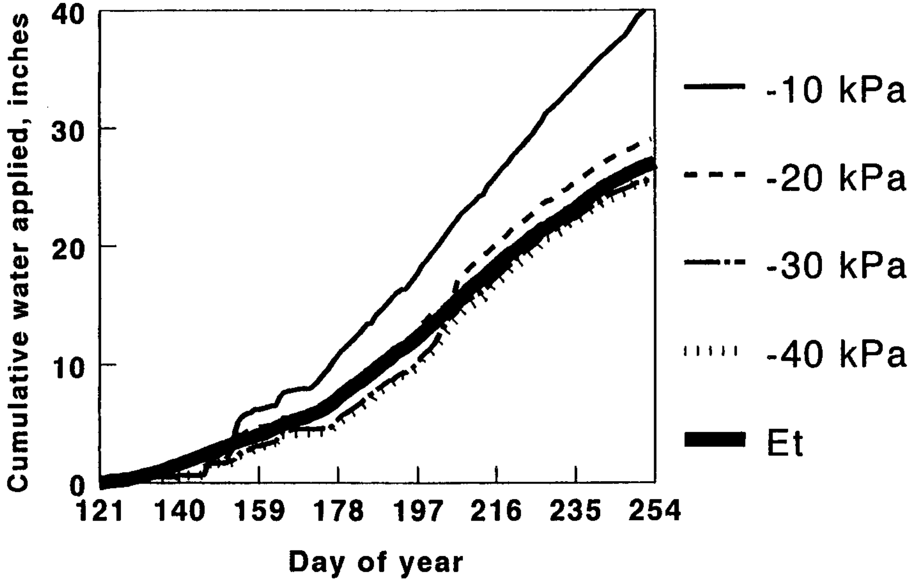

Fig. 2. Soil water potential at 8-inch depth for drip irrigated onions, Ontario, OR, 1995.

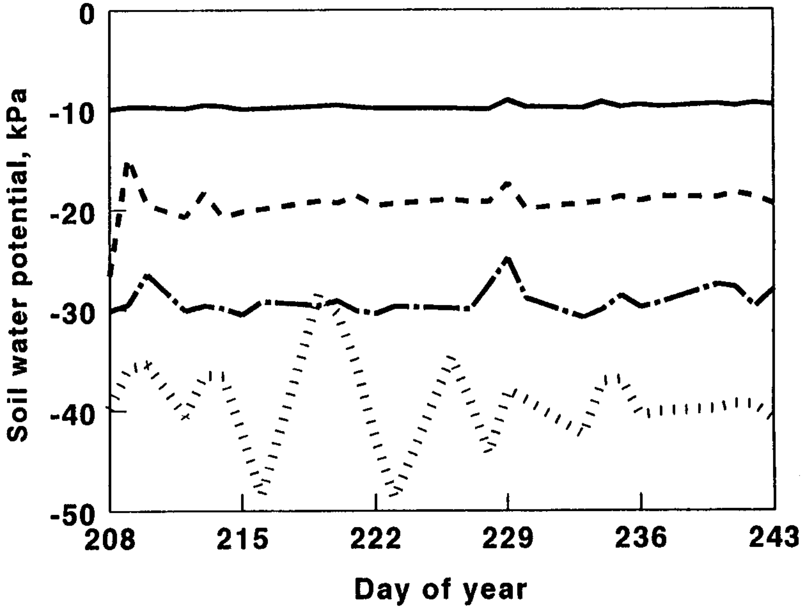

Fig. 3. Soil water potential at 8-inch depth for onions furrow irrigated at -25 kPa, Ontario, OR, 1994.

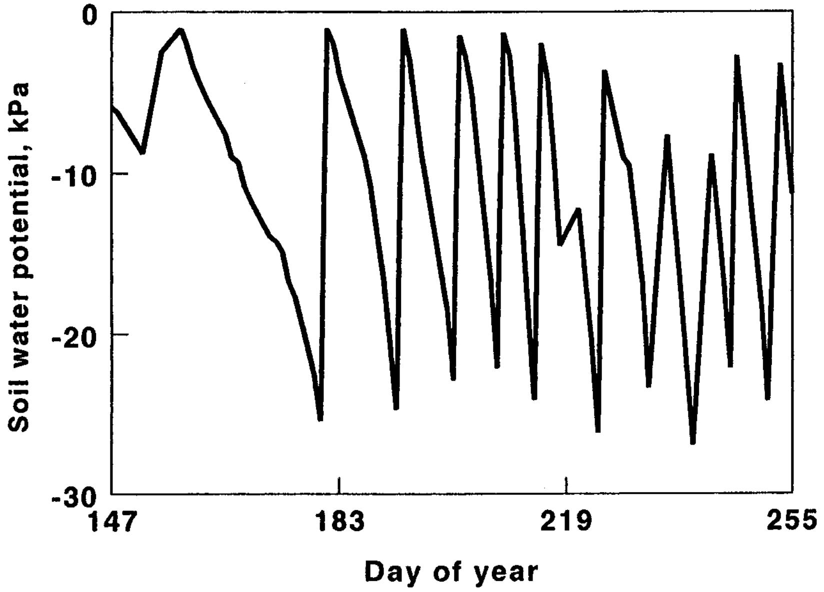

Fig. 4. Soil water potential at 20-inch depth for drip irrigated onions, Ontario, OR, 1995.