for fenoxaprop (5), it appears that complementary action provided by preemergence herbicides may overcome the problem.

The data in the present and published studies (2, 5) suggest that a single, well-timed application of fenoxaprop can eliminate smooth crabgrass as a problem for an entire season. Success appears possible only when fenoxaprop is applied after most smooth crabgrass seed has germinated for the year, and when crabgrass is growing vigorously and has less than four tillers. In situations where smooth crabgrass may survive or escape fenoxaprop treatment, it can be eliminated effectively by a second fenoxaprop application (2). Complementary action with preemergence herbicide + fenoxaprop tank mixes, however, can negate the need for a second fenoxaprop application, which would be most desirable for commercial lawn care specialists who may be unable to make a second annual fenoxaprop application due to economic or logistical restraints.

The fenoxaprop + preemergence herbicide strategy appears to be most beneficial when dealing with goosegrass, a species whose seed germinates throughout the summer in Maryland (6). These investigations indicate that a fenoxaprop + oxadiazon combination is an effective goosegrass control strategy when herbicides were applied in early summer to nontillered seedlings. More research is needed, however, to determine if fenoxaprop tank-mixed with preemergence herbicides would provide complementary action in controlling tillered goosegrass.

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Fertilizer Applications on Field-grown Statice

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Abstract. **Three cultivars of annual statice (*Limonium sinuatum* mill, and *L. bonduelli* Kuntze) were grown in a fertile, silty clay loam field and fertilized with varying amounts of granular 12N–5.3P–10K. Mean individual stem weight, flower stem number, and mean and total fresh weight increased significantly due to fertilizer applications. Cultivar differences limited increases in rosette diameter, mean stem length, individual stem weight, and flower stem number. Field fertilizer application rates between 45.4 and 68.1 kg N/ha increased total fresh weight of 'Iceberg' and 'Kampf's Blue', but did not affect 'Gold Coast'. Number of subsequent fertilizer applications beyond the initial application was not as critical as total amount applied.**

Annual statice, a horticultural crop used commercially as a filler flower in fresh or dried arrangements, is grown in the United States, primarily in Florida and California, or imported from Central and South America (14). Because research results now allow growers to hasten flowering (9, 10, 15), locations with 180 frost-free days (6) can produce crops that were commonly grown in semi-tropical areas. However, due to differences in soil and climatic conditions, cultural techniques must be evaluated to successfully produce statice in temperate regions.

The purpose of this research was to determine the amount and timing of granular fertilizer applications in order to produce marketable statice on fertile soils. Since statice is marketed on a fresh-weight basis, 454 g/bunch, and plant variables such as stem weight and length, as well as total yield, are important. General recommendations for annual flowers in Nebraska (5) suggest a split application of 39 kg N, 43 kg P, and 32 kg K/ha.

Decorticated seeds of annual statice *L. sinuatum* 'Iceberg' and 'Kampf's Blue' and *L. bonduelli* 'Gold Coast' were sown on 2 Apr. 1982 and 3 Mar. 1983 in flats containing 1 peat : 1 perlite (v/v). Within 3 to 4 weeks, seedlings had developed true leaves and were subjected to 2 weeks of 16° (day)/13°C (night) temperatures (2) and 16 hr of fluorescent and incandescent illumination with a photosynthetic photon flux (PPF) of 475 $\mu mol \cdot s^{-1} \cdot m^{-2}$ in a Kyser Sherer growth chamber. Relative humidity was maintained at 75%. After treatment, seedlings were transplanted into cell packs containing 1 peat : 1 perlite : 1 vermiculite (by volume) and were set on greenhouse benches. Greenhouse temperatures were maintained at 27° (day)/19° (night) with supplemental cool-white fluorescent lighting at a PPF of 75 to 100 $\mu mol \cdot s^{-1} \cdot m^{-2}$ for 12 hr. One week after transplant, seedlings received 1500 ml per flat of a completely soluble starter fertilizer (9.0 N–19.4P–12.5K) at a concentration of 100 ppm N plus a fungicidal drench. One week later, 200 ppm N of the same starter fertilizer was applied, and seedlings remained in the greenhouse for 2 more weeks before field transplanting.

