In Vitro Induction of Tetraploids in *Dieffenbachia* × ‘Star Bright M-1’ by Colchicine

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Abstract. Colchicine application successfully induced tetraploids from in vitro-cultured diploid *Dieffenbachia* × ‘Star Bright M-1’. Shoot clumps, each with six to eight small, undifferentiated shoot primordia, were cultured in liquid Murashige and Skoog (MS) medium and treated with colchicine at rates of 0, 250, 500, or 1000 mg L−1 for 24 h. In vitro survival of shoot clumps significantly decreased as colchicine concentrations increased. Shoot clumps that survived were transferred to colchicine-free MS medium containing 2.0 mg L−1 N′-isopentenyl) adenine and 0.10 mg L−1 indole-3-acetic acid. Shoots were harvested during four subsequent subcultures and planted in a soilless substrate in a shaded greenhouse. The number of plants that survived 6 months after ex vitro planting was 690, 204, 59, and 69 for colchicine treatments at 0, 250, 500, and 1000 mg L−1, respectively. The 332 plants from colchicine treatments along with 90 control plants (selected from 690 in the control treatment) were evaluated morphologically in a shaded greenhouse. Overall plant growth, including crown height, plant canopy, and leaf size, of colchicine-treated plants was significantly less than controls. Based on the growth data, 10, 32, 15, and 16 plants from the 0, 250, 500, and 1000 mg L−1 colchicine rates, respectively, were selected and analyzed by flow cytometry. Flow cytometry confirmed the presence of 13 tetraploids and 29 mixoploids among the 63 colchicine-treated selections; all 10 plants from the control were diploid. A colchicine rate of 500 mg L−1 for 24 h. In vitro survival of shoot clumps significantly decreased as colchicine concentrations increased. Shoot clumps that survived were transferred to colchicine-free MS medium containing 2.0 mg L−1 N′-isopentenyl) adenine and 0.10 mg L−1 indole-3-acetic acid. Shoots were harvested during four subsequent subcultures and planted in a soilless substrate in a shaded greenhouse. The number of plants that survived 6 months after ex vitro planting was 690, 204, 59, and 69 for colchicine treatments at 0, 250, 500, and 1000 mg L−1, respectively. The 332 plants from colchicine treatments along with 90 control plants (selected from 690 in the control treatment) were evaluated morphologically in a shaded greenhouse. Overall plant growth, including crown height, plant canopy, and leaf size, of colchicine-treated plants was significantly less than controls. Based on the growth data, 10, 32, 15, and 16 plants from the 0, 250, 500, and 1000 mg L−1 colchicine rates, respectively, were selected and analyzed by flow cytometry. Flow cytometry confirmed the presence of 13 tetraploids and 29 mixoploids among the 63 colchicine-treated selections; all 10 plants from the control were diploid. A colchicine rate of 500 mg L−1 produced a higher percentage of tetraploids (10.2%) than did the 250 (2.9%) or 1000 mg L−1 (1.4%) rates. Subsequent comparisons showed tetraploids had significantly smaller and thicker leaves, greater specific leaf weights, and longer stomata than diploids. Tetraploids also showed increased net photosynthetic rate, decreased gs, decreased intercellular CO2 concentration, decreased transpiration rate, and increased water use efficiency. Tetraploids appeared robust and their smaller size could make them potentially more durable plants used as living specimens for interior decoration.

Materials and Methods

In vitro culture establishment. Shoot tips, 10 to 15 mm in length, were dissected from *Dieffenbachia* × ‘Star Bright M-1’ grown in a shaded greenhouse at the University of Florida, Mid-Florida Research and Education Center in Apopka, FL. Lateral buds from the shoots were excised, sterilized, and placed onto culture media using established procedures (Knauss, 1976). Explants were placed aseptically on a culture medium consisting of MS salts (Murashige and Skoog, 1962) supplemented with Gamborg B5 vitamins (Gamborg et al., 1968), 30 g L−1 sucrose, 49.2 g L−1 Murashige and Skoog (M) agar, 0.5 g L−1 ascorbic acid, 0.1 g L−1 thiamine, 137 mg L−1 myo-inositol, and 0.1 mg L−1 each of Naa, NAA, and 2,4-D. Shoots from the clumps were exposed to 0.05% (w/v) colchicine in solid Murashige and Skoog (MS) media for 1, 2, or 4 d resulting in a recovery of tetraploids ranging from 12.9% to 41.8%. Colchicine along with oryzalin and trifluralin also successfully induced tetraploids of *Alocasia micholitziana* ‘Green Velvet’ (Thao et al., 2003) and *Spathiphyllum wallisii* Regal (Eckhaut et al., 2004). However, chemical induction of polyploidy has not been reported in *Dieffenbachia*.

