# CUT FLOWER CULTURAL PRACTICE EXPERIMENTS, 2006

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**EXECUTIVE SUMMARY:**

The cultural practice trials with cut flowers were conducted at East Ithaca Gardens on sandy loam soil. Some experiments were planted in a high tunnel on the site, others in the open field. Highlights of the trials described in more detail below are:

1. **Sunflower daylength screening test:** Exposing sunflower seedlings in the first three weeks after emergence to either 12 or 16 hr daylength revealed that 10 varieties were day neutral, 2 moderately sensitive and short-day, 11 strongly sensitive short day, and 2 moderately sensitive and long day in response. Varieties with strong short day response flowered 17 days in short days, on plants that were on average 30 in. tall.
2. **Snapdragon topping and time of planting trial:** Pinching out the growing point at node 7 of snapdragon seedlings increased stem yield by 34 and 48% in the two trials. The late (Group IV) variety Rocket was lower yielding and less responsive than the three earlier lines tested. Topping snapdragons that are spaced at 9 x 9 in. is a very promising low tech way of increasing stem yield without sacrificing stem length.
3. **Lisianthus topping trial:** Pinching lisianthus at node 3 or six stimulated stem length an average of 16% but had no significant effect on stem yield.
4. **Sunflower topping experiment:** Although pinching sunflowers quadrupled the no. of stems harvested, the resulting heads were quite small and the stems thin, and had a shorter vase life.
5. **Sunflower petal drop:** To screen sunflower varieties for their susceptibility to lose petals when handled, we devised a brushing test and tried it out with 21 varieties. Varieties ranged from losing no petals when brushed, to retaining no petals as a result of the same action.
6. **High and low tunnel temperature study:** Protecting plants in a high tunnel with a smaller tunnel covered with various materials provided improved frost

protection at night. During the day, clear low tunnel materials increased temperatures around the plant to dangerously high levels. Increased humidity around the plants, and significant shading from some low tunnel cover materials indicates that it would be best to open low tunnels during the day.

7. **Rudbeckia time of planting study:** Rudbeckia hirta is a obligate long day plant that requires long days for flowering. In four plantings from March to July, we found steadily decreasing yield with later planting dates, indicating that Rudbeckia seedlings should be planted to field or high tunnel as early as possible in the spring.

## SUNFLOWER DAYLENGTH SCREENING TEST

Work in 2005 indicated that some of the sunflowers commonly grown as cut flowers, and widely touted as “day-neutral” by seed companies, are actually strongly sensitive to short days. To check this further, we expanded our work to test more varieties in 2006. The results of those tests are given below.

**Materials and Methods:** In work sponsored by the ASCFG Research Fund, we tested the daylength response of 25 common cut flower sunflower varieties. Previous investigations by scientists in Belgium had revealed that some sunflowers are sensitive to daylength in the first three weeks after they emerge from the ground after sowing. It is during that time that the flower is formed, or prevented from being developed. We therefore started the varieties in 72-cell seedboxes, and exposed them to either 12 or 16 hours of daylength in a greenhouse by using blackout curtains at the end of the day, or shining artificial light on them after dark. Plants were kept under these treatments for three weeks from emergence, and then transplanted to the field. Plants were planted on beds using a square spacing of 9 by 9 in., with 4 rows per bed, and 6 ft. between bed centers. Black plastic covered the beds for weed control, and supplementary irrigation was supplied when needed by two trickle lines. The experiment was repeated three times in the summer of 2006, transplanting June 7, and three and six weeks later. There were about 24 seedlings per variety in each planting.

**Results and Discussion:** Giving the emerging seedlings short-day conditions for the first three weeks caused an amazing shortening in the time to flower of some varieties, while others did not show any effect (Table 1). Along with the earlier flowering, the plants were much smaller than normal, and the flower heads were much reduced in comparison to the same variety grown under long day conditions (Fig. 1). Many of the varieties that we found to show this sensitivity to daylength have been widely reported in seed catalogs to be daylength neutral, unfortunately. For instance, Sunbright and Sunbright Supreme, and the Sunrich lines (Gold and Orange), flower an average of 2 to 3 weeks earlier with the short day treatment than when exposed to long days, yet are widely designated as daylength-neutral by the seed catalogs (Tables 2, 3). The varieties that flowered extra early when given short day treatment also showed another trait that detracts from the appearance of the flower: plants tended to produce several flower buds in the upper part of the stem.

Our tests did identify other varieties that do not react to daylength, namely most of the Procuts (Tables 2, 3), as well as Sonja, Soraya, and Chianti, among others. Curiously enough, Procut Bicolor and Double Quick Orange flowered about a week earlier after long-day treatment than when exposed to 3 weeks of short days, so these would be classified as long-day varieties. A detailed description of the reaction of each of the 25 varieties to the daylength treatments is shown in Table 3.

