TRANSPLANTING METHODS FOR THE CULTIVATION OF CORN LILY *(VERATRUM CALIFORNICUM)*

Clinton C. Shock, Erik B. G. Feibert, Cheryl Parris, and Lamont D. Saunders, Malheur Experiment Station, Oregon State University, Ontario, OR

Introduction

Corn lily (*Veratrum californicum)* is of interest because it has the potential to provide pharmaceutical precursors for use against cancer. One method of establishing plantings of corn lily could be to transplant rhizomes from the wild to agricultural fields. If corn lily seedlings are grown in a nursery for use in a plantation, they would also need to be transplanted into a production field at some stage in their development. Prior experience over the last half century suggests that dormant corn lily rhizomes do not transplant well. Steve Monsen of Western Ecological Consulting had little success transplanting corn lily into a wide range of Utah locations, including back into the locations where they were dug (personal communication). Failure of past transplanting efforts could be due to stress during the handling of the plants, techniques of transplanting, the nature of the site where they were planted, or other factors. Poor transplant success in the past led us to hypothesize that corn lily rhizomes have low tolerance of desiccation.

Successful field cultivation of corn lily will depend on a better understanding about its transplanting requirements. Does very slight desiccation of corn lily prior to planting affect rhizome growth? To avoid desiccation, the rhizomes might have to be kept cool and moist until planted. Does transplanting introduce or spread disease in the corn lily root systems? Should rhizomes be treated with fungicides prior to planting? Does undue loss of roots prior to planting affect rhizome growth? Potential removal of roots prior to planting could provide a source of raw material for the pharmaceutical industry, but it might also reduce transplant survival and delay plant development.

Our preliminary research has shown that transplanted corn lily plants may be deficient in calcium. Would addition of gypsum to the soil at transplanting eliminate the calcium deficiency? Would treating the roots with rooting hormone stimulate root growth and plant survival? The trial reported here tested seven treatments in 2010-2012 for their effect on corn lily transplanting success and subsequent plant growth.

With sufficient irrigation, McCall, Idaho should be a favorable site for transplanting because corn lily grows naturally in the moist areas there. Transplanting corn lily to Ontario, Oregon should be considered a less favorable site, because it has a lower elevation and hotter climate than the elevation range (2,900-10,000 ft) where corn lily naturally occurs in this region.

Materials and Methods

Corn lily rhizomes for the trial were collected in early October, 2010 from the Manti-La Sal National Forest in Utah. The dormant plants consisting of rhizomes and roots (referred to here collectively as "rhizomes") were dug with about 4 in (10 cm) of roots and placed into wooden boxes and packed with ice for transport to Ontario where they were transferred into a cooler set at 32-34°F (0-1°C) and over 90% relative humidity until planting.

On October 19, 2010 the rhizomes were sorted subjectively into three size categories (small, medium, and large). The rhizome fresh weight for each plot was determined and rhizomes were submitted to one of seven treatments in 2010 before planting (Table 1). Rhizomes for the untreated check treatment received no treatment prior to planting. For the fungicide treatment, Captan (5% Captan) and Ridomil® MZ58 were applied to the rhizomes as dry powder formulations prior to planting. For the modest desiccation treatment, the rhizomes were left in a room heated to 70°F (21°C) for 24 hours prior to planting. For the pruning treatment, the roots of each rhizome were clipped roughly in half prior to planting, and the clipped roots were weighed. The gypsum treatment had the roots dusted with powdered gypsum with an additional 1.75 oz (50 g) of gypsum added to the planting hole. The root stimulant plus gypsum treatment had the roots dipped in a rooting hormone solution, then dusted with gypsum with 0.5 liter of rooting hormone solution and 1.75 oz (50 g) of gypsum added to the planting hole. The rooting hormone solution was prepared by mixing 0.22 cups (52 ml) of rooting hormone (0.0004% indole-3-butyric acid [IBA], Root Stimulator, Ferti-Lome, Bonham, TX) per gal (3.79 l) of water.

