CULTURAL PRACTICE STUDIES WITH CUT FLOWERS, 2007[a]

H.C. Wien
Department of Horticulture
Cornell University, Ithaca, NY 14853

TABLE OF CONTENTS:

EXECUTIVE SUMMARY:

1. **Snapdragon Topping Studies:** Removing the growing point of snapdragon plants and leaving 7 lower nodes increased stem yields by 26 and 38%, in a spring outdoor field and a fall tunnel trial, respectively. Pinching delayed anthesis in both trials by 18 and 17 days. Of the 5 varieties compared in the trial, pinching increased yields most in the earlier lines, which also showed less reduction in stem length with pinching. The earliest variety Chantilly Orange was significantly more susceptible to heat-induced flower bud inhibition than the others.
2. **Lisianthus Topping Experiments:** Two lisianthus varieties were topped at either node 3 or 6, in field and tunnel trials. As in 2006, pinching increased stem length, and increased yield when 6 nodes were left. Topping at node 3 delayed flowering in both trials and reduced yield in the fall trial. Topping is a useful technique in lisianthus as long as sufficient nodes are left on the plant to allow adequate stem numbers to develop.
3. **Sunflower Topping Trial:** As in previous years, topping of sunflowers resulted in the topped plants producing from 2 to 4 branches that flowered with adequate stem length. By spacing plants farther apart (12 x 12 in. vs. 9 x 9 in.), flowering head size increased to more attractive dimensions. A lower leaf necrosis limited branching and yield of topped plants in Sunrich Orange.
4. **Sunflower Daylength Screening Test:** Sixteen sunflower varieties were screened for their reaction to daylength during the seedling stage. Six showed no reaction in time of flowering or plant size, four showed to be slightly short-day in reaction, and 5 were classed very sensitive,

[a] The excellent technical assistance of Liza White, supervisor, and assistants Martha Gioumousis, Teddy Boucien and Liz Stuprich is gratefully acknowledged. Graduate assistant Joyous Tata conducted the sunflower petal abscission experiment reported here.

with more than 14 days delay in flowering when exposed to long day conditions. Short-day sensitive varieties displayed the formation of axillary buds in the upper leaf nodes when exposed to short days in the seedling stage, a feature which detracts from their appearance.

5. **Sunflower Photoperiod Experiments:** To determine during which weeks in the seedling stage sunflower plants are sensitive to daylength, plants were subjected to short or long photoperiod in week-long durations in various combinations. The most clear-cut result indicated that Sunrich Orange is most sensitive to daylength in week two after emergence, with the daylength in the first and third week adding only small additional effects.
6. **Sunflower Petal Abscission Trial:** Some sunflower varieties readily lose their petals if they are disturbed by brushing. This greatly detracts from their appearance. The current experiment sought an objective way of characterizing this disorder. Most satisfactory proved to be the break strength meter which records the exact force required to pull a petal from the receptacle of a flower. The results show that there are clear differences in susceptibility to petal abscission among varieties, and these results are similar to results of a brushing test carried out in 2006. The most susceptible varieties to petal loss were Moulin Rouge, Strawberry Blonde and Procut Bicolor, while the most resistant proved to be Sunrich Orange and Procut Lemon.
7. **Delphinium Mulching Trial:** To improve plant survival of delphinium in our field plots, we tested methods that would reduce soil temperature. Straw mulch was compared to a silver color plastic mulch, and a black plastic mulch control. Although there were differences among the three varieties, none of the mulching treatments affected the decline in plant numbers, down to an average of 43% stand by Oct. 10.

GENERAL INFORMATION:

The studies described below were conducted at Cornell University, at its East Ithaca research farm, where the soil consists of an Arkport sandy loam soil. The fields in which these experiments have been conducted have received yearly additions of compost. The high tunnel is in its fourth production season. It was obtained from Rimol, Inc., and has dimensions 98 ft. long, 32 ft. wide and 15 ft. high at the gables. It is covered by a single layer of clear polyethylene to which IR blocking compound has been added.

The flowers were grown in beds 40 in. wide, and about 4 in. high, spaced about 6 ft. apart and covered with black polyethylene plastic. These were irrigated by two trickle irrigation lines. Unless otherwise stated, plants in the experiments were grown in 4 rows 9 in. apart, and plants spaced 9 in. apart in the row.

1. SNAPDRAGON TOPPING STUDIES:

When snapdragon is planted at a 9 x 9 in. spacing in field or high tunnel, the plants produce a profusion of basal branches, which are lost if the main stem is harvested with maximum stem length. By topping the plants before they begin to flower, it may be possible to increase the number of stems harvested per plant. The current experiments repeated the trials of 2006, which showed a 41% yield increase with topping. We again tested the effect of topping on cultivars differing in earliness (Flowering Groups I to IV).

Materials and Methods: Five snapdragon varieties were used in the trials: Chantilly Orange (I), Animation Cognac (II), Apollo Cinnamon (II-III), Potomac Early White (III) and Opus Rose (III-IV). Trial 1 was sown in 72-cell trays in the greenhouse on March 18, and transplanted to the field on May 10. Trial 2 was sown in the greenhouse May 21 and transplanted to the high tunnel July 5. Treatments consisted of an untreated control and a soft pinch that left 7 nodes. One layer of plastic netting (Hortanova) was stretched horizontally about 6 in. above the ground to support the plants in both tunnel and outdoor experiments. Plots were arranged in a randomized complete block with factorial treatment arrangement and 3 replications.

Results and Discussion: Removal of the plant apex at node 7 resulted in a 5 and 4% decrease in average stem length in the two experiments, but increased yield (stems per plant) by 26 and 38%, respectively (Table 1). There was a significant interaction between varieties and stem length in both trials (Fig.1). Topping had little influence on length of stems in the early and midseason varieties, but resulted in shorter stems in the late, taller varieties. This interaction was significant at the 5% level in the field, and at the 1% level in the tunnel.

