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Morphological response of chrysanthemum morifolium varieties to a growth retardant as modified by light

James G. Staley

To the Graduate Council:

I am submitting herewith a thesis written by James G. Staley entitled "Morphological response of chrysanthemum morifolium varieties to a growth retardant as modified by light." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Landscape Architecture.

B. S. Pickett, Major Professor

We have read this thesis and recommend its acceptance:

Joe S. Alexander, H. D. Swingle

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

August 1, 1966

To the Graduate Council:

I am submitting herewith a thesis written by James G. Staley entitled "Morphological Response of Chrysanthemum morifolium Varieties to a Growth Retardant as Modified by Light." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Horticulture.

B. A. Tubbs
Major Professor

We have read this thesis and recommend its acceptance:

Joe S. Alexander

Homer D. Swingle

Accepted for the Council:

Hilton A. Smith
Dean of the Graduate School

MORPHOLOGICAL RESPONSE OF *CHRYSANTHEMUM MORIFOLIUM* VARIETIES TO A GROWTH RETARDANT AS MODIFIED BY LIGHT

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

James G. Staley

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CHAPTER I

INTRODUCTION

More than fifty years ago scientists discovered that the growth and behavior of many plants could be changed and often controlled by applying small amounts of organic chemicals to leaves, stems, or roots. These chemicals have become known as "growth regulators" and some have proved to be extremely useful. Today growth regulating chemicals are being used as standard practices in the production of farm crops and ornamental plants. The responses obtained from these compounds have been adapted to many commercial uses. New chemicals with new uses continually increase the list. How plants respond when sprayed, dusted, or soaked with growth regulators is of interest and practical value to the homeowner and to the amateur gardener as well as to the people producing crops for various commercial purposes.

When chrysanthemums are grown in partial shade they have a tendency to become spindly and subject to a greater amount of plant breakage than when grown in full sun. It has been a standard recommendation to plant in the full sun.

It was felt that perhaps the use of a growth regulator might extend the range of the chrysanthemum from full sun to partial shade.

Much work can be found on the use of growth regulators in greenhouse bench and pot culture of chrysanthemums but little work

has been done on outdoor chrysanthemums. Although previous studies have been made of light intensity and growth retardant effects on chrysanthemums, the two have not been combined under field conditions so far as could be discovered.

The objective of this investigation was to determine the morphological modifications resulting from use of the growth retardant N-dimethyl amino succinamic acid (Alar-50) on plants grown under different light intensity levels.

CHAPTER II

REVIEW OF LITERATURE

The story of growth regulators is one of the interesting chapters in science. Like most discoveries and developments, it came, not as a sudden revelation to a single man, but rather as a gradual unfolding to a great number of individuals over a period of time, culminating in a rapid surge of activity which began in the 1930's (23).

Duhamel Du Monceu (1758), one of the great French horticulturists, concluded that the formation of roots was caused by descending sap. He noted that, when the stems of plants were constricted as by girdling and ringing, a swelling often occurred just above the constriction, and roots were induced to form. The famous German botanist Julius Sachs (1880) decided that the differentiation of roots and flowers was due to minute amounts of chemicals moving upward and downward through the plant. In fact, he assumed the existence of definite root-forming and flower-forming substances. A Dutch scientist, M. W. Beijerinck (1888), from his work with plant galls, gave a name to the minute quantities of gall-forming materials given off by gall-producing insects, calling them "growth enzymes." However, it is the name of Charles Darwin which is most commonly associated with the early concepts of growth regulators in plants. Darwin wondered why plants turned towards the light. In a primitive dark room he germinated

grass seed and exposed the coleoptile to a light coming from one direction. The coleoptile bent towards the light. But when he covered the tip with tin foil, or cut it off, so that it was not acted upon by light, even though the region directly below was exposed to light, the coleoptile did not bend. On the other hand, if he placed the tin foil around the base of the coleoptile and exposed the tip to light, there was bending towards the light. From this he concluded that something was transmitted from the upper to the lower part which induced bending (23).

In 1909, a German scientist, Hans Fitting, working in Java, found that a water extract of orchid pollen when applied to an orchid flower would cause the petals to fall and the ovary to swell, just as would the pollen itself (23). Also, from 1910 to 1913, Jensen P. Boysen (3), in the laboratories of W. Pfeffer in Germany, discovered that, if the tip of an oat seedling coleoptile was cut off and then replaced, but with a thin coating of gelatin between the cut sections, the stimulus from the tip would pass through the gelatin and cause a curvature of the coleoptile. Tukey (23) reported that A. Paal discovered that, if he cut off the tip of the coleoptile of an oat seedling and applied it against the side of the cut stump, the coleoptile was induced to grow on that side and so to bend away from the tip. He concluded that the curvature was due to an unequal distribution of a growth regulating substance.

The next important step was made in 1926 by F. W. Went, working in his father's laboratory at Utrecht. It is of interest that young Went was then in military training, but found time in the evening or at night to carry on experiments with Avena seedlings. He cut off the tips of oat coleoptiles and placed them on tiny gelatin blocks so as to permit materials to diffuse into the blocks. The blocks were then placed against the cut stumps and caused them to curve away from the point of application. The experiments showed clearly that a substance was produced in the tip of the coleoptile which could be extracted, and which would cause curvature in a coleoptile to which it was applied (23).

It was not long until the new ideas of growth regulators were applied to practical problems. In fact, within a year of the identification of indoleacetic acid by Kogl, Haagen-Smit, and Erxleben (1933) it was shown by Went and his associates and later by Zimmerman and Hitchcock that, when this chemical was sprayed onto plants, roots might form on stems and even on fruits. Immediately 3-indoleacetic acid was employed in plant propagation to aid in the rooting of cuttings. Interest was further aroused in the possibility that other chemicals might induce rooting. Hurriedly, thousands of known chemicals were tested for activity, and chemists synthesized new compounds for trial. Some measure of the great interest in this field is shown by the fact that between 1934 and 1937 nearly 5,000 articles were published dealing with growth regulators (23).

The development of knowledge of growth regulators has had a remarkable effect on the agricultural sciences. Not only has it made possible a much better understanding of many physiological phenomena in plants, but also it has given the agriculturist a set of new tools for use in plant culture. The technological applications of these regulators have been expanded rapidly (12).

Cathey (5) reported that recently, new types of organic chemicals which retard stem elongation, increase green color of leaves, and indirectly affect flowering without causing malformations of the plants have been extensively studied. The term "growth-retarding chemical" or "growth retardant" refers to chemicals that slow cell division and cell elongation in shoot tissues and regulate plant height physiologically without formative effects. The selection of the word "retardant" implies a special action by the chemical. Treated plants are not ultimately stunted or completely suppressed from growing; rate of development and vigor of the plants are unaffected. In contrast to retardant-type regulators a common example of a growth inhibitor is maleic hydrazide (MH), chemically known as 1,2-dihydropyradzine-3,6-dione. This compound suppresses apical dominance by completely inhibiting cell division in the apical meristem. Applications of maleic hydrazide result in production of plants with short internodes, dark green leaves, several meristems that are functioning at one time, and unexpanded leaf blades. Supraoptimal concentrations suppress all growth processes. Powell and Andreasen (18) found that bench-grown chrysanthemum

plants sprayed with 1.2 per cent maleic hydrazide when plants had become established and at normal stage for pinching responded as follows:

1. Cessation of terminal growth.
2. Stimulation of laterals.
3. Retarded growth of laterals.
4. Delayed date of flowering.
5. Production of malformed leaves.
6. Production of a percentage of abnormal flowers.

In view of 3,4, and 6 above it was concluded that the use of maleic hydrazide would not be successful in production of Chrysanthemum morifolium. Powell and Andreasen's conclusion agreed with that of Mastalerz and Campbell (15) who found that 400 p.p.m. maleic hydrazide was effective in breaking the apical dominance of potted chrysanthemums. Growth of treated plants was slower than that of pinched plants, but they could not recommend the practice of applying MH for breaking apical dominance for commercial use.