The rhizomes were planted 19.7 inches (0.5 m) apart on 30-inch (0.76-m) beds immediately after treatment. The rhizomes were planted with the growth bud pointed up and the roots pointed down with the base of the bud 3 inches (8 cm) below the soil surface. Each plot was 1 bed wide and 10 rhizomes long. The experimental designs at both sites were randomized complete blocks with the treatments replicated five times. Drip tape (Aqua Traxx EA 508 1222) was installed after planting in each bed at 1-inch (2.5 cm) depth and offset 7 inches (17.8 cm) from the bed center. The fields at each site were irrigated automatically to maintain the soil water tension (SWT) in the root zone below 10 cb as described by Shock et al. (2013). Soil water tension was measured with five granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) installed at 8-inch (20-cm) depth in the center of the bed. The GMS had been previously calibrated to SWT (Shock 2003). The GMS were connected to a datalogger via multiplexers (AM 410 multiplexer, Campbell Scientific, Logan, UT). The datalogger read the sensors and recorded the SWT every hour. The datalogger made irrigation decisions every 12 hours based on the average SWT. The irrigations were controlled by the datalogger using a controller (SDM CD16AC controller, Campbell Scientific, Logan, UT) connected to a solenoid valve.

Ontario Procedures

The trials were conducted in a field of Owyhee silt loam (30% sand, 52.5% silt, and 17.5% clay) at Malheur Experiment Station, Ontario, Oregon. On November 3, 2009, 50 lb nitrogen (N)/acre, 100 lb phosphorus (P)/acre, 40 lb sulfate (SO_4)/acre, 4 lb zinc (Zn)/acre, 2 lb manganese (Mn)/acre, and 1 lb boron (B)/acre were broadcast. Analysis of a soil sample taken in April 2010 showed a pH of 7.9, 1.85% organic matter, 18 ppm P, 353 ppm potassium (K), 24 ppm SO_4, 1,932 ppm calcium (Ca), 432 ppm magnesium (Mg), 99 ppm sodium (Na), 4.1 ppm

Zn, 1.7 ppm copper (Cu), 11 ppm Mn, 11 ppm iron (Fe), and 1.5 ppm B. The soils where corn lily naturally grows have much lower pH, averaging 6.3 (Shock and Shock 2012), so 5 tons/acre of elemental sulfur were broadcast on September 30, 2010 to lower the pH. A soil sample taken on October 18, 2010 revealed substantial changes in pH, P, SO_4, Mn, Fe, and B: the results were a pH of 5.3, 2.39% organic matter, 31 ppm P, 283 ppm K, 358 ppm SO_4, 1,982 ppm Ca, 420 ppm Mg, 200 ppm Na, 3.9 ppm Zn, 2.9 ppm Cu, 113 ppm Mn, 67 ppm Fe, and 0.8 ppm B.

The trial was planted on October 20, 2010. On April 13, 2011, 50 lb N/acre as $CaNO_3$ was injected through the drip tape. In addition to the automated irrigation, on August 3, 2011 the trial was furrow irrigated using the furrows between the 30-inch (76.2 cm) beds to wash salt off of the field and leach salt from the root zone. On August 23, 2011 a thin layer of shredded tree bark was spread on the soil surface of all plots. On March 2, 2012, April 30, 2012, and June 7, 2012, Fe at 0.3 lb/acre (iron chelate, Sprint 138, Becker Underwood, Inc., Ames, IA) was injected through the drip tape. On May 7, 2012 and June 4, 2012, Ca as a foliar spray (InCa, Plant Impact, Preston, UK, 1 oz/gal water) was applied to all plots. Immediately after the Ca, Dithane® fungicide was sprayed on all plots.

McCall Procedures

The trial was conducted in a field of loamy sand (85% sand, 5% silt, and 10% clay). Analysis of a soil sample taken in the fall of 2009 showed a pH of 6.3, 1.63% organic matter, 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. On May 20, 2010, 200 lb/acre of gypsum, 100 lb N/acre as urea, 40 lb K/acre as K-Mag, 2.4 lb of Zn/acre as zinc sulfate, 2.4 lb Cu/acre as copper sulfate, and 1.2 lb B/acre were broadcast to correct the soil deficiencies.