These results indicate that daylength reaction can make a difference in sunflower performance under conditions of upstate New York. For instance, if you are in Zone 5 (like us), and plan to transplant sunflowers into a high tunnel by April 15, you will be starting your seed in the greenhouse at about March 21, when daylength is close to 12 hours. If daylength on those seedlings is not extended by artificial light, those plants will flower early, but they will be small and short, and perhaps unacceptable to your customers. To counteract the dwarfing effect of the short days, giving 4 hours of artificial light at the end of the day during the seedling stage will restore the daylength sensitive varieties to their summer size, but also makes them about 17 days later. When producing early sunflowers in lower latitudes, or in Florida in the winter, one would need to watch out for similar problems. Sowing these photosensitive varieties in the middle of the summer makes them behave similarly to our long-day treatment. Use of daylength-neutral varieties avoids this problem.

Table 1. Reaction to daylength of 25 sunflower varieties when exposed to either 12 or 16 hours during the first three weeks of growth in a greenhouse, before transplanting to the field. Flower diameter measures the diameter of the flower disk, when petals are perpendicular.

| Sensitivity type | No. of lines | Days to flower | | Plant height, in. | | Flower diameter, in. | |
|---|---|---|---|---|---|---|---|
| | | Short | Long | Short | Long | Short | Long |
| Day neutral | 10 | 65 | 66 | 52 | 52 | 2.2 | 2.4 |
| Slightly sensitive SD | 2 | 60 | 66 | 43 | 46 | 1.6 | 1.9 |
| Strongly sensitive SD | 11 | 53 | 70 | 30 | 54 | 1.6 | 3.0 |
| Slightly sensitive LD | 2 | 75 | 66 | 66 | 53 | 3.2 | 2.9 |

Fig. 1. Influence of daylength under which sunflower plants (variety Premier Light Yellow) were grown during the first three weeks, on plant appearance at flowering. Long day plants of the first planting (right) are shown with short day plants grown in the second planting.

Table 2. Classification of 25 varieties of sunflowers with regard to their sensitivity to daylength with regard to flowering. See Table 1 for characteristics of each category of plants.

| Day neutral | Slightly sensitive, short day | Strongly sensitive, short day | Slightly sensitive, long day |
|---|---|---|---|
| Procut Lemon | Chianti | Sunrich Orange | Procut Bicolor |
| Procut Yellow Lite | Valentine | Sunrich Gold | Double Quick Orange |
| Procut Peach | | Sunrich Orange Summer | |
| Sonya | | Sunbright | |
| Strawberry Blonde | | Sunbright Supreme | |
| Soraya | | Premier Yellow | |
| Ring of Fire | | Premier Light Yellow | |
| The Joker | | Solara | |
| Florenza | | Sunny | |
| Full Sun Improved | | Moonbright | |
| | | TH 472 | |

Table 3. The effect of seedling photoperiod on flowering and plant characteristics of 25 sunflower varieties grown in 2006. Seedlings were treated to either 12 or 16 hr photoperiod during the first three weeks after emergence, before being planted to the field. Experiment was conducted three times.

| | Days to Flower | | Plant height, cm | | Disk dia., cm | |
|---|---|---|---|---|---|---|
| Name | 12 h | 16 h | 12 h | 16 h | 12 h | 16 h |
| Chianti | 62 | 68 | 117 | 128 | 4.3 | 5.3 |
| Double Quick Orange | 83 | 72 | 177 | 140 | 8.5 | 7.7 |
| Florenza | 64 | 65 | 114 | 112 | 4.1 | 4 |
| Full Sun Improved | 69 | 72 | 157 | 183 | 7.6 | 9.1 |
| Moonbright | 60 | 75 | 112 | 167 | 4.4 | 7.7 |
| Premier Light Yellow | 45 | 63 | 38 | 95 | 3.4 | 5.5 |
| Premier Yellow | 48 | 64 | 36 | 97 | 3.4 | 5.9 |
| Procut Bicolor | 67 | 61 | 160 | 129 | 7.7 | 6.9 |
| Procut Lemon | 60 | 63 | 112 | 119 | 5.8 | 7.1 |
| Procut Peach | 60 | 60 | 144 | 138 | 6 | 6.8 |
| Procut Yellow Lite | 61 | 63 | 129 | 136 | 6.6 | 7.4 |
| Ring of Fire | 66 | 69 | 112 | 109 | 4.5 | 4.8 |
| Solara | 53 | 71 | 82 | 136 | 4.2 | 7.3 |
| Sonya | 65 | 68 | 86 | 90 | 3.4 | 3.4 |
| Soraya | 79 | 80 | 139 | 136 | 5.6 | 5.5 |
| Strawberry Blonde | 65 | 63 | 161 | 145 | 5.6 | 5.5 |
| Sunbright | 57 | 78 | 105 | 163 | 4.3 | 9.1 |
| Sunbright Supreme | 52 | 74 | 83 | 156 | 4.2 | 8.8 |
| Sunny | 56 | 79 | 101 | 160 | 4.6 | 8.9 |
| Sunrich Gold | 53 | 67 | 86 | 143 | 4.5 | 8.4 |
| Sunrich Orange | 53 | 68 | 85 | 143 | 4.3 | 8.5 |
| Sunrich Orange Summer | 49 | 69 | 63 | 123 | 4 | 7.2 |
| TH 472 | 48 | 68 | 60 | 111 | 4.1 | 7.9 |
| The Joker | 63 | 61 | 163 | 145 | 6.3 | 6 |
| Valentine | 58 | 65 | 104 | 113 | 4.1 | 4.5 |