In 1949, Mitchell, Wirwille, and Weil (16) reported that a new class of chemicals, the nicotiniums, reduced stem elongation of bean plants without gall formation or other formative changes. When 2,4-dichlorobenzylnicotinium chloride was applied in 1 per cent lanolin paste, the first internode on the treated plant was one-fourth the length of that on the untreated plant; the weight of most plant parts was significantly less than comparable parts of untreated plants, while

the primary leaves on treated plants weighed 28.2 per cent more than comparable leaves from untreated plants. The above workers also reported that picolinium and pyridinium, quaternary ammonium compounds of coal tar derivation, were active on bean plants.

A year later, Wirwille and Mitchell (26) reported that a series of quaternary ammonium carbamates also retarded growth of snap beans under greenhouse conditions, without the development of malformed leaves, stems, roots, and flowers. The most active compound in this group was (4-hydroxyl-5-isopropyl-2-methylphenyl) trimethyl ammonium chloride, I-piperidine carboxylate, designated Amo-1618. The iodide salt was called Amo-1619. Cathey (5) reported that these chemicals were found in preliminary screening tests initiated by the National Academy of Sciences, National Research Council, in cooperation with the Growth Regulator and Antibiotic Laboratory of the United States Department of Agriculture. In addition, morpholinium, peperidinium, quinaldinium, quinolinium, and a substituted hydrazine compound were shown to be growth retardants on snap beans and cucumbers.

Crowder (8) reported that Dr. Henry M. Cathey, horticulturist of the USDA's Agriculture Research Service, was successful in growing attractive chrysanthemum plants of desirable heights when Amo-1618 was applied. Leaves of the treated plants were a darker green than those of untreated plants, making them more attractive. Also, treated plants bloomed later than untreated ones. Cathey and Marth (7) reported that on Chrysanthemum morifolium Ramat Amo-1618 was found to be effective as

a growth retardant when mixed with the soil prior to planting of the cutting, when the basal ends of rooted or unrooted cuttings were soaked in aqueous mixture of .1 and .4 per cent concentration, or when the growing points were sprayed with the aqueous mixtures. The development of much darker green leaves than those found on the untreated plants was associated with the retardation of growth. Applications of Amo-1618 retarded elongation of stems in proportion to concentration. This reduction of stem length was associated with a delay in flowering. Flower diameter and fresh weight of the plants were also reduced by treatment with Amo-1618. Amo-1619 proved to be too phytotoxic for use on chrysanthemums.

Gowing and Leeper (11) showed in 1955 that Beta-hydroxyethyl-hydrazine, designated BOH, increased the number of flower buds on pineapple.

Cathey (5) found that the growth retarding effects of the phosphoniums was first reported in 1955. The compound triphenyl (triphenyl-methyl phosphonium chloride) caused cucumber plants to develop internodes much shorted than those of untreated plants. Later, Preston and Link (19) reported that several of the phosphoniums retarded growth of seventeen different species. The most active compound, 2,4-dichlorobenzyl tributyl phosphonium chloride, designated phosfon, affected the growth of more widely different species than did Amo-1618. Mastalerz (14) found that shorter chrysanthemums could be obtained by use of phosfon mixed into the soil prior to

planting. However, flowering was delayed approximately two weeks and no differences were found in flower and leaf size but leaf color was usually darker green on treated plants. Poole (17) found that higher levels of phosfon reduced plant height and flower diameter more than lower levels on Blue Chip variety of chrysanthemum. Cabler (4) in working with Blue Chip variety of chrysanthemum found that phosfon reduced flower diameter and delayed flower maturity but did not affect the total number of flowers. Phosfon also reduced plant height but had no effect on the fresh and dry weight of leaves, but did reduce fresh and dry weight of stems.

In 1960, a new group of quaternary ammonium compounds was reported by Tolbert (22). The most active compound, (2-chloroethyl) trimethylammonium chloride, an analog of choline, in that the hydroxy group in choline was replaced with a chlorine substituent. Cathey (5) reported that its trivial name was chlorocholine chloride, abbreviated to CCC. This chemical retarded the growth of a larger number of species than any of the earlier compounds.

Riddell (20) reported in 1962 that applications of sprays at 5 per cent of substituted maleamic and succinamic acids to foliage retarded the growth of legumes, vine crops, potatoes, and ornamental plants. The most active compound was N-dimethylamino maleamic acid, designated CO11. The compound was unstable in water. The form N-dimethylaminosuccinamic acid, designated B995, was stable in aqueous solutions and retarded growth of the same species as did CO11. Cathey

(5) reported that N-dimethylamino succinamic acid is unique in its chemical structure as a growth retardant. It does not contain a benzene ring, quaternary ammonium or phosphonium cation, or substituents that are of small size, nucleophilic, and nonionizable. All the previous compounds that were active contained one or all of these radicals. B995 is a free, ionizable acid with the C-C-N-N system as found in beta-hydroxyethyl hydrazine and maleic hydrazine.

Culbert (9) found that a single application of .5 per cent B995 to potted chrysanthemum plants 2-3 weeks after the start of short day treatment shortened the internodes most effectively and prolonged the life of the flowers when compared with untreated plants. Flower life was further extended by applying a second spray about five weeks after the first at a concentration of .25 per cent. In trials with nine varieties there were considerable differences in response between varieties and to different times of application. Flower life was increased by 10-60 per cent and plant height reduced by 4-40 per cent. It was anonymously (2) reported that single applications of B995 at either 2,500 p.p.m. or 5,000 p.p.m. applied to twelve standard chrysanthemum varieties at the time of disbudding resulted in considerable differences in the degree of response between varieties, but the ultimate height of the plants was noticeably reduced, particularly by treatment at 5,000 p.p.m. "Neckiness" of blooms was reduced. Two varieties showed an improvement in flower shape. Gortz (10) reported that treatment with B995 resulted in reduced chrysanthemum plant height, improved

leaf color and had almost no effect on the time of flowering, but in some cases it slightly reduced flower size. Yoder (27) reported that application of B995 at 2,000 and 4,000 p.p.m. to four varieties of chrysanthemums reduced stem length sufficiently when applied at disbudding. Flower size and shape were not affected, but flowering was five to ten days later than with untreated flowers.

In 1964, a plant growth retardant formulation named Alar-50 identical to B995 was released by the Chemical Division of United States Rubber Company. In 1965, this company released Alar-85, a new formulation (24).

Cathey (5) reported that Sachs presented a histological basis for understanding the action of growth retardants. Chrysanthemum morifolium Ramat was used with the basal end of rooted cuttings being soaked in solutions of Amo-1618. After four days, he observed that Amo-1618 retarded stem elongation by preventing cell division in the intercalary meristematic zone of the stem. Cell elongation was also retarded in the treated plants. The apical meristem continued to function in the presence of Amo-1618. When the plants were decapitated the lateral buds formed rosette-like structures in the leaf axils indicating that leaf initiation was a function of the apical meristem. Stem elongation, a function of the intercalary meristem, was retarded. As a result of treatment the stems were shorter because of the inhibition of cell division and elongation of the intercalary meristem. In general, the stems were not thickened. It was primarily internode elongation which was retarded by application of Amo-1618 on chrysanthemums.

On certain woody plants, the time of flower initiation was greatly accelerated by treatment with growth retardants. Growth retardants in general apparently promote flowering by modifying activity of the cambium. This results in abnormal types of cells in the xylem and the disappearance of sclerenchymatous cells adjacent to the cortex. The restriction of growth presumably alters the metabolism and creates conditions conducive to flower initiation. The flowers of most plants were not appreciably altered in size by growth-retarding substances (5).

Plants grown in soil treated with the growth retardant phosfon weighed less than those grown in untreated soil. Since the number of nodes and weight of leaves of the treated plants were unaffected, the reduction in weight was primarily due to reduction in stem length. The leaves of all plants grown in soil treated with the growth retardant phosfon were much darker green than those of untreated plants. Foliar applications of the growth retardant B995 at any dosage level enhanced the green color of the foliage as did the phosfon soil treatments (5).

Growth retardants in general then should be considered as anti-metabolites rather than as anti-auxins. They are not analogs of any known growth substance but they apparently give a competitive interaction which is distinguishable from independent effects with the naturally occurring growth substances (5).

Growth retardants are highly specific. There is no obvious correlation between taxonomic classification and plant response to a

particular compound. Even different cultivars of the same species vary in responsiveness to the applied chemical. Growth retardants thus far discovered have been active primarily on dicotyledon plants. They were found to be effective on a few monocotyledon species but have been inactive at all dosage ranges on gymnosperms (5).

