Cutting Propagation and Landscape Performance of an Underutilized Southeastern Native Herb, Coastalplain Honeycombhead (*Balduina angustifolia*)

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Abstract

Coastalplain honeycombhead (*Balduina angustifolia*) is a southeastern USA native wildflower with ornamental and pollinator value and limited horticulture information. We investigated its cutting propagation, stock plant feasibility, and landscaping performance (growth, visual quality, and flowering). While auxin was not needed to achieve >80% rooting percentages, application of 5,000 ppm IBA to cuttings improved rooting performance compared to cuttings treated with 0-2,500 ppm IBA. Photoperiod affected stock plant growth but not flowering, indicating photoperiod may be used for stock plant management as a source of cutting material. Cutting performance was improved in a peat-based mix compared to a 1:1 mix of perlite and vermiculite. In landscape trial 1 (testing effect of planting site), there was a low visual quality rating for plants installed in south Florida while plants in northwest and central Florida had higher visual quality (3 to 4 of the 7 months had a rating ≥3 out of 5). For landscape trial 2 testing the effect of population, there was high visual quality (3 of the 6 months had a rating ≥3 out of 5) for plants collected from all 3 populations, though there was a trend of reduced visual quality for plants from Navarre Beach compared Archbold or Bok Tower.

Species used in the study: Coastalplain honeycombhead *Balduina angustifolia* [(Pursh) B. L. Robinson].

Chemicals used in this study: indole-3-butyric acid (K-IBA).

Index words: asexual propagation, ecotypes, native landscaping, auxins, native plant.

Significance to the Nursery Industry

Basic horticultural information is lacking for most native species, limiting their availability and use in the nursery industry. Coastalplain honeycombhead (*Balduina angustifolia*) is an herb native to the southeastern USA with high horticultural potential and limited available information. In this paper, cutting propagation and landscape use recommendations are developed for Coastalplain honeycombhead. We recommend propagation using apical stem cuttings treated with 5,000 ppm K-IBA in a peat-based mix and using plants that are locally source for use in landscaping.

Introduction

Coastalplain honeycombhead is a southeastern USA native herbaceous annual to biennial which occurs in dry, nutrient poor ecosystems (Anderson and Menges 1997, FNAI 2010, Parker and Jones 1975, USDA NRCS 2021, Wunderlin and Hansen 2011). It has ornamental potential because of its symmetric rounded form and prolific yellow flowers that occur en masse during the fall (Parker and Jones 1975, Wunderlin and Hansen 2011). Coastalplain honeycombhead in the frost-free regions of Florida behave as a biennial while plants in regions with killing frost behave as an annual (Campbell-Martínez et al. 2021).

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Coastalplain honeycombhead may be useful in low-input landscaping and in bee, pollinator, and wildlife-friendly gardens and landscapes. It provides resources for several species, including birds, butterflies, bees, flies, wasps, beetles, and ants (Deyrup and Menges 1997, Glassberg et al. 2000, Stephens 2013, Stephens and Quintana-Ascencio 2015).

Seed propagation of this species has its challenges, including low germination rates, variable viability, and complex dormancy characteristics (Campbell-Martínez et al. 2021). Asexual (cutting) propagation may be a viable method for the propagation of this species when seed supply is limited or cannot be reliably used in commercial propagation systems. However, information on cutting propagation is lacking for coastalplain honeycombhead. Other species within the sunflower family (Asteraceae) have been successfully propagated by stem cuttings (Herrera-Moreno et al. 2013, Kunst-Barosky et al. 2011, Thetford and Miller 2002, Wassner and Ravetta 2000). Of these, some species require application of supplemental auxins to initiate root formation (Wassner and Ravetta 2000) while other species achieve high rooting percentages (>75%) without the use of supplemental auxins (Herrera-Moreno et al. 2013, Kunst-Barosky et al. 2011, Thetford and Miller 2002).

The potential of coastalplain honeycombhead to perform as a high-quality ornamental plant in a managed landscape is not well understood. Wild seeds collected from south Florida and grown in 4.4 L (1.2 gal) cylindrical pots containing potting mix displayed high plant quality (defined as good quality, very acceptable, nice color and good form, healthy and vigorous) a month after transplanting in March and late summer (August to October) when planted in an agricultural row crop system in south Florida during the spring (Smith et al. 2014). However, from April to July and during the fall after flowering, plant quality significantly declined until December, upon which the plants had senesced (Smith et al. 2014). Flowering during this study was acceptable [i.e., many open flowers and average to good flowering or abundant flowering, possible peak bloom (when highest percent of flowers at anthesis)] during the late spring to early summer (May to June) and again during the late summer (August to September). Flowering was of moderate quality during March, April, July, and from October until November upon which the plant senesced (Smith et al. 2014). However, coastalplain honeycombhead plants grown in three other potting mixes had poor visual quality and flowering throughout the same trial one month after transplanting, indicating this species may require specific growing protocols to function as an attractive plant in a managed setting.

