RESEARCH RESULTS FOR ORNAMENTAL HORTICULTURISTS

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Horticulture Series No. 26
Auburn University
Agricultural Experiment Station
R. Dennis Rouse, Director
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CONTENTS

Use of Sewage-Refuse Compost in the Production of Ornamental Plants

Kenneth C. Sanderson

Nature of Work:

Gouin (9) has pointed out that producers of greenhouse and nursery crops are ideal users of waste composts. Both heavy metals and threats to human health are less a problem. The greenhouse-nursery industry is also ideal because it uses large quantities of organic materials in their plant growing media (21). Traditionally the organic material has been sphagnum peat moss and several peat-based media (1, 3, 4) have been developed for use on ornamental plants. Sphagnum peat moss has become expensive and difficult to obtain, therefore substitutes involving residues have been tried (10 12). For plant disease, insect and weed control, media for ornamental plants is routinely steam or chemically pasteurized and this procedure would eliminate human pathogens (1). Prior to planting, ornamental media is also amended with various chemicals, i.e. limestone, that could influence human pathogens and heavy metal availability. A wide variety of plants with various tolerances and needs for many of the heavy metals are grown by the ornamental industry. Leep and Eardly (12) found that metal rich sewage medium had no determinental effect on plane tree maple, Acer pseudo-platanus L., seedlings growth; indeed, in most cases the seedlings from high sludge treatments performed significantly better than those grown in unamended potting medium. Also, the total metal burden in these plants was not found to be excessive. Large quantities of water and fertilizer are applied to ornamental plants to facilitate rapid growth and these applications may have an effect on heavy metal availability and accumulation. Using waste composts in ornamental production would involve dilution of any toxic pollutants. Dilution is not an acceptable solution to pollution problems according to some workers. However, dilution in the soil is far more acceptable than air or water dilution (2).

Research at the Auburn University Agricultural Experiment Station has primarily been concerned with a sewage-refuse compost. This compost was produced by the City of Mobile, Alabama by removing most of the metal, rags, and large items from municipal refuse and garbage, hammermilling, flaming to remove flexible plastic, spraying with raw sewage, and composting for 12-16 weeks in windrows. The "finished" compost had a dark brown granular appearance with much flexible and rigid plastic visible. Self 1/ found it contained 15 to 20% ground glass, 10 to 20% plastic and 20% moisture by weight. The glass did not present a problem in handling.

Spurway analysis of dilute acetic acid extracts revealed 0-5 ppm NO_3, 0-1 ppm P, 20-20 ppm K and 100-150 ppm Ca. The pH was 8.4 and soluble salts read 30-86 mhos (1:5 dilution). Ammonium acetate extraction for exchangeable bases revealed 0.9% total N, 0.2% P, 6.0 meg/100g K, 42.4 meg/100g Na. The compost had a C/N ratio of 38.5, an exchange capacity of 13.7 meg/100g, 34.2% total carbon and negative tests for NH_4, NO_3, Cl, and SO_4 ions. X-ray spectrographic analysis revealed the presence of Pb, Sn, Cu, Mn, Fe, and Zn.

In media experiments, the sewage-refuse compost was mixed 1:1 by volume with a silt loam soil, amended with superphosphate and steam pasteurized. A 1:1 by volume sphagnum peat moss media was used as a comparison in most experiments. Generally pH was adjusted with dusting sulfur for compost media and limestone for the sphagnum peat moss media. Additional calcium was added in the form of gypsum to compost media. A high analysis fertilizer was used on a regular basis either weekly (400 ppm N, 176 ppm P, 332 ppm K) or constant (200 ppm N, 88 ppm P, 166 ppm K). Standard commercial cultural procedures were followed for specific crops.

1/ Personal communication Dr. Raymond L. Self, Auburn University Ornamental Horticultural Field Station, Mobile, Al

Greenhouse crops in sewage-refuse media

Much of the research on greenhouse crops has considered chrysanthemums grown as standard cut flowers and potted plants. Early in their growth chrysanthemums grown in sewage-refuse media exhibited a marginal necrosis on their lower leaves. This injury was relatively unimportant in standard cut flower production because the flowers are cut above the injured area. However, this injury would greatly reduce the quality of potted chrysanthemums. Foliar analysis of cv. Giant Indianapolis No. 4 leaves from the fifth and sixth node (counting from the base of the plant) revealed excessive levels of P, K, B, Mn, and Zn in plants grown in the sewage-refuse medium (Table 1). Levels of Mg and Fe were below the ranges reported for optimum growth (5). Potted chrysanthemum leaves of cv. Sunstar plants grown in the sewage-refuse medium showed excess concentrations of P, Ca, and Zn while N, Fe, and Cu concentrations were low. Gogue and Sanderson (8) found high foliar K, Cu, B, and Zn in leaves of the standard chrysanthemums cvs. CF No. 2 Good News and Improved Albatross grown in sewage-refuse medium. These workers also observed a marginal injury on lower leaves and attributed it to B (7). Purvis (15) has noted that B is the most likely element to be phytotoxic in compost. Gogue (6) was unable to produce injury with Zn at foliar concentrations higher than those observed in plants grown in sewage-refuse medium.

The height flowering, stem weight, and flower diameter of chrysanthemum plants grown in sewage-refuse medium was less than that of plants grown in the sphagnum peat moss medium. Gogue and Sanderson (8) found that plants grown in sewage-refuse had smaller flowers, less dry weight and shorter stems than plants grown in a sphagnum peat moss medium. Negative correlations of these growth parameters with foliar K, Cu, Al, B, Na, and Zn concentrations were also reported by these workers.

