Stock Plant Management of *Lavandula angustifolia* ‘Wee One’ Using Plant Growth Regulators[1]

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Abstract

Lavandula angustifolia ‘Wee One’ is a drought-tolerant perennial being used in landscapes throughout the western United States. Increased demand has resulted in problems with stock plant management and propagation due to the relatively small and slow vegetative growth. The objective was to determine if gibberellic acid, benzyladenine, ethephon, or auxin [indole-3-butyric acid (IBA)] plant growth regulators (PGR) applied as a foliar spray on Wee One lavender plants could be used to increase the number of cuttings for production. Fifteen replications of Wee One Lavender were evaluated for four months for plant height, width, number of cuttings, and fresh and dry weight of the cuttings. This study was replicated twice, the first experiment was performed from March 2020 to July 2020 and the second experiment from August 2020 to December 2020. A secondary propagation study was conducted simultaneously to check if PGR residuals effected rooting. The use of different PGRs caused an increase of cuttings from stock plants throughout both experiments. Foliar applications of gibberellin (ProGibb T&O) at 100 $mg{\cdot}L^{-1}$ (ppm) increased stem length and branching in one experiment, resulting in a higher number of cuttings produced compared to nontreated control stock plants, although that effect was not seen in the other conducted study. In one study, ProGibb T&O application did not negatively impact the rooting of individual cuttings, while it did so in the other study.

Species used in this study: Wee One lavender [*Lavandula angustifolia* Mill].

Chemicals used in this study: gibberellic acid (GA_3), ethephon, indole-3-butyric acid(IBA), N-(phenylmethyl)-IH-purine 6-amine (BA).

Index words: Plant growth regulator, propagation, *Lavandula angustifolia* ‘Wee One’, vegetative cuttings.

Significance to the Horticulture Industry

Ornamental herbaceous perennials are in high demand as landscape plants in the western United States due to their relatively low maintenance. *Lavandula angustifolia* ‘ Wee One’ is one of several perennials being evaluated as part of the Plant Select® program. Plant Select® is a collaborative program between Colorado State University, Denver Botanic Gardens and professional horticulturalists to provide plants designed to thrive in the high plains and mountainous regions of the western states (Plant Select 2021).

With the higher demands for ornamental perennials, growers in the Plant Select® program have seen an increase in problems associated with propagation and stock plant management. Our plant of interest from the Plant Select® program is Wee One lavender. Research is lacking for specific propagation protocols to be used by the horticulture industry. Vegetative propagation is the most widely used method of propagation for Wee One lavender. However, success with vegetative propagation has been variable. Stock plant management and stock quality has a large impact on the success of cuttings taken from Wee One lavender. Stock plants treated with foliar applications of gibberellin (ProGibb T&O) at 100 $mg{\cdot}L^{-1}$ (ppm) resulted in larger stock plants with more cuttings compared to nontreated control plants in one study. Applications of plant growth regulator treatments to stock plants had a variable effect on the rooting of cuttings. All cuttings had a 90% rooting percentage by the end of 4 weeks.

Introduction

Wee One lavender is a selected dwarf clone of lavender being promoted by Plant Select®. This cultivar of lavender has a compact growth habit maturing to 25.5 cm (10.04 in) with attractive lavender-blue flowers. It is being promoted for xeric landscaping and small spaces (Plant Select 2021).

Softwood cuttings are the primary source for herbaceous perennial production. Softwood cuttings are taken from actively growing vegetative tissues. These tissues are formed early in the season before flowering or the formation of hardwood. Softwood cuttings are faster and easier to root than hardwood cuttings (Nau 1996).

Several management tools used for keeping stock plants in this softwood state are pruning and/or application of plant growth regulators. Pruning of lavender would occur early in the season and after blooming to induce a flush of new growth (Davis and McCoy 2020). The problem with pruning treatments is that ideally only two flushes of softwood vegetative growth would occur in a single growing season before the vegetative material forms semi-woody branches at the base of the lavender cuttings. An additional method that is gaining popularity in the horticulture industry for stock plant management is the use of plant growth regulators.

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Plant growth regulators are widely available for horticultural use. Multiple forms of active ingredients can be used for a variety of effects on various plant species. The three most common active ingredients are forms of gibberellins, cytokinin and ethylene (Davies 2010). These three plant growth regulators can be natural hormones that are extracted from plant tissues or synthetically made compounds. Five different plant growth regulators were tested in this stock plant management study. Each plant growth regulator tested has one of the three active ingredients or a combination of them.