Topping delayed first harvest by 18 and 17 days in the two experiments (Table 1). The varietal differences in stem length, yield and earliness were highly significant in both trials. In general, the flowering group designation, ranging from I to IV, coincided with the degree of earliness. The varieties in Groups I to III were the most productive of the trial, with the later varieties having lower yields in both trials.

In both trials there were periods of time during which a significant percentage of stems produced were unmarketable because only one or two florets had reached anthesis (Fig. 3). Incidence of this disorder varied significantly among varieties, with Chantilly being most susceptible, and Opus the least (Fig. 2). In the tunnel trial, topped plants had a significantly higher incidence of this disorder than controls, and Chantilly was especially affected, leading to a significant topping by variety interaction.

Table 1. Effect of topping five snapdragon varieties in spring and fall plantings on stem length, stems per plant and date of first harvest (days after sowing).

	Spring field trial			Fall tunnel trial		
Treatments	Stem length, cm	Stems per plant	1st harvest date, DAS	Stem length, cm	Stems per plant	1st harvest date, DAS
Control	53	10	91	62	8	67
Topped	50	13	109	60	11	84
Stat. sign.	*	**	***	*	***	***
Chantilly	47	12	90	56	11	72
Animation	50	13	94	58	10	69
Apollo	50	15	94	62	11	74
Potomac	51	8	108	64	7	82
Opus	59	10	113	67	7	80
Stat. sign.	***	***	***	***	***	***

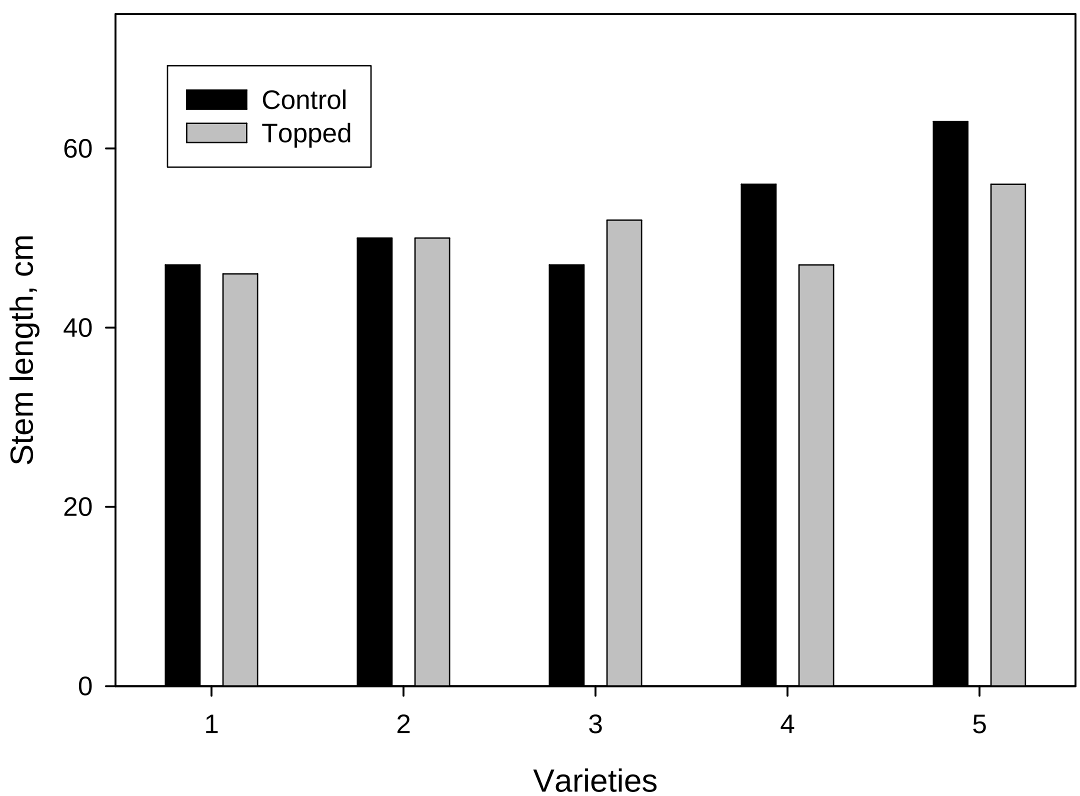


Fig. 1. The influence of topping on stem length of 5 snapdragon varieties differing in earliness. Spring field experiment, 2007. Varieties 1=Chantilly, 2=Animation, 3=Apollo, 4=Potomac, 5=Opus.

