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Response of *Ilex x meserveae* S. Y. Hu to Hand Shearing and Three Growth Retarding Chemicals

by

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Literature Review

Manual and mechanized pruning of ornamental plants has become increasingly costly due to escalating labor and energy costs. More cost effective means of shaping and controlling growth of these plants are being sought. Interest is increasing in using chemical pinching agents and growth retardants for these purposes.

In this study, three growth retardants, dikegulac (as Atrinal™), ancymidol (as A-Rest™), EL-500, α-(1-methylethyl)-α-[4-(triflouromethoxy)-phenyl]-5-pyrimidinemethanol, and hand shearing were studied to determine their ability to reduce growth and/or increase branching of *Ilex x meserveae* S. Y. Hu cv. Blue Princess.

Plant Material

'Blue Princess' holly, (*Ilex x meserveae* S. Y. Hu 'Blue Princess'), is one of a group of hollies called blue hollies, and are the result of hybridization of English holly (*Ilex aquifolium* L.) and Prostrate holly (*Ilex rugosa* Friedr. & Schmitt.) by Mrs. Kathleen Meserve (16). The resulting selections were dioecious evergreen hollies hardy to -28 C. In 1964, the first cultivars of this cross (*Ilex x meserveae*), 'Blue Boy' and 'Blue Girl' were released. "Blue Prince,' an improved male cultivar was released in 1972, and was the pollen source for fruit production in this study (16, 17). It is an upright, spreading plant that can reach 4.5 meters in height and 3.0 meters in width. The foliage is a glossy dark green, and the plant produces abundant flowers in spring and mid to late summer (17).

'Blue Princess,' an improved female selection released in 1973, produces abundant berries due to multiple flowering periods in spring and late summer through fall and has dark green evergreen foliage similar to English holly (17, 36). Its growth habit is more spreading than 'Blue Prince,' with a maximum height of 3.5 to 4.5 meters and spread of 3.0 meters. Once established in a container or in the field, it averages 50 to 70 cm of new growth per year, and is recommended to be sheared at least once annually (17). Other cultivars from this cross have since been released, but 'Blue Princess' is still the most fruitful and one of the most hardy in Kansas (27, 28).

Growth Retardants on Holly

Growth retardants have been used on various holly species and cultivars with varied success. Ilex crenata Thunb. 'Hetzi' has been successfully chemically pinched with EHPP (ethyl hydrogen 1-propylphosphonate), but with some phytotoxicity at high concentrations (22). Timing the application soon after bud break gave minimal damage with significantly increased branched (23). Undecanol (TIPNIP) and dimethyldodecylamine caprylate (ChemSHEAR) exhibitied a tendency to increase branching on the same cultivar (24).

BA (6-benzyl aminopurine) foliar sprays increased shoot number on Ilex crenata 'Helleri' and 'Rotundifolia,' with 'Rotundifolia' being more sensitive at lower chemical levels than 'Helleri.'

Leaf size decreased with increasing concentration, but no other phytotoxicity was evident (39).

Japanese holly (Ilex crenata) also exhibited strong phytotoxic symptoms from phosphon and chlormequat foliar sprays (9). In the same study, American holly (Ilex opaca Ait.) had significant reduction in shoot growth when sprayed with 1000 ppm ancymidol (9).

When Ilex cornuta Lindl. & Paxt. 'Burfordii' and Ilex aquifolium x cornuta 'Nellie R. Stevens' were treated with phosphon, cycocel and C011 (N-dimethyl-aminomeamic acid), the chemicals increased flowering, fruiting and total shoot growth on Burford holly (25). Cycocel and phosphon promoted flowering and new shoot growth on 'Nellie R. Stevens,' while C011 only promoted flowering. All three chemicals tended to reduce fruit set.

Dikegulac reduced height gain in one gallon container grown plants of Ilex x attenuata Ashe 'Fosteri' and Ilex cornuta 'Needlepoint' with 10 to 70 ml/liter dikegulac foliar sprays. 'Fosteri' plants showed slight chlorosis and a significant reduction in lateral as well as terminal growth. However, 'Needlepoint' plants showed little chlorosis and genreally seemed less sensitive to the dikegulac applications (38).

