stage. This suggests that the east coast grapefruit may have a lower metabolic rate with less potential for enzyme synthesis in response to treatment. The continued changes observed in grapefruit that was waxed after degreening was initiated (4) may provide an alternative approach to in-transit degreening.

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Influence of a Substituted Oxathiin, a Localized Growth Inhibitor, on the Stem Elongation, Branching, and Flowering of *Chrysanthemum morifolium* Ramat[1]

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Abstract. **2,3-dihydro-5,6-diphenyl-1,4-oxathiin, (UBI-P293) acts as localized blocker of cell division and expansion while well formed tissues are exempt and develop normally. When applied to vegetative chrysanthemum plants, UBI-P293 blocked development of the top 8–10 nodes; whereas lateral shoots developed at the same rate, number, and weight as those observed on manually pruned plants. When applied to plants initiating flowers, UBI-P293 caused chemical disbudding by blocking development of laterals while the terminal bud was exempt and expanded into a normal inflorescence. The optimum concentration for the 35 cultivars evaluated varied from 0.25 to 1.0% when applied between 15 to 24 short days. Higher concentrations or earlier applications of UBI-P293 inhibited all development.**

Regulation of the growth and form of plants is exerted through physical, environmental, and chemical means. The physiological state of plants determines the effectiveness and relative consistency of chemical or manual pruning techniques from one test to the next. Without this understanding, most treatments with chemicals will fail to gain acceptance due to their unpredictable results on plants (2, 20, 21). Chemical growth retardants such as succinic acid-2,2-dimethyl hydrazide (SADH, daminozide) and ancymidol (23) can be used to control growth with some degree of predictability; since there is a margin of safety in the response which they induce. Also, there is no killing of plant parts. Chemical growth inhibitors either kill or stop the growth of tissues (1, 4, 18, 28). Systemic growth inhibitors such as maleic hydrazide translocate and affect growth of tissues at distances from treated areas (3, 8, 9, 19, 24, 25, 28). New leaves, stems, and meristems which develop show typical auxin-like disruption of growth (11, 12, 13, 14, 17). Plants seldom resume normal growth; but may become senescent earlier than untreated ones. This paper reports research on the effects of a new localized chemical growth inhibitor, a substituted oxathiin, which acts as a localized growth inhibitor on stem elongation, branching, and flowering of chrysanthemum plants.

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[4]Chemical from Uniroyal Chemical Division of Uniroyal, Inc., Agricultural Chemicals Naugatuck, CN 06770.

Materials and Methods

Test plants. The test emulsions of the chemicals were applied to *Chrysanthemum morifolium* cvs. #4 Improved Indianapolis White, Bright Golden Princess Anne, Superchief, Streamer, Goldburst Mefo, Fred Shoesmith, and Iceberg[3]. The plants were grown from rooted cuttings in a pad and fan-cooled greenhouse, in photoperiodic conditions that assured their remaining in a vegetative condition throughout the experiments. These conditions consisted of natural photoperiods and 4 hr of light from incandescent lamps of 200 lux from 2200 to 0200 daily. To induce flowering, the plants were covered with black sateen cloth nightly from 1600 to 0800 to give the plants an 8 hr day.

Spray emulsions. UBI-P293[4] concn (47.3% a.i. emulsifiable concentrate) ranged from 0.125 to 1.0%. A blank emulsion, containing only the solvents and surfactants, was applied to plants to determine the toxicity of the carriers of the UBI-P293. The emulsions were used as soon as prepared.

Test method. The emulsions were applied with an ordinary throat atomizer. The entire top of the plant, including terminal meristem and surrounding leaves of various stages of maturity, was sprayed until the emulsion began to glisten on the foliage; 750 ml of emulsion were required to treat 100 chrysanthemum plants, 30 cm tall. A mechanical fogger with either a 0.33 or 2.29 mm orifice was also used to apply the emulsions to test plants. Thirty and 120 ml, respectively, were required to treat

Fig. 1. Plant of '#4 Improved Indianapolis White' chrysanthemum. Upper: Stem without manual pruning. Middle: Plant sprayed with 3% fatty acid esters to prune chemically. Lower: Plant sprayed with 0.5% UBI-P293 to block growth of terminal meristem and to permit development of lateral meristems.

