the potential benefits of supplemental irradiation, crop productivity also depends on the allocation of dry matter within the plant (particularly to above ground vegetative and floral tissue), and on the rate of flower development. In these respects, the lowest level of supplemental PAR during either rooting, LD or SD, again proved to be most beneficial. Time to harvest, final vegetative and flower dry weight and number of flowering stem breaks were all improved by supplemental PAR of 77 μmol $s^{-1}m^{-2}$ (Table 2). The 148 and 231 μmol $s^{-1}m^{-2}$ treatments did not result in further improvements.

The most significant effects on harvest traits resulted from combined treatments of 77 μmol $s^{-1}m^{-2}$ during rooting and LD or during rooting, LD and SD. Extension of the treatment into SD, however, only resulted in further increases in vegetative dry weight, and stem length. This response agrees with previous results (6) and probably reflects a partitioning of excess photosynthate to stem tissue in the absence of a large number of individual stem breaks. Procedures, such as successive pinches to induce further stem break development at the start of SD, could improve CGE and patterns of photosynthate allocation under supplemental irradiation during this stage.

Previous work has emphasized the importance of irradiance, during the first 2 weeks of SD, in flower weight and number, and in hastening maturity of chrysanthemums (2). In that study, increasing irradiance over the range 63 to 230 J $cm^{-2}day^{-1}$ about 109 to 203 μmol $s^{-1}m^{-2}$, 400–700 nm averaged over an 8-hr photoperiod) produced significant improvements in flower traits at harvest in 'Bright Golden Ann', but the influence of similar irradiances during rooting and LD production was not investigated. The present results have failed to demonstrate a similar responsiveness of 'Paragon' to increasing supplemental PAR between 77 and 231 μmol $s^{-1}m^{-2}$. The data do, however, indicate an improvement in all harvest traits at the lowest level (77 μmol $s^{-1}m^{-2}$) of supplemental PAR, irrespective of production stage. Since maximum photosynthetic rate in chrysanthemum is not achieved at 77 μmol $s^{-1}m^{-2}$ PAR, (4) it seems that factors other than photosynthetic potential limit further improvement in harvest traits at the 2 higher irradiances. The most likely explanation of this situation lies in reduced ability of plants in the present study to utilize photosynthetic products at the higher irradiances, as suggested by the reduction in CGE in the 148 and 231 μmol $s^{-1}m^{-2}$ treatments.

At the plant spacings and seasonal irradiances recorded in this study, commercial growers would be ill-advised to increase supplemental irradiation of pot chrysanthemums above 77 μmol $s^{-1}m^{-2}$, since little additional improvement in growth rate, plant size or flower weight can be expected. Some improvement in CGE (and probably RGR and harvest traits) undoubtedly could be achieved during LD by increasing plant density (by, for example, planting 5 rooted cuttings per 15 cm pot), as would occur normally in commercial production. Stimulation of greater sink activity, particularly at the start of SD, might also improve CGE, and possibly improve yield response to supplemental PAR in excess of 77 μmol $s^{-1}m^{-2}$. A more reliable production strategy appears to be the provision of supplemental PAR of 77 μmol $s^{-1}m^{-2}$ during rooting and LD. This combination significantly improves earliness, plant and flower size and number and permits the efficient and economical use of HPS lamps (6). Extension of the 77 μmol $s^{-1}m^{-2}$ treatment into SD could not be recommended unless procedures are adopted to direct increased dry matter production to a greater number of stem breaks and developing flowers. Increased capital and operating costs for lamp installation for SD use are still likely, however, to make this an uneconomical proposition.

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Suppression of Axillary Bud Growth on Pinched Potted Chrysanthemums with Naphthaleneacetic Acid

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Abstract. **Spray applications of NAA or NAA ethylester at 1000 ppm acid equivalent (A.E.) reduced axillary bud number by 30% and 21%, and weight by 73% and 52%, respectively, on pinched potted chrysanthemums, *Chrysanthemum* x*morifolium* Ramat. 'Mountain Snow' and 'Mountain Peak'. Diameter of floral sprays and vegetative heights also were reduced with increasing concentrations. Flower number was not affected by the treatments. NAA treatments caused leaf epinasty, but NAA ethylester treatments did not. Chemical names used: 1-naphthaleneacetic acid (NAA).**

Pinching of potted chrysanthemums increases the number of terminal flowers and the floral spray size by stimulating the growth of axillary buds located below the decapitated apex; however, some of these buds eventually require disbudding. Growth regulators, such as 2,3-dihydro-5, 6-diphenyl-1,4-oxathiin (P-293) (5, 7), emulsifiable oils (1, 2, 3) and naphthalene compounds such as 1- and 2-methyl naphthalene (1, 4), have been used in an attempt to remove lateral buds on pinched chrysanthemums.

Exogenous auxin has been shown to suppress the growth of axillary buds in decapitated plants by restoring apical dominance (6). The application of auxins to inhibit axillary bud growth and lessen the need for disbudding has not been investigated in pinched chrysanthemums. The objective of

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Table 1. Effect of NAA and NAA ethylester concentration on axillary bud growth and flowering of 'Mountain Snow' potted chrysanthemums.

