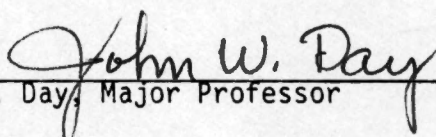
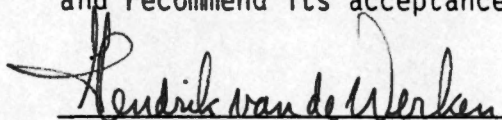


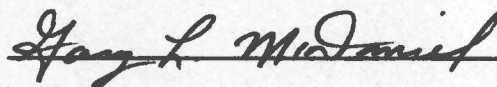
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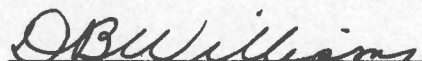
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John W. Day, Major Professor

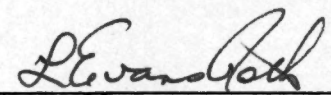
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Vice Chancellor
Graduate Studies and Research



THE EFFECTS OF DIKEGULAC SODIUM ON BUDBREAK IN CANES OF
DRACAENA FRAGRANS (L.) KER-GAWL. CV. MASSANGEANA

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Ann Rhamy Johnson

March 1981

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ABSTRACT

Leafless cane cuttings of Dracaena fragrans 'Massangeana' were soaked for 1, 6 or 12 hours in 0.00%, 0.05%, 0.10%, 0.20%, 0.40% or 0.80% dikegulac sodium solutions before placement in the propagation medium. The number of budbreaks per cane cutting increased with increasing concentration up to 0.20% dikegulac sodium and decreased at higher rates. Increasing dikegulac sodium concentration decreased survival, root quality, shoot length, the percentage of normal buds and the percentage of budbreaks in the upper half of the cane cuttings (the normal site of budbreak). Generally, as dikegulac sodium concentration increased, budbreak was delayed. As soaking time increased, root quality and shoot length decreased. Further investigation of the effects of dikegulac sodium on this cultivar at rates lower than 0.20% may be warranted.

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CHAPTER I

INTRODUCTION

Dracaena fragrans (L.) Ker-Gawl. cv. Massangeana (Striped Corn Plant) is a tropical foliage plant used extensively for interior plantscaping. 'Massangeana' is propagated commercially by either tip cuttings or leafless cane sections. U.S. growers generally obtain propagation material from stock plantings in Central America and the Caribbean Islands (11, 12, 29).

Leafless cane sections (29), such as those used in this research, are usually placed in peat or shavings and maintained under mist until buds sprout (within approximately two months) and roots develop (within approximately three months).

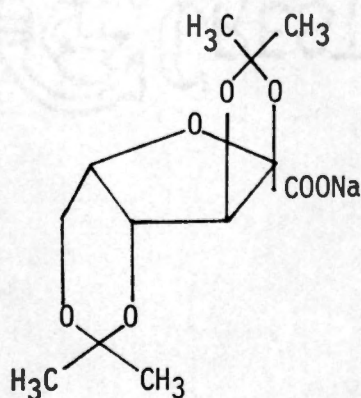
Buds generally sprout only near the top of cane sections. Therefore, growers typically plant three canes of different lengths per pot in order to produce a fuller plant. If buds could be forced to grow along the length of a cane section, a more attractive plant could be produced using fewer canes (29). Increased branching of 'Massangeana,' especially during propagation, could improve quality and reduce nursery production costs.

The purpose of this research was to determine the effects of dikegulac sodium, a growth regulator known to promote lateral branching in many plants, on budbreak in canes of Dracaena fragrans 'Massangeana.'

CHAPTER II

LITERATURE REVIEW

Dikegulac sodium is a systemic plant growth regulator effective for the chemical pinching and shaping of ornamental plants (1). This compound is an intermediate in the commercial synthesis of L-ascorbic acid (3). Its chemical identity is the sodium salt of 2,3:4,6 Bis-O-(1-Methylethylidene)- α -L-Xylo-2-Hexulofuranosonic acid and its structure is:



Dikegulac sodium is an odorless white solid. It is commercially available as AtrinalTM, a liquid concentrate which contains 200 grams per liter of active ingredient (1).

Bocion et al. (3) tested the growth-retarding activity of eleven monosaccharide derivatives on Poa pratensis L. The sodium salt of dikegulac was determined to be the most active compound. Subsequent tests with dikegulac sodium revealed that growth was also retarded in many herbaceous and woody plants. Other effects reported include increased petiole abscission in Phaseolus vulgaris L., increased

flower number in Gerbera jamesonii H. Bolus ex Hook., stimulation of fruit-ripening and parthenocarpic fruit set in tomato and the destruction of apical dominance in Rhododendron simsii Planch.

Several studies have been done to determine the plant physiological properties of dikegulac sodium (2, 4, 17, 35, 46). Arzee et al. (2) tested the effects of dikegulac sodium on apical growth and development of chrysanthemum, sunflower and zinnia. Concentrations of up to 500 mg/liter, applied as a foliar spray, temporarily arrested apical development, resulting in outgrowth of axillary buds. Leaves which expanded directly after treatment were convoluted and temporarily chlorotic. Leaves developing later were also irregularly shaped. Internodes did not elongate normally beneath these distorted leaves. This inhibition of internode elongation led Arzee et al. to conclude that dikegulac sodium works counter to gibberellins. Studies utilizing whole plant autoradiography showed that dikegulac sodium applied to a single leaf was translocated to the apex in minute amounts within hours. Histoautoradiographic studies revealed that this compound inhibited DNA synthesis throughout the apical meristem and resulted in a loss of normal cytohistological zonation. DNA synthesis was detected in the axillary buds. This reversal of apical dominance led Arzee et al. to the conclusion that dikegulac sodium opposes the effects of auxin. Also, due to the minute amounts sufficient to effect changes in the apical meristem, it was concluded that dikegulac sodium is probably analagous to a hormone.

Bocion and deSilva (4) studied its physiological effects on a variety of plants. Studies on chrysanthemum showed that dikegulac

sodium applied to leaves was translocated to the apex, apparently through the phloem. This compound also promoted parthenocarpic fruit set in pears. Growth was retarded in wheat, pea and Avena fatua L. by treatment with dikegulac sodium, an effect which was counteracted by gibberellic acid (GA_3). Interaction between dikegulac sodium and GA_3 was also found in studies of tomato callus. At higher concentrations, these compounds were again found to act antagonistically; however, at lower concentrations, dikegulac sodium and GA_3 applied in combination promoted growth more than GA_3 alone. Dikegulac sodium suppressed apical dominance in Lolium perenne L., Poa pratensis L. and azalea. In studies with azalea, the application of indole-3-acetic acid (IAA) in combination with dikegulac sodium reduced the transient chlorosis and leaf deformation noted on plants treated with dikegulac sodium alone; however, the resulting number of axillary shoots per plant was reduced by these treatments, as IAA tended to maintain apical dominance. The pinching effect of dikegulac sodium on azaleas was enhanced by simultaneous treatment with kinetin.

The effects of dikegulac sodium on citrus were studied by Shemy and Monselise (35). This compound inhibited elongation of the shoot and radicle of citrus seedlings at concentrations of 0.7-3.0 g/embryo; however, a lower concentration (0.3 g/embryo) promoted shoot elongation as compared with the control. Other tests showed no interaction between dikegulac sodium and benzyladenine on growth stimulation of citrus seedlings. Seedlings and mature trees sprayed with 1,000 mg/liter dikegulac sodium showed arrested growth, abortion of flowers, distortion of the young flush and stimulation of bud

sprouting. Treatment with 100 mg/liter did not have these effects and 4,000 mg/liter was nearly lethal. Girdling of six month old seedlings resulted in reduced translocation of this compound from a treated leaf to the apex. Dikegulac sodium applied to a leaf or a root was detected in the apex after 48 hours or 144 hours, respectively. In other tests, 1,000 mg/liter dikegulac sodium was sprayed on seedlings at different times before labelling with $^{14}\text{CO}_2$. The presence of labelled assimilates was reduced in the apex and increased in the leaves due to these treatments. Also, when the seedlings were treated sixteen days before exposure to $^{14}\text{CO}_2$, the level of labelled assimilates in the axillary buds was increased.

Gressel and Cohen (17), in studies on Spirodela oligorrhiza (Kurtz) Helgtem., determined that dikegulac sodium suppressed cytoplasmic and plastid RNA synthesis. However, they concluded that this was probably an indirect result of the general growth suppression and chlorosis caused by treatment with this compound.

Zilkah and Gressel (46) investigated the effects of dikegulac sodium on cell cultures of Solanum nigrum L. Dividing cells were found to be more susceptible to this compound, which led to the conclusion that the specific effect of dikegulac sodium on apical meristems is related to fundamental differences between dividing and nondividing cells.

Numerous studies have been done to determine the practical applications of dikegulac sodium on ornamental species. Azaleas, which require considerable pinching during commercial production, have been a popular subject for research on chemical pinching agents, including dikegulac sodium.

DeSilva et al. (15) reported that dikegulac sodium is an effective pinching agent for azaleas grown under commercial conditions. Foliar spray applications of 0.4-0.6% active ingredient were effective on all cultivars tested.

Washington and Self (41) tested the effects of 0.28%, 0.40% and 0.50% spray solutions of dikegulac sodium on azalea cultivars grown in the greenhouse and in the field. The number of lateral branches per shoot was increased by these treatments. The most effective rate was 0.50%. These results were consistent for both greenhouse- and field-grown plants. Also, Washington and Self noted that the growth of terminal buds was only temporarily inhibited by dikegulac sodium. This indicated that treated plants could potentially produce more flowering shoots than azaleas pinched by hand or with Off-Shoot-0, a compound which induces branching by destroying meristematic tissue in the terminal buds.

Self (34) found that the number of flower buds was increased on five azalea cultivars by foliar application of 0.2-0.4% dikegulac sodium solutions. Cuttings taken two weeks after treatment rooted equally well and the cuttings of most cultivars showed an increase in lateral branching due to dikegulac sodium treatment. Cuttings taken approximately three months later also rooted equally well; but they showed no differences in lateral branching, indicating that dikegulac sodium had only a temporary effect on these plants.

Schnall (33) studied the effects of dikegulac sodium on the propagation of three azalea cultivars. Cuttings of Rhododendron obtusum (Lindl.) Planch. 'Hinodegiri' were soaked in low concentrations of dikegulac sodium. No significant differences were observed

in the rooting or branching of these cuttings. However, when stock plants of R. obtusum 'Hinodegiri,' R. obtusum 'Coral Bells' and R. 'Red Ruffles' were sprayed with dikegulac sodium solutions prior to the harvest of cuttings, there were significant differences in the number of new shoots per cutting. The optimal rate was 0.50%. Also, treated stock plants developed significantly more shoots than untreated plants. Cuttings taken from treated stock plants rooted normally. This was also observed by Cohen (10) and Self (34). Shu and Sanderson (37) sprayed azalea cuttings with 0.50% dikegulac sodium three weeks after propagation. Again, no differences in rooting were observed between treated and untreated cuttings.