Here we investigate the effects of IBA concentrations and substrates on cutting propagation of coastalplain honeycombhead and the effects of photoperiod to maintain stock plants for use in cutting propagation. We also investigated landscape performance (survival, growth, visual quality, and flowering) of coastalplain honeycombhead in 2 trials that examined the effects of planting site or population on growth flowering, and visual appeal.

Materials and Methods

Cutting experiments. A series of two experiments were conducted to determine the effects of auxin and container media on cutting performance (rooting percentages, visual quality, root number, and root length) of coastalplain honeycombhead. In experiment 1, cuttings were harvested June 18, 2008 from the Poinciana Ridge (Martin County, FL). A single factor (auxin concentration) was tested with four levels, including a quick dip [bottom 1 cm (0.4 in) for 1 second] of the basal portion of cuttings in 0, 1,000, 2,500, or 5,000 ppm (mg/L) auxin solution consisting of distilled water and dissolved indole-3-butyric acid (K-IBA) [Hortus USA Corp., New York, NY, EPA Reg # 63310-22)]. Cuttings were stuck (6 replications each with 6 cuttings per IBA treatment) in Fafard 3B potting mix [40% Canadian sphagnum peat moss, 25% pine bark, 10% vermiculite, 20% perlite and trace amounts of dolomite lime, Silicon (RESiLIENCE), and a long-lasting wetting agent); Sun Gro Horticulture, Agawam, MA].

In experiment 2, cuttings were harvested July 31, 2008, from the Green Swamp Wilderness Preserve (West Tract, Sumpter County, FL). Two factors were tested including 0, 1,000, 2,500, or 5,000 ppm auxin as described in cutting experiment 1 and different potting mixes including Fafard 3B potting mix or a perlite and vermiculite (50:50 by volume) mix. A total of 288 cuttings were stuck (a total of 144 cuttings per propagation potting mix representing 6 replications each with 6 cuttings per IBA treatment). The experiment utilized a randomized complete block design and a 4 (auxin concentration) × 2 (potting mix) full factorial arrangement of treatments. For both experiments, cuttings were stuck in 72-cell trays and placed under intermittent mist operating from 6 am to 5 pm with 3 s of mist every 20 min until experiment termination within a Lexan-covered, climate-controlled greenhouse at the West Florida Research and Education Center in Milton, FL. Rooting was evaluated via a destructive harvest 5 weeks after sticking. The number of cuttings with roots was recorded and a rooting percentage was calculated. For each rooted cutting, the root visual quality, root length, and number of roots per cutting were recorded. Root class was defined using a scale based on a range of the proportion of the rootball media held cohesively after removal from pots (1 = 0-5%; 2 = 6-25%; 3 = 26-75%; 4 = 76-95%; 5 = 96-100%). Root length was recorded as the length of the longest root (cm). Six, 6-cell packs were the experimental units for evaluating the percentage of cuttings with roots, while the experimental units for all other variables were alive, rooted cuttings.

Photoperiod experiment. Container-grown stock plants [4 L (1 gal) pots planted with three rooted cuttings in July] maintained in a greenhouse were used to determine the extent to which plants were responsive to photoperiod (light treatments) as a method of reducing or eliminating floral development for stock plant management. Experimental design was a single factor (photoperiod) with stock plants subjected to three treatment levels including short day (9 hr photoperiod), night interruption photoperiod (9 hr + 10:00 p.m. - 2:00 a.m.), or long day (16 hr. photoperiod) treatments beginning August 15, 2009. Several plants had already shown signs of floral bud initiation at the time of potting, so all plants were pruned to a consistent height [approximately 0.3 m (1 ft)], thereby removing all existing flower buds and encouraging increased branching. Plants were evaluated after 2 months for height, mean width, and flowering. Flower ratings utilized a 1-5 scale where 1 = no flowers or flower buds; 2 = flower buds visible, no open flowers; 3 = one to several open flowers; 4 = many open flowers, average to good flowering; 5 = abundant flowering, possible peak bloom. This was a single factor experiment with 11 – 13 replicates per photoperiod treatment level.

Landscape performance. A series of two landscape trial experiments were conducted to determine the effects of seed source or geographic region of outplanting on landscape performance (survival, growth, visual quality, and flowering) of seedling transplants. For landscape trial 1, seeds were collected from Scrub Oak Preserve (Martin County, FL), sown in #30 ribbed-cone seedling trays (Landmark Plastic Cooperation, Akron, OH), and grown in the University of Florida Indian River Research and Education Center greenhouses for 4 weeks. Finished plugs were transplanted into 4 L (1 gal) pots with Atlas 3000 potting mix (40% Canadian sphagnum peat moss, 50% pine bark, 10% coarse sand; Atlas Peat and Soil Inc., Boynton Beach FL) with a manufacturer recommended rate of 15 g (0.53 oz per pot) of 15N:3.9P2O5:10K2O Osmocote Plus (Scotts Co., Marysville, OH). Finished plants were distributed and planted at 3 sites located in northwest (Milton), northcentral (Gainesville) and south (Fort Pierce) Florida. At each site, raised beds were prepared with semipermeable landscape fabric (Lumite, Gainesville, Georgia) that was cut to allow for transplanting and drip irrigation.

