DRIP-IRRIGATION MANAGEMENT FACTORS FOR UMATILLA RUSSET PRODUCTION

Clinton C. Shock, Eric P. Eldredge, and Lamont D. Saunders
Malheur Experiment Station
Oregon State University
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Introduction

This was the second year of testing 'Umatilla Russet' potatoes grown under drip irrigation. Last year's annual report has the data for the 1999 trial. Water quality and scarcity issues may lead some growers to adopt drip irrigation for production of potatoes. The objectives of this study were to investigate and document the performance of 'Umatilla Russet' under drip irrigation, and to explore the interaction of some of the management factors that will be necessary for understanding the use of drip irrigation to be used for potato production in Malheur County.

Materials and Methods

The 2000 Drip Factorial trial was conducted on a field of Owyhee silt loam where winter wheat was the previous crop. The wheat stubble was flailed, the field was furrow irrigated, disked, and 100 lb P/acre and 20 lb N/acre were broadcast. On October 12, 1999, the field was ripped with Telone II injected at 22 gal/acre, and on November 16 the field was bedded on 36-inch row spacing. A soil test March 30, 2000 showed available nitrate plus ammonia nitrogen totaled 106 lb N/acre in the top 2 ft of soil, 41 ppm extractable P, 484 ppm K, organic matter 1.7 percent, and pH 6.7.

Seed of 'Umatilla Russet' was hand cut into 2-oz seedpieces and treated with Tops MZ dust and planted April 27. Seed was planted using a Parma (Parma Corp., Parma, ID) two-row cup planter with the center furrowing shovel removed. Seedpiece spacing was 9 inches in the row, with rows 36 inches apart, and Thimet 20G was metered into the seed furrow at a rate of 1.7 oz/100 ft of row.

Plots were two rows wide by 50 ft long. Prowl at 1 lb ai/acre plus Dual at 2 lb ai/acre, in 30 gal/acre spray mix, was applied on May 4, 2000 and incorporated with a spike-tooth bed harrow on May 10. The bed harrow had a toolbar on the back carrying large wide shovels to lift soil out of the furrows. A vee of heavy chain was dragged from the shovel shanks to move soil into the center of the bed. Drip tape was injected 2 to 3 inches deep in the center of the level bed between the two potato rows. On the second pass with the bed harrow, in the opposite direction from the first pass, two drip tapes were injected 1 to 2 inches deep, 36 inches apart, directly over the potato rows. The drip tube was 1000 Path (Nelson Irrigation, Walla Walla, WA) 8 mil, 12-inch emitter spacing, 0.22 gal/min/100 ft flow rate.

A complete factorial set of treatments was arrangend in a randomized complete block design. One factor was one drip tube between two potato rows, versus a tape for each row. The second factor was irrigation automated to maintain the soil water potential at -15, -30, -45 or -60 centibar in the root zone as measured with Watermark sensors (Irrometer Corp, Riverside, CA). The four soil water potential levels and two tape placements were tested in all eight combinations in a randomized complete block design with five replicates. All the nitrogen fertilizer was injected through the drip tape. A 100 gallon tank with a drill motor agitation paddle was used to dissolve calcium nitrate. The solution was metered into the irrigation water using a model A30-2.5 percent Dosmatic metering pump (Dosmatic USA International, Inc., Carrolltown, TX). Fertilizer was injected to supply 50 ppm NO_3 in the drip system from June 2 to July 10, when additional calcium nitrate was injected to bring the total applied N on all plots to 140 lb N/acre. From July 11 to August 2 fertilizer solution was injected to maintain 50 ppm NO_3 in the drip system, resulting in total applied fertilizer of 180 lb N/acre. From August 3 through the final irrigation on September 19, no fertilizer was injected. Leaf petioles were monitored regularly to assure that plant nitrogen status remained in the ideal range.

Fungicide applications to prevent late blight infection included an aerial application of Bravo at a 1.5 pint/acre on June 6 and Dithane at 4 pint/acre on June 16. Powdered sulfur was applied at 30 lb/acre by airplane on July 11 and again on August 3 to control powdery mildew.

The vines were flailed on September 19. Potatoes were lifted on September 28 and 29 with a two-row digger (John Deere, Moline, IL) that laid the tubers back onto the soil in each row. The drip tape was dug along with the potatoes. It fed over the two-row primary chain digger and was gathered by hand and tied in bundles for disposal. At harvest, the potatoes in each plot were visually evaluated for the amount of tare dirt on the tubers and defects such as growth cracks, knobs, curved or irregularly shaped tubers, pointed ends, or stem end decay. All tubers from each row of each two-row plot were placed into burlap sacks and hauled to a barn where they were kept under tarps until grading.