Formulation	No. of buds/pot	Bud wt./pot (g)	Diameter of spray (cm)	Time to marketability (days)	Shoot ht (cm)	No. of flowers
NAA	58.8	13.2	27.0	66.3	14.8	23.0
NAA ethylester	63.7	17.5	31.8	62.8	16.8	24.2
Significance (F test)	*	**	**	**	**	NS
Concentration (ppm A.E.)						
NAA						
0	65.5	23.6	32.8	60.5	18.2	23.3
250	70.3	15.1	29.3	66.0	14.3	23.5
500	59.3	11.6	26.5	67.8	14.4	22.0
750	52.8	9.2	24.5	68.3	13.6	24.5
1000	46.0	6.4	21.8	69.0	13.8	21.8
Significance						
Linear	**	**	**	**	**	NS
Quadratic	*	NS	NS	NS	NS	NS
NAA ethylester						
0	71.5	24.6	34.8	60.5	17.7	21.3
250	67.8	20.5	33.0	62.0	17.5	23.3
500	61.5	16.2	30.0	63.0	16.7	23.8
750	61.3	14.4	30.3	63.5	16.6	24.8
1000	56.5	11.9	30.8	65.3	15.6	28.3
Significance						
Linear	**	**	**	*	*	NS
Quadratic	NS	NS	NS	NS	NS	NS

NS,*,**Nonsignificant (NS) or significant at 5% or (*), or 1% (**) levels.

this study was to determine the effectiveness of NAA and NAA ethylester in suppressing growth of axillary buds on pinched potted chrysanthemums.

Chrysanthemum cuttings (3/pot) were planted on 14 Dec. 1983 into 20 cm standard plastic pots containing a 3 peat : 1 vermiculite : 1 perlite mix (by volume) and rooted under intermittent mist and continuous light for 7 days. Plants then were placed in an unshaded fiberglass greenhouse, and the plants were fertilized daily with 200N–50P–250K (ppm) through the irrigation system. The growth retardant, 2, 2-dimethyl hydrazide (SADH), was sprayed onto the foliage at a concentration of 4000 ppm at 1, 12, and 21 days after placement into the fiberglass greenhouse. Plants were pinched on 26 Dec. and were first treated on 6 Jan. with NAA or NAA ethylester at concentrations of 0, 250, 500, 750, and 1000 ppm of the parent acid. The NAA ethylester treatments were reapplied on 13 and 20 January. Treatments were applied as foliar sprays with a plastic hand sprayer until run-off. The experiment was arranged as a randomized complete block design with 5 single pot replications per treatment.

Axillary flower buds greater than 2mm in diameter were removed, counted, and weighed 8 weeks after pinching, the standard time for disbudding chrysanthemums in Hawaii. Diameter of sprays and shoot heights were measured and number of flowers were counted at time of marketability (the length of time for 50% of the flower petals to open to a horizontal position). Shoot heights were taken from soil level to the top of the stems, excluding infloresences.

Since results for 'Mountain Snow' and 'Mountain Peak' were similar, only results from 'Mountain Snow' are reported. NAA treatments had lower bud numbers and weight compared to NAA ethylester treatments (Table 1). As the concentration of NAA and NAA ethylester was increased, lateral bud number and weight decreased. At 1000 ppm A.E., bud number and weight for NAA treatments were reduced 30% and 73%; for NAA ethylester treatments, bud number and weight were reduced 21% and 52%, respectively. The reduction in bud weight indicated that the size of lateral buds was decreased with increased concentrations.

Plants treated with NAA had smaller floral sprays diameters in contrast to NAA ethylester treatments. Diameters of floral sprays were reduced 34% by NAA and 11% by NAA ethylester treatments at 1000 ppm A.E., compared to controls. Flower number was not affected by formulation or concentration.

Increasing the concentration of NAA or NAA ethylester lengthened the time to marketability. The greatest delay for both formulations occurred with 1000 ppm A.E.. The NAA ethylester treatment required 4.8 days, whereas NAA required an additional 8.5 days to attain marketability compared to controls. A single application of NAA had a greater effect in lengthening time to marketability then 3 applications of NAA ethylester.

NAA treated plants had greater reduction in shoot height compared to plants treated with NAA ethylester. Increasing the concentration of both formulations decreased shoot height. Plants treated with NAA displayed epinasty of lower leaves after 1 week; however, symptoms of leaf epinasty were not evident at time of marketing. NAA ethylester treated plants did not display leaf epinasty.

The application of either NAA or NAA ethylester reduces the number and weight of axillary flower buds on pinched potted chrysanthemums. This treatment can be of value to commercial producers by reducing the amount of axillary buds requiring disbudding. The reduction of plant height after auxin treatment is also of value, since growth retardants commonly are used in potted chrysanthemum production to shorten plant height. Undesirable effects of the NAA and NAA ethylester treatments are the lengthened time to marketability and reduced size of floral sprays.

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