GROWTH OF TWO BEGONIA SPECIES AS INFLUENCED BY HAND PINCHING AND TWO GROWTH REGULATORS

by

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LITERATURE REVIEW

Dikegulac

Sodium 2,3:4,6-di-O-isopropylidene-2-keto-gulonate, is a derivative of gulose, a diastereomer of an aldohexose (21). Gulose, a six carbon aldehyde sugar, is treated with a mild oxidizing agent to form gulonic acid (12). Since the acid form is unstable, the sodium salt is used (2). This sugar derivative called dikegulac is the first synthetic growth regulant to be formed from a monosaccaride (5). Monosaccarides are important components in plant metabolism.

Use of Dikegulac on Woody and Herbacious Ornamentals

Dikegulac, the active ingredient of the growth regulator Atrinal®, has been an effective pinching agent and growth retardant of woody and herbaceous ornamentals. Prevention of shoot elongation on several trees and shrubs for more than three months has been achieved with dikegulac (24). Foliar applications of dikegulac reduced growth in Fraxinus uhdei, Ulmus pumila, Schinus molle, Alnus rombifolia, Morus alba, Ceratonia seliqua, and Acacia longifolia (10). Growth reduction of Ulmus parvifolia was observed after trunk banding with dikegulac n-pentyl ester (10). Also dikegulac has been shown to delay bud break and induce lateral shoot production on 5 year old pecan trees (17). Inhibition of flower and fruit set of ornamentals is possible with dikegulac (2). Conversly, a single application was reported to induce parthenocarpic fruit developement in Pyrus communis 'Williams' (5). Unlike GA_3, dikegulac induced

parthenocarpic fruit were not deformed.

Dikegulac has growth regulatory effects on turfgrass. In the greenhouse Poa pratensis, Lolium perenne, and Festuca rubra growth rates were inhibited by dikegulac (22). However, stimulation of tillering has been observed on Poa pratensis and Lolium perenne (5).

Under commercial growing conditions dikegulac inhibited apical dominance and promoted axillary shoot production of several azalea cultivars (8). Bocion et al. (6) reported increased flower production in Gerbera jamesonii, and Cyclamen persicum and axillary shoots in Begonia X hiemalis, and Fuchia X hybrida. On branching poinsettias (Euphorbia pulcherrima), dikegulac used as a pinching agent, produced a more rounded top plant (26). Apparently, the rounded effect was a result of the terminal flower and bract not being killed and becoming the largest on the plant. Foliar sprays on Chrysanthemum X morifolium reduced fresh and dry weights, stem lengths, and were phytotoxic at 100-5000ppm concentrations (18). Dikegulac treatments also resulted in production of more uniform Ficus elastica robusta plants with an 18% increase in leaf production (11). In comparison, a 20% increase in leaf production was observed after a manual pinch.

Physiological Effects of Dikegulac on Plants

Arzee et. al. (3) investigated the physiological effects of dikegulac on plants and found inhibition of DNA synthesis in the apical meristem but not in the axillary buds. When placed on a leaf surface, it is readily translocated to the apex. Studies indicate that dikegulac is moved through the phloem tissue (5). Tissues most

sensitive to dikegulac are the apical meristem and leaf primordia (3), which results in transient interveinal chlorosis, shortened internodes, and stimulation of axillary bud growth. Apparently, dikegulac acts hormonally upon the apex since it is required only in small amounts and is rapidly translocated to growing tissues. Dikegulac has been found to inhibit RNA synthesis of axenically cultured Spirodela by depressing uridine incorporation into plastid and cytoplasmic ribosomal RNA (2). Dikegulac acts unlike x-irradiation where the apex is permanently damaged and unlike other pinching agents whose effectiveness is dependent on its contact with the apex.

