

RESPONSE OF CORN LILY (*VERATRUM CALIFORNICUM*) TO DAY LENGTH

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Introduction

Corn lily (*Veratrum californicum*) is of interest because it has the potential to produce pharmaceutical precursors used in the treatment of cancer. The trial set out to determine if corn lily is sensitive to photo period. The thought was that corn lily is a long-day plant, requiring long days for both vegetative growth and flowering. If plants start growing when the days get long, then there might be differences in vegetative productivity from plants from different latitudes. Would planting a southern latitude cultivar at northern latitudes (longer day length) allow it to stay green longer, producing more growth? This question was investigated by controlling for day length. Alternatively, after winter dormancy, plant growth may be triggered by warm temperatures alone.

Materials and Methods

Corn lily plants from three locations (Table 1) were planted in three treatments with different day lengths. Five plants from each location were included in each treatment. Southern latitude plants were from the coastal mountains of California and northern latitude plants came from the Central Mountains and Sawtooth Mountains in Idaho. Plants collected from these locations were kept dormant in cool (0 to 1°C) and wet conditions until planted for the trial. The rootstock weight of the collected plants was recorded (Table 2). Root weight was considered in assigning individual plants to treatments so that large and small plants from each location were distributed across the day-length treatments.

Table 1. Locations where corn lily (*Veratrum californicum*) plant material was collected.

<i>Veratrum californicum</i> source (collection date)	Latitude N	Elevation
Coastal mountains, CA (April 13, 2010)	33° 20'	1,449 m (4,753 ft)
Central Mountains, ID (May 2, 2010)	44° 49'	1,487 m (4,880 ft)
Sawtooth Mountains, ID (May 15, 2010)	43° 36'	2,105 m (6,907 ft)

The trial started on May 17, 2010, day 1 of the trial. Rootstock was planted in 15-gallon pots in potting mix with the top of the rootstock 10 cm deep. Day-length treatments were 12, 14, and 16 hours. The day length was controlled in growth chambers. The temperature regime for all chambers was the same. A temperature of 25°C (77°F) was maintained for 14 hours and a temperature of 10°C (50°F) was maintained for 10 hours. The onset of daylight coincided with the onset of 25°C at 8:00 a.m. each day.

Tensiometers were installed 15 cm deep in 6 plant pots in each chamber on day 10. Soil water tension was monitored to irrigate the pots before the planting mix dried to -15 kPa in the 3 treatments. Watermark monitors (Irrometer Co., Riverside, CA) were programmed and installed in each chamber on day 10 to record air and soil temperature every hour. Growth of corn lily plants was monitored with measurements of height and stem diameter twice a week, then weekly. Pots in each chamber were moved randomly to new locations within the chamber once a week.

Symptoms of tip burn were noted on Day 18. The tip burn may have been caused by calcium deficiency. Calcium nitrate was applied at a rate of 1g Ca(NO₃)₂ /liter (composition 19 percent Ca, 15.5 percent N [nitrogen]). This was repeated two more times.

Results and Discussion

Corn lily plants grew at a rapid rate in all 3 treatments, exceeding 2 cm/day for the first 10 days, regardless of day length (Fig. 1). The full plant height was reached by day 22 of the trial. Plants in the three treatments grew at the same rate. Plants from the three locations grew to similar heights (Fig. 2).

Extreme high and low temperatures adversely affected the growth of corn lily. Two abrupt changes in the data displayed in Figures 1 and 2 were caused by external factors. Plant height decreased rapidly in the 14-hour day-length treatment after day 55 of the trial (Fig. 1). On day 55 the growth chamber reached 48°C (118°F) due to equipment malfunction. The plants did not tolerate this extreme environment. The spike in plant height for the Central Mountains plants on day 71 is an artifact of the data (Fig. 2). The plants from the Central Mountains had experienced a hard freeze in the field, prior to collection for this experiment, and had experienced a shorter life cycle independent of day length. Plants began dying off on day 43 of the trial and of the 15 original plants, only 3 were left 4 weeks later, day 71. The elevated average height of the Central Mountain plants on this date represents heights from the three remaining healthy plants; the data are not reliable.

