EVALUATION OF TWO AUTOMATED IRRIGATION SCHEDULING METHODS AND TWO FERTIGATION STRATEGIES FOR DRIP IRRIGATED POTATO

Clinton C. Shock, Erik B. G. Feibert, Kyle D. Wieland, and Alicia Rivera, Malheur Experiment Station, Oregon State University, Ontario, OR

Ami Gips, Yechiam Gets, Lior Doron, and Ofer Halperin, Netafim, Tel Aviv, Israel

John Taberna, Western Laboratories, Inc., Parma, ID

Introduction

Irrigation scheduling for potato can use soil water tension, soil water content, or crop evapotranspiration estimates. Measurement of evapotranspiration and the use of an allowable soil water depletion value can be used to automatically schedule irrigations. Netafim (Fresno, CA) has developed an irrigation scheduling method for potato using evapotranspiration estimates. The Malheur Experiment Station has developed soil water tension criteria for automatically or manually initiating potato irrigations. A range of soil water tensions have been evaluated for their effect on potato yield, grade, and processing quality under furrow, sprinkler, and drip irrigation on silt loam soil. For furrow or sprinkler irrigated potato the ideal irrigation criterion is 50 to 60 cb (Eldredge et al. 1992; Shock et al. 1993, 2003). For drip irrigation, which uses a higher irrigation frequency, the ideal criterion is 25 to 30 cb (Shock et al. 2002). Soil water tension has been measured using granular matrix sensors (GMS, Watermark soil moisture sensors model 200SS, Irrometer Co., Riverside, CA). Granular matrix sensors have been calibrated to soil water tension (Shock 2003). Drip irrigation allows the application of plant nutrients in liquid form through the irrigation system. This trial tested two automatic drip irrigation scheduling methods with two fertigation strategies.

Materials and Methods

The trial was conducted on an Owyhee silt loam previously planted to wheat at the Malheur Experiment Station, Ontario, Oregon. A soil analysis taken in the fall of 2018 showed that the top foot of soil had a pH of 7.7, 3.0% organic matter, 14 ppm nitrate-nitrogen (N), 5 ppm ammonium-N, 33 ppm phosphorus (P), 329 ppm potassium (K), 11 ppm sulfur (S), 2573 ppm calcium (Ca), 403 ppm magnesium (Mg), 65 ppm sodium, 2.6 ppm zinc (Zn), 5 ppm manganese (Mn), 1.3 ppm copper (Cu), 16 ppm iron, and 0.5 ppm boron (B). In the fall of 2018, the wheat stubble was shredded, and the field was irrigated. The field was then disked, moldboard plowed, and groundhogged. Based on the soil analysis, 50 lb N/acre as urea 22 lb P/acre as monoammonium phosphate, 166 lb K/acre as potassium chloride, 100 lb S/acre as elemental sulfur, 10 lb Mn/acre as manganese sulfate, and 3 lb B/acre as Granubor II were broadcast before

plowing. Following plowing, the field was fumigated with 20 gal/acre of Telone® II (dichloropropene) and bedded on 36-inch row spacing.

On April 4, 2019, 76 lb N/acre as urea and Admire® (imidacloprid) at 7 oz/acre (0.25 lb ai/acre) were shanked into both sides of the beds at 6-inch depth. On April 15, seed of 'Clearwater Russet' was cut by hand into 2.5-oz seed pieces, treated with Maxim® MZ (fludioxonil, mancozeb) dust, and stored to suberize.

The experiment consisted of a factorial design with two factors arranged in a randomized complete block with four treatments and four replicates (Table 1). The two factors were automated irrigation scheduling method and fertigation method. Two automated irrigation scheduling methods were tested: scheduling based on soil water tension (SWT) and scheduling based on potato evapotranspiration (NetBeat). Two fertigation methods were tested: fertigation based on in-season tissue testing (petiole analysis) and fertigation based on addition of previously determined crop nutrient uptake (Netafim).

Table 1. Treatments applied to potato crop.

Treatment No.	Irrigation scheduling	Fertigation method
1	Soil water tension (SWT)	Petiole analysis
2	SWT	Netafim
3	NetBeat	Petiole analysis
4	NetBeat	Netafim

Main plots were six potato rows wide by 105 ft long. Potato seed pieces were planted on April 19 and April 22 using a 2-row assist-feed planter with 9-inch seed spacing in 36-inch rows.

After planting, the plots were reconfigured by slightly flattening the 36-inch hills to create 72-inch beds with two potato rows. Drip tape was installed 2 inches deep and 4 inches to the inside of each potato row. The drip tape (DripNet PC, Netafim, Fresno, CA) had emitters spaced 12 inches apart and an emitter flow rate of 0.16 gal/hour at 10 psi.

After all bed preparation operations were finished, a sprinkler irrigation system was installed and herbicide was broadcast on the whole field using a ground sprayer. The herbicide was a mixture of 1.33 pt/acre (1.3 lb ai/acre) of Dual II Magnum® (metolachlor), 2 pt/acre (0.83 lb ai/acre) of Prowl® (pendimethalin), 5 pt/acre of Eptam® 7E (*S*-ethyl dipropylthiocarbamate), and 32 oz/acre of Roundup® (glyphosate). The herbicides were incorporated by applying 0.75 inch of water to the whole field with the sprinkler irrigation system. After the herbicide was incorporated, the sprinkler system was removed and the drip irrigation system for the treatments was connected. The field was sprayed with the herbicides Matrix® (rimsulfuron) at 1.5 oz/acre (0.4 oz ai/acre) and Shadow® 3EC (clethodim) and the fungicide Manzate® ProStick (mancozeb) at 1.5 lb/acre on May 29.

Soil water tension was measured using four granular matrix sensors (GMS, Watermark soil moisture sensors model 200SS, Irrometer Co., Riverside, CA) in every plot of all treatments. The sensors were installed at 8-inch depth below each of the middle two potato rows in each plot. The datalogger (CR1000, Campbell Scientific, Logan, UT) read and recorded the SWT every hour.

The SWT irrigation treatment was irrigated automatically by a datalogger program based on soil water tension feedback. The datalogger automatically irrigated all plots in the SWT treatment when the average SWT of all SWT treatment plots reached or exceeded 25 cb. Sensor readings outside of a reasonable range were eliminated prior to averaging. Irrigation durations were 7 hours to apply 0.6 inches of water. The datalogger made irrigation decisions every 8 hours. The datalogger controlled the irrigations for the SWT treatment using a controller (SDM-CD16AC controller, Campbell Scientific, Logan, UT) and solenoid valves (Rain Bird, Azusa, CA). Automatic irrigations were started on May 29 and terminated on September 15.

The NetBeat irrigation treatment was irrigated automatically based on potato evapotranspiration using a controller (NMC-Junior Pro, Netafim).

Plant nutrition in each treatment was monitored by weekly petiole and soil solution analyses starting May 29 and ending August 20 (Tables 3 and 4). To avoid damage to the harvest rows, petiole and soil samples were collected from the border rows in each plot. Composite petiole and soil samples were made that combined the samples from all the replicates of each treatment. The petiole and soil samples were analyzed by Western Laboratories, Inc., Parma Idaho.

The petiole analysis fertigation treatments had nutrients applied based on the weekly petiole analyses and the critical levels for each nutrient. The Netafim fertigation treatments had N and K applied during the season to supply the amounts taken up by the crop based on a crop uptake model. The Netafim fertigation treatment had the N and K applied weekly starting on June 6 and ending August 2. All nutrients were injected through the drip tape. Nitrogen was applied as a urea ammonium nitrate solution and K was applied as a potassium chloride solution.

The water for the drip system was supplied by a well that maintained a continuous and constant water pressure of 30 psi. Water applied to each treatment was measured by totalizing flow meters (model M, Netafim) read five times per week. The total water applied to each treatment was measured from emergence to the last irrigation on September 15. The well water was analyzed for nutrients on August 20 to determine the amount of nutrients applied to the crop in irrigation water. Potato 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. Potato ET_c was estimated and recorded from crop emergence on May 15 until September 15.

The field was sprayed aerially with the following insecticides to control psyllids: July 27 and August 16 with Agri-Mek® (abamectin) at 3.5 oz/acre (0.02 lb ai/acre) and August 4 with Beleaf® (flonicamid) at 2.8 oz/acre.

The percentage of vine lodging in each plot was rated subjectively on June 27.

Five biomass samples were taken biweekly starting June 26 and ending August 22. A sixth biomass sample was taken on October 7, just prior to vine kill. The biomass samples were taken by collecting all the vines and roots and tubers from 5 ft of the middle two rows starting 5 ft in from the bottom of each plot. The vines and tubers plus roots were weighed immediately and a subsample was taken for moisture measurement and nutrient analysis. The tuber plus root and vine subsamples were dried in a forced air oven until moisture loss stopped. The dry subsamples were weighed, ground, and analyzed for nutrients.

The potato vines were flailed on October 7. Forty feet of the middle two rows of each plot were harvested on October 14. All tubers from each plot were placed into burlap sacks and placed in a

barn where they were kept under tarps. All sacks from each plot were weighed. Four sacks from a representative area in each plot were selected for grading. Tubers were graded by market class (U.S. No. 1 and U.S. No. 2) and weight (<4 oz, 4–6 oz, 6–10 oz, 10–20 oz, and >20 oz). Tubers were graded as U.S. No. 2 if any of the following conditions occurred: growth cracks, bottleneck shape, abnormally curved shape, or two or more knobs. Marketable tubers are U.S. No. 1 and U.S. No. 2 larger than 4 oz. A 20-tuber sample from each split plot was placed into storage. The storage temperature was gradually reduced to 45°F.

After 6 weeks in storage, a 10-tuber sample from each plot was evaluated for specific gravity, fry color, and internal defects. Ten tubers per plot were cut lengthwise and the center slices from each tuber were fried for 2.5 min in 375°F soybean oil. Percent light reflectance was measured on the stem and bud ends of each slice using a Photovolt reflectance meter model 577-A (Photovolt Instruments, Minneapolis, MN) with a green tristimulus filter calibrated to read 0% light reflectance on the black standard cup and 71.7% light reflectance on the white porcelain standard plate. Specific gravity of all varieties was measured from a 10-tuber sample from each plot using the weight-in-air, weight-in-water method.

Data were analyzed with the general linear models analysis of variance procedure using NCSS (Number Cruncher Statistical Systems, Kaysville, UT) using Fisher's protected LSD (least significant difference) for means separation at the 95% confidence level.

Results and Discussion

The Netafim fertigation system applied substantially more N and over three times more K than the fertigation based on petiole analyses (Table 2). Additional amounts of N and K were applied to the treatments via the irrigation water. The total soil available N concentration decreased during the season from 153 lb/acre to just over 60 lb/acre for all treatments (Table 3). There was a tendency for the total soil available N concentration to be lower in the NetBeat irrigation scheduling than in the SWT irrigation scheduling starting in early July, consistent with the relative amounts of water applied to these treatments.

Petiole NO_3 concentrations of the treatments during the season were similar (Table 4, Figure 1). Petiole NO_3 concentrations increased over time, but remained below the critical level until mid-July, then decreased until mid-August, when they increased again. Soil solution N levels remained above the critical level for all treatments all season (Table 5, Figure 2).

Petiole and soil solution K concentrations remained at or above the critical level all season for all treatments (Table 6). Petiole K concentrations with petiole fertigation went below the critical level several times starting in mid-July (Table 6, Figure 3). For the Netafim fertigation with SWT irrigation treatment, the petiole K concentration went below the critical level only twice during the season. For the Netafim fertigation with the NetBeat irrigation the petiole K concentration went below the critical level five times before July 23. Unlike with petiole fertigation, the Netafim fertigation petiole K concentrations remained above the critical level in the latter part of the season. The soil solution K levels remained below the critical level all season for all treatments, except for three times for the SWT irrigation with petiole fertigation treatment (Figure 4).

Petiole concentrations of the other nutrients were generally above the critical levels all season.

The soil solution calcium levels remained above the critical level all season for all treatments (Table 7). Soil solution levels of the other nutrients went below the critical levels various times during the season.

The SWT irrigation scheduling system maintained the soil water tension on average just above the target of 25 cb (Table 8, Figure 5). The NetBeat irrigation scheduling system maintained the soil water tension on average at or below 20 cb. The average soil water tension and the average maximum soil water tension were lower for the NetBeat irrigation scheduling. The average minimum soil water tension was similar for both irrigation treatments. The SWT irrigation scheduling applied 32 inches and 31 inches of water plus precipitation from emergence to the last irrigation (treatments 1 and 2, Table 8, Figure 6). The NetBeat irrigation scheduling treatments applied 38 inches of water plus precipitation from emergence to the last irrigation (treatments 3 and 4). Potato evapotranspiration from emergence to the last irrigation totaled 28.9 inches.

Averaged over fertigation systems, there were no statistically significant differences in yield, grade, or tuber specific gravity between irrigation scheduling systems (Table 9). Averaged over fertigation systems, SWT irrigation scheduling had slightly higher tuber fry color than the NetBeat irrigation scheduling. Averaged over irrigation scheduling systems, the petiole fertigation system resulted in higher yield of marketable tubers and higher yield of tubers 10 to 20 oz. There were no statistically significant differences between irrigation scheduling systems or fertigation systems for the other yield categories. Vine lodging on June 27 was highest for Netafim fertigation with SWT irrigation scheduling followed by Netafim fertigation with Netafim irrigation scheduling, followed by petiole fertigation with either SWT or Netafim irrigation scheduling. Generalized lodging occurred 1 week later, by July 5, for all treatments.

Netafim fertigation with SWT irrigation scheduling had the highest vine N concentration, followed by petiole fertigation and Netafim fertigation with NetBeat irrigation scheduling, followed by petiole fertigation with SWT irrigation scheduling (Table 10). Petiole calcium concentrations were higher with petiole analysis based fertigation than with Netafim fertigation. Averaged over irrigation scheduling systems, tuber N concentration was higher for Netafim fertigation than for petiole fertigation (Table 11).