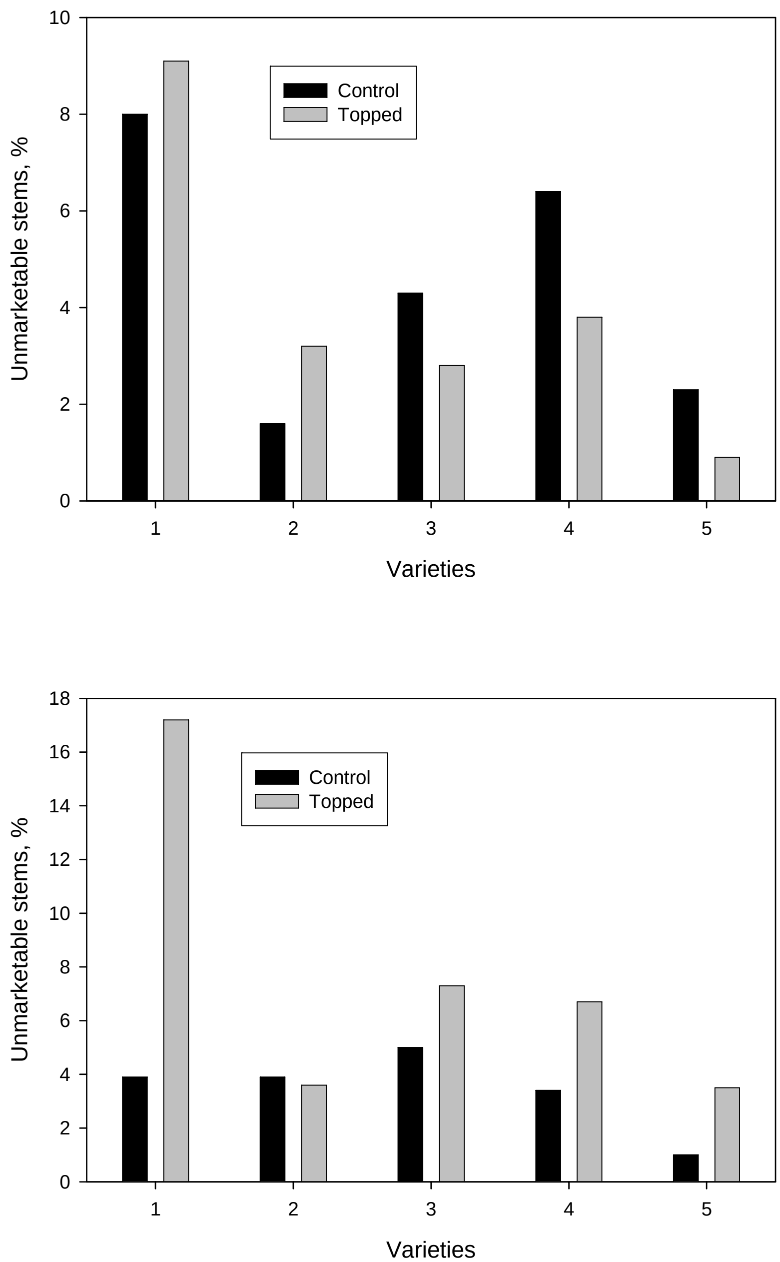


Fig. 2. Influence of variety and growing season on percent unmarketable stems. Top: spring field experiment; bottom: fall tunnel experiment. Variety designations are as in Fig. above.

The results of these trials confirm the findings of our 2006 experiments, that topping increases yields of snapdragon varieties. They also substantiate that varieties of Flowering Groups I to III are more productive than the FG IV lines, although all responded similarly to topping. FG IV lines have another characteristic which makes them less desirable for outdoor and high tunnel production. These lines produce a longer inflorescence than the earlier lines, one on which the basal florets start to open when the inflorescence tip is quite immature. Since these tips tend to wilt when the flower is harvested, we harvest these flowers when the basal florets have already wilted, thus detracting from flower appearance. The earlier varieties have shorter inflorescences, with more mature tips at time of anthesis.

Fig. 3. Incomplete development of flower buds on inflorescence of 'Chantilly Orange' snapdragon in the fall tunnel trial.

The lack of open florets on the flower head of particularly Chantilly (var. 1) is likely a response to abnormally high temperatures in the tunnel and the field. Since var. 1 was selected for production in greenhouses in winter, it was probably never selected to withstand high temperatures, but this disorder is a serious drawback for summer production.

2. LISIANTHUS TOPPING EXPERIMENTS:

The consistently positive response of snapdragon to topping led us to try the technique with lisianthus. In 2006, pinching the main stem at nodes 3 or 5 in a field experiment had no effect on yield, but stimulated stem length by 16%. The current experiments were conducted in both tunnel and open field to test these findings.

Materials and Methods: Two varieties were used in the experiments: Echo Champagne and ABC 2-3 Blue. The seedlings were purchased from Gro-N-Sell (Chalfont, PA) as plugs in 210 cell trays. For the tunnel experiments, seeds were sown in the week of Feb. 19 and 26 for Echo and ABC, respectively. They were transplanted in the tunnel on May 3. The field experiment's plugs were sown in the week of March 19 and 26 for Echo and ABC, respectively, and transplanted June 4. Topping treatments consisted of a soft pinch to leave 3 or 6 nodes, as well as an untreated control. Topping was done on June 1 and 11 for the two treatments, whereas in the field experiment, topping was carried out on July 2.

Results and Discussion: Topping the plants at 3 nodes increased stem length by 15 and 12% in the tunnel and field experiments, respectively (Table 2), but either left yield unchanged (in tunnel), or decreased it by 20%. The relatively late pinch employed in the field experiment delayed first flower date by 19 days, compared to 10 days in the tunnel experiment. Topping at node 6 left stem length unchanged, but boosted stem yields by 46 and 39% for tunnel and field experiment, respectively. Flowering was also not delayed as much as with the short pinch treatment. By reducing the plant to just 3 nodes, only those relatively longer basal branches grew. The upper branches of the lisianthus plants tend to be shorter, and these had a chance to grow out in the pinch at 6 nodes.

ABC Blue is a relatively tall, later cultivar that yielded similarly to Echo Champagne in the tunnel, but was 17% lower yielding in the field (Table 2). The results of these experiments confirm the 2006 findings, that pinching lisianthus can increase stem yields as long as at least 6 nodes are left.

Table 2. Effect of topping of two varieties of lisianthus at node 3 or 6, on stem length, stem yield and earliness. Experiments conducted in the high tunnel and in the field.

