Report Submitted to Fine Americas, Inc.

Comparison of Citadel ± Dazide to Cycocel ± B-Nine on Greenhouse Crops

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OBJECTIVE

Experiment 1 – The objective of this experiment was to determine the relative efficacy of Citadel (chlormequat chloride, Fine Americas, Inc.) to Cycocel (chlormequat chloride, OHP, Inc.) on several popular bedding plants.

Experiment 2 – The objective of this experiment was to determine the relative efficacy of Citadel + Dazide (daminozide, Fine Americas, Inc.) to Cycocel + B-Nine (daminozide, OHP, Inc.) on several popular bedding plants.

EXPERIMENTAL METHODS

Plant Material

On 17 March 2008, one 72-cell plug tray each of geranium (*Pelargonium* 'Merisnow'), Cape daisy (*Osteospermum* 'Margarita White'), pinks (*Dianthus* 'Bouquet Purple'), marigold (*Tagetes* 'Durango Tangerine'), and petunia (*Petunia* 'Wave Purple') were delivered from Heartland Growers, Inc. (Westfield, IN) to Purdue University (West Lafayette, IN). Plants species were selected based on need for height control and popularity in the mass market.

Greenhouse Environment

The plants were grown in a glass-glazed greenhouse with fan and pad cooling at Purdue University (lat. 40 °N). The temperature set point in the greenhouse was a constant 21 °C (70 °F) and under a 16-hour photoperiod (0600 to 2000 HR) consisting of natural daylengths with day-extension lighting provided from high-pressure sodium lamps. Actual average daily temperatures and Daily Light Integrals (DLI) are provided in Table 1. Plants were transplanted into 11.5-cm (4.5-inch) round pots filled with a commercial soiless medium composed of Canadian sphagnum peat and perlite (ProMix HP; Premier Horticulture) on 26 March 2008. *Petunia*, *Osteospermum* and *Pelargonium* were given a soft pinch on 4 April 2008 so that the number of nodes were similar among plants.

Table 1. Average temperatures and Daily Light Integral for each month of the experiment.

Month	Temperature	DLI
March	21.5 °C (70.7 ± 1.2 °F)	15.8 $mol \cdot m^{-2} \cdot d^{-1}$
April	21.7 °C (71.0 ± 1.4 °F)	12.0 $mol \cdot m^{-2} \cdot d^{-1}$
May	21.4 °C (70.6 ± 1.9 °F)	9.5 $mol \cdot m^{-2} \cdot d^{-1}$

Chemical Applications

On 09 April 2008, the chlormequat chloride ± daminozide applications were made according to Table 2. On the day of the application, plants were randomly assigned to twelve treatments containing six plants each. A single foliar spray (2 qt. /100 ft^2) was made between 9:00 and 10:00 a.m. on the day of application for each treatment according to the experimental protocol (Table 2). For each experiment a group of plants that were not treated with growth regulators were designated as the control.

Table 2. Bedding plant species and application rates used for each experiment.

Species	Expt. 1 Citadel or Cycocel	Experiment 2 Citadel + Dazide or Cycocel + B-Nine	Application Date
	Spray rate (ppm)		
Geranium (*Pelargonium* 'Merisnow')	0 ,750, 1000 or 1500	0, 1250 + 1250 or 1500 + 2500	09 April, 2008
Cape daisy (*Osteospermum* 'Margarita White')	0 ,750, 1000 or 1500	0, 1250 + 1250 or 1500 + 2500	09 April, 2008
Pinks (*Dianthus* 'Bouquet Purple')	0 ,750, 1000 or 1500	0, 1250 + 1250 or 1500 + 2500	09 April, 2008
Marigold (*Tagetes* 'Durango Tangerine')	0 ,750, 1000 or 1500	0, 1250 + 1250 or 1500 + 2500	09 April, 2008
Petunia (*Petunia* 'Wave Purple')	0 ,750, 1000 or 1500	0, 1250 + 1250 or 1500 + 2500	09 April, 2008

Data Collection

- **Measurements**

  Plant height was measured on the date of the chemical application and weekly until flower for all species except for *Petunia*. Height data for *Petunia* was collected weekly until 5 weeks after the application because plants had visible flower buds at the time of application. For *Petunia*, plant height was measured from the medium surface to the tip of the longest extended stem. For *Dianthus*, *Osteospermum*, *Pelargonium*, and *Tagetes*, plant height was measured from the base of the pot to the apex of the tallest shoot.

