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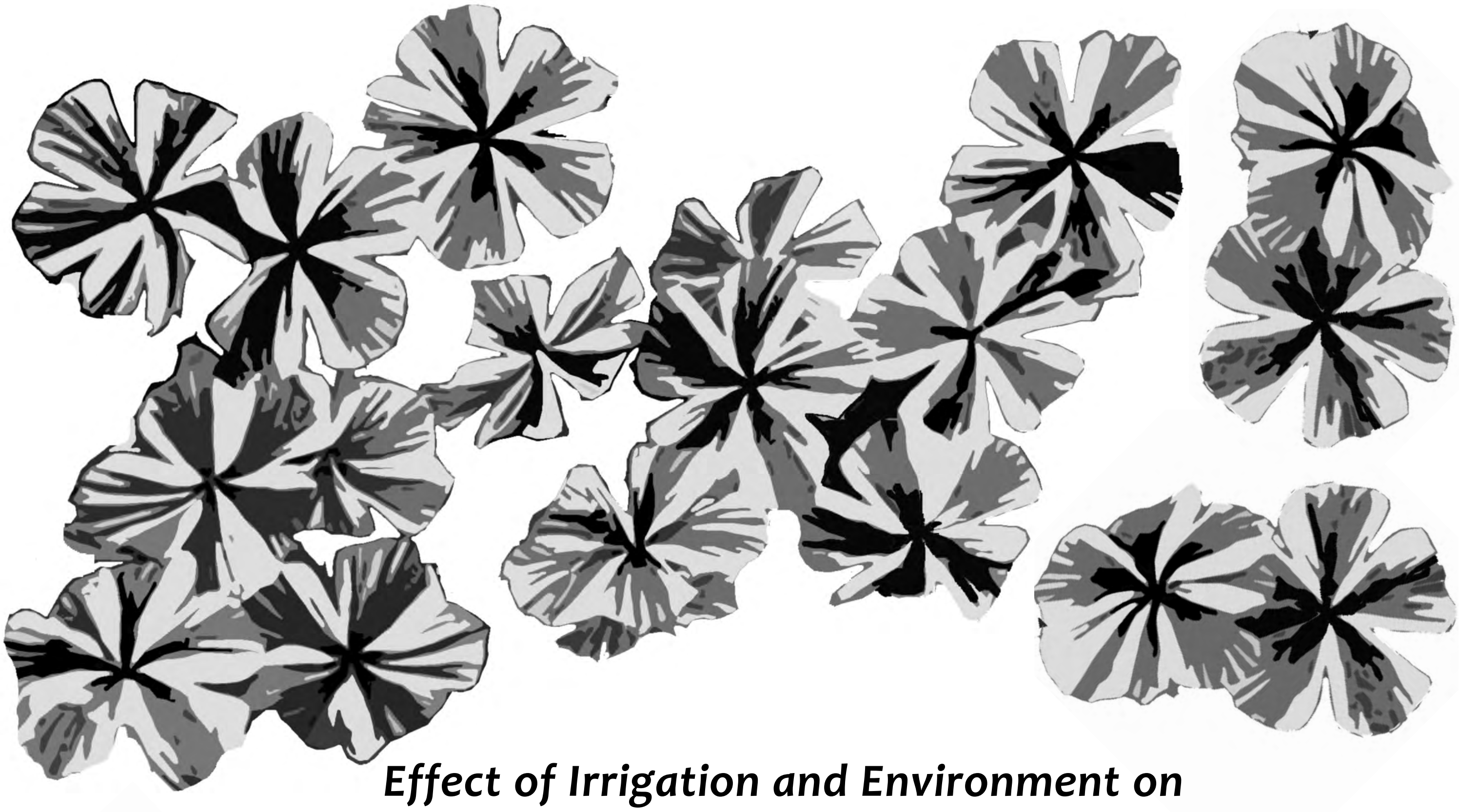
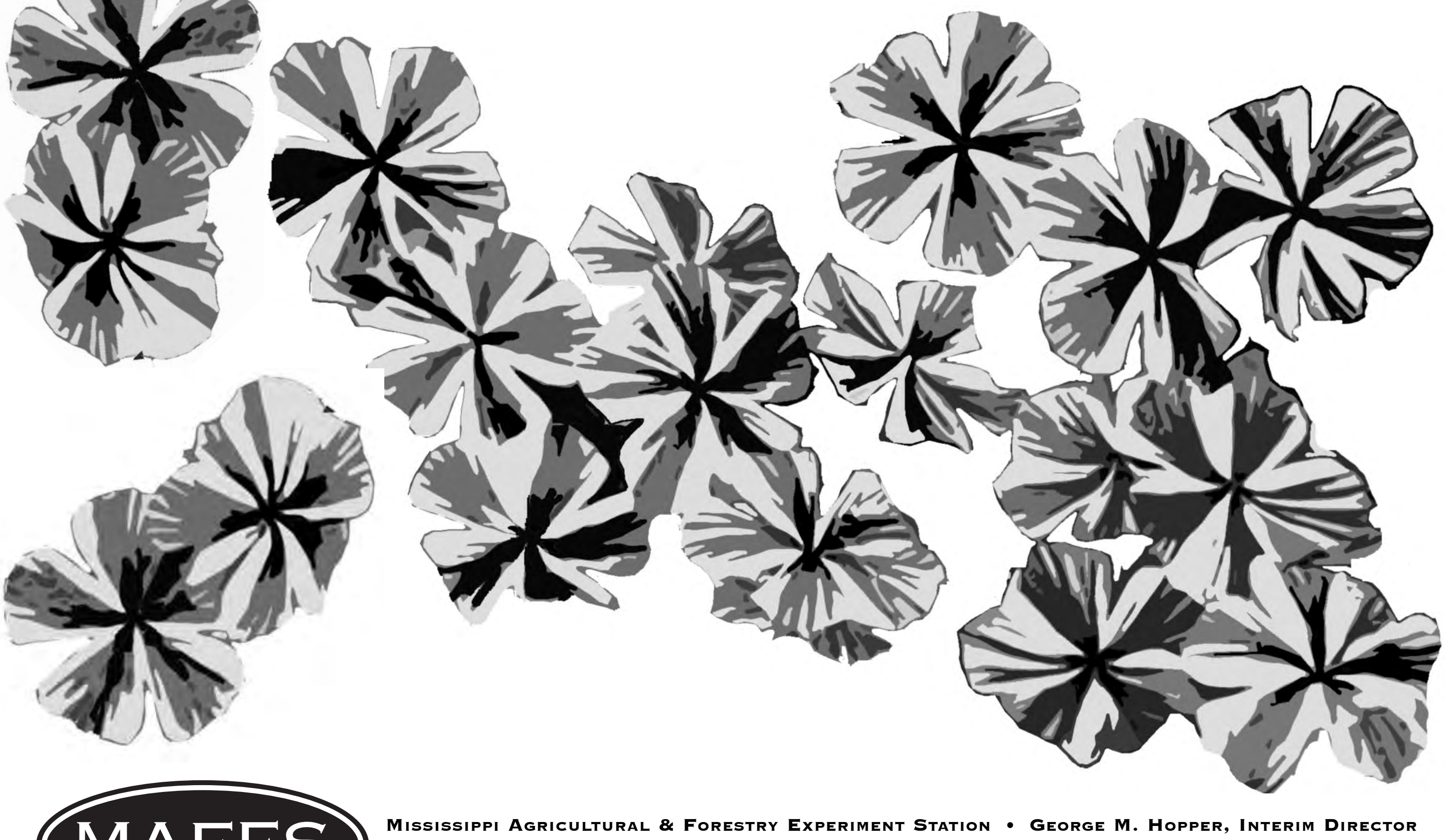


