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Growth and flowering response of woody and herbaceous floral crops grown in petroleum-based plastic pots and bioplastic pots containing poultry feather fibers

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ABSTRACT

Corylopsis sinensis var. *calvescens*, *Hydrangea serrata*, and the *Lilium* hybrids, 'Triumphator' and 'Mistress' were grown in injection molded bioplastic pots (BP) containing 30% feather fibers (BP 45 pot) and in petroleum-based pots (plastic pot). Temperature in the growing medium adjacent to the pot and the light transmitted through the pot were measured. Distribution of roots at the surface of the growing medium adjacent to the pots was observed. Macro- and micro-elements in the leaf tissue were analyzed, and flowering responses were recorded. Root development of *Lilium* hybrids grown in BP 45 pots produced a fewer roots to hybrids grown in the plastic pot based on the visual observation. Flowering, leaf size, and nitrogen concentration were not affected by pot types. However, there was a significant increase in shoot length and nitrogen concentration in leaves of *Corylopsis* and *Hydrangea* grown in BP 45 pots. The size and color of the leaves was large and darker in *Hydrangea* and *Corylopsis* when grown in BP 45 pots. This could result from the vigorous root mass development influenced by an increase in light transmission to the growing medium through BP 45 pots and not by the release of nitrogen from the BP 45 pots. The physical strength of BP 45 pots can be maintained for one year. We conclude that BP 45 pots processed with pellets containing 30% of feather fibers can be used to grow woody and herbaceous ornamental crops.

1. Introduction

Pellets processed from chicken feather fibers (Barone et al., 2005) were incorporated into the growing medium (Roh et al., 2012a,b) or for use as injected molded pots (Roh, 2013) and evaluated for growth and flowering of *Begonia boliviensis* A. DC. and hybrid lilies. Among different formulations of pellets or of pots containing feather fibers, pellet 45 (P 45) containing 30% feather fibers and injection molded pots prepared from P 45 (BP 45 pot) were successfully used to grow *Begonia* 'BonFire' and 'Triumphator' and 'Monte Grace' hybrid lilies. Nitrogen was released from feather fibers composed of about 91% keratin (Schmidt and Jayasundera, 2004). However, based on the analysis of the growing medium amended with P 45 and of the BP 45 pots and tissue analyses, the contribution of nitrogen to plants from P 45 and BP 45 pots was considered negligible (Roh, 2013; Roh et al., 2012a,b,c), even though nitrogen was released following steam hydrolysis of feathers (Choi and Nelson, 1996). Therefore, application of slow release fertilizer was needed to produce acceptable plants (Roh, 2013; Roh et al., 2012a,b,c).

Strength of BP pots due to biodegradation may become an issue for plants grown for a long period of time. In addition, the availability of nitrogen to plants grown in BP 45 pots must be considered (Roh et al., 2012a,b). Among three types of BP pots (BP 29, BP 32, and BP 45 pots), BP 45 pots were considered stable due to a low water absorption. The outside surface of the BP 45 pots did not show spaces between the processed feather fibers and other ingredients observed by low temperature-scanning electron microscope (Roh et al., 2012c). A bioplastic pot of unknown chemical composition (#1 BP pot) was reported to maintain physical strength after growing several woody plants including *Spirea japonica* for one season

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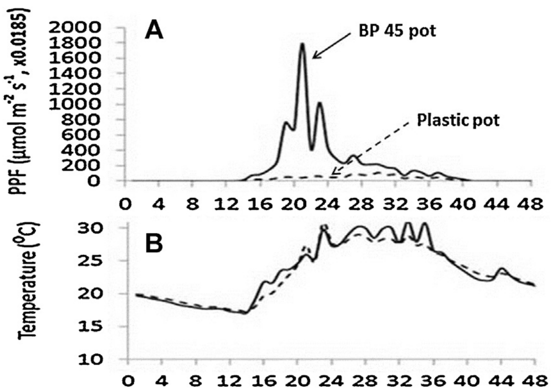

Fig. 1. Irradiance (A) and temperature (B) on May 3, 2010 in a petroleum based plastic and bioplastic BP 45 pot filled with growing medium. Data were recorded every 30 min for 24 h.

(Fare, 2012). *Petunia* grown in OP 47 pots resulted in plant size and the number of flowers similar to those grown in plastic pots (Nambuthiri et al., 2013).

The objectives of this study were to investigate the changes in temperature and light in the growing medium adjacent to the inner surface of BP 45 pots and to investigate whether plant growth and development of *Corylopsis*, *Hydrangea*, and *Lilium* hybrids were different in plants grown in BP 45 as compared to plastic pots on benches in a greenhouse environment.

