Table 4. Demographics of 600 property owners surveyed about lawns in Minnesota.

Parameter	%
Age (years)	
18-24	16.1
35–39	14.5
40–44	14.1
45–49	14.1
50–59	17.5
60–69	11.4
70–89	12.3
Education (years)	
<12	3.7
12	34.2
16	29.5
17–23	8.2
Refused	4.4
Income ($)	
<50,000	31.0
>50,000	43.0
Refused	22.8
Do not know	3.2
Gender	
Male	46.6
Female	52.9

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Maintaining Vegetative Potted Purple Velvet Plants

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ADDITIONAL INDEX WORDS. *Gynura aurantiaca*, ethephon, photoperiod, shade, flowering.

SUMMARY. The purple velvet plant (*Gynura aurantiaca*) has commercial potential as a potted plant due to its attractive purple foliage, if the malodorous flowers can be avoided. Plants were treated with seven concentrations of ethephon, three photoperiodic durations, three light intensities, and combinations of photoperiod and light intensity to inhibit flowering. Although foliar application of ethephon at 1200 to 4800 ppm ($\mu L \cdot L^{-1}$) completely inhibited flowering of purple velvet plants, plants were stunted and cutting harvest was impossible. Flowering was promoted at lower application rates of 150 to 300 ppm ($\mu L \cdot L^{-1}$). An 8-hour photoperiod increased plant quality and plants had the largest vegetative shoot number and the brightest purple color, compared to 12 or 16-hour photoperiods. All of the shoots were reproductive under the 16-hour photoperiod. Increasing the shade level from 0 to 60% (790 $\mu mol \cdot m^{-2} \cdot s^{-1}$ to 230 $\mu mol \cdot m^{-2} \cdot s^{-1}$) increased the number of vegetative shoots at 74 and 108 days after treatment commenced but reduced the total number of shoots by 28% at day 108. Plants grown under

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Approved for publication by the Director, Oklahoma Agricultural Experiment Station (OAES). Our research was supported in part by Alex R. Masson, Inc. and OAES under project H-2119. The authors thank Leah Aufill for technical assistance. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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60% shade and short days had 94% vegetative shoots 102 days after placement in treatment. Growing plants under 8-hour photoperiod and 60% shade from fall to spring is recommended to maintain vegetative stock plants and produce high quality marketable plants. Chemical names used: (2-chloroethyl) phosphonic acid (ethephon).

The genus *Gynura* consists of about 100 species of herbs and small shrubs native to tropical regions of Africa and Asia. Cultivated species such as the purple velvet plant have attractive green and purple foliage and are grown as hanging basket and potted plants (McConnel et al., 1981). The purple color is caused by numerous small deep purple trichomes that cover the leaves and stems (Kalmbacher, 1975). While the purple velvet plant is popular with indoor gardeners in North America and Europe, the terminal yellow to orange flowers, which appear from midwinter to early spring, are malodorous and detrimental to sales. The inflorescence is composed of several heads arranged in an open corymb; each head is 0.6 to 0.8 inch (1.6 to 2.0 cm) across and composed entirely of disc florets (Liberty Hyde Bailey Hortorium, 1976)

Purple velvet plants must remain vegetative for successful stock plant production and finished plant marketing. Bud abscission and flower senescence of miniature roses (*Rosa* sp.) was accelerated by foliar application of ethephon (Serek and Andersen, 1995). Ethephon has also been used for selective removal of flower buds in apple (*Malus* sp.) (Edgerton and Greenhalgh, 1969), and a single spray of 200 ppm ethephon applied to rooted chrysanthemum (*Dendranthema ×grandiflorum*) cuttings 3 d after planting delayed flower bud formation (Cockshull et al., 1979). A 2000 ppm ethephon spray almost completely inhibited flower bud opening in begonia (*Begonia ×cheimantha*) when applied in the early stages of flower bud formation (Moe and Smith-Eriksen, 1986), and 1500 ppm ethephon sprays removed camellia (*Camellia japonica*) flower buds with minimal abscission of leaves and vegetative buds (Woolf et al., 1992). Ethephon has been used to induce axillary shoot development and abscission of unwanted flower buds in azaleas (*Rhododendron simsii*) (Sanderson et al., 1988). To date, no published information is available on ethephon application to purple velvet plant.