The objectives of this study were to use colchicine to induce tetraploids of *Dieffenbachia* × ‘Star Bright M-1’ in vitro and determine if chemically induced tetraploids were stable and showed better adaptability to low-light conditions for interiorscaping.

 Cultivars of the aroid genus *Dieffenbachia* are valued as ornamental plants for their attractive foliage, ease of production, and their durability as living specimens for interior decoration. Since 1980, with the control of flowering and pollination techniques, many commercial *Dieffenbachia* cultivars have resulted from breeding programs that select for both aesthetics and tolerance of abiotic and biotic stresses (Henny, 2000). To facilitate commercial production, tissue culture methods have been used as a tool for fast and reliable increase of hybridized *Dieffenbachia* selections.

At least 80 commercial foliage plant cultivars have originated from somaclonal variation in tissue culture propagation (Chen and Henny, 2008). *Dieffenbachia* × ‘Star Bright M-1’ is a somaclonal variant of a commercial cultivar *D. X. ‘Star Bright’* (U.S. patent PP9051; Henny, 1995). The M-1 variant was selected out of a population of tissue culture-derived plants because its shorter internodes gave a more compact appearance and the lower leaves were wider than the parent cultivar. In addition, it showed improved adaptability to interior low-light conditions because older leaves were held longer on the plant. A strategy for enhancing plant adaptability to stressful environments is chromosome doubling (Udall and Wendel, 2006). Gene redundancy leads to genome buffering by increasing allelic diversity (Udall and Wendel, 2006), thus increasing plant tolerance to environmental stress. Polyploid plants can be more robust, have thicker leaves, larger fruit, a greater degree of drought and disease tolerance, improved adaptability, and resistance to environmental stress (Chakrabarti et al., 1998; Eckhaut et al., 2004). Additionally, chromosome doubling may provide an opportunity for novel phenotypic variation resulting from gene duplications (Udall and Wendel, 2006). Thus, an approach to further enhance the adaptability of the M-1 variant to interior low-light conditions could be chromosome doubling. Colchicine is the most widely used chemical agent for chromosome doubling. Tetraploids at frequencies of 83.3% and 80.0% were induced in *Xanthosoma sagittifolium* when in vitro-grown plants were treated with 1.25 mM or 2.5 mM of colchicine, respectively (Tambong et al., 1998). Colchicine has been reported to induce tetraploidy in nine *Zantedeschia* cultivars (Cohen and Yao, 1996). Rapidly multiplying in vitro shoot cultures were exposed to 0.05% (w/v) colchicine on solid Murashige and Skoog (MS) media for 1, 2, or 4 d resulting in a recovery of tetraploids ranging from 12.9% to 41.8%. Colchicine along with oryzalin and trifluralin also successfully induced tetraploids of *Alocasia micholitziana* ‘Green Velvet’ (Thao et al., 2003) and *Spathiphyllum wallisii* Regal (Eckhaut et al., 2004). However, chemical induction of polyploidy has not been reported in *Dieffenbachia*.

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containing full-strength MS salts, 30 g L\(^{-1}\) sucrose, and no growth regulators. Forty empty baby food jars were filled with 50 mL of these solutions, 10 jars per treatment, autoclaved for 30 min at 15 psi, and 121 °C. The 120 shoot clumps were aseptically transferred into the jars containing 0, 250, 500, and 1000 mg L\(^{-1}\) colchicine/MS liquid medium, three clumps per jar, and placed on a shaker at 80 rpm for 24 h. Shoot clumps then were removed aseptically from the colchicine/MS treatments, rinsed in autoclaved, deionized water, and then placed onto a colchicine-free medium containing MS salts, 9.8 μmol ZIP, 0.11 μmol IAA, 30 g L\(^{-1}\) sucrose, Gamborg B\(_{5}\) vitamins, and 8 g L\(^{-1}\) tissue culture-grade agar and cultured under a 16-h light photoperiod at 40 μmol m\(^{-2}\) s\(^{-1}\) provided by cool-white fluorescent lamps. The cultures were transferred to fresh medium at 6-week intervals. At the time of the second and third transfers, all developed shoots exceeding 2 cm in length were harvested, counted, removed from culture vessels, and transferred to a shaded greenhouse. In vitro survival was determined 12 weeks after colchicine treatment by counting the number of surviving shoot clumps. At 26 weeks after colchicine treatment, all developed shoots were harvested, counted, and planted. Because the number of control plants exceeded a manageable amount, 90 control plants were randomly selected for transfer to the greenhouse (three plants from each of 10 controls for each of the three harvest dates).