Effect of Irrigation and Environment on

Growth of Intensia Phlox



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Effect of Irrigation and Environment on Growth of Intensia Phlox

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Abstract

This study was conducted to evaluate the effects of irrigation and growth environments on growing liners of Intensia® phlox in 3.5-inch pots to retail size. Three Intensia® phlox cultivars were grown in greenhouse and cold-frame environments at Mississippi Agricultural and Forestry Experiment Station sites in Crystal Springs and Verona, Mississippi. Four irrigation treatments were evaluated: 40 ml of water per day per pot (40/0), 60 ml of water every other day (60/1), 70 ml of water every second day (70/2), and 80 ml of water every third day (80/3). In general, plants grown in a cold frame were more compact with a lower growth index (GI) — often a desirable trait — and had visual appearance ratings higher than or similar to plants grown in the heated greenhouse, depending on cultivars. Plants that received irrigation less frequently (70/2, 80/3) were more compact than more frequently watered plants (40/0, 60/1), depending on cultivars. However, plants grown in the heated greenhouse produced more flowers than plants grown in the cold frame. Regardless of environments, more frequently watered plants (40/0, 60/1) produced at least as many flowers, had higher or similar dry weight and growth index, and rated at least as well on visual appearance and root ratings, depending on cultivars. Results from this study indicated that growers can use cold frames to produce quality Intensia® phlox plants. More frequent, lighter irrigation tended to produce bigger plants with more flowers and higher overall quality ratings. However, less frequent, heavier irrigation tended to produce more compact plants, illustrating the choices and compromises growers have to make in selection of a production system.

Pam Collins, Valtcho Jeliazkov, and Frank Matta reviewed this manuscript and offered valuable suggestions for the improvement of the bulletin.

Effect of Irrigation and Environment on Growth of Intensia Phlox

INTRODUCTION

New landscape plants are released to the market each year. One plant that performed well in landscape evaluations at the Truck Crops Branch Experiment Station in Crystal Spring, Mississippi, was *Phlox* x *hybrid* Intensia® Phlox. It was rated among the 10 top-performing plants in both 2005 and 2006 landscape plant evaluation trials (Bi et al., unpublished data). Intensia® has been evaluated in other landscape trials in the United States and was reported to be a good landscape performer during the summer heat (Kmetz-González and Pasian, 2005; Bale and Durham, 2003; Winter, 2006). While Intensia® has been reported to be an excellent landscape plant, growers in Mississippi have experienced difficulties in nursery production (Winter, personal communication). Plants are often stretched and do not look attractive in retail settings. Researchers in Kentucky experienced trouble growing Intensia® in the greenhouse before transplanting into field beds (Bale, 2005). EuroAmerican Propagators (Bonsall, California) growing information directs growers to keep Intensia® liners dry during production (Parkinson, personal communication). Intensia® Phlox are a relatively new bedding crop, and no research has been reported on production irrigation requirements. Irrigation requirements for production of various bedding plants have been published. The quality of pansies irrigated once every 3 or 4 days was less than that of plants watered once a day or every second day, but flowering was not affected (Flohr and Conover, 1994). Flowering and plant quality of petunias grown in the same trial were adversely affected by a 3- or 4-day interval between irrigations. Vinca growth was strongly correlated with substrate water content, where lower water contents produced smaller plants with less dry weight (van Iersel, et al., 2007). The objectives of this trial were to determine the amount and frequency of irrigation required for optimum production of Intensia®, as well as to determine whether the liners could be grown in a cold frame or needed a heated greenhouse.

Materials and Methods

EuroAmerican Propagators provided size 84 plugs of three *Phlox hybrid* Intensia® cultivars — 'Cabernet,' 'Lavender Glow,' and 'Star Brite' — in February 2007 at the Truck Crops Branch Experiment Station in Crystal Springs, Mississippi, and the North Mississippi Research and Extension Center in Verona, Mississippi. We transplanted plugs into 3.5-inch containers (8.75 cm wide, 8.75 cm high) (one plug per container) in Fafard # 3 media (Conrad Fafard, Agawam, Massachusetts) and pinched at 3–4 nodes to promote branching. We kept the plugs in a heated greenhouse until March 12, when they were placed in two different environments: heated greenhouse and unheated cold frame. Plants in both research sites received irrigation treatments. The greenhouse and cold frame were covered with standard greenhouse plastic (six mil, 4-year poly). There were four irrigation treatments: 40 ml of water each day, 0-day interval between irrigations (40/0); 60 ml of water every other day, 1-day interval between irrigations (60/1); 70 ml of water every third day, 2-day interval between irrigations (70/2); and 80 ml of water every fourth day, 3-day interval between irrigations (80/3). Every 12 days, we added 200 mg of nitrogen per liter of water from 20-10-20 Peters Peat Lite Special (20N-4.3P-16.7K; The Scotts Co., Marysville, Ohio). Fertilization was applied to each pot with the 40- to 80-ml irrigation treatments.