In general, any condition favoring rapid growth and concomitant reduction in the concentration of carbohydrates in the developing tissues tend towards the production of a less differentiated type of structure with a corresponding reduction, on a plastochronic basis, of the rate of heteroblastic development. Several authors have found that high temperatures result in the development of a more juvenile type of leaf. The supply of growth substances, whether auxins or gibberellins, often has similar effects. On the other hand, factors favoring carbohydrate accumulation, such as low temperature, low growth rate, and high light intensity are usually associated with the development of a more differentiated, a more xeromorphic type of structure. The difference between sun and shade plants, or sun and shade leaves, illustrate this effect (5).

Light is an important factor in auxin formation, although not a simple one. There is some confusion concerning the necessity of light for auxin formation, but in general it would appear that green plants do require light for this function (12).

Evidence that auxins gradually disappear in darkened plants has been accumulated by several workers. Leopold (12) reported that

Zimmerman and Hitchcock in 1937 demonstrated that darkened tomatoes lose their sensitivity to geotropism and that the sensitivity can be restored by application of auxins to the plants. The formation of auxins in the light and their disappearance in the dark would suggest that a diurnal periodicity of auxin content may be present in a normal growth situation. Evidence for such periodicity in tomatoes has been produced by Went in 1944 as reported by Leopold (12). He found a generally higher auxin concentration during the day followed by a generally lower level at night, though secondary rises and drops also occurred.

The formation of auxin in response to light appears to be a function of leaves. Defoliation of expanding ginkgo twigs reduced the diffusible auxin in the apex 80 per cent in two days. Leopold (12) suggested that this is particularly striking since Gunckel and Thimann in 1949 obtained no diffusible auxin from the leaves themselves. It is suggestive, at least, that the leaves may be supplying a precursor from which auxin is produced in the tip.

Watson and Andrews (25) in 1953 found that plants of the chrysanthemum variety Gold Coast grown under 80 per cent light reduction resulted in greater flowering with temperatures 60-70° F. than in the lower 50-58° F. With 50° F. night temperature, there was no initiation of flower buds after twenty-seven short days while under 60° F. night temperature 99 per cent of the plants initiated flower buds after twenty-seven short days. Plants under normal light intensity showed a

contrast of eleven and ten days in the corresponding 51° and 61° F. night temperatures. It is apparent that the chrysanthemum variety Gold Coast when grown under 80 per cent light reduction required more than twice as long to initiate flowers when compared to those grown under normal daylight. Cathey (6) found that the temperature also altered the critical photoperiod necessary for initiation and development of flowers in several chrysanthemum varieties.

In 1961, Lockhart (13) found that visible radiation has two distinct morphological effects on stem growth. Irradiation reduces total length of stem and generally causes it to become thicker and stiffer as well. The most obvious effect of low intensity irradiation is usually morphological. In many cases low radiation energies may reduce the length of internodes but have little or no effect on plant height.

For the optimum expression and persistence of the effects of growth retardants, the relation to light intensity and temperature should be considered. Cathey (5) reported that Tolbert observed in experiments performed during the winter with growth retardants under low light intensity of short duration, treated wheat plants had the characteristic growth of plants in high intensity light. The chemicals thus reversed the elongated growth pattern obtained with low light intensity. When retested in spring with increasing light intensity and duration, the magnitude of effect with the same concentration was less; the distance between the bases of the first leaf blades

of the untreated plant was less in high light intensity. Applications of CCC also prevented the normal elongation of plants grown with high night temperature.

The dosages required to retard growth of chrysanthemums varied throughout the year. The response of Amo-1618 was less affected than that of other compounds, but the compound was slightly more active in summer than winter. Phosfon was as least twice as effective during summer as during winter. One application of CCC in winter retarded growth of chrysanthemums throughout the eleven weeks of flowering. Cuttings treated with CCC and grown in an air-conditioned greenhouse during summer responded only to dosages higher than those effective in winter. Similar cuttings grown during summer in uncooled greenhouses were unaffected by one application. The differences in response in winter and summer were not the result of the photoperiod, which was controlled, but possibly because of the existing light intensity or temperature or both (5).

CHAPTER III

MATERIALS AND METHODS

The study was conducted on Morgan Farm of the University of Tennessee in the summer of 1965. The plot was on Etowah silty clay loam having good tilth, water holding capacity, and moderate fertility. Four varieties of Chrysanthemum morifolium, Ostosa, Dolliette, Bright Forecast, and Red Mischief, were used. They were purchased as rooted cuttings, potted in 2¼-inch peat pots and placed in the experiment station greenhouse for four weeks before being planted in the field on June 23, 1965. Two weeks prior to field planting a soft pinch, removing about one-fourth inch of the stem terminal, was made to encourage basal branching.

The culture practices were based on those used by Alexander and Staley (1) in their Chrysanthemum morifolium variety trials of 1964.

Six treatments, on all four varieties, were used in the experiment as follows:

1. Normal light (100 per cent intensity), no growth retardant.
2. 75 per cent light intensity, no growth retardant.
3. 50 per cent light intensity, no growth retardant.
4. Normal light, N-dimethyl Amino Succinamic Acid (Alar-50) as .15 per cent active ingredient foliar spray (Alar-50 will be referred to as Alar throughout the remainder of this thesis).

5. 75 per cent light intensity, Alar treatment as in 4.

6. 50 per cent light intensity, Alar treatment as in 4.

Light intensities were determined with a Weston light meter and were controlled by cheesecloth covered frames large enough that growth of plants was not restricted. Each frame contained twenty-four plants set eighteen inches apart in three feet row spacings. Frames were placed over the plants one week after planting and remained in place throughout the experiment.

Three applications of an aqueous solution of .15 per cent Alar, applied at three-day intervals starting one week after field planting, were sprayed on the designated plants until runoff. Spraying was performed in the morning and no rainfall occurred within twenty-four hours after applications.

Data were collected during the flowering period on plant height, number of nodes, plant spread, plant breakage, fresh and dry weight of leaves, peduncle length and fresh weight, inflorescence size, fresh weight, and number of inflorescences and the flowering period.

Measurements were taken on all plants and are reported as averages. Individual plant height was considered as average height of most shoots. Number of nodes was counted on three-inch center sections of six randomly gathered stems. Average spread was treated as the mean of plant diameter. Plant breakage was determined by number of branches broken and is listed as a rating from zero to ten with zero as plant completely broken down and ten as no plant breakage, Fifty leaves were

harvested at random from each plant for fresh weight determinant and dried for twenty-four hours at 70° C. for dry weight determinant. Six peduncles were collected at random from each plant when inflorescences were at anthesis. Inflorescence size, expressed as mean diameter, and fresh weight were determined on six randomly gathered inflorescences at time of anthesis. Inflorescence count consisted of counting all inflorescences on each plant excluding the variety Red Mischief since as a cushion variety it was covered completely with inflorescences. The flowering period extended from anthesis until frost had damaged enough inflorescences as to make the plant unattractive.

Pertinent data were analyzed using Fisher's system of variance analysis as explained by Snedcor (21). Response of varieties to light intensity and growth retardant are reported and some reasons for apparent interactions are suggested.

CHAPTER IV

RESULTS AND DISCUSSION

I. PLANT HEIGHT

The influence of light intensity and Alar on height of chrysanthemum plants is shown in Tables I, II, and III.

Any reduction in light intensity resulted in increased plant height. It was noted from the mean results (Table I) that plants grown under the 75 per cent light intensity increased .86 inch in height as compared to plants grown under normal light intensity. The plants grown under the 50 per cent light intensity increased 2.32 inches in height. Plants grown in full sunlight were the shortest, those grown under 75 per cent light intensity were medium in height, and plants under the 50 per cent light intensity were the tallest.

Alar treated plants were shorter than the untreated plants. According to the data of Table II, Alar treated plants of all varieties were about five inches less in plant height. The tallest varieties without Alar treatment were also the tallest varieties with Alar treatment.