Snapdragons, Antirrhinum majus L. were grown in sewage-refuse compost amended medium because of their sensitivity to soluble salts and high boron requirements. Early in their growth, plants grown in sewage-refuse medium exhibited chlorosis, burning and spotting of their lower leaves. Height, flower head length, and stem weight/length ratio (a measure of stem strength) of plants grown in sewage-refuse medium was only slightly less than plants grown in sphagnum peat moss medium (Table 2). The fresh weight of plants grown in compost was 22% less than that of plants grown in sphagnum peat moss media. Data was averaged from 2 experiments involving Group II (winter flowering) cultivars in Experiment 1 and Group IV (summer flowering) in Experiment 2.

Easter lilies, Lilium longiflorum Thumb., were tested in sewage-refuse compost because of their high pH (6.8-7.2) and Ca requirements. Precooled bulbs of cvs. Ace and Nellie White grown in sewage-refuse medium were taller and averaged more flowers than plants grown in sphagnum peat moss medium (Table 2). Media were amended with 12.0N-2.6P-5.0K fertilizer and adjusted to pH 6.8 prior to bulb planting on January 2. Liquid fertilization was also used on a weekly basis.

The horticulture geranium Pelargonium x hortorum L. H. Bailey produced less dry weight when grown in sewage-refuse medium than when grown in sphagnum peat moss amended medium (Table 2). Visually the plants in the 2 media appeared comparable.

'Blaze', 'Eleanor', 'Dark Red Irene', and 'Summer Cloud' were grown in this experiment and their data were averaged.

The production of woody ornamentals in containers

When sewage-refuse compost was combined with sand, bagasse, perlite or vermiculite to produce soil-less media, woody plants exhibited chlorosis 6 months after potting (17). The chlorosis was attributed to rapid decomposition of the compost, slow release rate of a urea formaldehyde fertilizer, high soluble salts and high pH (17). The immaturity of the compost, low nitrogen, high soluble salts and a high pH resistant to change had been noted previously (19). Foliar element concentration and growth of plants grown in a 1:1 sand base medium for 1 year revealed that the various species performed differently with sewage refuse or sphagnum peat moss amendment (Table 3). Leaves of *Ilex* and *Viburnum* plants contained more N when grown in sewage-refuse medium than when grown in sphagnum peat moss medium. *Rhododendron* plants accumulated more foliar N in sphagnum peat moss medium. Both *Ilex cornuta* 'Matthew Yates' and *Rhododendron* plants had higher foliar K concentration when grown in sewage-refuse medium, however foliar K levels for *Juniper* plants were higher in sphagnum peat moss medium. With the exception of considerably higher foliar Ca concentrations in *Ilex cornuta* 'Matthew Yates' and *Juniper* plants grown in sewage-refuse medium, foliar Ca concentrations were comparable in both media. Sphagnum peat moss grown plants generally contained more foliar Mg. Foliar concentration of N, P, K, Ca, and Mg for *Rhododendron* cv. plants grown in both media species contained adequate Ca concentrations but none of the other elements in any of the 5 test plants were in the ranges judged sufficient by Smith (20), With the exception of the height of *Viburnum burkwoodii* Hort. Burkw. & Skipw., spread of *Ilex crenata* Thumb. 'Hetzii' and dry weight of *Juniperus conferta* Parl. and *Rhododendron* 'Evensong', plants grew better in sphagnum peat moss medium than in sewage-refuse medium (Table 3). All growth parameters for *Ilex cornuta* Lind. & Paxt. 'Matthew Yates' were greater when the plants were grown in sphagnum peat moss media.

Sanderson and Martin (18) demonstrated that the nutrition difficulties observed early in the growth of woody ornamentals grown in sewage-refuse medium could be overcome by the use of constant or bi-monthly application of high analysis (25N-4.4P-8.4K) fertilizer. In their work, dry organic and inorganic fertilizer did not produce as favorable growth results as liquid regimes in a soil:perlite medium amended with either sewage-refuse compost or sphagnum peat moss. Dry weight and total plant height of *Ilex cornuta* Lidl. 'Burfordii' and *Thuja occidentalis* L. were greater in sewage-refuse-amended medium than in sphagnum peat moss-amended medium.

Sewage refuse compost as a mulch

Large quantities of sewage-refuse could be used as mulches in the landscape, production of field-grown woody plants and on public lands such as highways and parks. Mulches can conserve moisture, reduce weeds, prevent wide flucuations in soil temperature, and influence soil nutrients. Sewage-refuse compost mulches have produced no apparent differences in the growth and flowering of *Petunia* x *hybrida* Hort. Vilm-Andr. (16) and *Chrysanthemum* x *morifolium* Ramat. (14). Appearance, odor, and possible health hazards would limit this compost's use in most landscape situations.

Sewage-refuse compost mulch was comparable in weed coverage but caused greater plant losses than sawdust mulches in the field production of woody ornamentals (Table 4). Four months after mulch application, liners mulched with sewage-refuse compost averaged 20-27% losses whereas no mulch and sawdust mulch plants averaged 4-6% losses. *Buxus harlandii* Hance, *Viburnum burkwoodii* Hort. Burkw. & Skipw. and *Rhododendron* 'Rose Banner' plants suffered 13-73% losses when mulched with sewage-refuse (Table 5). *Ilex cornuta* Lindl. & Pact. 'Matthew Yates', *Juniperus chinensis* L. 'Pfitzerana', *Juniperus conferta* Parl. and *Thuja occidentalis* L. 'Pyramidalis' plants had 0-20% and 0.7% losses, respectively, with sewage-refuse and sawdust mulches. Generally, sewage-refuse mulches increased soil pH, P, K, and Ca; however sawdust mulches caused a statistical reduction in soil pH and Ca. Growth of plants mulched with sewage-refuse exceeded that of unmulched plants but was less than that of sawdust-mulched plants (Table 4).