Growth Retardants

Dikegulac

Atrinal[1] is a systemic growth retardant currently labelled for use on woody and herbaceous plants. It is formulated as a liquid concentrate with 200 grams of dikegulac-sodium per liter, plus a surfactant (9). It appears to be unique in the realm of growth retardants by having a monosaccharide structural base (8). Dikegulac can be applied as a foliar spray, injected or bark-banded on larger plants (18).

Effects on Growth and Development

Generally, dikegulac foliar sprays elicit the same basic responses on various species of plants. Variations are due mainly to time of application, sensitivity of the plant to the chemical and the rate used.

On azaleas, transient yellowing to necrotic patches on new foliage appears first after treatment, followed by delayed vegetative and flower bud development resulting in fewer bypass shoots to hide the flowers (11, 21, 33). The number of axillary buds is increased on treated plants and these develop from farther down the stem than on hand pruned plants (11, 14; 33, 34, 35). New lateral shoots are longer than those on controls on some cultivars, resulting in a dense, spreading plant, with flowers more visible due to shorter

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[1] Atrinal is the trade name for dikegulac sodium marketed by Hoffman-LaRoche, Inc., a subsidiary of Maag Agrochemicals.

bypass shoots (35). The optimum amount of branching on azaleas is achieved by pruning or pinching the azaleas first, then applying the dikegulac spray within several days (14, 35).

Euonymus fortunei (Turcz.) Hand.-Mazz. 'Colorata' and Forsythia x intermedia Zab. exhibited similar responses to dikegulac spray applications, with delayed, lateral bud breaks following transient chlorosis (20, 26). Lateral branch growth of Euonymus however, was less than of control plants (20).

Nerium oleander L., Ligustrum japonicum Thunb., Osmanthus heterophylla (G. Don) P. S. Green, Xylosoma congestum (Lour.) Merr., Pyracantha coccinea M. J. Roemm., Callistemon citranus (Curtis) Stapf and Cotoneaster pannosus Franch. all had more but shorter lateral shoots develop following dikegulac treatments. Phytotoxicity varied from slight chlorosis on Osmanthus and Pyracantha to death of terminals on Nerium and Ligustrum, showing a wide range of response to the chemical (10, 31).

Ulmus parvifolia Jacq., Ulmus pumila L., Schinus molle L., Morus alba L., and Ceratonia siliqua L. trees showed reduced shoot growth following dikegulac spray applications, and toxicity again varied among species (18).

Dikegulac sprays have also been found to increase tillering in Poa pratensis L. and Lolium perenne L., as well as delay flowering in Lolium perenne (8, 29). Dikegulac has also increased parthenocarpic fruit set in pears (8).

Mechanism of Action

Bocion and DeSilva found the ability of dikegulac to overcome apical dominance on azalea was enhanced by addition of cytokinin and reversed by addition of IAA (indoleacetic acid) (8).

Arzee, et. al. (4), found that dikegulac is transported readily to the shoot apex where apparently only a small number of sensitive cells are affected and create the typical dikegulac growth pattern. The affected cells apparently cause disruption of the normal tunica corpus arrangement of the shoot apex and produce irregular sized cells with more intercellular spaces. Using C^{14} labelled thymidine on *Zinnia*, it was found that fewer nuclei in terminal shoots and new leaves contained the labelled material than in plants not treated with dikegulac, so apparently little DNA synthesis was occurring in these areas. In the axillary buds, however, the labelling was very dense compared to controls, indicating the apparent tranfer of growth activity from terminal to lateral buds. The authors suggested that reduced internode length of new shoots may be due to malformed leaves which were affected by the dikegulac in the development, and thus may not be able to provide the necessary constituents for internode elongation (4).

Dikegulac seems to work counter to auxins in overcoming apical dominances (4, 8) and counter to gibberellins in cell elongation.