Table III contains the data comparing Alar treated plants to untreated plants under the three light conditions. While plants untreated with Alar increased in height with reduced light intensity,

TABLE I

INFLUENCE OF LIGHT INTENSITY ON HEIGHT
OF CHRYSANTHEMUM PLANTS

Variety	Height of Plants in Inches			Varietal Mean
	100% Light	75% Light	50% Light	
Ostosa	15.33	17.08	17.91	16.77
Dolliette	15.83	16.25	18.16	16.75
Bright Forecast	19.91	20.16	21.99	20.77
Red Mischief	12.08	13.08	14.33	13.07
Exposure Mean	15.78	16.64	18.10	
Exposure Mean L. S. D. at 1%		.80		
Varietal Mean L. S. D. at 1%				.94
Light x Variety L. S. D. at 1%		3.36		

TABLE II

INFLUENCE OF ALAR ON HEIGHT
OF CHRYSANTHEMUM PLANTS

Variety	Height of Plants in Inches		Varietal Mean
	Check	Alar	
Ostosa	19.44	14.10	16.77
Dolliette	19.02	14.47	16.74
Bright Forecast	23.44	18.10	20.77
Red Mischief	15.38	10.77	13.07
Treatment Mean	19.32	14.36	
Treatment Mean L. S. D. at 1%	.67		
Varietal Mean L. S. D. at 1%			.94
Treatment x Variety L. S. D. at 1%	1.75		

TABLE III

INFLUENCE OF ALAR X LIGHT INTENSITY ON HEIGHT OF CHRYSANTHEMUM PLANTS

Treatment	Height of Plants in Inches			Treatment Mean
	100% Light	75% Light	50% Light	
Check	17.72	18.95	21.29	19.32
Alar	13.85	14.33	14.91	14.36
Exposure Mean	15.78	16.64	18.10	
Exposure Mean L. S. D. at 1%		.80		
Treatment Mean L. S. D. at 1%				.67
Treatment x Light L. S. D. at 1%		3.28		

plants treated with Alar showed much less response. Apparently Alar prevented the normal response of chrysanthemums to reduced light intensity.

Considering the height of varieties, Bright Forecast was the tallest. Ostosa and Dolliette were intermediate, and Red Mischief was the shortest.

II. NUMBER OF NODES

The effect of light intensity and Alar on number of nodes on three-inch stem sections of chrysanthemum plants is shown in Tables IV, V, and VI.

The number of nodes present on three-inch stem sections of chrysanthemums was slightly decreased with a 50 per cent reduction in light intensity (Table IV). Differences within light treatment of varieties were similar to the varietal means.

Increased number of nodes on three-inch stem sections occurred on all varieties with Alar treatment (Table V). The Alar treated plants of Red Mischief had an increase in node number of 83 per cent whereas the other varieties increased about 50 per cent in number of nodes when treated.

According to Table VI the number of nodes present on three-inch stem sections was more strongly influenced by Alar than by light intensity. The number of nodes present under maximum light intensity was 5.85 and with minimum light intensity was 5.24. With Alar treated

TABLE IV

EFFECT OF LIGHT INTENSITY ON NUMBER OF NODES ON CHRYSANTHEMUM STEMS

Variety	Number of Nodes on 3-Inch Stem Section			Varietal Mean
	100% Light	75% Light	50% Light	
Ostosa	4.94	4.33	4.33	4.52
Dolliette	6.05	6.06	6.00	6.02
Bright Forecast	4.94	4.33	4.44	4.56
Red Mischief	7.50	7.50	6.22	7.06
Exposure Mean	5.85	5.54	5.24	
Exposure Mean L. S. D. at 1%		.48		
Varietal Mean L. S. D. at 1%				.54
Light x Variety L. S. D. at 1%		1.72		

TABLE V

EFFECT OF ALAR ON NUMBER OF NODES
ON CHRYSANTHEMUM STEMS

Variety	Number of Nodes on 3-Inch Stem Section		Varietal Mean
	Check	Alar	
Ostosa	3.58	5.48	4.52
Dolliette	4.81	7.26	6.02
Bright Forecast	3.66	5.48	4.56
Red Mischief	5.03	9.11	7.06
Treatment Mean	4.26	6.82	
Treatment Mean L. S. D. at 1%		.40	
Varietal Mean L. S. D. at 1%			.54
Treatment x Variety L. S. D. at 1%		.74	

TABLE VI

EFFECT OF ALAR X LIGHT INTENSITY ON NUMBER OF NODES ON CHRYSANTHEMUM STEMS

Treatment	Number of Nodes on 3-Inch Stem Section			Treatment Mean
	100% Light	75% Light	50% Light	
Check	4.66	4.14	4.03	4.26
Alar	7.05	6.97	6.47	6.82
Exposure Mean	5.85	5.54	5.24	
Exposure Mean L. S. D. at 1%		.48		
Treatment Mean L. S. D. at 1%				.40
Treatment x Light L. S. D. at 1%		1.35		

plants the number of nodes was 6.82 whereas untreated plants had 4.26 nodes on three-inch stem sections. Under all light intensities Alar treated plants produced more nodes than untreated plants. Within treatments under the different light intensities no significant difference in number of nodes appeared.

Considering number of nodes on varieties, the shorter varieties, Red Mischief and Dolliette, produced more nodes than the taller varieties.

III. PLANT SPREAD

The influence of light intensity and Alar on spread of chrysanthemum plants is shown in Tables VII, VIII, and IX.

Reduction in light intensity from the normal resulted in increased plant spread (Table VII). Within varieties only Ostosa showed a significant difference in plant spread. Under the 50 per cent light intensity plants of Ostosa were 18.66 inches wide as compared with 14.79 inches under full sunlight.

In all cases, Alar treated plants were narrower plants than the checks (Table VIII). The treated plants were quite compact being about three inches narrower than the untreated plants.

Without Alar treatment the spread of plants of all varieties increased as light decreased. With Alar, however, the increase was not significant (Table IX). Apparently Alar prevented the normal response of chrysanthemums to reduced light intensity.

TABLE VII

INFLUENCE OF LIGHT INTENSITY ON SPREAD
OF CHRYSANTHEMUM PLANTS

Variety	Spread of Plants in Inches			Varietal Mean
	100% Light	75% Light	50% Light	
Ostosa	14.79	17.99	18.66	16.98
Dolliette	14.12	14.41	14.08	14.16
Bright Forecast	14.99	15.99	17.74	16.24
Red Mischief	14.58	16.16	16.50	15.74
Exposure Mean	14.58	16.14	16.62	
Exposure Mean L. S. D. at 1%		1.33		
Varietal Mean L. S. D. at 1%				1.53
Light x Variety L. S. D. at 1%		3.48		

TABLE VIII

INFLUENCE OF ALAR ON SPREAD
OF CHRYSANTHEMUM PLANTS

Variety	Spread of Plants in Inches		Varietal Mean
	Check	Alar	
Ostosa	18.49	15.47	16.98
Dolliette	15.27	13.13	14.16
Bright Forecast	16.88	15.60	16.24
Red Mischief	18.55	12.94	15.74
Treatment Mean	17.29	14.26	
Treatment Mean L. S. D. at 1%	.40		
Varietal Mean L. S. D. at 1%			1.53
Treatment x Variety L. S. D. at 1%	.82		

TABLE IX

INFLUENCE OF ALAR X LIGHT INTENSITY ON SPREAD OF CHRYSANTHEMUM PLANTS

Treatment	Spread of Plants in Inches			Treatment Mean
	100% Light	75% Light	50% Light	
Check	15.70	17.87	18.33	17.29
Alar	13.54	14.41	14.91	14.26
Exposure Mean	14.58	16.14	16.62	
Exposure Mean L. S. D. at 1%		1.33		
Treatment Mean L. S. D. at 1%				.40
Treatment x Light L. S. D. at 1%		1.93		

Of the four varieties in the test only Dolliette had a different spreading habit, tending to be quite upright.

IV. PLANT BREAKAGE

The effect of light intensity and Alar on breakage of chrysanthemum plants in shown in Table X, XI, and XII.

