CUT FLOWER CULTURAL PRACTICE STUDIES AND VARIETY TRIALS 2010

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EXECUTIVE SUMMARY:

1. **General Materials and Methods, and the Weather (P. 3):** Temperature conditions were warmer and sunnier than average early in the season, leading to accelerated early growth, especially in the high tunnel. Rainfall distribution was close to normal, with high precipitation in October.
2. **Tulips in the high tunnel (P. 6):** Four varieties of tulips were planted 4 in. deep in the high tunnel in early November 2009, and treatments of straw mulch and low tunnel protection compared. Plants flowered in the spring about 3 weeks earlier than outside, but low tunnels only advanced harvest date by two days, whereas straw mulch delayed flowering by four days, and increased stem length by 3 in. To extend the tulip harvest season in a high tunnel, choice of early and late varieties, and culture in bare ground and straw-covered beds appear to be promising.
3. **Larkspur Topping Trial (P. 9):** The trial was a repetition of a 2009 experiment, in which pinching the plants in the seedling stage increased stem yield by 42%. In 2010, yields were more variable, and not different between treatments. Whereas controls produced one long stem and short branches, the topped plants had stems of intermediate size. Topping delayed flowering by 4 days.
4. **Seedling Crowding Experiments (P. 10):** To determine which cut flower species are sensitive to delayed transplanting, especially out of small cell transplant trays, we compared the performance of five cut flower species when subjected to a combination of such treatments. Zinnia 'Uproar Rose' and lisianthus 'Echo Champagne' showed no yield decline if delayed from transplanting by 3 weeks, even if sown in a 200-cell tray. Celosia 'Spring Green' also transplanted readily, but unfavorable conditions in the field spoiled comb development. Both godetia 'Flamenco Salmon' and larkspur 'Sublime Dark Blue' had much reduced plant stand after crowding in the seedbox and delayed transplanting.

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5. **Petal loss in sunflower (P. 14):** When sunflower heads are harvested, the strength with which the petals are held in the head decreases until petals fall out spontaneously. Varieties differ in petal loss rate, and we are seeking practical means to increase petal retention. In this season, spray treatments of the cytokinin benzyl adenine to field-grown plants was ineffective, whereas dipping the flower heads in cytokinin solution after harvest gave positive results in one out of two trials. A comparison of petal retention strength among varieties indicated that sunflower breeders are making headway selecting for improved petal retention.
6. **Sunflower photoperiod screen (P. 20):** We tested 6 varieties for their sensitivity to daylength during the first three weeks after emergence, and found that three (Solar Power, Procut Gold and Procut Lemon) were insensitive, while Sun4U Bicolor, Sun4U Orange and Sunrich Orange flowered a week earlier (Sun4U lines), or 12 days earlier (Sunrich Orange) when grown under 12 hr daylength for the first 3 weeks.
7. **Rudbeckia Lighting Expt. (P. 23):** Rudbeckia hirta reacts to the short daylength prevalent in the late summer and fall by having reduced stem growth, and eventually, when days get short enough, ceasing to flower. A daylength extension to 16 hrs. allows the crop to be grown in a high tunnel. We attempted to bring about that daylength extension using solar-powered Christmas lights, but found that light intensity of these tiny lamps was insufficient to elicit a plant response.
8. **Delphinium Plant Stand Trial (P. 25):** The rapid decline of some varieties of delphinium in the field after bloom appears to be caused by a root disease. Our attempt to remedy the problem by treatment with a biological control agent, *Trichoderma harzianum* was ineffective in this field trial, but a late-flowering variety 'Centurion White' was much less susceptible than 'Guardian' . Thus variety selection appears to be the most effective way of having sustainable delphinium plantings.
9. **Amaranth and Celosia Variety Trial (P. 26):** Two trailing amaranths were compared, and 'Love Lies Bleeding' was more productive and healthier than 'Mira'. Of the four celosias grown, 'Red Flame' had an attractive scarlet comb, and good productivity. 'Cramer's Amazon' grew especially well in the high tunnel, and had colorful foliage as well as many stems with plume inflorescences.
10. **Aster Variety Trial (P. 29):** Six varieties of aster (Callistephus) were compared in a field planting protected from insect attack under a fabric low tunnel. The covering did nothing to prevent a severe attack of root disease (probably *Fusarium*), and none of the varieties showed tolerance or resistance.
11. **Bells of Ireland (P. 31):** The standard *Molucella laevis* was compared to a new variety 'Country Bells', but little difference was found. The latter was about a week later in flowering, but productivity and flower appearance were similar to the standard.
12. **Campanula variety trial (P. 32):** For years, the only early-flowering Canterbury Bell series has been 'Champion' released by Takii. The new 'Campana' series by Kieft changes that circumstance. We found the new pink and blue lines to be similar in productivity to 'Champion White', but about a week later in flowering. Flower quality of the new lines is excellent.

13. **Dianthus (P. 33)** is another converted biennial (to flowering in the first year) to which new varieties are being added. In this trial of 7 varieties, a new addition to the 'Sweet' series, 'Red with White Eye', is worth another look with good production, attractive appearance and a slight scent. Most of the 'Fandango' series is too short in stem to be used as a cut flower, but would make an attractive bedding plant.
14. **Gomphrena 'Fireworks' (P. 35)** was not compared with other globe amaranths in this trial, but was very prolific in both tunnel and outdoors, with many stems of good length. The rather small heads make an attractive filler.
15. Three varieties of **ornamental kale/cabbage (P. 35)** were compared in both tunnel and field. 'Lucir White' and 'Lucir Red' lack the waxy bloom on the green leaves, and this makes them susceptible to attack by flea beetles, necessitating insecticide spraying. 'Giraffe' has attractive frilly foliage and a relatively thin, tough stem. In comparison to the standard 'Crane Bicolor', the three new lines are earlier and have thinner stems.
16. **Lisianthus Variety Trial (P. 38):** Of the 14 lisianthus varieties tested this year, several double-flowered lines stood out: 'ABC 1-3 Misty Blue'; 'ABC 1-3 Green', Mariachi Yellow Improved', 'Mariachi Pink Picotee' and 'Mariachi Carmine' had good productivity and interesting flower colors.
17. **Marigold Variety Trial (P. 41):** Recent developments among marigolds make these more interesting as cut flowers. In our tunnel trial, 'American Babuda Yellow', 'American Narai Yellow', and the later 'American Babuda Deep Gold' had large, attractive globe-shaped flowers and long stems. The variety trial of these lines in the field failed because of insect damage, probably leafhoppers, that we did not control.
18. **Scabiosa (P. 43):** A variety trial of 4 entries, all Scabiosa caucasica, was very late in flowering, and therefore only moderately productive. The flowers were attractive as cuts, and will be evaluated again in 2011, since they are perennials.
19. **Snapdragon (P. 44):** Four varieties were compared in a spring-planted field trial. 'Calima Yellow' and 'Appeal Scarlet' were productive and had relatively long stems, and are worth growing as cut flowers.

GENERAL MATERIALS AND METHODS:

The 2010 cut flower trials were conducted at the East Ithaca Gardens, both in the field and in the high tunnel. The soil type for both is an Arkport Sandy Loam. In the field, about 2 in. of compost was applied in late fall 2009 and worked in. In April 2010, 50 lbs of N using a 20-10-10 fertilizer was spread on the land, and worked in with a disk. Thereafter, beds were formed on 6 ft. centers, with bed dimensions of 5 in. height, and 40 in. width. The beds were covered with 1 mil black plastic mulch, after two trickle irrigation lines were positioned on each bed. Supplemental nitrogen in the form of calcium nitrate at the rate of 30 lbs N per acre was applied as needed to the beds, when plants growing showed slow growth and yellow leaves. Typically, this was only needed once for each crop.

Soil management in the high tunnels consisted of a primary tillage operation using a walk-behind rototiller, and applying the same amount of fertilizer as outside. Building up the beds and applying the trickle tape and black plastic mulch was done by hand. To minimize salt buildup, no compost was applied in the tunnel in 2008, 2009 or 2010. An application of calcium nitrate at 30 lbs N/acre was applied through the trickle irrigation to all beds on Aug. 13.

Plants for the variety trials were started in greenhouses from seed in seedling trays in Redi-earth artificial soil mix, at recommended temperatures for the species. The time of sowing was adjusted to assume access to the tunnel in the third week of April, and outdoors a month later. Except where noted, spacing was a staggered grid of 4 rows, with 9 in. between plants and rows. There were usually 20 plants in each subplot, and 2 replications in both the tunnel and outdoor variety trials.

Plots in the tunnel were irrigated weekly all season long and twice weekly during the warmest periods. Stems were harvested at the recommended maturity stage for the species, and stem lengths were determined for each stem. Repeated harvests were made as needed, often at weekly or greater frequency. No insecticide nor fungicide applications were made to plots in the field in 2010, except that a severe attack of Japanese Beetle necessitated 1 application of Spectracide to the zinnia seedling crowding trial. In the high tunnel, we used only OMRI-approved methods of pest control in 2010. These included the use of banker plants and the aphid parasite Aphidius colemani for aphid control in ornamental kale, and several spider mite predators for spider mite control in marigold, coleus and amaranth. Except for two shielded sprays of glyphosate in the paths of the field planting area, for the rest of the season weed control was done by hand.

WEATHER CONDITIONS: Temperatures were significantly higher through the early and middle of the growing season, then decreased to the seasonal average at the end (Fig. 1). The relative earliness of plant growth was also aided by slightly drier conditions in April and May (Fig. 2). The very wet October came too late to affect most crops.