If the data from the freeze and overheating are placed aside, the growth observed follows a single pattern. Plants from the California and Sawtooth locations grown with 16-, 14-, and 12-hour day lengths grew to the same size (Fig. 3). Longer day lengths did not produce more vegetative height or prolong the vegetative period. The duration of the vegetative period lasted about 100 days.

Corn lily plant stem diameters peaked slightly at the beginning of the trials, around day 12, coinciding with the plants' rapid growth (Fig. 4). However, the stem diameters subsequently decreased in all of the treatments for the remainder of the trial. The decrease in stem diameter

was more pronounced in plants from the Central Mountains, preceding the general die-off of these individuals (Fig. 5). Data taken from the California and Sawtooth plant material demonstrate a consistent pattern in corn lily stem diameter in all of the day-length treatments (Fig. 6). The slow, steady decrease in corn lily stem diameter was not an expected growth pattern and merits further exploration.

Corn lily plants were weighed before the trial in May 2010 (Table 2). At this time the roots were covered in dirt. The roots were not washed due to fear that the plants would not grow well after additional handling. Consequently the 2010 root weights were not accurate. Corn lily plants were weighed again in April 2011 after overwintering. In April 2011 the dirt on the roots was excessive (up to 6 kg) and would not allow for comparison of the plants. The root systems were washed so no dirt remained and then were weighed. The 2011 weights were lower in all treatments than the weights from 2010 (Fig. 7). This difference may have been wholly or partially due to the dirt on the root systems in 2010. We do not know if the corn lily root systems grew or diminished between 2010 and 2011.

Corn lily plant weights from 2011 were used to compare the plants in the three treatments and three locations. The weights from 2010, while artificially elevated due to dirt, were used as a baseline. Comparisons were based on the 2011 root weights as proportions of the 2010 values. Plants from the 14-hour day-length treatment and from the Central Mountains had proportionally lower root weights in 2011 (Figs. 7 and 8). This was likely due to the plants' exposure to extreme high or low temperatures. If the data from the overheating (14-hour days) and freeze (Central Mountains) are put aside, corn lily plant weight varied by treatment (Fig. 9). The plants from the 16-hour day-length treatment had heavier roots in 2011 than those from the 12-hour day-length treatment. Plants from the 16-hour day-length treatment averaged 63 percent and 76 percent of their 2010 weight, respectively, for Sawtooth and California locations. In the 12-hour day-length treatment the 2011 weight proportions were lower, 50 percent and 55 percent of the 2010 weights, respectively, for Sawtooth and California locations. It is not known if the proportions used in observing this difference were related to actual loss or gain in root mass. The difference between the 16-hour and 12-hour day-length treatments may be significant. A repeat of this trial is merited with roots of the plants washed prior to the initiation of the trial.

Summary

Corn lily (*Veratrum californicum*) plants grew at greater than 2 cm/day during the first 10 days of the trial, regardless of day length. Day length did not contribute to corn lily plant growth. Plants from southern latitudes grown with longer day lengths did not experience greater vegetative growth. Corn lily grew rapidly to its full height. Corn lily stem diameter decreased over the course of the trial. Based on measurements taken in 2011 after the plants had overwintered, corn lily root weights were proportionally greater in the 16-hour day-length treatment than in the 12-hour day-length treatment. This potential difference in root growth in relation to day length merits exploration in a follow-up trial.

Table 2. Root weights of corn lily (*Veratrum californicum*) plants before the trial in May 2010 and from April 2011. The washed root weights in 2011 were less than the unwashed 2010 weights. Due to the dirt, it is not known if the plant weight of healthy plants actually increased or decreased. Plants that died are indicated.