Any reduction in light intensity resulted in increased breakage of plant branches. The data in Table X show that the breakage rating changed from 8.5 to 7.5 with a reduction in light intensity of 25 per cent and to 6.7 with a 50 per cent light reduction. Comparing the data within varieties only plants of Ostosa show an increased breakage rating with light reduction. Under normal light intensity only plants of Dolliette broke more than plants of Red Mischief. Under the 50 per cent and the 75 per cent light intensities plants of Ostosa, Dolliette, and Bright Forecast broke more than plants of Red Mischief.

Alar treated plants did not break as much as the untreated plants (Table XI). Treated plants showed no significant increase in breakage under any light intensity whereas untreated plants broke more under reduced light (Table XII). Since Alar tended to keep the plants shorter and narrower, the plants under reduced light did not break as badly as the untreated plants.

When varieties are compared, plants of Red Mischief broke less than the plants of other varieties.

TABLE X

EFFECT OF LIGHT INTENSITY ON BREAKAGE
OF CHRYSANTHEMUM PLANTS

Variety	Index of Breakage of Branches*			Varietal Mean
	100% Light	75% Light	50% Light	
Ostosa	8.50	7.16	4.33	6.66
Dolliette	7.16	6.16	6.33	6.55
Bright Forecast	8.33	7.00	6.66	7.33
Red Mischief	10.00	9.83	9.50	9.77
Exposure Mean	8.50	7.54	6.70	
Exposure Mean L. S. D. at 5%		.74		
Varietal Mean L. S. D. at 5%				.86
Light x Variety L. S. D. at 5%		1.72		

*10--No breakage
0--Complete breakage

TABLE XI

EFFECT OF ALAR ON BREAKAGE
OF CHRYSANTHEMUM PLANTS

Variety	Index of Breakage of Branches*		Varietal Mean
	Check	Alar	
Ostosa	5.55	7.77	6.66
Dolliette	5.33	7.77	6.55
Bright Forecast	6.44	8.22	7.33
Red Mischief	9.55	10.00	9.77
Treatment Mean	6.72	8.44	
Treatment Mean L. S. D. at 1%		.80	
Varietal Mean L. S. D. at 1%			1.15
Treatment x Variety L. S. D. at 1%		1.69	

*10--No breakage
0--Complete breakage

TABLE XII

EFFECT OF ALAR X LIGHT INTENSITY ON BREAKAGE
OF CHRYSANTHEMUM PLANTS

Treatment	Index of Breakage of Branches*			Treatment Mean
	100% Light	75% Light	50% Light	
Check	8.16	6.58	5.41	6.72
Alar	8.83	8.50	8.00	8.44
Exposure Mean	8.50	7.54	6.70	
Exposure Mean L. S. D. at 5%		.74		
Treatment Mean L. S. D. at 1%				.80
Treatment x Light L. S. D. at 1%		1.90		

*10--No breakage
0--Complete breakage

V. FRESH WEIGHT, DRY WEIGHT, AND PERCENTAGE DRY WEIGHT OF LEAVES

The effect of light intensity and Alar on fresh weight, dry weight, and percentage dry weight of chrysanthemum leaves is shown in Tables XIII through XXI.

Reduction of light intensity from the normal resulted in an increase in size of leaf (Tables XIII and XVI) and a decrease in percentage of dry weight (Table XIX).

Alar treatment resulted in an increase in leaf size (Tables XIV and XVII) and a decrease in the percentage of dry weight (Table XX).

When combined the increase in fresh weight ascribable to Alar and reduction in light intensity was 7.16 grams per 50 leaves; 3.94 grams can be considered as due to reduced light intensity and 3.22 grams can be ascribed to the treatment of Alar. In terms of dry weight, .20 grams can be ascribed to reduction in light intensity and .15 grams considered as due to the treatment of Alar. The reduction in percentage of dry weight due to reduced light intensity appears to be 5.95 per cent whereas 1.03 per cent reduction can be ascribed as due to the treatment of Alar. As would be expected, light was the primary influence in accumulation of dry weight. The effect of Alar in this direction is probably related to the increased photosynthetic area.

VI. PEDUNCLE LENGTH AND FRESH WEIGHT

The influence of light intensity and Alar on length and fresh weight of chrysanthemum peduncles is shown in Tables XXII through XXVII.

TABLE XIII

EFFECT OF LIGHT INTENSITY ON FRESH WEIGHT
OF CHRYSANTHEMUM LEAVES

Variety	Weight in Grams of 50 Leaves			Varietal Mean
	100% Light	75% Light	50% Light	
Ostosa	3.98	7.85	8.06	6.63
Dolliette	15.14	17.78	18.26	17.06
Bright Forecast	11.99	18.58	21.48	17.35
Red Mischief	4.31	8.28	6.91	6.50
Exposure Mean	8.86	13.12	13.68	
Exposure Mean L. S. D. at 1%		.80		
Varietal Mean L. S. D. at 1%				.93
Light x Variety L. S. D. at 1%		2.44		

TABLE XIV

EFFECT OF ALAR ON FRESH WEIGHT
OF CHRYSANTHEMUM LEAVES

Variety	Weight in Grams of 50 Leaves		Varietal Mean
	Check	Alar	
Ostosa	5.50	7.76	6.63
Dolliette	16.95	17.17	17.06
Bright Forecast	14.99	19.70	17.35
Red Mischief	5.51	7.49	6.50
Treatment Mean	10.74	13.03	
Treatment Mean L. S. D. at 1%		.67	
Varietal Mean L. S. D. at 1%			.93
Treatment x Variety L. S. D. at 5%		2.32	

TABLE XV

EFFECT OF ALAR X LIGHT INTENSITY ON FRESH WEIGHT OF CHRYSANTHEMUM LEAVES

Treatment	Weight in Grams of 50 Leaves			Treatment Mean
	100% Light	75% Light	50% Light	
Check	8.13	12.01	12.07	10.74
Alar	9.59	14.23	15.29	13.03
Exposure Mean	8.86	13.12	13.68	
Exposure Mean L. S. D. at 1%		.80		
Treatment Mean L. S. D. at 1%				.67
Treatment x Light L. S. D. at 5%		4.66		

TABLE XVI

EFFECT OF LIGHT INTENSITY ON DRY WEIGHT
OF CHRYSANTHEMUM LEAVES

Variety	Weight in Grams of 50 Leaves			Varietal Mean
	100% Light	75% Light	50% Light	
Ostosa	.66	1.11	.96	.91
Dolliette	3.84	3.40	3.46	3.57
Bright Forecast	3.13	3.69	4.15	3.66
Red Mischief	1.10	1.51	1.24	1.28
Exposure Mean	2.18	2.43	2.45	
Exposure Mean L. S. D. at 1%		.18		
Varietal Mean L. S. D. at 1%				.24
Light x Variety L. S. D. at 5%		.30		

TABLE XVII

EFFECT OF ALAR ON DRY WEIGHT
OF CHRYSANTHEMUM LEAVES

Variety	Weight in Grams of 50 Leaves		Varietal Mean
	Check	Alar	
Ostosa	.77	1.05	.91
Dolliette	3.71	3.43	3.57
Bright Forecast	3.37	3.94	3.66
Red Mischief	1.15	1.42	1.28
Treatment Mean	2.25	2.46	
Treatment Mean L. S. D. at 1%		.16	
Varietal Mean L. S. D. at 1%			.24
Treatment x Variety L. S. D. at 1%		.37	

TABLE XVIII

EFFECT OF ALAR X LIGHT INTENSITY ON DRY WEIGHT OF CHRYSANTHEMUM LEAVES

Treatment	Weight in Grams of 50 Leaves			Treatment Mean
	100% Light	75% Light	50% Light	
Check	2.10	2.35	2.30	2.25
Alar	2.27	2.50	2.60	2.46
Exposure Mean	2.18	2.43	2.45	
Exposure Mean L. S. D. at 1%		.18		
Treatment Mean L. S. D. at 1%				.16
Treatment x Light L. S. D. at 1%		1.46		

TABLE XIX

EFFECT OF LIGHT INTENSITY ON PERCENTAGE OF DRY WEIGHT OF CHRYSANTHEMUM LEAVES

Variety	Per Cent of Dry Matter			Varietal Mean
	100% Light	75% Light	50% Light	
Ostosa	16.82	14.41	11.79	14.34
Dolliette	25.38	19.10	18.96	21.15
Bright Forecast	26.52	19.98	19.44	21.98
Red Mischief	25.42	18.39	18.73	20.85
Exposure Mean	23.54	17.97	17.23	
Exposure Mean L. S. D. at 1%		1.60		
Varietal Mean L. S. D. at 1%				1.87
Light x Variety L. S. D. at 5%		2.40		