Treatment	Stem length, cm		Stems/plant		Date of first flower, DAT	
	Tunnel	Field	Tunnel	Field	Tunnel	Field
Echo Champagne	51	50	6.1	5.9	89	83
ABC Blue	64	58	6.0	4.9	92	87
Stat. sign.	***	***	ns	***	*	**
Control	54a	52a	5.2a	5.1b	86a	76a
Pinch node 3	62b	58b	5.4a	4.1a	95b	95c
Pinch node 6	57ab	54a	7.6b	7.1c	92b	84b
Stat. sign.	**	***	***	***	***	***
Interact. sign.	ns	*	ns	**	ns	**

3. SUNFLOWER TOPPING:

While topping is a common practice for cut flower species that form branches readily, on sunflowers grown for cut flowers, that normally form only a single stem, removing the growing point to force branches to form may not be worth while. In previous experiments, conducted at a 9 x 9 in. spacing on a 4-row bed, we found that topped sunflowers form about 4 branches of adequate stem length, but the flowers tend to be small and less attractive than those on untopped plants. The present experiment was conducted to determine if a wider spacing would allow the topped plants to produce larger flowers on more robust stems.

Materials and Methods: As in previous years, we compared two varieties: Procut Orange and Sunrich Orange. Treatments included two spacings on the bed: 9 x 9 in. with 4 rows per bed, and 12 x 12 in. with 3 rows per bed. Topping treatments were an untopped control and a soft pinch leaving 4 nodes. Experimental design was a split plot, with varieties as main plot and spacing and topping treatment in factorial arrangement as subplots. There were three replications. Seeds were sown on June 1, and transplanted on June 20. Plants were topped on July 2.

Results and Discussion: Topping at node 4 increased yield of stems from 1 to 3.6 per plant, but delayed flowering by 6 days (Table 3). Stem length of branches harvested was reduced by nearly 50%, but this is still an adequate stem length for cut flowers. The 39% reduction in flower diameter could constrain sale to some customers, however. By increasing the spacing from 9 x 9 in. to 12 x 12 in., branch number increased by 14%, and flower diameter by 13% (Table 3). Specifically, the flower diameter of the topped plants increased from 5.4 to 6.2 cm, perhaps sufficient enough to increase marketability.

Table 3. Effect of spacing and topping of sunflowers on stem yield, earliness of flowering, stem length and size of flower in a field experiment on Procut Orange and Sunrich Orange sunflower.

Treatments	Stems/plant	Days to first flower, DAS	Stem length, cm	Flower diameter, cm
Spacing: 9x9	2.1	68	91	7.0
12x12	2.4	66	95	7.9
Stat. sign.	*	*	ns	***
Topping: None	1.0	64	120	9.1
Topped	3.6	70	66	5.8
Stat. sign.	***	***	***	***
9x9, none	1.0	65	123	8.6
9x9, topped	3.3	71	59	5.4
12x12, none	1.0	64	118	9.6
12x12, topped	3.8	69	72	6.2
Interact. sign.	*	ns	**	ns

Procut Orange flowered 9 days earlier than Sunrich Orange in this trial, and was of shorter stature (Table 4). When topped, the former produced significantly more basal branches. This may have been due to a lower incidence of a lower leaf necrosis that severely affected Sunrich Orange in this trial. Since removal of the stem tip deprived it for a time of new leaves, the state of health of the old leaves could have severely affected the production of branches.

Fig. 4. Sunrich Orange topped at node 4, and showing a lower leaf necrosis that was much less prevalent in Procut Orange.

Table 4. The influence of variety and topping, and their interaction, on yield and components in the sunflower topping experiment.

Treatments	Stems/plant	Days to first flower, DAS	Stem length, cm	Flower diameter, cm
Procut Orange	2.6	63	85	7.1
Sunrich Orange	1.9	72	101	7.8
Stat. sign.	*	**	**	ns
Procut control	1.0	61	110	8.8
Procut topped	4.3	65	59	5.4
Sunrich control	1.0	68	130	9.4
Sunrich topped	2.8	75	72	6.2
Interact. sign.	***	ns	ns	ns

When yields are calculated on an area basis, assuming that beds are spaced 6 ft apart, Procut Orange at the closer spacing is nearly 4 times as productive as either variety that has not been topped at that spacing (Table 5). Topped Procut Orange plants grown at the wider spacing were 38% more productive than topped Sunrich Orange plants at the narrow spacing. This indicates that choice of variety and spacing can result in considerable increases in sunflower productivity through the use of topping.

Table 5. Stem numbers harvested per 100 ft. of row, for the two sunflower varieties when grown at two spacings in the bed, and subjected to a topping treatment.

	9 x 9 in. spacing		12 x 12 in. spacing	
Variety	Control	Topped	Control	Topped
Procut Orange	533	2,133	400	1,840
Sunrich Orange	533	1,332	400	1,240

4. SUNFLOWER DAYLENGTH SCREENING TEST:

Many sunflower varieties used as cut flowers are sensitive to daylength. In our 2006 screening trial, 11 varieties out of 25 tested flowered in 53 days when exposed to 12 hours daylength in the first 3 weeks after emergence, compared to 70 days if grown under 16 hour days in the same period. The current trial was conducted to expand the list of varieties tested, and to confirm the results of the previous year.

Materials and Methods: Sixteen sunflower varieties were grown in the same manner as in 2006. Specifically, seeds were sown in 72-cell trays, placed in either a 12 or a 16-hour daylength in a greenhouse at seedling emergence, and transplanted to the field 3 weeks later. Field conditions consisted of 4-row beds with 9 x 9 in. spacing, black plastic mulch and trickle irrigation. The experiment was conducted three times, sowing May 15, June 15 and June 29. There were 24 plants per plot, although in Reps 1 and 2, fewer were available in some varieties due to poor germination.