Measured from the biomass samples, the highest yield of vines and the highest N uptake by vines was for NetBeat irrigation scheduling with either petiole fertigation or Netafim fertigation and for Netafim fertigation with SWT irrigation scheduling (Table 12, Figures 7 and 9). The lowest yield of vines and the lowest N uptake was for SWT irrigation scheduling with petiole fertigation. Averaged over irrigation scheduling treatments, Netafim fertigation had higher vine yield and higher vine N and K uptakes (Table 12, Figure 11).

There were no differences in tuber biomass or nutrient uptake by the tubers between treatments, except for manganese and iron (Table 13, Figures 8, 10, and 12). Manganese uptake by the tubers was higher with petiole fertigation. Iron uptake by the tubers was highest at harvest with SWT irrigation scheduling and petiole fertigation. Netafim fertigation had higher tuber N uptake than petiole fertigation (Table 14).

There were no differences in total biomass (vines plus tubers) between treatments (Table 14). The highest total N uptake (vines plus tubers) was for NetBeat irrigation scheduling with either petiole fertigation or Netafim fertigation and for SWT irrigation scheduling with Netafim fertigation.

Averaged over fertigation systems, SWT irrigation scheduling had higher water use efficiency and higher K use efficiency than NetBeat irrigation scheduling (Table 15). SWT irrigation scheduling with petiole fertigation had the highest K use efficiency and the Netafim fertigation with both SWT and NetBeat irrigation scheduling had the lowest K use efficiency. Averaged over irrigation scheduling systems, the petiole fertigation system had higher N and K use efficiencies than the Netafim fertigation system.

Conclusions

Both total soil available N and soil solution N remained above critical levels all season for all treatments, whereas petiole nitrate levels remained below the critical level for most of the season for all treatments.

Both irrigation scheduling systems produced high yields of quality potatoes. The higher water application of the Netafim irrigation scheduling system did not increase tuber yield or grade. The higher N and K applications with the Netafim fertigation increased the amount of vine biomass and reduced marketable tuber yield compared to fertigation by petiole analysis.

References

Eldredge, E.P., C.C. Shock, and T.D. Stieber. 1992. Plot sprinklers for irrigation research. Agron. J. 84:1981-1984.

Shock, C.C., Z.A. Holmes, T.D. Stieber, E.P. Eldredge, and P. Zhang. 1993. The effect of timed water stress on quality, total solids and reducing sugar content of potatoes. American Potato Journal 70:227-241.

Shock, C.C. 2003. Soil water potential measurement by granular matrix sensors. P. 899-903. In: Stewart, B.A., and T.A. Howell (eds.). The Encyclopedia of Water Sci. Marcel Dekker, New York, N.Y.

Shock, C.C., E.P. Eldredge, and L.D. Saunders. 2002. Drip irrigation management factors for 'Umatilla Russet' potato production. Oregon State University Agricultural Experiment Station Special Report 1038:157-169.

Wright, J.L. 1982. New evapotranspiration crop coefficients. Journal of Irrigation and Drainage

Division, American Society of Civil Engineers 108:57-74.

Table 2. Nutrients applied in-season to four treatments. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Date	SWT irrigation Petiole fertigation				SWT irrigation Netafim fertigation			NetBeat irrigation Petiole fertigation				NetBeat irrigation Netafim fertigation		
	N	K	Mg	Zn	N	K	Mg	N	K	Mg	Cu	N	K	Mg
	lb/acre													
6-Jun	15				52			15				52		
7-Jun						78							78	
13-Jun	15				22	33		15	22	2		22	33	
20-Jun					22	33						22	33	
21-Jun	15		2					15		2				
27-Jun	15		2		22	33		15		2		22	33	
5-Jul	15		2		17	15	2	15		2		17	15	2
12-Jul					17	15						17	15	
19-Jul	15	15			17	15		15	15			17	15	
24-Jul		3		0.25		15			11		0.25		15	
2-Aug		15				15			15				15	
8-Aug	7.5	15						7.5	18					
16-Aug		15							15					
21-Aug		15							15					
Total	98	78	6	0.25	169	252	2	98	111	8	0.25	169	252	2

Nitrogen was applied as Uran (32% N), potassium as potassium chloride, magnesium as magnesium thiosulfate (4%), and copper as copper chelate (2%).

Table 3. Total available soil nitrogen for four treatments. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Date	SWT irrigation		NetBeat irrigation	
	Petiole fertigation	Netafim fertigation	Petiole fertigation	Netafim fertigation
	lb N/acre			
29-May	153	153	153	153
11-Jun	138	105	129	132
18-Jun	126	129	132	111
25-Jun	102	105	117	90
2-Jul	96	108	96	84
9-Jul	99	102	78	69
16-Jul	78	78	69	60
23-Jul	63	84	54	54
30-Jul	66	87	45	45
6-Aug	54	69	36	36
13-Aug	75	78	60	63
20-Aug	63	63	48	66
Average	93	97	85	80

Table 4. Petiole nitrate over time with four treatments. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Date	Critical level	SWT irrigation		NetBeat irrigation	
		Petiole fertigation	Netafim fertigation	Petiole fertigation	Netafim fertigation
	----------	----------	NO_3-N (ppm)	----------	----------
29-May	25000	8256	8256	8256	8256
11-Jun	24000	8192	8254	8172	8175
18-Jun	23000	9305	9875	9533	10213
25-Jun	22134	11582	10650	11392	12615
2-Jul	20933	14419	13227	14031	15270
9-Jul	19731	15826	16015	16205	17418
16-Jul	18530	16277	17166	17992	18221
23-Jul	17328	14934	15031	16094	17352
30-Jul	16127	12320	12575	12594	13039
6-Aug	14925	10804	10454	10430	10795
13-Aug	13724	13292	14011	13696	12163
20-Aug	12522	12239	11019	11634	13616

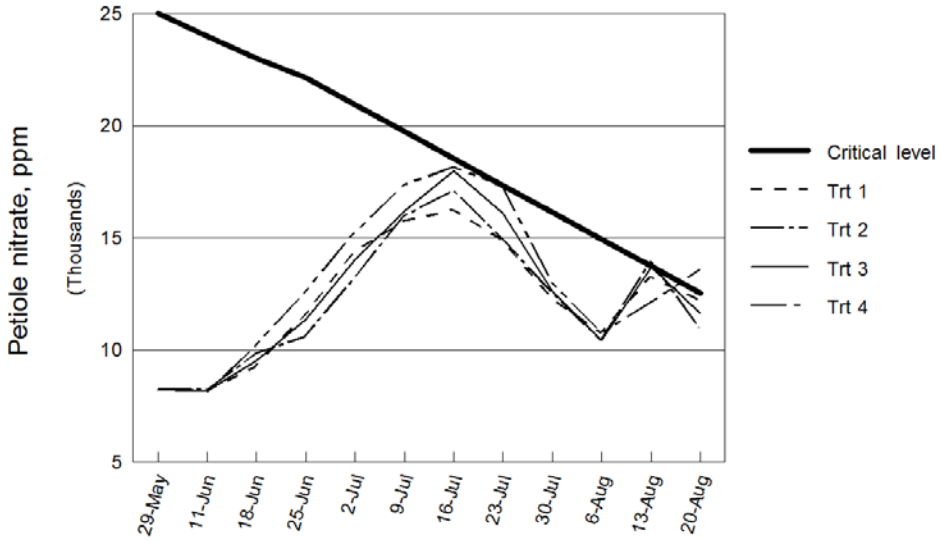

Figure 1. Petiole nitrate over time with four treatments. Trt 1: SWT irrigation, petiole fertigation; Trt 2: SWT irrigation, Netafim fertigation; Trt 3: NetBeat irrigation, petiole fertigation; Trt 4: NetBeat irrigation, Netafim fertigation. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Table 5. Soil solution nitrogen over time with four treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

		SWT irrigation		NetBeat irrigation	
Date	Critical level	Petiole fertigation	Netafim fertigation	Petiole fertigation	Netafim fertigation
	---------- lb/acre/day ----------				
29-May	7	22	22	22	22
11-Jun	6	20	15	18	19
18-Jun	5	18	18	19	16
25-Jun	4	15	15	17	13
2-Jul	3	14	15	14	12
9-Jul	2.5	14	15	11	10
16-Jul	1.5	11	11	10	9
23-Jul	1.5	9	12	8	8
30-Jul	1	9	12	6	6
6-Aug	0.5	8	10	5	5
13-Aug	0.5	10.7	11	9	9
20-Aug	0.5	9.0	9.0	6.9	9.4

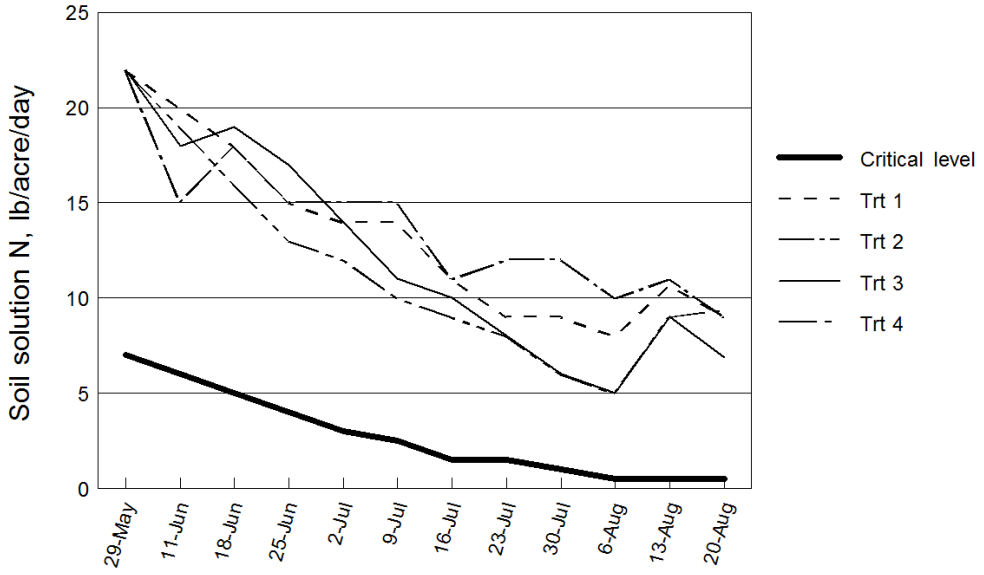

Figure 2. Soil solution nitrogen over time with four treatments. Trt 1: SWT irrigation, petiole fertigation; Trt 2: SWT irrigation, Netafim fertigation; Trt 3: NetBeat irrigation, petiole fertigation; Trt 4: NetBeat irrigation, Netafim fertigation. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Table 6. Potato petiole analyses for four treatments and critical ranges for each nutrient, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019. (Continued on the next page.)

	SWT irrigation		NetBeat irrigation		SWT irrigation		NetBeat irrigation	
Date	Petiole fert.	Netafim fert.	Petiole fert.	Netafim fert.	Petiole fert.	Netafim fert.	Petiole fert.	Netafim fert.
	---------- P, 0.2–0.55 % ----------				---------- K, 7.5–15% ----------			
29-May	0.4	0.4	0.4	0.4	11.3	11.3	11.3	11.3
11-Jun	0.6	0.5	0.5	0.5	11.5	7.0	7.0	7.1
18-Jun	0.5	0.5	0.5	0.5	10.1	8.0	8.0	8.4
25-Jun	0.3	0.3	0.4	0.5	9.6	9.6	9.1	6.6
2-Jul	0.3	0.3	0.3	0.5	8.8	7.9	8.2	6.5
9-Jul	0.3	0.3	0.3	0.3	8.3	6.8	9.3	6.5
16-Jul	0.4	0.3	0.2	0.3	7.3	8.3	7.6	7.2
23-Jul	0.2	0.2	0.3	0.2	8.8	8.4	6.2	8.6
30-Jul	0.3	0.3	0.2	0.2	7.1	8.6	6.7	7.6
6-Aug	0.4	0.4	0.2	0.3	6.7	9.8	6.1	8.8
13-Aug	0.2	0.3	0.3	0.3	7.7	9.0	6.9	10.2
20-Aug	0.2	0.3	0.3	0.3	7.3	9.7	7.1	10.1
	---------- S, 0.2–0.55% ----------				----------Ca, 0.45–2% ----------			
29-May	0.2	0.2	0.2	0.2	2.2	2.2	2.2	2.2
11-Jun	0.3	0.3	0.3	0.3	1.7	1.2	1.1	1.2
18-Jun	0.3	0.3	0.3	0.3	1.3	0.9	0.9	0.9
25-Jun	0.2	0.2	0.3	0.3	1.1	0.8	0.8	1.1
2-Jul	0.2	0.2	0.2	0.2	0.8	0.8	0.8	0.8
9-Jul	0.3	0.2	0.3	0.2	1.0	1.0	1.1	1.0
16-Jul	0.3	0.2	0.2	0.3	1.1	1.2	1.0	1.1
23-Jul	0.3	0.2	0.3	0.2	1.0	1.4	1.3	1.3
30-Jul	0.2	0.2	0.4	0.3	1.2	1.5	1.4	1.4
6-Aug	0.3	0.2	0.2	0.3	1.6	1.6	1.5	1.2
13-Aug	0.2	0.2	0.2	0.2	1.9	1.9	1.7	1.3
20-Aug	0.3	0.2	0.2	0.3	2.1	2.3	2.0	1.6
	---------- Mg, 0.4–1.7% ----------				---------- Zn, 23–55 ppm ----------			
29-May	0.5	0.5	0.5	0.5	51	51	51	51
11-Jun	0.4	0.4	0.4	0.4	46	54	53	57
18-Jun	0.4	0.4	0.4	0.4	56	38	54	59
25-Jun	0.3	0.3	0.3	0.5	41	32	50	45
2-Jul	0.3	0.4	0.4	0.3	36	24	52	39
9-Jul	0.4	0.4	0.5	0.4	32	31	41	32
16-Jul	0.5	0.5	0.5	0.5	25	40	30	35
23-Jul	0.6	0.7	0.6	0.6	22	30	32	30
30-Jul	0.8	0.7	0.7	0.6	26	35	32	31
6-Aug	0.6	0.7	0.7	0.6	29	45	39	34
13-Aug	0.4	0.6	0.5	0.5	35	41	35	36
20-Aug	0.5	0.5	0.5	0.4	26	30	32	35