## SNAPDRAGON TOPPING AND TIME OF PLANTING STUDY

Result of our 2005 study indicated that snapdragons at the 9 x 9 in. spacing we use produce branches on all basal nodes, and these develop even while the main shoot has not yet been harvested. Early-flowering cultivars (FG I-III) begin flowering significantly earlier that late varieties (FG IV) and thus may be more productive in the short, cool growing season of the Northeast. Two trials were conducted in 2006 to check on these observations, transplanting to the field in May, and into the high tunnel in July.

**Materials and Methods:** Four varieties of snapdragons were used in the trials: Chantilly Pink with White Throat (FG I-II), Animation Pink (II), Apollo Ivory (II-III) and Rocket White (IV). Trial 1 was sown in 72-cell trays on March 15, and transplanted to the field on May 8, while the second trial was sown on June 1 and transplanted to the high tunnel on July 13. Plants were spaced at 9 x 9 in. with 4 rows per bed, and 20 plants per subplot. Beds were covered with black plastic and watered with 2 trickle irrigation lines placed just below the plastic in the 40 in. wide bed. The topping treatment consisted of a soft pinch to leave 7 nodes. Plots were arranged in a randomized complete block with 3 replications.

Table 4. Effect of topping four varieties of snapdragon differing in earliness on stem length and yield when planted in the field in spring, or in summer into the high tunnel.

| | Spring field trial | | Fall tunnel trial | |
|---|---|---|---|---|
| Treatments | Stem length, cm | Stems per plant | Stem length, cm | Stems per plant |
| Control | 54.8 | 12.0 | 55.6 | 8.4 |
| Topped | 53.5 | 16.2 | 50.0 | 12.4 |
| Stat. signif. | ns | *** | ** | *** |
| Chantilly | 47.4 | 16.9 | 45.5 | 12.4 |
| Animation | 49.4 | 16.9 | 51.2 | 11.1 |
| Apollo | 62.5 | 13.2 | 62.7 | 9.1 |
| Rocket | 57.4 | 9.5 | 51.6 | 9.0 |
| Stat. signif. | *** | *** | *** | *** |
| Interaction | ns | *** | ns | ns |

**Results and Discussion:** Topping decreased stem length by 10% in the fall, but not the spring trial. In both experiments removal of the stem tip increased stem yield, by 35 and 48% in spring and fall, respectively (Table 4). Yields were higher in the spring than the fall trial, but stem lengths were comparable. Among the cultivars, there were consistent differences in stem length, with Apollo having the longest, and Chantilly the shortest stems. Stem yields were highest for the earliest varieties (Chantilly and Animation), and lowest for Rocket. In the spring trial, all cultivars except Rocket produced increased yield when topped, leading to a significant topping by variety interaction (Table 5, Fig. 2). The results imply that early and mid-season varieties (FG I to III) are better suited to our cool season producing environment than the late variety Rocket, and also more responsive to pinching.

Table 5. Stem yield of four snapdragon varieties in the spring field trial.

| Cultivars | Control | Topped |
|---|---|---|
| Chantilly | 14.1 | 19.7 |
| Animation | 13.3 | 20.5 |
| Apollo | 11.3 | 15.0 |
| Rocket | 9.3 | 9.8 |

The pattern of weekly harvest shows that topping delayed first harvest for the variety Animation Pink by three weeks, but the topped plants then produced a much larger yield of stems (Fig. 2). In contrast, both treatments of Rocket started yielding about the same time, and also did not vary much in the amount of stems produced.