Results and Discussion: As in 2006, the sunflower varieties showed varied reaction to the daylength manipulation during the first three weeks of growth. Varieties were distributed among the major categories of day-neutral, slightly or strongly short-day in their daylength response, and the plant attributes measured followed the expected patterns (Table 6). Later flowering brought about by daylength reaction allowed more vegetative growth, taller plants and larger flowers.

Table 6. Reaction of 16 varieties of sunflower to daylength treatments applied during the first 3 weeks before transplanting on days to flower, plant height and flower diameter.

Sensitivity type	No. of lines	Days to flower		Plant height, in.		Flower diameter, in.	
		Short daylength	Long	Short	Long	Short	Long
Day neutral	6	62	62	43	44	2.5	2.6
Slightly sensitive SD	4	56	64	35	43	1.9	2.7
Strongly sensitive SD	5	52	70	28	45	1.8	2.9
Slightly sensitive LD	1	70	62	55	46	3.3	2.7

The results of these trials compare well to those conducted in 2006, and confirm the photoperiod reaction of lines tested in both experiments (Table 8).

Table 7. The effect of seedling photoperiod on flowering date, plant height and flower disk diameter for 16 sunflower varieties, arranged in alphabetical order.

	Days to first flower		Plant height, cm		Flower disk dia., cm	
Name	12 h	16 h	12 h	16 h	12 h	16 h
Orange Glory	53	73	70	117	4.2	7.0
Orange King	57	71	107	145	6.4	9.3
Premier Lemon	44	62	34	80	3.2	5.2
Procut Apricot Lite	62	64	106	113	5	5.4
Procut Bicolor	70	62	140	117	4.7	6.6
Procut Early Orange	52	61	84	105	4.7	6.6
Procut Lemon	60	62	101	104	6.1	6.3
Procut Orange	55	62	90	105	4.8	6.8
Procut Peach	63	63	120	120	6.2	6.6
Procut Peach Blush	62	61	121	121	6.3	6.4
Procut Red/Lemon Bicolor	62	62	94	98	7.2	6.9
Procut White Lite	58	69	82	112	4.7	6.5
Procut Yellow	58	65	99	119	5.2	7.7
Procut Yellow Lite	63	62	117	116	6.9	7.9
Sunrich Orange	53	74	77	125	4.7	8
Tosca	51	68	70	111	4.7	7.4

Although at first thought it would seem advantageous to have sunflower varieties flower earlier after planting, the daylength sensitive varieties, when given short days during the seedling period nearly all produced ugly small flower buds in the axles of the upper leaves (Fig. 5). This was true of both the slightly sensitive and strongly sensitive short day varieties, except for Procut White Lite. Procut Bicolor, which is slightly long-day in reaction, did not show axillary bud formation under long day conditions, indicating that this characteristic is not absolutely linked to daylength reaction.

Fig. 5. Sunrich Orange flower after short day treatment for the first 3 weeks during seedling growth. Note prominent axillary bud in an upper leaf node.

Table 8. Classification of 37 sunflower varieties according to their seedling response to daylength, as determined in experiments in 2006 and 2007. Varieties are arranged in alphabetical order in each column.

Day neutral	**Slightly sensitive, short day**	**Strongly sensitive, short day**	**Slightly sensitive, long day**
Florenza	Chianti	Moonbright	Double Quick Orange
Full Sun Improved	Procut Early Orange	Orange Glory	Procut Bicolor
Procut Apricot Lite	Procut Orange	Orange King	
Procut Lemon	Procut White Lite	Premier Lemon	
Procut Peach	Procut Yellow	Premier Light Yellow	
Procut Peach Blush	Valentine	Premier Yellow	
Procut Red/Lemon Bicolor		Solara	
Procut Yellow Lite		Sunbright	
Procut Yellow Lite		Sunbright Supreme	
Ring of Fire		Sunny	
Sonya		Sunrich Gold	
Soraya		Sunrich Orange	
Strawberry Blonde		Sunrich Orange Summer	
The Joker		TH 472	
		Tosca	

5. SUNFLOWER PHOTOPERIOD EXPERIMENTS:

Our variety trials with sunflowers in the past two years, and research by others, have indicated that many sunflower varieties are sensitive to daylength during the first three weeks after emergence. We do not know, however, whether that sensitivity exists over the whole 3 weeks, or occurs only during a particular period during that time. To investigate that question, two experiments were conducted using our photoperiod benches, with grow-out after treatment in the greenhouse or in the high tunnel.

Materials and Methods: In both experiments, the same treatments were compared:

a. 3 weeks short days
b. 2 weeks short followed by 1 week long
c. 1 week short followed by 2 weeks long
d. 1 week long followed by 2 weeks short
e. 2 weeks long followed by 1 week short
f. 3 weeks long

Short days consisted of a 12-hour photoperiod on the daylength-controlled bench, while long days were given with 12 hours of high light plus 4 hours low intensity additional light, to give a 16 hour photoperiod. The greenhouse experiment was sown on March 15, with photoperiod controls started at emergence. In this trial, Premier Light Yellow, Sunrich Orange and Procut Lemon were compared. Plants were started in cell packs, and transplanted to 9 in. pots after the daylength treatments. Plants were grown until flowering in a greenhouse with supplemental metal halide lamps and temperatures of 80 F day and 70 F night. The second experiment had the same treatments, was sown April 6 and transplanted to the tunnel on May 3 at standard 9 x 9 in. spacing. Only Sunrich Orange and Procut Lemon were grown in this experiment.

Results and Discussion: In both experiments, Procut Lemon showed no significant difference in plant height, flower diameter, leaf number on the main stem, nor days to first flower as a result of the photoperiod treatments applied. The results of that variety will therefore not be shown. This was expected, since this variety is daylength-neutral in flowering.

