IRRIGATION CRITERIA FOR CORN LILY (*VERATRUM CALIFORNICUM*) PRODUCTION

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Introduction

Corn lily (*Veratrum californicum)* is of interest because it has the potential to provide pharmaceutical precursors for use in the treatment of cancer. The working hypothesis for this work is that corn lily is exceedingly sensitive to both water stress and water -logging stress, so it occupies a very narrow ecological niche of wet soil characterized by little variation in soil water tension (SWT) in the wet range. A corollary of this hypothesis is that successful production will be possible by mimicking these SWT conditions by very carefully controlled drip irrigation. Analysis of soil moisture data collected in 2009 from corn lily plants in the wild suggested the need for wet soil conditions in the range of 10 to 30 cb. Similar results have recently been found for corn lily from four monitored sites in 2010 (Shock, 2011).

Materials and Methods

Establishment (Ontario and McCall)

Rhizomes of corn lily were collected in early October, 2009 from two locations: Manti- La Sal National Forest in Utah and the Sawtooth Mountains, Idaho. The rhizomes were placed in a cooler set at 34°F and approximately 80 percent relative humidity until planting. On October 20, the rhizomes from each location were sorted subjectively into 3 size categories (small, medium, and large). Seven rhizomes for each row of each plot were counted, weighed, and dusted with dry Captan (5 percent Captan). The rhizomes were planted 19 inches (0.5 m) apart on 30-inch (0.76 m) beds immediately after treatment. The rhizomes were planted with the growth bud oriented up 3 inches (8 cm) below the soil surface. Each plot consisted of four beds with seven rhizomes per bed. In each plot the two beds on the south side contained the Utah selections and the two beds on north contained the Idaho selections. The outside rows in each plot were planted with the medium rhizomes and the inside rows were planted with the large rhizomes. As designed, there were no significant differences between the weights of rhizomes planted between treatments at either site (Table 1, McCall data not shown). At both Ontario and McCall, the Utah rhizomes weighed more than the Idaho rhizomes.

The experimental designs were randomized complete blocks with five irrigation treatments replicated four times. The layout of the planting at Ontario is described in Figure 1. The layout at McCall was similar with a different compass orientation. The two selections are split plots within the main plot. In Ontario, drip tape (T-tape 515-16-340) was installed after planting in each bed at 1-inch depth offset 7 inches from the bed center. All plants at Ontario were irrigated for 24 hours on November 24, 2009, following planting.

In October of 2010, corn lily rhizomes were collected at Manti- La Sal National Forest in Utah. In late October, the rhizomes were divided subjectively into two sizes. Seven medium roots were planted in border rows and seven large roots were planted in center rows of each split plot containing Utah plants at Ontario and McCall. Before planting, the roots for each split plot were weighed, dipped in liquid rooting hormone (indole-3-butyric acid), and dusted in gypsum. Each rhizome received another 50 g of gypsum in the planting hole.

Ontario Procedures

The trial was installed in a field of Owyhee silt loam (30 percent sand, 52.5 percent silt, and 17.5 percent clay) at the Malheur Experiment Station, Ontario, Oregon. Analysis of a soil sample taken on April 28, 2010 showed a pH of 7.9, 1.85 percent organic matter, 21 ppm nitrate-N, 3 ppm ammonium-N, 18 ppm phosphorus (P), 353 ppm potassium (K), 24 ppm sulfate (SO_4), 1,932 ppm calcium (Ca), 432 ppm magnesium (Mg), 99 ppm sodium (Na), 4.1 ppm zinc (Zn), 1.7 ppm copper (Cu), 11 ppm manganese (Mn), 11 ppm iron (Fe), and 1.5 ppm boron (B). Urea-ammonium nitrate was applied through the drip tape at 25 lb N/acre on May 3, 2010, 50 lb N/acre on May 21, and 50 lb N/acre on June 4. Ammonium polyphosphate at 25 lb P_2O_5/acre was applied through the drip tape on May 3. To reduce the soil pH, 5 tons/ acre of elemental sulfur were broadcast in the fall of 2010. Weeds were controlled by manual weeding.

On March 24, 2010, one Watermark soil moisture sensor (Model 200SS, Irrometer Co., Riverside, CA) was installed at 8-inch depth between 2 plants along the plant row in each of the middle 2 rows of each plot. The sensors were read daily and the average of all the sensors in a treatment (10 sensors total) was used as the criterion for irrigation decisions. All plots in a treatment were irrigated when the SWT reached the treatment criterion (Table 1). Irrigations were run manually until June 10.