**Ex vitro transfer.** Shoots were transferred into 288-celled trays containing Vergro Container Mix A (Verlite Co. Inc., Tampa, FL). The components of the mix were 2:1:1 (v/v) of Canadian peat:vermiculite:perlite. After 10 controls for each of the three harvest dates, all harvested shoots were aseptically transferred to a shaded greenhouse.

**Results**

**Colchicine effects on shoot cultures.** Colchicine effects were apparent between 12 and 26 weeks after treatment (Fig. 1). Shoot clumps not exposed to colchicine grew rapidly with a mean survival rate of 93.3%, whereas mean survival rates of shoot clumps treated by 250, 500, and 1000 mg L\(^{-1}\) colchicine were 63.3%, 30.0%, and 23.3%, respectively (Table 1). Number of shoots produced from control clumps was 690 compared with 306, 73, and 88 from colchicine-treated at 250, 500, and 1000 mg L\(^{-1}\), respectively (Table 1). In the greenhouse, survival rates of ex vitro transfer of shoots resulted from colchicine treatments of 0, 250, 500, and 1000 mg L\(^{-1}\) had the smallest growth index value, largest leaf length, and leaf-specific weight. Using an average of three leaves and three observations in each case, leaf area was measured using a LI-3100 area meter (LI-COR, Inc., Lincoln, NE). Leaf thickness was measured at points along the flat side of the leaf blade in the approximate center to the right or left of the midrib. Midrib thickness was measured by the thickness of the midrib when a leaf is cut at a 90° angle to the midrib and a micrometer is placed on the edge of the cut midrib. Leaf-specific weight was measured as the fresh weight per unit area.

**Experimental design and statistical analysis.** In vitro survival rates were analyzed based on four colchicine treatment levels and 10 baby food jar replications per treatment. Morphological, stomatal, flow cytometry, and photosynthetic data were analyzed using the statistical program MINITAB Release 14 (2005; Minitab Inc., State College, PA). Means that were significant were separated by Fisher’s protected least significant difference.

**Morphological changes.** In all morphological observations (Table 2), control plants were significantly larger than plants treated with colchicine. Primary stem height, canopy height, and width of control plants were the greatest values, whereas plants exposed to 1000 mg L\(^{-1}\) colchicine yielded the smallest values. Similarly, controls had the greatest growth index value, largest leaf length, and largest leaf width. Plants exposed to 1000 mg L\(^{-1}\) colchicine had the smallest growth index value in growth index, leaf length, and leaf width (Table 2). Statistically, however, there were no significant differences in these
This study showed that tetraploids could be induced by treating rapidly growing in vitro shoot cultures of *Dieffenbachia × Star Bright M-1* with colchicine at concentrations of 250, 500, or 1000 mg L⁻¹. Treatment of cultures at 500 mg L⁻¹ colchicine produced more tetraploids (10.2%) than did all other concentrations of tetraploids was 83.4% higher than the control plants was 37.8 μm. Mean stomata lengths of the 63 colchicine-treated plants were 40.2 μm but varied from 38.3 to 47.0 μm.

**Evaluation of tetraploid versus diploid leaves.** All leaf morphological comparisons of tetraploids to diploids were significantly different except for the midrib thickness (Table 5; Fig. 3). Leaves of tetraploids averaged 83% thicker than diploids. Leaves of tetraploids averaged 83% thicker than diploids and felt sturdier than leaves of the diploids. Leaf-specific weight of tetraploids was 53% greater than diploids.

Photosynthetic comparison showed that tetraploids had significantly higher net photosynthetic rate but lower gs, intercellular CO₂ concentration, and transpiration rate than diploids (Table 6). As a result, WUE of tetraploids was 83.4% higher than the diploids.

**Discussion**

Three indices between plants treated by 500 or 1000 mg L⁻¹ colchicine.

A second morphological evaluation of these 63 plants, plus 10 randomly selected control plants, substantiated the effects of colchicine concentration on morphology (Table 3). Control plants had significantly greater values in crown height, canopy height and width, growth index, largest leaf length, and width than treated plants. Overall, the assessment of morphological traits confirmed that increasing colchicine concentration significantly affected morphology of *Dieffenbachia × Star Bright M-1*, which might indicate polyploidy in treated plants.

