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# Rosetting of Lisianthus Cultivars Exposed to High Temperatures

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**Abstract:** Three lisianthus [Eustoma grandiflorum (Raf.) Shinn.] cultivars 0, 10, 17, 24, or 31 days from sowing were grown in 28C soil for 0, 7, 14, 21, or 28 days to determine the effects of high temperature during seedling growth on the development of rosetted plants. Increasing the duration of the high-temperature exposure increased the percentage of rosetted plants for all cultivars. Such exposure for 28 days resulted in 96%, 93%, and 18% rosetted plants for cultivars Yodel White, Yodel Pink, and GCREC-Blue, respectively. Seedling age did not affect percentage of flowering 'Yodel Pink' plants, but as seedlings age increased to 31 days, the percentage of flowering plants increased with 'GCREC-Blue' and decreased for 'Yodel White'. In a second experiment, four lisianthus cultivars were grown at 22C for 3 weeks and then exposed for 28 days to soil at 22, 25, 28, and 31C. Increasing soil temperature resulted in more rosetted plants for all cultivars. With soil at 31C, 83%, 58%, 19%, and 2% of the seedlings rosetted for the cultivars USDA-Pink, Yodel White, Little Belle Blue, and GCREC-Blue, respectively.

One factor limiting lisianthus production is the high percentage of plants that rosette and fail to flower within an acceptable cropping period (˜140 days). Lisianthus is described as an annual or biennial plant (Bailey and Baily, 1976). Rosette plants have a basal cluster of leaves and very short internodes, similar to the first season's growth of many biennials. Many rosetted seedlings have been observed in native stands of lisianthus in Grimes County, Texas (lat. 30ºN), during August and September when day temperatures frequently exceeded 35C. Lisianthus cultivars seeded May through October that form rosettes typically will not flower until April or May of the following year (Harbaugh, 1988). One or more side shoots of rosetted plants may elongate and flower. These semirosetted plants flower unpredictably and are of poor quality as cut flowers and potted plants.

As part of a national cooperative research project to study flowering in lisianthus, seeds were sown in February, June, and September in Bradenton, FL (lat. 27.5°N); Overton, Texas (lat. 32°N); and Beltsville, MD (lat. 39°N). Depending on cultivar, we observed that from 30% to 85% of the plants rosetted from the June seeding date in all three locations. Fewer than 5% of the February or September sown plants rosetted (unpublished data). Average greenhouse temperatures exceeded 28C at the three locations during production of plants from June sowings. These and other observations indicated that high temperatures during seedling production may cause or contribute to rosetting in some lisianthus cultivars.

Information on the effects of temperature on lisianthus growth development are sparse. Halevy and Kofranek (1984) reported that plants flowered 11 to 23 days earlier at 26 to 30/18C (day/night) than plants grown at 20 to 24/13C (day/night). However, temperature treatments were initiated 110 days from sowing. Several reports have indicated that temperatures >21C during seedling development will reduce quality of flowering plants (Roh and Lawson, 1987; Roh et al., 1989). Data on the effect of temperature on rosetting were not presented. Ohkawa et al. (1991) reported that air temperature >25C induced rosetting in 'Fukushihai' lisianthus seedlings. High-temperature treatments for >14 days completely inhibited bolting. The research reported here was conducted to determine the relationship between high temperature exposure during seedling development and the incidence of rosetting in several lisianthus cultivars.

***Seedling age and duration of high-temperature exposure (Expt. 1).*** Seeds were sown on 9 Jan. 1989, at Bradenton. Seedlings 0, 10, 17, 24, or 31 days following sowing were grown in 28 $\pm$ 1C soil for 0, 7, 14, 21, or 28 days. Only seedlings from the control (0 days from sowing) were exposed to the high temperature during germination since seeds germinated in 5 to 10 days. The plants were grown in growth chambers during the high temperature exposure and cool-white fluorescent and incandescent bulbs provided a photosynthetic photon flux (PPF) of 80 $\mu mol \cdot m^{-2} \cdot s^{-1}$ for 12 h. Air temperature was maintained in the range of $\pm$ 2C of the soil temperature. Germination and seedling development occurred in a controlled environment room when the plants were not being subjected to high temperature. The control room was maintained at 22 to 24C with a PPF of 30 $\mu mol \cdot m^{-2} \cdot s^{-1}$ for 12 h from cooling white fluorescent lamps. When the last high-temperature treatment was completed, all plants were transplanted into 0.5-liter (10-cm diameter) pots and grown in a fan-and-pad cooled glasshouse where the air ranged from 33/15C (day/night). Shading was provided by exterior paint, and the midday PPF ranged from 600 to 800 $\mu mol \cdot m^{-2} \cdot s^{-1}$.