The trial was planted on October 27, 2010. On June 21, 2011, 200 lb/acre of gypsum, 100 lb N/acre as urea, 40 lb K/acre as K-Mag, 2.4 lb of Zn/acre as zinc sulfate, 2.4 lb Cu/acre as copper sulfate, and 1.2 lb B/acre were broadcast. On May 1, 2012 2,000 lb gypsum/acre, 10 lb Cu/acre, and 100 lb Mg/acre were broadcast. On May 31, 2012, 20 lb N/acre was injected through the drip tape. On May 9, 2012, May 31, 2012, June 6, 2012, June 13, 2012, and June 28, 2012, Ca as a foliar spray (InCa, Plant Impact, Preston, UK, 1 oz/gal water) was applied to all plots. Immediately after the Ca, Dithane fungicide was sprayed on all plots on the same dates.

Data Collection and Statistics

All plants in each plot at Ontario were measured for height and diameter on June 17, 2011 and June 18, 2012. All corn lily plants in each plot at McCall were measured for height and diameter on June 22, 2011 and June 13, 2012. Treatment differences were compared using analysis of variance. Means separation was determined using Fisher's least significant difference test at the 5% probability level, LSD (0.05).

Results

Modest desiccation of the corn lily rhizomes prior to planting resulted in an average of 19% weight loss prior to planting. Averaged over sites, desiccation of rhizomes prior to planting resulted in among the lowest survivals in 2011.

By 2012, desiccation of rhizomes prior to planting and root pruning resulted in among the lowest rates of plant survival.

Averaged over sites, treatment of rhizomes with root stimulant and gypsum, gypsum only, or treatment of rhizomes with Captan were among the treatments with the highest survival in 2012 (Table 1). Averaged over sites, treatment of rhizomes with root stimulant and gypsum resulted in 81% survival in 2012. Averaged over sites, treatment of rhizomes with root stimulant and gypsum or gypsum only was among the treatments with the tallest plants in 2012.

At both sites and in both years, plant height increased with increasing rhizome weight at planting, but the effect was less pronounced in McCall (Figs. 1-4).

Considering plant size and survival, the treatment with rooting hormone and gypsum appears promising.

Discussion

Although prior trials with transplanting corn lily rhizomes had failed, these trials showed 94.9% success across all treatments (Table 1). We attribute the generalized success to the cold and moist conditions during handling and storage of the rhizomes from digging to transplant. Simply by allowing 24 hours of desiccation prior to planting caused a loss in transplant success, especially at McCall.

Neither the site at Ontario nor McCall was ideal for corn lily growth. At Ontario the climate may have been too hot and the soil was too salty once the pH was corrected. At McCall the plants that survived grew larger in 2012 than they had grown in 2011. The McCall site was not ideal due to summer frost and poor soil. The soil was much less fertile than typical sites where corn lily grows (Shock and Shock 2012) and it was difficult to maintain adequate soil nutrient levels.

The transplant treatment including gypsum and rooting hormone warrants further study and use. Other fungicides not used in this study might be beneficial.

References

Shock, C.C. 2003. Soil water potential measurement by granular matrix sensors. Pages 899-903 i*n* Stewart, B.A. and Howell, T.A. (eds). The Encyclopedia of Water Science. Marcel Dekker.

Shock, C.C., and M.P. Shock. 2012. Soils naturally supporting corn lily (*Veratrum californicum*). Oregon State University Malheur Experiment Station Annual Report 2011, Department of Crop and Soil Science Ext/CrS 141211-218.

Shock, C.C., F.X. Wang, R.J. Flock, E.B.G. Feibert, C.A. Shock, A.B. Pereira, and L.B. Jensen. 2013. Irrigation monitoring using soil water tension. Sustainable Agriculture Techniques, Oregon State University Extension Service. EM 8900 10p. http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/37569/em8900.pdf

Table 1. Corn lily (*Veratrum californicum*) plant height (2.54 cm = 1 in), plant diameter (25.4 mm = 1 in) and survival for rhizomes submitted to seven preplant treatments and planted in the fall of 2010. Corn lily plants were measured June 22, 2011 and June 13, 2012 at McCall, Idaho and June 17, 2011 and June 18, 2012 at Ontario, Oregon, Malheur Experiment Station Oregon State University.