Sanderson and Martin (32) applied foliar sprays of dikegulac sodium (3,000-6,000 mg/liter) to four azalea cultivars one week after shearing. Lateral branching was increased due to these treatments, but it was noted that branching occurred at least two weeks later in treated plants as compared to sheared controls. The delay in lateral branching was also observed during similar studies conducted by other researchers (6, 8, 22, 27). For most cultivars, flower number was not increased by dikegulac sodium. However, due to their compact growth habit, treated plants did appear to have more flowers. Also, dikegulac sodium treatment reduced the number of undesirable by-pass shoots in all cultivars (32).

Thus, dikegulac sodium has been found to be an effective pinching agent for many azalea cultivars (6, 8, 10, 15, 22, 27, 32, 33, 34, 36, 38, 41). But, there are problems associated with its use on azaleas (and some other species). One of these is the delay in lateral branching of treated plants as compared with those that are

hand-pinched, as discussed above. If subsequent chemical pinching with dikegulac sodium is done earlier than would be normal for hand-pinching, this delay can be overcome. Also, most researchers reported that dikegulac sodium can cause discoloration of shoot tips shortly after application and chlorosis of new lateral branches. These effects are transient, however, and they are usually dissipated within a few weeks (1).

Dikegulac sodium has also been tested on many species of woody landscape plants. Self (34) found that one to two foliar applications of 0.2-0.6% dikegulac sodium stimulated lateral bud development in Ilex cornuta Lindl. & Paxt. 'Burfordii,' Ilex crenata Thunb. 'Compacta,' Cleyera japonica Thunb., Pittosporum tobira (Thunb.) Ait. 'Variegatum' and Photinia glabra (Thunb.) Maxim. Malstrom and McMeans (23) observed delayed budbreak and increased lateral shoot development on pecan trees treated with 0.25% and 0.50% dikegulac sodium. Dikegulac sodium applied at 1,000 and 3,000 mg/liter was not found to be effective in stimulating bud development of dwarf shoots of Pinus strobus L. (9). Johnson and Lumis (21) treated Euonymus fortunei (Turcz.) Hand.-Mazz. 'Colorata' with foliar sprays of 0.05-0.40% dikegulac sodium. All treatments reduced shoot elongation and increased lateral branching. The optimal rate was 0.10%. Similarly, Ormrod and Lumis (26) found that foliar application of 0.1% dikegulac sodium increased branch number and decreased branch length of Forsythia x intermedia Zab. However, the effectiveness of this compound was decreased by the addition of sodium chloride to the growing medium.

The effects of dikegulac sodium (0.02-0.80%) on the branching and rooting of cuttings of woody ornamentals was studied by Wu (44). Cuttings were either soaked in dikegulac sodium solutions or were removed from stock plants which had been sprayed with dikegulac sodium 24 hours earlier. The latter treatment was found to be more effective on most species tested, with the exception of Lagerstroemia indica L. The optimal rate of dikegulac sodium varied according to species. Cuttings of Forsythia x intermedia showed maximum branching at 0.40%. The optimal rate for Juniperus conferta Parl. and Hedera helix L. was 0.02%. Lagerstroemia indica cuttings produced more branches when treated with 0.20% dikegulac sodium. This compound did not promote branching in cuttings of Ilex x attenuata Ashe 'Fosteri.' Wu also noted that, in some cases, dikegulac sodium was detrimental to rooting. Indolebutyric acid (IBA) treatment improved root development in all of the above species.

Dikegulac sodium also has practical applications as a growth retardant for many woody landscape species. Sachs et al. (31) found that the growth of several species of landscape shrubs and trees could be effectively inhibited for more than three months by foliar applications of 0.1-1.0% dikegulac sodium. Severe phytotoxicity was noted in the shoot tips of two species; however, treatment immediately after pruning eliminated this problem in Nerium oleander L.

Washington and Self (43) found that high rates of dikegulac sodium substantially reduced the growth of container-grown Photinia x fraseri Dress., Pyracantha coccinea M. J. Roem. and Trachelospermum jasminoides (Lindl.) Lem. Studies conducted on other container-grown woody ornamental species showed similar results (7, 38).

Hield et al. (19) found that foliar applications of dikegulac sodium inhibited the growth of several tree species. Trunk bark banding with dikegulac sodium reduced growth in Ulmus parvifolia Jacq., but this method of application was not effective for other species tested.

Ufferman et al. (40) injected dikegulac sodium (0.008-1.0 g/liter) into topped one- to two-year-old seedlings of Acer saccharinum L. and Platanus occidentalis L. These experiments were conducted under greenhouse conditions and the results showed that dikegulac sodium applied at the appropriate concentration for each species controlled regrowth without causing unacceptable phytotoxicity.

Roberts et al. (30) injected dikegulac sodium (3-375 g/liter) into five species of shade trees growing at different geographical locations. Trees were topped before injection and the results showed that regrowth can be significantly reduced, without unacceptable phytotoxicity, by use of the appropriate concentration for a particular species. Some differences in response were noted due to geographical location.

Dikegulac sodium has also been tested on other species commonly grown as ornamental pot plants. Washington and Self (42) treated Pachystachys lutea Nees. with 0.08-0.24% dikegulac sodium. At all rates, treated plants were found to have reduced height and more lateral shoots as compared with controls. The optimal rate was 0.16% dikegulac sodium. Menhenett (24) found that foliar sprays of dikegulac sodium (100, 200 and 500 mg/liter) effectively reduced stem growth in chrysanthemum; however, these treatments caused severe phytotoxicity.

Bocion et al. (5) investigated the effects of dikegulac sodium on six ornamental pot plants. Flower development was stimulated in Gerbera jamesonii and Cyclamen persicum Mill. by treatment with dikegulac sodium. Also, this compound was found to be an effective growth retardant and pinching agent for Pachystachys lutea, Kalanchoe blossfeldiana Poelln., Begonia Elatior Hybrids and Fuchsia x hybrida Hort. ex Vilm. at the appropriate concentration for each species.

Ellabban et al. (16) studied the effects of dikegulac sodium and other compounds on Ficus elastica Roxb. ex Hornem. 'Decora.' Dikegulac sodium was applied first as a 20,000 mg/liter foliar spray and later, after approximately 5 and 6-1/2 weeks, in a small piece of cotton on each axillary bud. This compound was found to promote lateral shoot development and to reduce internode length resulting in more compact plants; however, terminal shoots were killed.

Hodge and Morgan (20) tested the effectiveness of dikegulac sodium and other compounds in promoting the development of axillary buds in Ficus elastica robusta prior to the harvest of leaf-bud cuttings. Dikegulac sodium (2%) was found to produce a more uniform batch of plants than other treatments; however, regeneration of the treated stock plants was inhibited.

Research on the effects of dikegulac sodium on ornamental monocotyledons has not been extensive. Bocion et al. (3) and Bocion and deSilva (4) reported that dikegulac sodium retarded growth and increased tillering in the turfgrasses Poa pratensis and Lolium perenne. Parups and Cordukes (28) tested the effectiveness of dikegulac sodium as a growth retardant on the turfgrasses Poa pratensis, Lolium perenne and Festuca rubra L. Growth was retarded

in all three species under greenhouse conditions. However, in subsequent field studies on Poa pratensis, dikegulac sodium was not significantly effective as a growth retardant at the concentrations tested. Hanks and Menhenett (18) found that dikegulac sodium applied as a soil drench reduced stem and petal length in some tulip cultivars; however, it was concluded that other compounds were more effective in producing compact, pot-grown tulips. Washington and Self (42) reported that dikegulac sodium increased lateral branching and reduced stem length in Zebrina Schnizl. The optimal rate was 0.24% dikegulac sodium, but leaf size was slightly reduced on plants receiving this treatment.

There have been no reports on the effects of dikegulac sodium on Dracaena fragrans 'Massangeana.' However, attempts to induce lateral budbreak and/or improve rooting in this cultivar and related species have been made using other plant growth regulators.

Poole et al. (29) soaked either the terminal or basal ends of leafless cane sections of Dracaena fragrans 'Massangeana' in water, solutions of IBA or solutions of the sodium salt of benzyladenine (SD 4901) for 24 hours prior to placement in the propagating medium. The chemical treatments did not affect cutting survival or the position or number of budbreaks at the concentrations tested. However, survival was improved among those cuttings receiving the basal soak. A subsequent experiment revealed definite benefits to canes which had a small slice of the basal waxed end removed and which were soaked 18 hours in water or IBA solutions prior to placement in the propagating medium. Survival was increased and budbreak occurred earlier, resulting in increased shoot length at the end of the

experiment. Soaking in IBA solutions (50 and 75 mg/liter) did not promote a significantly larger number of buds, but an increase was noted in the length of the longest shoots as compared to water-soaked cuttings.

Oka (25) found that rooting was improved on tip cuttings of several species and cultivars of Dracaena by treatment with the appropriate concentrations of IBA and/or NAA (naphthaleneacetic acid). In Dracaena fragrans, the best rooting response was obtained when cuttings were treated with 5,000 mg/liter NAA or a combination of 2,500 mg/liter IBA + 2,500 mg/liter NAA.

Criley and Stevens (14) studied the effects of N⁶BA (N-6-benzyladenine), PBA (6-(benzylamino)-9-(2-tetrahydropyranyl)-9-H-purine) and chlorflurenol on bud initiation and development in Cordyline terminalis (L.) Kunth 'Onomea.' Both N⁶BA and PBA were found to stimulate bud initiation and development. The most effective treatment tested was 500 mg/liter PBA, although shoot growth was slightly stunted. Chlorflurenol stimulated bud initiation, but few of these buds subsequently developed into shoots.

Yee (45) treated Dracaena warneckeii compacta (D. deremensis Engl. 'Warneckii') with 1,000 mg/liter ethephon and 100 mg/liter PBA. There was little difference in the number of lateral shoots produced by the end of the experiment; however, it was noted that ethephon-treated plants produced larger lateral shoots than plants treated with PBA. Shoot size was smallest in the control plants.

Stevens and Criley (39) tested the effectiveness of various plant growth regulators on the promotion of root and lateral shoot development in stem cuttings of Dracaena marginata Lam. IBA at

concentrations up to 3,000 mg/liter stimulated root development. PBA (1,000 mg/liter) applied to the cuttings had no effect on rooting; however, rooting was inhibited when this compound was applied to stock plants prior to the harvest of cuttings. The highest level of root development was obtained when the top portion of cuttings was treated with 1,000 mg/liter PBA and the bottom portion was treated with 3,000 mg/liter IBA. When tests were made on the effects of PBA, N⁶BA and ethephon on lateral shoot development in rooted cuttings, no significant differences were found in the number of shoots initiated from these treatments. However, the number of lateral shoots developing on plants treated with N⁶BA and PBA increased with concentration up to 500 mg/liter. Ethephon was judged to be most effective at a rate of 1,000 mg/liter. Shoot length was not significantly affected by these treatments.

Criley (13) studied the effectiveness of several plant growth regulators in stimulating lateral shoot development in stock plants of Dracaena marginata and Dracaena marginata 'Tricolor.' The cytokinins PBA (100 and 250 mg/liter) and BA (250 mg/liter) were found to promote development of the largest number of shoots greater than 10 cm in length (an appropriate cutting size) on stock plants of Dracaena marginata 'Tricolor.' Cytokinin treatment slightly inhibited rooting, but this was overcome by treatment with 1,500 mg/liter IBA. Fertilized plants of Dracaena marginata had a significantly higher cutting yield as compared with plants which were not fertilized. The effects of the growth regulator and fertilizer treatments dissipated with time.