2. Materials and methods

2.1. Plant materials and general culture

One year old *Corylopsis sinensis* var. *calvescens* Rehder & E. H. Wilson (US National Arboretum NA 57931) plants grown in 10 cm plastic pots, rooted cuttings of *Hydrangea serrata* (Thunb.) Ser. (accession No. 6 collected from Jeju, Korea), and fully vernalized *Lilium* hybrid bulbs, 'Triumphator' (16–18 cm in circumference) and 'Mistress' (14–16 cm in circumference) were evaluated. *Corylopsis* plants were pruned to 3 shoots and trimmed to 10 cm and *Hydrangea* plants were pinched to 13 cm to remove flower buds and to induce the formation of lateral shoots. *Lilium* hybrids, 'Mistress' and 'Triumphator', 3 and 2 bulbs, respectively, per pot were planted. Plants were planted in a 2.45 L (16 cm width × 17 cm height) black petroleum-based pots (plastic pot) (Poly-Train Can No. 1-C, Nursery Supplies Inc., Orange, CA, USA) and the same size of BP 45 pots filled with Metro Mix 510 (Sun Grow Horticulture, Agawam, MA, USA) on March 22, 2010. At the time of planting, 3.2 g of 14N–6.1P–11.4K slow release fertilizer (Scotts Co., Maysville, OH, USA) was surface applied to the growing medium.

The greenhouse temperature was maintained as described (Roh et al., 2012c) and dropped by 2 °C every 10–14 days until December 14, 2010 when temperature was kept constant at 4 °C until February 25, 2011. Then temperatures were raised to 12/7 °C, and to 18/15 °C in March, 2011. Temperatures and light levels between 200 and 1200 nm were recorded using an HOBO pendant temperature/light data logger 64K-US 001-64 (Onset Computer Corporation, Boume, MA, USA) every 30 min until the completion of the experiment. Only data collected on May 3 are presented (Fig. 1). Loggers were placed 30 cm above the rim of the pot and also buried 3 cm deep and 1 cm from the inner surface of the pot. Pots placed on the bench and exposed to the greenhouse environment were spaced 30 cm apart starting from May 1 to avoid potential shading effects among plants. Light levels were converted to photosynthetic photon flux using the program of "unit conversion tool 5.1" (http://www.accelware.com/Unit_Conversion_Tool/).

2.2. Data collection and analysis

Data were collected from 10 plants each for *Corylopsis* and *Hydrangea*, 20 plants for 'Triumphator', and 30 for 'Mistress'. The pots were all randomized by species and due to the different growth habits, required different spacing and other cultural practices such as watering frequencies; *Hydrangea* requiring more frequent watering and more space as compared to *Lilium*. The date at anthesis was recorded when 2–3 inflorescences in *Corylopsis* had florets opened, 3–5 ray florets in *Hydrangea* showed color, and the first flower was openin the *Lilium* hybrids. The length of the three longest new shoots was recorded from the pruned position to the tip of the shoots in *Corylopsis* and *Hydrangea*, and from the growing medium to the bracts in *Lilium*. The number of total nodes and buds that reached anthesis was counted. Buds from every three nodes were collected and cut in half longitudinally. The presence of floral organs, anthers and stigma, were used to determine whether buds were under reproductive development. In *Lilium* hybrids, the number of primary and secondary flower buds and the number of leaves (Roh and Wilkins, 1977) was recorded. Pots were left in the greenhouse and on March 19, 2011, the circumference of bulbs and the number of stem bulblets greater than 0.5 cm in diameter were recorded. Data were subjected to the analysis of variance with pot types as a variable for each species, and means were compared by Tukey's honestly significant difference (HSD).

On August 1, 2010, two leaves formed in the middle of the new shoot of each plant of *Corylopsis* and Hydrangea, and five leaves of *Lilium* 'Triumphator' were collected. The leaves were photographed and the length and width recorded. The combined leaves from 5 plants were used for tissue analysis for macro- and micro-elements in duplicates to determine if the nutrition level followed the general recommendations (JR Peters, Allentown, PA, USA). Roots of *Lilium* 'Triumphator' at anthesis in June, 2010, and *Corylopsis*, *Hydrangea*, and *Lilium* 'Triumphator' grown in plastic and BP 45 pots were photographed on August 1, 2010.

3. Results

3.1. Shoot growth, leaf size, and root mass

Differences in growth between treatments were evident in both *Hydrangea* and *Corylopsis*, especially on the size and color of the leaves when plants were grown in the BP 45 pots as compared with plants in plastic pots. Leaves of *Hydrangea* grown in the BP 45 pots were significantly larger (20.5 cm in length and 10.6 cm in width) than those in the plastic pots (12.0 cm × 4.9 cm) and dark green as compared to those grown in the plastic pots (Fig. 2). The leaves of *Corylopsis* were larger in BP 45 pots (14.2 cm × 13.3 cm) than those in plastic pots (12.0 cm × 9.4 cm) and darker green when grown in the BP 45 pots. However, the size of the leaves in both *Lilium* hybrids was not significantly different (data not presented).

On August 1, the root distribution was different between pot types. When grown in BP 45 pots, root development was dense in *Corylopsis* and green *Hydrangea* roots were distributed below the medium surface and adjacent to the pot surface (Fig. 3). *Lilium* 'Triumphator' produced more roots when grown in plastic pots than grown in BP 45 pots. However, root development of *Lilium* 'Mistress' in BP 45 pots was very poor and lower leaves were yellow and dried out due to a bulb rot as compared to root development grown in plastic pots (images not presented).

3.2. Tissue analysis for macro-and micro-elements

Leaf nitrogen (N) concentration of *Corylopsis* was significantly higher in plants grown in BP pots; 1.65% in plastic pots vs. 2.59%