2011	Ontario			McCall			Average		
Treatments	Height	Diam.	Survival	Height	Diam.	Survival	Height	Diam.	Survival
	cm	mm	%	cm	mm	%	cm	mm	%
					2011				
Check	27.2	14.9	92.0	22.3	12.2	94.0	24.8	13.5	93.0
Captan	30.8	14.7	94.0	22.8	12.5	100.0	26.8	13.6	97.0
Captan + Ridomil	26.5	14.2	92.0	19.7	12.7	96.0	23.1	13.5	94.0
Pruning + Captan	25.7	16.3	100.0	22.5	12.6	96.0	24.1	14.5	98.0
Desiccation	21.9	16.0	92.0	15.7	11.9	82.0	18.8	14.0	87.0
Gypsum	26.5	15.0	96.0	23.2	12.3	98.0	24.8	13.7	97.0
Root stimulant + gypsum	32.3	14.0	98.0	24.8	12.8	98.0	28.6	13.4	98.0
Average	27.3	15.0	94.9	21.6	12.4	94.9	24.4	13.7	94.9
LSD (0.05)									
Treatment							3.2	NS	6.9
Site							1.9	0.5	NS
Trt. X Site							NS	NS	NS

2012	Ontario			McCall			Average		
Treatments	Height	Diam.	Survival	Height	Diam.	Survival	Height	Diam.	Survival
	cm	mm	%	cm	mm	%	cm	mm	%
					2012				
Check	28.8	13.0	64.0	35.3	12.8	72.0	32.0	12.9	68.0
Captan	31.8	13.5	62.0	33.3	12.2	82.0	32.5	12.8	72.0
Captan + Ridomil	26.8	10.2	70.0	36.1	13.0	60.0	30.9	11.5	65.6
Pruning + Captan	27.9	12.1	54.0	38.5	13.4	68.0	33.2	12.7	61.0
Desiccation	25.9	10.2	40.0	28.8	10.0	42.0	27.2	10.1	41.0
Gypsum	31.9	12.1	62.0	36.2	11.9	90.0	34.0	12.0	76.0
Root stimulant + gypsum	30.3	11.8	80.0	37.2	12.5	82.0	33.7	12.2	81.0
Average	29.1	11.9	61.7	35.0	12.2	70.9	31.9	12.0	66.4
LSD (0.05)									
Treatment							4.2	1.8	16.3
Site							3.1	NS	NS
Trt. X Site							NS	NS	NS

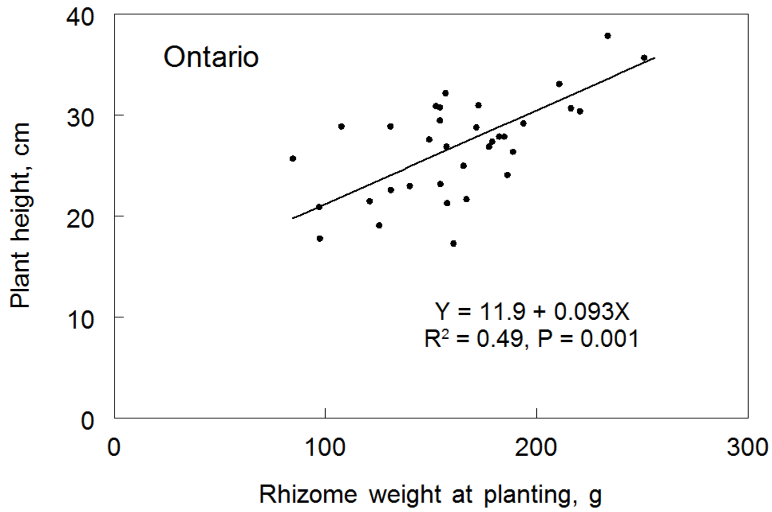

Figure 1. Corn lily (Veratrum californicum) *plant height in 2011 at Ontario, Oregon as influenced by rhizome fresh weight at planting in 2010, Malheur Experiment Station, Oregon State University.*

