Irrigation Criteria for Sweet Potato Production Using Drip Irrigation

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Abstract. *An irrigation criterion has not been established for sweet potato (*Ipomoea batatas*) production in the Pacific Northwest. Four sweet potato varieties were planted at Ontario, Oregon, on silt loam. Slips were established for 30 days at 25 kPa and then subjected to four soil water tension (SWT) irrigation criteria (40, 60, 80, and 100 kPa) using drip irrigation. Vine growth, soil cover, water application, and sweet potato yield and grade were evaluated. Marketable (44.1 tons/acre) and US number 1 yield were greatest with a SWT irrigation criterion of 40 kPa, using 358 mm of water and the SWT averaged 28 kPa.*

Keywords. Ipomoea batatas, soil water tension, yield,

Introduction

Sweet potato is a versatile crop cultivated mainly for tuber production. It is a long-season crop grown mainly in the southeastern United States and in California. Research suggests that the availability of irrigation water together with high temperatures during summer favors production of high-quality sweet potatoes in eastern Oregon. Recently, growers have indicated interest in growing sweet potato as a new crop in eastern Oregon. The valley has a number of crop produce processors who are willing to buy sweet potatoes grown locally as a strategy to cut the costs associated with sweet potato trucking from California and the southeastern United States. Purchasing locally produced sweet potatoes could significantly reduce the carbon footprint of sweet

potato processors in the Treasure Valley. Also, growers would be able to develop niche marketing for a crop that is loved by most consumers. Newly developed sweet potato varieties will produce mature tubers in 80 to 90 days, suggesting that plants transplanted in early June will produce mature tubers that could be harvested during September or early October, around the time of the first vegetation killing frost.

Critical factors for successful sweet potato production include irrigation scheduling and the amount of water to be applied. Irrigation scheduling options rely on the measurement of soil water content or soil water tension. Precise irrigation scheduling by soil water tension criteria is a powerful method to optimize plant performance. By utilizing the ideal soil water tension and adjusting irrigation duration and amount, it is possible to simultaneously achieve high productivity and meet environmental stewardship goals for water use and reduced leaching (Shock and Wang 2011).

Objectives

The overarching goal of this study was to assess the possibility of producing sweet potatoes in eastern Oregon. The specific objectives were to evaluate varieties and develop the irrigation criterion suitable for sweet potato production in eastern Oregon.

Materials and Methods

The field was plowed and disked during fall 2010 and fumigated on February 16, 2011 using metam sodium at 30 gal/acre through sprinklers. The beds (36 inches wide) were formed 3 weeks after fumigation followed by fertilizer to supply 100 lb nitrogen/acre that was shanked into beds. The study followed a split-plot design with irrigation criteria forming the main plots and varieties as subplots with treatments arranged in a randomized complete block. The study had three replications and drip tape was used to deliver irrigation water. Each subplot was 3 beds (9 ft wide) by 30 ft long.

Sweet potato slips were transplanted by hand on June 3 on 30 cm (12-inch) spacing within the row using the drip tape emitter spacing on top of the bed as markers. The drip tape used was Toro Aqua-traxx® 8-mil emitting 8,327 mm/min/30.5 m (0.22 gal/min/100 ft). Slips were transplanted 10 to 15 cm (4 to 6 inch) deep using a hand trowel. Plants were immediately irrigated for 5 hours (0.35 inch) in order to provide soil/transplant contact. Plots were irrigated again on June 4 for 2 hours (0.14 inch). Plants were irrigated again on June 10, 21 and July 5 to provide 0.5 inch of water each. Subsequent irrigations were automatically determined by the datalogger controller, depending on targeted criterion of soil water tension.

The irrigation criteria were 40, 60, 80, and 100 kPa of moisture tension and water was delivered through drip tape. Sweet potato plants in each plot were irrigated automatically and independently when the soil water tension dropped below the targeted irrigation criterion. The irrigation duration was predetermined based on the drip tape capacity to deliver 1.25 cm (0.5 inch) of water in 7 hours and 5 min per incident.

Soil water tension was measured in each main plot with four granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) installed at 20-cm (8-inch) depth in the center of 'Beauregard' rows. Sensors had been calibrated to local soil water tension (Shock et al. 1998). The sensors were connected to a datalogger (CR10X, Campbell Scientific, Logan, UT) through a multiplexer (AM 410 multiplexer, Campbell Scientific, Logan, UT). The datalogger read the sensors and recorded the hourly soil water tension.