  Date of first flowering was recorded for each plant, and time to flower was calculated. On the date that each plant flowered, the number of open flowers and flower buds were counted.

- **Photographs**
  Photographs of all plants, except *Petunia* were taken at 2 and 5 weeks after application. See the PowerPoint presentation included with this report and CD mailed to Kevin Forney.

Data Analysis
A completely randomized design was used. Data were analyzed using a SAS (SAS Institute, Cary, N.C.) mixed model procedure (PROC MIXED) and pairwise comparisons between treatments were performed using Tukey's honest significant difference (HSD) test at $P \leq 0.05$.

RESULTS

Experiment 1
***Pelargonium* 'Merisnow'**
A single spray application of Citadel or Cycocel at 1000 or 1500 ppm inhibited stem elongation by 1.2 to 1.8 inches compared to the untreated control at flower (Figure 1a). There were no significant differences in stem elongation between plants treated with Citadel or Cycocel at 750 ppm and the untreated control at flower (Figure 1a). For example, average plant height of control plants was 8.3 inches, and 7.8 inches and 7.5 inches in plants treated with 750 ppm Citadel or Cycocel, respectively. Time to flower and the number of flower buds were not significantly different among treatments (Table 3). An application of chlormequat chloride at 1500 ppm induced symptoms of phytotoxicity.

***Osteospermum* 'Margarita White'**
All rates of Citadel and Cycocel significantly suppressed stem extension at flower (Figure 1b). For example, at flower, plants treated with either 1500 ppm Citadel or Cycocel were 3.4 inches (39%) or 3.7 inches (42%) shorter, respectively than untreated plants. There were no significant differences in height between chemicals (Citadel or Cycocel) at each application rate. Both chemicals applied at 750 to 1500 ppm produced plants at or below 6 inches (Figure 1b). There were no differences in the number of flowers among all treatments. Symptoms of phytotoxicty were observed across all rates of chlormequat chloride applied.

***Dianthus* 'Bouquet Purple'**
At flower, Citadel or Cycocel at all rates effectively inhibited stem elongation by 2.6 to 4.8 inches compared to the untreated control (Figure 1c). However, there were no differences in stem elongation among all treatments. Plants treated with Citadel or Cycocel at 1500 ppm were 4.1 inches (30%) or 3.9 inches (29%) shorter, respectively than untreated plants. Time to flower and the number of flower buds were not significantly different among treatments (Table 3). No symptoms of phytotoxicity were observed in any treatment.

***Tagetes* 'Durango Tangerine'**
Stem elongation measured at flower was only reduced in plants treated with 1000 ppm chlormequat chloride (Figure 1d). Plants treated with Citadel or Cycocel at all rates were on

average 0.65 inches shorter than untreated plants. There were no differences between application rates of each chemical. Time to flower and the number of flower buds were not significantly different among treatments (Table 3).

***Petunia* 'Wave Purple'**

Stem elongation four weeks after application was not significantly inhibited by any chlormequat chloride treatment (Figure 1e). However, plants treated with Citadel at 1500 ppm were on average 2 inches shorter than untreated plants. Time to flower and the number of flower buds data was not collected because flower buds were present at the time of application.

Experiment 2

***Pelargonium* 'Merisnow'**

All rates of chlormequat chloride + daminozide effectively reduced stem elongation (Figure 2a). For example, one spray application of Citadel + Dazide or Cycocel + B-Nine at a rate of 1250 + 1250 ppm resulted in plants that were 1.0 and 1.1 inches shorter, respectively than the untreated control. Time to flower and flower bud number were not significantly influenced by chlormequat chloride + daminozide treatments (Table 4).

***Osteospermum* 'Margarita White'**

Height at flower was inhibited in all chemical treatments (Figure 2b). Plants treated with Citadel + Dazide or Cycocel + B-Nine at both rates were on average 3.2 inches or 36% shorter than untreated plants. There were no differences between application rates of each chemical. Time to flower and the number of flower buds were not significantly different among treatments (Table 4).

***Dianthus* 'Bouquet Purple'**

At flower, none of the chemical treatments were significantly different from the untreated control (Figure 2c). However, plants treated with Citadel + Dazide at 1250 + 1250 ppm or 2500 + 1500 ppm were 2.0 or 2.9 inches shorter than the untreated control. Time to flower was significantly different among treatments, but no trends were apparent. The number of flower buds was not significantly different among treatments (Table 4).