**Stomata observation.** Stomata observation showed that mean stomata length of control plants was 37.8 μm. Mean stomata lengths of the 63 colchicine-treated plants was 40.2 μm but varied from 38.3 to 47.0 μm.

**Flow cytometry analysis.** Flow cytometry screening of these 73 plants confirmed that 21 treated and 10 control plants were diploid, whereas 13 treated plants were tetraploid and 29 were mixoploid.

Table 1. In vitro percent survival of tissue cultured *Dieffenbachia × StarBright M-1* shoot clumps 12 weeks after treatment with four rates of colchicine in vitro and total number and mean percent survival of shoots harvested 6 months after transfer to the shaded greenhouse.

| Colchicine (mg L⁻¹) | Total no. of clumps survived | Percent clump survival at 12 wk | Total no. of shoots harvested | Total no. of shoots survived ex vitro | Mean percent survival ex vitro |
|---------------------|------------------------------|--------------------------------|-----------------------------|--------------------------------------|-------------------------------|
| 0                   | 28                           | 93.3 a                         | 690                         | 690                                  | 100.0 a                       |
| 250                 | 19                           | 63.3 b                         | 306                         | 204                                  | 66.4 b                        |
| 500                 | 9                            | 30.0 c                         | 73                          | 59                                   | 80.2 b                        |
| 1,000               | 7                            | 23.3 c                         | 88                          | 69                                   | 80.4 b                        |

Values followed by the same letter are not significantly different using Fisher’s least significant difference at P ≤ 0.05.

Table 2. Morphological characteristics of 422 *Dieffenbachia × Star Bright M-1* plants 18 months after treatment with four rates of colchicine in vitro or 12 months after transfer to the shaded greenhouse.

| Colchicine (mg L⁻¹) | No. of plants | Primary stem ht (cm) | Canopy ht (cm) | Canopy width (cm) | Growth index (m²) | Largest leaf length (cm) | Largest leaf width (cm) |
|---------------------|---------------|----------------------|----------------|------------------|--------------------|-------------------------|------------------------|
| 0                   | 90            | 13.8 a               | 30.6 a         | 30.0 a           | 918.0 a            | 22.4 a                  | 6.0 a                  |
| 250                 | 204           | 10.5 b               | 24.0 b         | 24.1 b           | 578.4 b            | 18.0 b                  | 5.3 b                  |
| 500                 | 59            | 9.2 c                | 21.9 c         | 22.6 bc          | 494.9 bc           | 16.9 bc                 | 5.0 bc                 |
| 1,000               | 69            | 8.6 c                | 20.1 c         | 21.0 c           | 422.1 c            | 15.3 c                  | 4.6 c                  |

Values followed by the same letter are not significantly different using Fisher’s least significant difference at P ≤ 0.05.

Table 3. Morphological characteristics of *Dieffenbachia × Star Bright M-1* selected based on visual indicators of polyploidy 18 months after treatment with four rates of colchicine in vitro and 12 months after transfer to the greenhouse.

| Colchicine (mg L⁻¹) | No. of plants | Crown ht (cm) | Canopy mean width (cm) | Growth index (m²) | Largest leaf length (cm) | Largest leaf width (cm) |
|---------------------|---------------|---------------|------------------------|--------------------|-------------------------|------------------------|
| 0                   | 10            | 13.4 a        | 29.9 a                 | 29.2 a             | 873.1 a                 | 22.1 a                 |
| 250                 | 32            | 7.5 b         | 17.9 b                 | 19.5 b             | 349.1 b                 | 13.8 b                 |
| 500                 | 15            | 6.5 bc        | 16.1 bc                | 17.9 b             | 285.2 bc                | 12.8 bc                |
| 1,000               | 16            | 6.0 c         | 14.7 c                 | 17.5 b             | 257.3 c                 | 11.6 c                 |

Values followed by the same letter are not significantly different using Fisher’s least significant difference at P ≤ 0.05.