Field experiments were conducted at the Univ. of Nebraska Horticultural Gardens at Lincoln. The area used for the experiment was a 75 × 22 m plot. The soil was a Sharpsburg silty clay loam (*Typic Arguidoll*) that had an analysis of 0.12% total N, 86 ppm extractable P, 608 ppm extractable K, 2.0% organic matter, CEC 30 meq/100 g, and a soil pH of 7.6. Bed preparation consisted of fall plowing followed by field cultivation.

Seedlings were planted 30.5 cm between plants with 122 cm between rows and 71 cm between plots. After planting, plants were overhead-irrigated as required and weeded mechanically. Flowers were harvested on a weekly basis when the individual inflorescences were three-quarters open and data were taken on rosette diameter, individual flower stem length, weight, and number as well as mean and total fresh weight.

Fertilizer study 1982. In 1982, two experiments were conducted. Experiment 1982-1 consisted of a control (no fertilizer) and treatments of successive 22.7 kg N/ha applications of 12.0 N–5.3 P–10.0 K every 2 weeks, for a total of six treatments over a 12-week period. Within each plot there were six plants. Experiment 1982-2 consisted of a control plus seven treatments: 34.1, 45.4, and 56.8 kg N/ha applied initially only and 22.7, 43.4, 45.4, and 56.8 kg N/ha applied initially and then repeated 4 weeks later. Each plot contained 10 plants.

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Table 1. Effect of single and multiple fertilizer applications on total number of flower stems of annual statice cultivars Iceberg, Gold Coast, and Kampf's Blue.

No. of flower stems

Expt. 1982-1[z]			
Treatment (kg N/ha)	Iceberg	Gold Coast	Kampf's Blue
0	5.3	4.7	3.3
22.7	14.2	50.2	6.8
2 (22.7)	8.7	43.2	2.8
3 (22.7)	25.5	37.2	7.8
4 (22.7)	6.5	34.8	5.5
5 (22.7)	7.3	39.0	4.5
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Mean	11.3	34.8	5.1
LSD[x]	11.8		
LSD[w]	12.8		

Expt. 1982-2[z]			
Treatment (kg N/ha)	Iceberg	Gold Coast	Kampf's Blue
0	16.3	40.5	6.7
34.1	13.8	35.8	14.0
45.4	16.3	38.7	7.3
56.8	33.0	35.8	15.7
22.7 + 22.7	17.5	40.7	12.0
34.1 + 34.1	17.0	49.5	12.7
45.4 + 45.4	20.8	40.3	15.7
56.8 + 56.8	19.0	38.5	16.0
	---	---	---
Mean	19.2	40.0	12.5
LSD[x]	15.1		
LSD[w]	14.0		

Expt. 1983[y]			
Treatment (kg N/ha)	Iceberg	Gold Coast	Kampf's Blue
0	100.0	329.3	54.0
22.7	116.3	354.8	100.7
22.7 + 22.7	106.3	248.8	65.0
22.7 + 34.1	118.8	280.3	63.8
22.7 + 22.7 + 45.4	86.5	305.5	61.3
22.7 + 45.4 + 68.1	117.8	313.8	75.8
	---	---	---
Mean	107.6	305.4	70.1
LSD[x]	23.3		
LSD[w]	25.5		

[z]Two plants/value/replication.
[y]Six plants/value/replication.
[x]Mean separation across columns, 5% level.
[w]Mean separation within columns, 5% level.

Table 2. Effect of single and multiple fertilizer applications on mean weight of individual stems of annual statice cultivars Iceberg, Gold Coast, and Kampf's Blue.