Table 6. (continued) Potato petiole analyses for four treatments and critical ranges for each nutrient, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

	SWT irrigation		NetBeat irrigation		SWT irrigation		NetBeat irrigation	
Date	Petiole fert.	Netafim fert.	Petiole fert.	Netafim fert.	Petiole fert.	Netafim fert.	Petiole fert.	Netafim fert.
	---------- Mn, 33–70 ppm ----------				---------- Cu, 5–30 ppm ----------			
29-May	52	52	52	52	9	9	9	9
11-Jun	50	63	75	45	11	21	12	13
18-Jun	52	72	55	45	14	18	13	11
25-Jun	58	64	43	34	12	14	13	13
2-Jul	55	59	42	40	9	10	10	11
9-Jul	43	43	42	45	7	8	7	9
16-Jul	52	51	38	49	7	7	5	7
23-Jul	61	43	42	39	8	6	4	5
30-Jul	75	51	52	47	6	5	5	5
6-Aug	80	50	64	45	7	4	6	6
13-Aug	63	55	59	51	5	4	6	5
20-Aug	46	52	42	52	5	5	7	5
	---------- B, 21–55 ppm ----------							
29-May	26	26	26	26				
11-Jun	22	33	32	34				
18-Jun	23	35	34	26				
25-Jun	26	35	41	22				
2-Jul	22	28	36	19				
9-Jul	27	30	32	21				
16-Jul	35	34	32	25				
23-Jul	42	36	35	26				
30-Jul	31	28	27	27				
6-Aug	23	24	25	26				
13-Aug	28	29	31	29				
20-Aug	21	21	22	22				

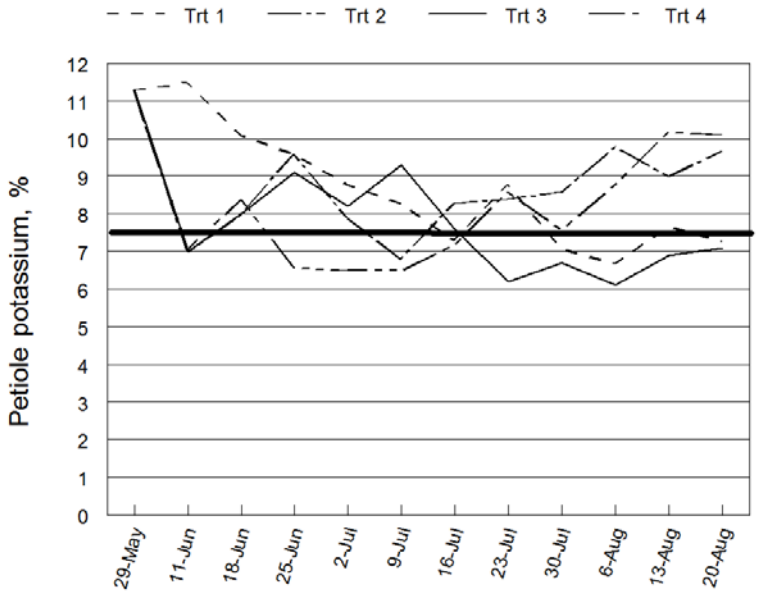

Figure 3. Petiole potassium over time with four treatments. Trt 1: SWT irrigation, petiole fertigation; Trt 2: SWT irrigation, Netafim fertigation; Trt 3: NetBeat irrigation, petiole fertigation; Trt 4: NetBeat irrigation, Netafim fertigation, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

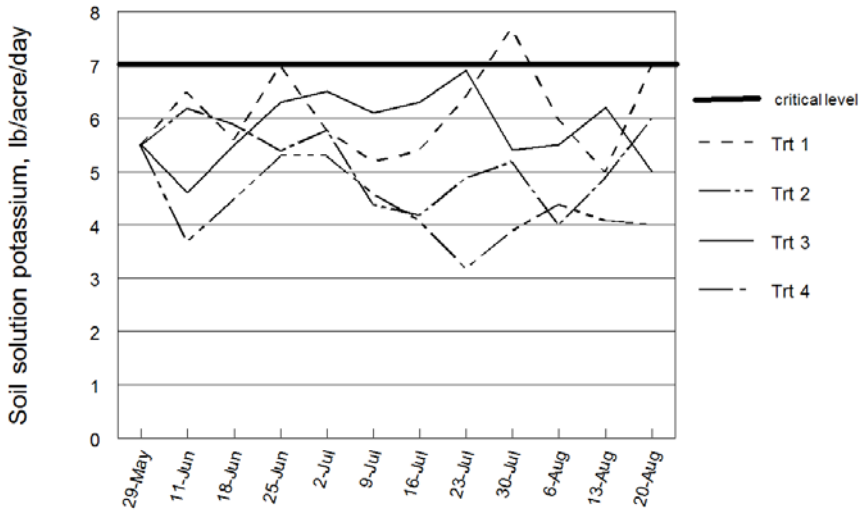

Figure 4. Soil solution potassium over time with four treatments. Trt 1: SWT irrigation, petiole fertigation; Trt 2: SWT irrigation, Netafim fertigation; Trt 3: NetBeat irrigation, petiole fertigation; Trt 4: NetBeat irrigation, Netafim fertigation, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Table 7. Soil solution analyses with four treatments and critical level for each nutrient, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019. (Continued on the next page.)

	SWT irrigation		NetBeat irrigation		SWT irrigation		NetBeat irrigation	
Date	Petiole fert.	Netafim fert.	Petiole fert.	Netafim fert.	Petiole fert.	Netafim fert.	Petiole fert.	Netafim fert.
	---------- P, 0.6 lb ----------				---------- K, 7 lb ----------			
29-May	2.9	2.9	2.9	2.9	5.5	5.5	5.5	5.5
11-Jun	2.0	1.9	1.6	2.2	6.5	6.2	4.6	3.7
18-Jun	2.1	2.8	2.0	2.5	5.6	5.9	5.5	4.5
25-Jun	1.7	3.9	2.4	3.3	7.0	5.4	6.3	5.3
2-Jul	1.4	2.8	1.6	2.1	5.8	5.8	6.5	5.3
9-Jul	2.1	3.2	2.1	2.9	5.2	4.4	6.1	4.6
16-Jul	2.6	4.0	2.6	4.2	5.4	4.2	6.3	4.1
23-Jul	1.4	4.5	1.6	5.2	6.4	4.9	6.9	3.2
30-Jul	2.1	5.0	2.4	2.6	7.7	5.2	5.4	3.9
6-Aug	2.5	4.4	2.6	2.8	6.0	4.0	5.5	4.4
13-Aug	3.0	3.5	3.4	4.1	5.0	4.9	6.2	4.1
20-Aug	4.0	4.0	4.0	3.0	7.0	6.0	5.0	4.0
	---------- S, 2 lb ----------				---------- Ca, 3 lb ----------			
29-May	3.2	3.2	3.2	3.2	5.2	5.2	5.2	5.2
11-Jun	4.7	3.2	4.1	2.0	4.9	4.6	4.7	4.4
18-Jun	2.9	2.8	5.4	2.9	5.9	5.7	4.4	4.4
25-Jun	1.6	2.2	2.9	2.8	4.6	4.6	4.6	3.1
2-Jul	2.0	2.6	3.0	3.9	5.3	5.2	4.7	3.8
9-Jul	1.9	1.7	1.9	2.7	4.8	4.6	4.8	4.8
16-Jul	2.6	2.3	1.6	2.4	5.4	5.7	5.0	5.9
23-Jul	3.0	2.5	2.4	1.8	6.7	6.0	4.4	4.2
30-Jul	2.1	2.2	2.4	1.6	5.4	5.9	5.2	5.0
6-Aug	3.0	3.2	2.6	2.4	3.9	5.7	4.2	4.9
13-Aug	2.0	1.6	2.1	2.0	3.0	4.8	4.4	4.6
20-Aug	2.0	2.0	2.0	2.0	4.0	5.0	4.0	5.0
	---------- Mg, 1 lb ----------				---------- Zn, 56 g ----------			
29-May	1.2	1.2	1.2	1.2	75	75	75	75
11-Jun	1.0	0.9	1.1	0.5	84	96	105	102
18-Jun	1.1	1.0	0.9	0.7	84	108	93	87
25-Jun	0.8	0.7	0.7	0.8	75	93	75	75
2-Jul	0.9	0.8	0.8	0.9	66	66	66	60
9-Jul	0.7	0.7	0.9	0.6	69	48	48	63
16-Jul	0.8	0.8	0.8	0.5	54	36	45	54
23-Jul	0.9	0.9	0.9	0.7	63	42	45	42
30-Jul	0.7	0.9	0.9	0.9	78	45	54	48
6-Aug	0.9	0.8	0.7	0.8	66	39	45	45
13-Aug	1.0	0.9	0.9	0.7	54	39	45	39
20-Aug	1.0	1.0	1.0	1.0	48	45	36	39

Table 7. (continued) Soil solution analyses with four treatments and critical level for each nutrient, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

	SWT irrigation		NetBeat irrigation		SWT irrigation		NetBeat irrigation	
Date	Petiole fert.	Netafim fert.	Petiole fert.	Netafim fert.	Petiole fert.	Netafim fert.	Petiole fert.	Netafim fert.
	---------- Mn, 40 g ----------				---------- Cu, 28 g ----------			
29-May	45	45	45	45	18	18	18	18
11-Jun	66	48	45	69	27	18	24	21
18-Jun	57	42	36	78	27	21	30	27
25-Jun	45	30	30	57	30	27	36	33
2-Jul	33	27	33	48	27	21	39	24
9-Jul	27	33	27	39	33	27	36	30
16-Jul	24	27	33	36	24	21	27	21
23-Jul	27	30	24	42	27	24	30	27
30-Jul	33	36	30	48	33	30	33	30
6-Aug	27	30	24	42	42	36	39	36
13-Aug	30	33	18	36	48	45	45	27
20-Aug	36	39	21	33	54	54	51	33
	---------- B, 28 g ----------							
29-May	42	42	42	42				
11-Jun	33	18	24	27				
18-Jun	39	23	30	35				
25-Jun	36	20	26	29				
2-Jul	29	21	26	29				
9-Jul	32	17	30	35				
16-Jul	36	21	27	33				
23-Jul	33	20	23	27				
30-Jul	32	23	27	33				
6-Aug	27	29	20	29				

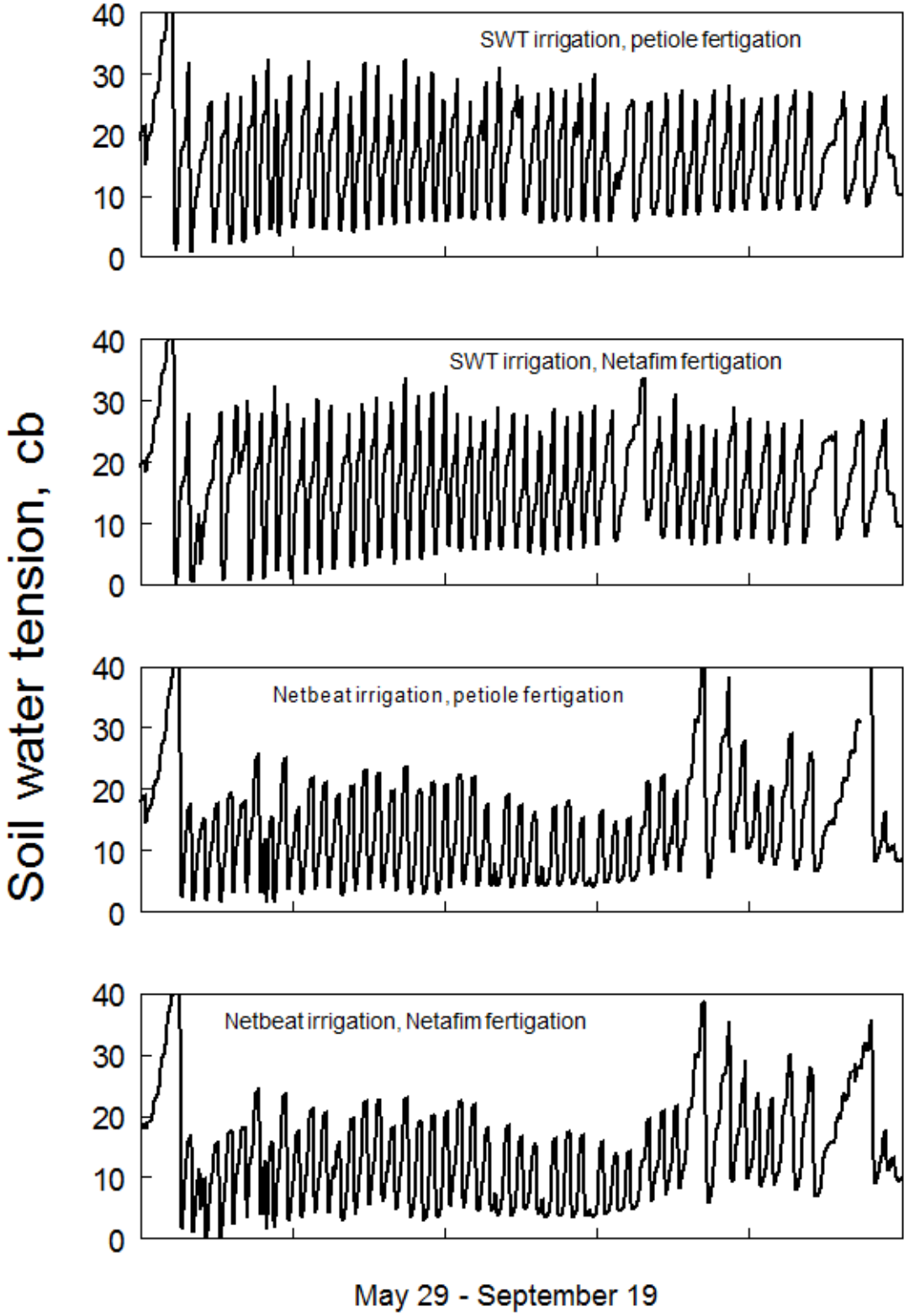

Figure 5. Soil water tension at 8-inch depth for four treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