Gibberellins (GA) is synthesized in young shoot tissues and developing seeds. Most GA is biosynthesized in the chloroplasts of plant cells (Davies 2010). Gibberellins are classified into multiple forms of GA based on chemical structure characteristics. Many of these gibberellins are found in plants but only a selected few are readily available for use in the horticulture industry. Gibberellic acid (GA_3) is the most widely available compound used. GA_3 promotes growth as cell elongation throughout the plant tissue (Moore 1984). Therefore, applications of GA_3 on herbaceous perennials could result in more cuttings from stock plants.

Cytokinin occurs in root tips and developing seeds. Movement of cytokinin occurs in the xylem of a plant. Cytokinin causes high levels of cell division to occur when present in a cell (Davies 2010). The effects can be even more pronounced in the presence of auxin. Along with the induction of cell division, plant cells can be encouraged to grow lateral buds (Davies 2010). Benzyladenine (BA) is a synthetic form of cytokinin that is readily available for use as a plant growth regulator (CFNP 2004). Research completed at Green Leaf Enterprises (nursery in Canada), showed that applications of BA increased the number of lateral offshoots in many perennial species (Martin and Singletary 1999). Auburn University reported similar results with *Hosta* species treated with BA. Offsets of *Hosta* increased when treated with BA and increased further when treated with more than one application of BA. Stock plants were not affected when these offsets were removed and retreated with BA (Garner et al. 1996). Therefore, applications of BA, which causes more lateral growth, could result in more cuttings from stock plants.

Ethylene is produced in most plant tissues as a response to stress. Ethylene is commonly found in the gas form in plants and moves through cells by diffusion across membranes (Davies 2010). Ethylene is often used in the horticulture industry since it can result in many wanted effects such as fruit ripening, flower/leaf senescence and increases in shoot/root growth (Davies 2010). Ethephon is the liquid form of ethylene that is sold as a plant growth regulator. Ethephon is readily absorbed by plants. Once ethephon is absorbed, ethylene is released and used by plant cells (Lopez and Walters 2017). Ethephon use in the greenhouse varies depending on the desired effect. Ethephon has been applied on a few herbaceous perennials at Michigan State University to research the potential use for stock plant management. On *Coreopsis verticillata* L. and *Veronica longifolia* L., ethephon treatments increased lateral branching and number of vegetative cuttings (Glady et al. 2007). Further studies from Michigan State showed that ethephon would be a valuable plant growth regulator for several herbaceous perennials for height control in the greenhouse (Hayashi et al. 2001). An increase in branching and decreased flower development could lead to more vegetative growth on herbaceous perennials.

The objectives of this stock plant management study for *Lavandula angustifolia* 'Wee One' was to determine if plant growth regulator treatment(s) result in more vegetative growth of high propagation quality. The rooting study objective was to determine if the plant growth regulator treatment(s) had any effects on the rooting of these cuttings. The final objective was to develop a stock plant management protocol for growers to improve their propagation.

Material and Methods

Stock plant management. The study was conducted at Colorado State University Horticulture Center which is located at 1707 Centre Avenue, Fort Collins, CO (lat. 40.577953° N, long. 105.080925° W; U.S Department of Agriculture hardiness zone 5b). The stock plant experiment was repeated for Wee One lavender. The first experiment was conducted starting in February 2020 and continued until July 2020. The second experiment was conducted starting in July 2020 and continued until December 2020.

Plants of uniform size of 3.5 cm (1.38 in) (72 plug tray) were purchased from a local greenhouse (Gulley Greenhouse, Fort Collins, CO) for the first experiment. Cuttings were rooted and grown by CSU for the second experiment to be at the same uniform starting plug size of 3.5 cm (1.38 in). A total of 90 plants were selected, so that five replicates of three plants (15 total) were placed in a randomized complete design and placed throughout the greenhouse bench for each of the five treatments and a nontreated control group.

The plants were transplanted from the 72-count plug tray into black #1 (2.84 L) containers. The media used in this study for the stock plants was Pindstrup Orange, which is a peat moss substrate composed of blonde peat moss, dolomite limestone, and a wetting agent (Pindstrup, Ryomgaard, Denmark). During the initial establishment period, plants were watered by hand when over 75% of those plants had visually dry soil with a 14 N - 4 P – 14 K fertilizer at 200 parts per million (ppm) nitrogen for every watering. Fertilizer was constantly injected using a Dosatron® model D14MZ2 (Dosatron, Clearwater, FL). Once a majority of all plants had roots striking the sides of the #1 containers, drip irrigation was installed in each pot. Each #1 container had one emitter placed above the media . The fertilizer regimen was switched to a 20-10-20 fertilizer at 200 ppm nitrogen continual feed. Using 4 L (1 gal) per hour emitters, irrigation was done twice a week for 30 minutes, for a total of 4 L of fertilized water per week per plant.

