Chemical Height Control of Containerized Seashore Mallow

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SUMMARY. The objective of this study was to determine the efficacy of plant growth regulators applied as foliar sprays on height and branching of seashore mallow (*Kosteletzkya virginica*). Five chemical plant growth regulators were applied: ancymidol [15, 25, and 50 mg·L⁻¹ (ppm)] (A-Rest; Elanco Products Co., Indianapolis), dikegulac sodium (500, 1000, and 1500 mg·L⁻¹) (Atrimmec; PBI/Gordon Corp., Kansas City, Mo.), paclobutrazol (10, 20, and 60 mg·L⁻¹) (Bonzi; Uniroyal Chemical Co., Middlebury, Conn.), chlormequat chloride (CCC) (750, 1000, and 1500 mg·L⁻¹) (Cycocel; Olympic Horticultural Products, Mainland, Pa.), and CCC/daminozide mixes (1000/2500, 1000/5000, and 1500/5000 mg·L⁻¹) (Cycocel and B-Nine; Uniroyal Chemical Co.). Ten replicate plants of each concentration were evaluated weekly for plant height and number of branches for 8 weeks. Plants that received CCC and CCC/daminozide treatments at all concentrations and paclobutrazol at 60 mg·L⁻¹ were 60%, 60%, and 48% shorter than control plants and had 113%, 100%, and 75% more branches than control plants, respectively. All concentrations of ancymidol and dikegulac sodium-treated plants were similar to control plants. Paclobutrazol was applied twice, and only the

highest concentration was effective for height control. Chlormequat chloride at the lowest concentration was as effective as all other concentrations of CCC and CCC/daminozide.

Seashore mallow is native to marshes in the southeastern United States (Fernald, 1950). The tolerance of seashore mallow to extreme moisture conditions, salts, and various soil types, in addition to its long flowering period, make it a promising ornamental perennial (Armitage, 1997). However, trials we conducted to assess development of containerized plants in greenhouses resulted in unattractive, excessively tall shoot systems.

Several plant growth regulators (PGRs) are used commercially to restrict growth and promote branching. Performance of PGRs varies greatly by species and cultivar (Latimer et al., 1998), and therefore, efficacy and concentrations must be determined for each taxon of interest. Response of seashore mallow to PGRs has not been documented. However, other genera within Malvaceae, such as hibiscus (*Hibiscus* spp.), have been studied (Shanks, 1972; Wang and Gregg, 1991). Warner and Erwin (2003) used PGRs on three hibiscus species to limit stem elongation and reported mixed results. Some species responded to specific PGRs, while others did not. Our objective was to determine the efficacy of foliar application of five PGRs on height and branching of seashore mallow.

Materials and methods

Seeds of seashore mallow were acquired in the wild from salt marshes in Delaware. On 12 Jan. 2002, seeds were sown in germination substrate (Super Fine; Conrad-Fafard, Agawam, Mass.), lightly covered with vermiculite, and placed on bottom heat at 28 °C (82.4 °F) under intermittent mist, applied for 15 s every 15 min. At 30% to 40% emergence, flats were removed from mist and irrigated with tap water once daily. Seedlings were transplanted into plastic pots [12.7-cm (5 inches) diameter, 818 cm³ (49.9 inch³) volume] containing soilless substrate (Sunshine LC1 Professional Growing Mix; Sungrow, Bellevue, Wash.) 23 d after sowing. Plants grew in a glass-glazed greenhouse for the duration

of the experiment. Night and day temperatures were 20 and 25 ± 3 °C (68.0 and 77.0 ± 5.4 °F), respectively. Plants were grown under natural irradiance in Ames, Iowa. An LI190SB quantum sensor (LI-COR, Lincoln, Nebr.) recorded photosynthetically active radiation (PAR) hourly. Mean PAR during the middle 5 h of photoperiods was 653 μmol·m⁻²·s⁻¹.

Ten plants were assigned randomly to each of 16 treatment groups when plants had three to four expanded true leaves and roots were visible at the edge of the substrate. Plant growth regulators were applied to runoff by using a hand-held misting bottle. The chemicals and concentrations were: ancymidol (15, 25, and 50 mg·L⁻¹), dikegulac sodium (500, 1000, and 1500 mg·L⁻¹), paclobutrazol (10, 20, and 60 mg·L⁻¹), CCC (750, 1000, and 1500 mg·L⁻¹), and CCC/daminozide mixture (1000/2500, 1000/5000, and 1500/5000 mg·L⁻¹). Distilled water was applied as a control and was used to make all solutions. Plants treated with paclobutrazol received a second application 10 d later per label recommendations.

Plants were supplied each day with tap water to prevent wilting. A 300 mg·L⁻¹ solution made of 75% Peters Cal-Mag 15-5-15 (15N-2.2P-12.5K) and 25% Peters All Purpose 21-5-20 (21N-2.2P-16.6K) for a total of 16.5N-2.2P-13.5K (Scotts Co., Marysville, Ohio) was applied twice at 1.7 L (0.45 gal) per pot.