TABLE XX

EFFECT OF ALAR ON PERCENTAGE OF DRY WEIGHT
OF CHRYSANTHEMUM LEAVES

Variety	Per Cent of Dry Matter		Varietal Mean
	Check	Alar	
Ostosa	14.35	14.33	14.34
Dolliette	22.14	20.15	21.15
Bright Forecast	23.44	20.52	21.98
Red Mischief	21.69	19.99	20.85
Treatment Mean	20.41	18.75	
Treatment Mean L. S. D. at 1%		1.31	
Varietal Mean L. S. D. at 1%			1.87
Treatment x Variety L. S. D. at 1%		4.40	

TABLE XXI

EFFECT OF ALAR X LIGHT INTENSITY ON PERCENTAGE OF DRY WEIGHT OF CHRYSANTHEMUM LEAVES

Treatment	Per Cent of Dry Matter			Treatment Mean
	100% Light	75% Light	50% Light	
Check	24.21	18.75	18.26	20.41
Alar	22.87	17.19	16.20	18.75
Exposure Mean	23.54	17.97	17.23	
Exposure Mean L. S. D. at 1%		1.60		
Treatment Mean L. S. D. at 1%				1.31
Treatment x Light L. S. D. at 1%		3.97		

TABLE XXII

INFLUENCE OF LIGHT INTENSITY ON LENGTH OF CHRYSANTHEMUM PEDUNCLES

Variety	Length of Peduncles in Inches			Varietal Mean
	100% Light	75% Light	50% Light	
Ostosa	3.07	3.43	3.67	3.38
Dolliette	2.47	2.17	2.60	2.40
Bright Forecast	3.37	4.19	4.45	3.99
Red Mischief	1.20	1.08	1.31	1.19
Exposure Mean	2.52	2.71	2.99	
Exposure Mean L. S. D. at 1%		.19		
Varietal Mean L. S. D. at 1%				.23
Light x Variety L. S. D. at 1%		.98		

TABLE XXIII

INFLUENCE OF ALAR ON LENGTH OF CHRYSANTHEMUM PEDUNCLES

Variety	Length of Peduncles in Inches		Varietal Mean
	Check	Alar	
Ostosa	4.13	2.63	3.38
Dolliette	2.74	2.07	2.40
Bright Forecast	4.90	3.09	3.99
Red Mischief	1.34	1.04	1.19
Treatment Mean	3.27	2.20	
Treatment Mean L. S. D. at 1%		.14	
Varietal Mean L. S. D. at 1%			.23
Treatment x Variety L. S. D. at 1%		.40	

TABLE XXIV

INFLUENCE OF ALAR X LIGHT INTENSITY ON LENGTH OF CHRYSANTHEMUM PEDUNCLES

Treatment	Length of Peduncles in Inches			Treatment Mean
	100% Light	75% Light	50% Light	
Check	2.94	3.29	3.63	3.27
Alar	2.11	2.15	2.38	2.20
Exposure Mean	2.52	2.71	2.99	
Exposure Mean L. S. D. at 1%		.19		
Treatment Mean L. S. D. at 1%				.14
Treatment x Light L. S. D. at 5%		.94		

TABLE XXV

EFFECT OF LIGHT INTENSITY ON FRESH WEIGHT OF CHRYSANTHEMUM PEDUNCLES

Variety	Weight in Grams of 6 Peduncles			Varietal Mean
	100% Light	75% Light	50% Light	
Ostosa	1.30	1.33	1.55	1.39
Dolliette	.77	.62	.82	.73
Bright Forecast	1.55	1.60	1.96	1.70
Red Mischief	.18	.12	.15	.14
Exposure Mean	.94	.19	1.11	
Exposure Mean L. S. D. at 1%		.12		
Varietal Mean L. S. D. at 1%				.15
Light x Variety L. S. D. at 5%		.28		

TABLE XXVI

EFFECT OF ALAR ON FRESH WEIGHT
OF CHRYSANTHEMUM PEDUNCLES

Variety	Weight in Grams of 6 Peduncles		Varietal Mean
	Check	Alar	
Ostosa	1.56	1.23	1.39
Dolliette	.83	.65	.73
Bright Forecast	2.12	1.29	1.70
Red Mischief	.17	.13	.14
Treatment Mean	1.16	.82	
Treatment Mean L. S. D. at 1%		.10	
Varietal Mean L. S. D. at 1%			.15
Treatment x Variety L. S. D. at 5%		.16	

TABLE XXVII

EFFECT OF ALAR X LIGHT INTENSITY ON FRESH WEIGHT OF CHRYSANTHEMUM PEDUNCLES

Treatment	Weight in Grams of 6 Peduncles			Treatment Mean
	100% Light	75% Light	50% Light	
Check	1.13	1.05	1.32	1.16
Alar	.77	.79	.92	.82
Exposure Mean	.94	.91	1.11	
Exposure Mean L. S. D. at 1%		.12		
Treatment Mean L. S. D. at 1%				.10
Treatment x Light L. S. D. at 5%		N. S.		

In general (Table XXII), any reduction in light intensity resulted in increased length of peduncles. However, peduncles of two varieties, Dolliette and Red Mischief, appear to be unaffected. Peduncle weights (Table XXV) were also unaffected for these two varieties. Ostosa and Bright Forecast produced longer peduncles under the low light conditions but the peduncle weight does not seem to have increased proportionately. These lighter peduncles may have contributed to breakage.

Alar treatment resulted in shorter peduncles (Table XXIII). A comparison between peduncle fresh weight and length indicates that the peduncles of Alar treated plants should be stronger than those on untreated plants (Tables XXIV and XXVII). This difference is greater for Ostosa and Bright Forecast, two varieties subject to breakage.

According to the data in Table XXIV, peduncle length remains approximately the same regardless of light intensity when Alar is used to control growth. Peduncles were signficantly shorter under 75 per cent and 50 per cent light intensities with Alar as compared to peduncles of untreated plants. The peduncles of the treated plants under low light intensity had the characteristic growth of peduncles on plants grown in full sunlight.

Considering varieties, peduncles of Bright Forecast were larger (longer and weighed more) than those of Ostosa. Peduncles of Ostosa were larger than those of Dolliette, whereas Red Mischief had the smallest peduncles.

VII. INFLORESCENCE SIZE AND FRESH WEIGHT

The influence of light intensity and Alar on inflorescence size (mean diameter) and fresh weight is shown in Tables XXVIII through XXXIII.

In general a 50 per cent light reduction resulted in increased inflorescence diameter (Table XXVIII). However, analysis of the varieties show Ostosa and Red Mischief the only two varieties with increased diameter of inflorescences. No significant difference occurred in fresh weight of any of the varieties due to light.

Alar treatment resulted in increased inflorescence size of Ostosa and Dolliette, but there was no change in inflorescences of Bright Forecast or Red Mischief.

Considering varieties, Ostosa produced the largest inflorescences and Red Mischief the smallest.

VIII. NUMBER OF INFLORESCENCES

The influence of light intensity and Alar on number of chrysanthemum inflorescences is shown in Tables XXXIV, XXXV, and XXXVI.

When light was reduced by 50 per cent the number of inflorescences on plants increased (Table XXXIV).