Initial soil samples were analyzed at a commercial lab. Experimental design was a randomized complete block with 3 plants replicated in 3 blocks for each planting site.

Visual quality and flowering were assessed every 4 weeks for 48 weeks. Visual quality was based on a scale of 1-5, where 1 = very poor quality - not acceptable, severe leaf necrosis or yellowing, not marketable, dead or almost dead; 2 = poor quality - not acceptable, sparse/uneven form, leaf yellowing, unhealthy appearance, not marketable; 3 = fair quality - marginally acceptable, somewhat desirable form and color, moderately healthy; 4 = good quality - very acceptable, minor flaws, nice color without yellowing, good form, healthy and vigorous, marketable; and 5 = excellent - perfect condition, premium color and form, extremely healthy and vigorous, very marketable. Flowering was based on a scale of 1-5, where 1 = no flowers or flower buds; 2 = flower buds visible, no open flowers; 3 = one to several open flowers; 4 = many open flowers, average to good flowering; and 5 = abundant flowering, possible peak bloom. The field conditions in northwest (Milton), northcentral (Gainesville), and south (Fort Pierce) Florida were as follows: the average air temperatures were 18.7, 19.8 and 22.5 C (65.7, 67.6, and 72.5 F) and the total rainfall amounts were 257, 127, and 129 cm (101, 50, and 51 in), respectively. Soil field conditions were as follows in northwest, northcentral, and south Florida, respectively: organic matter = 1.2, 2.9, and 2.8%, pH = 5.3, 6.4, and 5.9, electric conductivity = 0.01, 0.11, and 0.08 mmhos/cm, P = 20, 133, and 56 ppm, K = 17, 71, and 79, ppm, Mg = 7, 49, and 102 ppm, and Ca = 110, 499, and 1,132 ppm.

For landscape trial 2, seeds were collected in the early winter from 3 populations in Florida including Archbold Biological Station (south; 27.182804, -81.352935), Bok Tower Gardens (south-central; 27.936872, -81.577313), and Navarre Beach (northwest; 30.378181, 86.897092). Seeds were sown into seedling trays [30 cell Seedling Tray, Landmark Plastic Corporation, Akron, OH, Depth = 8.89 cm (3.5 in)] filled with a 3:1 mix of Fafard Metro-Mix 852 [Canadian sphagnum peat moss, pine bark, perlite and trace amounts of dolomite lime, Silicon (RESiLIENCE), and a long-lasting wetting agent; Sun Gro Horticulture, Agawam, MA] to builders sand and placed under intermittent mist. After the first true leaves emerged (at $\sim$ 3 weeks), trays were moved in a shade house, watered as needed, and thinned to one seedling per cell. Seedlings were fertigated (200 ppm 20N-10P_2O_5-20K_2O, JR Peters Inc., Allentown, PA) once weekly. Once seedlings had rootballs that held potting mix together when removed from seedling trays (at approximately 12 weeks), they were transported for field planting. Landscape trial 2 was planted in Citra, FL as a randomized complete block design within three rows (blocks) each with 5 transplants (subsamples) of Archbold and Navarre Beach and 2 transplants (subsamples; only 2 used due to lack of available plants) of Bok Tower. Plants were installed 0.9 m (3.0 ft) on center and watered 3 times per week. Each plant was fertilized upon planting with 9 grams (2.5 tsp) of 12-month 15N-3.9P-10K Osmocote Plus (Scotts Co., Marysville, OH) and fertigated every 2 weeks (15 N-0 P_2O_5-15 K_2O, JR Peters Inc., Allentown, PA) for 28 weeks. Air temperature [22.6 C (72.7 F)] and rainfall [174 cm (69 in) total] were monitored (frequency) over the 28 weeks of the trial. Soil field conditions were as follows: 1.01% organic matter, pH 6.1, electric conductivity 0.25 mmhos/cm, and 214 ppm P, 201 ppm K, 27 ppm Mg, and 457 ppm Ca. Plants that died within the first month were replaced with plugs sown at the same time as the original plantings. The assumption was made that these plants died due to transplant stress.

Growth and flowering data were recorded 0, 4, 8, 12, 16, 20, and 24 weeks after planting. Plant height (measured from the soil surface to top of foliage) and two perpendicular widths were recorded (cm) and a mean plant width calculated. Plant visual quality and flowering ratings were recorded monthly starting 4 weeks after planting. Visual quality considered plant form, color and overall appearance assessed on a qualitative scale from 1-5 in which; 1 = a nearly dead plant with low amounts of new growth, high levels of necrosis/chlorosis and poor form; 2 = good form, small amounts of necrosis/chlorosis but low amounts of new growth; 3 = plant has new growth but not throughout the entirety of the plant, little to no necrosis/chlorosis; 5 = extremely vigorous plant, large amounts of new growth, near perfect form/color. Flowering was assessed on a scale from 1-6 in which 1 = no flowers/flower buds; 2 = flower buds present but no open flowers; 3 = flower buds and flowers present but most flowers are not open; 4 = flower buds and opened flowers present most flowers are opened; 5 = numerous opened flowers, possible peak bloom; 6 = seed initiation.