100 chrysanthemum plants, 30 cm tall. All plants were sprayed uniformly until the foliage glistened. The lateral growth was harvested and weighed (to the nearest 0.1 g) 21 days after treatment. Numbers and locations of lateral flower buds were recorded on stems.

Results

I. Applications to vegetative chrysanthemum plants

Table 1. Effect of concentration of UBI-P293 and washing the foliage on the number and weight of the *lateral shoots* which developed on *vegetative plants* of '#4 Improved Indianapolis White' chrysanthemums.

UBI-P293 concn (%)	Spray Dry foliage Lateral shoots No.	Spray Dry foliage Lateral shoots Wt	Wash Immediately Lateral shoots No.	Wash Immediately Lateral shoots Wt	Wash After 5 min Lateral shoots No.	Wash After 5 min Lateral shoots Wt	Wash After 30 min Lateral shoots No.	Wash After 30 min Lateral shoots Wt
0.125	3.5b[z]	25.5b	0a	0a	0a	0a	0a	0a
0.25	3.5b	22.7b	0a	0a	2.7b	21.0b	3.7b	26.5b
0.5	3.5b	15.7a	4.0b	21.3b	3.5b	22.0b	3.2b	18.7ab
0.75	3.0b	12.7a	3.2b	21.0b	3.5b	22.0b	2.5b	18.5ab
1.0	3.2b	17.7a	3.5b	22.0b	3.2b	24.5b	3.0b	19.7ab
Manually pruned	3.0b	21.0b						

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

Concentration. Plants of '#4 Improved Indianapolis White' chrysanthemum were sprayed with various concn of UBI-P293. Growth of the top 8 to 10 nodes ceased (Fig. 1) when the chemical concn was >0.125%. A spray application of >0.5% also inhibited the growth of the lateral meristems (Table 1). Washing the top of plants immediately following the treatment reduced the effectiveness of the 0.125 and 0.25% spray applications and reduced the growth inhibiting effects of the 0.75 and 1.0% spray applications. Growth of plants sprayed with emulsions of 0.5, 0.75, and 1% and washed with water 5 or 30 min later was stopped; the number of lateral shoots and their weight 3 weeks after application of the chemical were similar to responses recorded from manually pruned plants. Plants sprayed with the blank emulsions showed no change in growth from unsprayed plants.

Method of application. Plants of '#4 Improved Indianapolis White' chrysanthemum were sprayed or fogged with emulsions containing 0.125 to 1.0% UBI-P293 (Table 2). Amount of chemical required to cause chemical pruning of the plants was directly related to the volume of liquid and concn of chemical which was applied. When the fogger with the 0.33 mm orifice was used, plant growth, regardless of the concn of chemical, was only partially stopped. Some shoots on the same plants were unaffected. When the fogger with a 2.29 mm orifice was used, the top growth of plants was uniformly stopped, and lateral shoots developed at the same rate and number as recorded on the manually pruned plants. The lowest concn of

Table 2. Effect of concn and method of applying UBI-P293 on the number and weight of the *lateral shoots* which developed on *vegetative plant* of '#4 Improved Indianapolis White' chrysanthemum.

UBI-P293 concn (%)	Spray dry foliage orifice diam 1.60mm Lateral shoots No.	Spray dry foliage orifice diam 1.60mm Lateral shoots Wt	Fogger without insert orifice diam 2.29mm Lateral shoots No.	Fogger without insert orifice diam 2.29mm Lateral shoots Wt	Fogger with insert orifice diam 0.33mm Lateral shoots No.	Fogger with insert orifice diam 0.33mm Lateral shoots Wt
0.125	2.5b[z]	9.8b	0a	0a	0a	0a
0.25	2.2b	8.9b	2.2b	7.3ab	0a	0a
0.5	2.7b	5.0ab	2.5b	6.8ab	0.7a[y]	6.6ab[y]
0.75	2.2b	4.4ab	2.0b	6.0ab	1.0a[y]	6.3ab[y]
1.0	3.0b	3.5ab	2.0b	5.7ab	1.0a[y]	6.5ab[y]
Manually pruned	2.7b	8.0b				

[y]Incomplete, some shoots on plants were unaffected by application of chemical.