Alar treated plants had fewer inflorescences than untreated plants (Table XXXV). This would be expected since the Alar treated plants were much smaller in size as previously shown. In general, the tendency of Alar to minimize the effects of light is apparent

TABLE XXVIII

INFLUENCE OF LIGHT INTENSITY ON INFLORESCENCE SIZE OF CHRYSANTHEMUMS

Variety	Mean Diameter in Inches			Varietal Mean
	100% Light	75% Light	50% Light	
Ostosa	2.37	2.38	2.48	2.41
Dolliette	2.08	2.08	2.13	2.09
Bright Forecast	1.70	1.66	1.75	1.70
Red Mischief	.92	1.00	1.03	.98
Exposure Mean	1.77	1.78	1.85	
Exposure Mean L. S. D. at 1%		.08		
Varietal Mean L. S. D. at 1%				.09
Light x Variety L. S. D. at 1%		.11		

TABLE XXIX

INFLUENCE OF ALAR ON INFLORESCENCE SIZE
OF CHRYSANTHEMUMS

Variety	Mean Diameter in Inches		Varietal Mean
	Check	Alar	
Ostosa	2.34	2.48	2.41
Dolliette	2.03	2.16	2.09
Bright Forecast	1.69	1.71	1.70
Red Mischief	.95	1.02	.98
Treatment Mean	1.75	1.84	
Treatment Mean L. S. D. at 1%		.06	
Varietal Mean L. S. D. at 1%			.09
Treatment x Variety L. S. D. at 1%		.12	

TABLE XXX

INFLUENCE OF ALAR X LIGHT INTENSITY ON SIZE
OF CHRYSANTHEMUM INFLORESCENCES

Treatment	Mean Diameter in Inches			Treatment Mean
	100% Light	75% Light	50% Light	
Check	1.73	1.73	1.80	1.75
Alar	1.80	1.84	1.89	1.84
Exposure Mean	1.77	1.78	1.85	
Exposure Mean L. S. D. at 1%		.08		
Treatment Mean L. S. D. at 1%				.06
Treatment x Light L. S. D. at 5%		N. S.		

TABLE XXXI

EFFECT OF LIGHT INTENSITY ON FRESH WEIGHT
OF CHRYSANTHEMUM INFLORESCENCES

Variety	Weight in Grams of 6 Inflorescences			Varietal Mean
	100% Light	75% Light	50% Light	
Ostosa	17.41	17.44	17.59	17.48
Dolliette	8.82	8.26	8.82	8.63
Bright Forecast	14.69	14.84	17.57	15.70
Red Mischief	1.27	1.46	1.70	1.47
Exposure Mean	10.54	10.50	11.42	
Exposure Mean L. S. D. at 5%		N. S.		
Varietal Mean L. S. D. at 1%				1.28
Light x Variety L. S. D. at 5%		1.79		

TABLE XXXII

EFFECT OF ALAR ON FRESH WEIGHT
OF CHRYSANTHEMUM INFLORESCENCES

Variety	Weight in Grams of 6 Inflorescences		Varietal Mean
	Check	Alar	
Ostosa	16.51	18.46	17.48
Dolliette	8.53	8.73	8.63
Bright Forecast	16.11	15.29	15.70
Red Mischief	1.35	1.60	1.47
Treatment Mean	10.62	10.82	
Treatment Mean L. S. D. at 5%		N. S.	
Varietal Mean L. S. D. at 1%			1.28
Treatment x Variety L. S. D. at 5%		N. S.	

TABLE XXXIII

EFFECT OF ALAR X LIGHT INTENSITY ON FRESH WEIGHT OF CHRYSANTHEMUM INFLORESCENCES

Treatment	Weight in Grams of 6 Inflorescences			Treatment Mean
	100% Light	75% Light	50% Light	
Check	10.95	9.80	11.12	10.62
Alar	10.14	11.20	11.73	11.02
Exposure Mean	10.54	10.50	11.42	
Exposure Mean L. S. D. at 5%		N. S.		
Treatment Mean L. S. D. at 5%				N. S.
Treatment x Light L. S. D. at 5%		N. S.		

TABLE XXXIV

EFFECT OF LIGHT INTENSITY ON NUMBER OF CHRYSANTHEMUM INFLORESCENCES

Variety	Number of Inflorescences Per Plant			Varietal Mean
	100% Light	75% Light	50% Light	
Ostosa	52	63	79	65
Dolliette	71	99	98	89
Bright Forecast	79	59	86	75
Exposure Mean	67	75	88	
Exposure Mean L. S. D. at 5%		10		
Varietal Mean L. S. D. at 5%				10
Light x Variety L. S. D. at 5%		18		

TABLE XXXV

EFFECT OF ALAR ON NUMBER OF CHRYSANTHEMUM INFLORESCENCES

Variety	Number of Inflorescences Per Plant		Varietal Mean
	Check	Alar	
Ostosa	75	55	65
Dolliette	98	80	89
Bright Forecast	80	69	75
Treatment Mean	84	68	
Treatment Mean L. S. D. at 1%		10	
Varietal Mean L. S. D. at 5%			10
Treatment x Variety L. S. D. at 5%		14	

TABLE XXXVI

EFFECT OF ALAR X LIGHT INTENSITY ON NUMBER OF CHRYSANTHEMUM INFLORESCENCES

Treatment	Number of Inflorescences Per Plant			Treatment Mean
	100% Light	75% Light	50% Light	
Check	72	83	83	84
Alar	62	64	77	68
Exposure Mean	67	74	88	
Exposure Mean L. S. D. at 5%		10		
Treatment Mean L. S. D. at 1%				10
Treatment x Light L. S. D. at 5%		13		

since a decrease in the amount of light brought about an increased number of inflorescences while addition of Alar tended to reduce the number (Table XXXVI). The increase apparently due to 50 per cent light reduction is twenty-six, whereas the decrease in inflorescence number due to the treatment of Alar is twenty-one.

IX. FLOWERING PERIOD

Effect of light intensity and Alar on date of flowering (time of anthesis) and the termination date of flowering (considered when flowers were damaged enough by frost so as to make the general appearance of the plant unattractive) is shown in Tables XXXVII through XLII.

Reduced light from the normal intensity delayed flowering and the termination date of flowering (Tables XXXVII and XL). Reduction of the light intensity by 25 and 50 per cent delayed flowering six days.

Alar treatment resulted in plants flowering earlier but apparently had no effect on termination date of flowering (Tables XXXVIII and XLI).

If Alar is considered alone there is some slight indication that some varieties may be affected by it. Dolliette flowered four days earlier when treated with the chemical (Table XXXVIII).

Data were taken on flowering termination dates. Two varieties, Ostosa and Dolliette, completed flowering five days earlier than Bright Forecast and Red Mischief. No difference appeared due to Alar.

TABLE XXXVII

INFLUENCE OF LIGHT INTENSITY ON DATE OF FLOWERING OF CHRYSANTHEMUMS

Variety	100% Light	75% Light	50% Light	Varietal Mean
Ostosa	Oct. 14	Oct. 25	Oct. 25	Oct. 21
Dolliette	Oct. 14	Oct. 22	Oct. 22	Oct. 19
Bright Forecast	Oct. 25	Oct. 29	Oct. 30	Oct. 28
Red Mischief	Oct. 25	Oct. 28	Oct. 28	Oct. 27
Exposure Mean	Oct. 20	Oct. 26	Oct. 26	
Exposure Mean L. S. D. at 1%		.25		
Varietal Mean L. S. D. at 1%				.25
Light x Variety L. S. D. at 1%		1.15		

TABLE XXXVIII

INFLUENCE OF ALAR ON DATE OF FLOWERING
OF CHRYSANTHEMUMS

Variety	Check	Alar	Varietal Mean
Ostosa	Oct. 21	Oct. 21	Oct. 21
Dolliette	Oct. 21	Oct. 17	Oct. 19
Bright Forecast	Oct. 28	Oct. 28	Oct. 28
Red Mischief	Oct. 27	Oct. 27	Oct. 27
Treatment Mean	Oct. 24	Oct. 23	
Treatment Mean L. S. D. at 1%	.20		
Varietal Mean L. S. D. at 1%			.25
Treatment x Variety L. S. D. at 1%	.35		

TABLE XXXIX

INFLUENCE OF ALAR X LIGHT INTENSITY ON DATE OF FLOWERING OF CHRYSANTHEMUMS

Treatment	100% Light	75% Light	50% Light	Treatment Mean
Check	Oct. 20	Oct. 27	Oct. 27	Oct. 24
Alar	Oct. 20	Oct. 25	Oct. 25	Oct. 23
Exposure Mean	Oct. 20	Oct. 26	Oct. 26	
Exposure Mean L. S. D. at 1%		.25		
Treatment Mean L. S. D. at 1%				.25
Treatment x Light L. S. D. at 1%		1.50		

TABLE XL

EFFECT OF LIGHT INTENSITY ON TERMINATION
OF FLOWERING PERIOD OF CHRYSANTHEMUMS

Variety	100% Light	75% Light	50% Light	Varietal Mean
Ostosa	Nov. 5	Nov. 15	Nov. 15	Nov. 12
Dolliette	Nov. 5	Nov. 15	Nov. 15	Nov. 12
Bright Forecast	Nov. 15	Nov. 18	Nov. 18	Nov. 17
Red Mischief	Nov. 15	Nov. 18	Nov. 18	Nov. 17
Exposure Mean	Nov. 10	Nov. 17	Nov. 17	
Exposure Mean L. S. D. at 1%		.25		
Varietal Mean L. S. D. at 1%				.25
Light x Variety L. S. D. at 1%		1.15		

Frost occurred on Nov. 2.