Ancymidol

A-Rest[1] is a 0.0264% solution of ancymidol, which is a substituted pyrimidinemethanol. It is a growth retardant for mainly herbaceous plants, which reduces internode elongation and may delay flowering on treated plants (1).

Effects on Growth and Development

Ancymidol is widely used for growth retardation in poinsettia (Euphorbia pulcherrima Willd. ex Klotzsch) and lily (Lilium longiflorum Thunb.) production (9). Also, ancymidol on chrysanthemum (Chrysanthemum x morifolium Remat.) and cucumber (Cucumis sativus L.) has been found to be more readily absorbed through the roots than the leaves (9, 15). Newly planted cuttings or seedlings are more susceptible to ancymidol than established plants (9). Plants removed from treated soil resume normal growth soon after removal, sometimes even exhibiting greater than normal shoot elongation soon after recovery (9).

Azaleas treated with ancymidol in July showed reduced height and increased flowering the following spring (30). On Forsythia x intermedia, foliar applications of ancymidol significantly reduced shoot length (26). Soil drenches applied to the same species produced shorter, darker leaved plants with some increase in branching and a delay in flowering over controls (32).

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[1]A Rest is marketed by Elanco Products Company, a division of Eli Lilly and Company.

Growing media may effect the performance of ancymidol soil drenches as pine bark has been found to reduce effectiveness. Hardwood bark, however, had no significant effect on ancymidol's growth retarding ability (7).

Mechanism of Action

Ancymidol is a non competitive, mixed function oxidase inhibitor of GA synthesis, by inhibiting oxidation of kaurene to kaurenol and kaurenal in higher plants (13). This seems to be a primary site at low concentrations, (K_m - 5µm), and at higher concentrations, the conversion of mevalonic acid to kaurene is also inhibited (12).

Ancymidol has been shown to reduce GA like activity in cucumber stem exudate on lettuce (*Lactuca* sp. L.) hypocotyls (15). Addition of GA_3 to ancymidol treated plants partially overcomes the inhibition while addition of GA_4 and GA_7 increased cucumber stem elongation with ancymidol than without. This suggests that ancymidol ties up compounds that would normally bind or interact with those particular GA's (15).

Ancymidol alters cell size, arrangement and contents in cucumber and other plants. Ancymidol decreased cell size and the spongy parenchyma was less organized (9). In cucumber, cell elongation was reduced and at higher ancymidol levels, cell division also declined. Ancymidol caused an increase in µg chlorophyll/unit leaf area, giving a darker green color, but since leaf area was often smaller, a decrease in total chlorophyll/ leaf (15).

EL-500

EL 500[1], α-(1-methylethyl)-α-[4-triflouromethoxy) phenyl]-5 pyrimidinemethanol, is an experimental growth retardant, a substituted pyrimidinemethanol similar structurally to ancymidol (1, 3). It is formulated as a 50% wettable powder and as a 5% granular formulation (3).

Effects on Growth and Development

EL-500 has been shown to be more effective as a drench than as a foliar spray (19). Drench applications have produced growth retardation by reducing internode elongation for fifteen months on some woody species. Normal growth resumed after this time (19). No phytotoxic symptoms have been observed with EL-500 except with high concentrations of 50-100 mg/pot drenches, which gave marginal leaf burn and leaf drop on *Acer saccharinum* L., *Populus fremontii* S. Wats., *Acacia longifolia* (Andr.) Willd., and *Xylosoma congestum* (Lour.) Merr. (19). The foliage of treated plants often develops a darker green color than that of untreated plants (19).

EL 500 caused moderate height reduction on poinsettias with no delay in flowering when applied to vegetative or flowering ('Eckespoint C-1') at 0.01-0.05 mg/pot. A higher rate of 0.1 mg/pot caused excessive retardation and delay in flowering, but no other phytoxic symptoms (5).