The treatments were applied using a Patriot 350 [13.25 L (3.5 gal)] CO_2 sprayer (Patriot, Santee, CA) starting two weeks before the first data collection date and then monthly throughout the duration of both replications. Five chemical plant growth regulators were applied to run off at the

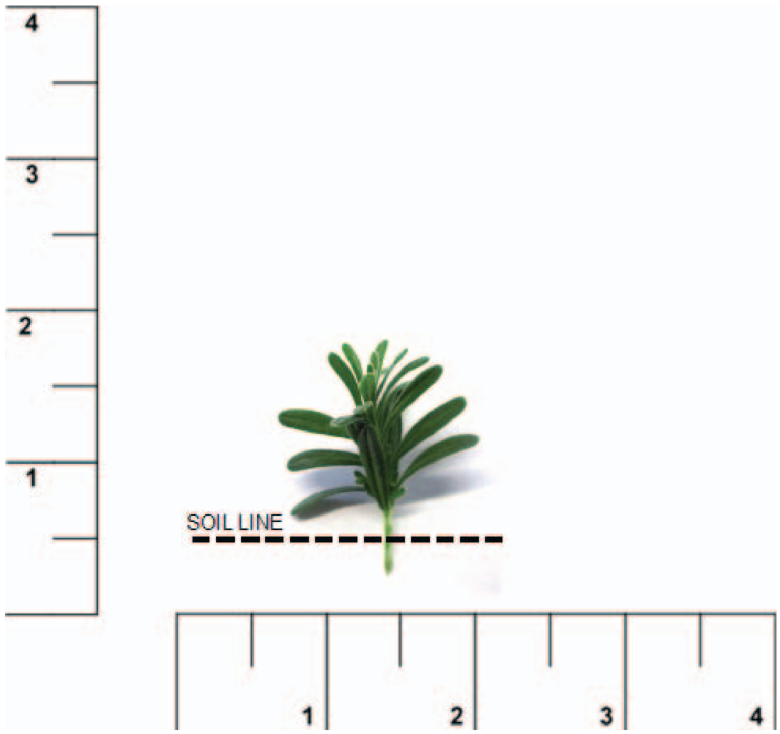

Fig. 1. Visual guide for Wee One lavender (Lavandula angustifolia 'Wee One') cutting protocol provided by Gulley Greenhouse, Fort Collins, CO. Cuttings show ideal size and preparation for harvest. Measurement in inches (1 inch = 2.54 cm)

optimal recommended rates: 1) 21.7% ethephon (2-chloroethyl) phosphonic acid [500 mg·L^{-1} (ppm)] (Verve, Nufarm Americas, Inc., Alsip, IL), 2) 0.09% kinetin plus 0.03% gibberellic Acid plus 0.045% synthetic auxin indole-3-butyric Acid [500 mg·L^{-1} (ppm)] (Gravity, Winfield Solutions, LLC, St.Paul, MN), 3) 1.8% N-(phenylmethyl)-IH-purine 6-amine plus 1.8% gibberellins A4 and A7 [100 mg·L^{-1} (ppm)] (Fascination, Valent USA Corp., Fresno, CA), 4) 2.0% cytokinin 6BA [N-(phenylmethyl)-1H-purine-6-amine] [400 mg·L^{-1} (ppm)] (Configure, Fine Agrochemicals Limited, Worcester, U.K.), and 5) 4.0% Gibberellin A3 [100 mg·L^{-1} (ppm)] (ProGibb T&O, Valent USA Corp., Fresno, CA). A nontreated control group of 15 plants was included in both experiments.

The first experiment treatments were applied on 28 February, 2020, 27 March, 2020, 24 April, 2020, and 22 May, 2020. The second experiment treatments were applied on 31 July, 2020, 28 August, 2020, 25 September, 2020, and 23 October, 2020. Cuttings were harvested monthly, starting approximately two weeks after the PGR treatment applications on a monthly basis. Each cutting was taken to the ideal specification indicated in Figure 1.

The greenhouse used for the stock plant management study was run by a Wadsworth control system. The greenhouse was heated by natural gas using a forced air heater. The greenhouse was cooled passively by automatic ridge vents and automatic pulled shade cloths and actively by a pad and fan system. The Wadsworth system (Wadsworth, Arvada, CO) had preset daytime temperatures that were maintained between 22.7-23.9 C (72.8-75 F). The temperatures at night were maintained between 16.8-18.9 C (62.2-66 F). No supplemental lightning was used during the experiments.