Weight of individual stems (g)

Expt. 1982-1[z]			
Treatment (kg N/ha)	Iceberg	Gold Coast	Kampf's Blue
0	13.6	4.9	17.6
22.7	16.7	6.7	19.1
2 (22.7)	18.2	7.2	24.7
3 (22.7)	17.9	6.8	24.4
4 (22.7)	18.5	7.1	29.3
5 (22.7)	17.6	7.3	22.9
	---	---	---
Mean	17.1	6.6	23.0
LSD[x]	6.5		
LSD[w]	6.3		

Expt. 1982-2[z]			
Treatment (kg N/ha)	Iceberg	Gold Coast	Kampf's Blue
0	12.4	6.3	18.5
34.1	17.7	6.9	19.0
45.4	19.5	6.0	20.6
56.8	19.7	6.7	21.5
22.7 + 22.7	20.2	6.3	18.9
34.1 + 34.1	20.0	6.9	22.1
45.4 + 45.4	21.2	7.2	20.7
56.8 + 56.8	19.1	7.3	21.2
	---	---	---
Mean	18.7	6.7	20.3
LSD[x]	5.7		
LSD[w]	5.7		

Expt. 1983[y]			
Treatment (kg N/ha)	Iceberg	Gold Coast	Kampf's Blue
0	15.8	6.1	20.1
22.7	14.3	6.5	18.8
22.7 + 22.7	17.3	7.2	21.6
22.7 + 34.1	18.9	7.0	21.4
22.7 + 22.7 + 45.4	17.5	7.2	20.9
22.7 + 45.4 + 68.1	17.4	6.7	22.6
	---	---	---
Mean	16.9	6.8	20.9
LSD[x]	1.8		
LSD[w]	2.5		

[z]Two plants/value/replication.
[y]Six plants/value/replication.
[x]Mean separation across columns, 5% level.
[w]Mean separation within columns, 5% level.

Both experiments were designed as split-plots and blocked by locations. Statice cultivars comprised the whole-plot factor. Fertilizer treatments comprised the sub-plot. There were three replications. Data were analyzed using the General Linear Model procedure of SAS (8). Main effect and interaction means were compared using contrasts and an LSD (12). A split-split plot analysis was also incorporated to determine the effect of time and treatment on the yield response of each cultivar for the entire harvest period.

Fertilizer study 1983. Based on the 1982 results, the 1983 experiment was started a month earlier to allow for a longer harvest period and consisted of a control plus five treatments: 22.7 kg N/ha alone; 22.7 plus a second application of either 22.7 or 34.1; 22.7 kg N/ha plus a second application of 22.7 plus a third application of 45.4 kg N/ha; and 22.7 plus a second application of 45.4 kg N/ha plus a third application of 68.2 kg N/ha. There were 2 weeks between additional fertilizer application. Each plot contained six plants of each cultivar. Fertilizer type and application procedure were the same as in previous experiments.

The experimental design was a split-plot consisting of four replications with the statice cultivars again as the whole-plot factor and fertilizer treatments as the sub-plot factor. Data were analyzed as in the previous experiments. Treatment means were compared using orthogonal contrasts. The LSD method was used to compare main effect and interaction means with a probability level of 0.05 (12).

In all experiments, fertilizer applications did not cause a significant mean increase in cultivar rosette diameters. The growth of the rosette was consistently limited to each cultivar, with 'Gold Coast' (18.0 and 21.4 cm, 1982 experiments) significantly smaller than either 'Kampf's Blue' (44.9, 49.2) or 'Iceberg' (45.5, 45.4) (data not shown) (1).

Contrary to previous reports, long-day cold treatment did not hinder flower production of 'Gold Coast', as it flowered within 4 weeks of field planting and produced the most stems and the greatest total fresh weight of all three cultivars (11). 'Iceberg' and 'Kampf's Blue' flowered ≈2 and 4 weeks later than 'Gold Coast'. Flowering, in general, occurred 30 days earlier than observed in Alcade, N.M. (4) and ≈50 days earlier than in Florida (17). The majority of inflorescences harvested were marketed through a local wholesaler.

Fertilizer applications did not produce a significant mean increase in stem length (data not shown). 'Iceberg' produced the tallest flower stems (41.2, 49.7 cm, 1982 experiments, 'Kampf's Blue' intermediate (36.5, 35.8), and 'Gold Coast' shortest (29.5, 27.9). These results are consistent with previous work (3, 4, 16, 17). Actual flower stem length, however, was slightly shorter than lengths reported for New Mexico (4), with 'Iceberg' and 'Kampf's Blue' 6 cm shorter and 'Gold Coast' 3 cm shorter.