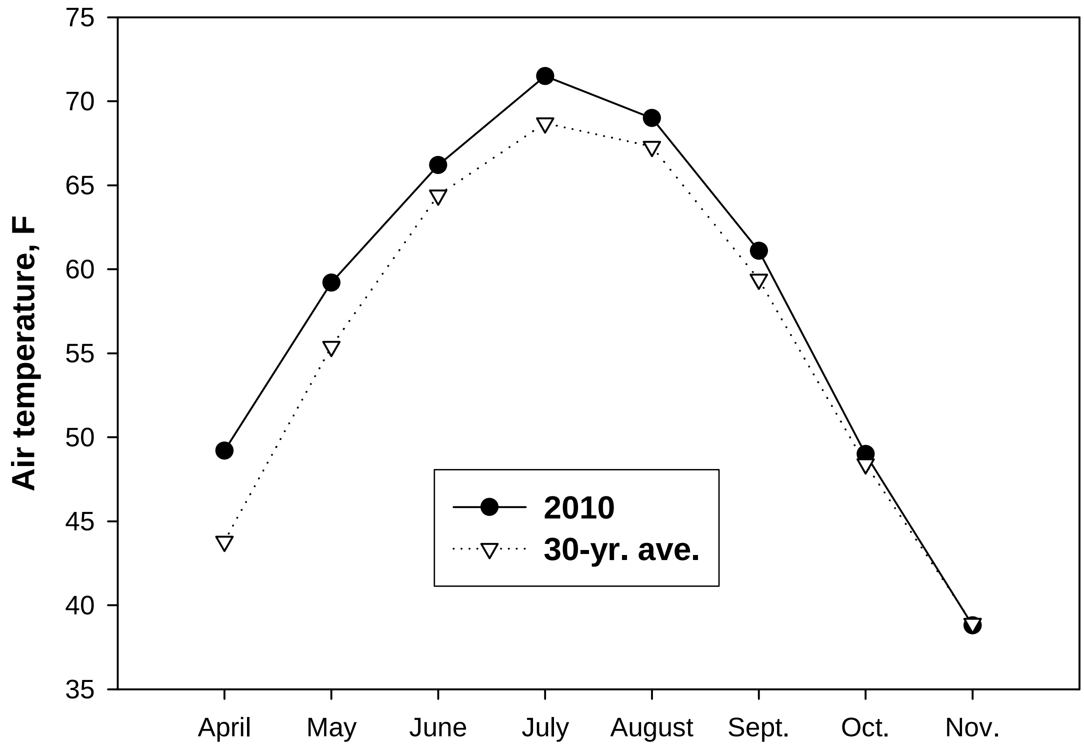

Fig. 1. Air temperature during the 2010 growing season at Ithaca, NY, compared to the 30-year average. From: www.nrcc.cornell.edu/climate/Ithaca/.

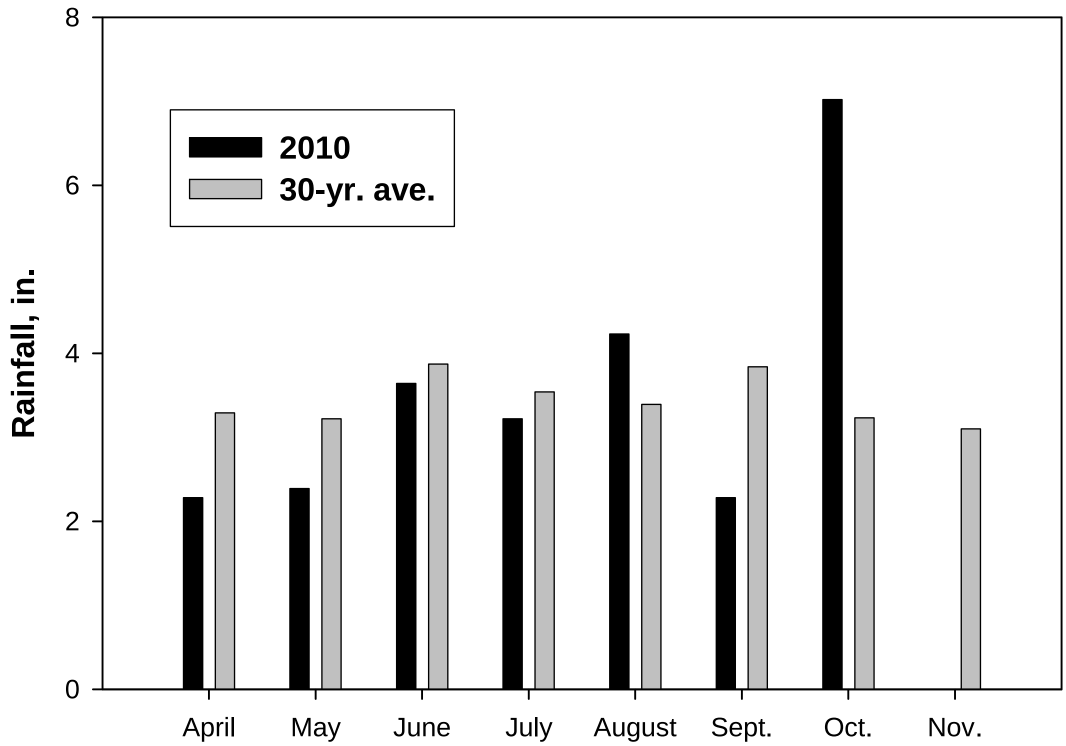

Fig. 2. Monthly rainfall totals in the 2010 growing season, compared to the 30-year average. From: www.nrcc.cornell.edu/climate/Ithaca/.

TULIPS AS CUT FLOWERS IN A HIGH TUNNEL: (Published in Cut Flower Quarterly, Summer, 2010)

Many of us growing cut flowers in high tunnels harvest our final crop in early November (Zone 5), heave a sigh of relief, and relax until spring fever hits us in February. But during that period the tunnel sits empty, and its valuable space is not used. With relatively little extra work in the fall, we could increase our late winter income from that structure: by growing cut flower tulips. Two things are essential for such an enterprise: a high tunnel that will withstand the winter storms and a means of keeping the planting watered over the winter period. For the former, check with your tunnel manufacturer for their winter guidelines. For winter irrigation, we need to assume that a trickle irrigation line could freeze on cold nights. We therefore need a way of easily shutting off and draining the water line. But with those factors in place, tulips are remarkably little work, and will yield superior quality stems about 3 weeks before they could be harvested from outside plots.

Materials and Methods: We explored the potential of high tunnel tulips in the winter of 2008/9 at the urging of Dr. Bill Miller, head of the Dutch Bulb Research Program at Cornell. In that first trial, tulips planted directly in the tunnel soil about 4 in. deep performed better than bulbs in crates in the tunnel.

In 2009/10, we investigated the effects of additional low tunnel protection, and soil mulching on earliness and stem length, using 5 tulip varieties donated by Dr. Miller's program. In early November, 2009, we prepared the plots by digging down about 5 in. and placing 35 bulbs of each variety in an area of 18 by 36 in. Low tunnels consisted of No. 9 wire hoops covered by a single layer of spun-bonded material (1 oz./yd^2). A straw mulch of about 2 in. depth was used as soil cover on some plots. All treatments were repeated in 3 places to avoid location effects.

Results and Discussion: As expected, the choice of variety made a big difference in earliness and stem length (Table 1). 'World's Favorite' was both early and tall, with a smooth deep orange calyx lined with yellow. Although later, 'Strong Gold' had a sturdy stem and a flower that stayed somewhat closed throughout the life of the flower. 'Ad Rem' looked like a later version of 'World's Favorite', but was susceptible to petal injury by cold weather.

Among the treatments applied, the low tunnel hastened flowering by only two days, and had no effect on stem length (not shown). Straw mulch cooled the soil, delaying plant emergence, and delaying flowering by 4 days. Although at first glance a disadvantage, mulching was helpful to spread out the harvest over a longer market window. In addition, the mulch stimulated the plants to stretch, adding 3 in. to the stem length. One drawback of the straw mulch treatment could be an increase in mouse damage, if mice are already frequenting the high tunnel.

Our results indicate that producing cut flower tulips in a high tunnel can result in the production of high quality flowers in a small area. Although the flower harvest was compressed into a short period, selecting later-flowering varieties as part of the mix could extend the harvest period, especially when combined with straw mulch and low tunnel treatments.

Table 1. Effect of variety and straw mulch on earliness and stem length in a high tunnel experiment over the 2009/2010 winter.

Variety/Treatment	Date of Flowering, April	Stem length, in.
Ad Rem	12	22
Border Prince	9	15
Double Focus	13	16
Strong Gold	12	21
World's Favorite	9	23
Statistical signif. (vars)	***	***
Not mulched	9	18
Straw mulch	13	21
Statistical signif. (mulch)	***	***

Fig. 3. Tulip varieties ‘Strong Gold’ (foreground), ‘Ad Rem’, ‘Double Focus’ and ‘Border Prince’ in the high tunnel.

Fig. 4. ‘World’s Favorite’ and ‘Double Focus’ in the vase.

Fig. 5. ‘Double Focus’ tulips in the high tunnel, on bare ground or mulched with 2 in. of straw.

LARKSPUR TOPPING TRIAL:

Larkspur is a productive and showy cut flower when grown early in a high tunnel. In a 2009 trial, we obtained a 42 % increase in stem number, with a harvest date delay of 5 days, by topping three larkspur varieties in the seedling stage. Although not as tall as the main stem of the plants that had not been topped, the branches that developed were 26% longer than branches on control plants. These positive results are worth testing on new varieties in 2010, including a variety used in the 2009 trial.

Materials and Methods: Three varieties: Frosted Skies (Gloeckner), Sublime White (Johnny’s) and Cannes Dark Blue (Gloeckner) were sown on March 1, grown in a cool greenhouse until April 19, and transplanted into the high tunnel at 6 x 6 in. spacing, with 30 plants per plot. Main plots consisted of a pinching treatment, applied just as the plants started to elongate, about May 7, with varieties as subplots.

Results and Discussion: In comparison to the previous year’s trial, trends were similar, but a higher degree of variation obscured trends. Topping produced no difference in average stem length, but in control plants, main stem length of 135 cm and branches of 46 cm were produced, whereas in the topped plants, stem length was more uniform (Table 2). Stem numbers also did not differ between treatments. As previously, plants flowered about 4 days later after topping than the controls. The results suggest that the lack of a yield decline with topping would allow an even closer plant spacing to be used, especially if there is demand for stems of more than a meter length.

Table 2. Stem length, productivity and earliness of three larkspur varieties grown in early spring in the high tunnel, comparing plants topped at node 6 with untopped control plants.

Variety/treatment	Stem length, cm	Stems/plant	Days to first flower
Frosted Skies	56	3.7	110
Sublime White	78	3.0	113
Cannes Dark Blue	64	4.0	108
Stat. signif.	**	ns	**
Control	62	2.7	108
Topped	70	4.5	112
Stat. signif.	ns	ns	***

SEEDLING CROWDING EXPERIMENTS: (Results summarized in a Cornell-copia article, Jan. 2011)

Many of the important cut flower species are transplanted. When field weather conditions are awful, should you wait for better weather, and for how long, or pitch the plants? To answer those questions for some species, we conducted trials in 2010 at Ithaca, NY (Zone 5). Experiments were run separately for zinnia 'Uproar Rose', lisianthus 'Echo Champagne', celosia 'Spring Green', larkspur 'Sublime Dark Blue' and godetia 'Flamenco Salmon'.