Initial measurements of height and width were taken before the first application of PGR treatments for all 90 plants after 4 weeks of growth after initial transplanting. Parameters measured monthly were plant height, width, number of cuttings taken, total fresh weight of cuttings, and total dry weight of cuttings. Stock plants were measured in centimeters at the highest leaf to the substrate and at two perpendicular widths. These three measurements of height and two widths were used to create a growth index (GI) used for analyses.

Cuttings from each individual stock plant were counted, placed in a paper bag and weighed immediately to determine the fresh weight (FW). After fresh weights were taken, cuttings were then placed in a drying oven at 70 C (158 F) for a minimum of 48 hours. After the cuttings were completely dried, the bags were weighed again to obtain the dry weights (DW). After the final harvest of cuttings, stock plants were allowed to grow for four weeks before harvesting shoot growth and analyzing the root system. No pruning was done on the stock plants between rounds of cuttings.

Cuttings were collected for the first experiment on 14 March, 2020, 11 April, 2020, 8 May, 2020, and 8 June, 2020. Cuttings were collected for the second experiment on 14 August, 2020, 11 September, 2020, 9 October, 2020, and 16 November, 2020. A selection of cuttings was also taken from the extra stock plants in each treatment group and used in the propagation experiment at the same date as harvests of shoot growth in experiment #1 and experiment #2. Extra stock plants were pre-labeled specific for rooting experiments because shoot growth harvesting on the 15 stock plants in each treatment group collected all ideal cuttings, leaving none for a rooting study.

One month after the last cutting harvest for each experiment, all fifteen stock plants from each treatment had all the shoot growth removed, dried, and weighed. Collection of shoot growth shows the average growth of the stock plant between harvest events. The root balls were removed from the pots and based on a determined rating scale of zero to five (zero being no roots and five being a vigorous fibrous root system), given a visual rating. A visual reference was photographed and displayed as root ratings were taken for the individual plants for consistency.

Propagation study. After each stock plant experiment, a propagation experiment was performed. Five stock plants from each treatment were randomly selected at the beginning of each replication and grown under the same conditions for a propagation study. The only variables of the propagation experiment were the plant growth regulator treatments and the nontreated control. Cuttings were harvested from each treatment two weeks after application of the plant growth regulators on March 14, 2020, April 11, 2020, May 8, 2020, and June 8, 2020 for the first experiment. For the second experiment, cuttings were harvested on August 14, 2020, September 11, 2020, October 9, 2020, and November 16, 2020. Rooting data was then collected every week for four weeks on the number of visible roots.

Ten randomly selected cuttings were chosen and then dipped for 30 seconds in 500 parts per million indole-3-butyric acid/1-naphthylacetic acid (IBA/NAA) (Dip 'N Grow, Clackamas, OR) and stuck in 26-strip plug trays. The media in a Jiffy Performa plug (Jiffy, Lorain, OH) is a blend of coco coir and peat moss with a small amount of binder. The plug trays were placed on heating mats (Redi Heat model RHD 2110, Phytotronics, Earth City, MO) that maintained a soil temperature of 23.9 C (75 F). The mist times on the bench were adjusted weekly; week one was 10 s every 15 min, week two was 10 s every 30 min, week three was 20 s every 60 min, and week four was 20 s every 60 min. This schedule was active for the entire 24 h period each day and controlled by a Nova 1626 ET (Phytotronics, Earth City, MO) six zone misting control system. Rooting data was collected weekly up to 4 weeks after sticking. Plants were pulled out of the propagation tray to determine number of visible roots. Visible roots were counted up to 30 individual roots along the sides of the cell then returned to the tray. Thirty roots per cutting was determined by our research group and from consults with Gulley Greenhouse (Fort Collins, CO) to be a well-rooted plug ready for transplant.

Experimental analysis. Data analysis was done using R version 4.0.4, statistical computing software (R Foundation for Statistical Computing, Vienna, Austria). Response variables include: average number of cuttings per plant per treatment, dry and fresh weight of cuttings, final dry weight, root ratings of stock plants, and growth index. Terms included in the model were predictor variables matching to the plant growth regulator treatments and the control (6 levels). Tukey adjusted pairwise comparisons and least squares means were calculated using the eemeans package in the R program for each response variable. Significant differences were noted using $\alpha = 0.05$ and 95% confidence intervals. Response variables for the rooting study included average number of roots per plant per treatment. Average number of roots were analyzed using a one-way analysis of variance (ANOVA) model. Tukey adjusted pairwise comparisons and least square means were calculated using the emmeans package for each response variable. Significant differences were noted using $\alpha = 0.05$ and 95% confidence intervals.

Results and Discussion

Number of cuttings harvested. The average number of harvested cuttings was totaled and averaged across all four harvest dates for analysis. Analysis of variance for Wee One lavender Experiment #1 revealed a significant effect of treatment for the average number of cuttings and the pairwise comparisons showed a significant difference at the significant level of 0.05. The plants treated with Configure had the numerically smallest number of cuttings and plants treated with Gravity had the numerically highest number of cuttings compared to the control (Fig. 2).