CHAPTER III

MATERIALS AND METHODS

The objective of this experiment was to determine the effects of dikegulac sodium (AtrinalTM) on cane cuttings of Dracaena fragrans 'Massangeana' ('Massangeana'). The experiment was initiated August 21-23, 1980. Leafless canes of 'Massangeana,' obtained from stock plantings in Costa Rica, were cut into sections 20 cm long. A total of 360 cane cuttings, taken in groups of five, were completely submerged for 1, 6 or 12 hours in five concentrations of dikegulac sodium: 0.05%, 0.10%, 0.20%, 0.40% or 0.80% active ingredient (equivalent to 2.5, 5, 10, 20 or 40 ml of commercial product/liter of water).¹ The control (0.00% concentration) contained 10 ml/liter of ACR 4031, the special AtrinalTM wetting agent. After soaking, the cuttings were air-dried, both ends were dusted with Captan 50% W.P. and the apical ends were capped with grafting wax.

Cuttings were placed in two 1.2 m x 3.1 m greenhouse benches filled with moist, sterilized river sand. Benches were covered with 57% shade cloth draped over supports approximately 120 cm overhead. Intermittent mist was not used; instead, the river sand medium was watered as necessary throughout the experiment.

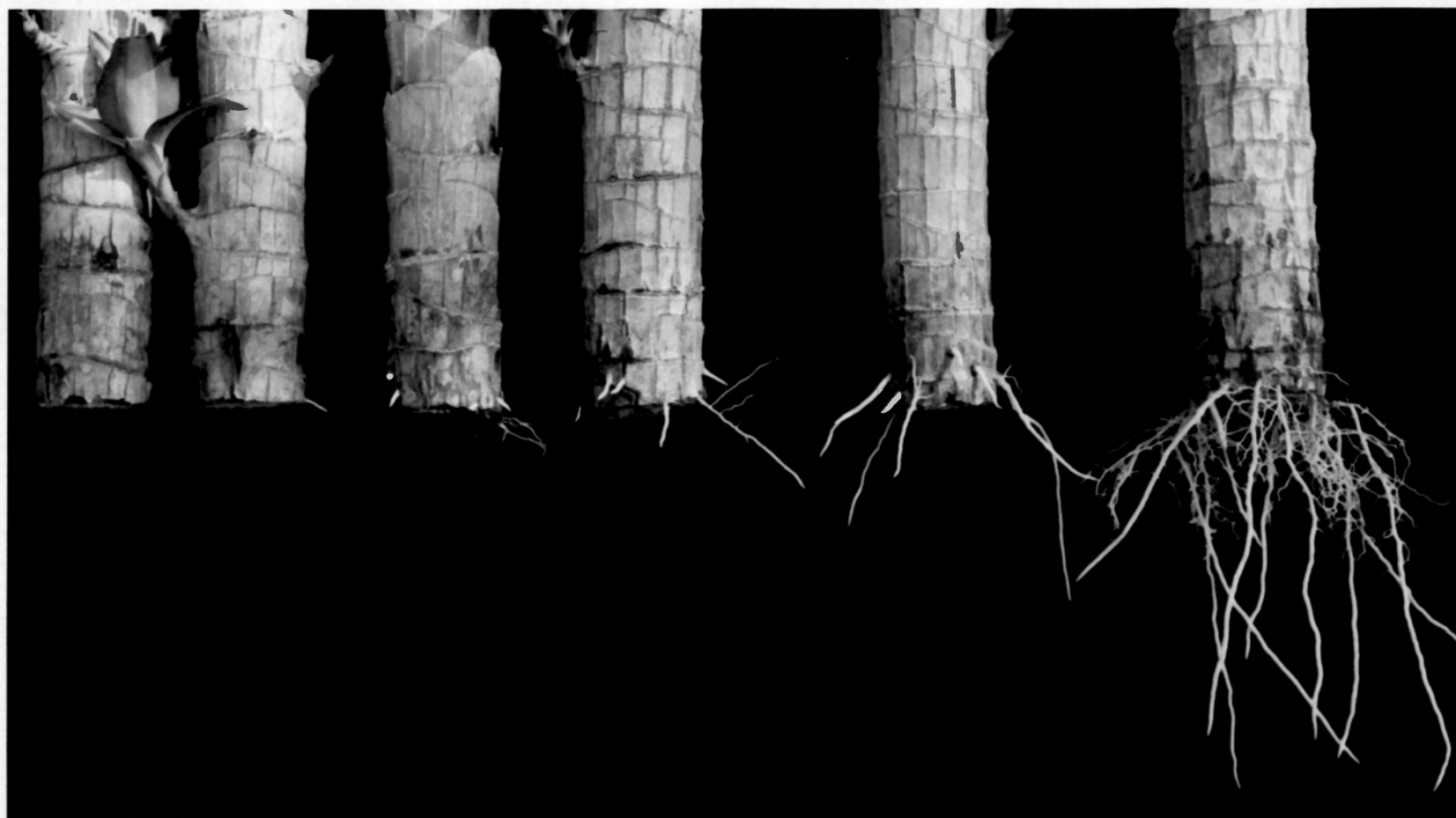
The experimental design was a randomized complete block with subsampling. Each treatment, consisting of five cuttings, was

¹AtrinalTM was supplied, in part, by H.L.R. Sciences, Inc., Vero Beach, Florida.

replicated four times. Treatments were completely randomized within each replication.

Beginning at Week 4 and continuing until the termination of the experiment at Week 16 (December 11-13, 1980), weekly budbreak counts were recorded for each cutting. At the termination of the experiment, the following data were recorded for each cane cutting:

1. Cutting survival--determined by visual inspection.
2. Visual root quality rating (Figure 1).
3. Number of budbreaks.
4. Length of shoots (cm), from base to leaf tips.
5. Bud abnormality--whether the bud was normal or distorted in appearance (Figures 2-5).
6. Budbreak location--whether the breaking bud was in the top or bottom half of the cane cutting.



0

1

2

3

4

5

Figure 1. Root quality rating system for *Dracaena fragrans* 'Massangeana' cane cuttings.

Figure 2. Example of bud abnormality in Dracaena fragrans 'Massangeana' promoted by dikegulac sodium treatment.

Figure 3. Another example of bud abnormality promoted by dikegulac sodium treatment.

Figure 4. Example of normal shoot development.

Figure 5. Example of a normal shoot.



Figure 2



Figure 3



Figure 4



Figure 5

CHAPTER IV

RESULTS

Analysis of variance showed that treatment of Dracaena fragrans 'Massangeana' cane cuttings with dikegulac sodium (AtrinalTM) produced significant effects (at the 5% level of probability) in all six variables measured at the termination of the experiment.

Cutting Survival

At the end of the experiment, 306 out of the original 360 cuttings remained alive (85% survival). This compares favorably with the normal range of 50%-90% survival for cane cuttings of this cultivar, as reported by Poole et al. (29).

Analysis of variance showed that dikegulac sodium concentration affected the percent survival of 'Massangeana' cane cuttings. Regression analysis indicated that a quadratic equation appropriately described the relationship between dikegulac sodium concentration and percent survival (Figure 6). The regression curve shows that survival was greater than 90% for cane cuttings treated with less than 0.20% dikegulac sodium and declined steadily at increasingly higher concentrations, ending in 55% survival of 'Massangeana' cane cuttings soaked in 0.80% dikegulac sodium.

There were no significant effects due to soaking time. There was a significant interaction between dikegulac sodium concentration and soaking time (Figure 7); however, there was no consistent trend in direction or magnitude.

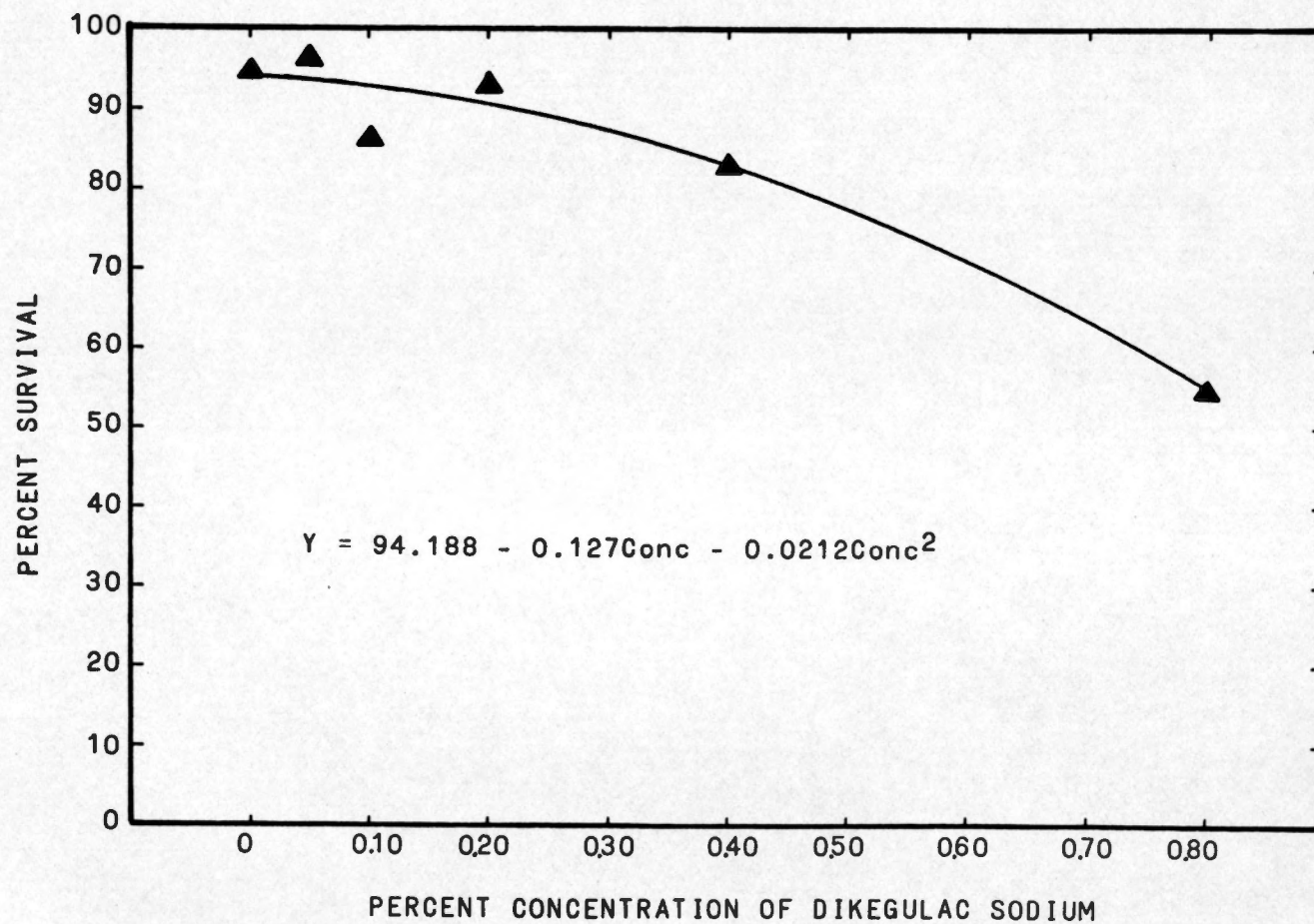


Figure 6. The effect of dikegulac sodium on percent survival of Dracaena fragrans 'Massangeana' cane cuttings 16 weeks after treatment.