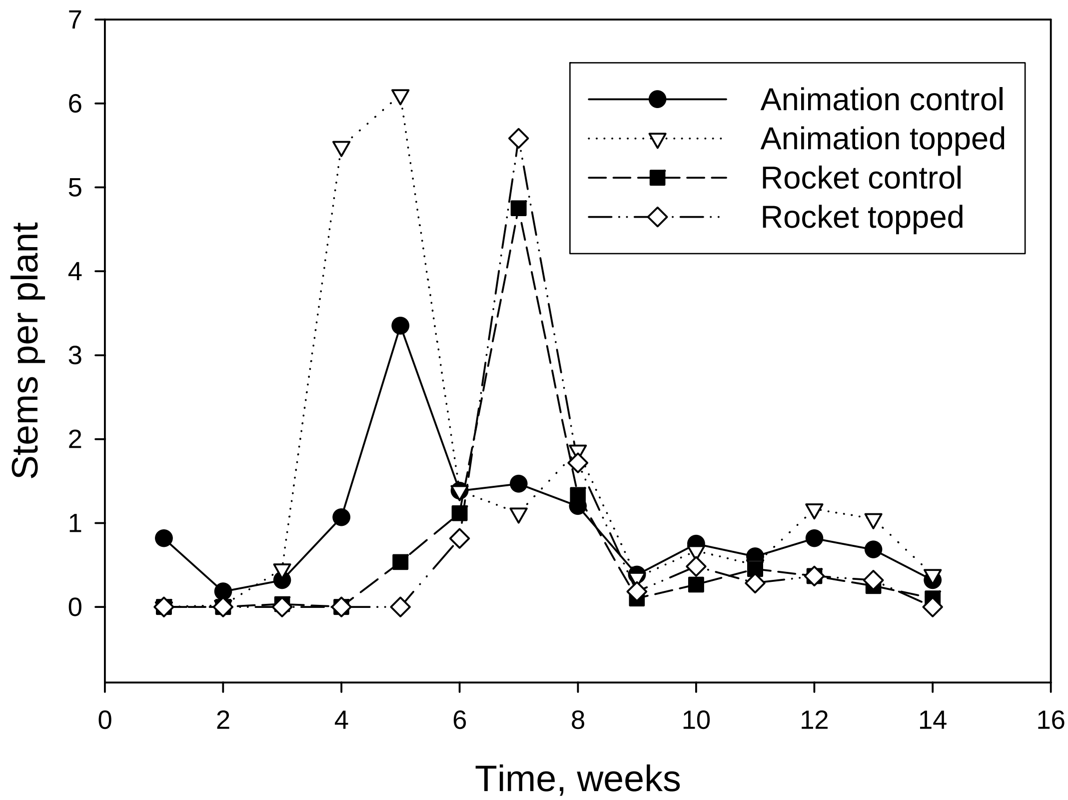


Fig. 2. Weekly yield of cut flower stems of Animation Pink and Rocket White snapdragons as affected by topping, when grown in the field in a spring crop.

**LISIANTHUS TOPPING EXPERIMENT**

When a preliminary topping trial with lisianthus in 2005 resulted in a 15% increase in stem yield, it was decided to see if these promising results could be confirmed.

**Materials and Methods:** Two varieties, ABC 2-3 Blue, and Cinderella Ivory, were sown on Feb. 24, and transplanted to the field on May 31. Topping treatments consisted of a control, and soft pinch leaving three or six nodes. Field spacing was 9 by 9 in., with four rows per bed. Beds were 40 in. across and 4 in. high, with 2 trickle lines and black plastic mulch. There were 3 replications. The pinch at node 3 was done on June 2; at node 6 on June 21.

**Results and Discussion:** The plants in this experiment grew well until cool fall conditions slowed growth. Topping stimulated a significant increase in stem length, perhaps because the main stems on the controls tend to be shorter than the side branches (Table 6). Yield of stems was not significantly affected by pinching at node 3 or 6, contradicting the results of the 2005 pinching experiment. Of the two cultivars, ABC

Blue had superior stem length, but both yielded similar stem numbers, and both reacted similarly to the topping treatment. Topping at higher nodes shifted the bulk of stem production to later in the season (Fig. 3).

Table 6. Stem length and yield of two lisianthus varieties when topped at nodes one or three in a 2006 field experiment.

| Cultivar | Stem length, cm | Stems per plant |
|---|---|---|
| ABC 2-3 Blue | 59 | 4.0 |
| Cinderella Ivory | 47 | 3.8 |
| Stat. signif. | *** | ns |
| Control | 48 | 3.0 |
| Topped at node 3 | 57 | 4.2 |
| Topped at node 6 | 54 | 4.5 |
| Stat. signif. | *** | ns (p=.09) |
| Interact. signif. | ns | ns |