Statistical analysis. For cutting and photoperiod experiments, data were subjected to an analysis of variance (ANOVA) to test for main effects and their interactions where appropriate using the General Linear Models procedures (PROC GLM using SAS Analytics Software) and significant treatment means separated by the LSMeans statement in SAS at $P \leq 0.05$. For landscape trial 1 and 2, main effects and their interactions were analyzed using generalized linear mixed models (PROC GLIMMIX in SAS 9.4). A Kenward-Rogers approximation was used for computing the denominator degrees of freedom for the fixed effects tests. Block was coded as a random effect. Repeated observations on the same experimental unit were accounted for in the model using the subject statement. Significant differences (α = 0.05) between means were computed using the ilink option of the LSMEANS statement. For landscape trial 1, at peak growth (September and October) data were analyzed statistically for visual quality and flower rating. For landscape trial 2, survival was analyzed statistically every 4 weeks and height, visual quality, and flower rating were analyzed at peak growth (August and October).

Results and Discussion

Cutting experiments. For cutting experiment 1, auxin application did not affect rooting percentage, which was on average 96%. Auxin application affected visual quality, root number per cutting, and root length at a threshold of $p \geq 0.05$ (Fig. 1). There was a trend of highest visual

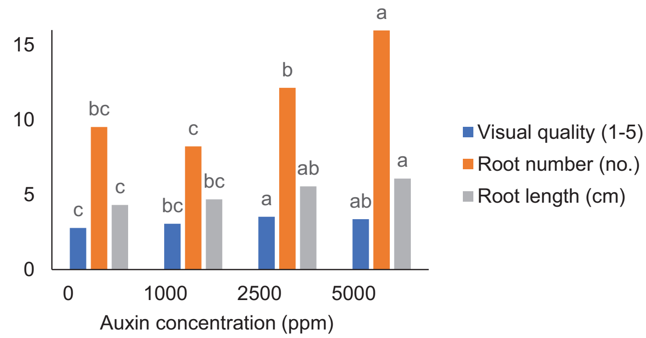

Fig. 1. Effects of auxin concentration [0, 1,000, 2,500, or 5,000 ppm of indole-3-butyric acid (K-IBA)] on the rooting performance of coastalplain honeycombhead (*Balduina angustifolia*) cuttings stuck mid-May and placed in a greenhouse under intermittent mist in northwest Florida in cutting experiment 1. Root class was defined using a scale based on a range of the proportion of the rootball media held cohesively after removal from pots (1 = 0-5%; 2 = 6-25%; 3 = 26-75%; 4 = 76-95%; 5 = 96-100%). The number of roots per plant and the length of the longest root (cm) were also recorded. Means for each response variable followed by the same letters are not significantly different at $\alpha = 0.05$.

qualities of root balls recorded for higher auxin concentrations (3.5 and 3.4 for 2,500 and 5,000 ppm IBA, respectively) and lowest for no or the lowest concentrations (2.8 and 3.1 for 0 and 1,000 ppm IBA, respectively). Similar visual qualities were recorded for cuttings treated with 1,000 compared to cuttings treated with 0 and 5,000 ppm IBA. Root number was larger for cuttings treated with 2,500 ppm IBA compared to 1,000 ppm IBA (12 vs 8 roots per cutting) and was similar compared to control (0 ppm IBA) cuttings (10 roots per cutting). A similar trend was noted for root length as was for visual quality with longer roots at higher concentrations [3.5 and 3.4 cm (1.4 and 1.3 in) for 2,500 and 5,000 ppm IBA] compared to lower concentrations [2.8 and 3.1 cm (1.1 and 1.2 in) for 0, and 1,000 ppm IBA]. Root number was largest (16 roots per cutting) for cuttings treated with 5,000 ppm IBA compared to all other auxin concentrations.

For cutting experiment 2, auxin concentration or potting mix did not affect rooting percentages, which was on average 82%. An interaction of the main effects of propagation potting mix and auxin concentration was evident with visual ratings at p≥0.05 (Fig. 2A). While all visual ratings were between 2 and 2.9 there was no difference noted among cuttings rooted in perlite/vermiculite, while there was a general trend of higher visual ratings as the rate of IBA increased when cuttings were propagated in Fafard3B. Cuttings rooted in Fafard and dipped in 5,000 ppm auxin had a higher root rating than all other treatments except for cuttings rooted in Fafard and dipped in 1,000 ppm auxin (2.6), which had similar results. Both auxin and propagation potting mix affected root number and root length but there was no interaction of these main effects (Fig. 2B-C). Application of IBA increased the number of roots per cutting (13-15) compared to the nontreated control (8), regardless of the application rate. Root length was greater than the nontreated control when IBA was applied at 5,000 ppm [2.7 cm (1.1 in) vs. 1.7 cm (0.67 in)] but root length