Premier Light Yellow and Sunrich Orange reacted strongly to the treatments, with a typical facultative short-day response. In the greenhouse trial, plants of both varieties flowered after about 15 leaves had formed on the main stem under 3 weeks of short days (SSS), compared to 23 and 28 for Premier Light Yellow and Sunrich Orange, respectively (Fig. 6). Intermediate durations and timings of short days produced a moderate increase in leaf number, with the full effect only occurring when all three weeks were composed of long days.

In the experiment that was transplanted to the tunnel, the effect was more clear-cut. In this trial, the daylength of the second week after emergence was most decisive (Fig.).

PHOTOPERIOD GREENHOUSE EXPT. 2007

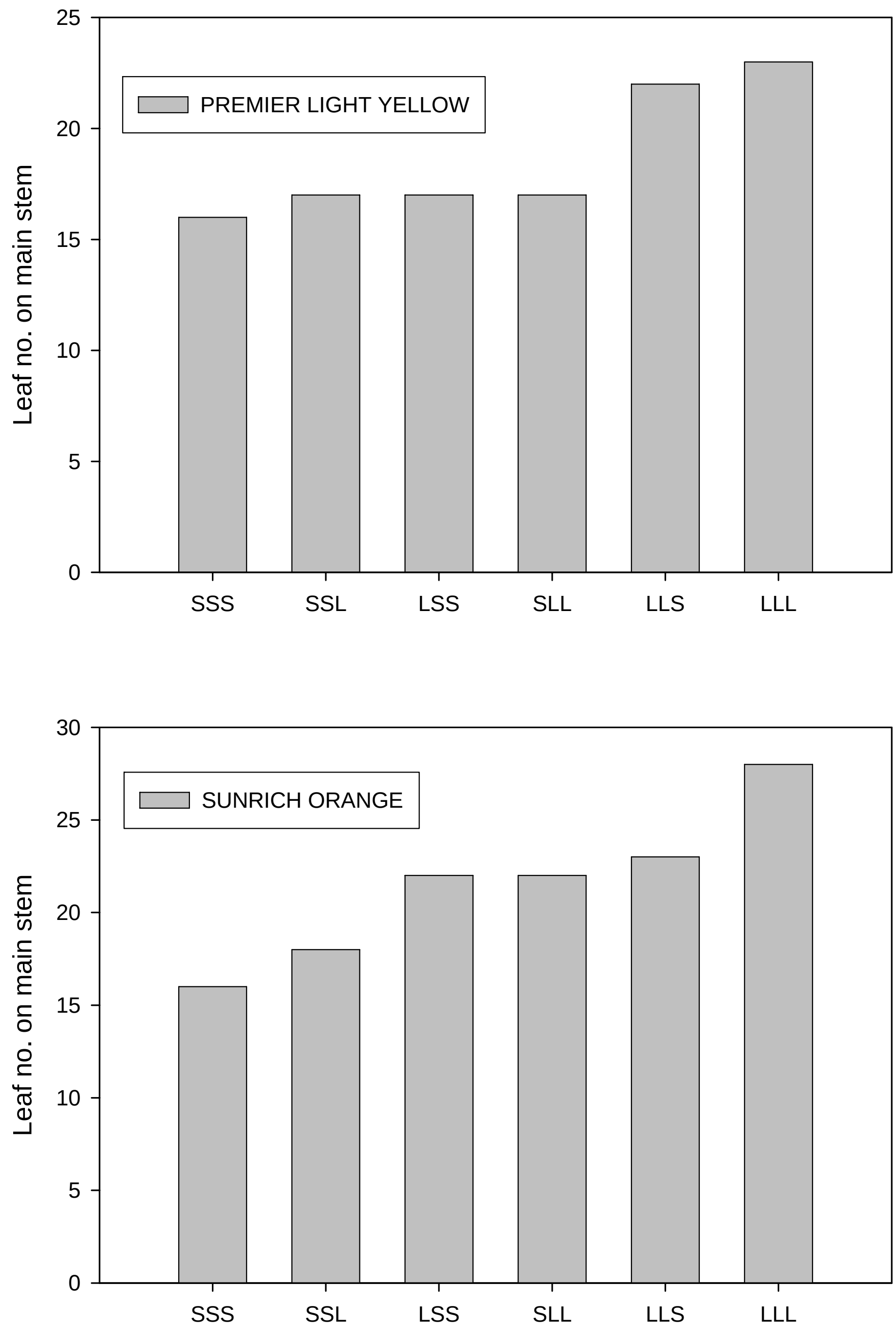
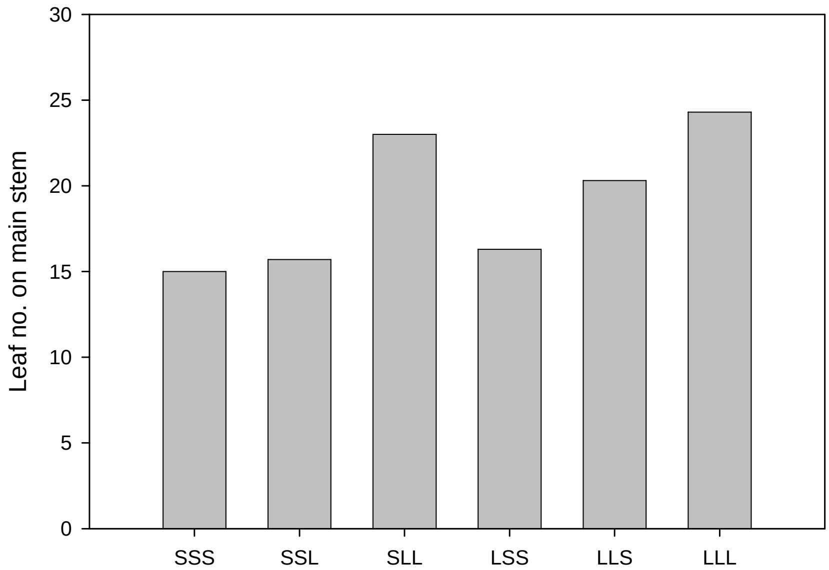


Fig. 6. Leaf number on the main stem of two sunflower varieties that were treated to either 12 hours or 16 hours photoperiod for the first three weeks before transplanting into large pots in the greenhouse. S = short days for a week; L = long days for a week.