Bocion et al. (5) noted that dikegulac interacts with plant hormones. The growth inhibitory effects of dikegulac on Triticum aestivum, Avena fatua, and Pisum sativum can be counteracted by similiar concentrations of GA_3, which would indicated that dikegulac interupts the biosynthesis or mode of action of GA_3. At low concentrations (10^{-6}M), however, dikegulac promotes growth of Lycopersicon esculentum callus tissue. When low concentrations of dikegulac and GA_3 were applied, the growth stimulating effect was additive. Dikegulac also increased ethylene biosynthesis in Pisum sativum seedlings 6-fold. When IAA was added ethylene production of dikegulac treated seeds decreased by 70%.

Uses and Mode of Action of Chlormequat

Chlormequat, the active ingredient of the plant growth regulator Cycocel® (2-chloroethyl trimethyl ammonium chloride) has been used for growth regulation on several horticultural crops. Primary use

of chlormequat is for height reduction of red poinsettias (23). It also aids in production of early budded, well shaped azalea plants (23). The flowering time of seed geraniums can be significantly reduced by 1000 ppm and 1500 ppm foliar sprays of chlormequat (7). Chlormequat is usually applied as a soil drench or as a foliar spray, but has been successful as a bulb dip in reducing the size of 'Enchantment' and 'Harmony' lilies (27). It was also tested as a granular formulation on poinsettias, but drenching resulted in superior height control (28).

Chlormequat, a quaternary ammonium compound has physiological effects on the plant. It causes decreased rate of cell division in the apical meristem and decreased cell elongation immediately below the apical meristem (15). Chlormequat also inhibits gibberellin synthesis by interupting the conversion of geranylgeranyl pyrophosphate to copalyl pyrophosphate. This may be reversed by the addition of GA_3. It can also inhibit sterol synthesis in tobacco, which may be counteracted by the addition of GA_3, β-sitosterol, stigmasterol, and cholestrol (25).

Begonia Elatior Hybrids

The Begonia Elatior hybrids (Begonia X hiemalis Fotsch.) or rieger begonias are a group of plants developed by pollinating Begonia X tuberhybrida Voss. with Begonia socotrana Hook. f. These hybrids combined the large colorful flowers of Begonia X tuberhybrida Voss. and the winter flowering habit of Begonia socotrana Hook. f. (9, 14). Rieger begonias are used for year-round pot plant production and have increased in popularity since their introduction into the United States by J.C. Mikkelsen (13). They may be used in

any season, and are currently in use in Europe for autumn festivals, Christmas, St. Valentines Day, and Mother's Day. Unlike the poinsettia and Easter lily, rieger begonias are still marketable even after the holiday period. It has been suggested that in the Spring, rieger begonias have a double value, as a Mother's Day pot plant and a plant that may be placed outside in a shady area to bloom all summer (29).

The rieger begonia group has many named cultivars with flower colors ranging form pink to white, red, orange, or yellow. The flowers may be single, double, or semi-double (14).

Rieger Elatior Begonia 'Northern Sunset'

Northern Sunset is a cultivar of the Rieger Elatior strain developed by the Ornamentals Research Service in Ontario, Canada (20). Since the rieger hybrids are sterile triploids, x-ray treatment was used to induce mutations of the rieger strain. Northern Sunset, a semi-double mutation, was developed from Renaissance a single flowered scarlet cultivar.

Northern Sunset grows from 25-30 cm high, and has large, (15x9 cm) shiny, double-serrate leaves. The flowers are described as semi-double (16 petals per flower compared to 10 per flower for Renaissance) with Empire Rose petals shaded darker at the tips. Petaloids are flushed with various shades of yellow. The flowers average 5 cm in diameter and have lovely golden colored stamens. Northern Sunset will flower profusely when exposed to at least 3 weeks of short days (10 hours). It is well suited for a pot plant and is resistant to powdery mildew.

Chemical Height Control of the Rieger Begonia

Chemical height control of the rieger begonia is necessary under certain environmental conditions. Growth regulation is needed when plants are closely spaced and during the growing season from Spring to Fall (1, 19). Currently, 0.15% ai. chlormequat sprays are recommended for height reduction (1, 13, 16, 19). Ancymidol drenches have also been proved to be effective at 0.125 mg/pot (13, 16). Under low light conditions ancymidol drenches at 0.062 mg/pot have been effective for height reduction(16). SADH sprays at 0.125, 0.250, and 0.500% were ineffective as a growth retardant for the rieger begonia (16). Dikegulac, a systemic growth regulator has been recommended for testing as a growth retardant on rieger begonias as a 0.05, 0.10, and 0.16% spray (4).