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

Table 3. Effect of addition of surfactant and solvents to the basic formulation of UBI-P293 on the number and weight of the *lateral shoots* which developed on *vegetative plants* of '#4 Improved Indianapolis White' chrysanthemum.

UBI-P293 concn (%)	Spray dry foliage		2 times the amount of surfactant and solvents		4 times the amount of surfactant and solvents	
	Lateral shoots		Lateral shoots		Lateral shoots	
	No.	Wt	No.	Wt	No.	Wt
0.125	2.5b[z]	9.8b	2.7b	9.3b	2.0b	5.9ab
0.25	2.2b	8.9b	2.7b	7.6b	3.2b	4.9ab
0.5	2.7b	5.0ab	3.5b	5.1ab	2.7b	2.6ab
0.75	2.2b	4.4ab	3.5b	5.6ab	Da[y]	Da[y]
1.0	3.0b	3.5ab	2.0b	4.5ab	Da[y]	Da[y]
Manually pruned	2.7b	8.0b				

[y]Dead, chemical treatment killed sprayed tissue.

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

UBI-P293, 0.125%, was insufficient to stop elongation of the plant but was sufficient to stop the growth of the top of the plant when applied with an ordinary large volume atomizer.

Surfactant and solvents. Plants of '#4 Improved Indianapolis White' chrysanthemum were sprayed with emulsions containing 0.125 to 1.0% UBI-P293 with 2 or 4 times of the surfactant and solvents by weight added to final spray emulsion (Table 3). Doubling the amount of surfactant and solvents did not alter relative effectiveness of various concn of UBI-P293. Quadrupling the amount of surfactant and solvents increased inhibitory effects of UBI-P293. Spray emulsions containing 0.75 and 1.0% of UBI-P293 and 4 times the amount of surfactant and solvent killed plants.

II. Applications to flowering chrysanthemum plants

Time of treatment. Plants of '#4 Improved Indianapolis White' chrysanthemum were placed on short days and were sprayed with various concn of UBI-P293 following 5, 10, 15, 20, and 25 short days (Table 4). The response of the plants depended on the time of treatment and the concn of the chemical. When UBI-P293 was applied to plants following 5 and 10 short days, the terminal inflorescence was blocked from further development. Plants receiving 10 short days were more responsive to UBI-P293 than those receiving 5 short days, in terms of the number and weight of lateral shoots which developed. The terminal inflorescence had reduced numbers of lateral flower buds and no compound lateral flowering shoots developed when the chemical was applied to plants following 15 and 20 short days (Fig. 2). The optimum concn of UBI-P293, which blocked the development of the lateral inflorescence buds without disrupting the development of the terminal flower buds, varied with the time of treatment: 0.25% for 15 short days, 1.0% for 20 short days. Concn greater than optimum inhibited the development of all meristems. Lower concn than optimum blocked the development of only a part of the lateral flower buds and inhibited stem elongation. Because the plants were less responsive to UBI-P293 following 20 short days than after 15 short days, the later time was preferred to avoid overtreatment. Development of peduncles of all inflorescences and individual florets were inhibited when the chemical was applied to plants following 25 short days. Elongation of the top 8 to 10 internodes was inhibited by the 0.125 to 1.0% treatments. The internodes which were already formed at the time of treatment, however, were unaffected. The quiescent lateral meristems in the region below the chemically inhibited area developed flower buds that matured 2 weeks later than the terminal inflorescence. The flowering display on the stem occurred twice, about 2 weeks

Fig. 2. Closeup of stem of '#4 Improved Indianapolis White' chrysanthemum. Upper: Stem without manual disbudding. Middle: Stem manually disbudded to remove lateral flower buds. Lower: Stem sprayed with UBI-P293; lateral flowers buds were blocked from further development.

apart. Terminal inflorescences opened at the same time as those on manually disbudded plants. Two weeks later the lowermost laterals opened.