Treatment	Source	Sample	Unwashed root weight 2010 (g)	Washed root weight 2011 (g)	Percent of 2010 weight	Dead plant in 2011
12 - hour day	Sawtooth	1	222	178	80	
12 - hour day	Sawtooth	2	643	188	29	yes
12 - hour day	Sawtooth	8	534	315	59	
12 - hour day	Sawtooth	10	480	241	50	
12 - hour day	Sawtooth	12	675	345	51	
12 - hour day	Central Mountains	16	1012	153	15	
12 - hour day	Central Mountains	18	197	0	0	yes
12 - hour day	Central Mountains	26	524	187	36	yes
12 - hour day	Central Mountains	27	326	110	34	yes
12 - hour day	Central Mountains	29	277	160	58	
12 - hour day	California	33	617	465	75	
12 - hour day	California	36	336	151	45	
12 - hour day	California	39	606	300	50	
12 - hour day	California	42	1128	706	63	
12 - hour day	California	45	1146	502	44	
14 - hour day	Sawtooth	3	824	267	32	
14 - hour day	Sawtooth	5	544	294	54	
14 - hour day	Sawtooth	9	339	171	50	
14 - hour day	Sawtooth	13	536	208	39	
14 - hour day	Sawtooth	15	187	85	45	
14 - hour day	Central Mountains	19	539	0	0	yes
14 - hour day	Central Mountains	22	330	92	28	yes
14 - hour day	Central Mountains	25	290	0	0	yes
14 - hour day	Central Mountains	28	220	0	0	yes
14 - hour day	Central Mountains	30	720	288	40	
14 - hour day	California	32	739	476	64	
14 - hour day	California	35	269	160	59	
14 - hour day	California	38	700	340	49	
14 - hour day	California	40	1110	487	44	
14 - hour day	California	43	1038	290	28	
16 - hour day	Sawtooth	4	1014	611	60	
16 - hour day	Sawtooth	6	233	136	58	
16 - hour day	Sawtooth	7	136	67	49	
16 - hour day	Sawtooth	11	512	354	69	
16 - hour day	Sawtooth	14	581	394	68	
16 - hour day	Central Mountains	17	308	81	26	yes
16 - hour day	Central Mountains	20	357	35	10	yes
16 - hour day	Central Mountains	21	543	97	18	yes
16 - hour day	Central Mountains	23	232	70	30	yes
16 - hour day	Central Mountains	24	655	228	35	yes
16 - hour day	California	31	623	628	101	
16 - hour day	California	34	346	224	65	
16 - hour day	California	37	911	1170	128	
16 - hour day	California	41	969	446	46	
16 - hour day	California	44	991	458	46	

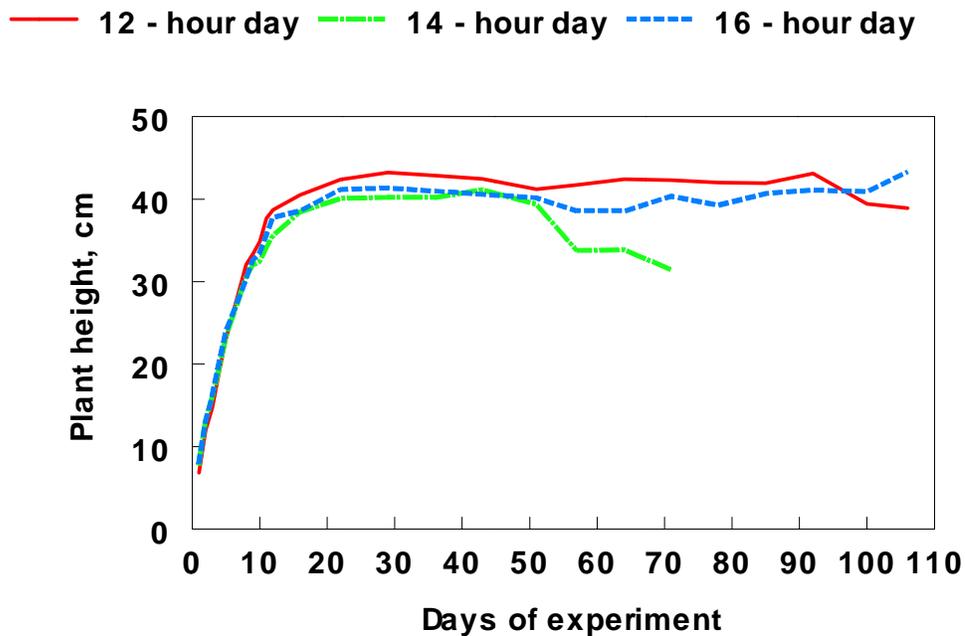


Figure 1. Plant height of corn lily (*Veratrum californicum*) from the three day-length treatments over time. The plants in all day-length treatments grew rapidly to approximately the same height. The decreased plant size in the 14-hour day-length treatment coincided with an equipment malfunction where the growth chamber overheated.