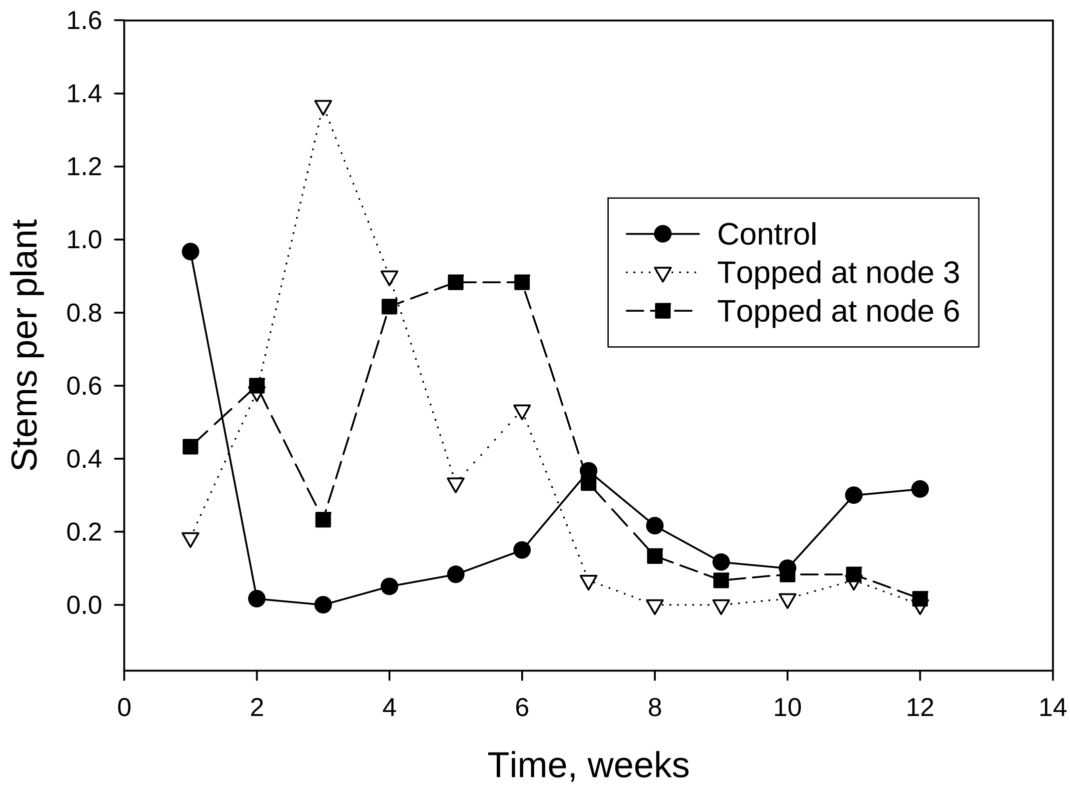


Fig. 3. Time course of stem harvest for ABC 2-3 Blue lisianthus when pinched at nodes 3 or 6 in a 2006 field experiment.

## SUNFLOWER TOPPING EXPERIMENT

The experiment was conducted to verify the results of a similar experiment conducted in the field in 2005, in which plant topping increased stem numbers significantly, but the flowers of one variety on the topped plants were too small to be commercially useful.

**Materials and Methods:** Plants were started in 72-cell trays in the greenhouse, and transplanted to the field about 3 weeks after emergence. Field arrangement was at a 9 x 9 in. spacing, 4 rows per black plastic-covered bed. Individual plots consisted of 24 plants, with two cultivars (Procut Orange and Sunrich Orange), and three topping treatments (control, topped leaving 4 nodes, and topped after 6 nodes). There were three replications. Flowers were harvested as they began to open.

**Results and Discussion:** Pinching the main stem apex on both varieties stimulated branch formation, so that four times as many stems could be harvested as the control plants. But topping delayed flowering by 7 to 10 days, and stem length and flower diameter were reduced to half of the control plants values (Table 7). There were significant variety by topping treatment interactions for all parameters measured. The later-flowering Sunrich Orange produced fewer branches when topped, and these tended to flower 10 days later, have significantly longer stems than the pinched Procut Orange plants, and have a somewhat smaller reduction in flower size. Nevertheless, the flower size of the pinched plants of both varieties was considerably reduced, and these smaller flowers may have to find a different market than the same varieties when not pinched. Although no formal comparisons were made, we also noted that the stems harvested from topped plants wilted readily in the vase, and had a short postharvest life.

Table 7. Stem yield, flowering date, and stem and flower size of two varieties of sunflower as affected by topping the plants at the four or six node stage. Experiment was conducted in the field.

| Treatment | Stems per plant | Flowering date | Stem length, cm | Flower diameter, cm |
|---|---|---|---|---|
| Procut Orange | 3.4 | 61 | 87 | 5.2 |
| Sunrich Orange | 2.7 | 74 | 109 | 6.5 |
| Stat. signif. | *** | *** | *** | *** |
| 1. Control | 1.0 | 61 | 143 | 8.7 |
| 2. Topped at node 4 | 4.1 | 70 | 77 | 4.6 |
| 3. Topped at node 6 | 4.0 | 71 | 74 | 4.2 |
| Stat. signif. | *** | *** | *** | *** |
| Procut 1 | 1.0 | 56 | 123 | 7.5 |
| Procut 2 | 4.7 | 63 | 69 | 4.4 |
| Procut 3 | 4.5 | 65 | 69 | 3.7 |
| Sunrich 1 | 1.0 | 67 | 163 | 9.9 |
| Sunrich 2 | 3.5 | 77 | 85 | 4.8 |
| Sunrich 3 | 3.6 | 77 | 79 | 4.8 |
| Interact. signif. | * | ** | ** | *** |

## SUNFLOWER PETAL DROP SCREENING TRIAL

A complaint frequently heard about sunflowers used as cut flowers is that certain varieties are prone to loss of petals before the flowers have started to senesce. We noticed this problem for the first time when carrying a bunch of freshly-harvested Procut Bicolor flowers through a narrow doorframe, and observed that petals were knocked off when brushed against the door. To gain a better understanding of varietal differences in susceptibility to this kind of mechanical damage, we devised a simple brushing test and compared the varieties in the photoperiod trial.

**Materials and Methods:** The brushing test consists of bending back the petals of the newly-opened flowers with the edge of the hand brushing the flower at right angles. One stroke was used for each of two sides of each flower, and six flowers were brushed in this manner on any one day. The brushing score is the number of petals dislodged by each stroke. For most of the varieties examined, the test was applied on at least two occasions.