Angel Wing Begonia

Angel wing begonia (14) (Begonia corallina Carriere.) is an old standard house plant which has received little interest from the scientific community. It is characterized by its vigorous caney stems growing from 2.4 to 3.0 meters tall. These cane-like stems often require support. The angel wing begonia has shiny green lanceolate leaves with white spots on top. The underside of the leaf is red turning green toward the margin. Begonia corallina Carriere. bears coral-red flowers on pendulous racemes.

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MANUSCRIPT

This manuscript is written in the style of and for publication in HortScience.

Growth of Two Begonia Species as Influenced by Hand Pinching and Two Growth Regulators[1]

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Abstract. Aqueous solutions of dikegulac (sodium 2,3:4,6-di-O-isopropylidene-2-keto-L-gulonate) treatments sprayed on Begonia X hiemalis 'Northern Sunset' and Begonia corallina in combination with hand pinching were compared to selected chlormequat ((2-chloroethyl) trimethyl ammonium chloride) treatments. Single applications of dikegulac at 0.10 and 0.16% active ingredient reduced internode length and increased stem number, which resulted in a bushy, compact Northern Sunset plant. Double spray applications of 0.10 and 0.16% and single applications in combination with a hand pinch produced a plant of inferior quality. Generally, chlormequat treated plants produced more flowers than dikegulac treated Northern Sunset plants. Dikegulac and chlormequat treatments had little effect on Begonia corallina.

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Begonias are used by horticulturalists as foliage and flowering pot plants. Begonia X hiemalis Fotsch., the rieger begonia, is currently produced year-round and sold as a flowering pot plant in the florist trade. In contrast, Begonia corallina Carriere., the angel wing begonia, has received little commercial interest from the professional horticulturalist, but has continued to be a favorite house plant of amateur horticulturalists. The rieger begonia is valued for its glossy dark green foliage and profuse flower clusters. The angel wing begonia is characterized by its shiny green lanceolate leaves with white spots on top and red undersides, and coral-red flowers borne on pendulous racemes (4). Production of these plants requires pinching to prevent excessive elongation and to stimulate lateral growth.

Dikegulac (sodium 2,3:4,6-di-O-isopropylidene-2-keto-L-gulonate (Atrinal®)) has shown potential as a pinching agent and growth retardant of woody and herbaceous ornamentals. Prevention of shoot elongation on several trees and shrubs for more than 3 months was achieved with dikegulac (7). Inhibition of flower and fruit set of ornamentals was reported with dikegulac (1). Under commercial growing conditions, dikegulac inhibited apical dominance and promoted axillary shoot production of 4 azalea cultivars (3). Dikegulac increased flower production in Gerbera jamesonii and Cyclamen persicum and axillary shoots in Begonia X hiemalis and Fuchia X hybrida (2).

Chlormequat (2-chloroethyl trimethyl ammonium chloride (Cycocel®)) has been used for growth regulation on several horticultural crops. Primary use of chlormequat is for height reduction of red poinsettias (6). It also aids in the production of early budded, well shaped azalea plants (6). Currently, 0.15% active ingredient chlormequat sprays are

recommended for height reduction of the rieger begonia (5).

The purpose of this study is to evaluate the effects of dikegulac, a new growth retardant, with those of chlormequat, the growth retardant currently in use with begonias. Treatments including sprays in combination with a hand pinch will also be evaluated.