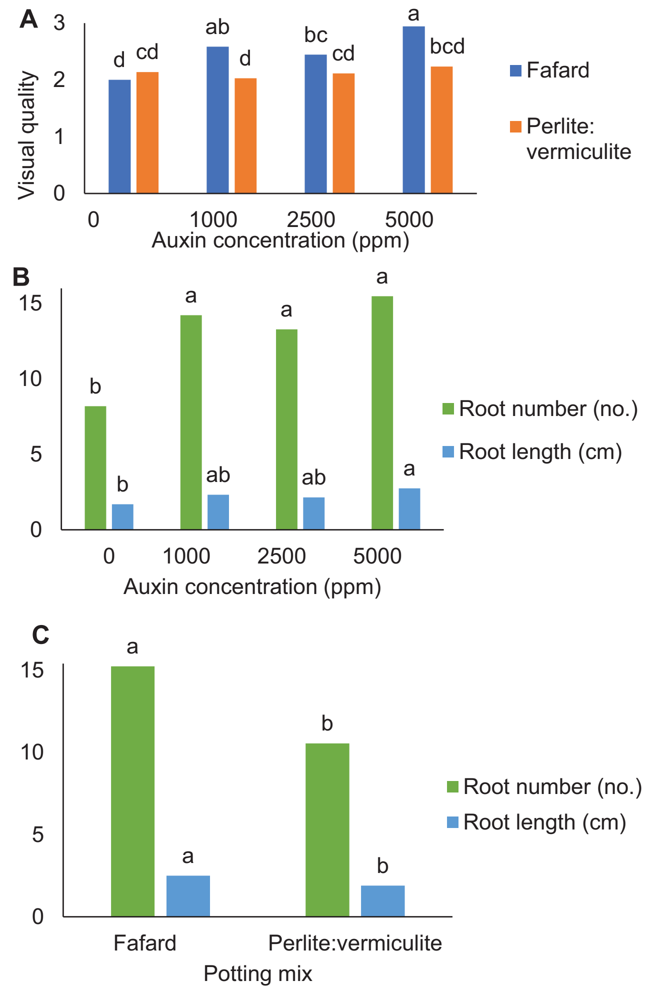

Fig. 2. Effects of auxin concentration (ppm KIBA) and potting mix [Fafard 3B with 40% Canadian sphagnum peat moss, 25% pine bark, 10% vermiculite, 20% perlite and trace amounts of dolomite lime, Silicon (RESiLIENCE), and a long-lasting wetting agent or a 50:50 mix by volume of perlite and vermiculite] on the visual quality (A) and the effect of auxin concentration (B) and potting mix (C) on root number per cutting and root length of coastalplain honeycombhead (*Balduina angustifolia*) in cutting experiment 2. Means for each response variable followed by the same letters are not significantly different at $\alpha = 0.05$.

did not differ among cuttings rooted with IBA at 1,000 [2.3 cm (0.91 in)], 2,500 [2.1 cm (0.83 in)], and 5,000 ppm (Fig. 2B). Regardless of auxin application root number and root length were greater with cuttings rooted in Fafard 3B compared to perlite/vermiculite (Fig. 2C), which could potentially be a result of the higher moisture retention due higher amounts of peat in Fafard 3B compared to perlite/vermiculite.

Coastalplain honeycombhead is easily propagated from spring stem cuttings and form finished 72-cell plugs with rootballs that contain potting mix and are transplant ready within 5 weeks. To our knowledge, this is the first documentation of successful cutting propagation of coastalplain honeycombhead or any species of *Balduina* within the literature. However, several species of Asteraceae are propagated by stem cuttings within the horticultural trade and many species within the family are known to root readily

Table 1. **Height (cm), width (cm) and flower ratings for coastalplain honeycombhead (*Balduina angustifolia*) 2 months after transplanting (August 15, 2009) 72-cell plugs into 4 L (1 gal) pots. At transplanting plants contained flower buds and thus were pruned to a consistent height to remove buds and increase branching. Plants were placed inside a polycarbonate greenhouse in Milton, Florida, and evaluated after 2 months. Means for each response variable followed by the same letters are not significantly different at α = 0.05.**

Photoperiod[z]	Height (cm)	Width (cm)	Flowering[y]
Long day	39a	21a	2.8a
Night interruption	33b	16b	2.4a
Short day	28c	16b	3.1a

[z]Photoperiod treatments of Short Day (9 hr. photoperiod), Night Interruption Photoperiod (9 hrs. + 10:00 p.m. - 2:00 a.m.), or Long Day (16 hr. photoperiod).