The datalogger was programmed to check the sensor readings in each main plot every 12 hours and irrigate the appropriate main plot if the average soil water tension was below the targeted criterion. The irrigations were controlled by the datalogger using a controller (SDM CD16AC controller, Campbell Scientific, Logan, UT) connected to solenoid valves in each main plot. The irrigation water was supplied by a well that maintained a continuous and constant water pressure of 241 kPa (35 psi). The pressure in the drip lines was maintained at 69 kPa (10 psi) by pressure regulators in each main plot. The automated irrigation system was started on July 8 and was turned off on September 29, 2011.

Integrated Pest Management

Preplant herbicides were not used because of the field proximity to sensitive crops. All plots were sprayed with glyphosate 0.86 kg ae/ha (Roundup® at 22 fl oz/acre) on May 26, 2011 to control all emerged weeds prior to transplanting. Sethoxydim (Poast®) at 0.214 kg ai/acre (16 fl oz/acre) plus nonionic surfactant (0.25% v/v) was applied on June 27, 2011 to control grassy weeds. Plots were hand-weeded on June 27 and July 28, 2011 to remove all broadleaf weeds. Later weed cohorts were sparsely distributed and were periodically removed by hand.

Sweet potato vines were flailed on October 4 and roots were dug using a 2-row digger set at 45-cm (18-inch) depth. Roots were picked by hand from the center row and later graded following California standards (May and Scheuerman 1998). In summary, the roots were graded based on California standards: U.S. No.1 were of uniform size, 4.4 to 9 cm (1.75 to 3.5 inches) in diameter and 7.5 to 23 cm (3 to 9 inches) long; U.S. No. 2 (mediums) included misshapen tubers and with a minimum diameter of 4 cm (1.5 inches); Jumbo weighed more than 567 g (20 oz) and was true to type.

The data were subjected to analysis of variance using PROCGLM procedure in Statistical Analysis Software (SAS) and means were compared using Fisher's protected least significant difference procedure at $P \leq 0.05$.

Results and Discussion

The average soil water tension increased with the increase in the targeted irrigation criterion (Table 1). The total amount of water applied from transplanting to harvest includes the water used during the plant establishment phase (June 3 to July 8) and daily rainfall. Total amount of water decreased with the increase in the targeted soil water tension. Sweet potato irrigated at the 40 kPa criterion received a seasonal total of

357.8 mm (14.1 inches) of water compared to 146.1 mm (5.8 inches) at 100 kPa. The water use efficiency (ton/acre marketable yield per inch of water applied) reflected the total amount of water used, which was directly related to the irrigation frequency needed to maintain the targeted irrigation criterion (Fig. 1).

Percent vegetative ground cover at 49 days after transplanting (July 22) was not influenced by the different irrigation criteria (Table 2). Differences in average percent ground cover were related to varietal characteristics. Ground cover for 'Covington' and 'Diane' averaged 80 and 83 percent, respectively, compared to 94 percent for Beauregard and 'Evangeline'. These results are supported by the average runner length for different varieties on July 22 (Table 2). Covington and Diane had shorter runners (51 and 39 cm; 20 and 15 inches) compared to Beauregard and Evangeline, which averaged 89 cm (35 inches).

The number of sweet potato runners per hill at 117 days after transplanting (September 28) was similar among irrigation criteria (Table 3); however, there were differences in the number of runners per hill that were attributed to varieties. Covington and Beauregard averaged 8 and 9 runners, compared to 11 and 12 for Evangeline and Diane, respectively. Beauregard had the longest average runner length at 379 cm (149 inches) and Diane had the shortest at 165 cm (65 inches).

Sweet potato yield varied among irrigation criteria and varieties (Table 4). The highest marketable yields were obtained when plants were irrigated at 40 kPa of moisture tension. There was a gradual decline in root yield with the increase in the targeted soil water tension to trigger irrigation. All varieties produced much lower yield at 80 and 100 kPa. Previous studies by May and Scheuerman (1998) indicated improved yield when sweet potatoes were irrigated at 25 kPa throughout the season or 25 kPa during plant development and 100 kPa during the root bulking stage. It is important to note that the irrigation criterion will be influenced by the soil type. Because the varieties responded similarly to irrigation at 80 and 100 kPa, the irrigation criteria could be changed to 25, 40, 60, and 80 kPa in future studies.

Conclusion

The results indicated that sweet potatoes could be grown successfully in eastern Oregon. Varietal differences in terms of growth habits and yield in response to available moisture were noted. Subsequent studies could help to determine the best variety and irrigation criterion and confirm the preliminary results. We believe the positional placement of irrigation water with drip irrigation may have reduced the weed pressure that would be expected with furrow or overhead irrigation.

References

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Table 1. Average hourly soil water tension, total water applied, marketable yield, and water use efficiency (ton/ha marketable yield per mm of water applied) for sweet potato exposed to four irrigation treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2011.