Photoperiod is commonly used to regulate flowering of daylength sensitive plant species. Beattie et al. (1989) showed that stock plants of obedient plant (*Physostegia virginiana*) had to be grown under short days to maintain vegetative meristems. Cavins (1999) also found that short days would prevent flowering of young campanula (*Campanula medium*) plants. Poinsettias (*Euphorbia pulcherrima*), however, must be placed under long days to remain vegetative (Kofranek and Hackett, 1965). Stefanis and Langhans (1983) recommended night interruption with light from incandescent lamps (long days) to keep chrysanthemums vegetative.

Light intensity may also influence flowering. Insufficient light intensity is thought to be the primary cause of failure to flower in african violet (*Saintpaulia ionantha*); no flowers occurred on african violet plants grown at 20 $\mu mol \cdot m^{-2} \cdot s^{-1}$ for 6 h (0.43 $mol \cdot m^{-2} \cdot d^{-1}$), and only 40% flowering occurred at 20 $\mu mol \cdot m^{-2} \cdot s^{-1}$ for 12 or 18 h (0.86 or 1.30 $mol \cdot m^{-2} \cdot d^{-1}$) (Hanchey, 1955). The percentage of african violet plants flowering increased with increasing light intensity and duration (Conover and Poole, 1981). Thus, a combination of shade and photoperiod could reduce flowering of both stock plants and marketed plants. The objective of our studies was to maintain vegetative purple velvet stock plants and finished plants by ethephon foliar sprays, photoperiod, or reduced light intensity.

Materials and methods

Plants were propagated directly into 4-inch (10-cm) [14-fl oz (0.4-L)] pots from tip cuttings using a commercial soilless medium (Universal Mix, Strong/Lite Horticultural Products, Pine Bluff, Ark.). Plants were grown in a corrugated polycarbonate-covered greenhouse set at 77/59 °F (25/15 °C) day/night temperatures. Plants were irrigated with 250 ppm N from a premixed commercial 20N–4.4P–16.6K fertilizer (Peter's Professional, Scott's Company, Marysville, Ohio). Data were subjected to analysis of variance using the general linear model (GLM) procedure (SAS Inst., Cary, N.C.).

Ethephon (expt. 1). Plants were propagated on 27 Mar. 1999 and sprayed on 19 May 1999 when new foliage growth commenced with 1.5 mL (0.05 fl oz) of 0, 150, 300, 600, 1200, 2400, or 4800 ppm ethephon (Florel, Lawn and Garden Products, Inc., Fresno, Calif.). Data collected once a week for 4 weeks included flower number and foliage chlorosis ratings. Chlorosis ratings ranged from 1 to 5: 5 = plants with >25% chlorotic leaves, 4 = plants with 10 to 25% chlorotic leaves, 3 = plants with 5 to <10% chlorotic leaves, 2 = plants with <5% chlorotic leaves, and 1 = plants without chlorotic leaves. Plants were arranged in a completely randomized design on greenhouse benches with 10 single plant samples per treatment.

Photoperiod (expt. 2). Cuttings were propagated on 9 Sept. 1999, pinched on 8 Oct. 1999 when roots reached the edge of the root media ball, and placed under 8, 12, or 16-h photoperiods on 1 Nov. 1999. The 8-h photoperiod received 8 h of natural daylight concurrent with 8 h of incandescent light. The 12-h photoperiod received 8 h of natural daylight along with 4 h of concurrent incandescent light and 4 h of day extension incandescent light. The 16-h photoperiod received 8 h of natural daylight and an additional 8 h of day extension provided by incandescent lights. Thus, each treatment had 8 h of natural daylight (0830 to 1630 HR, 820 $\mu mol \cdot m^{-2} \cdot s^{-1}$ maximum daily intensity) and 8 h of incandescent light (6 $\mu mol \cdot m^{-2} \cdot s^{-1}$) (Cavins, 1999). The number of vegetative and reproductive shoots was determined every 4 weeks for 3 months after placement of plants in the photoperiods. Plants were cut back after each data collection date to simulate cutting harvest. Twenty single plant samples were used per treatment.