**Fig. 1.** Shoots of *Dieffenbachia × Star Bright M-1* produced 26 weeks after in vitro treatment with colchicine at 0, 250, 500, or 1000 mg L⁻¹ for 24 h in liquid Murashige and Skoog medium in which A = 0, B = 250, C = 500, and D = 1000 mg L⁻¹.
treatment levels. High colchicine concentrations increased the proportion of mixoploids in Allocaasia (Thao et al., 2003). Similarly, higher levels of colchicine tended to produce mixoploids in Morus alba (Chakraborti et al., 1998). However, these authors showed that low concentrations of colchicine decreased the efficiency of converting diploid plants to tetraploids. In this study, both 250 and 1000 mg L⁻¹ treatments produced higher percentages of mixoploids than 500 mg L⁻¹ treatment (Table 4).

Colchicine concentrations at 500 mg L⁻¹ or 1000 mg L⁻¹ significantly reduced in vitro survival compared with 250 mg L⁻¹. Similarly, colchicine reduced ex vitro survival at all treatment rates compared with untreated plants. Although the significance of ex vitro survival affected by colchicine concentration was low, any decrease in survival of colchicine-treated shoots over nontreated controls is likely the result of a carryover effect of colchicine ex vitro as seen in Pyrus pyrifolia (Kadota and Niimi, 2002). Some clumps exposed to 250 mg L⁻¹ colchicine showed growth retardation and a small amount of necrosis. The percent of treated clumps that died was 36.7%, 70.0%, and 76.7% at 250, 500 and 1000 mg L⁻¹, respectively. In Dieffenbachia, there appears to be a threshold level between 500 and 1000 mg L⁻¹ rates as the percent of dead clumps leveled off. This contrasts with Allocaasia, in which colchicine was lethal at concentrations greater than 500 mg L⁻¹ (Thao et al., 2003). In future experimentation, improved success of colchicine-induced polyploidization and survival in vitro could be facilitated by more frequent transfer of explants to fresh media as observed in Buddleia globosa (Rose et al., 2000) or shorter exposure times and smaller dosages as seen in Spathiphyllum (Eeckhaut et al., 2004). Nevertheless, this study showed that a 24-h exposure to 500 mg L⁻¹ colchicine was the optimum in vitro treatment method and concentration range of colchicine for inducing polyploidization of Dieffenbachia hybrids.

This study also suggests that morphological data alone is insufficient to confirm the presence of polyploids but can be valuable tool to select candidates for flow cytometry analysis. The tetraploid plants obtained from all colchicine treatment levels had similarities in plant height, plant width, and leaf shape. Stomata length comparison between tetraploid plants from colchicine treatment and control plants indicated that diploid plants had an average stomata length of 37.5 μm, whereas 13 colchicine-treated plants had a stomata length of 47.0 μm. Stomata size is another source of data that can be used as a tool to prescreen for polyploids. This is in agreement with results from Xanthosoma (Tambong et al., 1998), Allocaasia (Thao et al., 2003), and Alstromeria (Lu and Bridgen, 1997) that stomata in polyploids were found to be significantly larger than diploids.

Flow cytometry is a valuable tool in confirming ploidy level of the 63 plants. This method is simple and convenient; more than 20 leaf samples can be run in 1 h to confirm the ploidy levels with Dieffenbachia. However, as a result of the expense of running large numbers of samples, reducing sample size based on morphology can significantly lessen the cost of screening using flow cytometry and increase the chance of identifying tetraploids. In this study, 66.7% of plants selected based on morphological screening had a ploidy change (either tetraploid or mixoploid) compared with 12.7%
Table 4. Ploidy level of 63 Dieffenbachia × 'Star Bright M-1' plants initially selected as potential polyploids based on morphological traits 18 months after treatment with four rates of colchicine in vitro.\(^a\)

| Colchicine (mg·L\(^{-1}\)) | No. selected for flow cytometry\(^b\) | Ploidy levels determined by flow cytometry | No. | Percent | No. | Percent | No. | Percent |
|---------------------------|-------------------------------------|-----------------------------------------|-----|---------|-----|---------|-----|---------|
|                           |                                     | 2×                                       |     |         |     |         |     |         | 4× |        | 2× + 4× |
|                           |                                     | 2×                                       |     |         |     |         |     |         |     |         |        |
| 0                         | 10                                  | 100.0                                   | 0   | 0.0     | 0   | 0.0     |     |         |     |         |        |
| 250                       | 32                                  | 40.6                                    | 6   | 18.8    | 13  | 40.6    |     |         |     |         |        |
| 500                       | 15                                  | 33.3                                    | 6   | 40.0    | 4   | 26.7    |     |         |     |         |        |
| 1,000                     | 16                                  | 18.8                                    | 12  | 75.0    |     |         |     |         |     |         |        |
| Total                     | 73                                  | 42.5                                    | 13  | 63.7    | 29  | 39.7    |     |         |     |         |        |

\(^a\)Plants had grown for 12 months after transfer to the greenhouse.