All sensors were connected to a CR1000 datalogger (Campbell Scientific, Logan, UT) via multiplexers in early June. The datalogger read the sensors every hour and made irrigation decisions every 12 hours. The irrigation decisions for each treatment were based on the average SWT. The irrigations were controlled by the datalogger using a controller (SDM CD16AC controller, Campbell Scientific) connected to solenoid valves in each plot. The automated irrigation system was started on June 10. Automated irrigations were terminated on July 26. On May 22, a wetter irrigation treatment irrigated at 5 cb was added. The Watermark soil moisture sensors for the 5-cb treatment were replaced with tensiometers with pressure transducers.

The water for the drip treatments was supplied by a well that maintained a continuous and constant water pressure of 35 psi. The pressure in the drip lines was maintained at 10 psi by pressure regulators in each plot. The amount of water applied to each treatment was recorded daily at 8:00 a.m. from a water meter installed between the solenoid valve and the drip tape. On June 14, all plants in each plot were measured for height and diameter. Only four treatments are included in the data analysis. The treatment irrigated at 5 cb was converted from an intermediate treatment after the main period of plant growth and did not result in meaningful data for the 2010 season.

McCall Procedures

The trial was installed in a field of loamy sand (85 percent sand, 5 percent silt, and 10 percent clay) at McCall, Idaho. Analysis of a soil sample taken in the fall of 2009, showed a pH of 6.3, 1.63 percent organic matter, 2 ppm nitrate-N, 3 ppm ammonium-N, 17 ppm P, 304 ppm K, 7 ppm SO_4, 846 ppm Ca, 102 ppm Mg, 21 ppm Na, 0.8 ppm Zn, 0.3 ppm Cu, 6 ppm Mn, 57 ppm Fe, and 0.2 ppm B. The soil analyses showed that the soil was deficient in available N, and deficient in Ca, Mg, S, Zn, Cu, and B. On May 20 the field was fertilized with 200 lb/acre of prilled gypsum (23 percent Ca and 18.5 percent S), 100 lb/acre N as urea, 2.4 lb/acre Zn as zinc sulfate, 2.4 lb/acre Cu as copper sulfate, 1.2 lb/acre B, as Granubor II, 20 lb/acre Mg, and 40 lb/acre K as K-Mag, and 75 lb/acre sulfate-S contained in the K-Mag and Zn and Cu sulfates. Weeds were controlled by manual weeding.

The establishment of an irrigation system at McCall required an electrical transformer, a power line to the research site and to the pump site, electrical control for the pump from the research site, installation of a pump, water filtration at the pump site, and piping from the pump to the research plots. The pumping of water and opening of valves to specific treatments was controlled by a data logger. Soil moisture sensors were installed and connected to a datalogger as in Ontario on June 25 and June 30. Drip tape (Toro Aqua Traxx, EA 508 1222-750, 0.13 GPH with emitters spaced 12 inches apart) was installed as in Ontario on June 8.

↑ N

Corn Lily Irrigation Trial Ontario Field B6.

Rows run east to west

Split plot numbers

Each split plot: two 30-inch beds 8 m long. Rhizomes planted 0.5 m apart in each bed of each split plot.
Idaho rhizomes in split plots 1-10, 21-30, Utah rhizomes in split plots 11-20, 31-40.

First 7 rhizomes in each split plot planted November 6, 2009. Next 7 rhizomes in Utah source split plots (11-20, 31-40) planted fall 2010.

1	2	3	4	5	6	7	8	9	10
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
21	22	23	24	25	26	27	28	29	30
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**

Irrigation plot numbers

Each irrigation plot: four 30-inch beds 8 m long. (2 split plots)

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20

Irrigation plots - treatments

5	3	2	4	1	2	5	4	1	3
2	1	4	5	3	4	1	3	2	5

Figure 1. Plot layout details for corn lily (Veratrum californicum) irrigation trial in Ontario, OR, 2010. Malheur Experiment Station, Oregon State University.

Results and Discussion

High amounts of spring rainfall made it impossible to impose different irrigation treatments during the early part of plant growth. At Ontario, by the end of the 2010 season the irrigation treatments had resulted in differences in applied water (Fig. 2). An unusually wet and cool spring kept soil moisture below 20 cb until mid-June (Fig. 3) when the plants had already been growing 80 to 90 days. There were differences in SWT only between the 10 cb and 15 cb treatments. By the end of June the plants were dormant.

Averaged over plant sources, the wettest treatment (10 cb) resulted in the tallest plants (Table 1). (A 5-cb treatment was added mid-season). There were no significant differences in plant diameter between treatments. The wettest treatment resulted in the highest percentage of surviving plants. The Utah plants were taller and had larger diameters than the Idaho plants. At Ontario there was no significant difference between plant sources in response to irrigation.