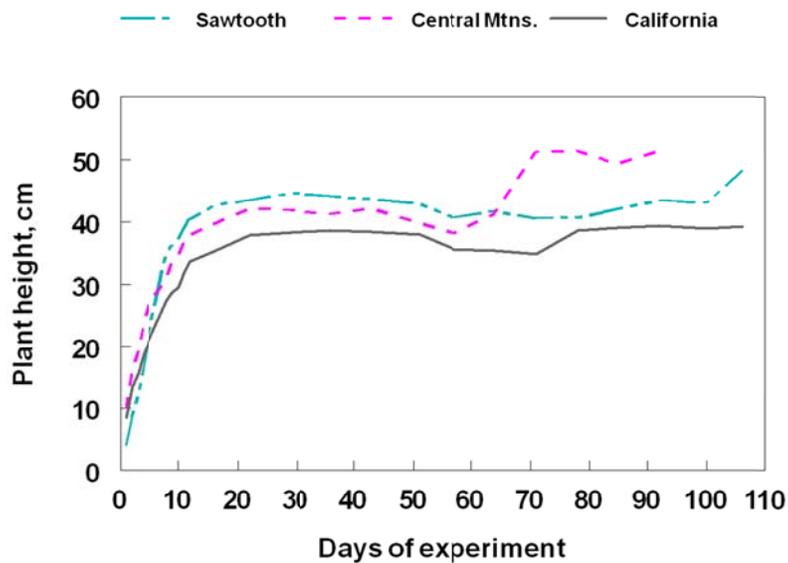


Figure 2. Plant height of corn lily (*Veratrum californicum*) from three geographic locations over time. Plants from all locations had similar growth patterns. The increase in average plant height in the Central Mountains plants was due to the death of all but three healthy plants.

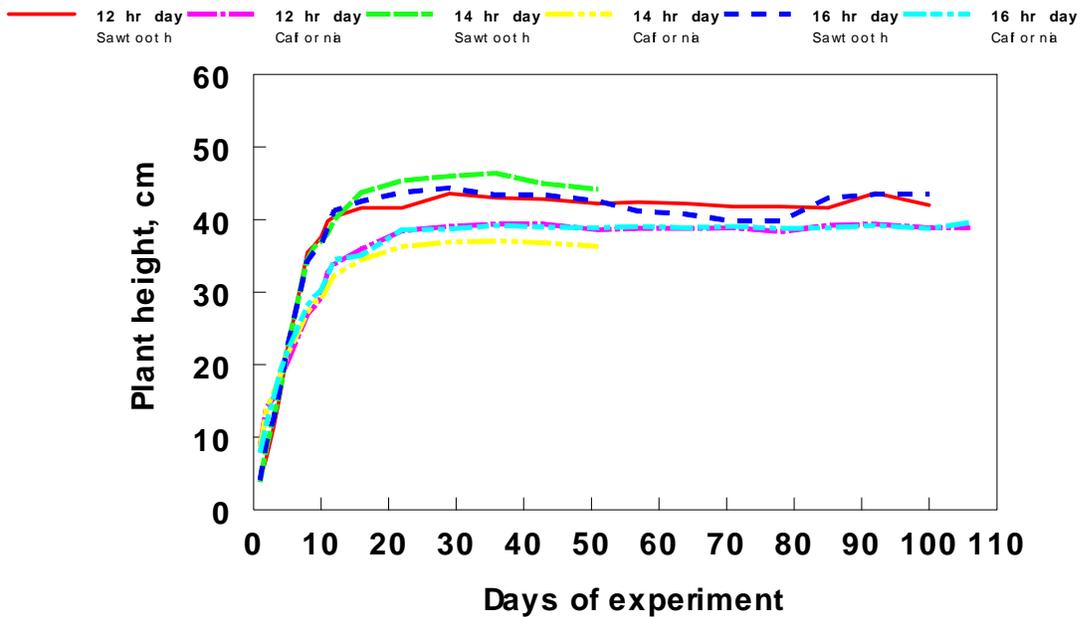


Figure 3. Plant height of corn lily (*Veratrum californicum*) from the three day-length treatments for plant material from California and the Sawtooth Mountains Day length did not appear to be a factor in plant top growth.