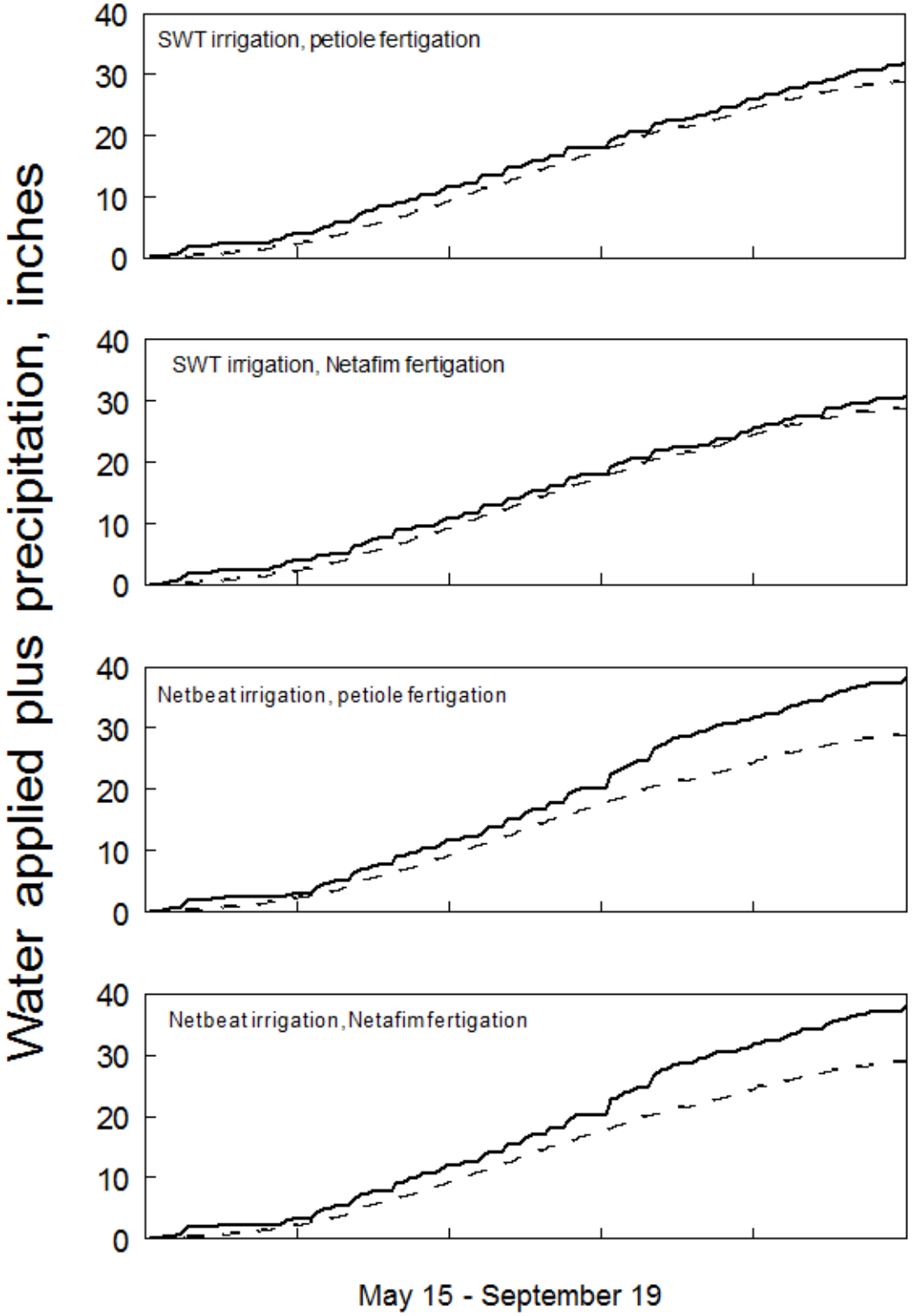

Figure 6. Cumulative water applied plus precipitation for four treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Table 8. Water applied, nutrients applied from irrigation water, and soil water tension for four treatments. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Treatment No.	Irrigation scheduling	Fertigation method	Total water applied plus precipitation		N applied from irrigation water	K applied from irrigation water	Average soil water tension	Average maximum soil water tension	Average minimum soil water tension
			inches	% of ET_c	lb/acre	lb/acre	cb	cb	cb
1	SWT	Petiole	32.0	110.5	8	12	15.6	27.9	5.8
2	SWT	Netafim	31.0	107.0	8	12	16.1	28.6	5.3
3	NetBeat	Petiole	38.3	132.2	10	14	13.3	20.9	4.4
4	NetBeat	Netafim	38.0	131.3	10	14	13.3	20.5	4.7

Table 9. Yield, grade, and vine fall over for four treatments. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Irrigation scheduling	Fertigation method	Total yield	Marketable	U.S. No. 1 Total	U.S. No. 1 >20 oz	U.S. No. 1 10 to 20 oz	U.S. No. 1 6 to 10 oz	U.S. No. 1 4 to 6 oz	U.S. No. 1 <4 oz	U.S. No. 2	Cull	U.S. No. 1	Fry color[a]	Specific gravity	Vine lodging[b]
		cwt/acre										%	%		%
SWT	Petiole	862.3	754.5	840.7	63.7	267.6	300.8	122.4	86.2	19.8	1.8	97.5	42.4	1.083	0.5
	Netafim	812.5	702.0	792.4	31.7	220.8	295.2	154.3	90.4	17.3	2.8	97.5	43.3	1.081	70.0
	Average	837.4	728.3	816.5	47.7	244.2	298.0	138.4	88.3	18.5	2.3	97.5	42.8	1.082	35.3
NetBeat	Petiole	893.8	783.5	869.1	66.1	284.5	293.6	139.3	85.6	20.1	4.6	97.2	42.2	1.085	2.3
	Netafim	832.2	720.0	805.5	44.2	210.7	309.3	155.8	85.5	25.6	1.2	96.7	41.0	1.080	25.5
	Average	863.0	751.7	837.3	55.2	247.6	301.4	147.5	85.5	22.8	2.9	97.0	41.6	1.082	13.9
Average	Petiole	878.0	769.0	854.9	64.9	276.0	297.2	130.9	85.9	19.9	3.2	97.4	42.3	1.084	1.4
	Netafim	822.3	711.0	798.9	38.0	215.8	302.2	155.0	88.0	21.4	2.0	97.1	42.2	1.081	47.8
	Average	850.2	740.0	826.9	51.4	245.9	299.7	143.0	86.9	20.7	2.6	97.3	42.2	1.082	24.6
LSD (0.05)															
Irrigation scheduling		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.2	NS	10.8
Fertigation		NS	47.4[c]	NS	NS	50.4[c]	NS	NS	NS	NS	NS	NS	NS	NS	10.8
Irrigation X Fertigation		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	15.3

[a] % light reflectance.
[b] June 27.
[c] LSD (0.10)

Table 10. Nutrient concentration in potato vines for four treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Irrigation scheduling	Fertigation	Date	N	P	K	S	Ca	Mg	Zn	Mn	Cu	Fe	B
			%						ppm				
SWT	Petiole	26-Jun	4.78	0.50	6.59	0.51	1.59	0.45	36.0	69.5	12.0	248.8	29.8
		11-Jul	4.20	0.34	6.04	0.50	1.57	0.55	35.3	50.0	8.0	340.3	29.5
		24-Jul	3.46	0.21	7.01	0.43	1.39	0.30	19.3	31.8	7.3	193.3	30.3
		7-Aug	3.03	0.27	6.56	0.48	1.91	0.36	37.0	38.5	9.7	649.9	33.1
		21-Aug	3.01	0.34	6.03	0.42	2.07	0.24	29.0	57.0	8.5	428.0	18.3
		7-Oct	2.43	0.22	4.73	0.40	1.48	0.34	31.8	46.0	13.3	741.4	27.0
		average	3.48	0.31	6.16	0.46	1.67	0.37	31.4	48.8	9.8	433.6	28.0
	Netafim	26-Jun	5.45	0.46	6.89	0.45	1.50	0.43	39.0	63.5	8.5	287.5	31.3
		11-Jul	4.90	0.31	5.92	0.44	1.42	0.47	29.8	47.8	8.8	385.3	27.0
		24-Jul	4.01	0.26	7.66	0.45	1.52	0.26	22.0	37.0	6.5	188.0	27.0
		7-Aug	3.92	0.32	7.52	0.45	1.51	0.29	47.2	39.8	10.0	566.7	18.9
		21-Aug	3.54	0.35	6.65	0.41	1.91	0.25	31.0	58.5	9.8	428.3	20.8
		7-Oct	2.60	0.20	4.90	0.34	1.44	0.36	24.0	40.5	12.0	686.8	26.6
		average	4.07	0.32	6.59	0.42	1.55	0.34	32.2	47.8	9.3	423.7	25.3
	Average	26-Jun	5.12	0.48	6.74	0.48	1.54	0.44	37.5	66.5	10.3	268.1	30.5
		11-Jul	4.55	0.32	5.98	0.47	1.49	0.51	32.5	48.9	8.4	362.8	28.3
		24-Jul	3.74	0.23	7.34	0.44	1.45	0.28	20.6	34.4	6.9	190.6	28.6
		7-Aug	3.47	0.29	7.04	0.46	1.71	0.32	42.1	39.1	9.9	608.3	26.0
		21-Aug	3.28	0.34	6.34	0.41	1.99	0.24	30.0	57.8	9.1	428.1	19.5
		7-Oct	2.51	0.21	4.81	0.37	1.46	0.35	27.9	43.3	12.6	714.1	26.8
		average	3.78	0.31	6.37	0.44	1.61	0.36	31.8	48.3	9.5	428.7	26.6
NetBeat	Petiole	26-Jun	5.13	0.49	6.47	0.45	1.45	0.42	41.5	68.3	9.0	247.8	29.5
		11-Jul	4.68	0.37	5.31	0.54	1.50	0.50	31.3	59.0	11.8	304.8	31.5
		24-Jul	4.10	0.26	7.25	0.46	1.43	0.25	21.0	35.8	7.0	182.3	27.3
		7-Aug	3.79	0.33	7.05	0.46	1.75	0.33	32.0	35.3	9.3	501.4	34.3
		21-Aug	3.15	0.40	6.75	0.50	2.22	0.24	29.0	65.5	8.8	342.0	16.0
		7-Oct	2.36	0.21	5.25	0.40	1.58	0.36	38.7	57.6	12.3	679.2	37.7
		average	3.87	0.34	6.35	0.47	1.65	0.35	32.2	53.6	9.7	376.2	29.4
	Netafim	26-Jun	5.21	0.44	6.84	0.46	1.46	0.43	36.8	79.8	9.0	282.8	31.5
		11-Jul	4.17	0.35	5.73	0.43	1.41	0.47	26.5	57.0	6.0	289.8	29.3
		24-Jul	4.00	0.31	7.61	0.46	1.25	0.23	21.8	35.5	7.3	208.3	26.3
		7-Aug	3.66	0.33	7.33	0.46	1.53	0.32	42.4	26.0	9.5	710.6	22.3
		21-Aug	2.76	0.39	6.63	0.41	1.84	0.24	29.8	61.0	9.3	420.5	18.8
		7-Oct	2.48	0.24	5.19	0.37	1.34	0.30	30.9	48.7	11.7	690.4	29.3
		average	3.71	0.34	6.55	0.43	1.47	0.33	31.3	51.3	8.8	433.7	26.2
	Average	26-Jun	5.17	0.46	6.65	0.45	1.46	0.42	39.1	74.0	9.0	265.3	30.5
		11-Jul	4.42	0.36	5.52	0.48	1.45	0.49	28.9	58.0	8.9	297.3	30.4
		24-Jul	4.05	0.28	7.43	0.46	1.34	0.24	21.4	35.6	7.1	195.3	26.8
		7-Aug	3.72	0.33	7.19	0.46	1.64	0.32	37.2	30.6	9.4	606.0	28.3
		21-Aug	2.95	0.39	6.69	0.45	2.03	0.24	29.4	63.3	9.0	381.3	17.4
		7-Oct	2.42	0.23	5.22	0.38	1.46	0.33	34.8	53.2	12.0	684.8	33.5
		average	3.79	0.34	6.45	0.45	1.56	0.34	31.8	52.4	9.2	405.0	27.8
Average	Petiole	26-Jun	4.96	0.49	6.53	0.48	1.52	0.43	38.8	68.9	10.5	248.3	29.6
		11-Jul	4.44	0.35	5.67	0.52	1.53	0.52	33.3	54.5	9.9	322.5	30.5
		24-Jul	3.78	0.24	7.13	0.44	1.41	0.27	20.1	33.8	7.1	187.8	28.8
		7-Aug	3.41	0.30	6.80	0.47	1.83	0.34	34.5	36.9	9.5	575.7	33.7
		21-Aug	3.08	0.37	6.39	0.46	2.14	0.24	29.0	61.3	8.6	385.0	17.1
		7-Oct	2.39	0.22	4.99	0.40	1.53	0.35	35.2	51.8	12.8	710.3	32.4
		average	3.67	0.33	6.25	0.46	1.66	0.36	31.8	51.2	9.7	404.9	28.7
	Netafim	26-Jun	5.33	0.45	6.86	0.46	1.48	0.43	37.9	71.6	8.8	285.1	31.4
		11-Jul	4.54	0.33	5.82	0.43	1.41	0.47	28.1	52.4	7.4	337.5	28.1
		24-Jul	4.01	0.28	7.63	0.45	1.38	0.24	21.9	36.3	6.9	198.1	26.6
		7-Aug	3.79	0.32	7.43	0.45	1.52	0.30	44.8	32.9	9.8	638.6	20.6
		21-Aug	3.15	0.37	6.64	0.41	1.88	0.24	30.4	59.8	9.5	424.4	19.8
		7-Oct	2.54	0.22	5.05	0.35	1.39	0.33	27.4	44.6	11.8	688.6	28.0
		average	3.89	0.33	6.57	0.43	1.51	0.34	31.7	49.6	9.0	428.7	25.7
Average		26-Jun	5.14	0.47	6.69	0.47	1.50	0.43	38.3	70.3	9.6	266.7	30.5
		11-Jul	4.49	0.34	5.75	0.48	1.47	0.50	30.7	53.4	8.6	330.0	29.3
		24-Jul	3.89	0.26	7.38	0.45	1.39	0.26	21.0	35.0	7.0	192.9	27.7
		7-Aug	3.60	0.31	7.11	0.46	1.68	0.32	39.6	34.9	9.6	607.1	27.2
		21-Aug	3.11	0.37	6.51	0.43	2.01	0.24	29.7	60.5	9.1	404.7	18.4
		7-Oct	2.47	0.22	5.02	0.38	1.46	0.34	31.3	48.2	12.3	699.5	30.2
LSD (0.05) Fertigation			NS	NS	0.37	NS	0.18	NS	NS	NS	NS	NS	NS
LSD (0.05) Date			0.27	0.04	0.46	0.04	0.15	0.04	6.4	11.3	NS	95.6	5.0
LSD (0.05) Irrigation X Fertigation			0.18	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LSD (0.05) Fertigation X Date			NS	NS	NS	NS	NS	NS	9.05	NS	NS	NS	NS