Materials and Methods: Treatments included: (1) Starting the seedlings in a 72-cell tray in a greenhouse, and transplanting to the field at the time the seedlings could be pulled (seedlings formed a root ball and could be removed from the tray without leaving seedling mix behind); (2) Similar to 1, except that seedlings were started in a 200-cell tray; (3) Seedlings started in a 200-cell tray, but transplanted to the field 2 weeks late; (4) Seedlings started in a 200-cell tray, transplanted 3 weeks late; and (5) Seedlings started in a 200-cell tray, transplanted to a 72-cell tray when treatment 1 went to the field, and not transplanted until week 5.

Results and Discussion: Since each species reacted differently to crowding and delayed transplanting, the results will be described for each in turn, from the toughest to the most sensitive:

Zinnia 'Uproar Rose': There was no difference in the no. of stems per plant over the season among any of the treatments. Seedlings transplanted on time out of large cells formed the largest plants at flowering, but the other treatments caught up. Plants produced 9 marketable stems averaging 20 in. in length. The worst treatment was #4, in which the plants had been crowded in small cells for 3 extra weeks, but aside from a 2-week delay in flowering, and a 17% shorter stem length; stem numbers were the same (Fig. 6).

Fig. 6. Zinnia 'Uproar Rose', after end of cutting period, showing no distinct differences among seedling treatments arrayed down the row.

Lisianthus 'Echo Champagne': As in similar experiments run in past years, lisianthus was not seriously affected by seedling crowding and delayed transplanting. Yields ranged from2 to 5 stems per plant, with seedlings transplanted 3 weeks late out of the 72-cell tray (#5) doing the best, and the 2-weeks delay treatment (#3) faring the worst. Stem lengths only varied from 14 to 16 in.

Celosia 'Spring Green': This cockscomb variety is non-branching, producing a single fan-shaped flower when well grown (Fig. 7). All treatments retained perfect stands after transplanting, so yields were judged on the basis of comb size. Paradoxically, although plants at flowering in treatment 1 were nearly 8 times bigger than those transplanted 3 weeks late from 200-cell trays, combs were less than half the size of the latter. Weather conditions after transplanting of the earlier treatment were cold and unfavorable for comb development, whereas the later transplants went into warmer field conditions. The results indicate that this variety of celosia does not react adversely to crowding, but is sensitive to weather conditions at transplanting.

Fig. 7. Celosia 'Spring Green' at harvest, with leaves stripped away. The left plant was grown in a 72-cell seedling tray, transplanted 25 days after sowing. The center plant was sown and transplanted on the same dates, but out of a 200-cell tray. The right plant stayed in a 200-cell tray for an additional 2 weeks.

Larkspur 'Sublime Dark Blue': This species is sensitive to poor seedling growth conditions. If delayed in the transplant container, the seedlings become tall and thin, and do not survive the transplant process (Fig. 8). Only 35 and 39% of seedlings held in the 200-cell containers for 2 and 3 weeks, respectively, survived in the field until flowering. Seedlings grown in 72-cell trays and transplanted promptly had high survival rates and produced the largest plants (Fig. 8). Transplanting from small to large cells helped survival, but the plants were too small at transplanting to be productive.

Godetia 'Flamenco Salmon': Conditions in the transplant container are the key determinants of success for this species. Crowding of seedlings in a 200-cell tray make seedlings thin and spindly, and the resulting plants lack branches and the ability to form many stems (Fig. 9). In addition, these weak crowded plants have reduced survival at transplanting, similar to larkspur.

Conclusions: These studies demonstrate that species that are easily transplanted tolerate crowding in the seedling stage, and delays in transplanting. Zinnia, lisianthus and celosia can be found in this class. Larkspur and godetia are sensitive to crowding in the seedling stage, and this inhibits their survival and further growth after transplanting. In the latter species, delay in transplanting is not helped by temporary transfer from small to larger cells.

Fig. 8. Larkspur 'Sublime Dark Blue' 14 days before flowering, showing Treatment 3 in foreground, and Treatment 1 behind it.

Fig. 9. Godetia 'Flamenco Salmon', harvested at first flowering. Growing seedlings in large cells and transplanting promptly yields the largest plants (left). Crowding in seedling containers reduces plant size, especially if transplanting is delayed by 2 or 3 weeks.

SUNFLOWER PETAL LOSS EXPERIMENTS:

Growers of cut flower sunflowers have long complained about the susceptibility of some varieties to loss of petals soon after the flowers open. In general, varieties with dark or bicolored petals tend to be more susceptible to the disorder than those with yellow or orange petals. A graduate student in our program, Ms. Joyous Tata has substantiated the varietal differences, and had preliminary indications of the involvement of the plant growth hormones the cytokinins in petal retention. To confirm those findings, and find practical ways of applying these chemicals to the plants, we conducted a series of experiments in greenhouse and field. Initially, tests to determine when best time to measure the retention strength of petals on the flower head were conducted.

1. **TIME COURSE OF PETAL RETENTION FORCE:** To measure how quickly after the flower opens the petals can be easily removed from the flower head, a couple of greenhouse experiments were conducted early in the growing season. In the first, sunflower plants growing singly in 9 in. pots in a 80/70 F greenhouse were tagged at anthesis (flower just opening, petals unfolding), and harvested daily up to 10 days later. Petal retention force was measured on detached sunflower heads placed on a scale, with a clip attached to a petal. The pulling force was provided by an electric drill with string winding around a shaft that was rotating slowly, pulling up on the petal at 0.56 cm/sec (Fig. 10).

Fig. 10. Petal retention force measuring apparatus, consisting of a balance(left) on which a sunflower head is placed, held down by a weight. A clip attached to a petal is pulled upward by a string attached to an electric drill (right). The force needed to detach the petal is indicated by a decrease in weight on the balance.

A minimum of 4 petals were pulled on each half of the flower head, and the readings averaged. In Expt. 1, flowers of 'Procut Lemon' and 'Strawberry Blonde' were compared. In Expt. 2, the same varieties were used, but flowers were harvest at anthesis (defined as the point at which petals on a head have unfolded at least to form a right angle with the flower disk), and placed with stems in tap water in a lighted storage room set at 20 C, and kept for various periods before measurement.

Results and Discussion: The general pattern of petal retention force showed little change for the first 4 days after anthesis, but then declined to zero (Figs. 11 and 12). If heads were harvested at successively later times after anthesis, there appeared to be little difference between the varieties (Fig. 11). Flowers harvested at anthesis and stored showed that 'Procut Lemon' retained petals more strongly than 'Strawberry Blonde' (Fig. 12). This may indicate that varietal differences in petal retention, at least for these two varieties, may be based on differences in ability to withstand postharvest conditions. More work is needed to confirm this speculation. The results also indicated that differences between varieties in pulling force should appear at about 7 days after anthesis.

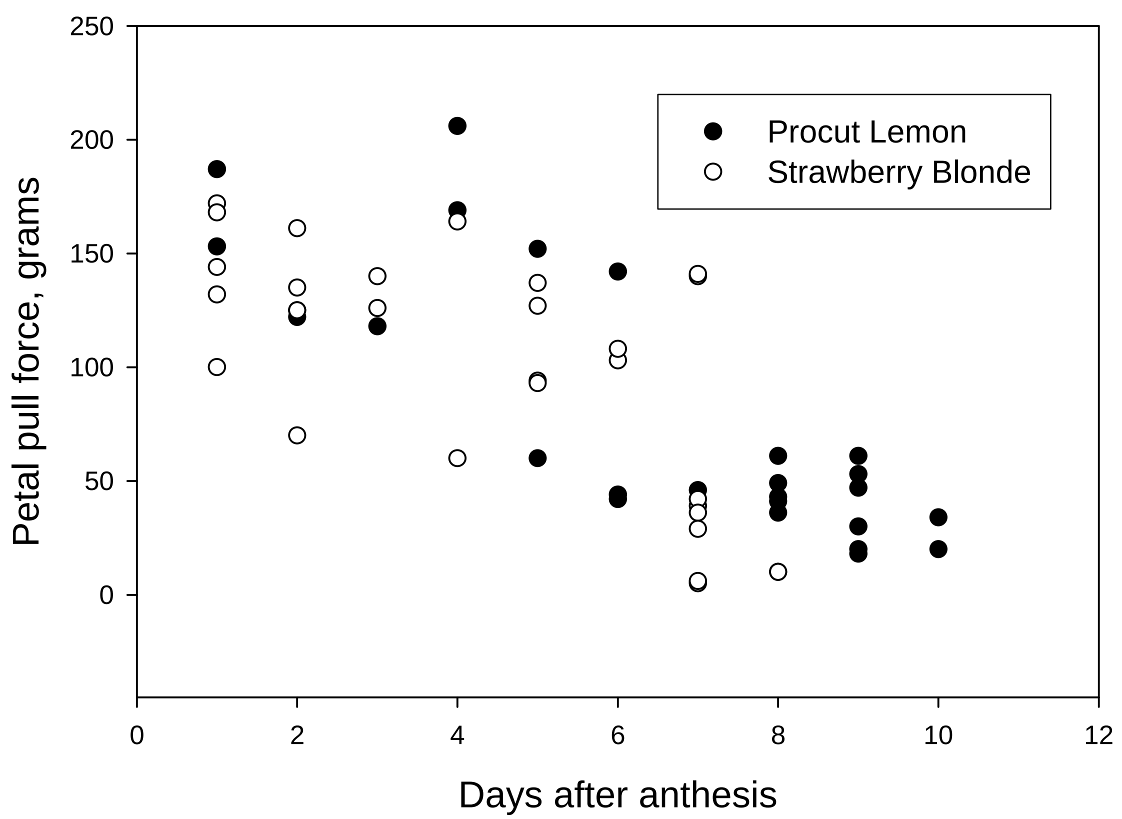

Fig. 11. Force required to remove petals from sunflower heads of varieties Procut Lemon and Strawberry Blonde when heads were sampled 1 to 10 days after flowers opened. In this experiment, heads remained attached to the plants until day of pull force measurement. Each point represents an average of 8 petals on a single head.