The experimental design was a split-split plot with environment (greenhouse or cold frame) being whole plots, irrigation treatments being subplot factors, and cultivars serving as the sub-subplot factors. There were four replications consisting of four pots for each cultivar in each environment. Data from Crystal Springs and Verona were analyzed jointly using PROC MIXED program (SAS Institute Inc., Cary, North Carolina).

Data collected at the termination of the study on April 30, 2007, were plant growth index (GI) [(height + widest width + perpendicular width) ÷ 3] and number of open flowers. Plant height was measured from substrate surface to the tallest plant part. A root rating was based on a rating of the four sides and bottom of the root ball. Each of these root ball surfaces was rated from 0–20, where a rating of 0 indicated that no roots grew out of the side, and 20 indicated that the side was 100% covered with roots. The root rating was calculated as the sum of the five surfaces of the root ball. A visual rating of 1–5 was assigned to indicate the overall growth and appearance of each plant; a rating of 1 indicated poor growth and appearance, and 5 indicated superior plant growth and appearance. Plants were cut at the substrate surface, and the aboveground biomass was harvested to determine plant dry weight. The samples were placed into a 60°C forced-air oven to dry, and dry weights were recorded.

The gravimetric water content of fallow pots was determined. Fallow pots received the same irrigation treatments that pots with phlox plants received for 12 days, which coincided with the water-soluble fertilizer application schedule. After fertilizing the pots, we collected a pre-irrigation soil sample before an irrigation treatment and a post-irrigation sample 24 hours after irrigation. Gravimetric water content (GW) was determined as follows: GW = (wet sample weight – dry sample weight)/dry sample weight.

The average maximum and minimum temperatures in the greenhouse during this trial were 82° and 69°F, while the maximum and minimum temperatures in the unheated cold frame were 85° and 51°F. The differences in maximum and minimum temperatures between the heated greenhouse and the unheated cold frame were 13° and 34°F, respectively. The cold frame was slightly warmer than the greenhouse during the day, but it was 18°F colder at night.

RESULTS

There were differences in gravimetric water (GW) content of samples collected before and after the irrigation treatments (Fig. 1). Both the pre- and post-irrigation samples had the lowest GW when treated with a 3-day interval between irrigations (80/3). There were no significant differences in post-irrigation GW between the pots watered every day (40/0) and those watered at 1- or 2-day intervals (60/1 or 70/2). The GW content was higher in the 60/1 treatment compared with the 70/2 and 80/3 treatments before irrigation, while the 40/0 treatment was the same as the 60/1 and 70/2 treatments.

There was a significant cultivar-by-irrigation interaction (P<0.01) with respect to the number of flowers per plant at the termination of the trial. Therefore, we ran an analysis of the number of flowers per plant for each cultivar. Plants in the greenhouse consistently had more flowers than plants in the unheated cold frame for each of the three Intensia® cultivars (Fig. 2). Irrigation treatments had a significant effect on the number of flowers per plant for 'Lavender Glow' and 'Star Brite,' but not for 'Cabernet' (Fig. 3). The 40/0 and 60/1 treatments produced more 'Lavender Glow' flowers than the 70/2 treatment, and the 80/3 treatment produced

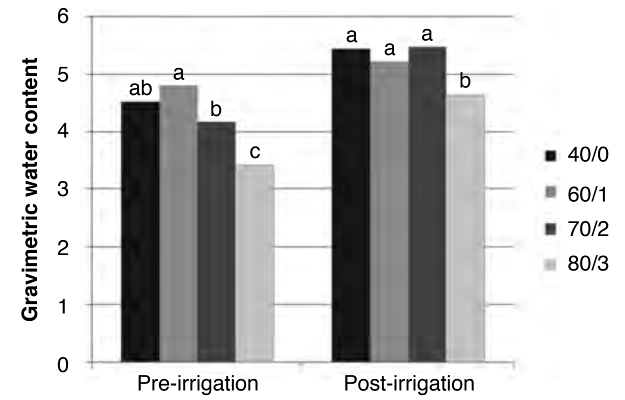

Figure 1. The effect of irrigation treatments on gravimetric water content (GW) of media in fallow pots measured before and after irrigation treatments. Gravimetric water content = (wet sample weight – dry sample weight)/dry sample weight). Means compared by Fisher's Protected LSD at *P*=0.05. Columns within a series with the same letter do not differ at the 5% significance level.