Overall, 'Gold Coast' produced the most harvestable stems; 'Iceberg' was intermediate; and 'Kampf's Blue' produced the fewest stems (Table 1). When unfertilized plants were compared to fertilized, results varied from experiment to experiment. However, in 1982-1, 'Iceberg' and 'Gold Coast' plants produced significantly more flower stems when

Table 3. Effect of single and multiple fertilizer applications on the mean fresh weight of annual statice cultivars Iceberg, Gold Coast and Kampf's Blue.

Mean fresh wt (g)											
Expt. 1982-1^z				Expt. 1982-2^z				Expt. 1983^y			
Treatment (kg N/ha)	Iceberg	Gold Coast	Kampf's Blue	Treatment (kg N/ha)	Iceberg	Gold Coast	Kampf's Blue	Treatment (kg N/ha)	Iceberg	Gold Coast	Kampf's Blue
0	27.3	8.4	30.0	0	72.3	59.5	60.5	0	158.4	189.6	156.6
22.7	99.8	59.9	61.4	34.1	69.4	46.9	133.2	22.7	149.7	220.2	233.7
2 (22.7)	93.8	56.3	41.6	45.4	98.2	42.2	84.3	22.7 + 22.7	184.1	188.2	159.2
3 (22.7)	127.2	47.2	89.4	56.8	169.7	54.1	82.3	22.7 + 34.1	222.0	183.2	182.6
4 (22.7)	64.5	48.4	77.5	22.7 + 22.7	109.7	41.8	168.6	22.7 + 22.7 + 45.4	167.4	198.8	186.6
5 (22.7)	69.2	71.8	51.6	34.1 + 34.1	124.7	68.3	99.4	22.7 + 45.4 + 68.1	198.8	197.2	225.4
				45.4 + 45.4	115.9	54.2	98.2				
				56.8 + 56.8	96.5	50.5	113.8				
	---	---	---		---	---	---		---	---	---
Mean	80.3	48.7	58.6	Mean	107.0	52.2	105.0	Mean	180.1	196.2	190.7
LSD^x	65.0			LSD^x	61.7			LSD^x	45.4		
LSD^w	57.3			LSD^w	55.7			LSD^w	43.4		

^{z}Two plants/value/replication.
^{y}Six plants/value/replication.
^{x}Mean separation across columns, 5% level.
^{w}Mean separation within columns, 5% level.

fertilized, as did 'Kampf's Blue' in the 1983 experiment. 'Iceberg' produced the greatest number of stems when either three applications of 22.7 (1982-1), one application of 56.8 (1982-2), or 22.7 + 34.1 kg N/ha (1983) were applied. This response is contrary to work in Florida, where stems increased in average weight but not in number (7).

The mean weight of individual flower stems was significantly different by cultivar (Table 2). Stems of 'Kampf's Blue' were heaviest, 'Iceberg' intermediate, and 'Gold Coast' lightest in all experiments. In 1982-1, fertilized 'Iceberg' and 'Kampf's Blue' plants produced significantly heavier stems than unfertilized plants (Table 2). In 1982-2, fertilized 'Iceberg' plants produced heavier stems than unfertilized plants with applications of 45.4 kg N/ha and higher, giving an increase in weight when each was compared to the control. In 1981, 'Kampf' Blue' and 'Iceberg' produced significantly heavier stems when fertilized with 22.7 + 45.4 + 68.1 kg N/ha and 22.7 + 34.1 kg N/ha, respectively. This increase is consistent with previous research in Florida (7). Individual stem weights reported from Florida (16) were ≈2.5 times heavier for 'Iceberg' and 'Kampf's Blue' and five times heavier for 'Gold Coast' flower stems compared to stems harvested in this research.