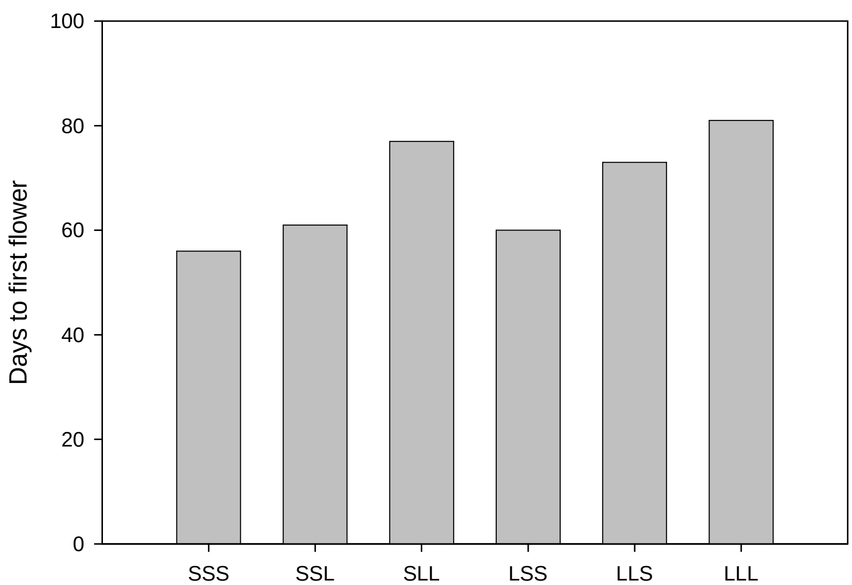


Fig. 7. Leaf number on the main stem (upper graph), and days from sowing to anthesis, for Sunrich Orange sunflower treated to either short (S) or long (L) day conditions in various combinations for the first three weeks, before transplanting to a high tunnel.

It appears that the second week after emergence is the one during which the Sunrich Orange variety is most sensitive to daylength, with only slight modifying effects from daylength in the other weeks (Fig. 7). This is most apparent in the results of the tunnel experiment.

Observations on the formation of axillary flower buds on the plants (see Fig. 5) indicated that these buds only formed if the plants had been given short days during week 2, the same period when the leaf number was being determined. The differences in response in the greenhouse compared to the tunnel may be ascribed to the difference in plant growth in 9 in. pots in the greenhouse, versus in the ground in the high tunnel. The size of the pots may have introduced considerable drought stress as the plants were increasing in size, and so the results of the tunnel experiment may be more reliable. These experiments will be repeated and expanded in 2008.

6. SUNFLOWER PETAL ABSCISSION TRIAL:

Some varieties of sunflower grown as cut flowers are very subject to loss of flower petals if the flower is brushed against a hard object. This can happen as early as when the flowers first open, and is very detrimental to flower appearance. Growers have known for years that there are varietal differences in this characteristic, but we have lacked a good method of measuring petal fall objectively. The current trial, sponsored by the Research Fund of the Association of Specialty Cut Flower Growers, was conducted by Joyous Tata, a graduate student in the program.

Materials and Methods:

Cut sunflowers were harvested just before the flower opened or when the flower first opened and their stems immediately placed in water. They were then transported to the lab in buckets, where force measurements for petals were taken using the petal break strength meter. This device consists of an arbor press and an electronic balance which is connected to a computer. The flower is placed on the electronic balance and a metal of known weight placed over the stem (Fig. 8). An alligator clip attached to the arbor is lowered to grab a selected petal and the force required to pull out the petal is measured. Seventeen varieties were tested; 3-4 petals per flower were pulled at any time and forces were recorded directly into a computer. A total of 444 petals were pulled on 10-20 replicates per variety.

Fig. 8. Petal break strength meter used to measure the force necessary to pull an individual petal out of the sunflower. The flower is resting on a scale, connected to a computer which measures the force reduction on the load cell as the petal is pulled slowly upward.

Fig. 9. Overall image of the scale, sunflower stem and flower, petal holding clip and arm attached to the arbor press.

Results and Discussion

Table 9. Classification of 17 sunflower varieties based on their minimum detachment force in Newton. Varieties not connected by the same letter are significantly different at α=0.05.