Shade (expt. 3). Cuttings were propagated on 4 Nov. 1999 and when roots reached the edge of the root media ball, on 26 Nov. 1999, cuttings were placed under three shade levels: 0, 30, or 60%, resulting in a maximum daily light intensity of 790, 375, or 230 $\mu mol \cdot m^{-2} \cdot s^{-1}$, and an actual shade percentage of 0, 47, or 71%, respectively. Data collected were similar to Expt. 2. Twenty single plant samples were used per treatment.

Photoperiod and 0% or 60% shade (expt. 4). Cuttings were propa-

gated on 11 Feb. 2000 under 60% shade in the 8-h photoperiod. When roots reached the edge of the root media ball on 10 Mar. 2000, plants were split in four equal groups of five plants and placed under 8 or 16-h photoperiods, with (305 $\mu mol \cdot m^{-2} \cdot s^{-1}$ maximum daily intensity, 69% actual shade) or without 60% shade (998 $\mu mol \cdot m^{-2} \cdot s^{-1}$). Data collected were similar to Expt. 2, except that data were collected only twice, 74 (24 Apr. 2000) and 102 (22 May 2000) d after placement in final shade treatment. Five single plant samples were used per treatment.

Results

ETHEPHON. Ethephon foliar application had no effect on flowering 1 week after treatment (Table 1). Two weeks after treatment flower number per plant was inversely related to ethephon rate. A curvilinear relationship existed between ethephon rate and flower number at 3 and 4 weeks after treatment. Ethephon increased flower number up to 300 ppm; however, higher ethephon concentrations decreased flowering. Flowering was inhibited at concentrations ≥1200 ppm for 4 weeks after treatment. Ethephon was not phytotoxic to the foliage as foliar chlorosis ratings were similar among treatments (data not presented), but ethephon levels ≥1200 ppm stopped shoot development and elongation (data not presented).

PHOTOPERIOD. The vegetative shoot number decreased with increasing photoperiod for all three data collection dates (Table 2). Effect of the 8-h photoperiod decreased with time as the reproductive shoot number increased from 42 to 96 d after treatment commenced. The 16-h photoperiod produced only reproductive shoots at all three data collection dates. Total shoot number decreased with increasing photoperiod at 68 and 96 d after treatment but the 12-h photoperiod had the highest total shoot number at day 42. Total shoot number increased with treatment time for the 8- and 12-h photoperiods, but not for the 16-h photoperiod.

SHADE. The vegetative shoot number increased with increasing shade at 74 and 108 d after treatment commenced but decreased with increasing shade at 46 d after treatment commenced (Table 3). Reproductive shoot number decreased with increasing shade. Total shoot number decreased with increasing shade at 46 and 108 d after treatment commenced but not at 74 d after treatment commenced. Total shoot number increased with treatment duration under 0% and 30% shade but not under 60% shade.

PHOTOPERIOD AND SHADE. At both treatment times, plants grown under the 8-h photoperiod and 60% shade had more vegetative shoots than any other combination (Table 4). Vegetative shoot number increased with treatment time for plants grown under the 8-h photoperiod but not for plants grown under the 16-h photoperiod. Number of reproductive shoots and total number of shoots per plant were not effected ($P \leq 0.05$) by the treatments.