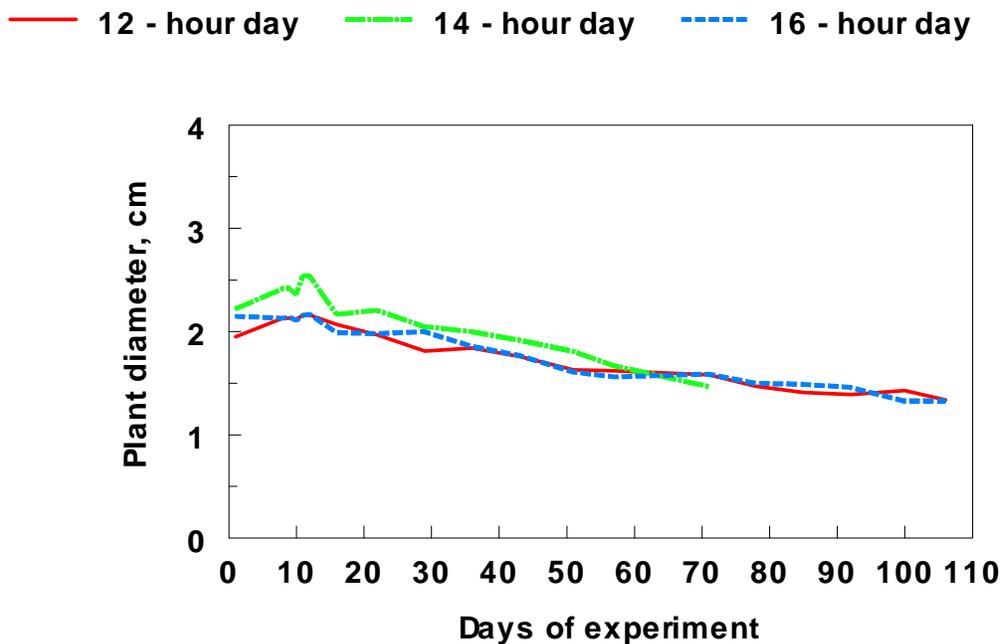


Figure 4. Plant stem diameter of corn lily (*Veratrum californicum*) from the three day-length treatments over time. After an initial increase in stem diameter, the diameters decreased slowly throughout the growing season.

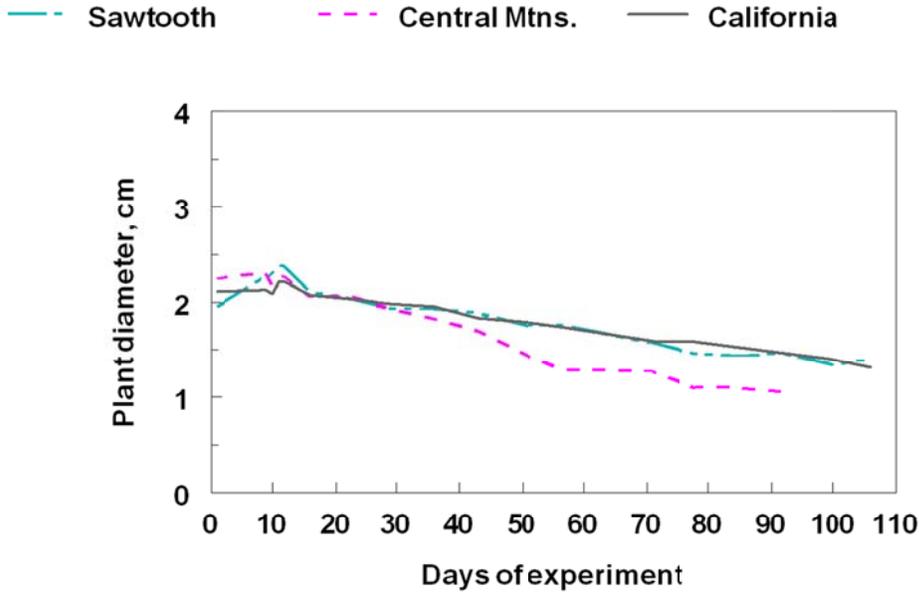


Figure 5. Plant stem diameter of corn lily (*Veratrum californicum*) from three geographic locations over time. Plants from the Central Mountains suffered from earlier die-off due to a hard freeze prior to their collection from the field for inclusion in the study.