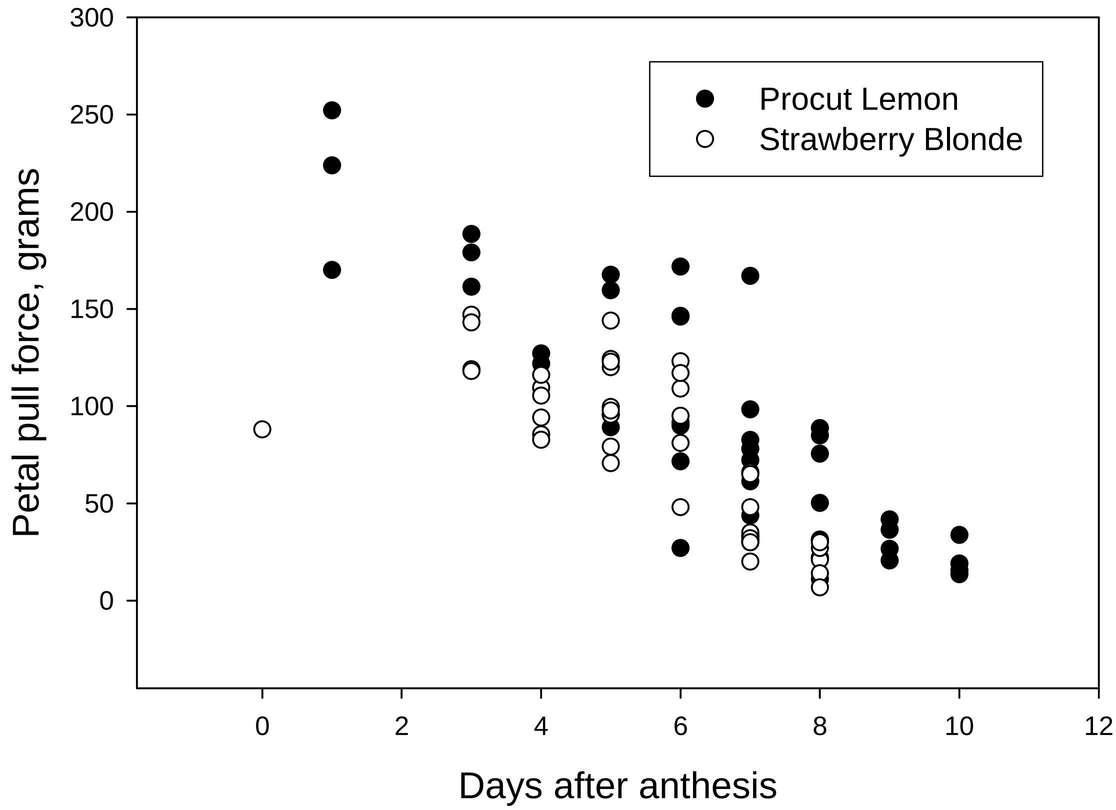

Fig. 12. Force required to remove petals from sunflower heads of varieties Procut Lemon and Strawberry Blonde when heads were sampled 1 to 10 days after flowers opened. In this experiment, plants were harvested at anthesis, and stored in a 20 C room until time of petal pulling. Each point represents an average of 8 petals on a single head.

2. **VARIETAL DIFFERENCES IN PETAL PULL FORCE:** Since the susceptibility of some sunflower varieties to petal loss was identified, some breeders have been selecting new lines that have better petal retention. Dr. Tom Heaton of Seed Sense, Inc. kindly supplied us with the original and advanced versions of 'Procut Bicolor', and we were eager to determine if progress in petal retention ability had been made.

   Materials and Methods: In an experiment planted in the high tunnel, we grew unreplicated plots of the following lines, and harvested flowers at anthesis:

   A. Procut Bicolor, original version
   B. Procut Bicolor, version 2
   C. Procut Bicolor, version 3
   D. Procut Bicolor, version 4
   E. Strawberry Blonde
   F. Procut Lemon

G. Cherry Rose

Plants were started in the greenhouse and transplanted to 9 x 9 in. spacing on May 28, with 2 seedlings per hole, to reduce head size. Plants were harvested at anthesis, and stored in a lighted storage room with stems in tap water at 20 C until petal retention force was measured using the instrument and technique described above. Heads were halved, and the petals on one side were pulled without disturbing the sepals. On the other half, all sepals below the petals to be pulled were trimmed back with scissors, to determine if sepals contributed to petal retention. For each harvest date, there were 5 petals measured per half head, with an average of 5 to 8 heads per variety. Each variety was sampled on days 1, 5 and 7 after harvesting at anthesis.

Results and Discussion: The pattern of pull strength decline in this trial was similar to that found in the greenhouse trials described above. There was a plateau of petal retention for the first 5 days, then pull strength declined linearly (Fig. 13). The rate of decline seemed faster for the original compared to version 4 of Procut Bicolor, but 'Procut Lemon' retained petals more strongly than either version.

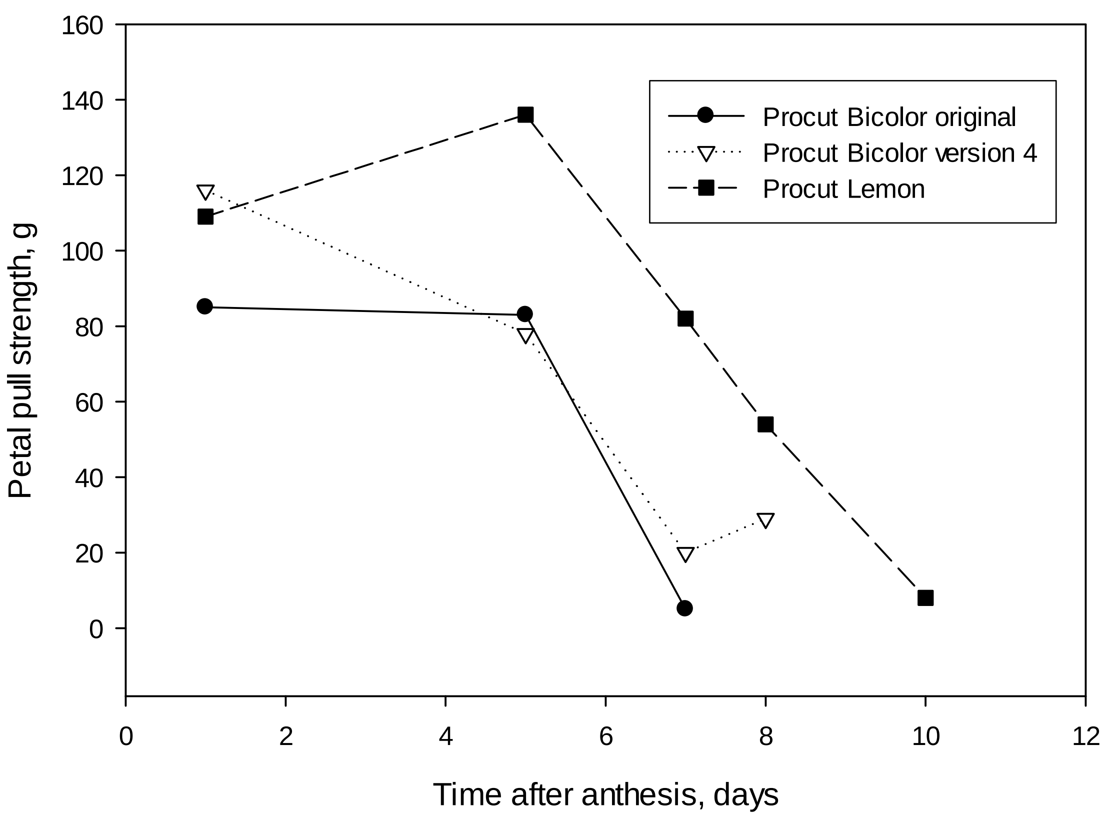

Fig. 13. Petal pull strength of three sunflower varieties with time after flower harvest.

Retention of petals of some versions of 'Procut Bicolor' (the original and version 3), was aided by the presence of sepals on the flower head (Table 3). The sepals appear to support the back of the petals, and prevent petals from breaking off, when they are pulled at an acute angle back from the head. Versions 2 and 4, and 'Procut Lemon' have good petal retention without sepal support.

Table 3 . Petal pull strength of six sunflower lines grown in a high tunnel, measured at 5 and 7 days after flower harvest. Pull strength was measured with heads intact, or sepals removed.

Variety	Petal pull force, g			
	Day 5		Day 7	
	Head intact	Sepals trimmed	Head intact	Sepals trimmed
Procut Bicolor V. 1	83	42	5	1
" V. 2	116	100	41	25
" V. 3	100	36	10	5
" V. 4	78	80	20	21
Strawberry Blonde	64	62	18	11
Procut Lemon	136	133	82	75

3. **CYTOKININ SPRAY TREATMENT FIELD EXPERIMENT:** Preliminary work by graduate student Joyous Tata indicated that dipping sunflower heads in cytokinin solution at anthesis could lengthen vase life, whereas stem uptake from the vase solution was not effective. It was thus thought that application of cytokinins as a spray onto the flower buds close to harvest might be a practical way of getting the chemical into the flower.

Materials and Methods: Three varieties of sunflower contrasting in tendency for petal loss (Strawberry Blonde, Chianti and Procut Lemon) were sown in seedling trays and transplanted to the field on July 13. They were arranged in a split plot experiment with cytokinin spray treatments as main plots, and varieties as subplots. Cytokinin treatments were 0, 100 and 300 ppm of benzyl adenine, applied to each variety at about 5 days before the flowers opened. The sprays were applied to Strawberry Blonde and Procut Lemon on Aug. 11, and Chianti on Aug. 17. Sprays covered the central flower bud and the surrounding leaves. There were 24 plants per plot, spaced 9 x 9 in. apart in 4-row beds, and each plot was separated from adjacent ones by a row of 'Moulin Rouge' plants as border. There were 3 replications.
At anthesis, flowers were harvested, placed in tap water in clean 5-gallon buckets into a storage room set at 68 F, with lights on a 12-hour timer. A week after harvest, petal pull strength was measured on 6 petals per flower.

Results and Discussion: There was no evidence that cytokinin application had any effect on petal pull strength in the three varieties tested (Table 4). As predicted from previous experiments, there were consistent differences in pull strength among the 3 varieties, with 'Chianti' having lowest retention values after 7 days storage, and 'Procut Lemon' the most (Table 4). The lack of response could be due to either a lack of uptake of the chemical by the plants, or ineffectiveness of the chemical in petal retention. To check the latter, head dip experiments were conducted, as described below.

Table 4. Petal pull strength of three sunflower varieties treated with sprays of cytokinin solution before anthesis, and stored at room temperature for a week after harvest at anthesis.

Variety	Cytokinin concentration, ppm			
	0	100	300	Ave.
Chianti	30	27	38	32c
Strawberry Blonde	54	47	46	49b
Procut Lemon	113	113	116	114a

4. **CYTOKININ HEAD DIP EXPERIMENT #1:** To determine if dipping of sunflower heads at anthesis in cytokinin solution would affect petal pull strength, field-grown plants of 'Cherry Rose' sunflower were harvested at anthesis and treated as described below.