Discussion

ETHEPHON. Ethylene in ornamentals is used to promote flower formation in bromeliads (Bromeliaceae) and certain bulbous plants (Halevy, 1995). Low ethephon concentrations (150 to 300 ppm) induced flowering in purple velvet plants (Table 1), which is similar to results for gladiolus (*Gladiolus*) (Abd El-Rahman and Abd El-Hamied, 1985). The differentiation and development of lobes, flower primordia, and the extension of the gladiolus flower spike were advanced as the concentration of ethephon decreased from 100 to 1 ppm, 1 month after planting. Also, 200 ppm ethephon on lychee (*Litchi chinensis*) shoots induced flowering 7 to 10 d earlier than those of untreated controls, but relatively few flower buds were formed (Chen and Ku, 1988). The mode of ethylene action in promoting flowering is not known (Halevy, 1990). One hypothesis on bulbous plants is that ethylene enhances carbohydrate mobilization from the reserve parts to the meristem. However, analysis of sugar concentration in triteleia (*Triteleia laxa*) corms did not reveal differences between ethylene treated and untreated corms (Han et al., 1989). Examination of the apical meristem of the ethylene-treated triteleia plants revealed that their apices grew at twice the rate of untreated plants. The increase in size of the apical dome was not due to an increase in cell size but to promotion of cell division. The primary effect of ethylene on flowering of triteleia, and perhaps also in other plants, may be the stimulation of cell division in the apical meristem, which seems to be correlated with apex size and its ability to produce flowers (Halevy, 1990).

In many plants, exogenous ethylene, applied either as the gas or by the use of ethylene-releasing agents such as ethephon, inhibits or delays flower formation (Arteca, 1996). High ethephon levels (1200 to 4800 ppm) completely inhibited purple velvet plant flowering (Table 1). Similar results were found on mango (*Mangifera indica*) but only with ethephon levels up to 800 ppm (Sauco et al., 1991). However, the purple velvet plants were stunted, preventing cutting harvest. Also, high concentrations of ethephon decreased the purple coloration of the foliage (loss of the foliar hairs) (personal observation). Ethephon did not produce results acceptable

Table 1. Effect of ethephon (Florel) on purple velvet flower development. Data are means of 10 plants per treatment; Expt. 1.

Ethephon [ppm ($\mu L \cdot L^{-1}$)]	Weeks after treatment (flower no./plant)			
	1	2	3	4
0	0.0	0.1	1.3	4.7
150	0.7	2.4	3.7	6.5
300	0.5	1.1	2.8	4.8
600	0.2	0.3	0.3	0.9
1200	0.0	0.0	0.0	0.0
2400	0.0	0.0	0.0	0.0
4800	0.0	0.0	0.0	0.0
Significance				
Linear	NS	0.0231[z]	0.0032	0.0001
Quadratic	NS	NS	0.0308	0.0013
Cubic	NS	NS	NS	NS
Residual	NS	NS	NS	NS

[z] $P > F$.

Table 2. Effect of photoperiod on purple velvet shoot development. Data are means of 20 plants per treatment; Expt. 2.

Days in photoperiod	Photoperiod (h)	Shoots (no.) Vegetative	Reproductive	Total
42	8	11.2	2.4	13.6
	12	5.6	11.0	16.6
	16	0	10.2	10.2
68	8	10.8	13.7	24.4
	12	6.6	10.9	17.5
	16	0	13.9	13.9
96	8	16.5	17.9	34.4
	12	6.3	19.6	25.8
	16	0	10.8	10.8
Significance				
Photoperiod (P)				
Linear (L)		0.0001[z]	NS	0.0001
Quadratic (Q)		NS	0.0200	0.0170
Days (D)				
L		0.0125	0.0001	0.0001
Q		NS	NS	NS
PL × DL		0.0066	0.0001	0.0001
PL × DQ		NS	NS	NS
PQ × DL		NS	NS	NS
PQ × DQ		NS	0.0001	0.0001

[z]$P > F$.

for commercial maintenance of vegetative purple velvet plants.