'Yodel Pink', 'Yodel White' (Sakata Seed Co., Yokohama, Japan) and 'GCREC-Blue' (a heat tolerant, semi-dwarf, blue selection made at the Gulf Coast Research and Education Center, Bradenton) were studied in this experiment. There were three plants per experimental unit and four replications. The percentage of plants in each experimental unit that rosetted (basal cluster of leaves with no visible stem elongation), semirosetted (basal cluster of leaves but with stem elongation or flowering from nonterminal shoots), or flowered (open flowers from the terminal shoot and the absence of a basal cluster of leaves) was recorded 172 days from seeding. Data were analyzed following arcsine transformation for data based on percentages (Little and Hills, 1975).

***Temperature regression (Expt. 2).*** Seedlings (21 days from sowing) of cultivars Yodel White; Little Belle Blue [released from U.S. Dept. of Agriculture (USDA)-Beltsville]; USDA-Pink (a heat sensitive, semi-dwarf, pink selection made at the USDA-Beltsville); and GCREC-Blue lisianthus were grown in 22, 25, 28, or 31 $\pm$ 1C soil for 28 days. Environmental conditions during germination and seedling production were the same as in Expt. 1, except the lights were on for 18 h. After the temperature treatements, seedlings were transplanted into 3.5 x 3.5 x 6-cm pyramidal cell transplant flats (35 ml soil per cell). Continued development occurred under greenhouse conditions as in Expt. 1, except daylength was extended from twilight to 0200 HR with 2 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of incandescent illumination.

The experiment was terminated 110 days from sowing, ~ 1 month after the first visible flower buds were observed in all cultivars. Data on the size of seedlings at transplanting, days to visible flower buds, and percentage of plants that were rosetted, semirosetted, or had visible buds by day (110) were recorded. The arcsine transformation was used for regression analyses of percentage data. There were 16 plants per experimental unit and four replications in time for temperature treatments. Seeds for the first two replications were sown 16 Jan. and for the two remaining replications 18 Feb. 1990.

***Experiment 1.*** Interactive effects between duration of high temperature exposure and plant age were not significant, so only main effects are presented and discussed. Increasing the duration of 28C exposure increased the percentage of rosetted plants for all cultivars (Table 1). However, the relative percentage of rosetted plants resulting from high temperature exposure was different for each cultivar. 'Yodel White' had 96% rosetted plants after seedlings were exposed to high temperature for 28 days, while 'Yodel Pink' had 93% and 'GCREC-Blue' had 18%. The percentage of semirosetted 'Yodel Pink' plants increased as the duration of high temperature exposure increased from 0 to 14 days. In 'Yodel White', the percentage of semirosetted plants increased with increased high-temperature exposure from 0 to 21 days, and rosetted plants increased with increased high temperature exposure from 0 to 28 days. As the duration of high temperature exposure increased, the percentage of normal flowering plants decreased for all cultivars due to the combined increase in rosetted and semirosetted plants.

Seedling age at time of high-temperature exposure did not affect the percentage of flowering 'Yodel Pink' plants (Table 1). Increasing the seedling age at the time of high temperature exposure from 0 to 31 days increased the percentage of flowering plants for 'GCREC-Blue' but decreased the percentage for 'Yodel White'.