Plant height was measured once weekly for 8 weeks. Height was measured as the distance between the top surface of growing substrate and the apex of the primary stem. Visual comparisons were made between control plants and treated plants. Distinct leaf color differences and flowering time were noted. The number of first-order lateral branches was counted at the end of 8 weeks.

A randomized complete-block design (SAS, 1999) was used, consisting of 16 treatment groups (five PGRs at three concentrations each and a control) with 10 replications each. Linear regression and analysis of variance were performed. Height and branch data from treated plants were compared with data from the controls by Dunnett's one-tailed *t* test (*P* ≤ 0.05). Rate effects for height and branching were determined by using a general linear model (GLM) procedure with

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Fig. 1. Mean height ($\pm$ SD) of seashore mallow measured 8 weeks after initial foliar application of plant growth regulators. Growth regulators were applied at three concentrations to 10 single-plant replications. Low, medium, and high concentrations for each chemical in units of $\text{mg}\cdot\text{L}^{-1}$ (ppm) were: chlormequat chloride (CCC) (750, 1000, and 1500), CCC/daminozide mixes (1000/2500, 1000/5000, and 1500/5000), paclobutrazol (10, 20, and 60), ancymidol (15, 25, and 50), and dikegulac sodium (500, 1000, and 1500) (1 cm = 0.39 inch).

Tukey's honestly significant difference (HSD) test for mean separation.

Results and discussion

Plants treated with all concentrations of CCC and CCC/daminozide mixtures were 60% shorter [35 cm (13.8 inches) vs. 90 cm (35.4 inches) tall] than control plants at week 8 (Fig. 1). Paclobutrazol at $60\text{ mg}\cdot\text{L}^{-1}$ resulted in plants 48% shorter than controls, whereas plants treated with paclobutrazol at 10 and $20\text{ mg}\cdot\text{L}^{-1}$ were similar to control. Paclobutrazol was the only PGR to show a decrease in height with an increase in concentration. Ancymidol and dikegulac sodium at all concentrations were similar in height when compared to control plants ($P = 0.50$). Average number of branches for plants treated with paclobutrazol, CCC, and CCC/daminozide increased from 8 to 14, 17, and 16 branches, respectively ($P < 0.01$) (Table 1). Concentration did not affect branch count. Plants treated with ancymidol and dikegulac sodium at all concentrations were similar to control plants in number of branches ($P = 0.96$) as well as leaf color and bloom time.

Fig. 2. Seashore mallow treated with plant growth regulators compared to control. (A) Control in background and plants treated with three concentrations of chlormequat chloride in foreground [left to right: 750, 1000, and $1500\text{ mg}\cdot\text{L}^{-1}$ (ppm)]. No statistical differences were found in height between rates. Note the difference in leaf color between treated plants and control. (B) Control on far right and plants treated with three concentrations of dikegulac sodium from left to right (500, 1000, and $1500\text{ mg}\cdot\text{L}^{-1}$). No differences in height or leaf color were found.

Replicates that received paclobutrazol, CCC, and CCC/daminozide treatments exhibited leaf chlorosis on <20% of plants immediately after application. At the end of week 8, no chlorosis was visible. Treated plants also showed darker green leaves 3 weeks after application, and flowering was delayed to 14 weeks compared with 12 weeks for control plants (Fig. 2). Depending upon the chemical and concentration applied, treatment can result in phytotoxicity in the form of chlorosis and delayed flowering (Gibson and Whipker, 2003; Kim et al., 1999).

Our results are similar to previous reports on another genus within Malvaceae wherein CCC effectively limited stem elongation in hibiscus spp. (Shanks, 1972; Wang et al., 1998;

Table 1. Average number of branches measured on seashore mallow 8 weeks after being treated with plant growth regulators (PGRs). Five PGRs were applied when three to four expanded leaves were present. Results were averaged across concentrations for plant growth regulators because there were no rate effects.

Plant growth regulator	Branches (no.)
Chlormequat chloride	17a ^z
Chlormequat chloride /daminozide	16a
Paclobutrazol	14a
Ancymidol	9b
Dikegulac sodium	10b
Control	8b

^zNumber of branches followed by the same letter are not significantly different (Tukey's HSD, $P = 0.05$).

Warner and Erwin, 2003). Warner and Erwin (2003) concluded that multiple applications of paclobutrazol were needed to control stem elongation in hibiscus species. Our research indicated that two applications of paclobutrazol were also effective for control height of seashore mallow.

Although paclobutrazol controlled height and increased branching, its label recommends multiple applications. The CCC/daminozide mix was also effective, but required the combination of two chemicals in higher concentrations than the most effective concentration of CCC alone. A single foliar application of CCC at 750 mg·L⁻¹ to seashore mallow when three to four expanded leaves are present would be most logical when considering material costs and increased labor for multiple applications. However, since no rate effects were noticed with CCC in this study, it is possible that a lower concentration may prove effective. Application at other growth stages may alter effectiveness as would the application method.

This information is valuable for growers interested in adding a durable and attractive native perennial to their product line. Further research should be conducted to determine if drench application of PGRs affects height or branching of seashore mallow.

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