\(^b\)Ten plants were randomly selected from control treatment and the rest of plants were selected based on visual characteristics of polyploidy, i.e., thicker leaves, deeper green color, and slower growth rate.

Table 5. Morphological comparison of tetraploids to diploids of Dieffenbachia × 'Star Bright M-1' at 20 months after treatment with four rates of colchicine in vitro or 14 months after transfer to the greenhouse.\(^a\)

| Ploidy | No. of plants | Leaf width: length ratio | Leaf area (cm\(^2\)) | Leaf thickness (mm) | Leaf midrib thickness (mm) | Specific wt (mg·cm\(^{-2}\)) | Stomate length |
|--------|---------------|--------------------------|----------------------|---------------------|---------------------------|-----------------------------|---------------|
| 2×     | 16            | 0.2 a                    | 11.0 a               | 0.3 a               | 2.1 a                     | 36.7 a                      | 37.5 a        |
| 4×     | 13            | 0.3 b                    | 67.4 b               | 0.6 b               | 2.3 a                     | 56.3 b                      | 47.0 b        |

\(^a\)Plants examined were selected based on flow cytometry results.

\(^b\)Values followed by the same letter are not significantly different using Fisher’s least significant difference test at P \(\leq 0.05\).

for the entire population. It is generally agreed that polyploids have larger cell size, thus larger leaves, fruits, and overall larger plant forms (Levin, 1983; Sparnaaj, 1979). Characterization of the identified Dieffenbachia tetraploids, however, showed that tetraploids were miniaturized (Table 6; Fig. 3), exhibited smaller leaf area, thicker and more leathery leaves, and increased specific leaf-weight specific. It is unclear why this exception occurred in the colchicine-induced tetraploids of Dieffenbachia × 'Star Bright M-1'. On the other hand, these altered morphological characteristics might suggest that tetraploids could be more robust and could be more tolerant to stressful environments. Photosynthetic evaluation showed that tetraploids had higher net photosynthetic rate, lower stomata conductance, intercellular CO\(_2\) concentration, and transpiration rate. As a result, WUE of tetraploids was 83.4\% higher than the diploids. The higher net photosynthesis is another exception in Dieffenbachia × 'Star Bright M-1' in which net photosynthetic rate of tetraploids was 39.6\% higher than the diploids. This exception is not unique; high rates were found in tetraploids of Beta vulgaris (Beyssel, 1957) and Hippocrepis comosa (Guern et al., 1975). The higher net photosynthetic rate could be attributable in part to the thicker leaves because net photosynthetic rate is measured based on unit leaf surface area. The higher net photosynthetic rate and higher WUE in tetraploids were found to increase adaptation to interior low-light conditions and tolerance to drought in our preliminary interspecies study, which may suggest that chromosome doubling could be a strategy for increasing plant tolerance to stressful environments such as interior low light and low humidity conditions.

Table 6. Net photosynthetic rate (\(P_n\), \(\mu\)mol CO\(_2\)·m\(^{-2}\)·s\(^{-1}\)), \(g_s\) (cm\(^{-1}\) H\(_2\)O·m\(^{-2}\)·s\(^{-1}\)), intercellular CO\(_2\) concentration (Ci, cm\(^{-1}\) m\(^{-3}\)), transpiration rate (E, mmol H\(_2\)O·m\(^{-2}\)·s\(^{-1}\)), and water use efficiency (WUE, \(\mu\)mol CO\(_2\)·mmol H\(_2\)O) of 2× and 4× Dieffenbachia × 'Star Bright M-1' grown in the shaded greenhouse.\(^a\)

| Ploidy | \(P_n\) | \(g_s\) | Ci | E | WUE |
|--------|--------|--------|----|---|-----|
| 2×     | 1.438 b| 0.016 a| 203.167 a| 0.486 a| 2.95 b |
| 4×     | 2.007 a| 0.011 b| 127.283 b| 0.372 b| 5.41 a |

\(^a\)The value of \(P_n\), \(g_s\), Ci, E, and WUE was mean of nine leaves (three leaves per replicate). The values of canopy height and width, root, shoot, and total dry weights were mean of three containerized plants. Means followed by different letters within columns were significantly different based on Fisher’s least significant difference test at P \(\leq 5\%\).

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