Table 11. Nutrient concentration in potato tubers for four treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Irrigation scheduling	Fertigation	Date	N	P	K	S	Ca	Mg	Zn	Mn	Cu	Fe	B
			---------- % ----------						---------- ppm ----------				
SWT	Petiole	26-Jun	1.84	0.30	2.98	0.16	0.37	0.20	17.18	22.04	4.05	506.85	5.53
		11-Jul	1.65	0.27	1.90	1.43	1.27	0.21	17.00	43.75	5.00	204.25	30.25
		24-Jul	1.58	0.27	4.47	0.22	1.56	0.27	30.00	43.25	7.00	187.50	28.00
		7-Aug	1.55	0.38	2.63	0.21	0.13	0.08	24.50	48.50	9.00	425.50	26.75
		21-Aug	1.67	0.31	2.51	0.21	0.19	0.25	36.00	75.75	13.50	268.50	19.50
		7-Oct	1.58	0.38	2.64	0.22	1.10	0.21	31.78	25.25	7.34	348.53	23.25
		average	1.64	0.32	2.85	0.41	0.77	0.20	26.08	43.09	7.65	323.52	22.21
	Netafim	26-Jun	1.91	0.32	2.88	0.16	0.30	0.20	19.82	25.99	4.48	703.54	5.51
		11-Jul	1.89	0.28	1.89	0.25	1.01	0.21	15.50	33.75	5.50	182.00	39.25
		24-Jul	1.82	0.27	4.10	0.23	1.65	0.23	24.25	42.00	7.50	214.50	29.50
		7-Aug	1.84	0.37	2.78	0.20	0.20	0.10	34.25	43.00	10.25	376.75	30.50
		21-Aug	1.79	0.27	2.82	0.23	0.71	0.20	33.50	50.50	15.00	332.75	22.75
		7-Oct	1.93	0.40	2.91	0.23	1.10	0.21	34.50	19.25	8.08	286.75	22.75
		average	1.86	0.32	2.90	0.21	0.83	0.19	26.97	35.75	8.47	349.38	25.04
	Average	26-Jun	1.87	0.31	2.93	0.16	0.34	0.20	18.50	24.01	4.26	605.20	5.52
		11-Jul	1.77	0.27	1.90	0.84	1.14	0.21	16.25	38.75	5.25	193.13	34.75
		24-Jul	1.70	0.27	4.28	0.22	1.60	0.25	27.13	42.63	7.25	201.00	28.75
		7-Aug	1.69	0.38	2.70	0.20	0.16	0.09	29.38	45.75	9.63	401.13	28.63
		21-Aug	1.73	0.29	2.67	0.22	0.45	0.23	34.75	63.13	14.25	300.63	21.13
		7-Oct	1.76	0.39	2.78	0.23	1.10	0.21	33.14	22.25	7.71	317.64	23.00
		average	1.75	0.32	2.87	0.31	0.80	0.20	26.52	39.42	8.06	336.45	23.63
NetBeat	Petiole	26-Jun	1.75	0.31	2.91	0.16	0.31	0.18	16.94	17.41	3.79	496.08	5.19
		11-Jul	1.73	0.26	2.27	0.93	1.09	0.23	17.00	41.25	5.50	215.25	29.25
		24-Jul	1.64	0.30	4.10	0.21	1.71	0.28	31.75	44.50	7.00	213.50	31.25
		7-Aug	1.66	0.37	2.49	0.19	0.16	0.10	25.00	40.00	9.75	471.00	26.25
		21-Aug	1.65	0.29	2.98	0.21	0.22	0.23	45.50	72.50	12.25	244.25	19.75
		7-Oct	1.83	0.30	1.95	0.20	1.06	0.21	31.84	20.75	7.92	183.99	22.00
		average	1.71	0.30	2.78	0.31	0.76	0.20	28.00	39.40	7.70	304.01	22.28
	Netafim	26-Jun	1.94	0.31	2.81	0.16	0.32	0.19	17.74	24.02	3.98	633.04	5.81
		11-Jul	1.75	0.30	2.27	0.22	0.80	0.23	17.25	37.75	4.75	215.50	27.25
		24-Jul	1.77	0.29	3.20	0.22	1.42	0.25	26.00	47.75	5.75	217.50	27.25
		7-Aug	1.84	0.40	2.70	0.21	0.30	0.09	24.75	45.75	10.75	458.75	25.75
		21-Aug	1.75	0.31	2.70	0.19	0.28	0.19	31.00	62.75	9.75	311.75	16.00
		7-Oct	1.73	0.31	2.24	0.21	1.15	0.21	27.25	15.75	9.21	254.80	21.25
		average	1.80	0.32	2.65	0.20	0.71	0.19	24.00	38.96	7.36	348.56	20.55
	Average	26-Jun	1.84	0.31	2.86	0.16	0.31	0.18	17.34	20.71	3.88	564.56	5.50
		11-Jul	1.74	0.28	2.27	0.57	0.95	0.23	17.13	39.50	5.13	215.38	28.25
		24-Jul	1.70	0.30	3.65	0.22	1.57	0.27	28.88	46.13	6.38	215.50	29.25
		7-Aug	1.75	0.38	2.59	0.20	0.23	0.09	24.88	42.88	10.25	464.88	26.00
		21-Aug	1.70	0.30	2.84	0.20	0.25	0.21	38.25	67.63	11.00	278.00	17.88
		7-Oct	1.78	0.30	2.10	0.20	1.10	0.21	29.55	18.25	8.57	219.39	21.63
		average	1.75	0.31	2.72	0.26	0.73	0.20	26.00	39.18	7.53	326.28	21.42
Average	Petiole	26-Jun	1.80	0.30	2.95	0.16	0.34	0.19	17.06	19.72	3.92	501.47	5.36
		11-Jul	1.69	0.26	2.09	1.18	1.18	0.22	17.00	42.50	5.25	209.75	29.75
		24-Jul	1.61	0.28	4.28	0.21	1.64	0.28	30.88	43.88	7.00	200.50	29.63
		7-Aug	1.60	0.38	2.56	0.20	0.14	0.09	24.75	44.25	9.38	448.25	26.50
		21-Aug	1.66	0.30	2.74	0.21	0.20	0.24	40.75	74.13	12.88	256.38	19.63
		7-Oct	1.70	0.34	2.30	0.21	1.08	0.21	31.81	23.00	7.63	266.26	22.63
		average	1.68	0.31	2.82	0.36	0.76	0.20	27.04	41.25	7.67	313.77	22.25
	Netafim	26-Jun	1.92	0.31	2.84	0.16	0.31	0.19	18.78	25.01	4.23	668.29	5.66
		11-Jul	1.82	0.29	2.08	0.23	0.90	0.22	16.38	35.75	5.13	198.75	33.25
		24-Jul	1.80	0.28	3.65	0.22	1.53	0.24	25.13	44.88	6.63	216.00	28.38
		7-Aug	1.84	0.38	2.74	0.20	0.25	0.09	29.50	44.38	10.50	417.75	28.13
		21-Aug	1.77	0.29	2.76	0.21	0.49	0.19	32.25	56.63	12.38	322.25	19.38
		7-Oct	1.83	0.35	2.57	0.22	1.12	0.21	30.88	17.50	8.65	270.78	22.00
		average	1.83	0.32	2.77	0.21	0.77	0.19	25.48	37.36	7.92	348.97	22.80
Average		26-Jun	1.86	0.31	2.89	0.16	0.33	0.19	17.92	22.36	4.07	584.88	5.51
		11-Jul	1.75	0.27	2.08	0.70	1.04	0.22	16.69	39.13	5.19	204.25	31.50
		24-Jul	1.70	0.28	3.96	0.22	1.58	0.26	28.00	44.38	6.81	208.25	29.00
		7-Aug	1.72	0.38	2.65	0.20	0.19	0.09	27.13	44.31	9.94	433.00	27.31
		21-Aug	1.71	0.30	2.75	0.21	0.35	0.22	36.50	65.38	12.63	289.31	19.50
		7-Oct	1.77	0.34	2.44	0.21	1.10	0.21	31.34	20.25	8.14	268.52	22.31
LSD (0.05) Fertigation			0.09	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LSD (0.05) Date			0.11	0.03	0.53	NS	0.16	0.06	3.50	8.12	2.15	141.90	2.76
LSD (0.05) Irrigation X Fertigation			NS	NS	NS	NS	NS	NS	2.36	NS	NS	NS	NS
LSD (0.05) Irrigation X Date			NS	0.04	NS	NS	NS	NS	NS	NS	NS	NS	NS
LSD (0.05) Fertigation X Date			NS	NS	NS	NS	NS	NS	4.97	NS	NS	NS	NS