Soil water tension	Hourly soil water tension	Total water applied[1]	Marketable yield[2]	Water use efficiency
kPa	kPa	mm	ton/ha	ton/mm
40	27.7	357.8	44.1	0.12
60	44.4	256.2	38.2	0.15
80	48.6	158.8	24.8	0.16
100	58.9	146.1	23.6	0.16
LSD (0.05)	4.2	40.3	3.1	0.02

[1] Total applied water for each criterion includes the amount applied uniformly to all treatments during plant establishment phase (37.8 mm) and rainfall from June 3 to September 29, 2011 (27.9 mm). 25.4 mm = 1 in.
[2] 1 metric ton/ha is equivalent to 892 lb/acre.

Table 2. Sweet potato vegetative percent ground cover and average runner length on July 22 (49 days after transplanting) in response to differential irrigation criteria at Malheur Experiment Station, Ontario, OR, 2011.

Irrigation criterion	Percent ground cover				Average runner length			
	Covington	Beauregard	Evangeline	Diane	Covington	Beauregard	Evangeline	Diane
(kPa)	---------- % ----------				---------- cm ----------			
40	88	95	94	83	56	107	91	43
60	75	93	94	83	48	84	79	33
80	82	93	93	83	51	81	86	38
100	75	94	93	80	48	89	86	41
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Average[1]	80 b	94 a	94 a	83 b	51 b	91 a	86 a	39 b

[1] Because there was no significant difference among irrigation criteria, the means among water tension were used to compare variety performance. Average values within a row and group followed by the same letter are not significantly different according to LSD 0.05%.

Table 3. Number of sweet potato runners per hill and average length (cm) on September 28 (117 days after transplanting) in response to differential irrigation criteria at Malheur Experiment Station, Ontario, OR, 2011.

Irrigation criterion	Number of runners/hill				Average length/runner			
	Covington	Beauregard	Evangeline	Diane	Covington	Beauregard	Evangeline	Diane
(kPa)	---------- Number ----------				---------- cm ----------			
40	6	9	9	11	224	452	358	198
60	6	9	10	12	213	399	340	175
80	13	10	12	12	145	348	262	158
100	5	8	11	12	175	315	226	130
LSD (0.05)	NS	NS	NS	NS	36	36	36	91
Average[1]	8 b	9 b	11 a	12 a	191 c	379 a	297 b	165 c

[1] Because there was no significant difference among irrigation criteria, the means among water tension were used to compare variety performance. Average values within a row and group followed by the same letter are not significantly different according to LSD 0.05%.

Table 4. Sweet potato yield and grade in response to differential irrigation criteria and variety at Malheur Experiment Station, Oregon State University, Ontario, OR, 2011.

Irrigation criterion	Sweet potato yield[1]					
	Total	Marketable	U.S. No. 2	U.S. No. 1	Jumbo	Discard[2]
(kPa)	(tons/ha)[3]					
	Beauregard					
40	54.2	49.4	9.7	34.6	5.1	4.8
60	51.6	47.1	8.7	32.8	5.6	4.5
80	38.2	32.2	6.5	22.4	3.4	6.0
100	33.2	27.8	6.6	20.8	0.4	5.4
Average	44.3	39.1	7.9	27.6	3.6	5.2
	Covington					
40	53.6	41.4	15.9	24.5	1.0	12.2
60	42.2	31.1	13.0	17.7	0.4	11.1
80	31.8	16.8	9.5	7.3	0.0	15.1
100	30.4	15.0	6.4	8.6	0.0	15.4
Average	39.5	26.1	11.2	14.5	0.4	13.4
	Diane					
40	49.5	43.0	5.5	35.1	2.4	6.5
60	42.3	38.3	5.5	31.0	1.8	4.0
80	34.2	29.1	6.4	21.3	1.3	5.2
100	32.8	29.0	4.8	21.2	3.0	3.8
Average	39.7	34.8	5.6	27.2	2.1	4.9
	Evangeline					
40	48.6	42.6	7.5	32.0	3.1	6.0
60	41.3	36.5	6.9	27.9	1.7	4.9
80	27.1	21.3	5.7	14.1	1.5	5.9
100	28.5	22.7	5.5	14.4	2.7	8.3
Average	36.4	30.8	6.4	22.1	2.3	5.6
LSD (0.05)						
Irrigation	2.7	3.1	1.3	3.1	1.2	1.3
Variety	2.7	3.1	1.4	3.1	1.3	1.4
Irrigat. X Variety	NS	NS	2.2	NS	NS	NS

[1] Sweet potato grades were based on California standards: U.S. No.1 were of uniform size, 4.4 to 9 cm (1.75 to 3.5 inches) in diameter and 7.5 to 23 cm (3 to 9 inches) long; U.S. No. 2 (mediums) included misshapen tubers and with a minimum diameter of 4 cm (1.5 inches); Jumbo weighed more than 567 g (20 oz) and were true to type.
[2] Discarded roots were <3.8 cm (<1.5 inches) in diameter.
[3] 1 metric ton/ha is equivalent to 892 lb/acre.