The mean fresh weight of harvested flower stems of 'Iceberg' and 'Kampf's Blue' responded to fertilizer applications (Table 3). In 1982-1, flower stems harvested from fertilized plants of all cultivars were significantly heavier than stems from unfertilized plants. Many of the individual application rates, when compared to the unfertilized control, were significantly different, particularly total application amounts between 45.4 and 68.1 kg N/ha for flower stems harvested from 'Iceberg' and 'Kampf's Blue' in 1982-2 and from 'Kampf's Blue' in 1983. Specifically, 'Iceberg' showed a significant increase in mean fresh weight with one to three applications of 22.7 kg N/ha (1982-1), 22.7 + 34.1 kg N/ha (1983), and 56.8 kg N/ha (1982-2). 'Kampf's Blue' significantly increased when low levels 34.1 or 2 (22.7) kg N/ha (1982-2) and 22.7 kg N/ha^{-1} (1983) were applied. Apparently, the total amount of fertilizer is more important than how many times beyond the initial application it is applied. This observation was verified further when the time and treatment effects on yield response were tested and showed no significant difference.

Total fresh weight differed for all cultivars (data not shown). In all experiments, total fresh weight of 'Iceberg' was significantly increased by fertilizer applications. When each experiment was viewed separately, individual applications of 22.7 kg N/ha (1982-1), 56.8 and 45.4 + 45.4 kg N/ha (1982-2), and 22.7, 34.1, and 22.7 + 45.4 + 68.2 kg N/ha (1983) showed significant differences when compared to the control.

In 1982-2 and 1983, total fresh weight from 'Kampf's Blue' plants was increased significantly by fertilizer applications at or above 56.8, except 34.1 + 34.1 kg N/ha (1982-2) and all levels in 1983, when compared to control plots. Total fresh weight of 'Gold Coast' plants was increased significantly by all levels of fertilizer in 1982-1 only. If commercial production of statice were attempted with plants planted on standard commercial space [49,383 plants/ha (17)], the predicted average yields (total fresh weight), based on 1983 data, would be 8420, 9990, and 5980 $kg{\cdot}ha^{-1}$ for 'Gold Coast', and 'Kampf's Blue', respectively. These yields, although considerably less than predicted for Florida (17), would be comparable or better for 'Iceberg' and 'Kampf's Blue' than predicted yields for New Mexico (3, 4), providing the shorter temperate growing season is taken into account.

Total fertilizer rates between 45.4 and 68.1 kg N/ha, when applied to 'Iceberg' and 'Kampf's Blue' plants, gave consistently better results (mean and total fresh weight) compared to unfertilized plants. Number of applications did not appear to influence flowering, as long as at least one-half of the total fertilizer amount was applied initially. Apparently, field application of fertilizer to statice does not promote floral initiation, but rather nutrient availability, which may affect flower stems once they are bolting in terms of weight increases, or may allow additional stems to grow (13). An increase in the individual stem weight and number should be translated into increases in mean and total fresh weight. For 'Gold Coast', fertile field conditions including preplant fertilizer applications appeared to be sufficient.

This range of fertilizer rates was lower than recommended for New Mexico (4) (e.g., split application of 43.2 and 172.7 kg N/ha, but comparable to that of Florida (15) (e.g., 103 to 124 kg N/ha of slow-release fertilizer plus superphosphate, trace elements, and dolomite, as needed to adjust pH).

Although it has been shown that the three tested cultivars will produce marketable flowers in a temperate region, it is important to note that peak harvest times of July, August, and September also coincide with peak harvest times of other regions, which will affect market price and total profitability. Thus, a thorough cost and market analysis for production of this crop is suggested before decisions on colors and quantities grown are effected.

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Woody Seedling Response to Growth Retardants in Hydroponics

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Abstract. **Two- to 3-month-old seedlings (10 to 12 cm tall) were grown in solution culture to which varying levels of ancymidol or dikegulac were added. Height growth of green ash (*Fraxinus pennsylvanica* Marsh.) at 11 days after treatment was inhibited ≈50% by 12.5 mg·liter^{-1} dikegulac. Growth of green ash and silver maple (*Acer saccharinum* L.) at 7 days was inhibited 75% to 80% by 0.125 mg·liter^{-1} ancymidol. Growth responses of these seedlings were linearly related to the logarithm of dikegulac and ancymidol concentrations. Chemical names used: 2,3:4,6-bis-*O*-(1-methylethylidene)-α-L-*xylo*-2-hexulofuranosonic acid)(dikegulac); α-cyclopropyl-α-(4-methoxyphenyl)-5-pyrimidinemethanol (ancymidol).**