Analysis of experiment #2 revealed a significant effect of treatment for the average number of cuttings and the pairwise comparisons showed a significant difference at the significant level of 0.05. The plants treated with Verve had the numerically smallest number of cuttings and plants treated with ProGibb had the numerically highest number of cuttings (Fig. 2). In experiments #1 and #2, the significant treatment effect showed that PGR application affected the growth of shoots. In one but not the other experiment, stock plants treated with a gibberellic acid plant growth regulator such as ProGibb and Gravity had an increased average number of cuttings compared to the nontreated control. Stock plants treated with gibberellic acid by the Bluebird Nursery showed an increase in the number of cuttings taken from a stock plant (Ackerman and Hamernik 1994). The results of increased number of cuttings strongly correlates with each plant growth regulator ingredient of either GA, BA, or ethephon that causes an increase in lateral branching and cell elongation (Davies 2010).

Fresh weight per cutting. Average fresh weight was calculated by dividing the total fresh weight of cuttings by the total number of cuttings harvested for each plant, averaged over the four harvest dates. Analysis of variance for Wee One lavender in Experiment #1 revealed a significant effect of treatment for the average fresh weight of cuttings and all pairwise comparisons showed a significant difference at the significant level of 0.05. The plants treated with Verve had the numerically smallest fresh weight of cuttings and plants treated with ProGibb T&O had the numerically largest fresh weight of cuttings. Nontreated plants had the second highest average fresh weight of cuttings in both experiments, suggesting that treating stock plants with a PGR could decrease the quality of cuttings, making them thinner, such as the response seen with Verve application in experiment #2. A thinner cutting could potentially impact how well a cutting could root. Further research would be required to support these claims.

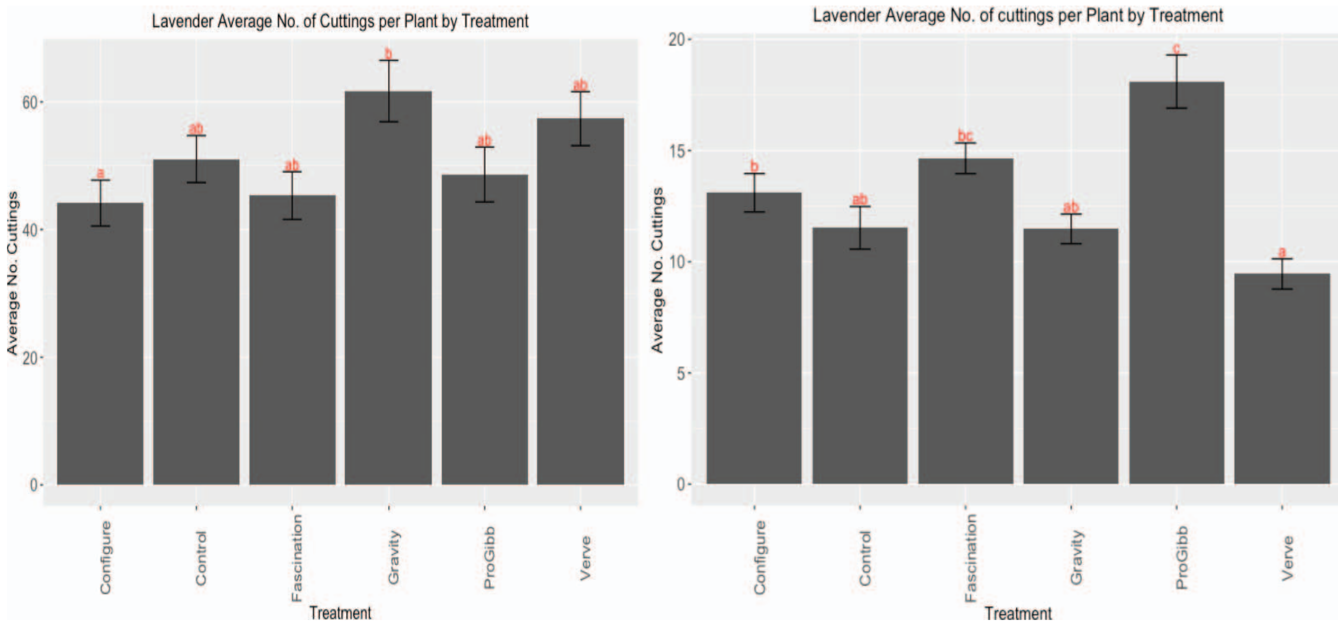

Fig. 2. Mean number of cuttings harvested per plant from Wee One lavender stock plants averaged over four harvest dates for Expt. 1 (left) and Expt. 2 (right) as influenced by five plant growth regulator treatments: Configure (2.0% BA), Fascination (1.8% BA and 1.8% GA), Gravity (0.09% Cytokinin, 0.03% GA, 0.045% IBA), ProGibb (4.0% GA), Verve (Ethephon 21.7%), and a nontreated control. Plant growth regulators were foliarly applied using a CO_2 sprayer. Mean separation on top of error bars with Tukey adjusted least square means at P$<$0.05 (lower case letters).