The increase in soil pH and nutrients with sewage-refuse mulches was even more evident in experiments conducted on flat and slope sites located on an Interstate highway (Table 6). Soil under sewage-refuse mulch contained more P, K, Ca, and Mg than unmulched soil and soils mulched with turffiber, pecan hulls, pine straw or sawdust. Nitrogen content of Forsythia intermedia Zabel. leaves from plants mulched with sewage-refuse (2.71%) exceeded that of leaves of no mulch (2.35%), turffiber (2.28%), pecan hulls (2.19%), pine straw (2.41%) and sawdust (2.36%) plants. With the exception of pecan hulls, the soil moisture content under the various mulches was similar. Mulching also did not seem to affect soil temperature. Sewage-refuse mulches exhibited the greatest resistance to erosion of any of the mulches tested. Sewage-refuse mulches' resistance to erosion supports Scarsbrook et. al (19) recommendation that sewage-refuse compost be used on highway cuts and fills.

Conclusions:

The greenhouse-nursery industry is uniquely qualified to utilize sewage-refuse compost. In the production of ornamental plants there is a need for large quantities of organic matter to formulate various media. The formulation and use of sewage-refuse compost would be environmentally safe. The standard industry practice of media pasteurization would eliminate most health hazards not eliminated by composting. Sewage-refuse compost contains many nutrients which ornamental plants utilize and heavy metals do not present serious problems in the production of some ornamental plants.

Both greenhouse and woody ornamental plants have been successfully grown in media amended with sewage-refuse compost. A marginal leaf burn was observed in some herbaceous plants grown in sewage-refuse amended media and boron has been identified as the cause of this toxicity. High pH, high soluble salts, and other elements may require attention. Leaching and cultural practices may reduce or eliminate toxicity problems. Sewage-refuse compost mulches have been shown to have a beneficial effect on highway plantings. As a mulch sewage-refuse compost controls weeds, resists erosion, and increases soil nutrients.

At present, economics are the greatest deterrent to sewage-refuse compost use. It's simply cheaper to bury, burn or dump our wastes. In the future, changes in laws, traditions and habits; and economic incentives may make compost use more feasible. However, the future will also bring an increasing understanding that we have no alternative except to utilize all our resources, including wastes, in the most judicious manner. Composting is a judicious use, nonetheless the energy value of waste may preclude all uses except energy generation.

Table 1. Foliar element concentration of two chrysanthemum cultivars grown in sewage-refuse- and sphagnum peat moss-amended media

Element concentration	Giant Indianapolis # 4		Sunstar	
	Sewage-refuse	Sphagnum peat	Sewage-refuse	Sphagnum peat
N%	5.20	4.02	4.15	4.60
P%	0.62	0.88	0.72	1.25
K%	6.60	5.43	5.60	4.97
Ca%	2.02	1.94	3.15	2.02
Mg%	0.22	0.68	0.35	0.77
Mn, ppm	900	780	390	216
Fe, ppm	226	114	146	130
Cu, ppm	36	12	23	17
Al, ppm	338	332	450	278
B, ppm	179	87	76	57
Na, ppm	550	660	1,200	1,140
Zn, ppm	494	320	320	67

Table 2. Growth of snapdragons, Easter lilies and geranoums in sewage-refuse- and sphagnum peat moss amended media

Crop	Media 1:1 (v/v) Sewage-refuse: Soil	Sphagnum peat moss: Soil
Snapdragons[z]		
Height (cm)	91.4	94.3
Fresh weight (g)	48.3	62.3
Flower head length (cm)	22.9	19.8
Stem weight/length vation (g/cm)	0.3	0.3
Easter lilies[y]		
Height (cm)	41.9	38.9
No. flowers per plant	4.7	5.0
Geraniums[x]		
Dry weight (g)	15.7	20.4

[z] Means based on 10 plants each in Exp. 1 cvs. Jackpot, Twenty Grand and Sakata 148 and Exp. 2 Potomac Pink and Potomac White.

[y] Means based on 10 plants each, cvs. Nellie White and Ace.

[x] Means based on 16 plants.

Table 3. Foliar element concentration and growth of woody ornamentals grown in sphagnum peat moss- and sewage-refuse- amended media

Plant	Per cent by weight					Plant growth		
	N	P	K	Ca	Mg	Height (cm)	Spread (cm)	Dry weight (g)
Ilex cornuta cv. Matthew Yates								
Sand: sphagnum peat moss[z]	1.70	0.04	0.51	0.69	0.20	24.9	23.9	25.8
Sand: sewage-refuse compost	1.84	0.04	0.56	0.92	0.09	22.9	21.9	22.7
Ilex crenata cv. Hetz								
Sand: sphagnum peat moss	1.81	0.04	0.53	1.32	0.27	30.0	23.5	38.8
Sand: sewage-refuse compost	1.86	0.05	0.52	1.33	0.19	26.2	28.7	32.7
Juniperus conferta								
Sand: sphagnum peat moss	1.50	0.05	0.44	0.54	0.08	33.0	39.1	57.9
Sand: sewage-refuse compost	1.50	0.06	0.38	0.72	0.05	28.0	29.0	60.0
Rhododendron cv. Evensong								
Sand: sphagnum peat moss	1.61	0.05	0.32	0.59	0.10	20.7	25.2	17.6
Sand: sewage-refuse compost	1.46	0.05	0.43	0.60	0.08	19.2	20.9	18.2
Viburnum burkwoodi								
Sand: sphagnum peat moss	1.64	0.05	0.51	0.71	0.08	32.5	25.7	21.6
Sand: sewage-refuse compost	1.81	0.04	0.51	0.72	0.06	36.8	25.2	19.1

[z] Sphagnum peat moss media were amended with dolomitic limestone to adjust pH to 5.0 (Rhododendron, Ilex) and 6.0 (Juniperus, Viburnum). Sulfur was used to adjust pH of sewage-refuse media. Gypsum added to sewage refuse media to supply Ca.