**Results and Discussion:** The brushing test revealed that some cultivars have petals that are held tightly, and none are dislodged, but others consistently lose 3 or more petals when the edge of the hand is brushed against the flower (Table 8). Two of the most susceptible to petal loss are Chianti and Procut Bicolor, and these affirm the general sense that varieties with darker petals tend to be more abscission-prone. However, there are exceptions to that rule, as seen with varieties like Sunrich Gold, Sunbright and Sunrich Orange Summer. Double Quick Orange also appears to be susceptible, but this is the only cultivar tested that has many thin ray flowers that can inflate the total of abscised petals when brushed. Although this test gives a general indication of petal loss susceptibility, we will be refining the test in 2007, and trying to understand the physiological basis for this susceptibility.

Table 8. The effect of brushing against the petals of open sunflower flowers on petal abscission. The brushing score is the number of petals dislodged with each brush stroke.

| Cultivar | Brushing score | Standard dev. |
|---|---|---|
| Procut Yellow Lite | 0.29 | 0.42 |
| Valentine | 0.4 | 0.47 |
| Sunny | 0.42 | -- |
| Ring of Fire | 0.51 | 0.38 |
| Full Sun Improved | 0.53 | 0.3 |
| The Joker | 0.63 | 0.47 |
| Sonya | 0.69 | 0.55 |
| Procut Peach | 0.76 | 0.58 |
| Sunrich Orange | 1.05 | 0.29 |
| Sunbright Supreme | 1.11 | 0.5 |
| Florenza | 1.28 | 1.08 |

| | | |
|---|---|---|
| TH 742 | 1.42 | 1.09 |
| Premier Yellow | 1.82 | 0.8 |
| Premier Light Yellow | 1.83 | 1.2 |
| Moonbright | 1.92 | -- |
| Procut Lemon | 1.94 | 0.54 |
| Sunrich Gold | 2.12 | 1.95 |
| Sunbright | 2.12 | 1.94 |
| Strawberry Blonde | 2.62 | 1.22 |
| Sunrich Orange Summer | 2.62 | 2.01 |
| Chianti | 3.33 | -- |
| Double Quick Orange | 3.47 | 3.16 |
| Procut Bicolor | 3.54 | 0.37 |

## HIGH AND LOW TUNNEL TEMPERATURE STUDY

High tunnels consist of a greenhouse frame structure covered by a single layer of clear polyethylene. They are generally unheated, and crops are grown in the ground. They are used primarily for extending the growing season at both ends, and providing rain and wind protection during the summer months. On sunny days, even if outdoor temperatures are in the 50's F, air temperatures in the high tunnel can quickly rise into the 90's unless ventilation is provided. At night, the transparency of the polyethylene to infrared radiation allows the tunnel temperature to plummet to levels below the outside. The current studies were conducted to see if low tunnels over crops growing in high tunnels could moderate temperatures to improve growth. The theory is that low tunnel covers that provide moderate shade would reduce maximum temperature around the plant, and block the escape of infrared radiation at night. Two trials were conducted, one in the spring, and one in the fall.

**Materials and Methods:**

I. Spring trial

Cover materials:

1. Uncovered control
2. Clear polyethylene, IR blocking, 6 mil thickness
3. Covertan non-woven fabric, 0.6 oz/yd$^2$
4. Floating row cover, 2.0 oz/yd$^2$

II. Fall trial

Cover materials:

1. Uncovered control
2. Covertan non-woven fabric, 0.6 oz/yd$^2$
3. Floating row cover, 2.0 oz/yd$^2$
4. Svensson woven fabric #1 (with Al reflective strips)
5. Svensson woven fabric #2 (clear with net reinforcement)

In the spring trial, an early transplanted crop of sunflowers was grown in the center 3 beds in the high tunnel, and each bed served as a replication. Temperature sensors were installed to monitor air temperatures in one replication of each treatment, as well as at an equivalent height outside the high tunnel. To shield the sensors (Hobo sensors linked to a Hobo weather station), they were suspended in the middle of a horizontal white plastic pipe of 2.5 cm dia. and 25 cm long, connected to a vertical black metal chimney that served to draw air past the sensor as the chimney was heated by the sun. The shielded sensors were placed at crop height among the sunflower seedlings.

In the fall trial, the center three beds were again used for the low tunnels, and were covering a snapdragon topping trial, and lisianthus and trachelium variety trials. In this trial, sensors were placed in two replications of the low tunnels.

**Results and Discussion:** One day after the low tunnels were erected in the high tunnel in spring, we were fortunate to have a frost outside the tunnel. The IR-blocking properties of the polyethylene covering the high tunnel allowed air temperature in the high tunnel to drop only to freezing, while the outside air got to 25 F (Fig. 4). The low tunnels provided additional protection, increasing the low temperature to 33, 36 and 37 F for the Covertan, heavy floating row cover and the clear polyethylene, respectively.