Materials and Methods: The harvested flowers were trimmed to the central flower and one leaf and stem, with total length of about 10 in. These were dipped upside down into a 3000 ml of cytokinin solution to which two drops of detergent had been added. Flowers were kept in the solution for 5 minutes, then placed in quart jars, with 3 flowers per jar, and kept in the lighted storage room for a week, as with the bud spray experiment. Cytokinin concentrations were 0, 100 and 300 ppm, and there were 3 flowers per jar, and three replications. Pull strength readings were taken after a week of storage.

Results and Discussion: Petal pull strength readings after one week of storage averaged 80 g across treatments, and there were no significant differences among treatments. The results echoed the lack of effect of cytokinin application as a spray treatment to the flower head, and place doubt on the role of these hormones on flower petal abscission in sunflower.

5. **CYTOKININ HEAD DIP EXPERIMENT #2:** The experiment was repeated using the original version of Procut Bicolor, raised in the high tunnel in Sept-Oct. At anthesis, flowers were harvested, trimmed as above, dipped for 6 min., and stored in quart jars in the lighted storage room for 5 and seven days. There were 5 replications per treatment. At the end of each storage period, flowers were halved, and petal pull force measured on five petals per half. Measurements were made on one half of the flower leaving sepals intact, and the other with sepals removed with a pair of scissors just before measurement. Presence of sepals in this variety protects the petals from abscission.

Results and Discussion: In contrast to Head Dip Expt. 1, there appeared to be a positive reaction to dipping the heads in cytokinin solution (Table 5). For intact heads, petals on heads dipped in 300 ppm BA were retained more strongly than those given the other two treatments. The effects did not become significant until flowers had been stored for 7 days. Petals from heads whose sepals had been removed before measurement showed a similar, but less distinct trend. Sepals afford significant protection to petals in this variety; sepal removal reduced pull force by 38% in this experiment.

Table 5. Petal pull force (g) of sunflower Procut Bicolor, original version, as affected by presence or absence of sepals and time after the start of postharvest storage.

Treatments	Head intact	Sepals removed
Time: 5 days	128	78
Time: 7 days	133	85
Stat. signif.	n.s.	n.s.
Control	126	78
100 ppm BA	116	76
300 ppm BA	150	90
Stat. signif.	n.s.	n.s.
Interaction:		
Control, 5 days	134	91
100 ppm, 5 days	129	78
300 ppm, 5 days	123	64
Control, 7 days	119	66
100 ppm, 7 days	103	73
300 ppm, 7 days	177	115
Interaction signif.	*	P= 0.06

SUNFLOWER FIELD PHOTOPERIOD SCREEN:

Many sunflower varieties grown as cut flowers are sensitive to daylength in the seedling stage. In past years, we have screened 42 varieties for their reaction to short (12 hrs) or long (16 hrs) days in the first three weeks after emergence, and found that 57% flowered 7 days or more earlier after short day treatment. These earlier flowering plants tend to be smaller at flowering, and have a proliferation of flower buds on the stem. Short days would occur if these varieties were sown in a greenhouse in mid-March, for an early crop to be transplanted to a high tunnel.
To check new varieties for this disfiguring characteristic, we screened 4 new and 2 standard varieties for their reaction to daylength in 2010.

Materials and Methods: Seeds of the following varieties were sown in 72-cell trays in a greenhouse, and exposed to either 12 hours or 16 hours daylength on a bench in which black curtains were pulled over the plants for the specified period during the first three weeks after emergence. At the end of that time, the plants were transferred to a field plot, in which plants were arranged in 24-plant plots, with varieties as subplots and daylength treatments as main plots. There were 2 replications.

Varieties and Souces:

1. Sun-4-U Bicolor (Gloeckner)
2. Sun-4-U Orange
3. Solar Power
4. Procut Gold (Seed Sense)

5. Procut Lemon
6. Sunrich Orange (Harris)

Results and Discussion: As in previous screening tests conducted with sunflowers, some of the varieties did not react to the photoperiod in the seedling stage with a change in flowering date and plant appearance (Table 6). These included 'Solar Power', 'Procut Gold' and 'Procut Lemon'. The two 'Sun4U' lines, and 'Sunrich Orange' flowered earlier after short day treatment, and these plants were shorter and had smaller flowers. The appearance of flower buds on the upper nodes of the main stem was reduced under long day conditions in the varieties that were daylength sensitive, but not in the others (Table 7).

Table 6. Flowering dates and stem length of six sunflower varieties exposed in the first three weeks after emergence to either 12 or 16 hrs. daylength prior to transplanting to the field. The interaction of daylength treatment and variety is significant at the 0.001 level for both variables.

	Flower date, days after sowing			Stem length, cm	
Variety	Short day	Long day	Difference	Short day	Long day
Sun4U Bicolor	57	64	7	121	142
Sun4U Orange	58	64	6	132	136
Solar Power	68	68	0	172	164
Procut Gold	60	56	-4	124	108
Procut Lemon	60	58	-2	106	96
Sunrich Orange	56	68	12	88	138

Table 7. Influence of early photoperiod on the flower diameter, leaf number on the main stem and on the no. of flower buds on the upper 4 nodes of the main stem.

	Flower dia., cm		Main stem leaf no.		Bud no.	
Variety	Short day	Long day	Short day	Long day	Short day	Long day
Sun4U Bicolor	5.1	6.2	16	16	1.6	0.6
Sun4U Orange	6.1	7.2	14	14	1.1	0
Solar Power	7.0	7.0	23	21	2.2	1.8
Procut Gold	6.4	5.9	17	17	0	0
Procut Lemon	6.5	6.0	16	16	0	0
Sunrich Orange	4.8	8.0	12	22	0.8	0

Fig. 14, Four sunflower varieties in the photoperiod test: ‘ Procut Gold’ (upper left), ‘Solar Power’ (upper right), ‘Sun4U Orange’ (lower left), and ‘Sun4U’ Bicolor’ (lower right).

RUDBECKIA LIGHTING EXPERIMENT:

Rudbeckia hirta is a colorful perennial species that produces cut flowers with yellow to red-brown flowers. Unfortunately, under the short daylengths of late summer and fall, these plants fail to flower, or produce flowers with very short stems. From experiments in 2009, we determined the light levels needed to trigger the daylength response in this species, and found that we could have high enough intensity to stimulate stem elongation, but the type of solar light did not have a satisfactory light distribution. In the present experiment, conducted in the high tunnel, we repeated using mains lights and a no-light control, and tried using solar Christmas tree lights, draped over the plants, to stimulate stem elongation and flowering.

Materials and Methods: There were 3 lighting treatments: an unlit control, solar cell-powered Christmas tree lights that were draped on the plants, and grid-powered button lights facing downward above the plant canopy (Fig. 16). The solar lights came on at dusk, and stayed lighted into the night; the grid-powered lights were connected to a timer to extend daylength to 16 hrs. Within each plot, there were 18 plants of 'Prairie Sun' and 'Autumn Colors' Rudbeckia, spaced 12 x 12 in. apart in 3 rows on each bed. All main plots were surrounded by black landscape cloth barriers 2 ft. high, to prevent light contamination from one plot to another. There were 3 replications. Seeds were sown on June 16, and the seedlings transplanted on July 29. Plants were allowed to grow under natural daylengths until Sept. 13, when the light treatments were installed. Open flowers were harvested at anthesis from all plots until the end of the experiment on Nov. 4.

Results and Discussion: As in the previous year, the lighting treatments produced significant differences in stem length among the plants (Table 8). The unlit control plants were the shortest, and those exposed to high intensity grid-powered lights were tallest. The intensity of the solar lights was too low to bring about a practical degree of stem extension. Stem yield per plant was variable among treatments, and was not significant (Table 8).

The plants started to flower before the lighting treatments were started, and in the daylengths of late August and early September, stem length was already rather short (Fig. 15). The plants given high light intensities already showed a response in height within two weeks, and maintained these longer stems until the end of the experiment. The unlit controls produced progressively shorter stems as daylength decreased into November (Fig. 15). By that time, even flowers in the solar light treatment were essentially sessile (Fig. 16).

Taken together with the results of the 2009 trial, there appears to be no practical way of extending daylength with solar lights to modify flowering and stem length in Rudbeckia. As light intensities of solar lights become higher, and their cost decreases, this approach might be tried again.

Table 8. Stem length and yield of two varieties of Rudbeckia, grown in the high tunnel in the fall, either under natural light conditions, or with daylength extended to 16 hrs. using solar lights or with grid-powered lights.

Treatments	Stem length, cm	Stems/plant
Control	21 c	3.6
Solar lights	25 b	3.7
Grid-powered lights	38 a	4.4
Treat. stat. signif.	***	n.s.
Prairie Sun	30	4.1
Autumn Colors	26	3.4
Var. stat. signif.	**	n.s.

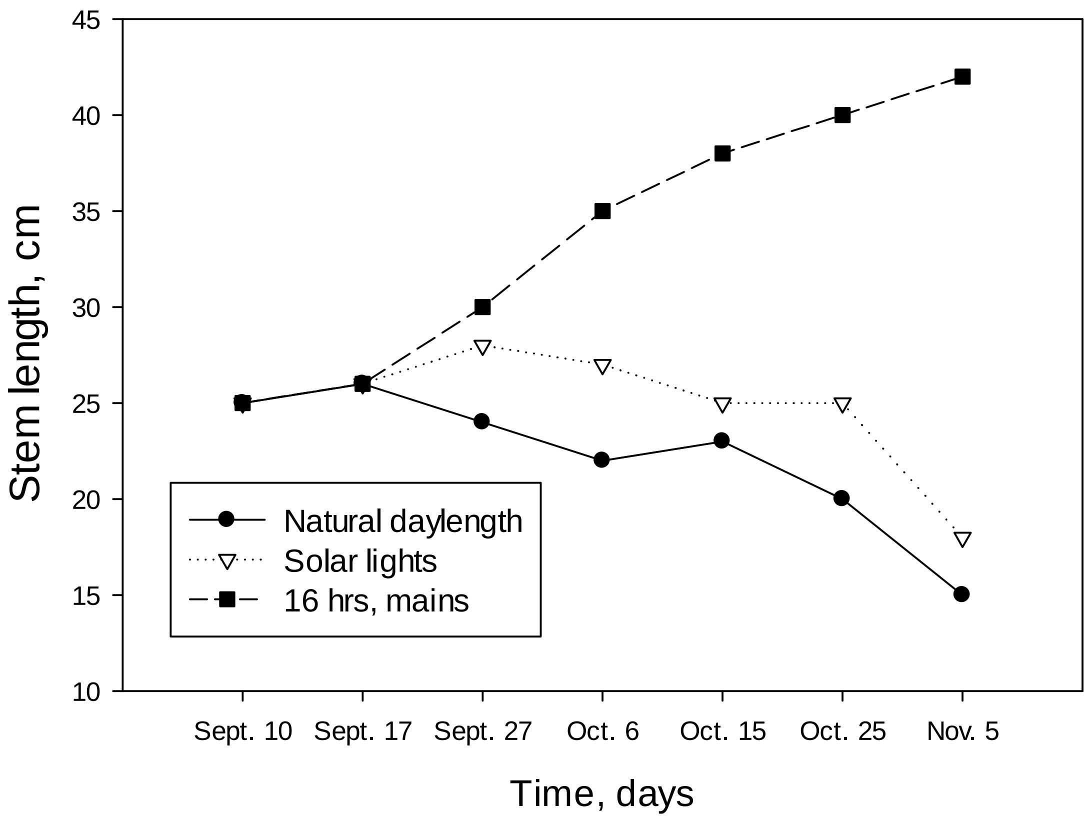

Fig. 15. Length of harvested stems of two varieties of Rudbeckia grown in a high tunnel, as influenced by exposure to either natural light, solar-powered lights or mains-powered lamps on a 16 hr. timer.