***Tagetes* 'Durango Tangerine'**

Neither Citadel + Dazide nor Cycocel + B-Nine significantly suppressed stem extension at flower (Figure 2d). For example, at flower, all rates of chlormequat chloride + daminozide were on average only 0.15 inches or 3 % shorter than untreated plants. Time to flower in plants treated with chlormequat chloride + daminozide was delayed by 2 to 6 days (Table 4). There were no significant differences in the number of flowers among all treatments.

***Petunia* 'Wave Purple'**

At flower, plant treated with Citadel + Dazide effectively suppressed stem elongation (Figure 2e). For example, plants sprayed with 1250 + 1250 ppm or 2500 + 1500 ppm Citadel + Dazide were on average 4.2 inches or 23% shorter than untreated plants. There were no significant differences in height among plants treated with Cycocel + B-Nine at either rate tested. Flowering data was not collected because plants had visible flower buds at the time of application.

CONCLUSIONS

Our results indicate that a single foliar application of Citadel or Cycocel of 1000 or 15000 ppm was effective at reducing stem elongation in *Pelargonium*, *Osteospermum*, *Dianthus* and *Tagetes*. Chlormequat chloride alone was not effective in reducing stem elongation in the aggressive *Petunia* 'Wave Purple'. Citadel + Dazide or Cycocel + B-Nine were effective in inhibiting stem elongation in *Pelargonium*, *Osteospermum*, and *Petunia*. These results should be considered for Northern U.S. condition and rates for other parts of the country could vary.

Time to flower was influenced by chlormequat chloride ± daminozide in *Osteospermum*, *Dianthus* and *Tagetes*, however no trends were apparent. Flower bud number was not influenced by Citadel ± Dazide or Cycocel ± B-Nine applications or rates (Tables 3 to 4). We observed symptoms of phytotoxicity in *Pelargonium* and *Osteospermum* treated with chlormequat chloride alone.

Table 3. The effects of a single foliar spray of Citadel or Cycocel on days to flower, number of flower buds and phytotoxicity in *Pelargonium* 'Merisnow', *Osteospermum* 'Margarita White', *Dianthus* 'Bouquet Purple' and *Tagetes* 'Durango Tangerine'.

Plant growth regulator	Rate (ppm)	Plant Species			
		Pelargonium	*Osteospermum*	*Dianthus*	*Tagetes*
			Days to flower		
Control		31 a[z]	34 b	25 a	13 a
Citadel	750	30 a	40 a	26 a	13 a
	1000	29 a	34 b	22 a	13 a
	1500	33 a	36 ab	22 a	13 a
Cycocel	750	32 a	38 ab	26 a	14 a
	1000	31 a	36 ab	25 a	15 a
	1500	32 a	36 ab	25 a	14 a
Significance		NS	***	NS	NS
			Flower number		
Control		6.8 a	11.3 a	21.5 a	7.8 a
Citadel	750	7.0 a	14.7 a	29.3 a	8.0 a
	1000	8.0 a	14.5 a	26.5 a	7.0 a
	1500	5.8 a	11.6 a	25.0 a	7.8 a
Cycocel	750	5.3 a	13.7 a	25.0 a	9.2 a
	1000	7.0 a	14.7 a	22.2 a	7.8 a
	1500	6.5 a	12.9 a	26.3 a	7.7 a
Significance		NS	NS	NS	NS
			Phytotoxicity (%)		
Citadel	750	0	33	0	0
	1000	33	67	0	0
	1500	17	100	0	0
Cycocel	750	0	17	0	0
	1000	0	33	0	0
	1500	33	100	0	0

[z]Within-column means followed by different letters are significantly different by Tukey=s honest significant difference (HSD) test at $P \leq 0.05$.

NS, *** Nonsignificant or significant at $P \leq 0.001$, respectively.

Table 4. The effects of a single foliar spray of Citadel + Dazide or Cycocel + B-Nine on days to flower and number of flower buds in *Pelargonium* 'Merisnow', *Osteospermum* 'Margarita White', *Dianthus* 'Bouquet Purple' and *Tagetes* 'Durango Tangerine'.