EL 500 caused reduction in stem elongation

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[1]EL 500 is a product of Elanco Products Company, a division of Eli Lilly and Company.

with no phytotoxicity on several cultivars of chrysanthemums. Cultivars varied in their response at the different rates (from 0.05 to 0.1 mg/pot), indicating an apparent cultivar specificity for response to EL-500 (5, 6). On the same cultivars, EL-500 showed more growth reduction at lower rates than ancymidol (6). The chemical also reduced stem elongation of tomato and geranium (6).

Mechanism of Action

The mechanism of action of EL-500 is not known at present, however, since it has properties and growth reducing abilities similar to ancymidol, the mechanism may be related to disruption of GA synthesis as with ancymidol (6, 13). Woody plants treated with GA sprays after EL-500 drenches showed resumed normal growth within thirty-six days of treatment with GA (19). Similar reversible ancymidol activity has been previously noted (15). A fungicide of the same substituted pyrimidinemethanol group, triarimol, shows the same general, but reduced growth retardation (37). EL-500 appears to be a persistent, effective subapical growth retardant on woody and herbaceous plants (6, 19).

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A Master's Thesis

prepared in a manner

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Introduction

Use of growth retarding chemicals or chemical pinching agents to shape or contain woody ornamentals has been gaining interest as an alternative to mechanical or manual pruning due to increasing energy and labor costs (3, 9, 23, 25).

Three basic methods for restricting plant height by using chemicals to modify stem growth have been described (20). The term growth retardant is usually restricted to those compounds which retard stem elongation by inhibiting cell division and cell expansion in the subapical meristematic zone of the stem (6, 7, 20). This results in a plant having shortened internodes, but with leaf size, leaf number, and apical dominance remaining relatively unaffected. Internode shortening can often be reversed by application of gibberellin. Growth inhibitors are compounds that suppress apical dominance by inhibiting cell division in the apical meristem; their effects are not reversible by gibberellin. Applications of inhibitors result in the production of plants with shortened internodes, dark green leaves, multiple functionary meristems, and unexpanded leaf blades (6, 17, 20).

Dikegulac has been shown to promote branching on azaleas (9, 16, 22, 23, 24), *Euonymus fortunei* 'Colorata,' (15), *Forsythia x intermedia* (16), and to reduce shoot growth on these and other woody species (8, 13, 21). This compound has properties characteristic of both retardants and inhibitors. Cell division is inhibited in the apical meristem, resulting in loss of apical dominance and proliferation of lateral shoots and reduction in leaf size. It also shortens internodes in the same way as true retardants (17). Ancymidol, used widely for reducing stem growth on poinsettias and lilies (10), has also shown growth retarding effects on Forsythia x intermedia (16, 22), and azaleas (19). EL-500 is an experimental growth retardant structurally similar to ancymidol (1, 2). It has successfully retarded stem elongation on poinsettias and several woody plant species with little phytotoxicity (4, 14), and has shown to be more persistent and effective at lower rates than ancymidol on chrysanthemums (5).

'Blue Princess' a recent release from the group of blue hollies developed by Mrs. Kathleen Meserve (11), is a spreading shrub with dark, evergreen leaves and abundant berries. It has been suggested that the plants should be pruned at least once annually to maintain shape and to enhance branching (12).

In this study, the effects of three chemicals, dikegulac, a chemical pinching agent and growth inhibitor, ancymidol and EL-500, growth retardants, were tested to determine their ability to reduce growth and/or promote branching on Ilex x meserveae cv. Blue Princess. By comparing the effects of these chemicals to sheared and unsheared plants, it is hoped that a well-branched plant of commercial quality can be produced by the use of growth retardants.

Materials and Methods

Cuttings of *Ilex x meserveae* 'Blue Princess' were planted in four liter containers six months prior to treatment in a 5:1:1, bark : shale : sand media mix. The plants were fertilized in October, 1980 and June, 1981 with 18-6 12 slow-release fertilizer. Prior to treatment, plants were sheared in April and October of 1980 to achieve uniform size. The plants were kept in a pad and fan cooled greenhouse with temperatures ranging from 4.8°C to 42.0°C. Plants were hand-pollinated to facilitate fruit set.