Fig. 16. Sessile flowers of ‘Prairie Sun’ rudbeckia, with solar light suspended from a net grid above the foliage. Photograph made Nov. 8, 2010.

DELPHINIUM PLANT STAND TRIAL:

Over the years, we have had difficulty preventing plant death of delphinium in the year of establishment. Typically, plants produce one flower spike, and then turn yellow and die. Inspection of the root system indicates a root disease problem, but isolation attempts have not turned up recognizable pathogens. We have tried cooling the soil after transplanting using straw mulch, or silver reflective mulch, and found no effect on plant stand. A trial with 3 compost media in which seedlings were grown also had no effect. In 2009, we applied ‘Rootshield’ to lisianthus seedlings at transplanting, and saw a distinct reduction in plant mortality. The current trial tested if this treatment could improve plant stand of delphinium.

Materials and Methods: Two soil treatments were applied to determine the effect on delphinium plant stand: a control and a soil drench with T-22 Trichoderma (‘Rootshield’), applied at the rate of 4 oz. per gallon of water at transplanting. Two varieties were compared, namely ‘Guardian Mix’, which in previous trials has been susceptible to plant decline, and ‘Centurion White’, a vigorous variety that maintained plant stand very well in 2009.

Plots consisted of 18 plants spaced 12 x 12 in. apart in 3 rows per bed. The experimental design had soil treatment as main plots, and varieties as subplots. There were 3 replications. Seeds were sown on March 23 in the greenhouse in 72-cell trays, and transplanted to the field on May 17.

Results and Discussion: Adding Trichoderma T-22 (‘Rootshield’) to the transplant solution had no discernible effect on plant performance or plant stand (Table 9). There was however a big difference in the performance of the two varieties used in the trial. Growth of ‘Centurion White’ was much more vigorous than ‘Guardian Mix’. Flower stems were significantly taller, and 92% were still growing actively on Sept. 15, whereas ‘Guardian’ had shorter stems, and only 24% of plants were still growing actively by Sept. 15. Although stem yields were the same for the two varieties, ‘Guardian’ produced that yield early, whereas ‘Centurion’ started flowering nearly 20 days later, and continued producing long stems late into the fall. The trial was allowed to overwinter into 2011, and stand counts will again be taken in spring to determine plant survival. The results indicate that ‘Rootshield’ is not an effective remedy for the plant decline afflicting some delphinium varieties in our trials. Some varieties have more vigorous growth and yield well into the fall, and hopefully in the following year.

Table 9. Stem length, yield, days to flower and plants actively growing for two delphinium varieties treated with ‘Rootshield’ in a field experiment.

	Stem length, cm	Stems/plant	Days to first flower	Plants growing on Sept. 15, %
Control	61	4.5	111	54
Rootshield	58	4.5	110	62
Treat. stat. signif.	ns	ns	ns	ns
Guardian Mix	49	4.4	101	24
Centurion	69	4.6	119	92
Var. stat. signif.	**	ns	***	**
Interaction signif.	ns	ns	ns	ns

VARIETY TRIALS

AMARANTH AND CELOSIA:

This trial was conducted in both high tunnel and field. Seeds were started on March 29 and April 8, for tunnel and field, respectively, and transplanted around April 21 and May 14, respectively. Plants were spaced 9 x 9 in. apart in 4 rows, with 24 plants per plot. There were 2 replications in both locations.

Varieties tested included:

1. Celosia Red Flame (Genesis)
2. Amaranthus caudatus Mira (Goldsmith)

3. Celosia Celway Purple (Kieft)
4. Celosia Celway Terra Cotta (tunnel); Celosia Spring Green (Harris) (field)
5. Celosia Cramer’s Amazon (Johnny’s)
6. Amaranth Love Lies Bleeding (Johnny’s) Tunnel only

Results and Discussion: The relatively early planting of both trials exposed the plants to cool conditions in tunnel and field after transplanting, so that flowering and vigorous growth was relatively delayed. The plants eventually outgrew the early stunting, and produced reasonable yields (Tables 10, 11). ‘Red Flame’ produced stems of moderate length. The flower was a dark red comb of medium size, and performed well in both tunnel and field. This is a promising variety that is worthy of further trial.

‘Celway Purple’ is a plume type of celosia, and in these trials was of similar productivity and stem length to ‘Red Flame’. Color and head type were not as attractive as the latter, however. ‘Celway Terra Cotta’ (Fig. 17) was only grown in the tunnel, and was productive and of similar stem length as ‘C. Purple’. The plume colors of orange and pink blended in with the green leaves. ‘Cramer’s Amazon’ grew vigorously in the tunnel, producing plants more than 6 ft. tall, with red and green variegated foliage and relatively small and late plumes.

Of the two amaranths grown, ‘Love Lies Bleeding’ was the more productive, with long trailing purple flower heads that were produced all summer long in the tunnel (Fig. 18). Although the first stem was quite thick and massive, it would seem that topping the plants in the vegetative stage would yield smaller stems more useful in arrangements. ‘Mira’ has similarly trailing flowers, but the color of the inflorescence varies from green to green with pink spots, to almost completely purple. Stems and flowers were more massive than ’LLB’, so topping might be useful to reduce these characteristics. The variety appeared to be susceptible to root rot, with early yellowing and senescence of leaves terminating plant life and limiting stem yields.

Table 10. Stem length, yield and earliness of six amaranth and celosia varieties grown in the high tunnel in 2010.

Variety	Stem length, cm	Stems/plant	Days to first flower
Celosia Red Flame	55	6.1	80
Amaranth Mira	83	2.1	97
Celosia Celway Purple	61	9.9	77
Celosia Celway Terra Cotta	62	13.7	89
Celosia Cramer’s Amazon	96	14	91
Amaranth Love Lies Bleeding	69	7.1	84

Table 11. Stem length, yield and earliness of flowering of six amaranth and celosia varieties grown in the field in 2010.

Variety	Stem length, cm	Stems/plant	Days to first flower
Celosia Red Flame	52	5.0	78
Amaranth Mira	82	0.4	97
Celosia Celway Purple	61	5.8	97
Celosia Spring Green	28	1.0	59
Celosia Cramer's Amazon	96	15	99

Fig. 17. 'Celway Terra Cotta' celosia in high tunnel.

Fig. 18. Amaranth 'Love Lies Bleeding'

Fig. 19. 'Celway Purple' celosia

ASTER (*Callistephus chinesis*):

The trial consisted of 4 new varieties and 2 standards, and was conducted only in the field. Seedlings were sown in the greenhouse on April 6, and transplanted to the field on May 19. Spacing in the field was 9 x 9 in., with 24 seedlings per plot. There were 2 replications. To guard against early infection with aster yellows disease, carried by leafhoppers, the planting was protected by a low tunnel covered with 'Typar' spun-bonded fabric, held up by hoops made from electrical pipe, roughly 3 ft high and 4 ft wide. The fabric stayed in place until early August, when the plants started to touch the fabric, and were starting to flower.

Varieties included:

1. Palette Mix (Gloeckner)
2. Nina Semi Double Rose (Takii)
3. Nina Semi Double Salmon Pink
4. Nina Semi Double Salmon Pink
5. Idyll Mix (Harris)
6. Giant Princess Formula Mix (Johnny's)

Results and Discussion: In spite of nearly season-long covering, the planting suffered a high mortality from disease. From the symptoms, it was most likely aster wilt (*Fusarium conglutinans*), a soil-borne fungus that can also be carried on the seed. All varieties in the trial seemed to be susceptible. Aster yellows disease was not apparent in the planting.

All the new varieties were similar in having flower size of 1 to 2 in. diameter, with relatively leafy and branched stems. Palette Mix had single flowers ranging in color from white through pink to purple and dark blue. The Nina series has double flowers (Fig. 20) with centers still visible. The white line appeared to be most productive, and would make an attractive filler in the vase. The two standards included were both double types with quill-shaped petals. Without a better means of controlling plant disease, the aster crop will remain a risky proposition, at least in our location (Fig. 21).

Table 12. Stem length, yield and earliness of six aster (*Callistephus*) varieties grown in the field in 2010.

Variety	Stem length, cm	Stems/plant	Days to first flower
Palette Mix	54	4.2	127
Nina Semi Double Rose	52	3.8	127
Nina S. D. Salmon Pink	58	6.8	122
Nina S. D. White	52	11.8	108
Idyll Mix	53	2.8	122
Giant Princess Mix	57	5.2	113

Fig. 20. Aster ‘Nina Semi Double Rose’


Fig. 21. Aster trial with hoops that held up the protective fabric. Note high incidence of collapsed and dead plants.

BELLS OF IRELAND (*Molucella laevis*):

After many years of only having a single cultivar of Molucella , a second one has now been made available. We compared the two in the high tunnel. Seeds were sown on March 11, and the plants were transplanted on April 21. Plants were spaced 9 x 9 in., with 20 plants per plot, and two replications. The two varieties were Country Bells (Genesis) and the standard Bells of Ireland (Harris).

Results and Discussion: Both accessions were productive and tall, yielding nearly 10 stems per plant (Table 13). 'Country Bells' was a week later in flowering date than the standard, but did not differ from it in stem strength. Both lines have a tendency to droop in the vase, an undesirable trait.

Table 13. Stem length, yield and days to first flower for two cultivars of *Molucella* in a high tunnel trial in 2010.

Variety	Stem length, cm	Stems/plant	Days to first flower
Country Bells	80	8.8	104
Bells of Ireland	62	9.8	97

Fig. 22. *Molucella* 'Country Bells' growing with support netting in the high tunnel.