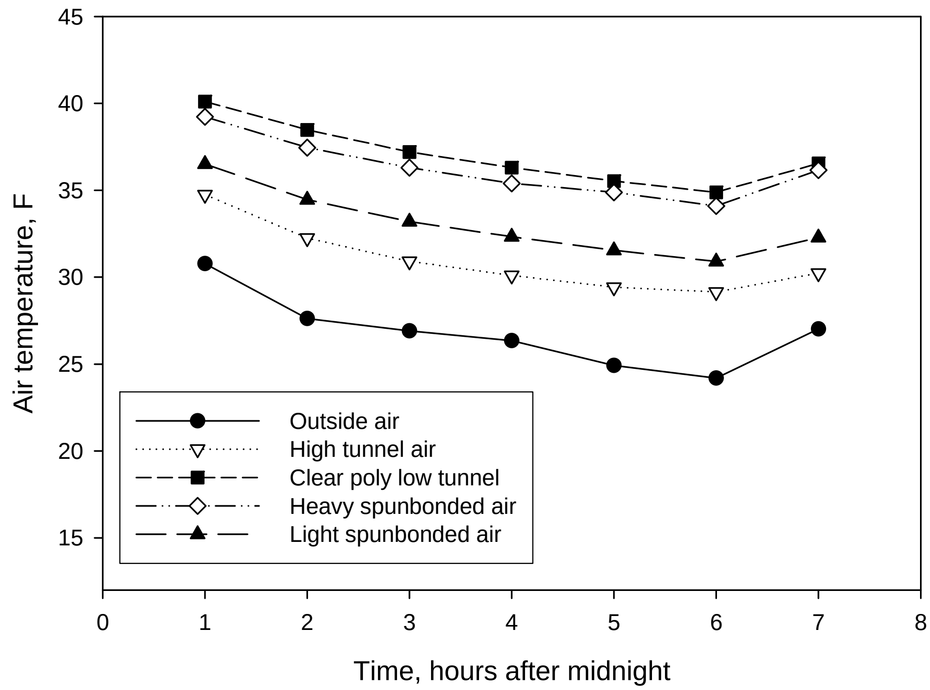


Fig. 4. Air temperatures in high and low tunnels on the morning of April 26, 2006.

Later that morning, the sky was clear, and the sun quickly warmed the high and the low tunnels. Although the temperature only rose to about 65 F outside, the high tunnel air temperature reached 85 F, while the low tunnels became correspondingly hotter (Fig. 5). The light and heavy non-woven covers increased the maximum temperature an additional 5 F, but the air inside the clear poly low tunnel reached 130 F, and cooked the sunflower seedlings inside. This one day test illustrates both the opportunities and hazards of low tunnels: unless the grower is prepared to vent them daily, maximum temperatures inside can injure plant growth. The non-woven materials provide some shade, and reduce the temperature buildup. These fabrics are also effective in maintaining night temperatures when outside temperatures dip below freezing.