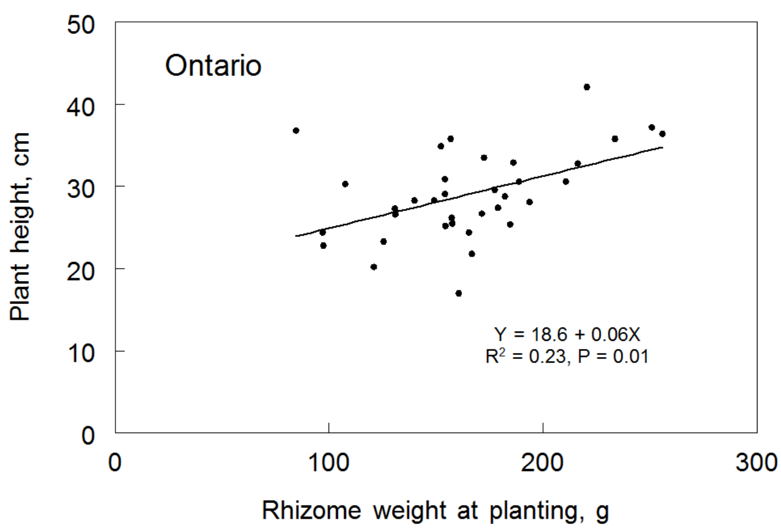

Figure 2. Corn lily (Veratrum californicum) *plant height in 2012 at Ontario, Oregon as influenced by rhizome fresh weight at planting in 2010, Malheur Experiment Station, Oregon State University.*

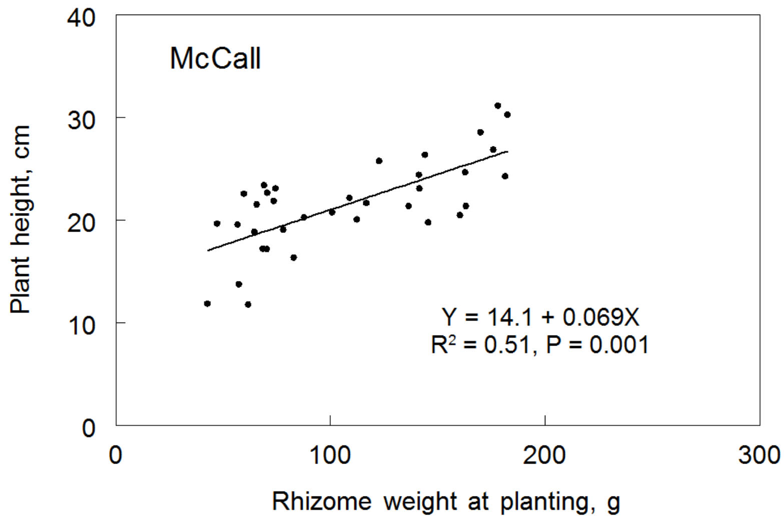

Figure 3. Corn lily (Veratrum californicum) *plant height in 2011 at McCall, Idaho as influenced by rhizome fresh weight at planting in 2010, Malheur Experiment Station, Oregon State University.*

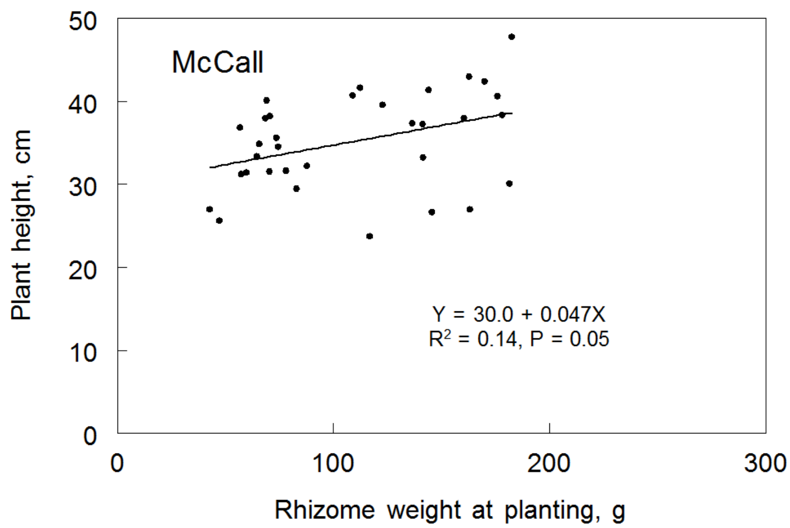

Figure 4. Corn lily (Veratrum californicum) *plant height in 2012 at McCall, Idaho as influenced by rhizome fresh weight at planting in 2010, Malheur Experiment Station, Oregon State University.*