Table 12. Vine biomass and nutrient uptake by potato vines for four treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Irrigation scheduling	Fertigation	Date	Vine fresh wt.	Vine dry wt.	N	P	K	S	Ca	Mg	Zn	Mn	Cu	Fe	B
			---- tons/acre ----		---------- lb/acre nutrient uptake ----------										
SWT	Petiole	26-Jun	24.5	1.9	177.2	18.4	244.5	18.9	58.8	16.7	0.14	0.26	0.05	0.93	0.11
		11-Jul	30.9	2.4	206.4	16.6	295.3	24.3	76.9	26.6	0.17	0.24	0.04	1.68	0.15
		24-Jul	27.2	2.2	156.4	9.4	315.7	19.2	63.0	14.2	0.09	0.14	0.03	0.87	0.14
		7-Aug	25.0	2.4	142.1	12.4	310.2	22.3	88.3	16.6	0.17	0.18	0.05	2.91	0.15
		21-Aug	22.7	2.1	126.3	14.2	253.0	17.5	87.5	10.1	0.13	0.24	0.04	1.85	0.08
		7-Oct	9.0	1.3	65.5	5.9	128.9	10.8	39.5	9.4	0.08	0.13	0.03	1.99	0.07
		average	23.2	2.1	145.6	12.8	257.9	18.9	69.0	15.6	0.13	0.20	0.04	1.70	0.12
	Netafim	26-Jun	30.2	2.3	249.8	21.4	315.7	20.5	68.9	19.5	0.18	0.29	0.04	1.32	0.14
		11-Jul	33.3	2.6	256.5	16.2	305.6	23.3	73.3	24.2	0.16	0.25	0.05	2.00	0.14
		24-Jul	33.9	2.7	213.7	13.5	408.1	23.9	81.1	13.8	0.12	0.20	0.03	1.01	0.14
		7-Aug	29.6	2.6	200.5	16.2	384.5	22.8	77.7	15.1	0.23	0.21	0.05	2.93	0.10
		21-Aug	27.1	2.5	179.9	17.6	338.6	20.8	97.2	12.5	0.16	0.30	0.05	2.21	0.10
		7-Oct	11.8	1.6	84.1	6.5	163.3	11.3	48.0	11.9	0.08	0.14	0.04	2.41	0.09
		average	27.6	2.4	197.4	15.2	319.3	20.4	74.4	16.2	0.15	0.23	0.04	1.98	0.12
	Average	26-Jun	27.3	2.1	213.5	19.9	280.1	19.7	63.9	18.1	0.16	0.28	0.04	1.12	0.12
		11-Jul	32.1	2.5	231.5	16.4	300.5	23.8	75.1	25.4	0.17	0.24	0.04	1.84	0.14
		24-Jul	30.6	2.5	185.0	11.5	361.9	21.6	72.0	14.0	0.10	0.17	0.03	0.94	0.14
		7-Aug	27.3	2.5	171.3	14.3	347.3	22.6	83.0	15.9	0.20	0.19	0.05	2.92	0.12
		21-Aug	24.9	2.3	153.1	15.9	295.8	19.2	92.4	11.3	0.14	0.27	0.04	2.03	0.09
		7-Oct	10.4	1.5	74.8	6.2	146.1	11.1	43.7	10.6	0.08	0.14	0.04	2.20	0.08
		average	25.4	2.2	171.5	14.0	288.6	19.7	71.7	15.9	0.14	0.21	0.04	1.84	0.12
NetBeat	Petiole	26-Jun	28.6	2.1	216.4	20.5	271.8	18.9	61.2	17.5	0.17	0.29	0.04	1.03	0.13
		11-Jul	33.8	2.7	248.3	19.3	276.0	28.5	78.5	26.5	0.17	0.31	0.07	1.60	0.17
		24-Jul	30.7	2.5	204.0	12.9	362.1	22.7	72.7	12.4	0.11	0.18	0.04	0.90	0.14
		7-Aug	30.9	2.8	208.4	18.3	388.4	25.5	96.7	18.2	0.18	0.19	0.05	2.77	0.19
		21-Aug	30.0	2.7	173.7	21.6	368.9	27.7	123.8	12.3	0.16	0.35	0.05	1.83	0.09
		7-Oct	10.3	2.0	91.8	8.6	203.8	16.0	63.8	14.5	0.15	0.22	0.05	2.62	0.16
		average	27.4	2.5	190.4	16.9	311.8	23.2	82.8	16.9	0.16	0.25	0.05	1.79	0.14
	Netafim	26-Jun	31.5	2.3	238.2	20.3	308.3	21.2	66.3	19.3	0.17	0.37	0.04	1.28	0.14
		11-Jul	34.7	2.6	222.2	18.2	300.8	22.5	73.7	24.6	0.14	0.30	0.03	1.51	0.16
		24-Jul	32.8	2.6	210.0	15.7	396.0	23.7	65.2	12.1	0.11	0.19	0.04	1.08	0.14
		7-Aug	31.4	2.7	198.9	17.7	400.0	25.0	83.9	17.3	0.23	0.14	0.05	3.99	0.12
		21-Aug	29.8	2.9	161.4	22.3	381.7	23.5	107.7	14.1	0.18	0.36	0.05	2.48	0.11
		7-Oct	12.4	2.0	96.9	9.1	191.0	13.7	50.1	11.6	0.13	0.18	0.05	2.57	0.11
		average	28.8	2.5	187.9	17.2	329.6	21.6	74.5	16.5	0.16	0.25	0.04	2.15	0.13
	Average	26-Jun	30.1	2.2	227.3	20.4	290.1	20.0	63.8	18.4	0.17	0.33	0.04	1.15	0.13
		11-Jul	34.2	2.6	235.3	18.8	288.4	25.5	76.1	25.5	0.15	0.30	0.05	1.55	0.16
		24-Jul	31.7	2.6	207.0	14.3	379.0	23.2	68.9	12.2	0.11	0.18	0.04	0.99	0.14
		7-Aug	31.2	2.7	203.6	18.0	394.2	25.2	90.3	17.8	0.20	0.17	0.05	3.38	0.16
		21-Aug	29.9	2.8	167.6	21.9	375.3	25.6	115.7	13.2	0.17	0.35	0.05	2.15	0.10
		7-Oct	11.3	2.0	94.3	8.9	197.4	14.8	57.0	13.1	0.14	0.20	0.05	2.59	0.13
		average	28.1	2.5	189.2	17.0	320.7	22.4	78.6	16.7	0.16	0.25	0.05	1.97	0.14
Average	Petiole	26-Jun	26.6	2.0	196.8	19.4	258.2	18.9	60.0	17.1	0.15	0.27	0.04	0.98	0.12
		11-Jul	32.3	2.5	227.4	18.0	285.6	26.4	77.7	26.5	0.17	0.28	0.05	1.64	0.16
		24-Jul	29.0	2.4	180.2	11.1	338.9	21.0	67.8	13.3	0.10	0.16	0.03	0.89	0.14
		7-Aug	28.0	2.6	175.2	15.4	349.3	23.9	92.5	17.4	0.17	0.19	0.05	2.84	0.17
		21-Aug	26.4	2.4	150.0	17.9	310.9	22.6	105.6	11.2	0.14	0.30	0.04	1.84	0.09
		7-Oct	9.7	1.7	78.6	7.3	166.3	13.4	51.7	11.9	0.12	0.17	0.04	2.31	0.11
		average	25.3	2.3	168.0	14.8	284.9	21.0	75.9	16.3	0.14	0.23	0.04	1.75	0.13
	Netafim	26-Jun	30.8	2.3	244.0	20.8	312.0	20.9	67.6	19.4	0.17	0.33	0.04	1.30	0.14
		11-Jul	34.0	2.6	239.4	17.2	303.2	22.9	73.5	24.4	0.15	0.27	0.04	1.75	0.15
		24-Jul	33.3	2.6	211.9	14.6	402.0	23.8	73.1	13.0	0.12	0.19	0.04	1.05	0.14
		7-Aug	30.5	2.6	199.7	16.9	392.2	23.9	80.8	16.2	0.23	0.17	0.05	3.46	0.11
		21-Aug	28.5	2.7	170.7	19.9	360.2	22.2	102.5	13.3	0.17	0.33	0.05	2.34	0.11
		7-Oct	12.1	1.8	90.5	7.8	177.1	12.5	49.1	11.7	0.10	0.16	0.04	2.49	0.10
		average	28.2	2.5	192.7	16.2	324.5	21.0	74.4	16.3	0.16	0.24	0.04	2.06	0.12
Average		26-Jun	28.7	2.1	220.4	20.1	285.1	19.9	63.8	18.2	0.16	0.30	0.04	1.14	0.13
		11-Jul	33.2	2.6	233.4	17.6	294.4	24.7	75.6	25.5	0.16	0.27	0.05	1.69	0.15
		24-Jul	31.1	2.5	196.0	12.9	370.5	22.4	70.5	13.1	0.11	0.18	0.03	0.97	0.14
		7-Aug	29.2	2.6	187.5	16.2	370.8	23.9	86.7	16.8	0.20	0.18	0.05	3.15	0.14
		21-Aug	27.4	2.6	160.3	18.9	335.5	22.4	104.1	12.3	0.15	0.31	0.05	2.09	0.10
		7-Oct	10.9	1.7	84.6	7.5	171.7	13.0	50.4	11.8	0.11	0.17	0.04	2.40	0.11
LSD (0.05) Irrigation			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.03
LSD (0.05) Fertigation			NS	NS	10.6	NS	26.9	NS	NS	NS	NS	NS	NS	NS	NS
LSD (0.05) Date			2.2	0.4	20.8	2.7	46.5	3.9	15.2	3.8	0.03	0.07	NS	0.75	0.03
LSD (0.05) Irrigation X Fertigation			2.7	0.2	15.0	NS	NS	1.7	NS	NS	NS	NS	NS	NS	NS

Table 13. Tuber biomass and nutrient uptake by potato tubers for four treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Irrigation scheduling	Fertigation	Date	Tuber fresh wt.	Tuber dry wt.	N	P	K	S	Ca	Mg	Zn	Mn	Cu	Fe	B
			------ tons/acre ------		---------- lb/acre nutrient uptake ----------										
SWT	Petiole	26-Jun	9.9	1.3	49.4	8.1	79.7	4.4	10.0	5.4	0.025	0.050	0.000	1.300	0.000
		11-Jul	18.7	3.3	107.6	17.7	121.3	97.7	86.7	13.5	0.125	0.275	0.000	1.350	0.200
		24-Jul	22.7	4.6	144.5	24.7	403.8	20.0	143.0	24.7	0.275	0.400	0.075	1.725	0.250
		7-Aug	29.3	6.0	184.4	45.4	312.4	24.8	15.4	9.5	0.275	0.575	0.100	5.150	0.325
		21-Aug	35.8	7.5	250.6	47.2	376.0	32.0	27.6	40.7	0.550	1.125	0.225	4.150	0.300
		7-Oct	43.6	11.8	303.9	74.3	519.6	42.9	213.9	40.2	0.625	0.500	0.150	7.050	0.425
		average	26.7	5.7	173.4	36.2	302.1	37.0	82.8	22.3	0.313	0.488	0.092	3.454	0.250
	Netafim	26-Jun	9.3	1.2	45.5	7.5	68.9	3.8	7.2	4.7	0.050	0.075	0.000	1.900	0.000
		11-Jul	14.2	2.4	89.4	13.1	92.3	11.5	42.7	10.0	0.075	0.150	0.000	0.850	0.175
		24-Jul	21.7	4.1	149.8	21.8	341.3	18.8	135.2	18.6	0.200	0.325	0.075	1.750	0.250
		7-Aug	24.8	4.8	176.8	35.0	269.0	19.0	20.8	10.4	0.350	0.400	0.125	3.675	0.300
		21-Aug	32.6	6.5	232.4	35.2	367.4	30.1	94.7	26.2	0.425	0.625	0.200	4.550	0.275
		7-Oct	40.7	10.4	322.5	66.5	496.0	39.2	185.0	34.3	0.575	0.325	0.150	5.000	0.375
		average	23.9	4.9	169.4	29.8	272.5	20.4	80.9	17.4	0.279	0.317	0.092	2.954	0.229
	Average	26-Jun	9.6	1.3	47.4	7.8	74.3	4.1	8.6	5.0	0.038	0.063	0.000	1.600	0.000
		11-Jul	16.5	2.8	98.5	15.4	106.8	54.6	64.7	11.7	0.100	0.213	0.000	1.100	0.188
		24-Jul	22.2	4.4	147.2	23.2	372.6	19.4	139.1	21.6	0.238	0.363	0.075	1.738	0.250
		7-Aug	27.0	5.4	180.6	40.2	290.7	21.9	18.1	9.9	0.313	0.488	0.113	4.413	0.313
		21-Aug	34.2	7.0	241.5	41.2	371.7	31.0	61.1	33.4	0.488	0.875	0.213	4.350	0.288
		7-Oct	42.2	11.1	313.2	70.4	507.8	41.0	199.4	37.2	0.600	0.413	0.150	6.025	0.400
		average	25.3	5.3	171.4	33.0	287.3	28.7	81.9	19.8	0.296	0.402	0.092	3.204	0.240
NetBeat	Petiole	26-Jun	8.5	1.1	38.7	6.9	64.9	3.4	6.6	4.0	0.000	0.025	0.000	1.075	0.000
		11-Jul	16.2	2.7	95.3	14.5	132.8	48.5	58.3	12.2	0.100	0.200	0.000	1.250	0.150
		24-Jul	22.7	4.5	147.6	27.0	379.0	19.0	154.7	25.3	0.300	0.400	0.050	1.950	0.275
		7-Aug	30.8	6.3	209.2	47.5	316.4	23.5	18.4	11.7	0.300	0.500	0.125	6.025	0.325
		21-Aug	36.3	7.5	246.6	44.0	445.0	31.9	32.4	35.7	0.675	1.075	0.175	3.675	0.300
		7-Oct	45.5	11.8	342.9	56.0	366.7	37.6	199.5	38.5	0.625	0.425	0.150	3.425	0.400
		average	26.7	5.7	180.0	32.6	284.1	27.3	78.3	21.2	0.333	0.438	0.083	2.900	0.242
	Netafim	26-Jun	8.6	1.1	43.0	6.8	62.3	3.5	7.1	4.2	0.000	0.025	0.000	1.400	0.000
		11-Jul	15.8	2.7	94.1	15.8	116.3	11.7	44.1	12.5	0.100	0.200	0.000	1.175	0.125
		24-Jul	21.1	4.0	143.0	23.7	255.1	17.8	115.2	20.0	0.200	0.425	0.050	1.800	0.250
		7-Aug	26.3	5.1	189.1	40.4	279.2	21.0	24.6	8.4	0.250	0.475	0.100	4.350	0.250
		21-Aug	37.5	7.6	265.3	47.0	406.5	29.6	43.5	29.5	0.475	0.950	0.150	5.025	0.225
		7-Oct	48.9	12.7	338.4	59.0	435.5	40.0	229.0	41.1	0.525	0.325	0.200	5.150	0.425
		average	26.3	5.6	178.8	32.1	259.1	20.6	77.2	19.3	0.258	0.400	0.083	3.150	0.213
	Average	26-Jun	8.6	1.1	40.8	6.9	63.6	3.5	6.9	4.1	0.000	0.025	0.000	1.238	0.000
		11-Jul	16.0	2.7	94.7	15.1	124.5	30.1	51.2	12.4	0.100	0.200	0.000	1.213	0.138
		24-Jul	21.9	4.3	145.3	25.4	317.1	18.4	134.9	22.7	0.250	0.413	0.050	1.875	0.263
		7-Aug	28.5	5.7	199.2	43.9	297.8	22.2	21.5	10.0	0.275	0.488	0.113	5.188	0.288
		21-Aug	36.9	7.6	255.9	45.5	425.8	30.7	37.9	32.6	0.575	1.013	0.163	4.350	0.263
		7-Oct	47.2	12.3	340.7	57.5	401.1	38.8	214.2	39.8	0.575	0.375	0.175	4.288	0.413
		average	26.5	5.6	179.4	32.4	271.6	23.9	77.8	20.2	0.296	0.419	0.083	3.025	0.227
Average	Petiole	26-Jun	9.2	1.2	44.0	7.5	72.3	3.9	8.3	4.7	0.013	0.038	0.000	1.188	0.000
		11-Jul	17.5	3.0	101.4	16.1	127.0	73.1	72.5	12.9	0.113	0.238	0.000	1.300	0.175
		24-Jul	22.7	4.6	146.0	25.9	391.4	19.5	148.8	25.0	0.288	0.400	0.063	1.838	0.263
		7-Aug	30.0	6.1	196.8	46.4	314.4	24.2	16.9	10.6	0.288	0.538	0.113	5.588	0.325
		21-Aug	36.0	7.5	248.6	45.6	410.5	31.9	30.0	38.2	0.613	1.100	0.200	3.913	0.300
		7-Oct	44.5	11.8	323.4	65.1	443.1	40.2	206.7	39.3	0.625	0.463	0.150	5.238	0.413
		average	26.7	5.7	176.7	34.4	293.1	32.1	80.5	21.8	0.323	0.463	0.088	3.177	0.246
	Netafim	26-Jun	9.0	1.2	44.3	7.2	65.6	3.6	7.2	4.4	0.025	0.050	0.000	1.650	0.000
		11-Jul	15.0	2.5	91.8	14.4	104.3	11.6	43.4	11.2	0.088	0.175	0.000	1.013	0.150
		24-Jul	21.4	4.1	146.4	22.8	298.2	18.3	125.2	19.3	0.200	0.375	0.063	1.775	0.250
		7-Aug	25.5	5.0	182.9	37.7	274.1	20.0	22.7	9.4	0.300	0.438	0.113	4.013	0.275
		21-Aug	35.1	7.1	248.8	41.1	387.0	29.8	69.1	27.8	0.450	0.788	0.175	4.788	0.250
		7-Oct	44.8	11.6	330.5	62.7	465.7	39.6	207.0	37.7	0.550	0.325	0.175	5.075	0.400
		average	25.1	5.2	174.1	31.0	265.8	20.5	79.1	18.3	0.269	0.358	0.088	3.052	0.221
Average		26-Jun	9.1	1.2	44.1	7.3	68.9	3.8	7.7	4.5	0.019	0.044	0.000	1.419	0.000
		11-Jul	16.2	2.8	96.6	15.2	115.7	42.3	58.0	12.0	0.100	0.206	0.000	1.156	0.163
		24-Jul	22.0	4.3	146.2	24.3	344.8	18.9	137.0	22.1	0.244	0.388	0.063	1.806	0.256
		7-Aug	27.8	5.6	189.9	42.0	294.3	22.1	19.8	10.0	0.294	0.488	0.113	4.800	0.300
		21-Aug	35.5	7.3	248.7	43.3	398.7	30.9	49.5	33.0	0.531	0.944	0.188	4.350	0.275
		7-Oct	44.7	11.7	326.9	63.9	454.4	39.9	206.8	38.5	0.588	0.394	0.163	5.156	0.406
LSD (0.05) Fertigation			NS	NS	NS	NS	NS	NS	NS	NS	NS	0.043	NS	NS	NS
LSD (0.05) Date			3.1	0.8	25.3	4.9	65.5	12.6	20.7	9.0	0.063	0.002	0.032	0.583	0.052
LSD (0.05) Irrigation X Fertigation			NS	NS	NS	NS	NS	NS	NS	NS	NS	0.071	NS	NS	NS
LSD (0.05) Irrigation X Fertigation X Date			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.165	NS