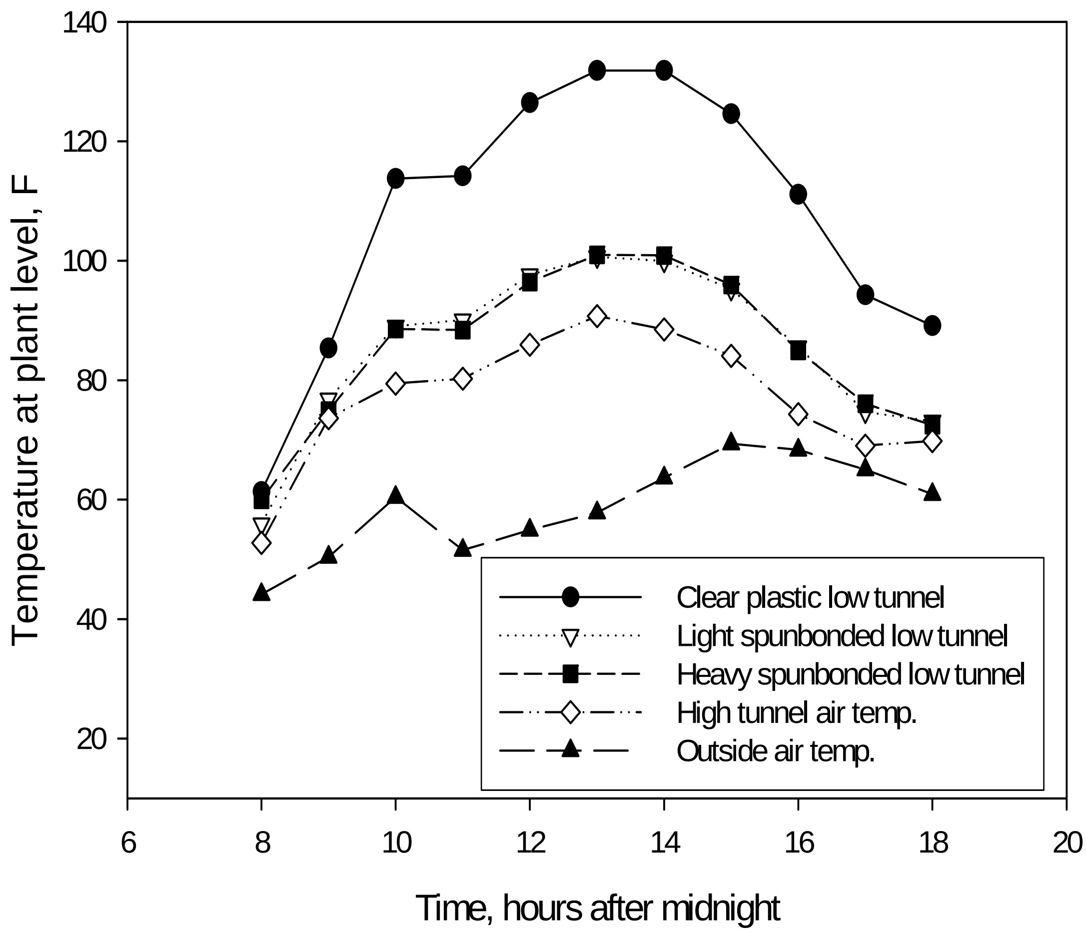


Fig. 5. Maximum air temperatures on April 26, 2006 in the high tunnel and in low tunnels erected inside it.

In the fall trial, there were several days when temperatures dipped below freezing during the night, allowing a comparison of low tunnel cover materials for frost protection. When minimum temperatures dipped below freezing on four dates, high tunnel air temperatures were 6 F higher, and the low tunnel cover materials increased temperatures an additional 2 or 3 F (Table 9). When low tunnel cover materials were kept over the crop during sunny days, air temperatures in the low tunnels again rose above ambient in the high tunnel, and the two Svensson materials might allow dangerously high temperatures during periods when the sun is stronger, such as in April/May. Light interception by the low tunnel materials was significant especially for the heavy floating cover, and would lead to etiolated growth if the cover was left on for long periods. Moisture condensed on the inside of the low tunnel materials in the night and early morning, indicating that they produce a high humidity environment that would allow disease buildup if left on for long periods of time. The moisture buildup was especially noticeable with the Svensson materials. The results of the fall trial substantiate those of the spring experiment: for optimum temperature, light and humidity management, it is best to open the low tunnels during the day, covering only at night.

Table 9. Minimum and maximum air temperatures outside, inside the high tunnel, and in low tunnels inside the high tunnels, covered with various materials. Data are averages of readings taken Oct. 6, 7, 13 and 16, 2006, with two replicate locations per reading. Light interception readings for the low tunnel materials were taken with a quantum sensor.

| | Outside | High tunnel | Covertan nonwoven | Floating cover | Svensson Al foil | Svensson clear with net |
|---|---|---|---|---|---|---|
| Min. temp. °F | 29 | 35 | 37 | 40 | 39 | 40 |
| Max. temp. °F | 59 | 79 | 87 | 84 | 91 | 94 |
| Light interception, % | -- | -- | 20 | 58 | 33 | 28 |

**RUDBECKIA TIME OF PLANTING STUDY**

Rudbeckia hirta is a perennial that produces long-stemmed flowers when planted in early spring, but fails to flower when sown in July. Greenhouse tests have indicated that the species is an obligate long day plant, and the present study was set up to confirm the relationship of planting date and productivity of this species, repeating tests that were also conducted in 2005.

**Materials and Methods:** Three varieties were included in the test: Indian Summer, Goldilocks and Prairie Sun, and these were sown in 72-cell trays in the greenhouse on March 8, May 1, June 1 and July 1. The first two plantings were transplanted in the field on May 8 and June 21, respectively, whereas the last two plantings were transplanted to the high tunnel on July 21 and August 30. Stems were harvested throughout the season as the flowers opened, and stem length measured at harvest. There were insufficient plants of Indian Summer in Planting 3, so only the other two cultivars will be reported for that planting.

**Results and Discussion:** Planting date profoundly influenced the yield of Rudbeckia (Table 10). The later the sowing date, the lower the yield, until in July, when hardly any flowering stems were produced by the plants. This study substantiates the results of greenhouse daylength studies, which showed that these Rudbeckia varieties will be inhibited from flowering at a 12-hour daylength. The yield decline was particularly striking for Goldilocks, which begins flowering earlier than the other two varieties. Plants from the May 1 sowing date of this variety started flowering before an adequate vegetative frame had been established. Much of the leaf area of the plant was removed with the first harvest, leaving the plants unable to generate additional flowers. Many plants of this variety senesced after the first harvest in the May 1 planting. The results point out the importance of early planting for maximum productivity of this long-day species.

Table 10. Rudbeckia yield and stem length when planted at four different dates in spring and summer, 2006.

| Sowing date | Stems per plant | | | Stem length, cm | | |
|---|---|---|---|---|---|---|
| | Ind. Sum. | Goldilocks | Prair. Sun | Ind. Sum. | Goldilocks | Prair. Sun |
| March 8 | 32 | 36 | 30 | 47 | 41 | 42 |
| May 1 | 18 | 12 | 17 | 47 | 36 | 42 |
| June 1 | -- | 7 | 7 | -- | 34 | 36 |
| July 1 | 0 | 1 | 0 | 0 | 26 | 0 |

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