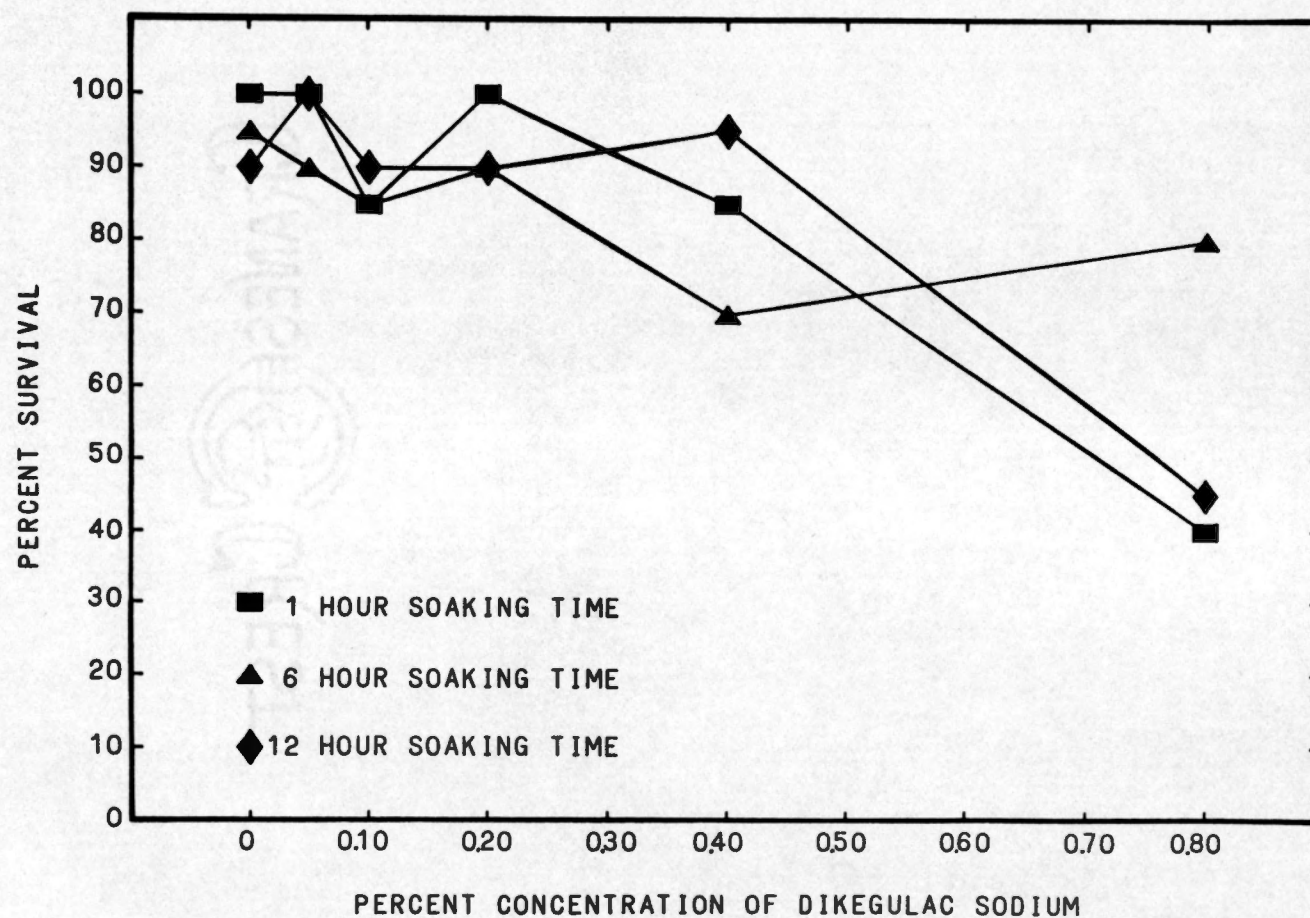


Figure 7. Interaction between concentration of dikegulac sodium and soaking time on the percent survival of *Dracaena fragrans* 'Massangeana' cane cuttings 16 weeks after treatment.

Root Quality Rating

Of the surviving cuttings, 36.6% had developed roots by the termination of the experiment. Analysis of variance showed that dikegulac sodium concentration affected the visual root quality rating. Regression analysis indicated that an asymptotic curve best described the relationship between dikegulac sodium concentration and root quality of 'Massangeana' cane cuttings (Figure 8).

The highest mean root quality rating (2.23 out of a possible 5) occurred in the control cuttings. Root quality declined sharply as dikegulac sodium concentration was increased up to 0.20%. However, there was little further decrease in root quality at concentrations above 0.20%. Root quality was affected by soaking time, decreasing slightly as soaking time increased (Figure 9). Also, there was an interaction between dikegulac sodium concentration and soaking time on root quality (Figure 10). It appeared that the 0.00% soak for 12 hours and the 0.10% soak for 1 hour may have depressed root quality, but no consistent trend occurred.

Number of Budbreaks

Analysis of variance showed an effect on number of budbreaks due to dikegulac sodium concentration. Regression analysis indicated that a cubic polynomial most appropriately described the relationship between budbreak number and concentration (Figure 11).

Dikegulac sodium stimulated budbreak in 'Massangeana' cane cuttings with increasing concentration up to 0.20% (4.9 budbreaks/cane), compared to the control (3.3 budbreaks/cane). At concentrations above 0.20%, the number of budbreaks was decreased to 1.9/cane

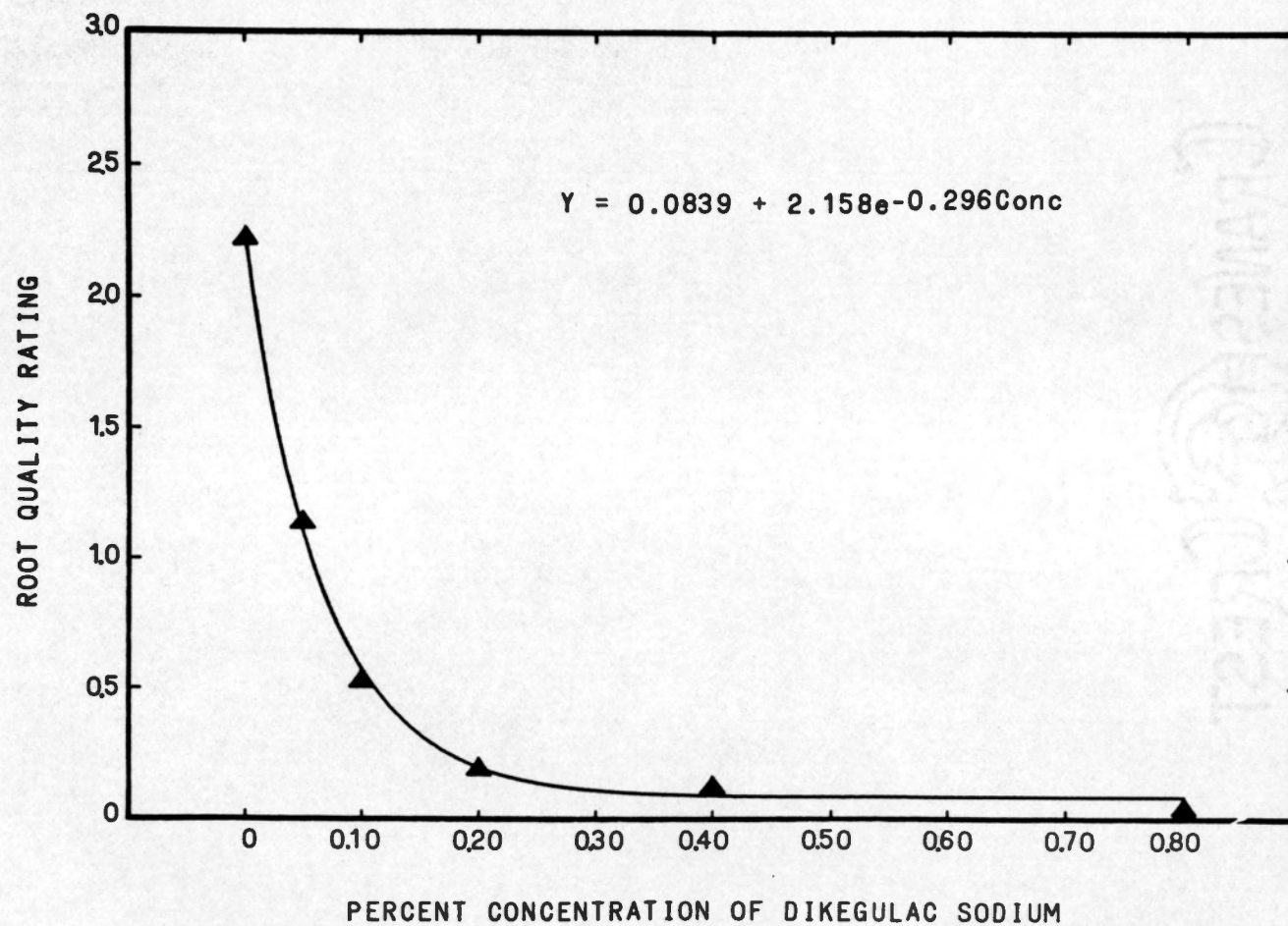


Figure 8. The effect of dikegulac sodium on the root quality rating of Dracaena fragrans 'Massangeana' cane cuttings 16 weeks after treatment.