Aqueous solutions of dikegulac were sprayed once at 0.05, 0.10, and 0.16%, twice at 0.05, 0.10, and 0.16%, and once at 0.05, 0.10, and 0.16% in combination with a hand pinch (All concentrations are presented in % active ingredient.). These were compared with aqueous solutions of chlormequat sprayed once at 0.15% and sprayed once at 0.15% in combination with a hand pinch. Spray treatments were applied until run-off with a 1.2 liter hand pump sprayer. The single spray application, the first spray of the double spray applications, and the hand pinch were done on September 2, 1979. The second spray of the double spray application was made on September 30. Chlormequat and dikegulac treatments were compared with control and hand pinch treatments.

Begonia X hiemalis 'Northern Sunset' and Begonia corallina plants, were transplanted into 15.2 cm plastic azalea pots filled with a mixture of fibrous peat:coarse perlite:field soil (12:5:3). The media was amended with 2.27 kg/m^3 dolomite and 9 g/pot of timed release fertilizer (14-6.0-5.9). These plants were located on a wire bench, spaced on 30.0 cm centers, and arranged in 5 rows. Each row was a block and contained 13 randomized treatments. Data was analyzed by SAS computer analysis system which produced ANOVA tables and Duncan's multiple range test at the 5% level. Fifty percent shade cloth covered all the plants from transplanting until October 15. Shade cloth was drawn over the Begonia X hiemalis

plants from 7PM to 7AM from September 2 to September 30, to insure flower initiation.

Height and flower number for Begonia X hiemalis and height and leaf number for Begonia corallina were recorded weekly. Diameter measurements were taken every 2 weeks on Begonia X hiemalis. Visual ratings were taken every 2 weeks on both species. Plants were scored from 0 to 10, 0 indicating a dead plant and 10 indicating an excellent plant. Scores were based on the following characteristics: 1) color of leaves (to indicate chlorosis), 2) general vigor, 3) amount of damage from spray applications, and 4) shape (compactness). On November 18 average internode length measurements were taken, shoots were removed and dried for 48 hours at 65°C and weighted. Roots of Begonia corallina were also removed and dried.

Dikegulac treated Northern Sunset plants exhibited a brief period of interveinal chlorosis one week after spraying, lasting approximately one week. Table 1 presents data for average internode length, height, stem number, and flower number for Begonia X hiemalis 'Northern Sunset'. Shortened internodes compress the foliage into a smaller area and results in a more compact plant. All treated Northern Sunset plants, except those receiving a 0.05% dikegulac spray in combination with a hand pinch, had shorter internodes than the control plants. Plants receiving chlormequat at 0.15% in combination with a hand pinch had internodes that were 40% longer than those sprayed with dikegulac at 0.16% in combination with a hand pinch. None of the treated plants differed in height from the control plants. However, Northern Sunset plants sprayed with dikegulac at 0.16% in combination with a hand pinch were 20%

shorter than those sprayed with chlormequat at 0.15% in combination with a hand pinch. Increasing stem number produces a fuller more attractive plant. Northern Sunset plants treated with single spray applications of dikegulac at 0.10 and 0.16% increased stem number by 3.6 and 4.3 times respectively. This demonstrated dikegulac's ability to eliminate apical dominance and stimulate axillary buds, as these stems originated from axillary buds below the soil surface. As the concentration for single spray applications of dikegulac increased so did the stem number, but as the concentration increased for repeated spray applications and single applications in combination with a hand pinch increased, stem number decreased. Treated plants did not differ in flower number from the control. Chlormequat treated plants produced more flowers than those sprayed with dikegulac. For all dikegulac treatments, as the concentration increased, flower number decreased.

Table 2 presents data for shoot dry weight, visual ratings, and plant diameter measurements of Begonia X hiemalis 'Northern Sunset'. None of the treated plants differed in shoot dry weight from the control. Plant quality increased with an increase in visual ratings. Treated plants did not differ in visual ratings from the control. As dikegulac concentrations increased for all types of dikegulac treatments, visual quality ratings decreased. Treated plants did not differ in plant diameter from the control. In general, as dikegulac concentrations increased for single applications diameter increased. Conversely, as dikegulac concentrations increased for double applications and single applications in combination with a hand pinch diamster decreased.