PHOTOPERIOD. All of the shoots were reproductive under the 16-h photoperiod (Table 2). Vegetative shoot number was highest under the 8-h photoperiod, which would make purple velvet a facultative long day plant with respect to flowering, with a critical daylength of 8 h or less. Photoperiod also influenced the quality of the cuttings, with the 8-h photoperiod producing the darkest purple color (personal observation). The subsequent production of finished plants under 8-h photoperiods would also produce dark purple plants. However, reproductive shoot number increased with days in treatment indicating the photoperiod alone is not suitable for control of reproductive shoots.

SHADE. Increasing the shade level increased the number of purple velvet vegetative shoots and could be used

Table 3. Effect of 0%, 30%, or 60% shade on purple velvet shoot development. Data are means of 20 plants per treatment; Expt. 3.

Days in shade	Shade level (%)	Shoots (no.) Vegetative	Reproductive	Total
46	0	7.3	5.6	12.9
	30	6.7	5.3	12.0
	60	6.5	2.4	8.9
74	0	8.5	5.6	14.0
	30	12.0	2.5	14.4
	60	12.2	1.0	13.2
108	0	2.2	14.8	17.0
	30	4.2	11.0	15.2
	60	9.8	2.6	12.3
Significance				
Shade (S)				
Linear (L)		0.0001[z]	0.0001	0.0042
Quadratic (Q)		NS	NS	NS
Days (D)				
L		0.0274	0.0001	0.0001
Q		0.0001	0.0001	NS
SL × DL		0.0001	0.0001	NS
SL × DQ		NS	0.0141	0.0177
SQ × DL		NS	NS	NS
SQ × DQ		0.0305	0.0174	NS

[z]$P > F$.

Table 4. Effect of 0% or 60% shade and 8- or 16-h photoperiods on purple velvet vegetative shoot development. Data are means of five plants per treatment. Expt. 4.

Days in shade (%)	Shade level (h)	Photoperiod	Shoots (no.) Vegetative	Reproductive	Total
74	0	8	6.8	8.8	15.6
		16	1.8	11.8	13.6
	60	8	7.8	5.2	13.0
		16	2.2	8.4	10.6
102	0	8	12.0	3.4	15.4
		16	1.2	13.6	14.8
	60	8	12.6	0.8	13.4
		16	2.6	9.0	11.6
Significance					
Shade (S)			NS	NS	NS
Photoperiod (P)			0.0021[z]	NS	NS
Days (D)			0.0234	NS	NS
S × P			NS	NS	NS
S × D			NS	NS	NS
P × D			0.0209	NS	NS
S × P × D			NS	NS	NS

[z]*P* > F.

commercially for stock plant production (Table 3). The highest percentage of vegetative shoots (93%) was at 74 d after beginning of the 60% shade treatment and decreased thereafter, indicating that plant maturity might play a role in the flowering of purple velvet plants. Lyons and Booze-Daniels (1986) indicated that a specific node number may affect floral induction in california poppy (*Eschscholzia californica*). In addition, Lyons and Neale (1983) identified a negative linear relationship between number of unfolded california poppy leaves and days to anthesis. While increasing shade decreased total shoot number at 46 and 108 d after treatment, the decrease was primarily due to decreased reproductive shoot number which would allow easier cutting harvest of vegetative shoots.

PHOTOPERIOD AND SHADE. Plants grown under 8-h photoperiod and 60% shade had the most vegetative shoots (Table 4). Armitage (1995) showed similar results in hamelia (*Hamelia patens*); flowering was delayed under low light intensity, and flower development was completely arrested under 8-h photoperiod. Adams et al. (1998) also showed that flowering of petunia (*Petunia ×hybrida*) was significantly delayed when photosynthetic photon flux (PPF) decreased from 13 to 6.5 mol·m^{-2}·d^{-1}, and photoperiods were less than 14 h. Corr and Widmer (1990) observed that decreased irradiance lowered the number of flowers per plant of calla lily (*Zantedeschia elliottiana* and *Z. rhemannii*). The combination of 8-h photoperiod and 60% shade overcame increased flowering due to increased plant maturity as the percentage of vegetative shoots increased from 60% at 74 d to 94% at 102 d after treatment commenced.