[y]Flowering scale of 1-5 scale where 1 = no flowers or flower buds; 2 = flower buds visible, no open flowers; 3 = one to several open flowers; 4 = many open flowers, average to good flowering; 5 = abundant flowering, possible peak bloom.

from cuttings (Biasi and Bona 2000, Bortoloso et al. 2018, Fascella et al. 2012, Grigoriadou et al. 2020, Ramos-Palacios et al. 2012, Sun et al. 2019). While auxin is not necessary to initiate rooting, the application of auxins improved rooting performance for coastalplain honeycombhead. A similar response was seen by other species in Asteraceae. For *Baccharis trimera* (Less.) DC., auxin (IBA) application did not increase rooting percentages (93%) but did increase the root number per cutting when compared to a nontreated control (Biasi and Bona 2000). Likewise, rooting percentage of stem cuttings of *Artemisia arborescens* L. were not affected by NAA (1-Naphthaleneacetic) application (Fascella et al. 2012). Other species of Asteraceae may need IBA to initiate or improve rooting percentages (Grigoriadou et al. 2020).

Photoperiod experiment. Height and width were affected by photoperiod while the flowering of plants was not at a threshold of $p \geq 0.05$ (Table 1). Plants were tallest [39 cm (15 in)] and widest [21 cm (8 in)] when grown under the long day (16 hour of light) photoperiod. Plant height was lowest for short day plants [28 cm (11 in)] and of intermediate height [33 cm (13 in)] under the night interruption photoperiod. Plant width was similar for plants grown under the night interruption [16 cm (6 in)] and short day [16 cm (6 in)] photoperiods. Flowering was similar for all photoperiods and ranged from 2.4 to 3.1, indicating the presence of flower buds on all plants and one to several open flowers on most plants regardless of the photoperiod imposed over the 5 week trial period. This may suggest long day conditions promote vigorous vegetative growth which coincides with vigorous growth observed in the wild during summer. While we saw no effect of photoperiod on flowering here, it is still possible flowering was unaffected by photoperiod here because plants were flowering before they were pruned for this experiment. Future research should begin experiments when plants are entirely vegetative to confirm findings here.

The photoperiod to which stock plants are exposed can affect growth, phenology, and quality of material produced

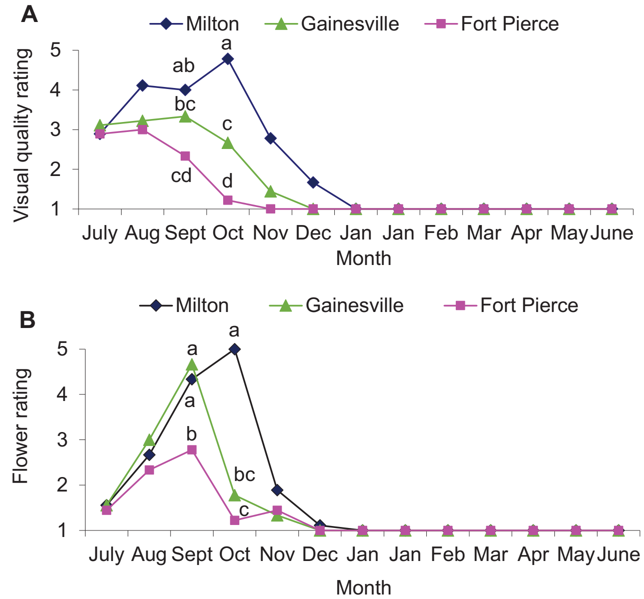

Fig. 3. **Monthly visual quality (A) and flower (B) rating for coastalplain honeycombhead (*Balduina angustifolia*) trialed in raise beds in northwest (Milton), northcentral (Gainesville), and south (Fort Pierce) Florida in landscape trial 1. At peak vegetative growth and flowering (September and October), data were analyzed. Means followed by the same letters are not significantly different at $\alpha = 0.05$. Visual quality was based on a scale of 1-5, where 1 = Very poor quality - Not acceptable, 3 = Fair quality - marginally acceptable, somewhat desirable form and color, moderately healthy; and 5 = Excellent - Premium color and form, extremely healthy and vigorous, very marketable. Flowering was based on a scale of 1-5, where 1 = No flowers or flower buds; 3 = One to several open flowers; and 5 = Abundant flowering, possible peak bloom.**

for cutting propagation (Hansen and Ernstsen 1982, Jackson 2008). For short lived, monocarpic, plants like coastalplain honeycombhead, the maintenance of plants in their vegetative state is necessary, otherwise plants flower and die during or shortly after the propagation cycle, reducing their utility in landscaping. While vegetative growth was promoted for coastalplain honeycombhead during long days compared to night interruption or short-day plants, all plants remained in a reproductive state after an initial pruning regardless of the subsequent photoperiod treatment, and thus no improvement in stems for use in stem cutting propagation was achieved by placing plants under long days. Plants used in this experiment were flowering at experiment initiation and were pruned to remove flowering. While some species may revert from flowering to vegetative growth in response to photoperiod, this was not the case for coastalplain honeycombhead (Battey and Lyndon 1986, Nanda and Krishnamoorthy 1967). Future studies to develop stock plants for this species should investigate the photoperiodic effects on vegetative plants.