Cultivars. Seven cultivars of chrysanthemums were sprayed with various concn of UBI-P293 following 18, 21, 25 and 28 short days (SD) (Table 5). The cultivars varied greatly in their responsiveness to UBI-P293 because of differing stages of development of floral axes. The optimum concn of UBI-P293

Table 4. Effect of UBI-P293 concn and time of treatment on the number of lateral inflorescents (single flower) or lateral flowering shoots (branched flowering shoot) which developed on plants of '#4 Improved Indianapolis White' chrysanthemums.

	Spray treatment after start of short days									
	5 SD		10 SD		15 SD		20 SD		25 SD	
UBI-P293 concn (%)	Lateral flower buds No.	Lateral flowering shoots No.	Lateral flower buds No.	Lateral flowering shoots No.	Lateral flower buds No.	Lateral flowering shoots No.	Lateral flower buds No.	Lateral flowering shoots No.	Lateral flower buds No.	Lateral flowering shoots No.
0.125	14.0c[z]	–[y]	7.0c	–	13.0c	–	14.0c	–	14.0c	–
0.25	10.3c	–	5.3c	–	1.0b	–	3.0b	–	5.0c	–
0.5	Ia[x]	4.3	Ia	2.0	Ia	0	2.0b	–	5.0c	–
1.0	Ia	3.3	Ia	1.0	Ia	0	0b	–	4.0bc	–
Control	18.3d	0								

[x]I = blocked development of terminal inflorescence, lateral flowering shoots with several inflorescences.

[y]Development only of terminal inflorescence, lateral flowering shoots could not be formed because of the stage of development of shoot.

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

and treatment time was 0.6% at 18 SD for 'Superchief' (Fig. 3), 0.25% at 21 SD for 'Iceberg', 'Bright Golden Princess Anne', and 'Fred Shoesmith'; and 0.6% at 25 SD for 'Goldburst Mefo'.

Twenty-eight additional cultivars were sprayed with various concn of UBI-P293 following 15, 18, 21, 25 and 28 SD (data not given). The optimum concn of UBI-P293 and treatment time for chemically disbudding the cultivars was 0.6% at 15 SD for 'Illini Pink'; 0.25% at 18 SD for 'Dignity', 'Donolopes White Spider', 'Luyona', 'Nob Hill', 'Promenade', 'Southern Comfort', and 'Wildfire'; 0.5% at 18 SD for 'Giant Betsy Ross', 'Goldstar', '#2 Good News', and 'Firedance'; 0.6% at 18 SD for 'Golden Mandalay', 'St. Moritz', and 'Torch'; 0.7% at 18 SD for 'Illini Trophy'; 0.75% at 18 SD for 'Bright Yellow May Shoesmith', 'GRA Improved Albatross', and 'May Shoesmith'; 0.5% at 21 SD for 'Always Pink' and 'Puritan'; 0.6% at 21 SD for 'Onward'; and 1.0% at 21 SD for 'Explorer'. As with the cultivar #4 Indianapolis White, in general spray application earlier than the optimum time or in greater concn of UBI-P293 inhibited terminal and lateral growth of the entire floral axis; both florets on the capitulum and the primoridial meristems were permanently blocked from further development. The quiescent meristems, beneath the responsive area, grew over the inhibited area and flowering was delayed at least 2 weeks on these plants. Spray applications later than the optimum time inhibited the development of the florets.

Apical meristem and surrounding leaves of the cultivar Streamer were sensitive to all concn of UBI-P293 tested; and tissues were killed without being chemically disbudded. The results are not reported. The cultivars Hostess, Mrs. Roy, Trident, and Winter Carnival were similar to the response of the cultivar Streamer; the tissues were injured without chemically disbudding the lateral flower buds.