Conclusion

Purple velvet stock and finished plants should be grown under 8-h photoperiod and 60% shade (230 to 305 µmol·m^{-2}·s^{-1} maximum light intensity) to maintain vegetative growth and reduce flowering. Both 8-h photoperiod and 60% shade were required for greatest percent of vegetative growth (94%) as 16-h photoperiod and shade resulted in 27% vegetative shoots and 8-h photoperiod and high light intensity resulted in 79% vegetative shoots. Long days of 12-h or greater should be avoided. Ethephon sprays were not commercially useful.

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Multiple Trinexapac-ethyl Applications Reduce Kentucky Bluegrass Sod Storage Temperatures

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ADDITIONAL INDEX WORDS. plant growth regulators, *Poa pratensis*, sod heating, stress tolerance

SUMMARY. **Sod heating during storage can limit the distance sod may be shipped. Two experiments were conducted to determine the effect of multiple preharvest applications of trinexapac-ethyl [4-cyclopropyl-α-hydroxy-methylene)-3,5-dioxocyclohexanecarboxylic acid methyl ester] at 0.23 kg·ha^{-1} (0.21 lb/acre) on kentucky bluegrass (*Poa pratensis*) sod temperatures during the first 24 h of storage. Experimental design was completely randomized with three replications and a 2 (trinexapac-ethyl verses control) × 3 (8-h storage intervals) factorial arrangement of treatments. Trinexapac-ethyl treatments were applied 6 and 2 weeks before harvest in the first experiment and 10, 6, and 2 weeks before harvest in the second experiment. Two and three applications of trinexapac-ethyl reduced sod storage temperatures. The reduction in rate of heating in treated sod became significantly different than untreated sod within 4 h after harvest. Mean sod temperatures in both experiments were 3 °C (6 °F) cooler in treated sod after 12 h of storage than untreated sod. These results suggest that trinexapac-ethyl could be used by sod growers to extend storage times and increase shipping and market areas. A multiple application program can enable sod growers to maximize the enhancement effects of trinexapac-ethyl on sod storage life.**

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Univ. of Nebraska-Lincoln, Agricultural Research Division journal series 13280. We would like to thank Todd Valley Farms for assistance throughout this research. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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Internal heating of sod stacked postharvest can cause plant tissue to deteriorate and is a limiting factor determining the distance sod can be shipped (King, 1970). Bermudagrass (*Cynodon dactylon*) sod when stacked on pallets was 12 °C (22 °F) above ambient, after storage for five days (Maw et al., 1998). Cool-season turfgrasses such as kentucky bluegrass and creeping red fescue (*Festuca rubra*) heat more rapidly than bermudagrass and have a shorter storage time (Darrah and Powell, 1977; King et al., 1982).

Several management practices have been used to increase sod storage life. Reduction of mowing height and removal of clippings have been shown to decrease sod heating in kentucky bluegrass and creeping red fescue (Darrah and Powell, 1977; King et al., 1982). King et al. (1982) reported increased sod heating when sod received 240 kg·ha^{-1} (214 lb/acre) of nitrogen compared with no nitrogen application. Temperatures of sod stacked on pallets when harvested early in the morning were also found to be lower than sod harvested later in the day (Darrah and Powell, 1977).

The primary use of trinexapac-ethyl is to reduce leaf elongation. It inhibits the 3β-hydroxylase enzyme late in the gibberellic acid biosynthesis pathway (Rademacher et al., 1992). A partial inhibition of respiration in plants by trinexapac-ethyl (Heckman, 2000) gives sod growers the potential to decrease metabolic activity of the sod system and delay high temperatures that lead to poor quality sod.

The use of plant growth regulators (PGRs) in the sod industry has been minimal compared to use in the golf industry. Trinexpac-ethyl is a PGR used to reduce canopy heights and mowing frequency. Nontarget effects of trinexapac-ethyl such as sod storage temperature reduction have only been briefly investigated. A single preharvest application of trinexapac-ethyl has