Varieties										**Mean Force**
Sunrich Orange (SO)	A									2.58
Procut Lemon (ProL)	A									2.55
Tosca(T)		B								2.25
Procut Yellow Lite (PYL)		B	C							2.14
Procut Apricot Lite (PAL)		B	C	D						2.10
Procut Orange (PO)		B	C	D	E					1.99
Procut Early Orange (PEO)		B	C	D	E	F				1.89
Apricot Lite (AL)			C	D	E	F				1.83
Pro Red Lemon Bicolor(PRLB)					E					1.81
Orange King (OK)					E	F				1.81
Orange Glory (OG)				D	E	F				1.79
Premiere Lemon(PL)					E	F				1.76
Procut Peach (PP)						F	G			1.56
Procut Peach Blush (PPB)							G	H		1.36
Procut Bicolor (PBC)								H	I	1.16
Strawberry Blonde (SB)								H	I	1.15
Moulin Rouge (MR)									I	0.90

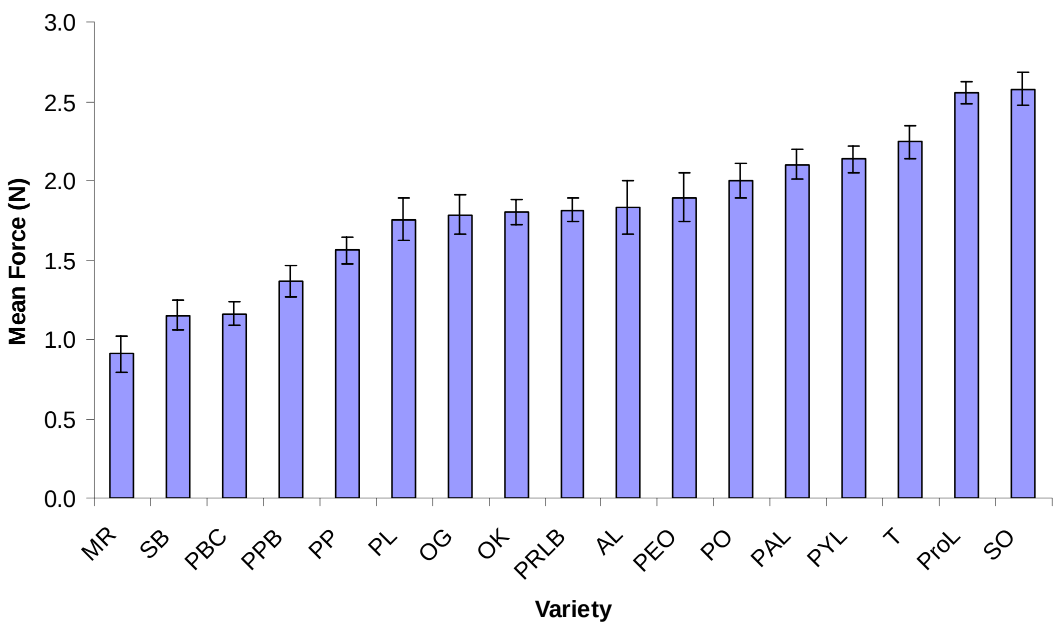


Fig_10. Minimum detachment force for 17 sunflower varieties arranged in ascending order. The varietal names are the same as in Table 9 above.

From the results in Table 9, we grouped sunflower varieties into four categories based on susceptibility to petal abscission by using the minimum force required to detach their petals. Table 10 is a summary of the categories.

Table 10. Classification of sunflower varieties according to their susceptibility to petal loss.

Very Resistant	Slightly resistant	Moderately resistant	Very susceptible
Sunrich Orange	Tosca	Apricot Lite	Procut Bicolor
Procut Lemon	Procut Yellow Lite	Procut Red Lemon Bicolor	Strawberry Blonde
	Procut Apricot Lite	Orange King	Moulin Rouge
	Procut Orange	Orange Glory	
	Procut Early Orange	Premier Lemon	
		Procut Peach	
		Procut Peach Blush	

Fig. 11. When a finger is brushed past the base of the petals, the petals readily abscise (bottom), or stay attached. This brushing test was used as a preliminary assessment tool in 2006.

Now that an objective petal loss force measurement technique has been developed, it will be used to study the factors causing abscission and ways in which abscission can be slowed down, such as treatment with specific plant hormones. Furthermore, we intend to study the morphology and anatomy of the cells at the abscission layer to check if anatomical or morphological changes at different bud development stages could be a factor.

7. DELPHINIUM MULCHING TRIAL:

When growing delphinium at our farm, we find that most varieties produce one or two stems, and then die out. A significant exception is the bellamosum type, which behaves more like a true perennial, with good plant longevity. On the possibility that the early die-out could be due to excessively high soil temperatures under the black plastic mulch, we tested three ground cover treatments in the current trial.

Materials and Methods: We compared the effect of three mulch treatments in the field: a black plastic control, straw mulch to a depth of about 4 in., and a reflective silver plastic mulch. Plants of the varieties Aurora White, Guardian Blue and Candle White Shades were sown in seedling trays in a greenhouse on March 10. On May 15 the plants were transplanted into the mulched plots, spaced 12 in. apart in 3 rows per bed. Plants were harvested when they flowered, and stand counts were taken at regular intervals through the season, until the final harvest on Oct. 10.

Results and Discussion: None of the mulch treatments significantly affected any of the variables that were measured in the experiment (Table 11). There were, however, significant differences among varieties. Aurora White and Candles White shade were nearly 2 weeks later in flowering than Guardian, and they also had superior stem length. Aurora White produced fewer stems, and also tended to suffer plant mortality to a greater degree than the other two varieties. From these results, it seems unlikely that plant longevity in Delphinium could be improved through the use of soil cooling mulches.

Table 11. The influence of different mulching treatments on stem length, plant yield, plant stand and earliness of flowering of three delphinium varieties grown in the field in 2007.

Treatment	Stem length, cm	Stems/plant	Days to first flower, DAS	Plant stand, % on Oct. 10
Black plastic	50	3.1	116	44
Straw	51	2.5	117	52
Silver plastic	50	2.8	118	46
Stat. signif.	ns	ns	ns	ns
Aurora White	53a	1.2b	126a	33
Guardian Blue	41b	3.3a	105b	50
Candles White Shades	57a	3.8a	121a	59
Stat. signif.	***	***	***	*
Interaction sign.	ns	ns	ns	ns