CAMPANULA:

For many years, the Champion series of *Campanula medium* that flowers without the need for a cold treatment has been a popular cut flower for spring. Now the Campana series has been released, and can be compared to the standard.

Materials and Methods: The trial was conducted in the high tunnel. Seeds were sown on March 1, and the seedlings transplanted on April 21 to a 9 x 9 in. spacing in 4 rows. There were 24 seedlings per plot, in two replications. Varieties included:

1. Campana Deep Blue (Kieft)
2. Campana Pink
3. Champion White (Harris)

Results and Discussion: The two new accessions were comparable in stem length and yield to 'Champion White', but were nearly a week later in flowering (Table 14). The flowers of the new lines were attractive (Figs. 23,24), and represent an alternative source for this desirable and attractive cut flower.

Table 14. Stem length, yield and first flowering time for three Campanula varieties in the 2010 high tunnel trial.

Variety	Stem length, cm	Stems/plant	Days to first flower
Campana Deep Blue	44	7.4	104
Campana Pink	50	6.4	106
Champion White	46	6.7	99

Fig. 23. Campana Deep Blue

Fig. 24. Campana Pink

DIANTHUS:

This is another species that has been converted by flower breeders from the biennial Sweet William to varieties that flower in the first year from sowing.

Materials and Methods: This trial was conducted only in the field. Seeds were sown March 22, and transplanted on May 5. Spacing was 9 x 9 in., with 20 seedlings per plot, in two replications. Varieties included in the trial:

1. Sweet with Red Eye (Ball)
2. Fandango Crimson (Goldsmith)
3. Fandango Crimson Picotee
4. Fandango Purple Picotee

5. Volcano Mix (Genesis)
6. Sweet Mix (Harris)
7. Amazon Rose Magic

Results and Discussion: Plants in the trial grew well and were productive. Of the varieties grown, 'Fandango Crimson', and 'Fandango Crimson Picotee' had insufficient stem length, and harvest was discontinued early in the season because of that fact (Table 15). These varieties would be better suited for bedding plant use than as cut flowers. 'Fandango Purple Picotee' was somewhat taller in this trial, and may be worth another look. The flower has a dark red center with purple outer fringe, and frilly petal edges (Fig. 25).

'Sweet Red with White Eye' is a productive, attractive variety with crimson petals and a pink eye and a slight scent. It is a promising addition to the 'Sweet' series. None of the new lines can match the 'Amazon' series in stem strength and stem length, as indicated by 'Amazon Rose Magic' in this trial.

Table 15. Stem length, yield and earliness of seven dianthus lines grown in a field trial in 2010.

Variety	Stem length, cm	Stems/plant	Days to first flower
Sweet Red with White Eye	37	12.2	92
Fandango Crimson	30	2.8^z	102
Fandango Crimson Picotee	30	4.8^z	93
Fandango Purple Picotee	35	14.4	95
Volcano Mix	38	9.4	101
Sweet Mix	39	10.9	96
Amazon Rose Magic	46	11.8	104

^{z}Stems too short, harvest discontinued

Fig. 25. Dianthus 'Fandango Purple Picotee'.

GOMPHRENA:

Globe amaranth is a popular cut flower of medium height that thrives in warm weather. The new variety 'Fireworks' (Harris Seeds) was advertised to be something different, so we planted it in both tunnel and field, at 12 x 12 in. spacing. The seeds were sown on April 22, and transplanted June 2 in both locations.

The variety was notable for its rapid growth. It started to flower in early July in the high tunnel, and 10 days later in the field, and produced a profusion of cuttable flowers all summer long. Stem length averaged 77 cm in the tunnel, and 73 cm in the field. The plants produced an impressive 46 stems each in the tunnel, and 20 in the field, but the latter total could have been higher if we had kept up with harvesting. Flower heads were small in comparison to many gomphrena varieties, but made an attractive filler in mixed bouquets (Fig. 26).

Fig. 26. *Gomphrena globosa* 'Fireworks' showing vigorous plant growth (left), and closeup of flower on right.

ORNAMENTAL KALE:

In the cold conditions of fall, the inner developing leaves of some kale and cabbage varieties develop purple, pink or white. Combined with a long stem, these lines make exotic cut 'flowers' in fall bouquets.

Materials and Methods: The trial was conducted in both high tunnel and field. Seeds were sown in the greenhouse on June 24, and set out in both locations on July 23. A 6 x 6 in. spacing with 6 rows per bed was used in the trials, and Hortanova netting was laid on the ground at transplanting for use as a plant support later in the season. The tunnel trial had 24 seedlings per plot; in the field, lack of seedlings required that the Lucir lines were unreplicated. To assess susceptibility to insect pests, insecticide sprays were deliberately delayed in both trials, but as damage became disruptive, organic materials were used for insect control. During summer and early fall, lower leaves were removed as the plant stems lengthened. This procedure resulted in smoother leaf scars on the stem and facilitated final harvests. Plant harvests began on October 15, and lasted until Nov. 15 in both locations. Varieties included in the trial:

1. Lucir Red (Takii)
2. Lucir White (Takii)
3. Giraffe (Murikami)
4. Crane Bicolor (Harris)

Results and Discussion: Color development was temperature-dependent, and reverted to green in intervening warm spells (Fig. 27).

Table 16. Stem length and diameter of the colored heart of the plant at harvest for four ornamental kale varieties grown in the field and the high tunnel.

	Stem length, cm		Heart diameter, cm	
Variety	Field	High tunnel	Field	High tunnel
Lucir Red	41	50	8.4	9.4
Lucir White	47	62	8.0	8.0
Giraffe	46	50	8.6	8.8
Crane Bicolor	57	63	9.6	10.7

The Lucir varieties had in general somewhat thinner stems and smaller colored hearts than the standard 'Crane Bicolor' (Table16). All varieties got tall enough to be useful in arrangements, and the spacing used kept the plants small enough so they did not overwhelm other items in the vases. The Lucir lines have no waxy bloom on the leaves, and this appears to make them more attractive to flea beetles, that caused considerable scarring in both locations, until insecticide applications were used. These lines appeared to be equally susceptible to attack by cabbage maggots as the other two lines.

Fig. 27. 'Crane Bicolor' (upper left), showing white center reverting to green in warm weather; 'Lucir Red' (upper right); 'Giraffe' (lower left) and 'Lucir White' (lower right). Note flea beetle damage on lower leaves of the Lucir lines.

LISIANTHUS:

With its resemblance to roses, the large range of available colors, and its long vase life, lisianthus has become a valuable cut flower. For 2010, the ASCFG variety testing program made available 14 new lines, and we planted them both in the high tunnel and in the field.

Materials and Methods: For both trials, seeds were started in 128-cell trays in a greenhouse. The intended plant population of 20 seedlings per plot, spaced 9 x 9 in. in 4 rows, was not reached in all cases, due to low germination. 'Excalibur Yellow' and 'Mariachi Yellow Improved' had only enough seed to be planted in the tunnel. There were 2 replications for each planting. The tunnel planting was sown Feb. 2 and transplanted May 4; the field planting was sown March 1 and transplanted May 28.

Results and Discussion: Overall, stems were generally longer on tunnel-grown plants, but only 3 varieties were clearly more productive in the high tunnel environment (Table 17). Although plants in the tunnel took about 2 weeks longer from sowing to flowering than those grown in the field, the one month earlier planting date in the tunnel still allowed actual flower harvest to start 2 weeks earlier in the tunnel.

Table 17. Stem length, yield and earliness of flowering (days after sowing) for 14 new lisianthus varieties and one standard line, grown in the high tunnel and the field in 2010.

	Stem length, cm		Stems/plant		First flower date, DAS	
Variety (Source)	Tunnel	Field	Tunnel	Field	Tunnel	Field
ABC 1-3 Green (Ball)	42	35	5.5	5.8	164	143
ABC 1-3 Misty Blue	38	33	6.8	7.0	158	141
Excalibur Pure White (Sakata)	42	42	7.6	3.6	166	151
Excalibur Yellow	49		5.0		170	
Mariachi Yellow Improved	48		6.1		164	
Mariachi Carmine	38	37	4.6	4.3	166	158
Mariachi Pink Picotee	42	41	5.5	3.4	168	155
Piccolo 2 Pure White	46	39	3.8	3.7	169	150
Piccolo 2 Purple	40	38	4.8	5.5	169	146
Rosita 2 Jade	43	40	5.6	5.3	163	148
Rosita 2 Purple	39	37	3.0	2.6	175	159
Arena 4 White (Takii)	48	49	2.2	2.9	197	177
Arena 3 Red	54	46	2.2	2.1	183	176
Vulcan 2 Deep Purple	46	40	2.8	4.6	174	158
Echo Champagne (Johnny's)	46	37	7.4	3.6	156	148

Fig. 28. 'ABC 1-3 Misty Blue' lisianthus

The two ABC lines were among the earliest varieties in the trial. 'Misty Blue' was particularly noteworthy in its unusual color and high productivity (Fig. 28).

Fig. 29. 'Mariachi Yellow Improved'

' Excalibur Pure White' looked promising in the high tunnel, but the presence of a number of green off-types prevented a fair evaluation in the field. 'Mariachi Yellow Improved' was another noteworthy line, with large double flowers on long stems (Fig. 29). The plants had a tendency to lean without support, so would need netting to prevent lodging. 'Mariachi Carmine' has an interesting flower color, and attractive striped buds. Although stem length could be improved, the similarity to a rose flower is noteworthy.

Another interesting Mariachi line is' Mariachi Pink Picotee', featuring a delicate pink flower edge (Fig . 30). Of moderate productivity and medium stem length, it suffered in the field planting from nearly 50% rosetting (plants stayed short, did not extend flowering stems).

The 'Piccolo' series lines have single flowers of relatively small size, and stem length and productivity that are not particularly outstanding (Fig.30). The Rosita series was represented by 'Rosita 2 Jade', a green double flower of medium size, and Rosita 2 Purple, with a deep purple double flower (Fig. 30). 'Jade' was the more productive and taller of the two.