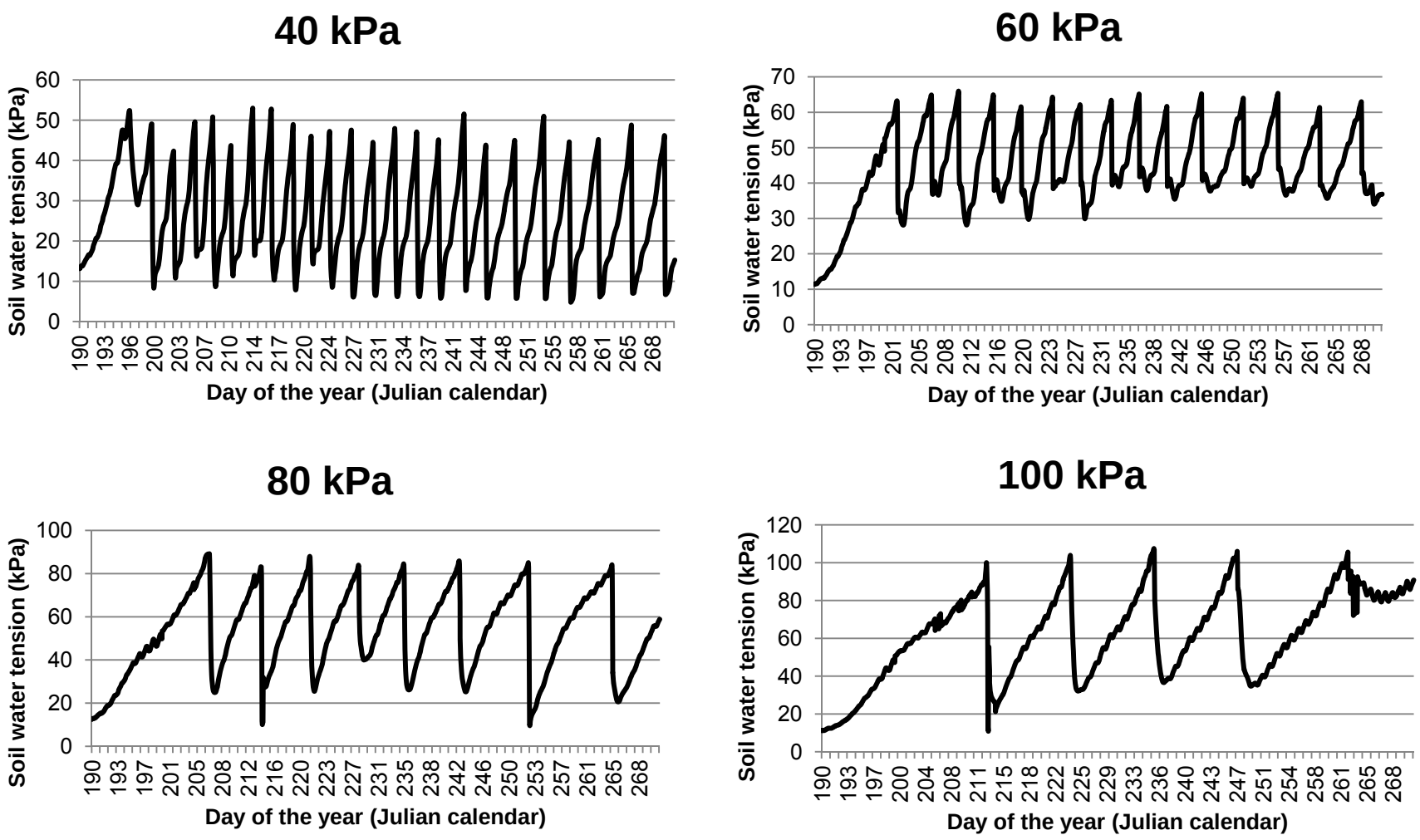

Figure 1. Soil water tension at 17.8-cm (7-inch) depth over time for sweet potato production at Malheur Experiment Station, Oregon State University, Ontario, OR, 2011. Each peak represents 1.25 cm (0.5 inch) of water delivered by drip irrigation with different irrigation criteria.