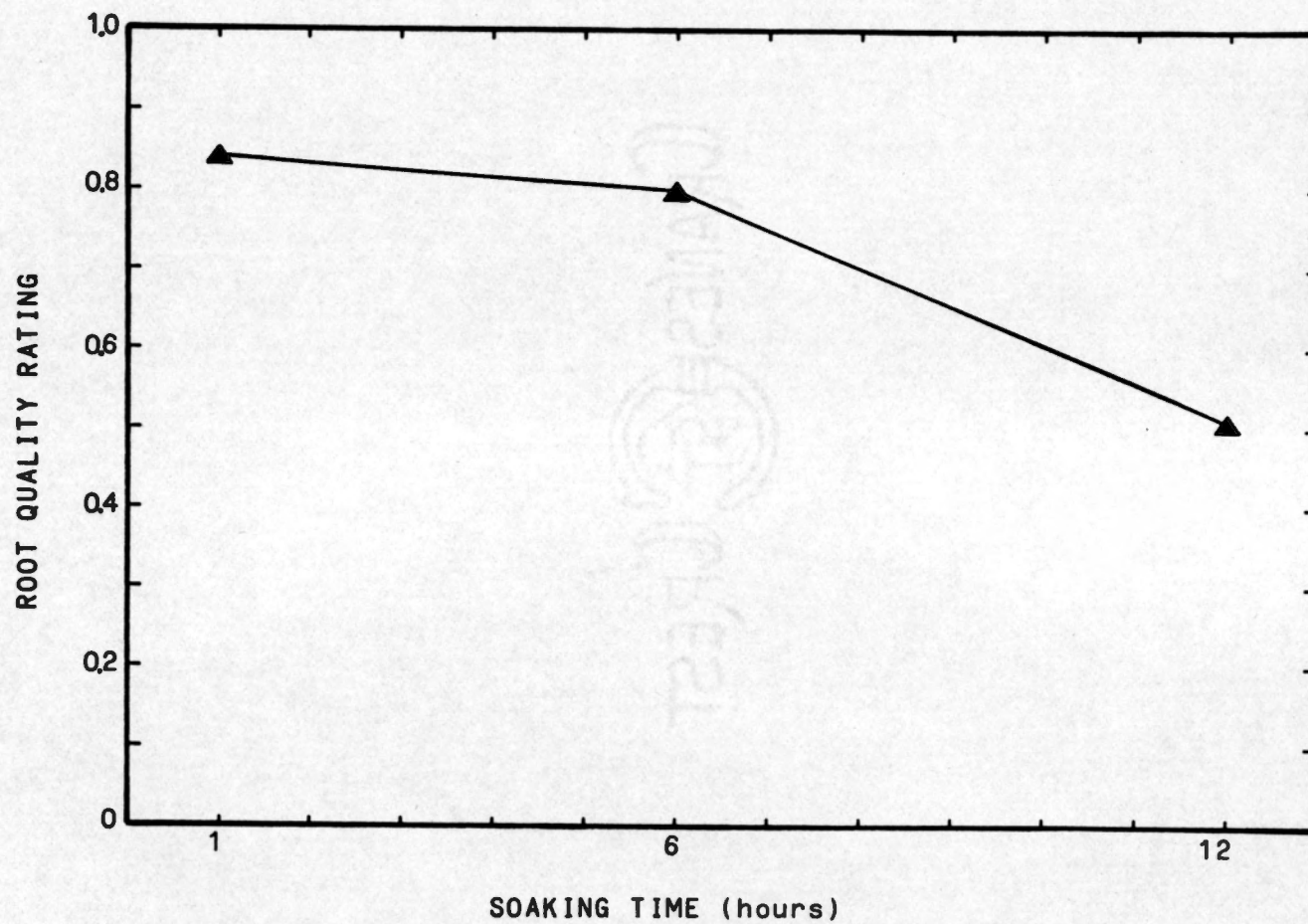


Figure 9. The effect of soaking time on the root quality rating of Dracaena fragrans 'Massangeana' cane cuttings 16 weeks after treatment.

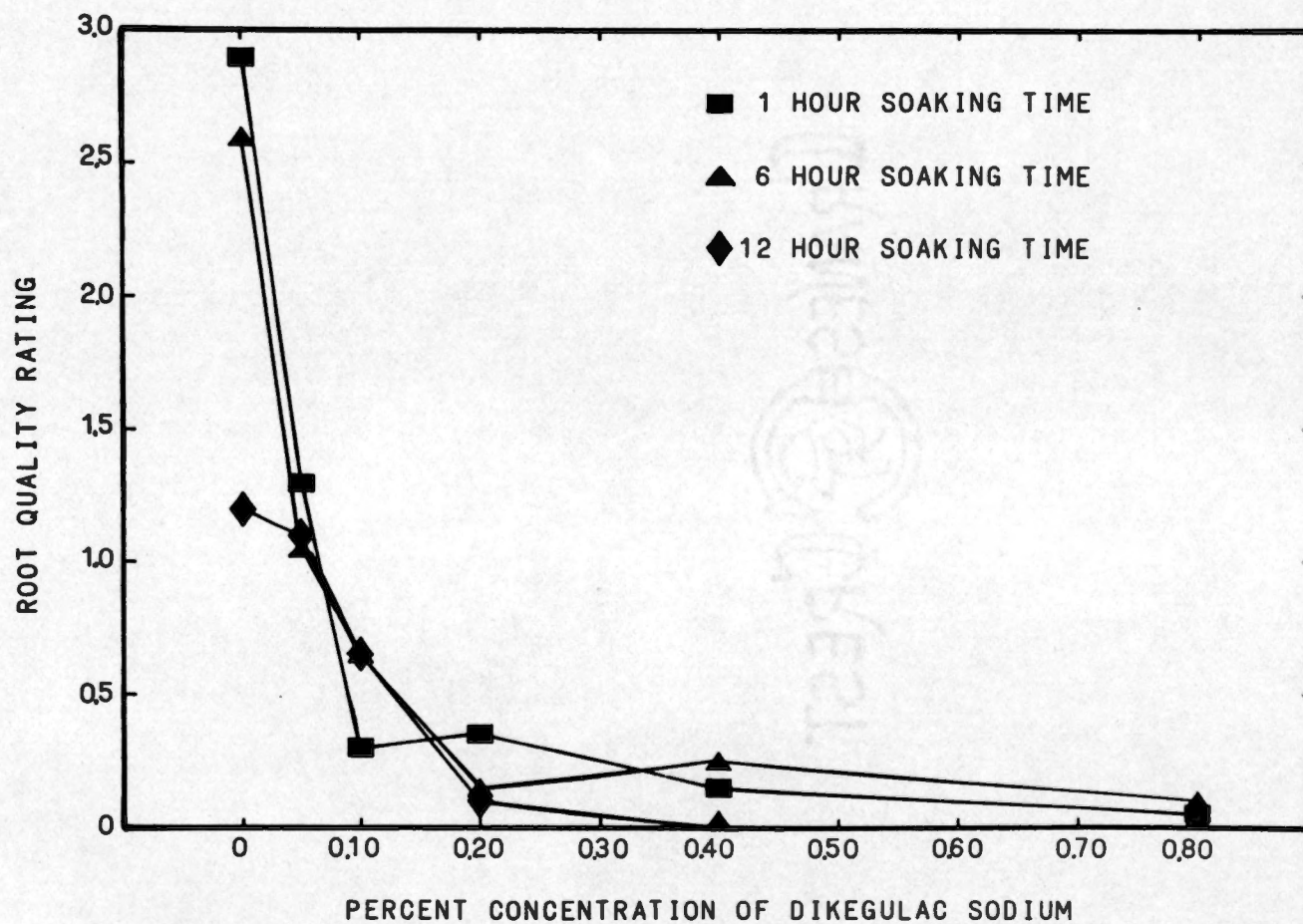


Figure 10. Interaction between dikegulac sodium concentration and soaking time on the root quality rating of *Dracaena fragrans* 'Massangeana' cane cuttings 16 weeks after treatment.

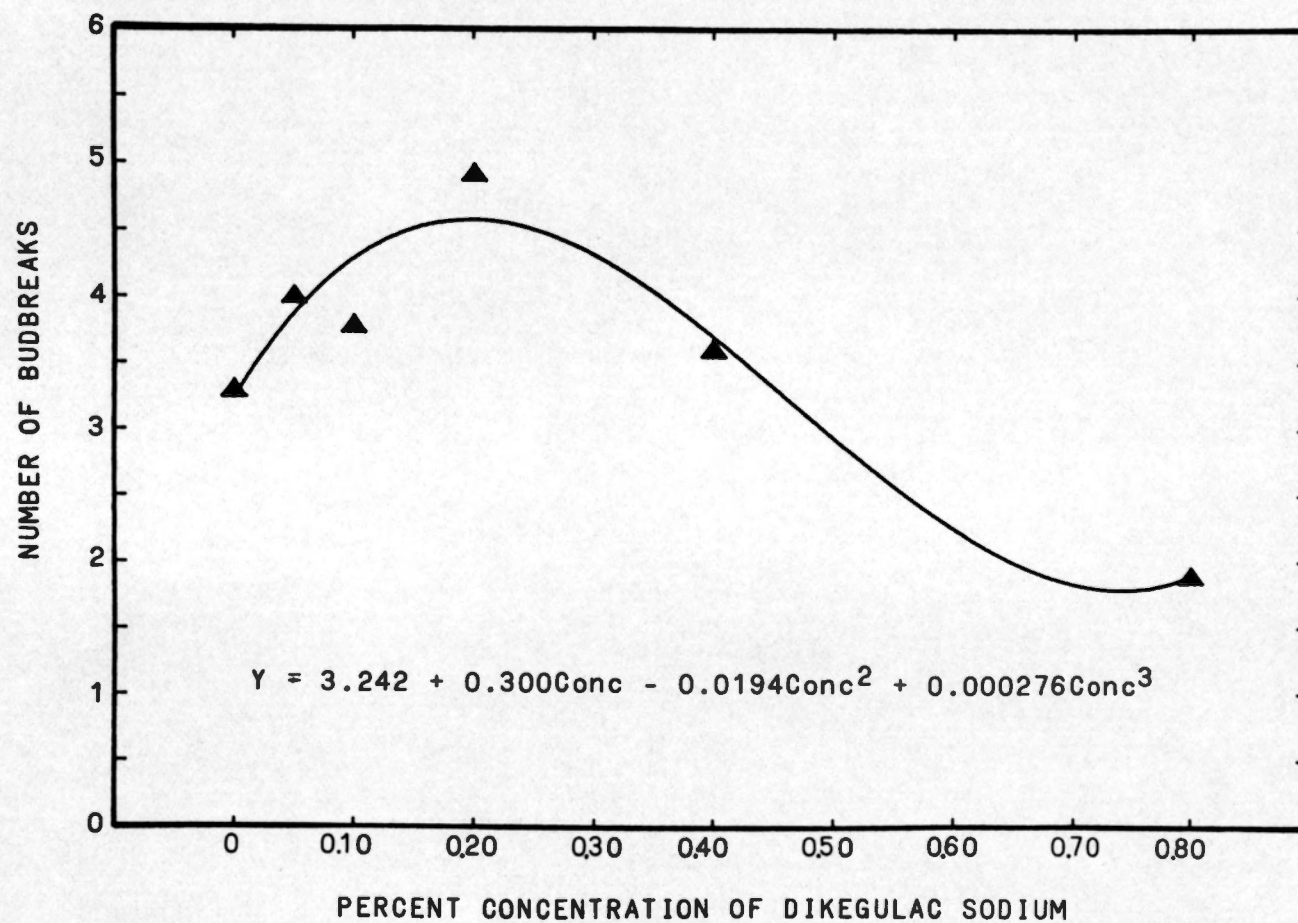


Figure 11. The effect of dikegulac sodium on the number of budbreaks per cane of Dracaena fragrans 'Massangeana' cane cuttings 16 weeks after treatment.

for cuttings soaked in 0.80% dikegulac sodium solutions. There was no effect on number of budbreaks due to soaking time and no interaction between concentration and soaking time. The number of budbreaks per individual cane cutting ranged from zero to eight by the end of the experiment.

Shoot Length

Analysis of variance showed that dikegulac sodium concentration affected shoot length in 'Massangeana' cane cuttings. Regression analysis indicated that an asymptotic curve best described the relationship between concentration and shoot length (Figure 12).

Shoot length declined sharply from a mean of 11.04 cm in control cuttings to 1.26 cm in cuttings treated with 0.20% dikegulac sodium. At concentrations above 0.20%, there was relatively little further depression of shoot length. Cuttings treated with 0.80% dikegulac sodium had a mean shoot length of 0.56 cm. Shoot length decreased as soaking time increased (Figure 13). There was no interaction between concentration and soaking time on shoot length.

Bud Abnormality

Many of the buds on 'Massangeana' cane cuttings in this experiment were distinctly abnormal in appearance (Figures 2 and 3, page 18). Several of these buds developed multiple meristems. Subsequent elongation of distorted buds was minimal as compared with normal buds, which developed into shoots (Figures 4 and 5, page 18).