Discussion

Control of growth and shaping of plants can be accomplished by chemicals which inhibit plant processes. Compact plants can be produced by using chemicals which can be placed into 4 categories: a) those that kill the apical meristem and permit the release of arrested lateral meristems; b) those that stop cell division in the apical meristem, thus allowing growth of lateral meristems; c) those that retard internode elongation without arresting the control exerted by the apical meristem; and d) those that slow the activity of the apical meristem and disrupt the natural movement of growth substances that regulate development of lateral meristems.

We use chemicals of these different types to prune plants chemically with fatty acid esters (7), to inhibit cell division with maleic hydrazide (22, 28), 2,3,5-triiodobenzoic acid (10, 27), fluorenols, cytokinins (5), and morphactins (24) to disrupt the control of the apical meristem with ethephon (23), and selected petroleum fractions (6, 15, 16). In the case of the fatty acid esters, the effects are exerted through physical means; the esters eventually evaporate from the plant into the atmosphere.

The chemicals which inhibit cell division or disrupt the functioning of the apical meristem exert their effects on the plants for many weeks following a foliar application by moving systemically and affecting growth throughout the plant.

UBI-P293 chemically pruned plants in a manner similar to the action of fatty acid esters with no visible change on the growth of lateral meristems when applied to vegetative plants (26). When applied to plants initiating inflorescences, it blocked all development of inflorescences already initiated but not well developed; UBI-P293 totally blocked the expansion of some axillary inflorescences while others were totally exempt from any effects. Some plants had one normal-sized terminal inflorescence while all laterally-borne inflorescences were completely arrested from further development. From a horticultural viewpoint, the standard chrysanthemums had been chemically disbudded to leave one exhibition-sized inflorescence.

Cultivars varied in responsiveness to optimum time and UBI-P293 concn required to block the development of all of the

Fig. 3. Plants of '#4 Improved Indianapolis White' chrysanthemum. Left: Untreated, left to right sprayed with 0.6% UBI-P293 following 18, 21, 25, and 28 short days.

Table 5. Effect of concentration of UBI-P293 and the time of treatment on the stem length and number of lateral inflorescences which developed on 6 cultivars of chyrsanthemum. I = blocked development of terminal inflorescence.

UBI-P293 (concn (%)	Spray treatment after start of short days: 18 SD Stem length (cm)	18 SD Lateral flower buds (No.)	21 SD Stem length (cm)	21 SD Lateral flower buds (No.)	25 SD Stem length (cm)	25 SD Lateral flower buds (No.)	28 SD Stem length (cm)	28 SD Lateral flower buds (No.)
Cultivar: 'Superchief' = 9 wk.								
0.25	48c[z]	10.0c	46c	5.0c	50c	12.3c	45c	8.3c
0.5	43b	0b	40b	0.3b	46bc	10.8c	46c	8.3c
0.6	43b	0b	39ab	0.3b	47bc	10.3c	46c	8.0c
0.8	33a	Ia	38ab	0b	45b	6.3c	46c	6.6c
1.0	34a	Ia	35a	Ia[y]	44b	6.0c	46c	6.3c
Control:								
Untreated	57c	13c						
Manually disbudded	57c	0b						
Cultivar: '#4 Improved Indianapolis White' = 9 wk								
0.25	25a	Ia	30a	0b	36b	3.6bc	38c	10.3c
0.5	27a	Ia	29a	0b	34b	1.0b	38b	8.6c
0.6	25a	Ia	28a	Ia	37b	0.3b	39b	8.6c
0.8	25a	Ia	29a	Ia	34b	0b	37b	3.3bc
1.0	25a	Ia	26a	Ia	35b	0b	35b	3.3bc
Control:								
Untreated	47c	12c						
Manually disbudded	41bc	0b						
Cultivar: 'Iceberg' = 10 wk.								
0.25	40b	3.0bc	39ab	1.0b	52b	12.3c	42b	8.0c
0.5	33a	Ia	36a	Ia	47b	10.2c	47b	6.6c
0.6	36a	Ia	35a	Ia	47b	10.0c	44b	6.6c
0.8	32a	Ia	34a	Ia	44b	8.0c	45b	Ia
1.0	33a	Ia	33a	Ia	42b	Ia	46b	Ia
Control:								
Untreated	57c	10c						
Manually disbudded	49b	0b						
Cultivar: 'Bright Golden Princess Anne' = 10 wk.								
0.25	32a	0b	32a	0.3b	39ab	10.3c	38ab	8.0c
0.5	27a	Ia	29a	Ia	37ab	1.3b	36a	3.3b
0.6	29a	Ia	30a	Ia	38ab	2.0b	39ab	3.6b
0.8	29a	Ia	29a	Ia	34a	0.3b	33a	2.0*b
1.0	30a	Ia	30a	Ia	33a	0.3b	34a	1.0*b
Control:								
Untreated	52c	10c						
Manually disbudded	49c	0b			*Flower inhibited			
Cultivar: 'Fred Shoesmith' = 10 wk.								
0.25	29b	3.0b	27ab	0b	34a	99.3c	35b	8.0c
0.5	21a	3 Ia	20a	Ia	29ab	3.3b	31b	6.0c
0.6	17a	Ia	21a	Ia	28ab	3.0b	34b	7.6c
0.8	19a	Ia	24a	Ia	27ab	2.0b	34b	5.5c
1.0	19a	Ia	23a	Ia	27ab	1.3b	32b	4.3bc
Control:								
Untreated	42c	10c						
Manually disbudded	41c	0b						
Cultivar: 'Goldburst Mefo' = 11 wk.								
0.25	48	11.0	30a	Ia	48c	5.0c	49c	8.8c
0.5	28a	Ia	31a	Ia	40b	4.0c	44b	0.6b
0.6	30a	Ia	27a	Ia	37b	0b	44b	0b
0.8	28a	Ia	30a	Ia	37b	0b	41b	Ia
1.0	24a	Ia	32a	Ia	39b	Ia	42b	Ia
Control:								
Untreated	53c	11.0c						
Manually disbudded	54c	0b						