Table 3 presents data for height and internode length of Begonia corallina. Treated Begonia corallina plants did not differ

in height from the control plants. When comparing dikegulac and chlormequat treated plants, single sprays of chlormequat at 0.15% produced shorter plants than single sprays of dikegulac at 0.05, 0.10, and 0.16%. Treated plants did not differ in internode length from the control, however, the hand pinched plants had longer internodes than the sprayed plants.

None of the treated Begonia corallina plants differed in shoot dry weight, root dry weight, leaf number or visual ratings from the control plants.

In conclusion, it appears that dikegulac alters the nature of growth of Begonia X hiemalis 'Northern Sunset', not the amount. This study suggests that concentrations of dikegulac sprayed once at the rates of 0.10 and 0.16% to be most effective for producing a good quality plant. These concentrations reduced internode length and increased stem number, which resulted in a bushy, compact plant. Plants receiving repeat applications of 0.10 and 0.16% spray and single applications in combination with a hand pinch were inferior in quality.

Dikegulac and chlormequat treatments had little effect on Begonia corallina. When comparing dikegulac and chlormequat treatments, single applications of chlormequat at 0.15% produced shorter plants than single sprays of dikegulac at 0.05, 0.10, and 0.16%. Since all treated plants did not differ from the control, one can conclude that higher concentrations of dikegulac and chlormequat are required for the production of a compact angel wing begonia.

Table 1. Influence of hand pinching and two growth regulators on average internode length, height, stem number, and flower number of Begonia X hiemalis 'Northern Sunset'.

Treatment		Conc. (%ai.)	Average Internode Length (cm)	Height (cm)	Stem Number	Flower Number
Control		--	22.3a[z]	13.1ab	2.5c	18.0abcd
Hand pinch		--	17.6bc	12.6ab	4.3c	19.3abcd
Dikegulac	1 spray	0.05	15.1bcd	13.0ab	3.5c	15.8abcd
	1 spray	0.10	14.9bcd	13.4ab	9.0ab	10.8cd
	1 spray	0.16	14.2bcd	14.1a	10.8a	7.4d
	2 sprays	0.05	15.2bcd	14.5a	6.5bc	24.4abc
	2 sprays	0.10	13.8bcd	12.8ab	3.5c	4.8d
	2 sprays	0.16	12.5cd	12.6ab	3.7c	2.0d
hand pinch &	1 spray	0.05	18.4ab	12.4ab	5.3bc	13.5bcd
hand pinch &	1 spray	0.10	15.7bcd	14.0a	4.0c	7.0d
hand pinch &	1 spray	0.16	11.9d	10.9b	4.5c	3.8d
Chlormequat	1 spray	0.15	14.8bcd	12.7ab	3.8c	26.8ab
hand pinch &	1 spray	0.15	16.7bc	13.6a	3.8c	29.0a

[z] Mean separation, within columns, by Duncan's multiple range test, 5% level.

Table 2. Influence of hand pinching and two growth regulators on shoot dry weight, visual ratings, and plant diameter of Begonia X hiemalis 'Northern Sunset'.

Treatment		Conc. (%ai.)	Shoot Dry Weight (gm)	Visual Ratings[z]	Plant Diameter (cm)
Control		--	26.5a[y]	5.9abc	18.1ab
Hand pinch		--	25.5a	5.5abc	18.2ab
Dikegulac	1 spray	0.05	26.0a	6.1abc	17.5ab
	1 spray	0.10	23.0a	6.4ab	21.3ab
	1 spray	0.16	26.5a	5.7abc	21.1ab
	2 sprays	0.05	27.8a	7.4a	22.1a
	2 sprays	0.10	25.0a	5.9abc	21.4ab
	2 sprays	0.16	26.0a	4.1c	16.5b
hand pinch &	1 spray	0.05	26.5a	5.6abc	20.6ab
hand pinch &	1 spray	0.10	26.0a	5.2abc	20.2ab
hand pinch &	1 spray	0.16	26.0a	5.1bc	20.2ab
Chlormequat	1 spray	0.15	26.8a	5.3abc	17.6ab
hand pinch &	1 spray	0.15	25.5a	6.1abc	19.1ab

[z] Visual rating scale: 0.0= completely dead; 10.0= excellent quality.
[y] Mean separation, within columns, by Duncan's multiple range test, 5% level.