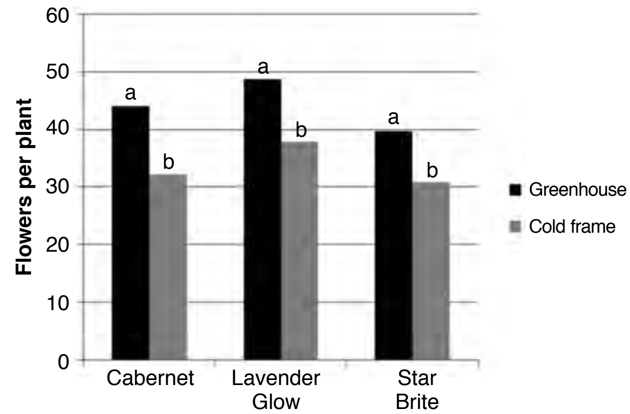

Figure 2. The effect of growing environment on the number of flowers per plant of Intensia® phlox 'Cabernet,' 'Lavender Glow,' and 'Star Brite' at the end of the study. Means compared by Fisher's Protected LSD at *P*=0.05. Columns within a series with the same letter do not differ at the 5% significance level.

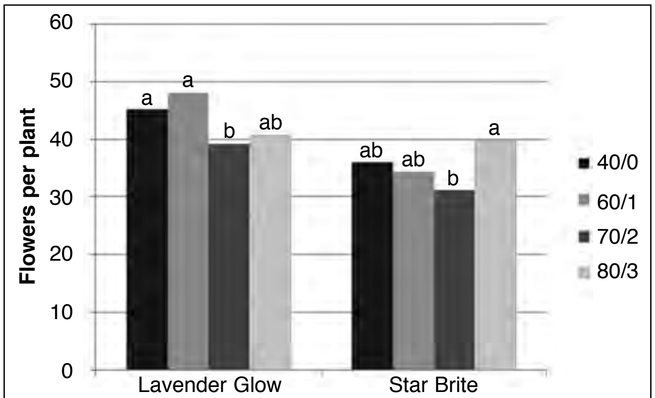

Figure 3. The effect of irrigation treatment on the number of flowers per plant of Intensia® phlox 'Lavender Glow' and 'Star Brite' at the end of the study. Means compared by Fisher's Protected LSD at *P*=0.05. Columns within a series with the same letter do not differ at the 5% significance level.

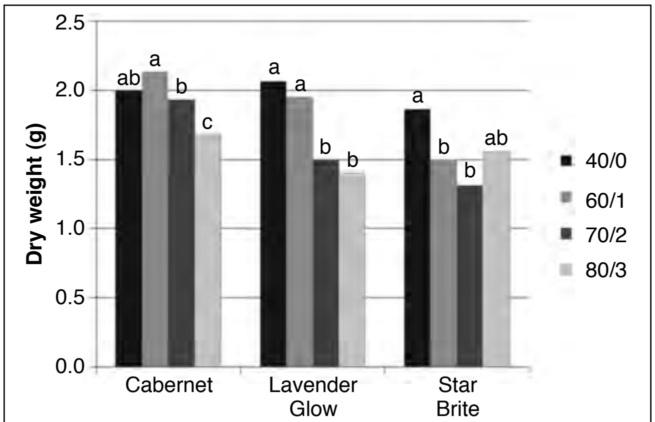

Figure 4. The effect of irrigation treatment on plant dry weight (g) of Intensia® phlox 'Cabernet,' 'Lavender Glow,' and 'Star Brite' at the end of the study. Means compared by Fisher's Protected LSD at *P*=0.05. Columns within a series with the same letter do not differ at the 5% significance level.

significantly more ‘Star Brite’ flowers than the 70/2 treatment.