In McCall, an unusually wet spring delayed the start of operations. Further delays were caused by difficulties in accessing a water supply for the irrigation system. In addition, hail damage to the plants resulted in shattered plants and early dormancy. Irrigation treatments were not applied at McCall in 2010. Soil water tension for the McCall plots remained below 20 cb until early July due to precipitation. By mid-July the plants were dormant.

References

Shock, C.C. 2011. Micro-climatic characteristics of the natural environment supporting and not supporting corn lily (*Veratrum californicum*). Oregon State University, Malheur Experiment Station Annual Report 2010.

Table 1. Corn lily (*Veratrum californicum)* rhizome weight at planting, plant height, diameter, and survival in response to decreasing soil moisture at Ontario on June 14, 2010. Oregon State University, Malheur Experiment Station, Ontario, Oregon.

Selection	Irrigation criterion	Amount of water applied per irrigation	Total water applied plus precipitation	Rhizome weight at planting	Height	Diameter	Survival
	cb	------------ inches ------------		lb/acre	cm	cm	%
Idaho	10	0.15	24.2	3274.0	17.8	1.22	96.4
	15	0.29	14.4	2424.3	16.1	1.22	92.9
	20	0.29	5.5	3443.0	16.5	1.50	96.4
	30	0.29	4.3	2863.4	16.5	1.29	92.9
	average			3001.2	16.7	1.3	94.6
Utah	10	0.15	24.2	6792.2	30.1	1.65	98.2
	15	0.29	14.4	6426.7	23.7	1.50	87.5
	20	0.29	5.5	6694.0	24.1	1.47	85.7
	30	0.29	4.3	6204.7	24.6	1.43	85.7
	average			6529.4	25.7	1.5	89.3
Average	10	0.15	24.2	5033.1	24.0	1.4	97.3
	15	0.29	14.4	4425.5	19.9	1.4	90.2
	20	0.29	5.5	5068.5	20.3	1.5	91.1
	30	0.29	4.3	4534.0	20.6	1.4	89.3
LSD (0.05)	Treatment			NS	2.7*	NS	4.9*
	Selection			1042.9	2.6	0.14	NS
	Trt X Sel.			NS	NS	NS	NS

*LSD (0.10)

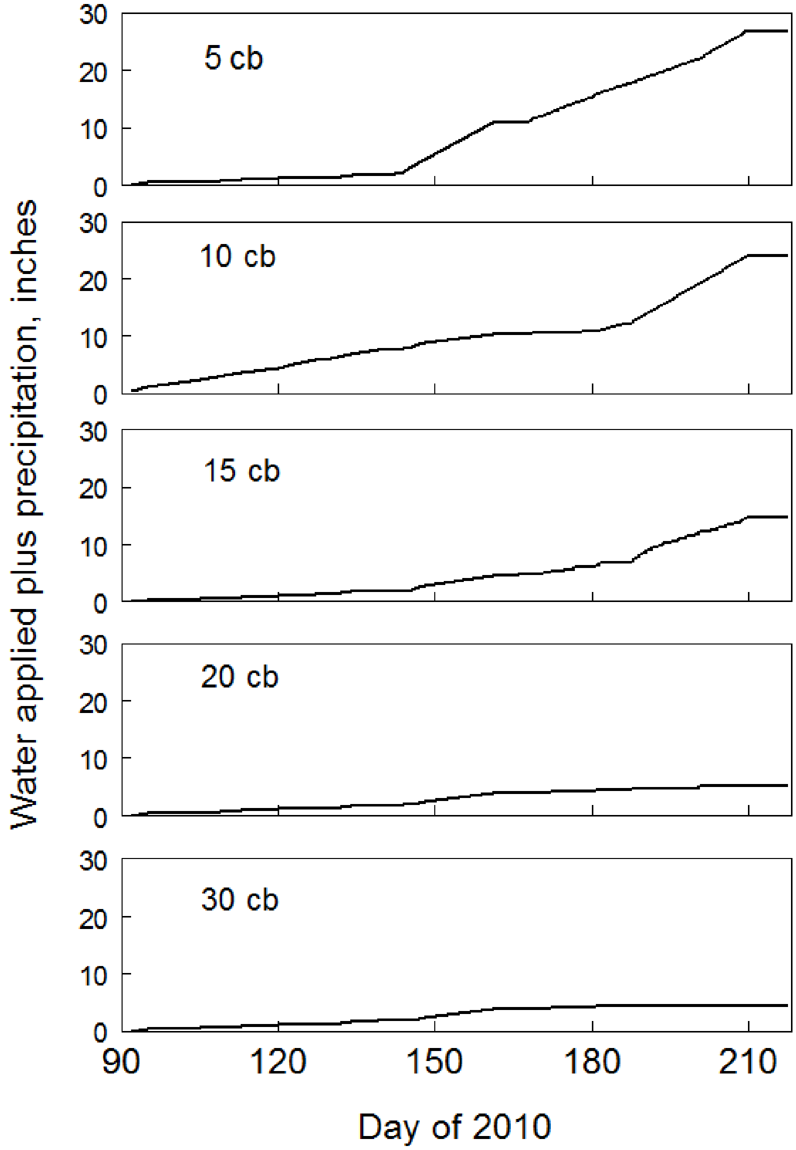

Figure 2. Cumulative water applied plus precipitation for five irrigation treatments applied to corn lily (Veratrum californicum) at Ontario, Oregon, 2010. Oregon State University, Malheur Experiment Station.