Plant growth regulator	Rate (ppm)	Plant Species			
		Pelargonium	*Osteospermum*	*Dianthus*	*Tagetes*
		Days to flower			
Control		31 a[z]	32 b	22 b	13 b
Citadel + Dazide	1250 + 1250	32 a	35 ab	30 a	17 a
	1500 + 2500	30 a	38 a	25 ab	18 a
Cycocel + B-Nine	1250 + 1250	30 a	37 a	24 ab	15 ab
	1500 + 2500	31 a	36 a	21 b	18 a
Significance		NS	NS	*	*
		Flower number			
Control		6.4 a	11.8 a	22.8 a	7.2 ab
Citadel + Dazide	1250 + 1250	5.8 a	13.2 a	21.3 a	9.2 a
	1500 + 2500	5.3 a	14.2 a	19.8 a	7.8 ab
Cycocel + B-Nine	1250 + 1250	5.8 a	12.7 a	27.8 a	6.2 b
	1500 + 2500	4.8 a	12.7 a	24.2 a	7.5 ab
Significance		NS	NS	NS	NS

[z]Within-column means followed by different letters are significantly different by Tukey=s honest significant difference (HSD) test at $P \leq 0.05$.

NS, * Nonsignificant or significant at $P \leq 0.05$, respectively.

Figure 1. The effects of Citadel and Cycocel treatments on final height at flower of **(A)** *Pelargonium* 'Merisnow', **(B)** *Osteospermum* 'Margarita White', **(C)** *Dianthus* 'Bouquet Purple', and **(D)** *Tagetes* 'Durango Tangerine'. Height of **(E)** *Petunia* 'Wave Purple' 4 weeks after the Citadel and Cycocel application. Treatments with the same letter are not statistically different at $P \leq 0.05$.

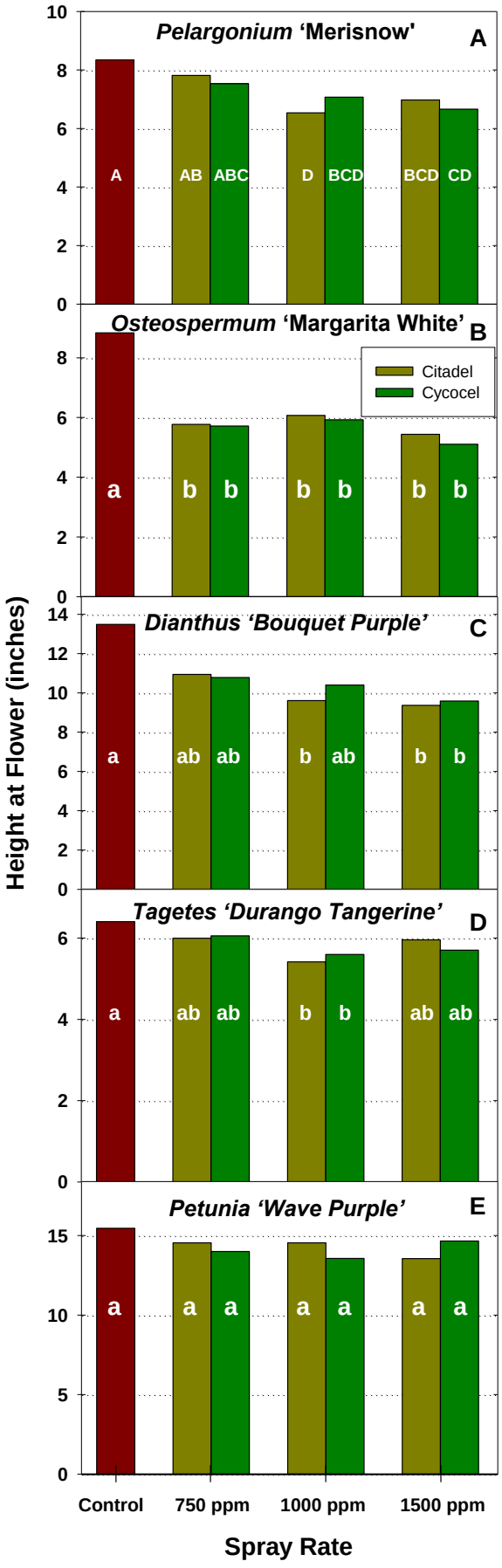

Figure 2. The effects of Citadel + Dazide and Cycocel + B-Nine treatments on final height at flower of **(A)** *Pelargonium* 'Merisnow', **(B)** *Osteospermum* 'Margarita White', **(C)** *Dianthus* 'Bouquet Purple', and **(D)** *Tagetes* 'Durango Tangerine'. Height of **(E)** *Petunia* 'Wave Purple' 4 weeks after the Citadel and Cycocel application. Treatments with the same letter are not statistically different at $P \leq 0.05$.