There was a significant cultivar-by-irrigation interaction ($P<0.01$) for plant dry weights at the termination of the trial. Subsequently, we analyzed the effects of irrigation for each cultivar. Irrigation treatment affected plant dry weight for each of the Intensia® cultivars (Fig. 4). The 60/1 treatment produced heavier ‘Cabernet’ and ‘Lavender Glow’ plants than the 70/2 and 80/3 treatments. The 40/0 irrigation treatment produced heavier ‘Star Brite’ plants than the 60/1 and 70/2 treatments. There were no differences in plant dry weight due to the growing environment (greenhouse vs. cold frame) for ‘Lavender Glow’ or ‘Star Brite.’

There was a significant cultivar-by-irrigation interaction in the visual ratings of the phlox ($P<0.01$), so each cultivar was analyzed separately to determine the effects of irrigation (Fig 5). The 80/3 irrigation produced significantly lower rated ‘Cabernet’ plants, while the 70/2 treatment resulted in significantly lower rated ‘Star Brite’ plants. The 40/0 treatment produced higher rated ‘Lavender Glow’ plants than the 70/2 and 80/3 treatments. The cold frame significantly improved visual ratings for ‘Cabernet’ and ‘Star Brite’ (Fig. 6).

A significant interaction of environment and irrigation treatment affected root growth ratings (P = 0.0424). Analysis of the data by growing environment revealed that irrigation affected root growth of plants in the cold frame. In the cold frame, the 40/0 irrigation treatment produced significantly more roots per plant for all cultivars compared with the other irrigation regimes (Fig. 7). In the greenhouse, 60/1 irrigation was significantly better than the remaining irrigation treatments (Fig. 8). Irrigation had no effect on the root growth of ‘Lavender Glow’ or ‘Star Brite’ grown in the greenhouse.

There was a cultivar-by-irrigation interaction effect on plant growth index (GI) ($P = 0.03$). We analyzed the GI data for each cultivar separately to examine the effects of irrigation and environment. Irrigation treatment affected GI of ‘Lavender Glow’ and ‘Star Brite’ (Fig. 9). The 40/0 irrigation treatment produced significantly larger ‘Lavender Glow’ plants, and the 40/0, 60/1, and 80/3 treatments yielded larger ‘Star Brite’ plants than the 70/2 treatment. There was an interaction between the irrigation and environment effects ($P< 0.01$) in the GI analysis of ‘Cabernet’ (Fig. 10). The 60/1 treatment produced the largest ‘Cabernet’ plants grown in the greenhouse, and the 40/0 and 60/1 treatments produced larger plants than the 70/2 treatment in the cold frame.

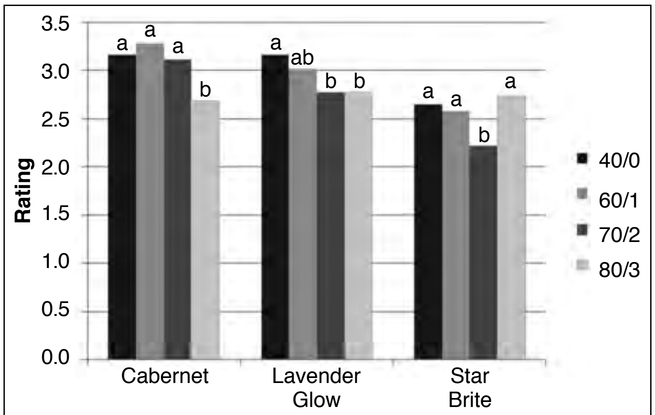

Figure 5. The effect of irrigation treatment on the visual ratings of Intensia® phlox ’Cabernet,’ ‘Lavender Glow,’ and ‘Star Brite’ at the end of the study. Visual rating: 1= poor growth and appearance, 5 = superior growth and appearance. Means compared by Fisher’s Protected LSD at P=0.05. Columns within a series with the same letter do not differ at the 5% significance level.

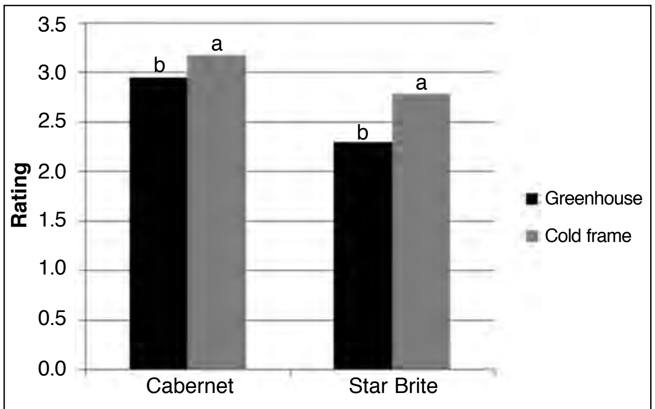

Figure 6. The effect of growing environment on the visual ratings of Intensia® phlox ‘Cabernet’ and ‘Star Brite’ at the end of the study. Visual rating: 1= poor growth and appearance, 5 = superior growth and appearance. Means compared by Fisher’s Protected LSD at P=0.05. Columns within a series with the same letter do not differ at the 5% significance level.