Landscape performance trials. The interaction of month (September and October) and planting site influenced visual quality rating ($F_{2,48} = 4.89$, $p = 0.0117$) and flower rating ($F_{2,48} = 26.13$, $p = <0.0001$) for plants in landscape

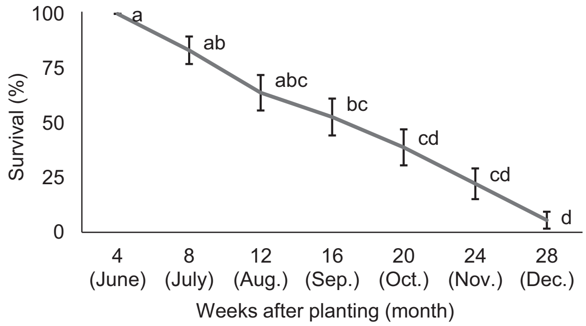

Fig. 4. Percentage survival (%) for coastalplain honeycombhead (*Balduina angustifolia*) plants in landscape trial 2. Seeds were collected from 3 populations (Archbold, Bok Tower, and Navarre Beach), grown in 30-cell liners and planted on May 17th, 2018. Plants were observed monthly for 7 months. Means with different letters are different at p<0.05.

trial 1, indicating plant visual quality and flower ratings over time differed across planting sites. Plants were of fair quality (~3+ visual quality rating) at all planting sites during July and August (Fig. 3A). By September, plants were performing higher when grown in Milton (4.0) than in Fort Pierce (2.3), while plants grown in Gainesville had a similar visual quality (3.33) compared to the other two populations. However, by October, plant visual quality for plants grown in Milton (4.8) was higher than for plants grown in Gainesville or Ft. Pierce, which were both below the acceptable threshold of 3 (2.7 and 1.2, respectively) (Fig. 3A). This prolonged high visual quality of plants is likely due to the milder summer climate experienced by plants grown in Milton compared to Gainesville or Ft. Pierce. Peak flowering occurred during September for plants grown in Gainesville and Fort Pierce while plants grown in Milton had peak flowering extended from September to October (Fig. 3B). Plants grown in Fort Pierce had the lowest flower rating during September compared to the other populations. This prolonged flowering for plants in Milton is also likely due to the milder summer climate experienced by plants grown in Milton compared to Gainesville or Ft. Pierce.

Survival among plants in landscape trial 2 differed over time ($F_{6,42} = 12.81$, $p \leq 0.0001$). Survival declined steadily throughout the trial (Fig. 4). While initial (June) survival was 100%, by September survival was significantly less (53% survival). By December almost all plants had died (6% survival). Population ($F_{2,30} = 6.53$, p=0.0045) and month ($F_{1,30} = 4.59$, p=0.0405) affected plant height (Fig. 5A). Plants were taller as the time progressed from August [18-39 cm (7-15 in)] to October [32-58 cm (13-23 in)]. Throughout the trial, plants grown from seed collected in Archbold were taller than plants grown from seed collected in Bok Tower or Navarre Beach. Population ($F_{2,30} = 3.38$, p=0.0473) and month ($F_{1,30} = 6.53$, p=0.0160) affected the visual quality of plants (Fig. 5B). Plants grown from seed from all three populations were on average above the acceptable threshold of 3 (4.0-5.0) during October. In August only two populations had plants grown from seed with visual quality ratings above 3 (3.8-4.0) and Navarre Beach plants had an unacceptable rating of 2.8. Throughout