Analysis of variance for Wee One lavender in Experiment #2 revealed a significant effect of treatment for the average fresh weight of cuttings and the pairwise comparisons showed a significant difference at the significant level of 0.05. The plants treated with Verve had the numerically smallest fresh weight of cuttings and plants treated with Configure had the numerically largest fresh weight of cuttings. The significant differences in experiment #1 and #2 showed that the fresh weight of cuttings could either increase or decrease after PGR application, when compared to the nontreated control cuttings (Table 1). Cuttings treated with GA plant growth regulators can cause cell elongation and cell differentiation (Davies 2010). This cell elongation increases the length of cuttings on the stock plant, therefore correlating to a larger fresh weight as more shoot growth was harvested.

Dry weight per cutting. Average dry weight per cutting were calculated by dividing the total dry weight of cuttings by the total number of cuttings harvested for each plant during each harvest date and averaged over the four harvest dates. Analysis of variance for Wee One lavender in Experiment #1 revealed a significant effect of treatment for the average dry weight of cuttings and the pairwise comparisons showed a significant difference at the significance level of 0.05. The plants treated with Gravity had the numerically smallest dry weight of cuttings and plants treated with ProGibb T&O had the numerically largest dry weight of cuttings.

Analysis of variance for Wee One lavender in Experiment #2 revealed no significant effect of treatment on the average dry weight of cuttings. The plants treated with Fascination had the numerically smallest dry weight of cuttings and plants treated with Configure had the numerically largest dry weight of cuttings. Dry weights of the cuttings correlated with the fresh weight of cuttings and followed the same trends in both experiments (Table 1). Comparing fresh and dry weights of the cuttings shows the amount of water originally in those cuttings. Fresh weight has been a better indication of cutting quality than dry weight (Markovic and Klett 2020).

Growth index. A single parameter for size was calculated to represent overall plant growth by averaging the measured height and two widths of each stock plant. Statistical analysis of growth index was completed for each time point, beginning with initial measurements and occurring before each data collection period. Subsequent analyses contain all treatments averaged over the five time points.

Analysis of variance of Wee One lavender in Experiment #1 revealed no significant effect of treatment for the average growth index and all pairwise comparisons showed no significant difference at the significant level of 0.05. The numerically smallest plants were the nontreated control ones and the numerically largest plants had been treated with ProGibb 400 ppm. No significant difference was noted as all stock plants in each treatment group and the nontreated control had a growth index between 8.05 cm (3.17 in) and 9.25 cm (3.64 in).

Analysis of variance for experiment #2 revealed a significant effect of treatment for the average size index and some of the pairwise comparisons showed significant difference at the significant level of 0.05. The numerically smallest plants had been treated with Verve at 100 ppm and the numerically largest plants had been treated with

Table 1. **Individual cutting fresh weight, individual cutting dry weight, and growth index of Wee One Lavender stock plants averaged over four harvest dates (Expt. 1 and Expt. 2) as influenced by five plant growth regulator treatments: Configure (2.0% BA), Fascination (1.8% BA and 1.8% GA), Gravity (0.09% Cytokinin, 0.03% GA, 0.045% IBA), ProGibb (4.0% GA), Verve (Ethephon 21.7%), and a nontreated control[z].**

Treatment	Rate (ppm)[y]	Fresh wt (g)	Dry wt (g)	Growth Index (cm)[w]
Experiment 1				
Control	0	0.0804 cd	0.0116 ab	8.07 a
Configure	400	0.0796 bcd	0.0118 ab	8.31 a
Fascination	100	0.0749 abc	0.011 a	9.03 a
Gravity	500	0.066 ab	0.0103 a	8.13 a
ProGibb	100	0.0931 d	0.0128 b	9.25 a
Verve	500	0.0652 a	0.0109 a	8.46 a
Experiment 2				
Control	0	0.0505 ab	0.01054 ab	4.99 ab
Configure	400	0.053 b	0.01122 b	5.36 b
Fascination	100	0.0455 ab	0.00859 a	5.68 bc
Gravity	500	0.05 ab	0.01041 ab	5.08 ab
ProGibb	100	0.0501 ab	0.00994 ab	6.33 c
Verve	500	0.0389 a	0.00939 ab	4.35 a

[Z]Treatments were applied foliarly, the control was left nontreated. Mean separation in columns with Tukey adjusted least squares means at P<0.05 (lowercase letters).