Eighteen treatments, including untreated control and hand sheared plants were used. Treatments were completely randomized with six replications and one plant as the experimental unit. Hand shearing removed approximately one-half of the new growth. Dikegulac was applied as single foliar sprays of 0.16, 0.23, 0.39 and 0.55% and as 0.23, 0.39 and 0.55% double and delayed foliar sprays. Ancymidol was applied as a 0.02% single and double foliar spray and as 1.5 and 3.0 mg/pot drenches. EL 500 was applied as 1.5 and 3.0 mg/pot soil drenches.

Spray concentrations of the chemical in distilled water were applied to the point of run-off with a 0.95 liter trigger sprayer. Precautions were taken to avoid getting the chemical on the media. Soil drench applications contained the chemical in 350 ml of distilled water which was poured on the slightly moist media. Single sprays and the first of double sprays plus the drench applications were made on April 23, 1981, and delayed applications and the second application of double spray treatments were made three weeks later on May 14, 1981.

All new growth over 5 mm in length was measured and classified as terminal, lateral or adventitious (from old wood) at the end of the vegetative growth flushes in early July and October in 1981, and in early February, 1982. The number of berries on each plant was also counted at these times. Visual observations on phytotoxicity were recorded periodically throughout the study.

Results

The treatments's effects in reducing the total amount of new shoot growth over nine months was determined. Then, at the end of the nine months, the new growth was broken down to average terminal shoot length and average lateral shoot length to determine where the growth reduction occurred. The amount of lateral branching in response to treatments was calculated by dividing the total number of lateral breaks on each plant by the number of terminal shoots, and the amount of new growth arising from old wood was determined by expressing the number of adventitious shoots as a percentage of all new lateral and adventitious growth.

The greatest reduction in total growth (52%) was achieved by double spray applications of 0.55% dikegulac two months after application (Table 1). EL-500 1.5 and 3.0 mg/pot drenches gave the most consistent total growth reduction compared to control and hand sheared plants during the nine month study. Single dikegulac sprays of 0.39% and

0.55% ai reduced total growth for at least two months, while double applications of 0.23, 0.39, and 0.55% dikegulac reduced the total growth over a five month period. Ancymidol 3.0 mg/pot soil drench reduced total growth over five months, but the foliar applications were not significantly effective.

All treatments, including hand shearing, effectively reduced average terminal growth determined after nine months. All the single and double dikegulac foliar treatments and both EL-500 drenches had average terminal shoot lengths less than hand sheared plants. The greatest reduction was 59% from the double 0.55% dikegulac spray (Table 2).

Lateral shoot growth was significantly reduced by all dikegulac treatments and the 3.0 mg/pot EL-500 drench. Lateral shoot growth of plants receiving the double 0.02% ancymidol spray was significantly greater than of the control plants. These findings agree with reports for other woody species (7). With the exception of the delayed dikegulac sprays, these treatments produced significantly shorter lateral shoots than hand sheared plants. The 0.39% double application reduced average lateral shoot growth 56% as compared to controls and 52% as compared to hand sheared plants.

All single and double dikegulac applications increased the number of lateral branches per stem (Table 3), with the 0.39% single and double applications and the 0.16% single application providing and increase in branching over 200% over controls and over 100% increase compared to hand sheared plants. Of the dikegulac treatments, all but the 0.55% double spray application significantly increased lateral branching over hand sheared plants.

All chemical treatments tended to induce new shoots from older wood (two years or older). The greatest percentage of these adventitious shoots resulted from the double 0.55% dikegulac spray. At least 10% of lateral shoots came from adventitious buds on old wood on plants that received either the 0.39 or 0.55% dikegulac delayed spray, the single or double ancymidol spray, or the 1.5 or 3.0 mg/pot EL-500 drench (Table 3).

Observed phytotoxicity from the treatments varied from none in ancymidol and EL-500 drenches, to marginal foliar burn in ancymidol sprays, to chlorotic, small new growth and dead terminals on dikegulac treated plants. Dikegulac induced chlorosis appeared within four weeks after treatment and disappeared by the fourth to fifth month. The number of dead terminals per plant increased with rate on single and double dikegulac applications (Table 4). All treatments with ancymidol, EL-500 or no chemicals did not have these dead terminals. Ancymidol and EL-500 treated plants became darker green soon after treatment. After three to five months, the normal green color returned on ancymidol treated plants and deepened on the EL-500 treated plants.