Table 4. Per cent weed coverage and plant loss after 4 months, soil pH and nutrient content and plant growth after 1 year under various mulches

Mulch	Per cent weed coverage	Per cent plant loss	Soil pH	Soil elements Kg/hectare			Plant height (cm)	Plant spread (cm)
				P	K	Ca		
None	57a[z]	6	6.3ab	142a	104ab	437a	76	66
2.5 cm Sawdust	16bc	4	6.0b	128a	57b	300c	86	89
5.0 cm Sawdust	4c	5	6.0b	113a	45b	298c	97	107
2.5 Sewage-refuse	28abc	20	6.4a	246a	102ab	389ab	79	79
5 cm Sewage-refuse	20abc	27	6.5a	231a	136ab	395ab	76	84

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

Table 5. Per cent plant loss of various woody ornamentals 4 months after mulching with sewage-refuse compost and sawdust

Plant	Sewage-refuse		Sawdust	
	2.5 cm	5.0 cm	2.5 cm	5.0 cm
Buxus harlandii	67	73	0	13
Ilex cornuta'Matthew Yates'	0	13	0	0
Juniperus chinensis'Pfitzerana'	0	20	0	7
Juniperus conferta	7	0	0	0
Rhododendron'Rose Banner'	13	33	0	0
Thuja occindentalis'Pyramidalis'	13	0	0	7
Viburnum burkwoodii	40	34	20	12

Table 6. Effect of various highway mulches on soil pH, nutrients, moisture and temperature

Mulch	Soil						
	pH[z]	Nutrients				Moisture[y]	Temperature[x]
		P	K	Ca	Mg	per cent	o C
		(Kg/hectare)					
None	6.1	22	104	804	102	60	19.6
Turffiber	6.0	21	93	837	101	62	19.6
Pecan hulls	5.9	22	190	780	104	67	19.8
Pine straw	6.1	22	86	834	104	63	19.6
Sawdust	5.9	18	95	888	100	62	20.1
Sewage-refuse compost	6.8	29	201	1200	108	62	19.7

[z] Samples for soil analysis were taken to a 15-20 cm depth with a soil tube after removing the mulch which had been applied 11 months earlier.

[y] Moisture reading made with gypsum blocks located in the center of 8 mulch plots at a 15 cm depth. 6 months data (July-January).

[x] Mean of weekly readings for 6 months (July-January) with a telethermometer from thermister probes located in the center of 8 plots at 15 cm depth.

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Effect of Dikegulac Sodium on Vegetative Shoot Growth of Greenhouse Azaleas, *Rhododendron* cv.

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Nature of Work:

Dikegulac sodium, the sodium salts of 2,3:4,6-bis-0-(1-methylethylidene-α-L xylo-2-hexulofuranosonic acid), has been tested as a pinching agent on *Rhododendron* sp. (1, 4, 5, 6, 7, 8, 10, 11, 12, 14, 15). Researchers reported that dikegulac sodium sprays destroy apical dominance and induce the production of axillary shoots (2, 4). Delayed plant growth (5, 10, 14, 15) as well as retardation (4, 10) has raised serious questions concerning the use of dikegulac sodium in the production of *Rhododendron* cv. Heursel (11) has reported that the growth delay might last 6 to 24 weeks depending on the number of applications, plant metabolism and environmental conditions. Vigorous growth generally was restored 6 to 7 weeks after a single application under a good growth environment (11). Cohen (6) also has noted that dikegulac sodium increased branching per stem on Rhododendron with no effect on shoot length 7 weeks after application. The purpose of the present work was to define the delayed growth effect of dikegulac sodium on vegetative shoot growth of greenhouse azaleas, *Rhododendron* cv.

1/ Appreciation is expressed to Hoffmann - LaRoche, Nutley, N. J. for their support of this investigation; Yoder Brothers, Fort Myers, FL and Blackwell Nurseries, Semmes, AL for furnishing the plants; and R. M. Patterson and J. C. Williams, data analysts, Auburn University, AL for statistical assistance.

Plants, 25 x 25 cm in size of the azalea cv. Kingfisher, 15 x 20 cm in size of azalea cv. Alaska, Red Gish and Red Wing were potted in 15.0 x 11.3 cm clay pots containing Canadian sphagnum peat moss amended with 1.48 Kg/m^3 each of dolomitic limestone and gypsum. Fertilization consisted of applying 25-10-10 soluble fertilizer (containing 25.0% N, 4.4% P and 8.2% K) at the rate of 2.5 g/l. Approximately 120-180 ml of fertilizer solution were applied to the plant medium of each pot every 2 weeks. Iron sulfate (1.9 g/l) was added to the fertilizer solution to prevent iron deficiency. Appropriate insect and disease control methods were used whenever necessary. Plants were grown in a glass greenhouse with a light intensity of 48.5 klx (measured at noon). Plants were sheared on December 23, 1978. A 0.50% dikegulac sodium spray was applied by a low pressure, high volume sprayer to run-off on sheared plants on January 3, 1979, for comparison with untreated sheared plants. No surfactant was added in the spray material. A randomized complete block design was used with 7 replications, 3 plants per treatment (subsample) on cv. Kingfisher and 3 replications, 4 plants per treatment (subsample) on cv. Alaska, Red Gish and Red Wing. Photoperiod was supplemented during the night starting 2 weeks after treatment on January 17, 1979, by using constant light from incandescent bulbs (208.3 lux at the top of plants) from 10 p.m. to 2 a.m. Two shoots were chosen at random from each plant and tagged for shoot length measurement at various node positions on January 31, February 7 and February 14, 1979. Node positions were determined by beginning at the shoot apex. Total shoot number of each plant was recorded on February 14, 1979.