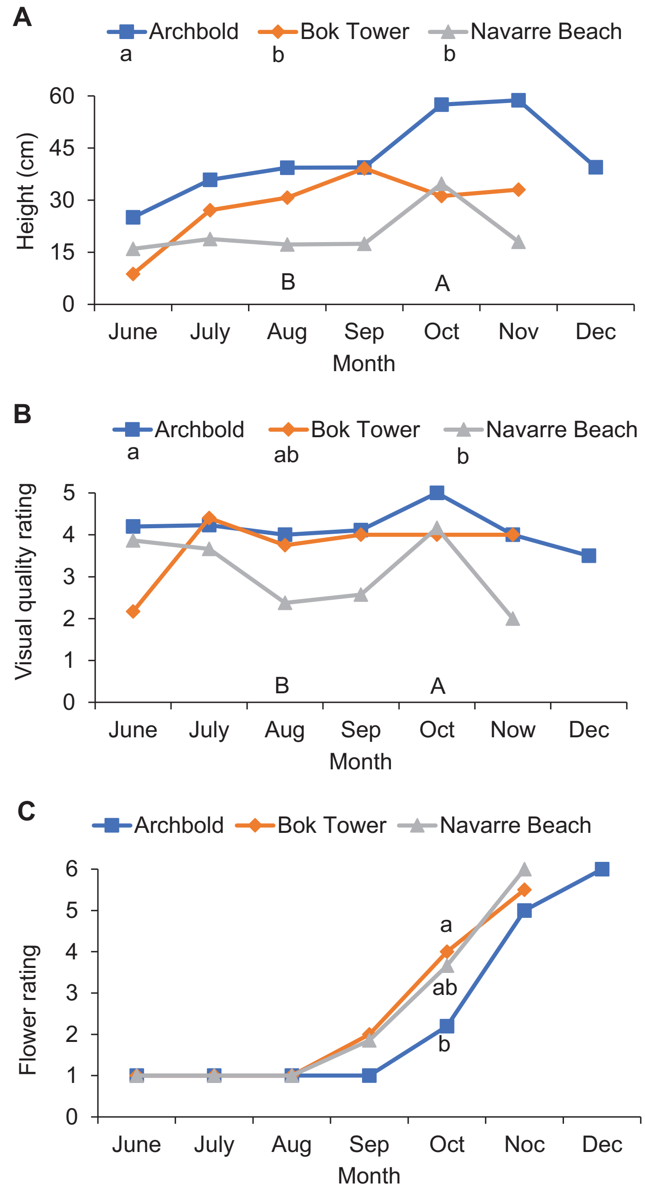

Fig. 5. Plant height (A), visual quality rating (B), and flower rating (C) for 3 seed sources of coastalplain honeycombhead (*Balduina angustifolia*) trialed in northcentral Florida (Citra). Seeds were collected from Archbold, Bok Tower, and Navarre Beach populations, grown in 30-cell liners and planted mid-May. Means with different lowercase letters below population indicate different means averaged across season while uppercase letters between seasons indicate differences means averaged across populations. Visual quality ratings were based on a scale of 1 to 4 in which 1 = nearly dead without new growth, poor form; 2 = good form but minimal new growth; 3 = new growth but not throughout the entirety of the plant, little to no necrosis/chlorosis; 4 = extremely vigorous plant, large amounts of new growth, near perfect form/color. Flower ratings (flower abundance) was based on a scale of 1-6 where 1 = no flowers/flower buds; 2 = flower buds present but no open flowers; 3 = flower buds and flowers present but most flowers are not open; 4 = flower buds and opened flowers present most flowers are opened; 5 = numerous opened flowers, possible peak bloom; and 6 = seed initiation. Different lowercase letters within rows by response were significantly different (P≤0.05).

the trial, plants grown from seed collected in Archbold always had a visually quality rating >3 and plants grown from seed collected in Bok Tower had a visual quality rating >3 except initially (2.2). The visual quality rating for plants grown from seed in Navarre Beach was below 3 for half of the trial. Plants began flowering between September and October, displayed peak anthesis between October and November, and produced fruit from November to December (Fig. 5C). Population ($F_{2,9} = 5.12$, p=0.0310) had an effect during the only date (October) we compared flower rating. During October plants grown from seed collected in Archbold had mainly flower buds (rating of 2.2) while plants grown from seed collected in Bok tower had more plants with most flowers open (rating of 4.0).

Coastalplain honeycombhead can be successfully used as an ornamental landscape plant in Florida, as had been demonstrated previously for this species (Smith et al. 2014) and numerous other species, when container grown plants are planted within their native range (Lubell 2013, Norcini et al. 2001a, Thetford et al. 2018). Most plants had an acceptable plant visual quality rating ($\geq$3) for 3 or more months, which is similar to many annual ornamental plants used in Florida landscapes (Campbell-Martínez personal observation). Flowering was most prolific during the fall for this study. Coastalplain honeycomb in research by Smith et al. (2014) displayed prolific flowering in the fall and the summer as plants were planted in spring, which was a much earlier planting time than this study. Future studies should examine optimal planting times to maximize the use of coastalplain honeycombhead in landscaping.

Plants installed in landscapes using genetic materials from populations far away from their provenance generally had reduced visual quality ratings compared to plants with local genetics. Similar results have been observed for other Florida native plant species including lance-leaf coreopsis (*Coreopsis lanceolata* L.), lyre-leaf sage (*Salvia lyrata* L.), and black-eyed Susan (*Rudbeckia hirta* L.) (Norcini et al. 2001a, Norcini et al. 2001b). This is similar to results seen with container-grown plants installed during ecosystem restoration projects where there is a mounting body of evidence that using ecotypes collected local to the restoration site have higher success than ecotypes collected far from the restoration site (Menges 2008). This can, in part, be explained by population level differences present within many species. For example, seeds of a Florida coastal dune native endemic herbaceous species, squareflower [*Paronychia erecta* (Chapm.) Shinners], have different germination requirements based on provenance of seed collection (Campbell et al. 2022).

In conclusion, coastalplain honeycombhead can be easily propagated from cuttings (within 5 weeks) and installed into landscapes without specialized protocols. We recommend the application of 5,000 ppm IBA and sticking cuttings in a peat-based potting mix. Cuttings taken in spring can transplanted via 4 L (1 gal) containers in the summer using standard nursery operation procedures. We recommended using plants collected from as nearby populations as possible, though plants from populations far away from planting location may perform satisfactorily.

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