Analysis of variance showed that dikegulac sodium concentration affected bud abnormality. A specific mathematical function describing this relationship was not apparent, but the functional

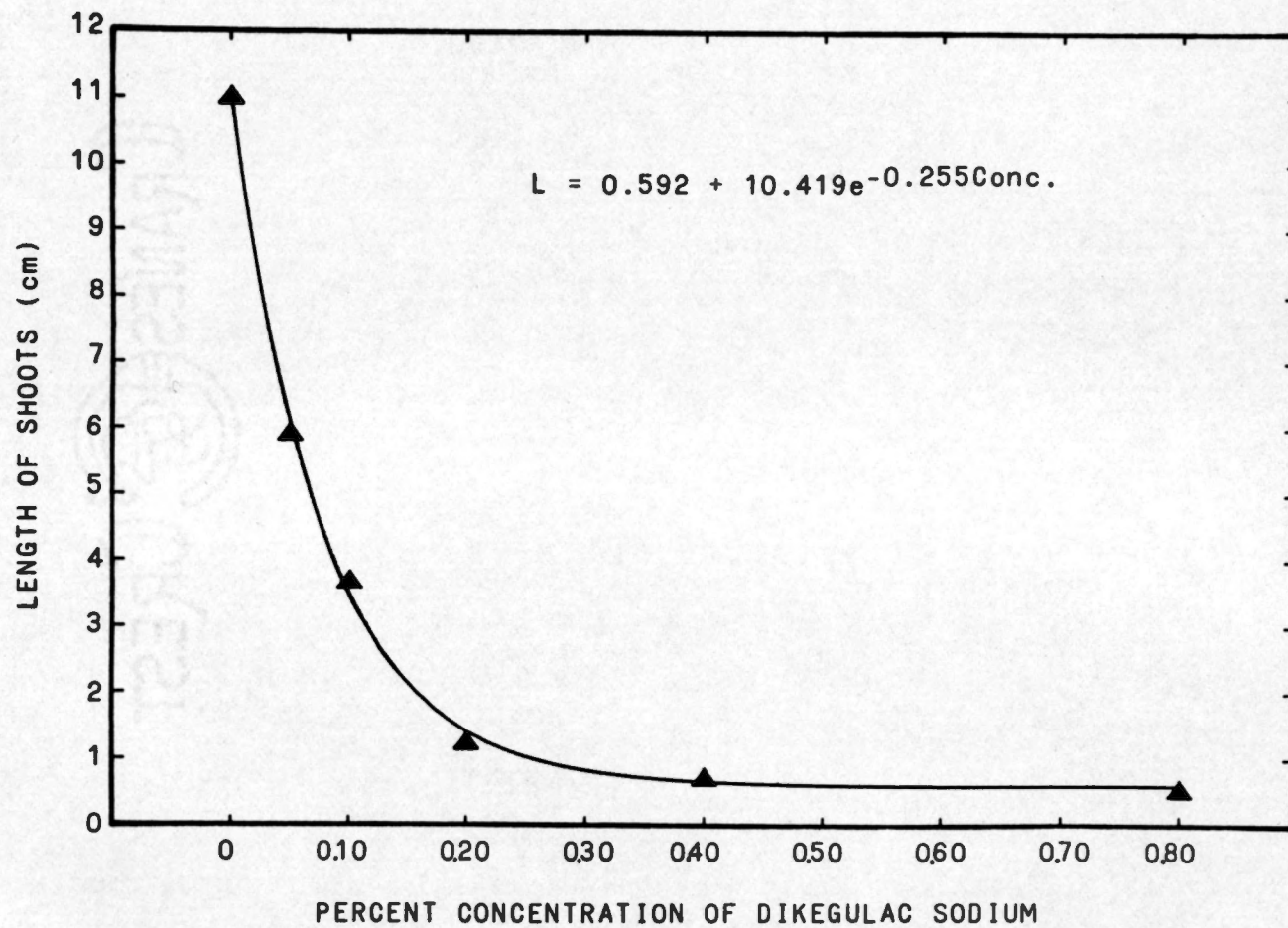


Figure 12. The effect of dikegulac sodium on shoot length of Dracaena fragrans 'Massangeana' cane cuttings 16 weeks after treatment.

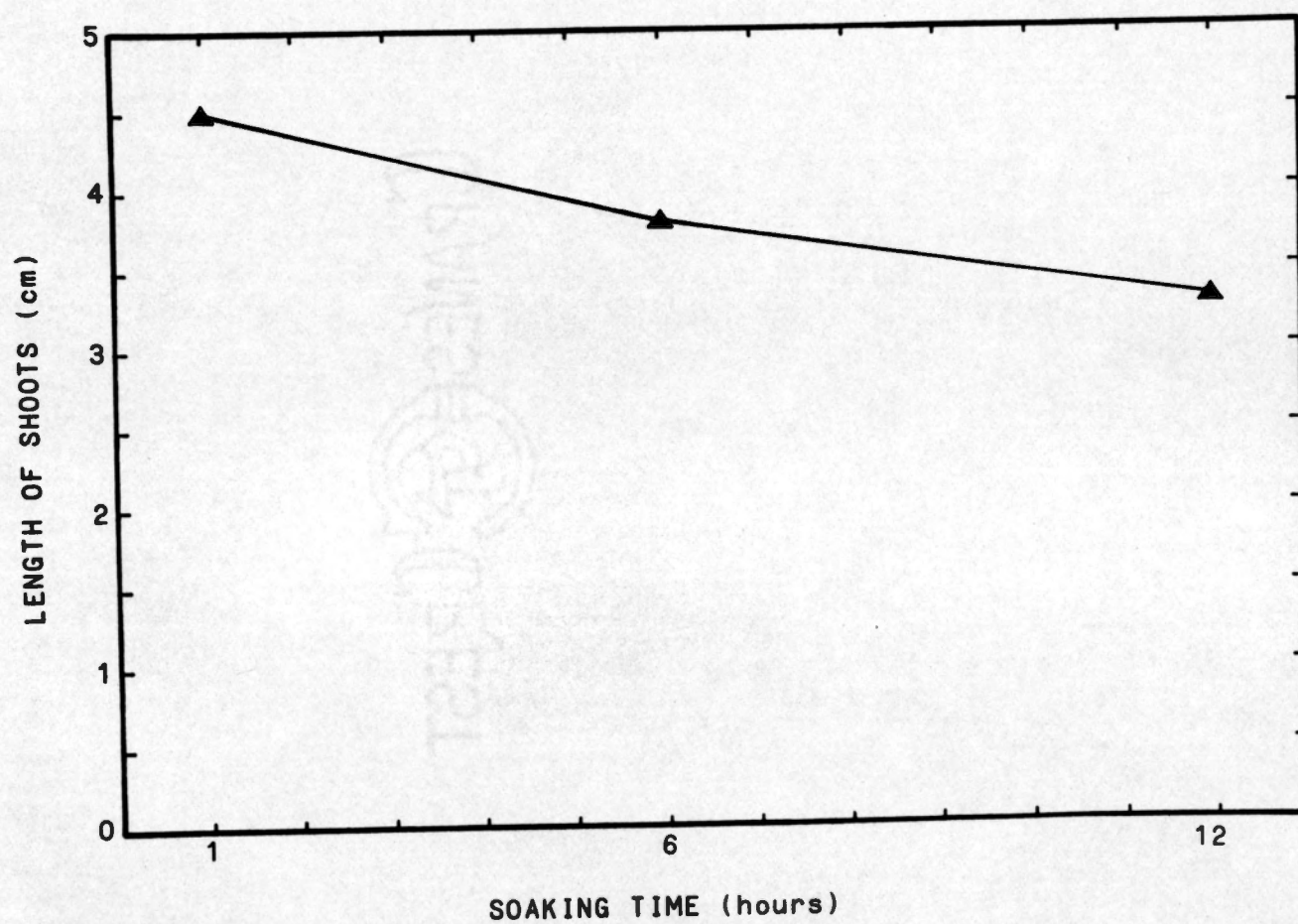


Figure 13. The effect of soaking time on shoot length of Dracaena fragrans 'Massangeana' cane cuttings 16 weeks after treatment.

relationship can be seen from the line graph presented in Figure 14.

The mean percentage of normal buds was high for the control cuttings (>99%), but declined sharply with increasing concentration of dikegulac sodium up to 0.20% (52.5% normal buds). Little change was observed in the low percentage of normal buds at concentrations greater than 0.20%. There was no effect due to soaking time and no interaction between dikegulac sodium concentration and soaking time on bud abnormality.

Location of Budbreak

Normal budbreak in 'Massangeana' cane cuttings occurs only at the upper 3-4 nodes (29). One of the objectives of this experiment was to determine if budbreak could be induced along the entire length of the cane by treatment with dikegulac sodium.

Analysis of variance showed that increasing dikegulac concentration affected the location of budbreak. Regression analysis indicated that a quadratic equation appropriately described the relationship between dikegulac sodium concentration and budbreak location (Figure 15).

The maximum mean percentage of budbreaks in the upper half of canes occurred in the control cuttings (>98%). This percentage declined gradually with increasing dikegulac sodium concentration. Canes treated with 0.80% dikegulac sodium had only 67% of the budbreaks in the upper half of the cane. There was no effect due to soaking time and no interaction between dikegulac sodium concentration and soaking time on budbreak location.