***Experiment 2.*** For all cultivars except 'GCREC-Blue', the percentage of rosetted plants was higher the higher the temperature, form 22 to 31C (Table 2). As in Expt. 1, 'GCREC-Blue' appeared to be less sensitive to high temperatures, with 97% flowering plants at 31C. 'USDA-Pink' was the most sensitive cultivar, with 34% rosetted plants even at 22C. 'Little Belle Blue' had <5% rosetted or semirosetted plants at $\leq$28C, but 31C resulted in 19% rosetted and 25% semirosetted plants. 'Yodel White' had similar percentages of rosetted (20%) and semirosetted (24%) plants after exposure to 28C.

In general for all cultivars, as temperatures increased to 28C, seedling width and number of leaves increased (Table 2). The mean number of days to visible bud increased as temperature increased to 31C. These results indicated that higher temperatures resulted in larger plants. However, the production of larger transplants would be of little value commercially since many of the large transplants did not flower on schedule.

In summary, the results of both experiments support the hypothesis that high temperature exposure of lisianthus seedlings causes development of rosetted and semirosetted plants. The percentage of rosetted plants increased as the duration of exposure to 28C soil increased from 0 to 28 days and as soil temperature increased from 22 to 31C. Cultivars varied in their sensitivity to high temperatures during the seedling stage. The pink cultivars were the most sensitive in both experiments, with 34% rosetted plants for 'USDA-Pink' at the lowest temperature of 22C. The cultivar GCREC-blue was selected for heat tolerance from a tissue cultured line of 'Blue Poppy' at the Gulf Coast

Research and Education Center. The low tendency to form rosetted plants by 'GCREC-Blue' at high temperature exposure (2% rosetted plants with 31C soil for 28 days) indicated that breeding efforts can reduce the high temperature sensitivity in lisianthus.

**Literature cited**


Bailey, L.. and E. Z. Baily. 1976. Hortus Third. MacMillan, New York

Halevy, A.H. and A.M. Kofranek. 1984. Evaluation of lisianthus as a new flower crop. HortScience 19:845-847.

Harbaugh, B.K. 1988. Scheduling lisianthus (*Eustoma grandiflorum*) production. Gulf Coast Res. and Educ. Center Res. Rpt. BRA1988-25.

Little, T.M. and F.J. Hills. 1975. Statistical methods in agricultural research. Univ. of California Press, Davis.

Ohkawa, K., A. Kano, K. Kanematsu, and M. Korenaga. 1991. Effects of air temperature and time on rosette formation in seedlings of *Eustoma grandiflorum* (Raf.) Shinn. Scientia Hort. 48:171-176.

Roh, M.S., A.H. Halevy, and H.F. Wilkins. 1989. *Eustoma grandiflorum*, p. 322-327. In: A.H. Halevy (ed.). Handbook of flowering. Vol. VI. Crit. Rev. Plant Sci. Nutr. Press, Boca Raton, FL.

Roh, M.S. and R.H. Lawson. 1987. Research and development on new crops in the United States Department of Agriculture. Acta Hort. 205:39-48.

**Table 1.** Percentage of rosetted, semirosetted, and flowering lisianthus. 'Yodel Pink', 'Yodel White', and 'GCREC-Blue; cultivars as a result of exposing 0 to 31-day-old seedlings (from sowing) to 0, 7, 14, 21, or 28 days of 28C soil temperature.