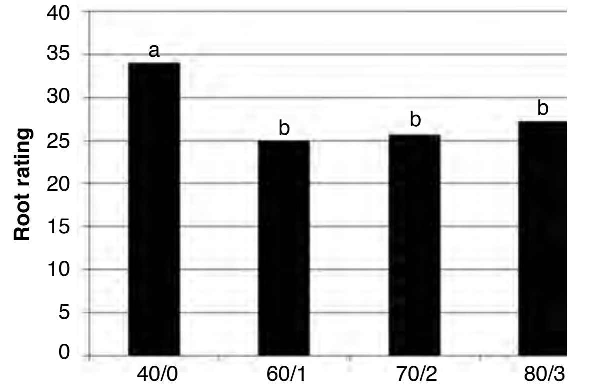

Figure 7. The effect of irrigation treatment on the root ratings of Intensia® phlox 'Cabernet,' 'Lavender Glow,' and 'Star Brite' in the cold frame at the end of the study. Root rating was determined by observing the four sides and bottom of the root ball. Each of these five root ball surfaces was rated from 0–20 where a rating of 0 indicated that no roots grew out to the side of that surface and 20 indicated that the side of the root ball was 100% covered with roots. The ratings of the five surfaces was added together for possible root ratings ranging from 0–100 where 0 indicated that no roots grew to the side of the root ball and 100 indicated that roots grew out to the sides of all five surfaces and completely covered those surfaces. Means compared by Fisher's Protected LSD at *P*=0.05. Columns within a series with the same letter do not differ at the 5% significance level.

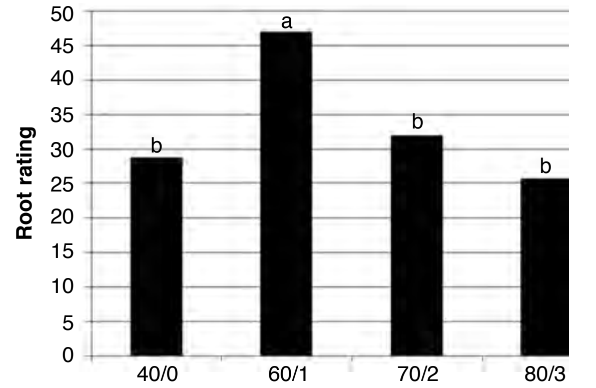

Figure 8. The effect of irrigation treatment on the root ratings of Intensia® phlox 'Cabernet,' 'Lavender Glow,' and 'Star Brite' in the greenhouse at the end of the study. Root rating was determined by observing the four sides and bottom of the root ball. Each of these five root ball surfaces was rated from 0–20 where a rating of 0 indicated that no roots grew out to the side of that surface and 20 indicated that the side of the root ball was 100% covered with roots. The ratings of the five surfaces was added together for possible root ratings ranging from 0–100 where 0 indicated that no roots grew to the side of the root ball and 100 indicated that roots grew out to the sides of all five surfaces and completely covered those surfaces. Means compared by Fisher's Protected LSD at *P*=0.05. Columns within a series with the same letter do not differ at the 5% significance level.