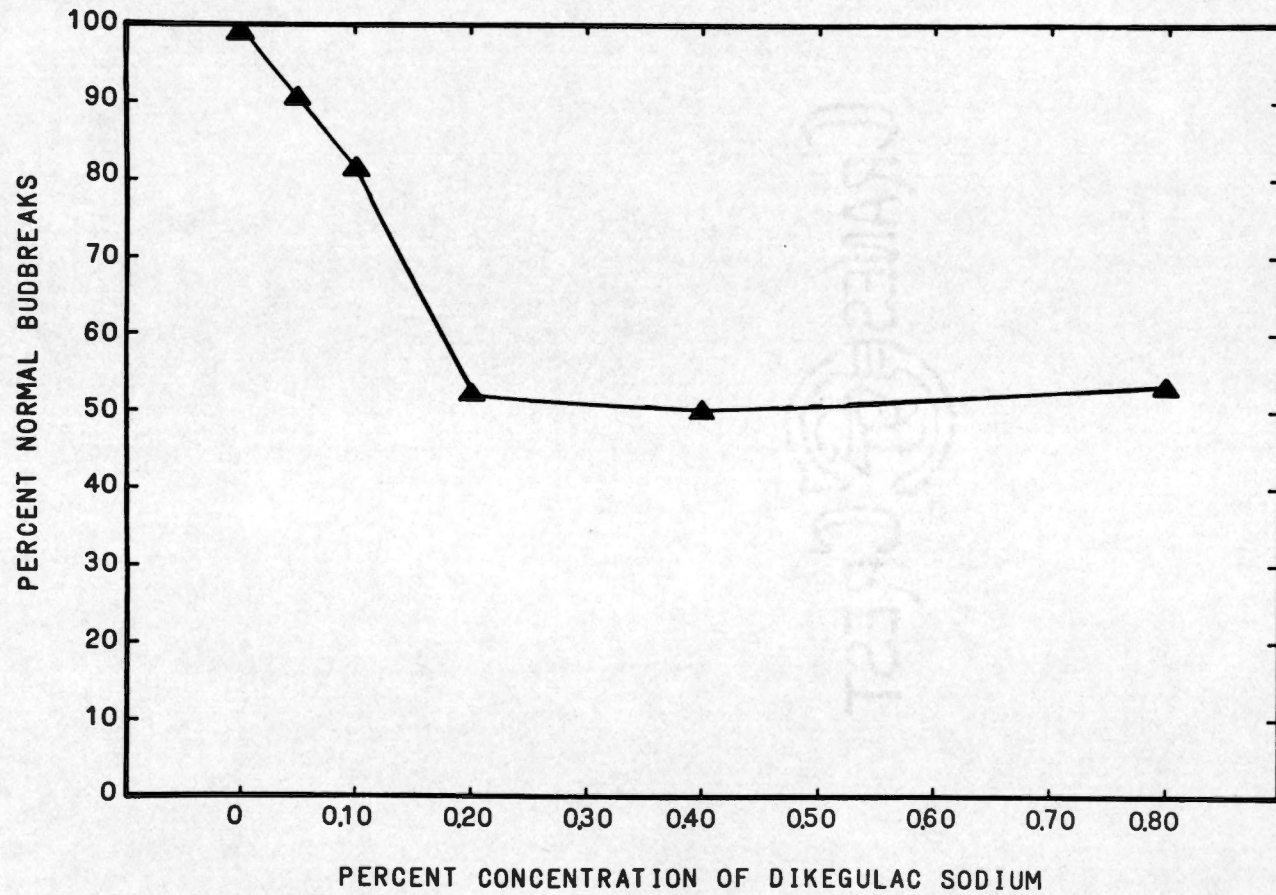


Figure 14. The effect of dikegulac sodium on bud abnormality in *Dracaena fragrans* 'Massangeana' cane cuttings 16 weeks after treatment.

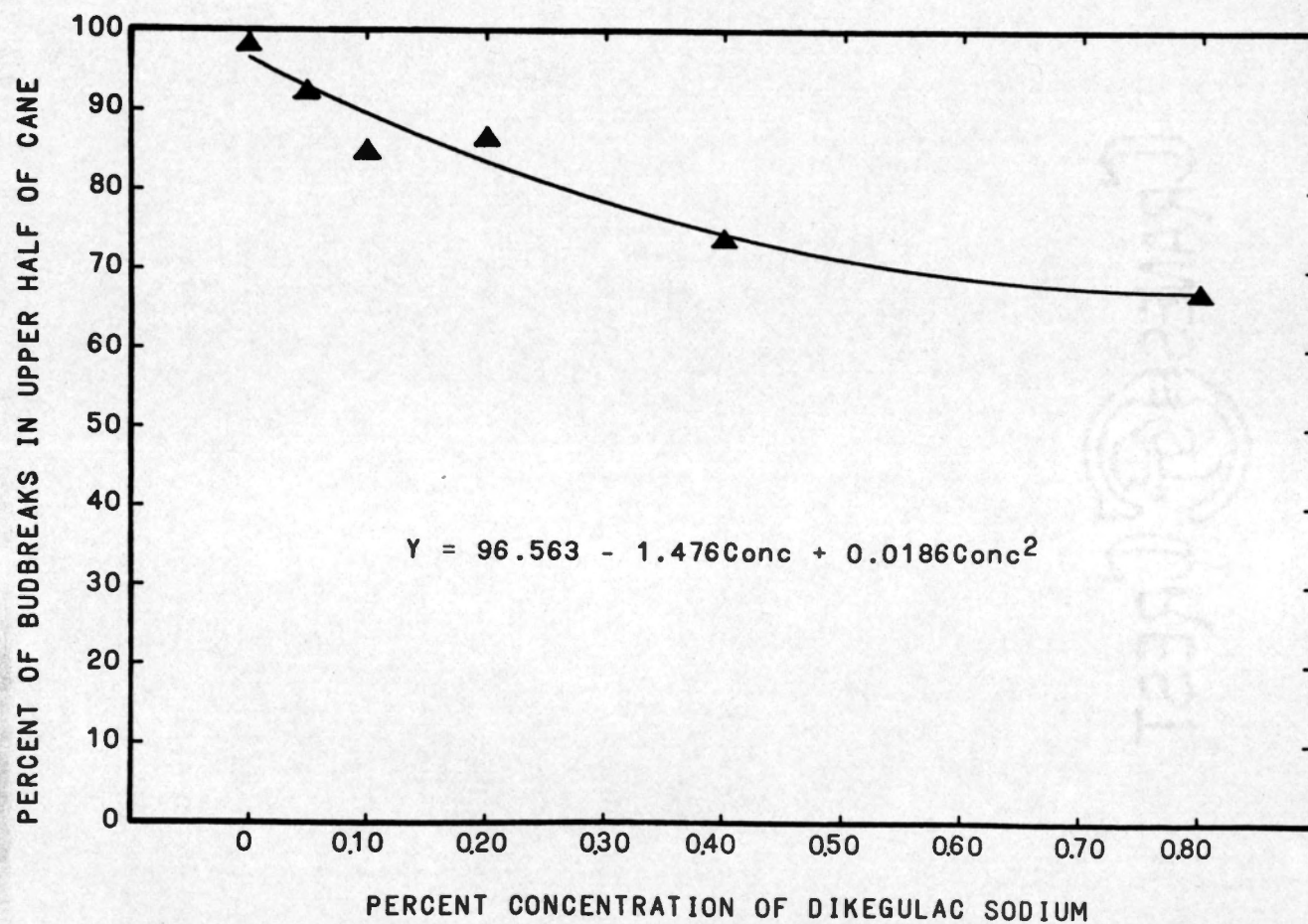


Figure 15. The effect of dikegulac sodium on budbreak location of Dracaena fragrans 'Massangeana' cane cuttings 16 weeks after treatment.

Weekly Budbreak Counts

There were differences in the weekly mean number of budbreaks per cane on 'Massangeana' cane cuttings due to dikegulac sodium concentration and soaking time (Figures 16-18). Generally, as dikegulac sodium concentration increased, budbreak was delayed. Budbreak was slowest in 'Massangeana' cane cuttings soaked in 0.40% and 0.80% dikegulac sodium solutions, regardless of soaking time. This delay was especially long for cuttings soaked for 1 or 12 hours in 0.80% dikegulac sodium. Control cuttings had relatively rapid budbreak, with few new budbreaks after 6 weeks, except for those soaked in water for 6 hours. For all soaking times, the greatest number of budbreaks per cane after 9 weeks was found on those canes soaked in 0.20% dikegulac sodium.

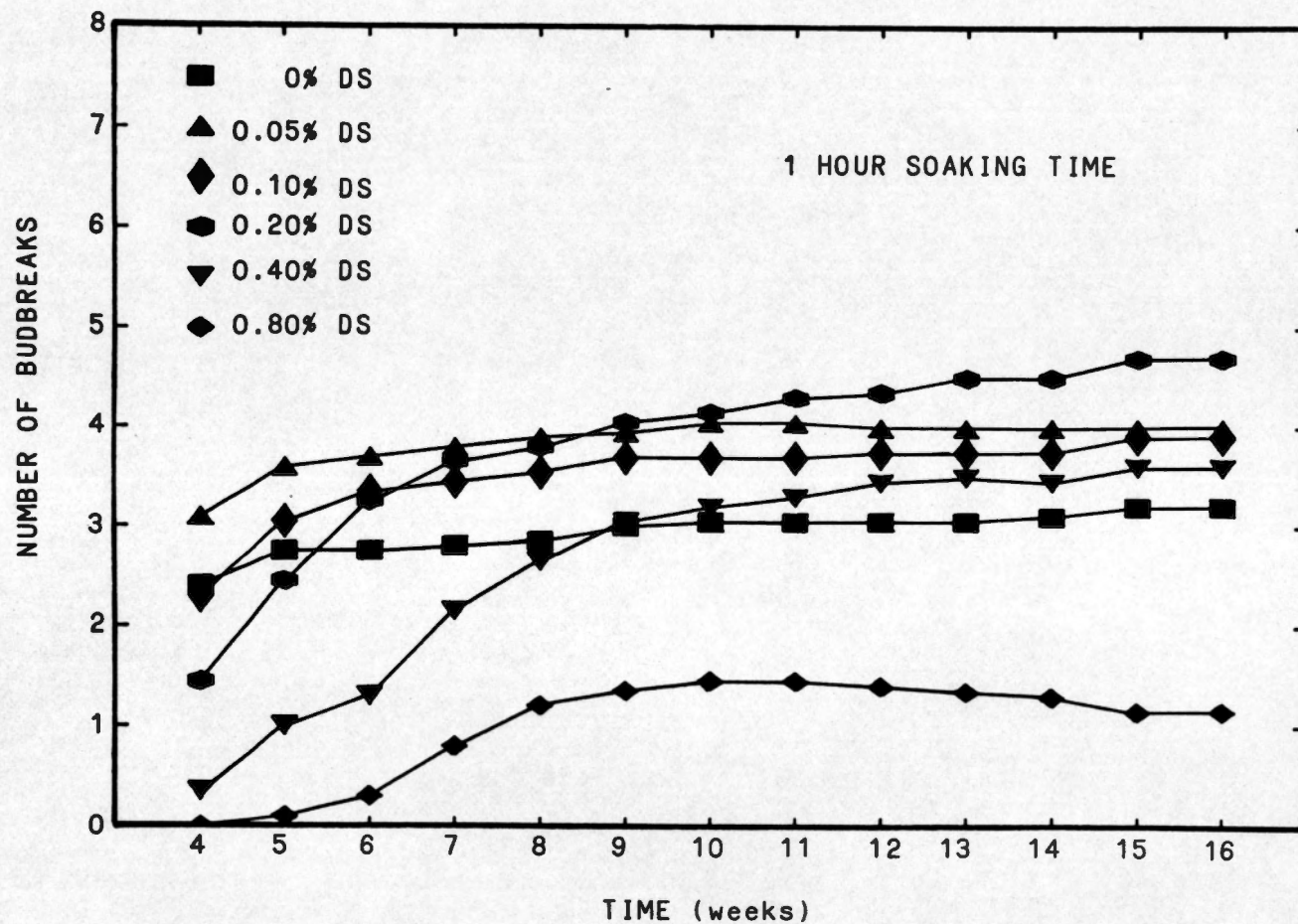


Figure 16. The mean number of budbreaks per cane (recorded weekly) on *Dracaena fragrans* 'Massangeana' cane cuttings soaked in dikegulac sodium (DS) solutions for 1 hour before placement in the propagation medium.