[Y]1 ppm = 1 mg.L-[1]

[x]Fresh and dry weights were taken as a total for each plant harvested and the average individual cutting weight was determined using total weight and dividing by the number of cuttings harvest from the signal plant. 1 g = 0.0353 oz.

[w]Growth index was determined from one height and two width measurements at the largest diameter cross-sections, equation GI = (Height + Width 1 + Width 2)/3; 1 cm = 0.3937 inch.

Table 2. **Influence on Wee One Lavender stock plants by influenced by five plant growth regulator treatments: Configure (2.0% BA), Fascination (1.8% BA and 1.8% GA), Gravity (0.09% Cytokinin, 0.03% GA, 0.045% IBA), ProGibb (4.0% GA), Verve (Ethephon 21.7%), and a nontreated control on cuttings with number of visible roots. Data was collected and averaged over four harvest dates[z].**

Treatment[z]	Rate (ppm) [y]	Avg. number of visible roots[x]
Experiment 1		
Control	0	12.62 b
Configure	400	10.22 ab
Fascination	100	11.9 b
Gravity	500	12.5 b
ProGibb	100	7.78 a
Verve	500	11.93 b
Experiment 2		
Control	0	5.28 bcd
Configure	400	2.85 a
Fascination	100	3.5 ab
Gravity	500	5.67 cd
ProGibb	100	6.45 d
Verve	500	4.17 abc

[Z]Treatments were applied foliarly, the control was left nontreated.

[Y]1 ppm = 1 mg.L-[1].

[x]Mean separation in columns with Tukey adjusted least squares means at P<0.05 (lowercase letters).

ProGibb T&O at 100 ppm. While significant differences were observed in experiment #2, the data followed a similar trend as in experiment #1 (Table 1). The nontreated control plants were numerically smaller in size while plants treated with ProGibb were the numerically largest. The application of plant growth regulators has an effect on the overall growth of a stock plant when compared to nontreated plants. In both experiments, stock plants treated with ProGibb T&O had the numerically largest growth index. The active ingredient in ProGibb T&O is gibberellic acid. Gibberellic acid causes cell elongation and increases in lateral branching (Davies 2010). Similar results were seen in stock plants treated with gibberellic acid by the Bluebird Nursery, which showed an increase in the number of cuttings taken (Ackerman and Hamernik 1994). An increase in the number of cuttings taken correlates to an increase in the size and lateral branching of a stock plant.

Difference between Expt. 1 and Expt. 2. Differences in response between experiment #1 and #2 are partially due to the time of year the experiment was carried out. The first experiment was from February 2020 to June 2020 while the second experiment was July 2020 to December 2020. It is possible that fewer cuttings and smaller plants were produced in the second study because of lower ambient temperatures and lower light intensities in the greenhouse. During the second experiment, Colorado was experiencing large wildfires. These wildfires were producing large amounts of smoke that covered a large portion of the state. Fort Collins was one of the cities that was highly affected, with multiple poor air quality alerts being sent to residents during August through October 2020 (O'Donnell 2020).

Propagation experiment. Rooting data was taken weekly starting after week two for a period of four weeks on the mist bench. The rooting data collected counted the number of visible roots to a total of 31 visible roots. Statistical analysis was performed using the visible number of roots averaged over the four-month time points for each experiment.

Analysis of variance for Wee One lavender in Experiment #1 revealed a significant effect of treatment on the average number of visible roots and the pairwise comparisons showed a significant difference at the 0.05 level. The cuttings treated with ProGibb had the numerically lowest number of roots. Analysis of experiment #2 revealed a significant effect of treatment for the average number of visible roots and the pairwise comparisons showed a significant difference. The cuttings treated with Configure had the numerically lowest number of visible roots and the cuttings treated with ProGibb T&O had the numerically highest number of visible roots (Table 2). The trend between experiment #1 and experiment #2 for the number of roots was similar with the exception of plants treated with ProGibb T&O. The cuttings treated with ProGibb T&O had the numerically lowest number of roots in experiment #1 and the numerically highest in experiment #2. ProGibb T&O and Configure contain gibberellic acid. Applications of gibberellic acid can lead to shorter and thinner roots produced (Fonouni-Farde et al. 2019). Because of the differences between experiment #1 and #2 with ProGibb T&O and other PGR's with gibberellic acid as the active ingredient, it is not possible to state that applications of GA caused negative effects to rooting of cuttings and root formation. Further research needs to be completed to see if continued applications of GA shows these negative effects.