Dikegulac sodium-treated plants exhibited the necrotic leaf tip and chlorosis reported by other workers (2,5,7,9,13,14,15) 3 to 4 weeks after treatment on newly developing leaves. The chlorosis disappeared in 6 to

8 weeks. It is suggested that this characteristic chlorosis may serve as an activity indicator of dikegulac sodium. Also, a difference in chlorophyll content of the leaves on dikegulac sodium-treated plants may provide a measurement of this chemical's inhibitory effect on plant growth.

Number of producing shoots

Four weeks after treatment, dikegulac sodium-treated plants produced new shoots at every node position from shoot apex to sixth (on cv. Alaska), the eighth (on cv. Kingfisher)and the ninth (on cv. Red Gish and Red Wing) nodes (Table 1). Whereas hand sheared plants (check) originated new nodes to only the fourth (on cv. Alaska), the fifth (on cv. Red Wing) and the sixth (on cv. Kingfisher and Red Gish) nodes. Shoot emergence from dikegulac sodium-treated plants averaged 4.0 (cv. Alaska), 5.1 (cv. Red Wing) and 5.2 (cv. Kingisher and Red Gish) nodes (Table 2). However, shoot emergence from check plants averaged 3.1 (cv. Alaska), 3.3 (cv. Kingfisher), 3.5 (cv. Red Wing) and 3.6 (cv. Red Gish) nodes. The mean number of nodes producing shoots on dikegulac sodium-treated plants exceeded that of check plants for the cv. Alaska, Kingfisher and Red Wing but not on Red Gish.

New shoot length

New shoots were shorter on the sheared plants treated with dikegulac sodium than on the check plants (Table 2). However, after 4 to 5 weeks, the increases in shoot length were not different from check plants except on cv. Kingfisher. At the 5 to 6 week interval shoot length increases on dikegulac sodium-treated plants were longer than the check plants for all the cultivars tested (Table 3). This suggested that dikegulac sodium did not exert a strong depressive effect on shoot growth 6 weeks after treatment.

New shoot length varied by node position (Table 1). Dikegulac sodium-treated plants produced uniform shoots from 1 to 4 nodes on cv. Alaska, 2 to 4 nodes on cv. Kingfisher, 1 to 5 nodes on cv. Red Wing and 1 to 2 and 4 to 5 nodes on cv. Red Gish plants; whereas, the check plants only produced uniform shoots from 1 to 2 nodes on cv. Alaska, Kingfisher and Red Wing at 4 weeks after treatment. Shoot length increased rapidly on cv. Alaska at 5 and 6 weeks so that dikegulac sodium-treated plant's shoot lengths were not as uniform as at 4 weeks after treatment. In contrast, shoot development became uniform from nodes 1 to 3 on check plants. New shoot lengths of dikegulac sodium-treated cv. Red Gish plants were uniformly produced at nodes 2,4 and 5 as well as at nodes 1, 5 and 6 respectively 6 weeks after treatment; however, check plants produced different shoot lengths at every node. Shoots developing from the first node on dikegulac sodium-treated plants were never the longest shoots and shoots developing from node 5 were as long as node 1 shoots. Dikegulac sodium initially exerted a strong inhibitory effect on apical shoot development, so that new shoots could initiate from lower node positions. Apical dominance was rapidly restored on sheared plants and resulting new shoots initiated near the shearing point confirming Barrick and Sanderson's work (3). Due to the small number of shoots developed from nodes 6 to 9 the means do not represent the actual shoot lengths observed. Occasionally, a shoot developed at nodes 6 to 9 would be as long as any other shoots on the plant.

Number of new shoots

The total number of new shoots produced by the dikegulac sodium-treated plants exceed the number produced by the check plants (Table 2). This result agrees with other worker's findings (4,5,6,7,8,10,11,12,14,15). Also, increased axillary shoot development resulted in a more compact plant.

This work shows that a single 0.5% dikegulac sodium spray on sheared azalea plants does not exert a strong depressive effect on shoot growth. Furthermore, a greater number of shoots and shoots of more uniform length are produced at more and lower node positions thus yielding a more compact plant.

Table 1. Mean shoot length at different node positions on sheared azalea cv. Alaska, Kingfisher, Red Gish and Red Wing plants 4 to 6 weeks after dikegulac sodium- and no (check) treatment.