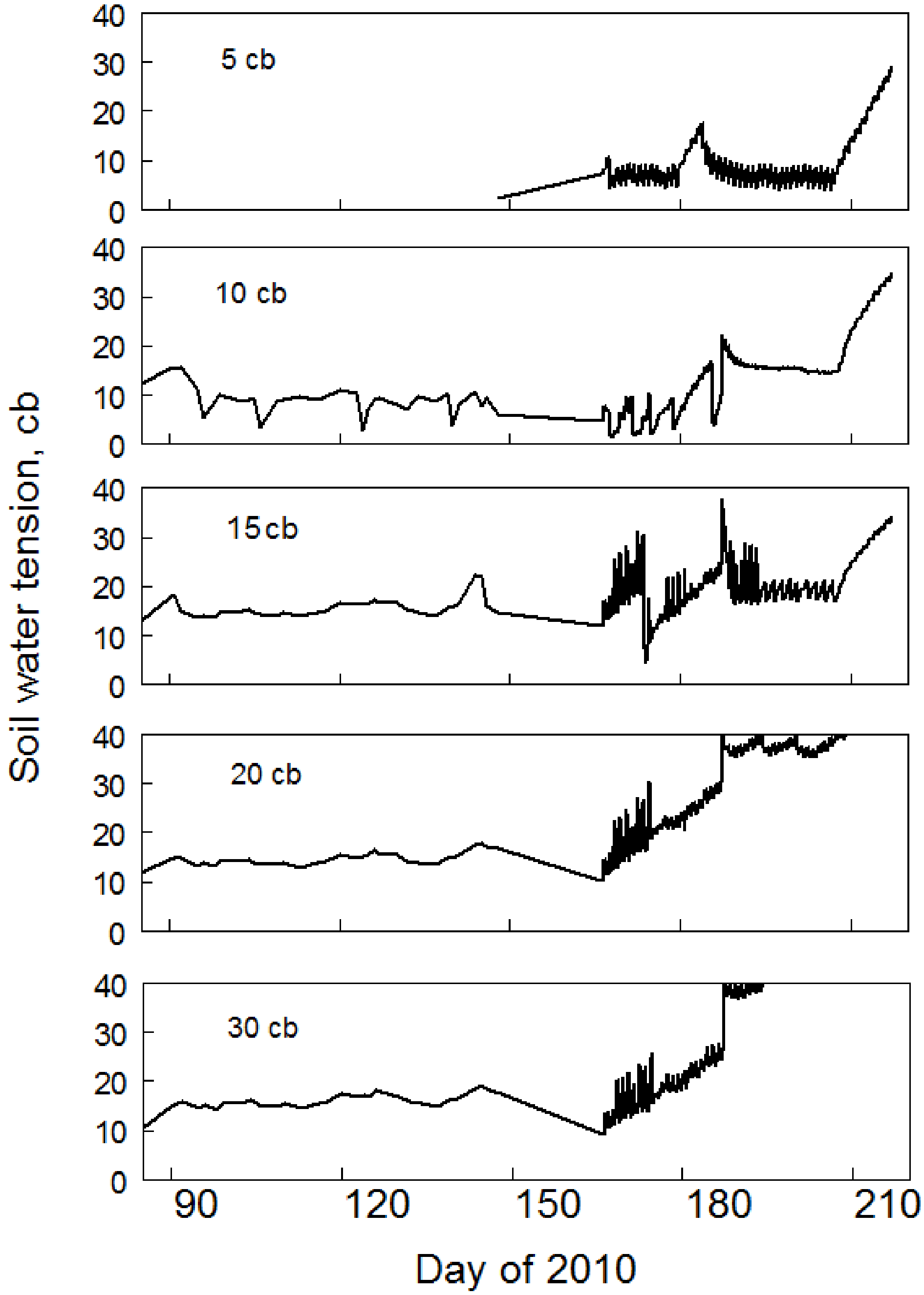

Figure 3. Soil water tension over time at Ontario, Oregon for four irrigation treatments applied to corn lily (Veratrum californicum) in 2010. Oregon State University, Malheur Experiment Station, Ontario, Oregon.