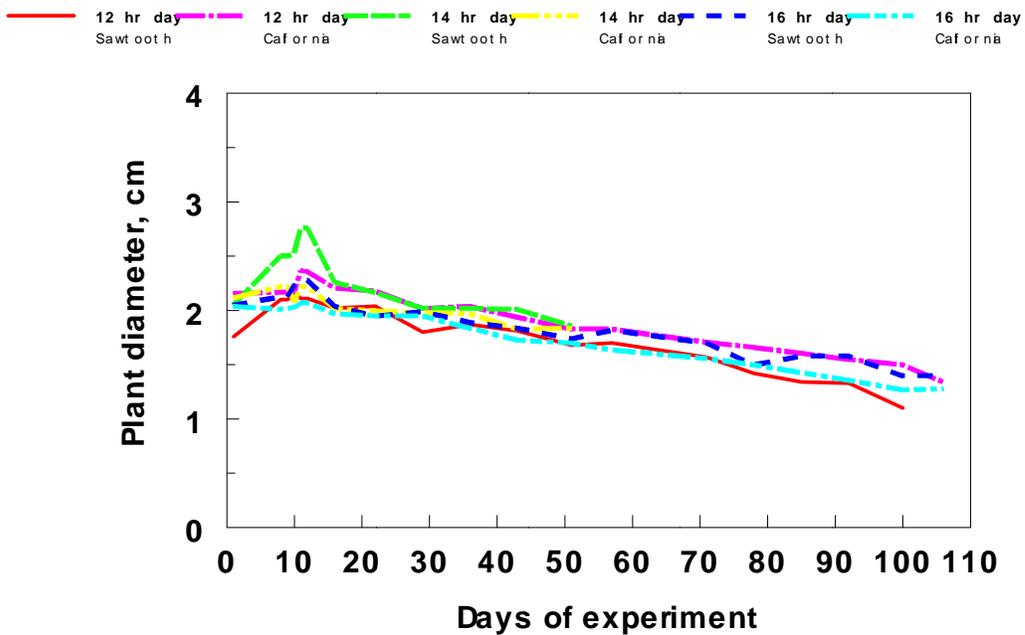


Figure 6. Plant stem diameter of corn lily (*Veratrum californicum*) from the three day-length treatments for plant material from California and the Sawtooth Mountains. day length was not a factor in plant size as measured by stem diameter.

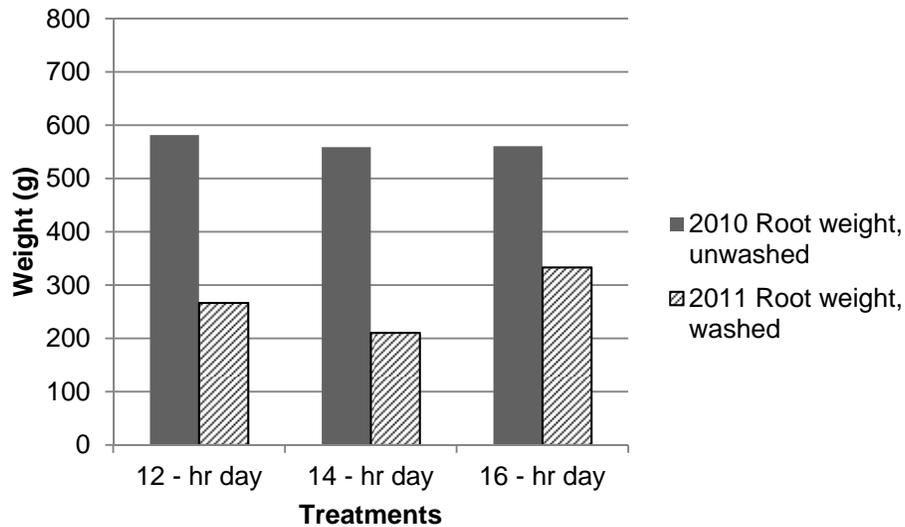


Figure 7. Root weights of corn lily (*Veratrum californicum*) from the three day-length treatments. Weights were higher before the trial in 2010 than afterward in 2011. This difference was due at least in part to comparing weights of unwashed and washed roots. The 14-hour day-length treatment had lower weights in 2011. This was probably due to the plants dying off when the chamber overheated.