Tubers were graded October 2 and 3 and a 20-tuber sample from each row of each plot was placed into storage. The storage was kept near 100 percent relative humidity and the temperature was gradually reduced to 45°F. Samples were removed from storage December 4 through 5, specific gravity was measured, and 40 tubers/plot were cut lengthwise and center slices were fried for 3.5 minutes in 375°F soybean oil. Percent light reflectance was measured on the stem and bud ends of each fried slice using a model 577 Photovolt Reflectance Meter (Seradyn, Inc., Indianapolis, IN), with a green tristimulus filter, calibrated to read 0 percent light reflectance on the black standard cup and 73.6 percent light reflectance on the white porcelain standard plate.

Results and Discussion

Potatoes planted on April 27 did not fully emerge until May 26 due to cool, dry, windy weather in early May. The summer of 2000 was not intensely hot, with the highest temperature 102°F on August 2. The heat was prolonged, however. During June, July, and August, there were 7 days at 100°F or higher, and 56 days at 90°F or hotter. Daytime high temperatures over 86°F are stressful for potatoes, and 70 days between June 1 and August 31 had high temperatures 86°F or above. The hot, dry weather prevented late blight from developing in 2000. Hot, windy weather also increased evapotranspiration. The monthly total pan evaporation in 2000 measured at the U.S. Weather Bureau Class A pan at Malheur Experiment Station exceeded the 52-year June average by 21 percent, July by 14 percent, and August by 25 percent. The wind-run monthly totals exceeded the 52-year average by 45 percent in June, 43 percent in July, and 56 percent in August.

Tape Placement

The average total yield of all eight treatments was 469 cwt/acre, with no significant difference between one tape per row and one tape per two rows (Table 1). Total U.S. No. One grade tubers was also not significantly different between one tape or two. The trend was for more under 4 oz tubers to be produced with a drip tape on every row. Treatments with a drip tape for every row of potato plants averaged 204 cwt/acre in the 6- to 12-oz grade, compared with 150 cwt/acre with one tape for two rows. Conversely, the treatments with one tape for two rows produced 137 cwt/acre over 12 ounce, compared to 68 cwt/acre for a tape each row. A tape for each row also produced significantly more U.S. No. 2 grade tubers.

Soil Water Potential

Treatments with irrigation automated at -45 and -60 kPa yielded less than the -15 and -30 kPa treatments. The -15 kPa treatment with an average of 355 cwt/acre produced more U.S. No. Ones than the -45 and -60 kPa treatments. Marketable yield, which includes the U.S. No. One and U.S. No. 2 grades, averaged 393 cwt/acre overall, with the -60 kPa treatment producing less marketable yield. There was more rot with -15 kPa treatments.

Tuber Quality

Tuber quality for processing was also affected by irrigation levels and tape placement. Both the use of a drip tape for every row and irrigation at -30 kPa favored high tuber specific gravity. Stem end fry color was lightest with a tape on each row and -15 kPa soil water potential. Average fry color was lighter with two tapes, and there was a significant interaction of lighter fry color at wetter soil water potential for two tapes compared with one tape. More tare dirt was seen on the tubers at harvest in the wetter treatments.

Water Use

The automated irrigation system read the soil moisture sensors in each plot every 6 hours, and if the average of the sensor readings from all five replicates of a treatment

was less than that treatment's irrigation criterion, the irrigation valve to that treatment was opened. Plots with two tapes received 1.5 hour irrigation, and plots with one tape received 3 hours irrigation, so that each irrigation applied 0.4 acre-inch/acre regardless of the number of tapes. If the 0.4 acre-inch/acre irrigation did not sufficiently wet the soil to bring the sensor readings back above the criterion for a treatment, at the next 6 hour interval an additional irrigation was applied. This was a feedback control system, and the soil water potential was oscillated around the criterion. The oscillation was more pronounced in the drier treatments that had a pattern of irrigating four times a day for 3 or 4 days, then not irrigating for 3 days. The two -15 kPa treatments irrigated every day, but not always all four times every day. The treatments with two tapes received less water for a given soil water potential irrigation criterion because the sensors were closer to the tape, which reduced the feedback oscillation of irrigation frequency.

The automated irrigation system applied more water than the AgriMet estimate of evapotranspiration (AgMet Et) of 26.6 acre-inches/acre on only one treatment, the -15 kPa with one drip tape per two rows, which received 28.9 acre-inches/acre of water (Fig. 1). This was 80 percent of the 36.2 acre-inches/acre pan evaporation for the irrigation period, June 1 through September 5. Two tapes at -15 kPa resulted in 22.0 acre-inches/acre of water applied. The -30 kPa treatment with one tape applied 20.0 acre-inches/acre, and -30 kPa with two tapes applied 19.3 acre-inches/acre. The -45 kPa treatment with one tape applied 17.1 acre-inches/acre, and the -45 kPa with two tapes applied 15 acre-inches/acre. The -60 kPa treatment with one tape applied 17.8 acre-inches/acre, and the -60 kPa with two tapes applied 12.8 acre-inches/acre.