| | Yodel Pink | | | Yodel White | | | GCREC-Blue | | |
|---|---|---|---|---|---|---|---|---|---|
| Variable | Rosetted | Semirosetted | Flowering | Rosetted | Semirosetted | Flowering | Rosetted | Semirosetted | Flowering |
| Days exposed[z] | | | | | | | | | |
| 0 | 9 | 9 | 82 | 0 | 9 | 91 | 0 | 0 | 100 |
| 7 | 35 | 29 | 36 | 20 | 17 | 63 | 1 | 1 | 98 |
| 14 | 35 | 34 | 11 | 20 | 28 | 52 | 11 | 9 | 80 |
| 21 | 91 | 7 | 2 | 58 | 27 | 15 | 9 | 3 | 88 |
| 28 | 93 | 7 | 0 | 96 | 4 | 0 | 18 | 13 | 69 |
| Linear | ** | NS | ** | ** | ** | ** | ** | NS | ** |
| Quadratic | NS | ** | ** | NS | NS | NS | ** | ** | NS |
| Seedling age (days) | | | | | | | | | |
| 0 | 54 | 19 | 27 | 33 | 7 | 60 | 19 | 5 | 76 |
| 10 | 54 | 20 | 26 | 37 | 18 | 45 | 5 | 9 | 86 |
| 17 | 62 | 13 | 25 | 47 | 17 | 36 | 7 | 8 | 85 |
| 24 | 62 | 12 | 26 | 40 | 17 | 43 | 3 | 7 | 90 |
| 31 | 54 | 20 | 26 | 38 | 25 | 37 | 2 | 0 | 98 |
| Linear | NS | NS | NS | ** | NS | * | NS | * | * |
| Quadratic | NS | NS | NS | NS | NS | NS | NS | NS | NS |

[z]Duration x plant age interactions were not significant. The main-effect values represent the means of 20 observations for duration treatments (four replications averaged over five seedling age treatments) and plant age (four replications averaged over five duration treatments of high temperature).

NS, *, ** Nonsignificant or significant at $P = 0.05$ or 0.01, respectively.

**Table 2.** Growth responses[z] of four lisianthus cultivars grown at 22C for 21 days from sowing and then grown in 22, 25, 28, or 31 C soils for 28 days.

| Soil temp (ºC) | Flowering stage | | | Seedling[y] | | |
|---|---|---|---|---|---|---|
| | Rosette (%) | Semirosette (%) | Visible bud (%) | Width (cm) | Leaves (no.) | Visible bud (days) |
| | | | *USDA-Pink* | | | |
| 22 | 34 | 3 | 63 | 1.6 | 6.2 | 96 |
| 25 | 35 | 14 | 51 | 2.4 | 7.1 | 98 |
| 28 | 65 | 8 | 27 | 3.1 | 7.3 | 102 |
| 31 | 83 | 4 | 13 | 2.5 | 7.5 | 102 |
| Linear | ** | NS | ** | * | ** | * |
| Quadratic | NS | * | NS | ** | NS | NS |
| | | | *Yodel White* | | | |
| 22 | 0 | 0 | 100 | 3.6 | 7.2 | 87 |
| 25 | 5 | 4 | 91 | 3.9 | 7.2 | 92 |
| 28 | 20 | 24 | 56 | 5.9 | 7.6 | 94 |
| 31 | 58 | 16 | 26 | 4.3 | 7.4 | 100 |
| Linear | ** | * | ** | NS | NS | ** |
| Quadratic | NS | NS | NS | NS | NS | ** |
| | | | *Little Belle Blue* | | | |
| 22 | 1 | 1 | 98 | 2.8 | 7.3 | 86 |
| 25 | 5 | 1 | 94 | 3.5 | 7.6 | 87 |
| 28 | 3 | 3 | 94 | 4.3 | 8.4 | 88 |
| 31 | 19 | 25 | 56 | 3.8 | 7.9 | 92 |
| Linear | * | NS | ** | * | * | * |
| Quadratic | NS | NS | * | NS | NS | NS |
| | | | *GCREC-Blue* | | | |
| 22 | 0 | 0 | 100 | 2.8 | 6.0 | 92 |
| 25 | 0 | 0 | 100 | 2.8 | 6.5 | 91 |
| 28 | 0 | 0 | 100 | 3.3 | 7.2 | 91 |
| 31 | 2 | 1 | 97 | 3.1 | 7.1 | 94 |
| Linear | NS | NS | * | NS | NS | NS |
| Quadratic | NS | NS | NS | NS | NS | NS |

[z]Values for seedling width, leaves, and days to visible bud represent the mean of 64 observations (four replications of 16-plnat experimental units). Percentage values represent the mean of four replications for percentage of 16-plant experimental units which were rosette, semirosette, or flowering.
[y]Data recorded after temperature treatments, 64 days from seeding.
NS, *, **, Nonsignificant or significant at P = 0.05 or0.01, respectively.