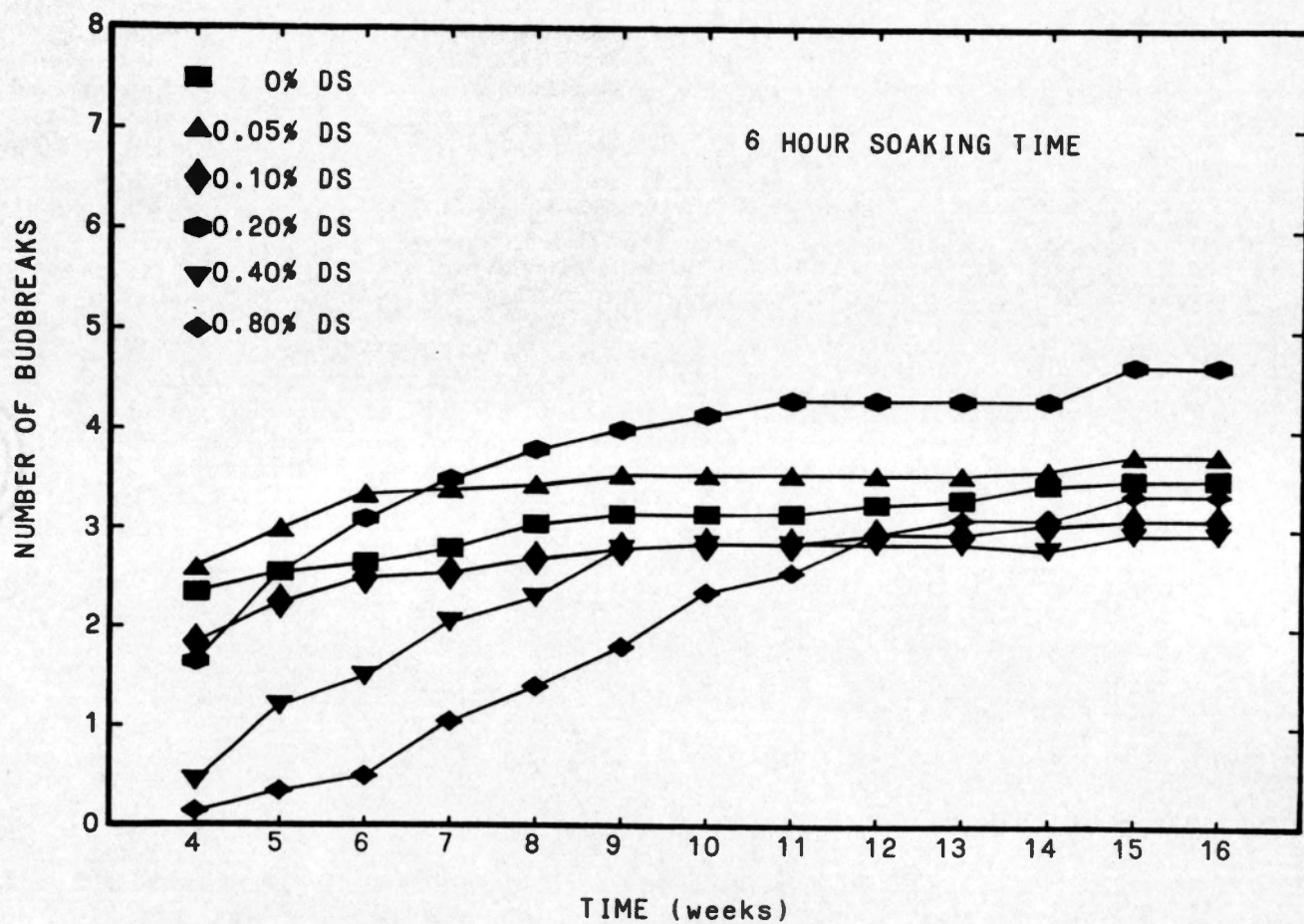


Figure 17. The mean number of budbreaks per cane (recorded weekly) on *Dracaena fragrans* 'Massangeana' cane cuttings soaked in dikegulac sodium (DS) solutions for 6 hours before placement in the propagation medium.

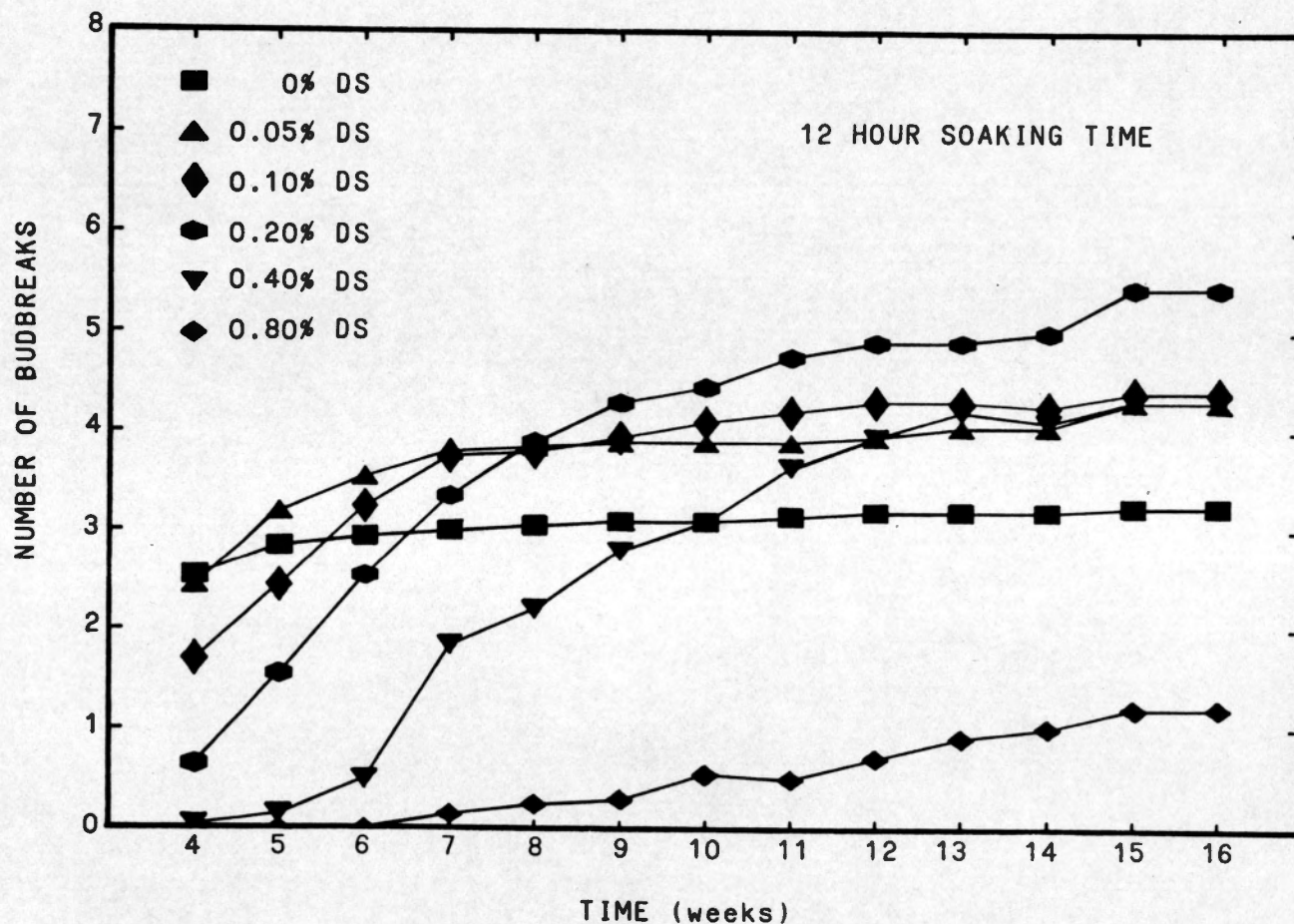


Figure 18. The mean number of budbreaks per cane (recorded weekly) on *Dracaena fragrans* 'Massangeana' cane cuttings soaked in dikegulac sodium (DS) solutions for 12 hours before placement in the propagation medium.

CHAPTER V

DISCUSSION

One of the primary objectives of this research was to determine if treatment with dikegulac sodium (AtrinalTM) could increase budbreak in cane cuttings of Dracaena fragrans 'Massangeana.' The results showed that maximum budbreak occurred when cane cuttings were soaked in dikegulac sodium solutions at a rate of 0.20%. However, at this concentration rooting was inhibited, shoot development was suppressed and about half of the buds were abnormal in appearance. Budbreak on cane cuttings treated with 0.05% and 0.10% dikegulac sodium was also increased as compared with the control cuttings, but the negative effects of dikegulac sodium on rooting, shoot development and bud abnormality were less at these rates than at rates of 0.20% and higher.

Soaking time, in general, had little effect on budbreak of 'Massangeana' cane cuttings as affected by dikegulac sodium concentration. However, root quality and shoot length were decreased by longer soaking times (Figure 9, page 25; Figure 13, page 30). The six hour soaking time appeared to be somewhat beneficial to cane cuttings soaked in 0.80% dikegulac sodium (Figure 7, page 22; Figure 17, page 36).

Poole et al. (29) reported that soaking the basal ends of 'Massangeana' cane cuttings in water for 18 to 24 hours prior to placement in the propagating medium improved survival. The results

of this experiment showed that there was no difference in survival of 'Massangeana' cane cuttings submerged for 1, 6 or 12 hours in water or dikegulac sodium solutions. Longer soaking times were not generally beneficial and reduced root quality and shoot length. This suggests that soaking canes for 1 hour prior to placement in the propagation medium may be sufficient to derive the benefits reported by Poole et al. (29).

Generally, as dikegulac sodium concentration increased, budbreak was delayed and subsequent shoot development was suppressed. These results agree with those reported by many researchers studying the effects of this compound on other plant species. The inhibition of shoot development after budbreak could be due to a general suppression of growth by dikegulac sodium. This could perhaps be overcome by treatment of the budbreaks with gibberellins. Also, this inhibition of development could be a result of competition between the larger number of active buds for available nutrients (13). Possibly, fertilizer treatments could improve shoot development.

Budbreak in 'Massangeana' cane cuttings usually occurs prior to rooting (29). The delay in budbreak and development in treated cuttings may be related to the decline in root quality at increasing concentrations of dikegulac sodium. The effect of dikegulac sodium on root quality could possibly be overcome by concomitant treatment of 'Massangeana' cane cuttings with auxin (13, 25, 39).

CHAPTER VI

SUMMARY AND CONCLUSIONS

The purpose of this experiment was to investigate the effects of dikegulac sodium (AtrinalTM) on leafless cane cuttings of Dracaena fragrans 'Massangeana.' Cuttings were soaked for 1, 6 or 12 hours in water or in 0.05%, 0.10%, 0.20%, 0.40% or 0.80% dikegulac sodium solutions prior to placement in the propagation medium.

Weekly observations made throughout the experiment showed that generally, as dikegulac sodium concentration increased, budbreak was delayed. Analysis of the data collected at the termination of the experiment (after 16 weeks) showed that dikegulac sodium concentration significantly affected 'Massangeana' cane cuttings. Increasing dikegulac sodium concentration decreased survival, root quality, shoot length, percentage of normal buds and the percentage of budbreaks in the upper half of the canes (the normal site of budbreak). Budbreak increased with increasing concentration up to 0.20%, then decreased at higher rates. Longer soaking times decreased root quality and shoot length.

Future tests of dikegulac sodium on 'Massangeana' cane cuttings should be done within the concentration range of 0.00% to 0.20%. Possibly, tests of its interaction with other growth regulators and fertilizer treatments would provide useful information. Further studies are needed before a definite statement can be made regarding

the suitability of dikegulac sodium for commercial propagation of
Dracaena fragrans 'Massangeana.'

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VITA

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