At the beginning of the second flush of growth, about three to four months after treatment, dikegulac treated plants initiated growth of multiple shoots at many of the lateral or terminal bud locations. These shoot clusters stopped growth soon after initiation (5 mm or less in length), resulting in the presence of dwarfed witch's broom or bur-like shoot clusters at the terminal buds or nodes of the treated plants' branches. The presence of many of these clusters (along with dead terminal shoots), would probably reduce the marketability of these plants. The number of lateral clusters per plant increased with concentration of the dikegulac in the single and double applications (Table 4). The terminal clusters increased with rate only in the single and delayed applications, with the discrepancy in the double application probably due to the higher number of dead terminals in these treatments. The highest acceptable number of clusters per plant seemed to be about 50 total, since the 0.39% dikegulac single spray treated plants (8.6 terminal and 41.5 lateral clusters) appeared commercially acceptable.

Berry production varied widely among the plants within a single treatment, but no significant difference in number was brought out by the various treatments (Appendix 1). Although no significant difference in berry number was observed, EL 500 treated plants as a group appeared to have more berries per plant, possibly because of the reduced vegetative growth which allowed the axillary borne berries to be more visible.

Discussion

In general, at nine months after treatment, EL 500 drenched plants appeared the most attractive due to the dense, dark green leaves on com pact branches and the visible fruit. The chemical strongly checked the growth of the plant with no phytotoxicity for over twelve months. New growth appeared after this period, but the darker green foliage was retained. Due to its prolonged retardation of growth with no apparent phytotoxicity, EL-500 would seem to hold promise for use on blue hollies grown as hedges and landscape plants where a specific controlled size is needed. Its efficacy as a soil drench should prompt studies on the media effects on growth retardation, since different soil types and media could greatly enhance or reduce its effectiveness.

Ancymidol, although effective as a growth retardant for a limited period, did not produce as visually attractive plant as EL 500, and its effects were not as persistent as the other two chemicals.

Although total growth was not significantly reduced at nine months, plants treated with dikegulac at the onset of new growth (single and double applications), did have more, but shorter lateral shoots, and shorter terminal shoots, producing a more compact and dense plant. Injury from the chemical detracted from this increased branching, and until new growth resumed nearly one year after treatment, most of these plants did not appear to be of commercial quality. Nearly all of the reduced shoot clusters failed to resume growth, however, lateral and terminal growth arising from other shoots masked the dead terminals and dwarfed clusters. Plants receiving delayed applications of dikegulac as a group did not show the increased branching or the same degree of growth reduction and development of dwarfed shoot clusters as the other dikegulac treatments, possibly due to the more advanced stage of growth (near the end of the first growth flush) at the time of application. Plants receiving the 0.39% dikegulac single spray applications were superior visually, with even, dense branching and a compact total plant form with minimal injury. Dikegulac would appear to hold promise as a pinching agent for blue hollies. Lower rates, perhaps in the 0.23 to 0.39% dikegulac concentration range would provide adequate branching with acceptable phytotoxicity. None of the chemicals seemed to affect the fruit set of the holly.

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Table 1.
New growth of holly two, five and nine month after treatment *