Table 14. Total plant biomass and nutrient uptake by potato vines and tubers for four treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Irrigation scheduling	Fertigation	Date	Total fresh wt.	Total dry wt.	N	P	K	S	Ca	Mg	Zn	Mn	Cu	Fe	B
			---- tons/acre ----		---------- lb/acre nutrient uptake ----------										
SWT	Petiole	26-Jun	34.4	3.2	226.6	26.5	324.2	23.3	68.9	22.1	0.2	0.3	0.0	2.2	0.1
		11-Jul	49.6	5.7	314.0	34.3	416.6	122.1	163.6	40.0	0.3	0.5	0.0	3.0	0.3
		24-Jul	49.9	6.8	300.9	34.1	719.5	39.2	205.9	38.9	0.4	0.5	0.1	2.6	0.4
		7-Aug	54.3	8.3	326.4	57.8	622.6	47.2	103.7	26.1	0.4	0.8	0.1	8.1	0.5
		21-Aug	58.5	9.6	376.9	61.3	628.9	49.5	115.1	50.8	0.7	1.4	0.3	6.0	0.4
		7-Oct	52.6	13.1	369.4	80.2	648.5	53.7	253.4	49.5	0.7	0.6	0.2	9.0	0.5
		average	49.9	7.8	319.0	49.0	560.1	55.8	151.8	37.9	0.4	0.7	0.1	5.2	0.4
	Netafim	26-Jun	39.5	3.5	295.3	28.9	384.6	24.3	76.1	24.1	0.2	0.4	0.0	3.2	0.1
		11-Jul	47.5	5.0	345.9	29.2	397.9	34.7	116.0	34.2	0.2	0.4	0.0	2.8	0.3
		24-Jul	55.6	6.8	363.5	35.3	749.4	42.6	216.3	32.4	0.3	0.5	0.1	2.8	0.4
		7-Aug	54.4	7.4	377.3	51.2	653.5	41.8	98.5	25.5	0.6	0.6	0.2	6.6	0.4
		21-Aug	59.7	9.0	412.3	52.7	706.0	50.9	191.9	38.7	0.6	0.9	0.2	6.8	0.4
		7-Oct	52.5	12.1	406.7	73.0	659.3	50.5	233.0	46.1	0.7	0.5	0.2	7.4	0.5
		average	51.5	7.3	366.8	45.0	591.8	40.8	155.3	33.5	0.4	0.5	0.1	4.9	0.3
	Average	26-Jun	36.9	3.3	260.9	27.7	354.4	23.8	72.5	23.1	0.2	0.3	0.0	2.7	0.1
		11-Jul	48.6	5.4	329.9	31.8	407.2	78.4	139.8	37.1	0.3	0.5	0.0	2.9	0.3
		24-Jul	52.7	6.8	332.2	34.7	734.5	40.9	211.1	35.6	0.3	0.5	0.1	2.7	0.4
		7-Aug	54.3	7.9	351.8	54.5	638.0	44.5	101.1	25.8	0.5	0.7	0.2	7.3	0.4
		21-Aug	59.1	9.3	394.6	57.0	667.5	50.2	153.5	44.8	0.6	1.1	0.3	6.4	0.4
		7-Oct	52.6	12.6	388.0	76.6	653.9	52.1	243.2	47.8	0.7	0.5	0.2	8.2	0.5
		average	50.7	7.5	342.9	47.0	575.9	48.3	153.5	35.7	0.4	0.6	0.1	5.0	0.4
NetBeat	Petiole	26-Jun	37.1	3.2	255.0	27.4	336.8	22.3	67.9	21.5	0.2	0.3	0.0	2.1	0.1
		11-Jul	49.9	5.4	343.6	33.8	408.8	77.0	136.8	38.7	0.3	0.5	0.1	2.8	0.3
		24-Jul	53.4	7.0	351.6	39.9	741.1	41.7	227.3	37.7	0.4	0.6	0.1	2.9	0.4
		7-Aug	61.7	9.1	417.6	65.8	704.8	49.0	115.1	29.9	0.5	0.7	0.2	8.8	0.5
		21-Aug	66.2	10.3	420.3	65.6	813.9	59.5	156.1	48.0	0.8	1.4	0.2	5.5	0.4
		7-Oct	55.8	13.8	434.7	64.6	570.5	53.6	263.3	53.0	0.8	0.6	0.2	6.0	0.6
		average	54.0	8.1	370.4	49.5	596.0	50.5	161.1	38.1	0.5	0.7	0.1	4.7	0.4
	Netafim	26-Jun	40.1	3.4	281.2	27.1	370.6	24.7	73.4	23.4	0.2	0.4	0.0	2.7	0.1
		11-Jul	50.5	5.3	316.3	33.9	417.0	34.1	117.8	37.0	0.2	0.5	0.0	2.7	0.3
		24-Jul	53.8	6.7	353.0	39.4	651.1	41.5	180.4	32.1	0.3	0.6	0.1	2.9	0.4
		7-Aug	57.7	7.9	388.0	58.0	679.2	45.9	108.5	25.7	0.5	0.6	0.2	8.3	0.4
		21-Aug	67.3	10.5	426.7	69.2	788.2	53.1	151.2	43.5	0.7	1.3	0.2	7.5	0.3
		7-Oct	61.2	14.7	435.3	68.1	626.5	53.7	279.1	52.7	0.7	0.5	0.2	7.7	0.5
		average	55.1	8.1	366.8	49.3	588.8	42.2	151.7	35.8	0.4	0.7	0.1	5.3	0.3
	Average	26-Jun	38.6	3.3	268.1	27.2	353.7	23.5	70.6	22.5	0.2	0.4	0.0	2.4	0.1
		11-Jul	50.2	5.4	330.0	33.9	412.9	55.5	127.3	37.9	0.3	0.5	0.0	2.8	0.3
		24-Jul	53.6	6.8	352.3	39.6	696.1	41.6	203.9	34.9	0.4	0.6	0.1	2.9	0.4
		7-Aug	59.7	8.5	402.8	61.9	692.0	47.5	111.8	27.8	0.5	0.7	0.2	8.6	0.4
		21-Aug	66.8	10.4	423.5	67.4	801.1	56.3	153.6	45.8	0.7	1.4	0.2	6.5	0.4
		7-Oct	58.5	14.2	435.0	66.3	598.5	53.6	271.2	52.9	0.7	0.6	0.2	6.9	0.5
		average	54.6	8.1	368.6	49.4	592.4	46.3	156.4	36.9	0.5	0.7	0.1	5.0	0.4
Average	Petiole	26-Jun	35.8	3.2	240.8	26.9	330.5	22.8	68.4	21.8	0.2	0.3	0.0	2.2	0.1
		11-Jul	49.8	5.6	328.8	34.1	412.7	99.5	150.2	39.4	0.3	0.5	0.1	2.9	0.3
		24-Jul	51.7	6.9	326.2	37.0	730.3	40.5	216.6	38.3	0.4	0.6	0.1	2.7	0.4
		7-Aug	58.0	8.7	372.0	61.8	663.7	48.1	109.4	28.0	0.5	0.7	0.2	8.4	0.5
		21-Aug	62.4	9.9	398.6	63.4	721.4	54.5	135.6	49.4	0.8	1.4	0.2	5.8	0.4
		7-Oct	54.2	13.5	402.0	72.4	609.5	53.6	258.4	51.3	0.7	0.6	0.2	7.5	0.5
		average	52.0	8.0	344.7	49.3	578.0	53.2	156.4	38.0	0.5	0.7	0.1	4.9	0.4
	Netafim	26-Jun	39.8	3.4	288.2	28.0	377.6	24.5	74.8	23.8	0.2	0.4	0.0	2.9	0.1
		11-Jul	49.0	5.2	331.1	31.6	407.4	34.4	116.9	35.6	0.2	0.4	0.0	2.8	0.3
		24-Jul	54.7	6.7	358.3	37.4	700.2	42.1	198.3	32.3	0.3	0.6	0.1	2.8	0.4
		7-Aug	56.0	7.6	382.6	54.6	666.4	43.9	103.5	25.6	0.5	0.6	0.2	7.5	0.4
		21-Aug	63.5	9.8	419.5	61.0	747.1	52.0	171.5	41.1	0.6	1.1	0.2	7.1	0.4
		7-Oct	56.9	13.4	421.0	70.5	642.9	52.1	256.0	49.4	0.7	0.5	0.2	7.6	0.5
		average	53.3	7.7	366.8	47.2	590.3	41.5	153.5	34.6	0.4	0.6	0.1	5.1	0.3
Average		26-Jun	37.8	3.3	264.5	27.5	354.1	23.7	71.6	22.8	0.2	0.3	0.0	2.6	0.1
		11-Jul	49.4	5.4	330.0	32.8	410.1	67.0	133.6	37.5	0.3	0.5	0.0	2.9	0.3
		24-Jul	53.2	6.8	342.2	37.2	715.3	41.3	207.5	35.3	0.4	0.6	0.1	2.8	0.4
		7-Aug	57.0	8.2	377.3	58.2	665.0	46.0	106.5	26.8	0.5	0.7	0.2	7.9	0.4
		21-Aug	63.0	9.9	409.0	62.2	734.3	53.3	153.6	45.3	0.7	1.3	0.2	6.4	0.4
		7-Oct	55.6	13.4	411.5	71.5	626.2	52.9	257.2	50.3	0.7	0.6	0.2	7.6	0.5
LSD (0.05) Fertigation			NS	NS	NS	NS	NS	NS	NS	NS	NS	0.1	NS	NS	NS
LSD (0.05) Date			4.8	1.1	34.4	6.3	105.9	11.7	24.4	10.1	0.1	0.1	0.0	0.9	0.1
LSD (0.05) Irrigation X Fertigation			NS	NS	20.9	NS	NS	NS	NS	NS	0.02	NS	NS	NS	NS
LSD (0.05) Irrigation X Fertigation X Date			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 15. Water use efficiency, nitrogen use efficiency, and potassium use efficiency for four treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

			Fertilizer efficiencies for in-season fertilizer		Fertilizer efficiencies for total fertilizer applied[a]	
Irrigation scheduling	Fertigation	Water use efficiency	N use efficiency	K use efficiency	N use efficiency	K use efficiency
		cwt total yield/inch of water applied	cwt total yield/lb N applied	cwt total yield/lb K applied	cwt total yield/lb N applied	cwt total yield/lb K applied
SWT	Petiole	26.9	8.8	11.1	3.7	3.4
	Netafim	26.2	4.8	3.2	2.7	1.9
	Average	26.6	6.8	7.1	3.2	2.6
NetBeat	Petiole	23.3	9.1	8.1	3.8	3.1
	Netafim	21.9	4.9	3.3	2.7	1.9
	Average	22.6	7.0	5.7	3.3	2.5
Average	Petiole	25.1	9.0	9.6	3.8	3.2
	Netafim	24.1	4.9	3.3	2.7	1.9
	Average	24.6	6.9	6.4	3.2	2.6
LSD (0.05)						
Irrigation scheduling	NS	2.3*	NS	1.0	NS	NS
Fertigation	NS	NS	1.0	1.0	0.4	0.4
Irrigation X Fertigation	NS	NS	NS	1.3	NS	NS

[a]includes fertilizer applied in the fall of 2018, preplant in 2019, and nutrients from the irrigation water.
*LSD (0.10)

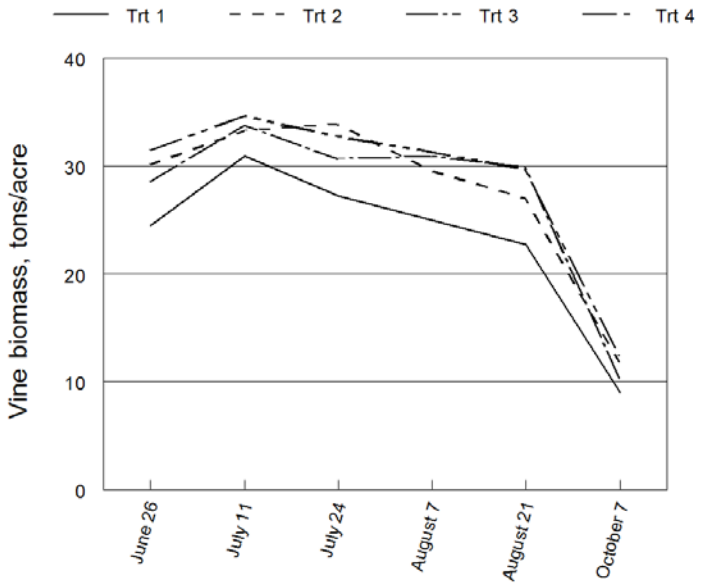

Figure 7. Vine biomass over time for four treatments. Trt 1: SWT irrigation, petiole fertigation; Trt 2: SWT irrigation, Netafim fertigation; Trt 3: NetBeat irrigation, petiole fertigation; Trt 4: NetBeat irrigation, Netafim fertigation. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