This study was conducted to determine whether GA, BA, ethephon, or IBA applications improved the number of cuttings taken from a stock plant while maintaining successful rooting percentages for cuttings of Wee One lavender. While the application of a PGR had variable effects on growth and cuttings harvested from stock plants, plants treated with a GA-based PGR had increased growth and a higher number of cuttings when compared to nontreated plants in one but not the other study. Increased number of cuttings from stock plants in both experiments can be attributed to the effects of gibberellic acid on lateral branching and stem elongation of Lavender. Plants overall in Experiment #2 were smaller and had a reduced number of cuttings due to the smaller top growth. More in-depth research will need to be performed to determine which physiological and environmental traits are involved in that growth response.

Despite some differences between the first and second experiment, it is possible to make some recommendations to perennial propagators for future stock plant care and rooting of Wee One lavender. Based on the research conducted, lavender stock plants could have more shoots for cuttings if treated monthly with applications of ProGibb T&O at a rate of 100 ppm. Our experiments did not last as long as many growers keep their stock plants, therefore, no claims can be made about the longevity of the stock plant in relation to additional treatments of a PGR.

After completing the rooting study, no negative effect was seen on the number of visible roots on the cuttings taken from stock plants treated with any of the PGR treatments. All cuttings had a rooting percentage of 90% or above. We are not able to conclude that applications of ProGibb T&O will not decrease a propagator's rooting percentage or number of visible roots on Wee One lavender cuttings.

Literature Cited

Ackerman, R., and H. Hamernik. 1994. Gibberellic Acid to Extend Shoots and Bud Break on *Heuchera* and *Scabiosa*. Proc. Intl. Plant. Prop. Soc. 44:545–546.

Certified Family Nurse Practitioner (CFNP). 2004. TAP Report for 6-Benzyladenine. https://www.ams.usda.gov/sites/default/files/media/6%20Benzyladenine%20TR.pdf . Accessed 15 January 2021.

Davies, P. J. 2010. Plant Hormones: Biosynthesis, Signal Transduction, Action! Springer, Dordrecht, Netherlands. p. 36–155.

Davis, J. M. and J. McCoy. 2020. Lavender: history, taxonomy, and production. NC State Extension. https://newcropsorganics.ces.ncsu.edu/herb/lavender-history-taxonomy-and-production/. Accessed 15 January 2021.

Fonouni-Farde, C., Miassod, A., Laffont, C., Morin, H., Bendahmane, A., Diet, A., and F. Frugier. 2019. Gibberellins negatively regulate the development of *Medicago truncatula* root system. https://doi.org/10.1038/s41598-019-38876-1. Accessed 15 January 2021.

Garner, J. M., Keever, G. J., Eakes, D. J., and J.R. Kessler. 1996. Sequential benzyladenine (BA) applications enhance offset formation in *Hosta*. Proc. Intl. Plant. Prop. Soc. 33:707–709.

Glady, J. E., Lang, N. S., and E.S. Runkle. 2007. Effects of ethephon on stock plant management of *Coreopsis verticillata*, *Dianthus caryophyllus*, and *Veronica longifolia*. HortScience. 42:1616–1621

Hayashi, T., Heins, R. D., Cameron, A. C., and W.H. Carlson. 2001. Ethephon influences flowering, height, and branching of several herbaceous perennials. Scientia Hort. 91:305–323.

Lopez, R. and K. Walters. 2017. Tips for improving the efficacy of ethephon PGR spray applications.<https://www.canr.msu.edu/news/tips_for_improving_the_efficacy_of_ethephon_pgr_spray_applications. Accessed 15 January 2021.

Markovic, S.J. and J.E. Klett. 2020. Increasing stock production of two herbaceous perennials with the application of plant growth regulators. HortTechnology 30:421–427.

Martin, S. A. and S. Singletary. 1999. N-6-benzyladenine increases lateral offshoots in a number of perennial species. Proc. Intl. Plant. Prop. Soc. 49:329–334.

Moore, G.M. 1984. Mechanisms of hormone action in plants. Proc. Intl. Plant. Prop. Soc. 34:79–90.

Nau, J. 1996. Ball Perennial Manual: Propagation and Production. Chicago Review Press, Inc. Chicago, IL. p. 16–20.

O'Donnell, K. 2020. Air Quality Advisory Issued for Larimer County | Larimer County. https://www.larimer.org/spotlights/2020/08/14/air-quality-advisory-issued-larimer-county. Accessed 15 January 2021.

Plant Select. 2021. https://plantselect.org. Accessed 15 January 2021.