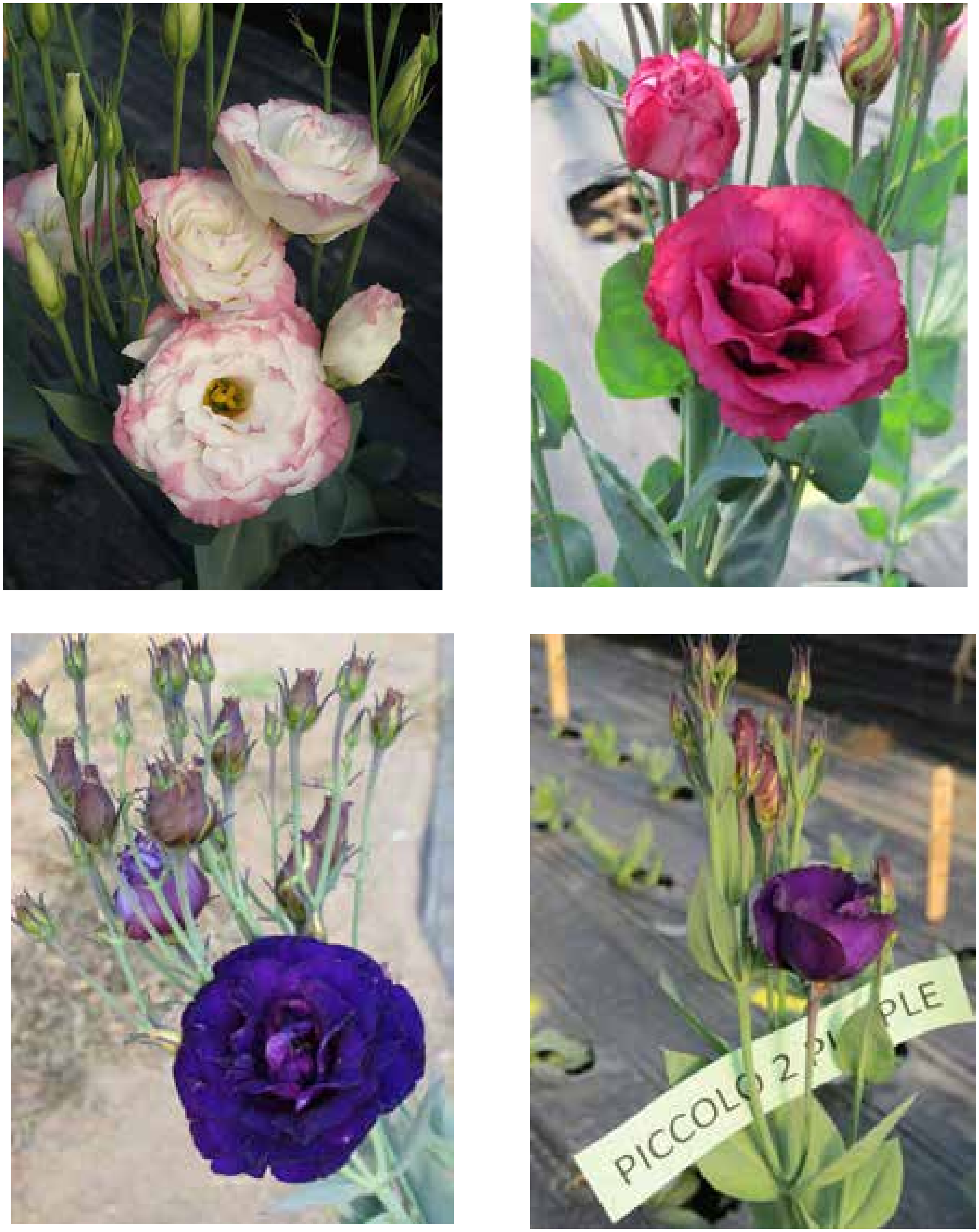

Fig. 30. Mariachi Pink Picotee (upper left), Mariachi Carmine (upper right), Rosita 2 Purple (lower left) and Piccolo 2 Purple (lower right).

Neither of the two Arena lines were early enough for even the tunnel conditions. 'Arena 4 White' had tall, very large double flowers, but more than half of the plants rosetted in both trials, and yield was unacceptably low. 'Arena 3 Red' was similarly late and unproductive. 'Vulcan 2 Deep Purple' resembled the Piccolo series with its small single flowers and less than average productivity. 'Echo Champagne' continues to be the "one to beat" in earliness and productivity, especially in the high tunnel.

MARIGOLD:

The marigold has traditionally been a bedding plant, prized for its colorful show in containers and flower beds. Recently, selections to increase stem length have been successful, and the current trial compares five new lines with a standard long-stemmed variety.

Materials and Methods: The trial was planted in both high tunnel and the field, at 12 x 12 in. spacing, with 3 rows per bed and 15 seedlings per plot. For the tunnel, seeds were started in the greenhouse on April 3, and transplanted on May 5; for the field trial, the corresponding dates were April 19 and May 17.

Varieties included in the trials:

1. American Babuda Deep Gold (Gloeckner)
2. American Babuda Yellow
3. American Bali Yellow
4. American Narai Yellow
5. American Pagoda Yellow
6. Giant Orange (Johnny's)

Results and Discussion: Growth of the plants was vigorous in the high tunnel without application of pesticides, but in the field, growth was stunted and flowering delayed, probably by a high incidence of leaf hoppers. Since this did not occur in the high tunnel, we decided not to spray either trial, but as a result, the field plots yielded only one quarter to half the no. of stems. Thus only the tunnel results are recorded here, with the caution that control of insect pests may be necessary for marigold production in field conditions.

Table 18. Stem length, yield and date of first flowering (from sowing), for six marigold varieties grown in the high tunnel in 2010.

Variety	Stem length, cm	Stems/plant	Days to first flower
American Babuda Deep Gold	69	7.2	92
American Babuda Yellow	57	10.4	82
American Bali Yellow	34	8.0	89
American Narai Yellow	42	13.6	80
American Pagoda Yellow	27	6.6	88
Giant Orange	61	14.3	80

Fig. 31. 'American Babuda Yellow (top), 'American Narai Yellow' (left), and 'Giant Orange' (right)

Of the varieties grown, 'American Pagoda Yellow' and 'American Bali Yellow' had stems that were too short to be considered cut flowers (Table 18). 'American Babuda Deep Gold' was the latest and tallest variety in the trial and had relatively long branches for easier harvesting. ' American Babuda Yellow' was productive, with intermediate stem length, and among the earliest in the tria (Fig. 31). 'American Narai

Yellow' was shorter than 'American Babuda Yellow', but more productive. The standard line included, 'Giant Orange' had good stem length and productivity, but was susceptible to branch and flower stem breakage. It also had a stronger "marigold" smell than the other lines.

Tests of these lines in the vase showed them to have at least a 2 week vase life, and they provided a welcome emphasis in arrangements. Unfortunately, although productive, we found that there was a strong antipathy to this flower among fellow staff members and the general public.

SCABIOSA:

We have grown the annual *Scabiosa attropurpurea* in previous years, and have been impressed with its huge poduction of attractive pin-cushion flowers. The current test is a planting of a perennial species, *Scabiosa caucasica*, developed to flower in the first year.

Materials and Methods: Seeds for the trial were sown on April 6 and transplanted to the field on June 2. Plants were spaced 12 x 12 in., with 18 plants per plot. Varieties included were:

1. Fama Deep Blue (Benary)
2. Fama Deep Blue Improved
3. Fama White
4. Perfecta White

A fifth plot of what was thought to be a similar sized plant was also included, Gomphrena 'Fireworks', but proved to be so much faster growing and vigorous, that it will be described separately in its own section.

Results and Discussion: The plants in this trial were very slow growing, and required frequent weeding to remove weeds that emerged next to the plants in the planting hole. Flowering finally started in mid-August, but yields were not impressive (Table 19). Perhaps more can be expected in future years of this perennial crop. Flowers looked elegant and attractive, and lasted at least a week in the vase (Fig. 32).

Table 19. Stem length, stem yield and date of first flowering for four scabiosa varieties grown in the field.

Variety	Stem length, cm	Stems/plant	Days to first flower
Fama Deep Blue	47	5.4	128
Fama Deep Blue Impr.	44	7.2	126
Fama White	40	5.7	128
Perfecta White	49	3.6	130

 

Fig. 32. Scabiosa caucasica 'Fama Deep Blue'. Image at right taken after a light frost.

SNAPDRAGON:

To evaluate new snapdragon varieties for cut flower purposes, a spring-planted field trial gives a good indication of productivity. Accordingly, we planted two new varieties and two standards in this evaluation. Sowing and transplant dates were March 23 and May 10, respectively, with 9 x 9 in. spacing. Plants were supported with horizontal netting in the field, and harvests began on June 1. Varieties included:

1. Calima Pure White (Kieft)
2. Calima Yellow
3. Chantilly Yellow (Takii)
4. Appeal Scarlet (Gloeckner)

Results and Discussion: In the relatively early growing season of 2010, the plants made good growth and produced well (Table 20). Particularly notable was 'Calima Yellow', with good stem length and more than 6 stems per plant. 'Appeal Scarlet' confirmed its promising performance of 2009, producing the highest yield in the trial (Fig. 33). The open faced flowers of the 'Chantilly' series are attractive, but the early flowering reduced total yield.

Table 20. Stem length, stem yield and days from sowing to first flower for four snap dragon varieties grown in the field in 2010.

Variety	Stem length, cm	Stems/plant	Days to first flower
Calima Pure White	50	5.7	82
Calima Yellow	63	6.4	83
Chantilly Yellow	53	5.4	73
Appeal Scarlet	55	8.4	86

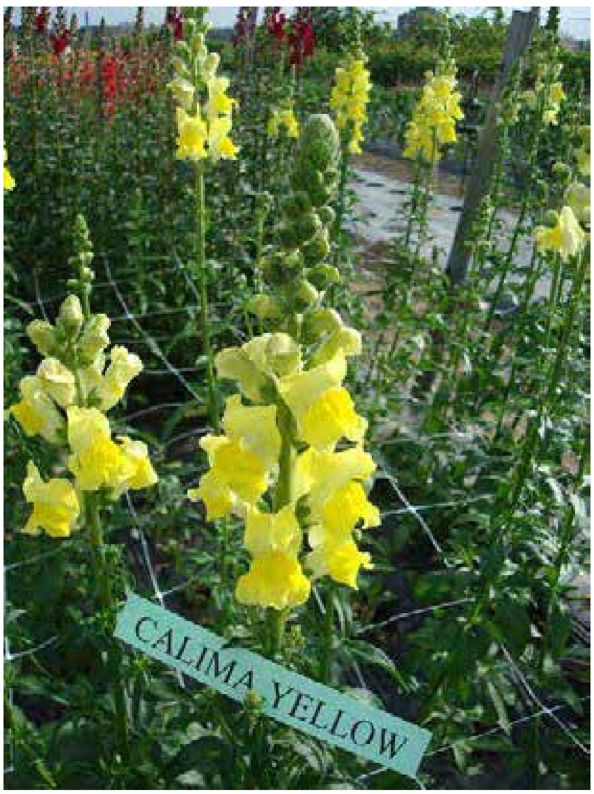

Fig. 33. Snapdragon Calima Yellow (left) and Appeal Scarlet (right) in the field trial.