Node[z]	cv. Alaska New shoot length (mm) at week			cv. Kingfisher New shoot length (mm) at week			cv. Red Gish New shoot length (mm) at week			cv. Red Wing New shoot length (mm) at week		
	4	5	6	4	5	6	4	5	6	4	5	6
						Dikegulac sodium 0.50%						
1	11.2a	17.8bc	22.9bc	7.0bcd[y]	9.5b	11.6b	7.8b	10.3bc	12.5cd	8.8ab	12.6ab	15.5b
2	16.4a	27.0ab	34.5ab	13.1a	18.4a	22.5a	9.7b	15.6b	20.8b	11.6a	18.2a	24.6a
3	16.4a	30.9a	40.9a	14.2a	20.2a	25.9a	14.8a	22.3a	29.3a	10.6ab	18.7a	24.6a
4	10.1a	20.7b	26.3b	11.3a	17.7a	24.0a	9.2b	16.1b	20.3b	8.9ab	16.7ab	23.6a
5	3.8b	8.3cd	12.8cd	7.6b	11.3b	14.4b	6.8bc	12.5bc	16.0bc	7.4abc	13.8ab	20.2ab
6	0.8b	2.2d	3.3de	2.4c	4.1c	6.0c	3.7cd	6.9cd	9.3cd	5.4bcd	10.7bc	14.1b
7	0.0b	0.0d	0.0e	1.0c	1.7c	2.2cd	1.8d	6.5cd	8.5d	2.8cde	4.5cd	6.1c
8				0.3c	0.6c	1.0d	0.7d	1.3de	1.9e	0.6de	1.2d	1.8c
9				0.0c	0.0c	0.0d	0.3d	0.7e	1.6e	0.3e	0.8d	1.2c
10							0.0d	0.0e	0.0e	0.0e	0.0d	0.0c
S.E.	2.1	3.3	3.9	1.1	1.4	1.6	1.2	2.0	2.3	1.6	2.3	2.4
						Check						
1	35.5a	47.7a	54.2a	28.3a	34.7b	38.1b	25.6b	29.8b	33.5b	31.8a	38.7a	42.8ab
2	37.5a	46.0a	52.8a	31.3a	39.6a	44.8a	29.9a	36.6a	42.3a	33.5a	41.8a	47.8a
3	28.8b	38.8a	43.7a	23.0b	32.0b	35.5b	21.3c	22.7c	25.4c	25.3b	31.4b	36.7b
4	12.2c	16.8b	19.3b	8.3c	11.1c	12.2c	9.3d	9.4d	11.2d	17.1c	20.0c	22.0c
5	0.0d	0.0c	0.0c	4.0d	5.4d	6.1d	1.1e	2.0e	2.1e	2.8d	4.3d	5.1d
6				0.1e	0.3e	0.3e	0.4e	1.4e	1.4e	0.0d	0.0d	0.0d
7				0.0e	0.0e	0.0e	0.0e	0.0e	0.0e			
S.E.	2.1	3.3	3.9	1.1	1.4	1.6	1.4	2.2	2.6	1.7	2.3	2.5

z/ Node position counting from shoot apex.

y/ Mean separation in columns for treatment and week by Duncan's multiple range test, 5% level.

Table 2. Number of nodes with shoots, shoot length and total number of shoots on sheared azalea cv. Alaska, Kingfisher, Red Gish and Red Wing plants 4 to 6 weeks after dikegulac sodium treatment.

Treatment	No. node with shoots at week z/	Shoot length (mm) at week z/			Total shoot no. at week
	4	4	5	6	6
		cv. Alaska			
Dikegulac sodium 0.50%	4.0*	14.8*	27.0*	35.5*	95.0*
Check	3.1	37.0	48.4	55.2	54.0
S.E.	0.1	0.9	1.5	2.3	6.8
		cv. Kingfisher			
Dikegulac sodium 0.50%	5.2**	11.0*	16.2*	20.8*	95.8*
Check	3.3	28.9	37.5	41.7	58.0
S.E.	0.2	1.4	1.9	2.4	6.2
		cv. Red Gish			
Dikegulac sodium 0.50%	5.2	10.6*	17.7	23.0	126.6*
Check	3.6	24.6	32.3	36.7	76.6
S.E.	0.4	2.0	3.0	3.1	3.4
		cv. Red Wing			
Dikegulac sodium 0.50%	5.1*	11.5*	19.6*	26.6*	73.3*
Check	3.5	32.0	39.4	44.7	38.9
S.E.	0.0	0.7	0.2	0.8	0.9

z/ Data from 2 randomly selected shoots per plant, 3 replications.

*,** Significantly different from the check at the 5% and 1% level, respectively.

Table 3. Mean length increase (mm) of new shoots on sheared azalea cv. Alaska, Kingfisher, Red Gish and Red Wing plants between 4 to 5 and 5 to 6 weeks after dikegulac sodium treatment.

Treatment	Week interval	
	4 to 5 wk	5 to 6 wk
	cv. Alaska	
Dikegulac sodium 0.50%	12.2	8.5
Check	11.5	6.7
S.E.	0.6	1.3
	cv. Kingfisher	
Dikegulac sodium 0.50%	5.3*	4.5
Check	8.6	4.2
S.E.	0.7	0.6
	cv. Red Gish	
Dikegulac sodium 0.50%	6.7	5.4
Check	7.6	4.4
S.E.	0.7	0.4
	cv. Red Wing	
Dikegulac sodium 0.50%	8.2	7.0
Check	7.4	5.3
S.E.	0.5	1.0

*Significantly different from the check, 5% level.

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California Nurseries: Innovations, Management and Problems

Kenneth C. Sanderson

<u>Nature of Work</u>: During the summer of 1977, the author traveled over 10,000 miles in California while on sabbactical leave from Auburn University. Observations were made at nearly 75 ornamental establishments, 20 botanical gardens, and 6 universities. Among the nurseries visited were C and M, Nipomo; Dahstrom and Watt, Smith River; Fern Mesa, Santa Maria; Lewis Gardens, Vista; Monrovia, Azuza; Nakona and Sons, Redwood City; Oki, Sacramento; Olive Hill, Fallbrook; Rogers Gardens, Newport Beach; Sunnyside, Watsonville; and Tropico, Gardena.

<u>Results and Discussion</u>: California nurseries featured innovations in management, greenhouse heating, media, salesmanship, and disease control. Zone control management, television- and watch dog- security, tissue culture laboratories, and attractively landscaped premises were observed. One garden center is so attractive that they charge admission to the center on weekends. One nursery is grinding up styrofoam plastic packing material for use in its potting media.