During the 2000 season, average potato yields were 400 cwt/acre in Malheur County. This was similar to yields in the current trial. Typically, 43.2 acre-inches of water are applied using furrow irrigation, and 36 acre-inches are applied using sprinkler irrigation. From the county yield and water use figures, sprinkler and furrow irrigation result in 1,110 and 930 lb of potatoes for each acre-inch of water applied. Using drip irrigation with a tape for every row and irrigating at -30 kPa, yield was 2,220 lb/acre-inch of applied water, with adequate tuber grade and quality. The -45 and -60 kPa treatments with one tape per row, and the -45 kPa treatment with one tape for two rows, had even higher water use efficiency, but tuber quality was adversely affected.

Future Opportunities with Drip Irrigation

The drier treatments in this study were based on soil water potential that would be in the acceptable range of dryness for furrow or sprinkler irrigated potatoes. With this automated irrigation system, driven by soil moisture sensors, the drier treatments resulted in several days between irrigations at peak Et, as shown by the flat sections of the lines in Figure. 1. If the objective were to grow a potato crop with a limited water supply, the crop might be stressed less with a daily irrigation with and less Et.
Drip irrigation could be used to deliver systemic fungicides or insecticides in small doses directly to the root system of the crop, possibly reducing production costs and chemical use. Hypothetically, these smaller doses could substitute for high rates of soil fumigants used to prepare the soil for a potato crop. A systemic fungicide might replace aerial spraying on a scheduled basis to protect the foliage from late blight. Systemic fungicide could also potentially improve yields by preventing early vine death, thus prolonging the growing season.

Table 1. Umatilla russet yield, grade, and processing quality when grown with automated drip irrigation using either one tape for every two rows or a tape for every row, at four levels of soil water potential. Malheur Experiment Station, Oregon State University, Ontario, OR, 2000.

				Yield by grade									Fry color			
Number of drip tapes		U.S. No. one	Total yield	Total marketable	Total U.S. No. one	Over 12 oz	6 to 12 oz	4 to 6 oz	Under 4 oz	U.S. No. two	Cull	Specific gravity	Stem end	Bud end	Average	Sugar ends
	kPa	%	cwt/acre									g cm^{-3}	% Reflectance			%
1	-15	66.3	506	445	337	168	149	19.5	40.0	108.6	20.9	1.0882	34.0	42.3	38.1	11.0
	-30	69.2	455	397	318	144	146	28.1	50.5	78.8	8.3	1.0928	32.5	41.6	37.0	12.0
	-45	67.3	465	412	314	135	151	26.9	42.6	98.7	10.6	1.0872	35.3	42.7	39.0	4.5
	-60	65.6	439	383	290	101	155	33.7	51.1	93.1	5.2	1.0871	33.7	42.5	38.1	7.5
	Mean	67.1	466	409	314	137	150	27.1	46.1	94.8	11.2	1.0888	33.9	42.3	38.1	8.8
	kPa															
	-15	73.7	507	413	374	101	225	48.7	72.7	39.0	21.1	1.0933	38.8	45.0	41.6	3.0
2	-30	74.2	516	429	382	78	244	60.2	78.7	46.9	8.5	1.0957	36.7	43.6	40.2	3.0
	-45	67.1	448	347	301	46	188	67.3	91.8	45.8	9.1	1.0903	32.9	42.4	37.9	11.5
	-60	64.8	413	317	269	47	158	64.3	87.1	48.3	8.6	1.0917	35.5	43.3	39.4	8.5
	Mean	70.0	471	377	332	68	204	60.1	82.6	45.0	11.8	1.0928	36.0	43.6	39.8	6.5
Average	kPa															
	-15	70.0	506	429	355	134	187	34.1	56.4	73.8	21.0	1.0907	36.4	43.7	39.9	7.0
	-30	71.7	486	413	350	111	195	44.2	64.6	62.9	8.4	1.0943	34.6	42.6	38.6	7.5
	-45	67.2	457	380	307	91	170	47.1	67.2	72.3	9.8	1.0888	34.1	42.6	38.5	8.0
	-60	65.2	426	350	279	74	156	49.0	69.1	70.7	6.9	1.0894	34.6	42.9	38.8	8.0
Overall	Mean	68.5	469	393	323	102	177	43.6	64.3	69.9	11.5	1.0908	34.9	42.9	38.9	7.6
LSD(0.05)	Tapes	NS	NS	37	NS	23	19	8.4	9.7	17.9	NS	0.0032	2.1	NS	1.7	NS
	kPa	5.8	46	52	47	32	28	11.9	NS	NS	9.7	0.0045	NS	NS	NS	NS
	Tapes x kPa	NS	65	73	66	NS	39	NS	NS	NS	NS	NS	4.3	NS	3.3	NS