		Total Growth (mm)		
Treatment	Rate	Two Months	Five Months	Nine Months
control	-	3198 ab[z]	3918 a	4709 abcd
hand sheared	-	2830 abc	4083 a	5191 ab
dikegulac	0.16% single spray	2765 abcd	3780 ab	4852 abc
dikegulac	0.23% " "	3280 a	4189 a	5402 a
dikegulac	0.39% " "	2262 cdef	3441 ab	4723 abcd
dikegulac	0.55% " "	1712 ef	3225 abc	4409 abcd
dikegulac	0.23% double "	2265 cdef	3604 ab	4541 abcd
dikegulac	0.39% " "	1698 ef	2715 bc	3676 cdef
dikegulac	0.55% " "	1533 f	2720 bc	3658 cdef
dikegulac	0.23% delayed "	2608 abcde	3563 ab	4113 abcde
dikegulac	0.39% " "	2656 abcd	3915 a	4660 abcd
dikegulac	0.55% " "	2534 abcde	3758 ab	4409 abcd
ancymidol	0.02% single "	2425 abcdef	3147 abc	3986 bcde
ancymidol	0.02% double "	2409 abcdef	3653 ab	4479 abcd
ancymidol	1.5 mg/pot drench	2300 bcdef	3256 abc	3809 cdef
ancymidol	3.0 mg/pot drench	1908 def	2782 bc	3492 def
EL 500	1.5 mg/pot drench	1858 def	2223 c	2573 f
EL 500	3.0 mg/pot drench	1939 cdef	2159 c	2841 ef

* Each value represents mean of six plants

z Mean separation in columns by LSD, 5% level.

Table 2.

Average terminal and lateral shoot length of hollies nine months after treatment *

Treatment	Rate	Average Terminal Length (mm)	Average Lateral Length (mm)
control		131.3 a[z]	71.5 b
hand sheared		100.9 bc	65.8 bc
dikegulac	0.16% single spray	57.7 efg	39.8 efg
dikegulac	0.23% " "	68.1 def	49.1 cdefg
dikegulac	0.39% " "	50.2 fg	35.4 fg
dikegulac	0.55% " "	46.7 fg	36.8 fg
dikegulac	0.23% double "	52.0 efg	36.8 fg
dikegulac	0.39% " "	52.3 efg	31.7 g
dikegulac	0.55% " "	41.0 g	38.4 efg
dikegulac	0.23% delayed "	77.9 cde	50.1 cdefg
dikegulac	0.39% " "	92.4 bcd	43.1 efg
dikegulac	0.55% " "	96.9 bc	50.9 cdef
ancymidol	0.02% single "	104.4 b	62.8 bc
ancymidol	0.02% double "	90.6 bcd	93.9 a
ancymidol	1.5 mg/pot drench	106.5 b	69.4 b
ancymidol	3.0 mg/pot drench	84.4 cd	60.7 bcd
EL-500	1.5 mg/pot drench	67.6 def	55.6 bcde
EL 500	3.0 mg/pot drench	69.8 def	43.3 defg

z Each value represents mean of six plants

* Mean separation by LSD, 5% level

Table 3.

Number and location of new lateral shoots of holly nine months after treatment *

Treatment	Rate	Number of Laterals/ Terminal	% laterals from old wood
control		2.2 ab[z]	3
hand sheared		3.2 abc	3
dikegulac	0.16% single spray	6.6 e	6
dikegulac	0.23% " "	5.6 e	8
dikegulac	0.39% " "	6.8 e	4
dikegulac	0.55% " "	5.2 e	6
dikegulac	0.23% double "	5.8 e	8
dikegulac	0.39% " "	6.5 e	8
dikegulac	0.55% " "	5.0 cde	24
dikegulac	0.23% delayed "	3.1 ab	6
dikegulac	0.39% " "	3.6 bcd	12
dikegulac	0.55% " "	3.4 abcd	10
ancymidol	0.02% single "	2.3 ab	11
ancymidol	0.02% double "	1.7 a	14
ancymidol	1.5 mg/pot drench	1.7 a	7
ancymidol	3.0 mg/pot drench	1.9 a	6
EL-500	1.5 mg/pot drench	1.8 a	12
EL-500	3.0 mg/pot drench	1.6 a	13

[z]Each value represents mean of six plants

*Mean separation by LSD, 5% level

Table 4.