Major problems confronting the industry involve labor, water, and energy. Unionization efforts and Occupational Safety and Health Act regulations are a major concern. Poor water quality has necessitated the use of reverse-osmosis and deionization. Energy problems related to greenhouse heating have been met by the installation of dual heating systems (oil-gas), foam insulated greenhouses and solar heating. Foot and vehicle baths of copper sulfate, copper napthalene spraying of wooden growing benches, and aerated steam are used to control diseases.

<u>Publications</u>:

None

A New Chemical Pinching Agent for Ornamentals

Kenneth C. Sanderson

Nature of Work: A new chemical pinching agent may replace shearing of pruning on many woody ornamental plants. Tests in Europe (1,6) and the US (2,4,5) have shown that Atrinal successfully pinches and shapes plants and increases the number of shoots without destroying plant tissue. The chemical has been reported to cause branching, growth retardation or both in a wide range of plants including cereals, cultivated and weed grasses, herbaceous and perennial plants and woody ornamentals.

Chemically, Atrinal is the sodium salt of 2,3:4, 6-Bis-0-(1-methylethylidene)-α-L-xylo-2 hexulofuranosonic acid and has the common name of dikegulac. Supplied as a foliar spray, Atrinal is taken up through the leaves and translocated throughout the plant to the meristematic zones of growth.

Auburn's initial experiment was conducted on small, young plants of rhododendron cultivar Kingfisher growing in a greenhouse in January.

Azalea growers have reported that fatty acid pinching agents (Off-Shoot-0 and Emgard 2046) produce more shoots and develop the best plant formation in combination with mechanical shearing (7). A second greenhouse experiment was initiated in July to test Atrinal in combination with shearing. Plants of the cultivars Alaska, Gloria and Red Ruffles (10 x 10 inches in size) were sheared one week before spraying at the rate of 18.3 milliliters per plant. Atrinal treatments were applied to the plants at concentrations of 3,000 to 6,000 parts per million using a low-pressure high-volume sprayer. A 42,000 ppm Off-Shoot-0 spray was also included. A randomized complete block design with five replications and three plants per treatment was used for each cultivar.

On November 18, all plants were placed in a refrigerator at 45^{o} under a continuous light intensity of 10 footcandles at the plant's top. The plants were moved to a greenhouse during January 9 to 30, 1976, and flowered using standard commercial practices.

Early workers (1) found Atrinal inhibited apical dominance and retarded growth in Ligustrum vulgare, Thuja occidentalis and Rhododendron simsi. Hield and Debie (2) have used Atrinal to retard vegetative growth of landscape plantings of Xylosma congestum, Pyracantha coccinca, Callistemon citrinus. Cotoneaster pannosus, Nerium oleander, Eucalyptus globulus, Fraxinus uhdei and Ulmus parvifolia.

These workers reported long-term inhibition and simultaneous axillary bud growth on these plants. Phytotoxicity was observed with high treatment rates on Nerium and Eucalpytus plants.

Auburn's research has considered Atrinal as a pinching agent in Ilex cornuta 'Dwarf Burfordi', Pieris phillyreifolia, Rhododendron prunifolium and Terstroemia gymnanthera. Liners in four-inch pots were sprayed with concentrations of 2,000 to 6,000 ppm in a greenhouse experiment conducted from June to December.

Research and Discussion:

Experiment 1 - Unsheared Azlaeas

A week to 10 days after spraying with Atrinal, the immature leaves at the top of the plant turned yellow or chlorotic for seven to fourteen days, however mature foliage was unaffected. Shoot data were recorded in April, and Atrinal increased shoot number af follows:

Treatment	No. of shoots per plant
None	42
Sheared	65
1,000 ppm Atrinal	42
2,000 ppm Atrinal	48
3,000 ppm Atrinal	50
4,000 ppm Atrinal	52

Experiment 2 - Sheared Azaleas

Four to six weeks after treatment, shoot and leaf inhibition was most pronounced on all Atrinal. Growth appeared normal, but compact, approximately three months after treatment. The growth retardation associated with Atrinal treatment will make the timing of applications critical in order to faciliate shoot development and flower bud initiation.

Spraying two weeks earlier than normal for hand pinching is suggested to allow complete bud development. The application of long days, growth stimulants or both to stimulate shoot elongation after pinching and lateral branch initiation warrants investigation.

Sprays of 4,000 to 5,000 ppm Atrinal produced more shoots in Gloria and Red Ruffles plants whereas Alaska plants responded best to concentrations of 5,000 to 6,000 ppm as shown here.

Treatment	Shoots per plant cultivars		
	Alaska	Gloria	Red Ruffles
None	102	110	65
3,000 Atrinal	129	140	97
4,000 Atrinal	126	167	117
5,000 Atrinal	136	172	117
6,000 Atrinal	136	162	107
42,000 ppm Off-Shoot-0	108	135	82

Flowering time did not vary more than three days in any treatment. Due to compacted growth, Atrinal-treated plants appeared very floriferous, however 'Alaska' and 'Gloria' plants did not differ statistically in the total number of flowers. 'Red Ruffles' plants treated with 5,000 Atrinal had more flowers than untreated plants as follows:

Treatment	Flowers per plant cultivar		
	Alaska	Gloria	Red Ruffles
None	220	204	102
3,000 ppm Atrinal	221	246	102
4,000 ppm Atrinal	241	230	127
5,000 ppm Atrinal	236	229	140
6,000 ppm Atrinal	243	225	132
42,000 ppm Off-Shoot-O	210	233	112

Atrinal treatments had a profound effect on bypass shoots. The highest number of bypass shoots was observed on 'Red Ruffles' plants treated with Off-Shoot-O. Flower abortion was noted in two out of 15 plants receiving Off-Shoot-O. Bypass shoots in 'Gloria' plants were reduced by all concentrations of Atrinal.