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

[y]I – blocked development of terminal inflorescence, lateral flowering shoots with several inflorescences.

lateral flower buds while the terminal one developed at a rate, and with the size and floret numbers, similar to those recorded from the manually disbudded flowers. Every cultivar of chrysanthemum will need to be tested to determine the optimum concn and treatment time so that the chemical can be used successfully. The flowering of the cultivars 'Mrs. Roy', 'Streamer', and 'Trident' were not controllable with UBI-P293. One would expect to find that other cultivars probably exist which cannot be successfully disbudded with the chemical.

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Effects of Four Rootstocks on Yield and Quality of Pistachio Nuts[1]

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Abstract. **During the first 5 years of production, significantly greater yields of pistachios were obtained with the 'Kerman' on seedlings identified as *Pistacia atlantica* Desf. than with 'Kerman' on seedlings of *P. palaestina* Boiss., *P. terebinthus* L., or *P. vera* L. The least productive combination was 'Kerman' on *P. vera*, the species that produces the edible pistachio nut. Weight per nut, percent blank nuts, and percent nuts with split shells did not differ significantly among the rootstock combinations.**

Seedlings of at least 8 species of *Pistacia* have been used in various parts of the world as rootstocks for *P. vera* (7). Because of their resistance to nematodes (5, 6), and growth characteristics, seedlings of *P. atlantica* and *P. terebinthus* are generally used in the U.S. Of about 12,141 ha (30,000 acres) of pistachios that have been planted in California during the past 6 years, approximately 99% are on *P. atlantica* or *P. terebinthus* rootstocks. Seedlings of both species grow more slowly the first year or two than those of *P. vera*; but, according to Joley (6), cultivars budded on them shortly outgrow and outyield those on *P. vera* roots. The objective of the study reported here was to measure the response in terms of nut yield and quality of 'Kerman' when grown on seedling rootstocks identified as *P. atlantica, P. terebinthus, P. palaestina,* and *P. vera.*

Materials and Methods

Seeds of *P. atlantica* and *P. terebinthus* were obtained from the then existing U.S. Plant Introduction Station, Chico, CA. Seeds of *P. palaestina* were obtained from Turkey, and those of *P. vera* were from an open-pollinated 'Kerman' tree in the university orchard. In 1964, seedlings of each species were

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