Number and location of dwarfed multiple shoot clusters and dead terminal buds on dikegulac treated holly nine months after treatment *

Dikegulac Treatment	Dead Terminals	Number of Shoot Clusters/Plant: Terminal Location	Number of Shoot Clusters/Plant: Lateral Location
0.16% single spray	7.8 cd[z]	9.2 bcd	29.3 cd
0.23% " "	8.1 cd	4.4 d	5.2 d
0.39% " "	13.5 c	8.6 bcd	41.5 cd
0.55% " "	16.3 bc	11.1 bcd	115.3 b
0.23% double "	7.8 cd	13.6 b	66.6 bc
0.39% " "	24.1 ab	11.6 bc	105.0 b
0.55% " "	32.4 a	2.3 d	129.0 a
0.23% delayed "	11.9 cd	11.8 bc	28.2 cd
0.39% " "	12.2 cd	12.8 bc	18.5 d
0.55% " "	1.0 d	24.4 a	45.8 cd

* Each value represents mean of six plants

z Mean separation in columns by LSD, 5% level

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Appendix 1.

Number of berries per plant two, five and nine months after treatment *

Treatment	Rate	Berry Number per Plant		
		Two Months	Five Months	Nine Months
control		29.8 a[z]	31.0 a	31.8 a
hand sheared		22.5 a	23.2 a	23.7 a
dikegulac	0.16% single spray	23.8 a	25.3 a	25.3 a
dikegulac	0.23% " "	17.7 a	20.2 a	20.5 a
dikegulac	0.39% " "	35.5 a	38.0 a	39.0 a
dikegulac	0.55% " "	26.2 a	29.3 a	19.7 a
dikegulac	0.23% double "	29.7 a	33.8 a	35.7 a
dikegulac	0.39% " "	26.0 a	28.1 a	28.8 a
dikegulac	0.55% " "	16.2 a	22.3 a	25.3 a
dikegulac	0.23% delayed "	28.5 a	28.0 a	31.5 a
dikegulac	0.39% " "	42.8 a	44.5 a	43.3 a
dikegulac	0.55% " "	19.0 a	21.0 a	22.3 a
ancymidol	0.02% single "	22.7 a	24.2 a	24.2 a
ancymidol	0.02% double "	16.3 a	18.7 a	20.2 a
ancymidol	1.5 mg/pot drench	42.5 a	32.2 a	54.7 a
ancymidol	3.0 mg/pot drench	27.7 a	34.2 a	41.3 a
EL-500	1.5 mg/pot drench	36.8 a	41.7 a	50.5 a
EL-500	3.0 mg/pot drench	34.0 a	38.5 a	41.2 a

* each value represents mean of six plants

z Mean separation by LSD, 5% level

Response of _Ilex x meserveae_ S. Y. Hu
to Hand Shearing and
Three Growth Retarding Chemicals

by

Pamela Borden

B. S., Purdue University, 1978

An Abstract of a Master's Thesis

submitted in partial fulfillment of the

requirements for the degree

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Kansas State University
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Abstract

Dikegulac (Atrinal™), ancymidol (A-Rest™), EL-500, α-(1-methylethyl)-α-[4-(triflouro methoxy) phenyl]-5-pyrimidinemethanol and hand shearing were tested for their effectiveness in reducing total shoot growth and increasing lateral branching of four liter container-grown *Ilex x meserveae* 'Blue Princess' maintained in a cool greenhouse. Single and double 0.23% and 0.39% single spray applications of dikegulac reduced total growth over two months, while 0.39 and 0.55% double spray applications of dikegulac and 3.0 mg/pot soil drenches of ancymidol reduced total shoot growth for five months. Only EL-500 1.5 and 3.0 mg/pot soil drenches reduced total shoot growth over nine months after treatment.

Lateral branching was significantly greater than controls in hand sheared and all single and double (0.16 to 0.55%) dikegulac treated plants, with all but the 0.55% dikegulac double application significantly increasing branching over hand sheared plants. All chemically treated plants tended to have more lateral breaks from two year or older wood than the untreated and hand sheared plants.

All dikegulac plants exhibited varying degrees of phytotoxicity which increased with rate and number of applications. All EL-500 plants were distinctly darker green than the plants receiving other treatments. No significant difference in berry number per plant was produced by any of the treatments.