Table 3. Influence of hand pinching and two growth regulators on height and internode length of Begonia corallina.

Treatment		Conc. (%ai.)	Height (cm)	Internode Length (cm)
Control		--	18.7ab[z]	28.5ab
Hand pinch		--	20.0ab	38.8a
Dikegulac	1 spray	0.05	21.6a	24.1b
	1 spray	0.10	22.0a	24.0b
	1 spray	0.16	21.0a	27.0b
	2 sprays	0.05	20.5ab	26.5b
	2 sprays	0.10	17.2ab	21.5b
	2 sprays	0.16	20.8ab	21.1b
hand pinch &	1 spray	0.05	18.4ab	26.0b
hand pinch &	1 spray	0.10	17.0ab	19.5b
hand pinch &	1 spray	0.16	17.7ab	22.2b
Chlormequat	1 spray	0.15	14.3b	16.7b
hand pinch &	1 spray	0.15	15.7ab	20.8b

[z] Mean separation, within columns, by Duncan's multiple range test, 5% level.

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APPENDIX

Table 4. Influence of hand pinching and two growth regulators on shoot dry weight, root dry weight, leaf number, and visual ratings of *Begonia coralliina*.

Treatment		Conc. (%ai.)	Shoot Dry Weight (gm)	Root Dry Weight (gm)	Leaf Number	Visual[z] Ratings
Control		--	29.3a[y]	4.8a	7.4a	5.0a
Hand pinch		--	29.3a	4.7a	8.8a	5.4a
Dikegulac	1 spray	0.05	26.3a	4.5a	9.5a	5.3a
	1 spray	0.10	31.8a	4.5a	9.2a	4.7a
	1 spray	0.16	28.8a	4.5a	9.1a	5.2a
	2 sprays	0.05	29.5a	4.8a	8.4a	5.4a
	2 sprays	0.10	28.0a	4.8a	8.9a	4.8a
	2 sprays	0.16	28.5a	4.8a	10.8a	5.4a
hand pinch &	1 spray	0.05	26.5a	4.5a	9.1a	4.9a
hand pinch &	1 spray	0.10	27.3a	4.3a	9.2a	4.0a
hand pinch &	1 spray	0.16	29.3a	4.8a	11.0a	5.4a
Chlormequat	1 spray	0.15	26.3a	4.7a	6.1a	4.4a
hand pinch &	1 spray	0.15	28.5a	4.5a	10.2a	5.6a

[z] Visual rating scale: 0.0= completely dead; 10.0= excellent quality.
[y] Mean separation, within columns, by Duncan's multiple range test, 5% level.

GROWTH OF TWO BEGONIA SPECIES AS INFLUENCED BY HAND PINCHING AND TWO GROWTH REGULATORS

by

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Aqueous solutions of dikegulac (sodium 2,3:4,6-di-O-isopropylidene-2-keto-L-gulonate) treatments sprayed on Begonia X hiemalis 'Northern Sunset' and Begonia corallina in combination with hand pinching were compared to selected chlormequat ((2-chloroethyl) trimethyl ammonium chloride) treatments. Single applications of dikegulac at 0.10 and 0.16% active ingredient reduced internode length and increased stem number, which resulted in a bushy, compact Northern Sunset plant. Double spray applications of 0.10 and 0.16 and single applications in combination with a hand pinch produced a plant of inferior quality. Generally, chlormequat treated plants produced more flowers than dikegulac treated Northern Sunset plants. Dikegulac and chlormequat treatments had little effect on Begonia corallina. It was concluded that dikegulac affected the nature not the amount of growth of Begonia X hiemalis 'Northern Sunset' and that higher concentrations of dikegulac and chlormequat should be considered for use on Begonia corallina.