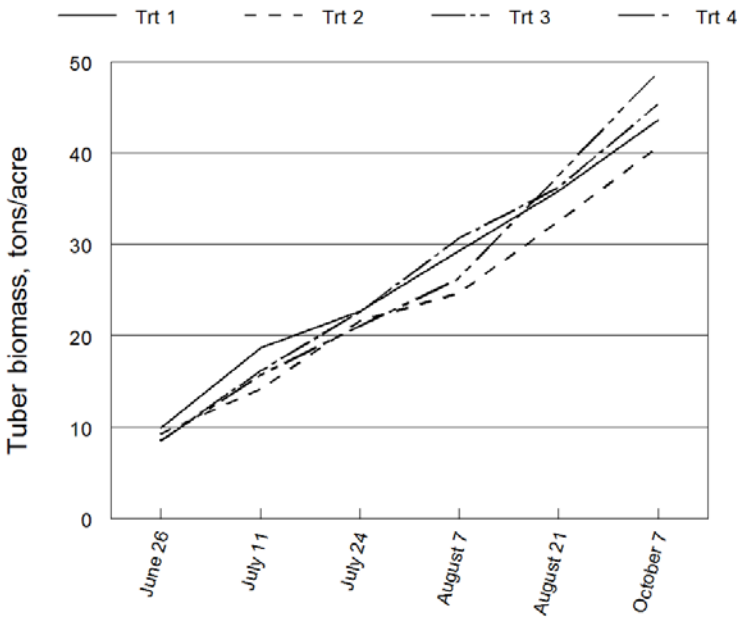

Figure 8. Tuber biomass over time for four treatments. Trt 1: SWT irrigation, petiole fertigation; Trt 2: SWT irrigation, Netafim fertigation; Trt 3: NetBeat irrigation, petiole fertigation; Trt 4: NetBeat irrigation, Netafim fertigation. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

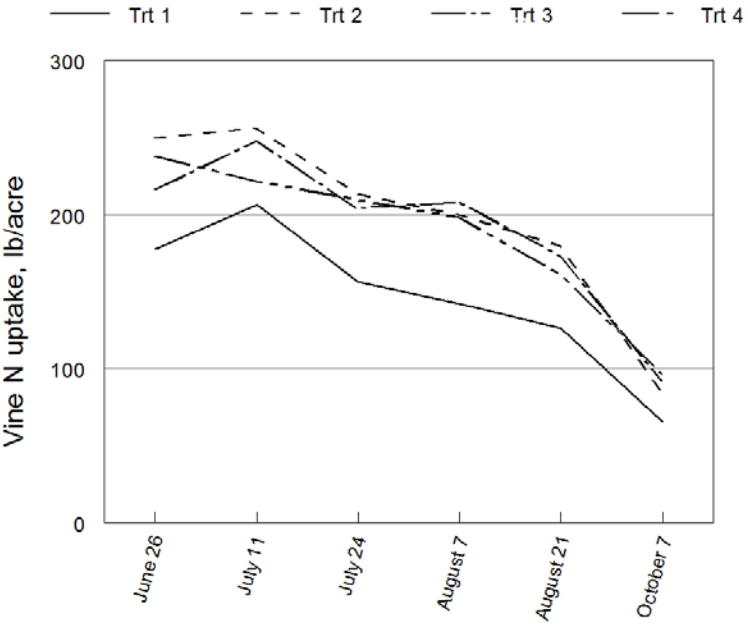

Figure 9. Vine N uptake over time for four treatments. Trt 1: SWT irrigation, petiole fertigation; Trt 2: SWT irrigation, Netafim fertigation; Trt 3: NetBeat irrigation, petiole fertigation; Trt 4: NetBeat irrigation, Netafim fertigation. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

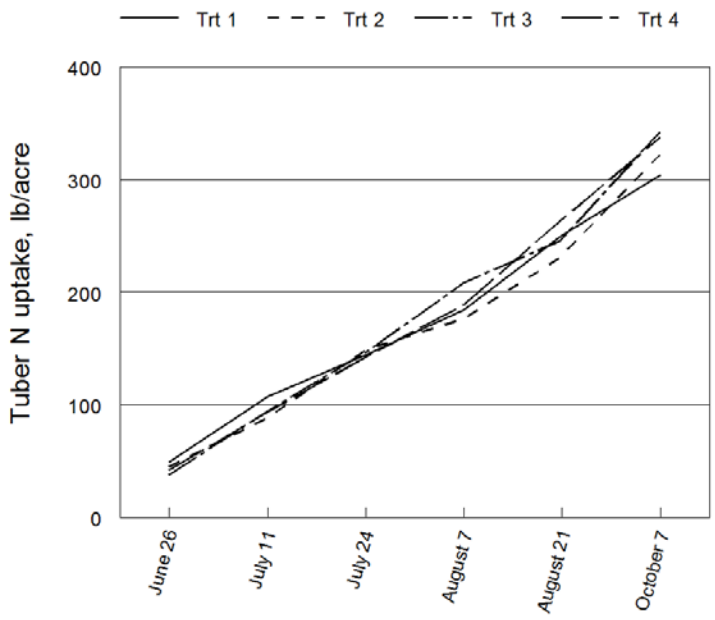

Figure 10. Tuber nitrogen uptake over time for four treatments. Trt 1: SWT irrigation, petiole fertigation; Trt 2: SWT irrigation, Netafim fertigation; Trt 3: NetBeat irrigation, petiole fertigation; Trt 4: NetBeat irrigation, Netafim fertigation. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

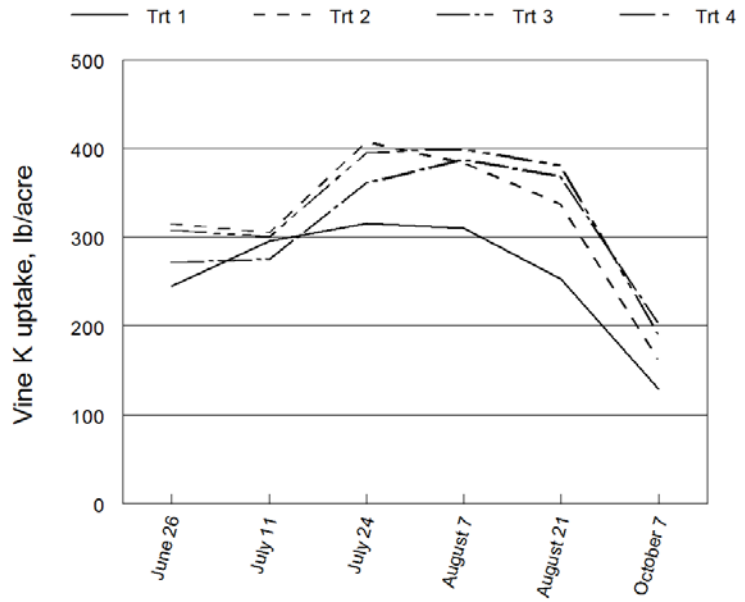

Figure 11. Vine potassium uptake over time for four treatments. Trt 1: SWT irrigation, petiole fertigation; Trt 2: SWT irrigation, Netafim fertigation; Trt 3: NetBeat irrigation, petiole fertigation; Trt 4: NetBeat irrigation, Netafim fertigation. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

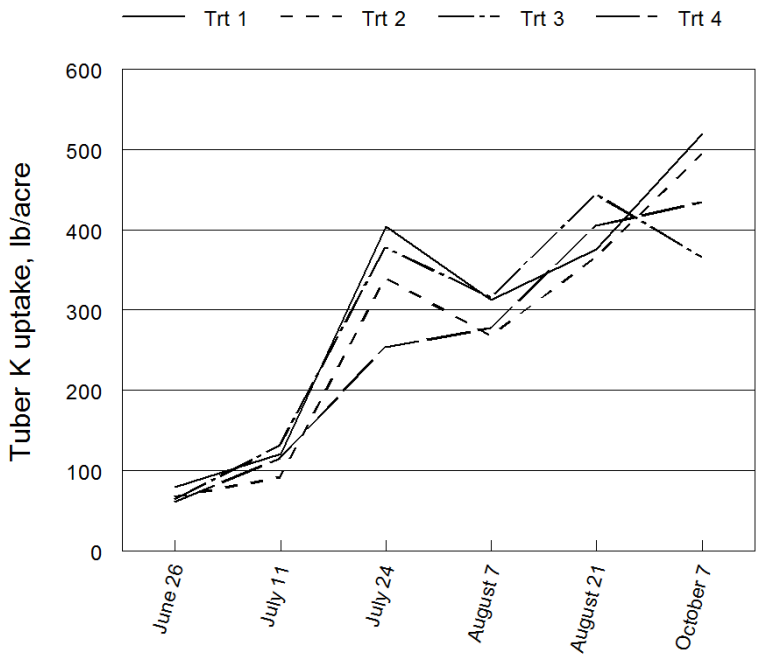

Figure 12. Tuber potassium uptake over time for four treatments. Trt 1: SWT irrigation, petiole fertigation; Trt 2: SWT irrigation, Netafim fertigation; Trt 3: NetBeat irrigation, petiole fertigation; Trt 4: NetBeat irrigation, Netafim fertigation. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

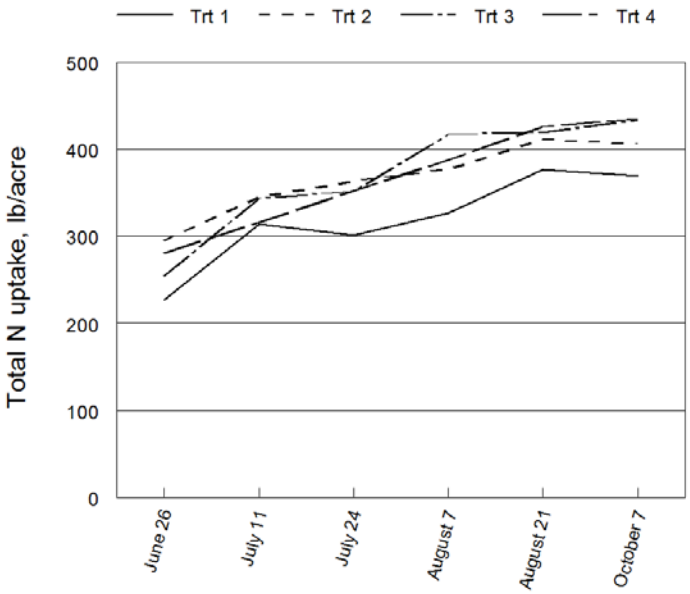

Figure 13. Total nitrogen uptake over time for four treatments. Trt 1: SWT irrigation, petiole fertigation; Trt 2: SWT irrigation, Netafim fertigation; Trt 3: NetBeat irrigation, petiole fertigation; Trt 4: NetBeat irrigation, Netafim fertigation. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

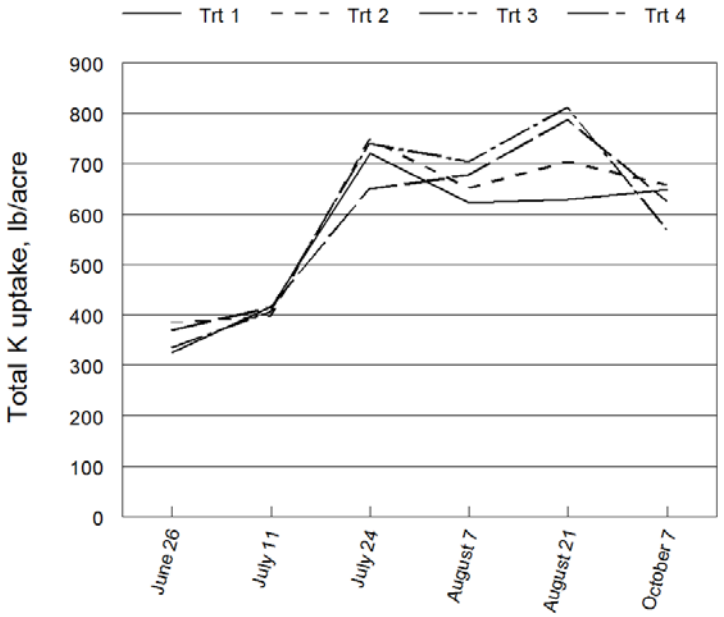

Figure 14. Total potassium uptake over time for four treatments. Trt 1: SWT irrigation, petiole fertigation; Trt 2: SWT irrigation, Netafim fertigation; Trt 3: NetBeat irrigation, petiole fertigation; Trt 4: NetBeat irrigation, Netafim fertigation. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

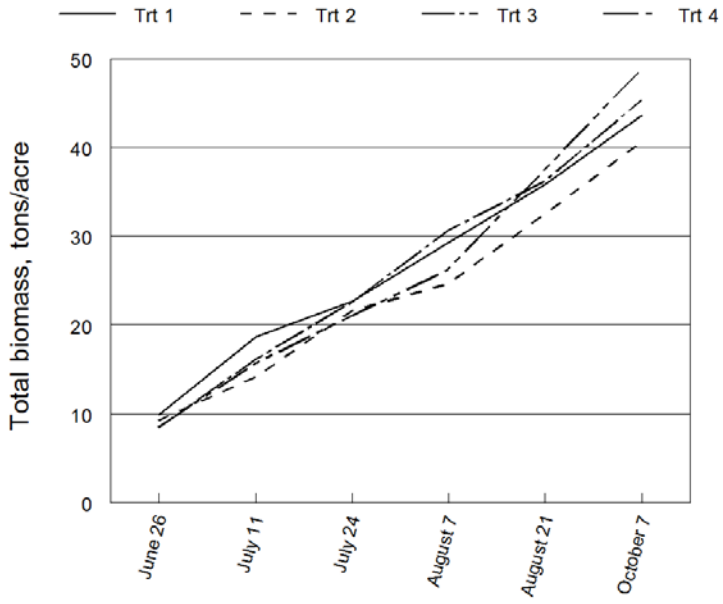

Figure 15. Total biomass over time for four treatments. Trt 1: SWT irrigation, petiole fertigation; Trt 2: SWT irrigation, Netafim fertigation; Trt 3: NetBeat irrigation, petiole fertigation; Trt 4: NetBeat irrigation, Netafim fertigation. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.