TABLE XLI

EFFECT OF ALAR ON TERMINATION OF FLOWERING PERIOD OF CHRYSANTHEMUMS

Variety	Check	Alar	Varietal Mean
Ostosa	Nov. 12	Nov. 12	Nov. 12
Dolliette	Nov. 12	Nov. 12	Nov. 12
Bright Forecast	Nov. 17	Nov. 17	Nov. 17
Red Mischief	Nov. 17	Nov. 17	Nov. 17
Treatment Mean	Nov. 15	Nov. 15	
Treatment Mean L. S. D. at 1%		N. S.	
Varietal Mean L. S. D. at 1%			.25
Treatment x Variety L. S. D. at 1%		N. S.	

Frost occurred on Nov. 2.

TABLE XLII

EFFECT OF ALAR X LIGHT INTENSITY ON TERMINATION
OF FLOWERING PERIOD OF CHRYSANTHEMUMS

Treatment	100% Light	75% Light	50% Light	Treatment Mean
Check	Nov. 10	Nov. 17	Nov. 17	Nov. 15
Alar	Nov. 10	Nov. 17	Nov. 17	Nov. 15
Exposure Mean	Nov. 10	Nov. 17	Nov. 17	
Exposure Mean L. S. D. at 1%		.25		
Treatment Mean L. S. D. at 1%				N. S.
Treatment x Light L. S. D. at 1%		N. S.		

Frost occurred on Nov. 2.

The seven-day difference in termination of flowering between the full sunlight chrysanthemums and the shade group is probably due to protection from frost combined with reduced light intensity.

CHAPTER V

SUMMARY AND CONCLUSION

The study of the effects of light intensity and N-dimethyl amino succinamic acid (Alar) on morphological development of four Chrysanthemum morifolium varieties was carried out during the summer of 1965 on Morgan Farm of the University of Tennessee, Knoxville.

When light intensity was reduced 25 per cent some morphological changes were apparent. Plants were taller and more spreading. There were fewer nodes per stem section. Leaves were larger. Peduncle length and stem length increased resulting in a more fragile plant. Percentage of dry weight was less. More inflorescences were produced. Flowering was delayed as was the termination of the flowering period. With a light reduction of 50 per cent most of these changes were enhanced.

Plants treated with three applications of an aqueous solution of .15 per cent N-dimethyl amino succinamic acid resulted in shorter plants with larger, darker green leaves. The stems and peduncles were shorter, and there were fewer inflorescences per plant. More nodes appeared per stem section. Inflorescence size and flowering date were not modified to any extent.

In general it appears that some varieties respond more to reduced light and Alar treatment than others. From the results it appears that

the cushion type chrysanthemums, such as Red Mischief, may be satisfactorily grown under partial shade without any chemical growth retardant treatment. Indications are that plants of the intermediate and taller varieties can be more attractive under partial shade with Alar treatment than those not treated. Although Alar treated plants were smaller than untreated ones they made attractive plants when grown under reduced light intensities whereas the untreated plants were spindly and were subject to more breakage.

In summary, the combined effects of partial shade with Alar resulted in attractive plants with good flowering characteristics but somewhat later in flowering than those grown in full sun.

LITERATURE CITED

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1. Alexander, J. S. and J. G. Staley. 1965. Hardy Chrysanthemums for the Garden. Tenn. Farm and Home Sci. 55:18-19.

2. Anonymous. 1965. Retardants Improve Growth of Standards. Hort. Abs. 35:642.

3. Boysen, J. P. 1936. Growth Hormones in Plants. McGraw-Hill Book Co., New York, N. Y.

4. Cabler, J. F. 1966. The Effect of Phosfon on Growth of Chrysanthemum morifolium "Blue Chip." Hort. Abs. 36:158.

5. Cathey, H. M. 1964. Physiology of Growth Retarding Chemicals. Ann. Rev. Plant Physiol. 15:271-302.

6. Cathey, H. M. 1957. The Effect of Temperature Upon Critical Photoperiod Necessary for Initiation and Development of Flowers of Chrysanthemum morifolium. Proc. Amer. Soc. Hort. Sci. 69: 485-491.

7. Cathey, H. M. and P. C. Marth. 1960. Effectiveness of a Quaternary Ammonium Carbamate and a Phosphonium in Controlling Growth of Chrysanthemum morifolium "Ramat." Proc. Amer. Soc. Hort. Sci. 76:609-619.

8. Crowder, J. 1958. Shorter Chrysanthemums for Pots and Gardens. Hort. Mag. 36:529.

9. Culbert, J. R. 1966. Longer Life for Chrysanthemum Flowers. Hort. Abs. 36:157.

10. Gortz, H. 1965. B-Nine. Hort. Abs. 35:642.

11. Gowing, D. P. and R. W. Leeper. 1955. Induction of Flowering in Pineapple by Beta-Hydroxyethyl Hydrazine. Science. 122:1267.

12. Leopold, A. C. 1955. Auxins and Plant Growth. University of Calif. Press, Berkeley and Los Angeles, Calif.

13. Lockhart, J. A. 1961. Morphological Effects of Visible Radiation. Plant Growth Reg. 4:543-544.

14. Mastalerz, J. W. 1960. Chemicals Added to Soil Shorten Greenhouse Plants. Pa. Sci. Farmer. 7(4):7.

15. Mastalerz, J. W. and F. J. Campbell. 1956. Maleic Hydrazide--A Substitute for Pinching Potted Chrysanthemums. Proc. Amer. Soc. Hort. Sci. 68:511-517.

16. Mitchell, J. W., J. W. Wirwille and L. Weil. 1949. Plant Growth-Regulating Properties of Some Nicotinium Compounds. Science. 110:252-254.

17. Poole, R. T. 1966. The Effect of Phosfon on Growth and Flowering of Chrysanthemum morifolium "Blue Chip." Hort. Abs. 36:157.

18. Powell, E. N. and R. C. Andreasen. 1957. Responses of Bench-Grown Chrysanthemum morifolium to Maleic Hydrazide. Proc. Amer. Soc. Hort. Sci. 70:482-489.

19. Preston, W. H. Jr. and C. B. Link. 1958. Use of 2,4-Dichlorobenzyltributylphosphonium Chloride to Dwarf Plants. Plant Physiol. 33:xlix.

20. Riddell, J. A., H. A. Hageman, C. M. J'Anthony and W. L. Hubbard. 1962. Retardation of Plant Growth by a New Group of Chemicals. Science. 136:391.

21. Snedecor, G. W. 1946. Statistical Methods. 4th ed. The Iowa State College Press, Ames, Iowa.

22. Tolbert, N. E. 1960. (2-Chloroethyl) Trimethylammonium Chloride and Related Compounds as Plant Growth Substances. J. Biol. Chem. 235:475-479.

23. Tukey, H. B. 1954. Plant Regulators in Agriculture. John Wiley and Sons, Inc., New York, N. Y.

24. United States Rubber Co. Alar-85 Infor. Bull. No. 306-R5A. Naugatuck, Conn.

25. Watson, D. P. and P. S. Andrews. 1953. The Effect of Light Intensity on the Flowering of Chrysanthemum Variety Gold Coast. Proc. Amer. Soc. Hort. Sci. 61:551-554.

26. Wirwille, J. W. and J. W. Mitchell. 1950. Six New Plant Growth Inhibiting Compounds. Botan. Gaz. 111:491-494.

27. Yoder Bros. Inc. 1965. B-Nine Reduces Neckiness of Natural Standard Chrysanthemums. Hort. Abs. 35:403.