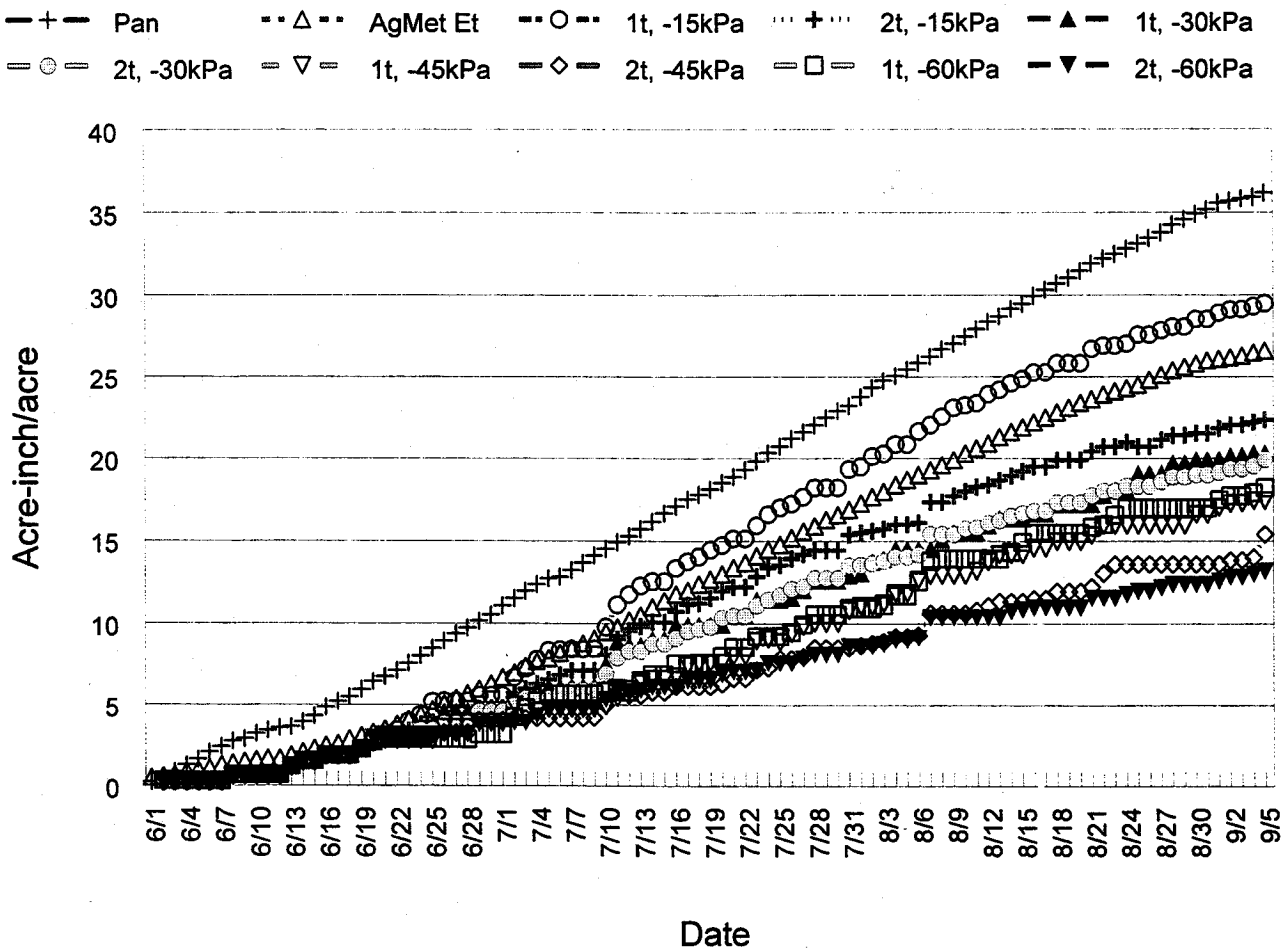

Figure 1. Comparison of cumulative potato evapotranspiration AgriMet ET_c and pan evaporation to the cumulative water applied (plus rainfall) by eight different drip irrigation treatments. Irrigation was automated at soil water potential of -15, -30, -45, or -60 kPa with either one tape (1t, between two potato rows), or two tapes (2t, one on each row). Malheur Experiment Station, Oregon State University, Ontario, OR, 2000.