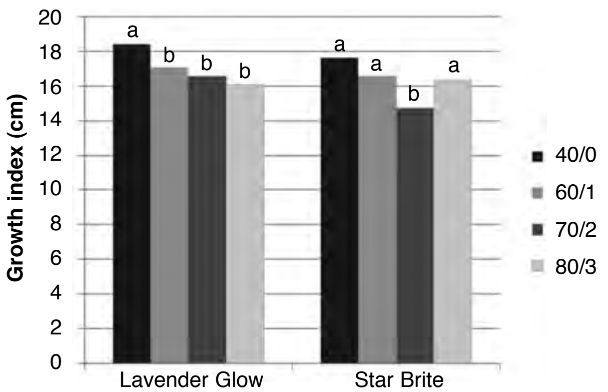

Figure 9. The effect of irrigation treatment on the growth index (GI) of 'Lavender Glow' and 'Star Brite' Intensia® phlox in both growing environments (greenhouse and cold frame). GI = (height + width1 + width2)/3. Means compared by Fisher's Protected LSD at *P*=0.05. Columns within a series with the same letter do not differ at the 5% significance level.

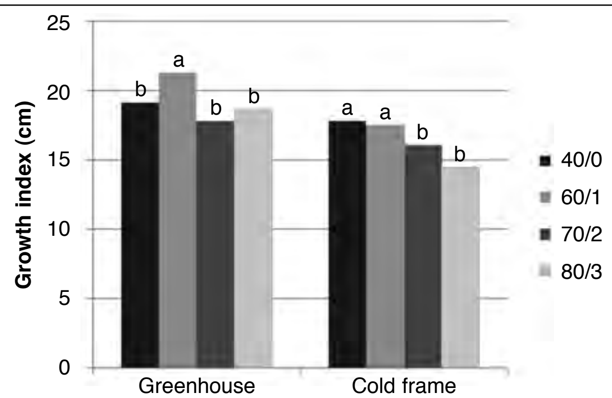

Figure 10. The effect of irrigation treatment on the growth index (GI) of 'Cabernet' Intensia® phlox in both growing environments (greenhouse and cold frame). GI = (height + width1 + width2)/3. Means compared by Fisher's Protected LSD at *P*=0.05. Columns within a series with the same letter do not differ at the 5% significance level.

DISCUSSION

Results from this study indicated that regardless of the environment, plants receiving irrigation at higher frequencies with lower volume at each irrigation (40/0, 60/1) produced as many or more flowers than plants receiving irrigation at lower frequencies with higher volume at each irrigation (70/2, 80/3). A similar response was seen in pansy, where irrigation interval did not affect flowering (Flohr and Conover). The 80/3 irrigation treatment produced plants with less dry weight than the 40/0 and 60/1 treatments for two of three Intensia® cultivars. The substrate gravimetric water content was lowest in the 80/3. This is similar to results of gaura and vinca growth, where plant dry weight was reduced by lower substrate water contents (Burnett and van Iersel, 2008; van Iersel et al., 2007). Dry weights of agastache, ornamental pepper, and vinca were not affected by reduced substrate water content, but dusty miller, petunia, and plumbago were affected (Niu et al., 2006). Plants receiving 40/0 and 60/1 irrigation had a GI larger than or similar to plants receiving irrigation at lower frequencies with higher volume per irrigation (70/2, 80/3). This response was also seen with shoot growth of gaura, which increased with higher substrate water content (Burnett and van Iersel, 2008). Visual appearance and root ratings for plants receiving higher frequency, lower volume irrigations (40/0, 60/1) were higher than or similar to ratings for plants that received lower frequency, higher volume irrigations (70/2, 80/3).

However, plants receiving irrigation at lower frequencies (70/2, 80/3) were more compact (lower GI), which is a desirable trait, than plants that received irrigation at higher frequencies (40/0, 60/1), depending on cultivars. This finding agrees with the results of Burnett and van Iersel (2008), who reported decreased shoot length with decreased substrate water content. Environment also has significant influence on plant growth and quality. Plants grown in the heated greenhouse produced more flowers than plants grown in the cold frame. However, in general, plants grown in the cold frame were more compact than plants grown in the heated greenhouse, depending on cultivars. They also had similar or higher visual appearance ratings.

In conclusion, results from this study indicate that growers can use cold frames to produce quality Intensia® phlox plants. More frequent, lighter irrigations resulted in higher substrate water contents, which tended to produce bigger plants with more flowers and higher overall quality ratings. This has been seen in other bedding plant crops (Flohr and Conover, 1994; Burnett and van Iersel, 2008; van Iersel et al., 2007). However, less frequent irrigation tended to produce more compact plants. Growers must make production decisions based on the trade-off among desirable plant traits and available production systems.

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