Mature woody plants respond more slowly than annuals to growth retardants applied to foliage or soil. Sterrett (9) reported that bean (*Phaseolus vulgaris* L. 'Black Valentine') plants responded to injections of dikegulac in 10 days, whereas California privet (*Ligustrum ovalifolium* Hassk.) required 4 weeks. From 4 to 7 weeks were required for foliarly applied dikegulac to inhibit growth of various woody species (7, 8). Granular soil applications, soil drenches, and foliar-applications of ancymidol inhibited growth of a number of woody species in 5 to 8 weeks (6). Growth retardants modify plant growth in several ways. Ancymidol, a subapical meristematic (gibberellin biosynthesis) inhibitor, interferes with internodal growth (2), and dikegulac inhibits apical cell growth by interfering with DNA synthesis (1). The objective of this investigation was to develop a hydroponic bioassay for root-applied growth retardants. Ancymidol and dikegulac were used to validate the method.

Green ash and silver maple seeds were collected in the fall, air-dried, and stored at 4°C until use. Samples were removed from dry storage at 6- to 8-week intervals and stratified at 4° between layers of moist paper towels for 10 weeks. Seeds were planted in 1.5-liter plastic pots containing 1 vermiculite : 1 perlite (v/v) and placed in a growth chamber at 8° to 10° with a 16-hr photoperiod. A low level of light [40 to 50 μmol·s^{-1}·m^{-2} photosynthetically active radiation (PAR)] was provided from a combination of incandescent and fluorescent lamps. Seedlings 3 to 5 cm tall (40 to 75 days after planting) were transplanted into 1-liter opaque plastic containers containing 0.5-strength Hoagland and Arnon's nutrient solution (4) modified to provide a chelated source of iron rather than ferric tartrate. the solution was adjusted to pH 6 with 0.1 M KOH. Trees were supported by inserting the stems into split-rubber stoppers, which were then placed in precut holes in the container lids. Lids were painted silver to reduce thermal absorption and algal growth. Initially, four seedlings were planted in each container of nutrient solution, which was aerated continuously with filtered air bubbled into the liquid. Plants were thinned to two per container after 7 to 10 days. Aeration was controlled separately to each con-

Table 1. Inhibition of growth of green ash seedlings at 20 days after application of dikegulac to nutrient solution.

Dikegulac (mg·liter^{-1})	Growth[z] (cm ± SE)	Inhibition (%)
0	10.1 ± 2.0	0
12.5	5.2 ± 0.7	49
25.0	3.8 ± 0.7	62
50.0	2.2 ± 0.5	78

[z]Growth is the change in height over 20 days. Means for eight replicates of two trees each.

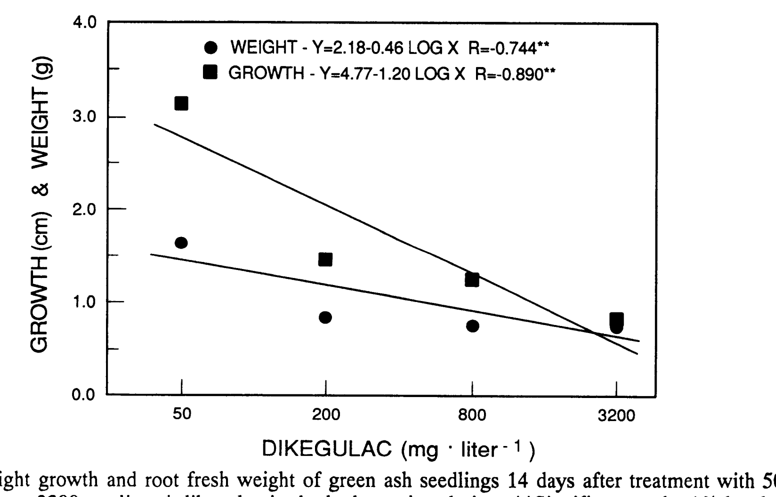

Fig.1. Height growth and root fresh weight of green ash seedlings 14 days after treatment with 50, 200, 800, or 3200 mg·liter^{-1} dikegulac in the hydroponic solution. **Significant at the 1% level.

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