Treament	Bypass shoots per plant cultivar		
	Alaska	Gloria	Red Ruffles
None	49	33	57
3,000 ppm Atrinal	22	14	57
4,000 ppm Atrinal	23	14	37
5,000 ppm Atrinal	15	8	39
6,000 ppm Atrinal	18	8	40
42,000 ppm Off-Shoot-O	34	27	65

Auburn's investigations show that Atrinal treatments increase shoot number in azaleas. When used in combination with shearing, Atrinal increases shoot number, compacts growth and reduces bypass shoots. A spray concentration of 5,000 ppm was found to be effective on the cultivars tested.

Experiment 3 - Woody Ornamentals

Atrinal appeared to be a high effective pinching agent on Rhododendron prunifolium plants, but plants rapidly outgrew treatment effects.

Ilex cornuta 'Dwarf Burford' plants did not exhibit the typical, temporary yellowing of immature foliage associated with Atrinal treatment. Excessive dosage rates, original growth condition of the plants and season of the year might explain the response of Ilex plants. Ilex growth was so poor that the plants were discarded after eight months (shoots were still too small to count at that time). Pieris phillyreifolia seemed to respond to Atrinal treatment, but the vining habit of growth made shoot counting impossible. Terstroemia plants sprayed with 4,000 ppm Atrinal had more shoots than sheared plants as shown by the following data:

Treatment	Number shoots per plant
Sheared	12
2,000 ppm Atrinal	10
3,000 ppm Atrinal	20
4,000 ppm Atrinal	22
5,000 ppm Atrinal	12

Conclusions

Research shows that Atrinal is a safe and effective chemical pinching agent. Results indicate that it can be used alone or in combination with shearing to increase shoot numbers and develop a better plant formation in azaleas. Initial test results show that Atrinal is also effective on certain woody ornamentals.

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A Sabbatical View of Instruction at the Largest Ornamental Horticulture School in the United States

Kenneth C. Sanderson

Nature of Work:

During 1976-77 Auburn University granted the author a 9-month leave of absence to teach at California Polytechnic State University (Cal Poly) plus a 3-month sabbatical leave to study California's ornamental industry. While on the staff of the Ornamental Horticulture Department at Cal Poly, the author taught floriculture courses, advised students, was a member of Ornamental Horticulture Club, and served on departmental committees concerned with the operation of the greenhouses and limiting student enrollment. During my studies in the industry, many products of Cal Poly's teaching program were also observed in managerial positions throughout the state.

Cal Poly is a part of the California State University and Colleges and is fully approved as a 4-year degree-granting institution by the Western Association of Schools and Colleges. The campus consists of over 5,000 acres (20, 234.3 m^2) and adjacent to San Luis Obispo, an urban community of 35,000 located on U.S. Highway 101, midway between San Francisco and Los Angeles and 12 miles from the coast of central California. Enrollment figures for fall quarter of 1977 exceeded 17,000.

Results and Discussion:

The Ornamental Horticulture program is quite different from that of a traditional land-grant university. Since the primary responsibility of the faculty is teaching, the staff is not involved in research or extension. Faculty have been selected for their academic and commercial experience. Instructors receive strong support in the classroom from the university administration, a renown afdio-visual department, and clerical staffs throughout the university. The OH department furnished laboratory set-up and clean-up personnel, laboratory assistants and graders. Instruction is occupationally oriented with the objective being to prepare the graduate to enter commercial practice. A constant inter-play between general principles and practical application characterizes instruction. The latest techniques and "know how" are more important than academic history and theory in the classroom. Enrollment figures for the fall quarter 1977 were 767 students and 20 staff.

More than 40 courses stress the production and marketing of nursery crops, cut flowers, pot plants and tropical foliage plants; landscape design and construction; turf management; floral design and marketing; and diseases and pests. Unique course offerings include Bonsai, Ikebaba and tissue culture. Some courses are designed to aid the student in passing federal and state examinations necessary for certain ornamental operations. Courses cover 4 areas of specialization: nursery production and management, floriculture production and management, landscape technology and floral design. A basic OH curriculum exists for all students. Students take many ornamental courses during their first 2 years.

Cal Poly provides practical experience to its students in many ways including: 1) an Agricultural Enterprise program, 2) a senior thesis, 3) a special projects course, 4) laboratory exercises, 5) internship programs, and 6) public service projects sponsored by the OH club and the Department.

The Agricultural Enterprise Program is the most distinctive feature of Cal Poly's OH Department and approaches the zenith of practical experience. This program provides students with production, management, and sales experience while permitting them to share in the profits from their efforts. The enterprise program is financed by a non-profit corporation, the California State Polytechnic University Foundation which performs many funding functions within the university. This foundation operates under a lease agreement made with the Trustees of the California State University and Colleges and approval of the State Department of Finance. All accounts are subject to audit by the State Department of Finance and other control agencies.

The practical experience provided a Cal Poly student is in stark contrast to that of a traditional land-grant university. While the latter stress theory, Cal Poly stresses modern commercial techniques and action. It is felt that a blend of the two systems is needed in teaching ornamental horticulture today. Recent criticisms of ornamental horticulture instruction by industry make it imperative that the land-grant institutuions initiate practical experience programs. The high priority on teaching and teaching methods at Cal Poly should also be considered in land-grant institutions that have historically placed major emphasis on research. Request for graduates and observations of their successful performance in the industry makes criticisms of Cal Poly's program difficult. Nonetheless, it is apparent in the classroom that some Cal Poly students wish to be challenged in a different way. Evidence of the need for some basic theory is that Cal Poly is placing students in our most highly respected ornamental graduate schools. Also, it has been observed that some training on basic theory would facilitate the solution of production problems encountered by graduates in the industry.

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