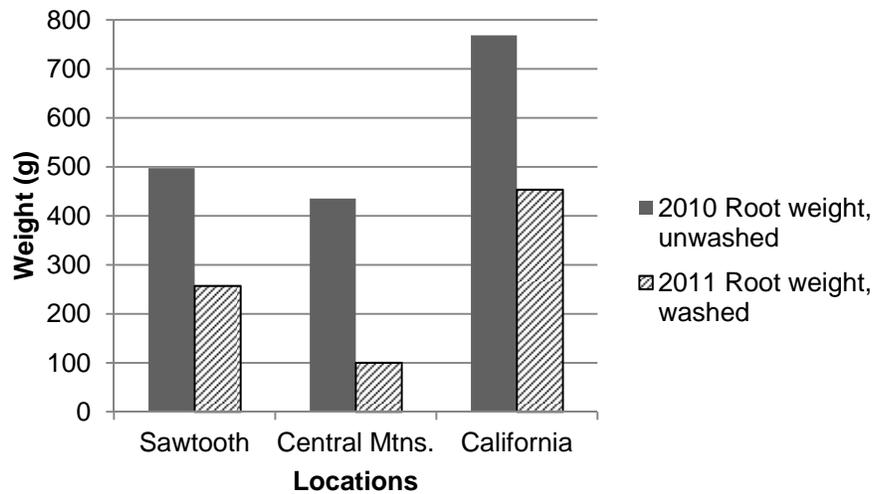


Figure 8. Root weights of corn lily (*Veratrum californicum*) from three geographic locations. Many plants from the Central Mountains died and this was reflected in the 2011 root weights. These plants froze in the field prior to their collection for the trial. The plants from Sawtooth Mountains and California performed similarly to each other. While the plants had different absolute weights they had similar relative weights, respectively 53% and 59% of their 2010 weights. The weight difference between 2010 and 2011 was due to comparing unwashed and washed roots.

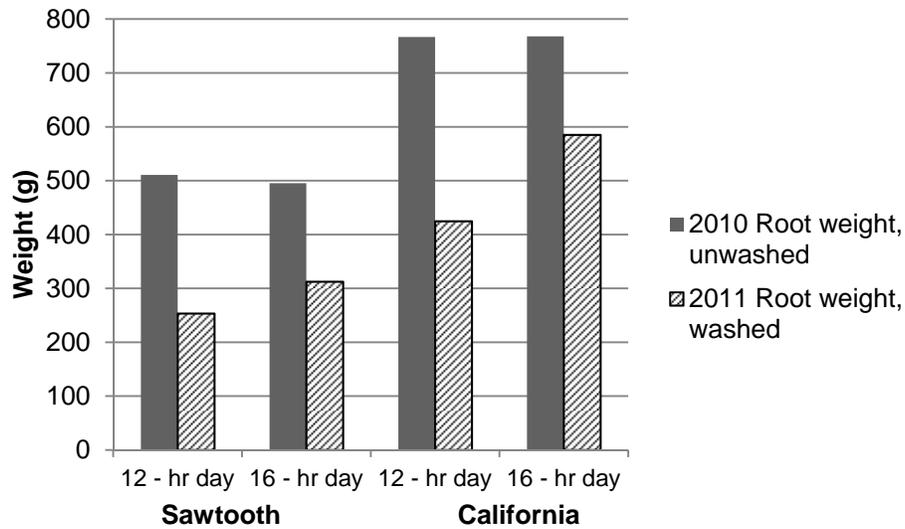


Figure 8. Root weights of corn lily (*Veratrum californicum*) from two of the day-length treatments for plant material from California and the Sawtooth Mountains. The difference in the size of plants from these locations masked the treatment results. The corn lily grown in the 16-hour day-length treatment had retained more of their original root weight in April 2011 than those from the 12-hour day-length treatment. The weight difference observed between 2010 and 2011 was produced artificially by comparing unwashed and washed roots. It is not known if the root weight increased or decreased during the trial.