

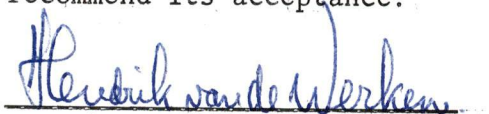
August 5, 1968

To the Graduate Council:

I am submitting herewith a thesis written by Byoung Moon Choo entitled "A Study of Several Methods to Extend the Shelf Life of Cut Chrysanthemum Morifolium." 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.

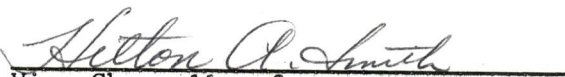

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Vice Chancellor for
Graduate Studies and Research

A STUDY OF SEVERAL METHODS TO EXTEND THE
SHELF LIFE OF CUT CHRYSANTHEMUM MORIFOLIUM

A Thesis
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Byoung Moon Choo

August 1968

ACKNOWLEDGMENT

The author is sincerely grateful to many people who have provided assistance during the writing of this thesis. Professor H. van de Werken, under whose guidance the study was completed, is due special attention.

A special vote of thanks is owed to Dr. B. S. Pickett, Head of the Department, for his careful guidance in the organization of this study. Appreciation is also extended to Professor J. Alexander for his suggestions relating to this work.

The writer wishes to express appreciation to his parents and to his wife, Soonja, for their unlimited encouragement and support.

ABSTRACT

The effects of three growth retardants, Methyl-2-chloro-9-hydroxy-fluorene-(9)-carboxylate (Morphactine IT 3456) at 40 ppm, N-dimethyl amino succinamic acid (B 995) at 300 ppm, and 2,4-dichlorophenoxyacetic acid (2,4-D) at 50 ppm and controlled atmosphere storage, 5% oxygen in 95% nitrogen and 5% carbon dioxide in air, on shelf life of cut Chrysanthemum morifolium 'Indianapolis' were studied. The chrysanthemum flowers were held in the growth chamber at temperatures from 32 to 34 degrees F. with 1,000 foot candles of light intensity for six days while they were subjected to various treatments. After removal from the environator, all flowers were placed in tap water in open air in a room maintained at temperatures from 66 to 70 degrees F. with a light intensity of 20 foot candles.

Flowers in IT 3456 treatment showed that this chemical maintained the quality of flowers for six days and delayed the control. B 995 did not show better results than the control, however, 2,4-D stimulated the physiological processes of chrysanthemum flowers causing early senescence.

Neither decreased oxygen nor increased carbon dioxide levels showed to be of benefit.

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CHAPTER I

INTRODUCTION

Quality control of horticultural products after harvest continues to interest plant physiologists. Intent of prolonging the life of cut flowers belongs to this category. Although cut chrysanthemum flowers last longer than roses and carnations, they stay in saleable condition for only two weeks after cutting when kept at 35 degrees F.

Many problems exist in the holding of cut flowers. Some of the factors affecting keeping quality of cut flowers are temperature, humidity, air circulation, atmospheric composition, other products such as ethylene gas, light intensity, size of bunching, water condition and prepackaging. Therefore, improved quality maintenance of cut flowers could be obtained by controlling and modifying these factors during storage.

Customers obtain their cut flowers through the retailer, who obtained them from the wholesale florists, wholesale growers, and shippers or assemblers (27). If the retailer is in an area 100 miles or less from the flower producer or wholesaler, flowers can arrive at the retailer within a few hours after they are harvested. When shipping flowers from greater distances, it may take several days. At the retail shop, flowers must often be stored for a period of time until they are sold to the public.

According to Moore (27), average spoilage losses to retail florists are 10 cents per dollar. Therefore, control of spoilage losses by environmental modification is of great importance. White (49) reports that at 35 degrees F., cut chrysanthemum flowers can be stored perfectly for two weeks without any other modified condition. If the freshness of cut chrysanthemum flowers can be extended beyond two weeks by environmental modifications or use of growth regulators or both, it will be helpful in reducing the amount of spoilage losses to the retailer and in extending the vase-life of cut chrysanthemums for the public.

A number of studies have shown that the "controlled atmosphere storage," developed by F. Kidd and C. West in England, and several growth retarding chemicals extend shelf life of some horticultural crops. Reduction of the rate of respiration, by both increased carbon dioxide concentrations or decreased oxygen level, has been one of the most efficient methods of prolonging the storage-life of horticultural crops.

The objective of this study has been to investigate the effects of growth regulators, 2,4-dichlorophenoxyacetic acid (2,4-D), N-dimethyl amino succinamic acid (B 995 or Alar), and Methyl-2-chloro-9-hydroxyfluorene-(9)-carboxylate (Morphactin IT 3456), and "controlled atmosphere storage" on the quality of cut chrysanthemum flowers during and after storage.

CHAPTER II

REVIEW OF LITERATURE

1. GENERAL METHOD

Temperature

Cold storage has been used to extend the life of cut flowers. Hitchcock et al. (12) found from their early study that low temperature (5 to 10 degrees C.) and high humidity are effective in prolonging the life of cut flowers. Neff et al. (30) stored marigolds at temperatures of 33 and 40 degrees F. They found that dry storage at 40 degrees F. gave better results than 33 degrees F. stored in water. Fischer (5) recommended 31 degrees F. as optimum storage temperature for flowers. A different report was made by Whiteman (50). He reported that the recommended temperature for cut flowers is 35 degrees F. According to U. S. D. A. (42), the average freezing point of chrysanthemum petals is 28.4 degrees F. and 29.6 F. for the leaves. However, the majority of investigators report that the optimum storage temperature for most species of cut flowers lies between 31 to 33 degrees F. Similar reports for vegetable crops have been made by Parsons (34). He suggests that most vegetables kept best at 32 degrees F.

Light

The effect of light on the physiology of plants has long been a well-known fact. Intensity, quality, and duration of light, all effect plant

physiology. Woltz et al. (51) report that light and refrigeration each prolong the storage life of cut flowers. Mitchell (24) found a side effect of light on plants. In a study with bean plants, he found that more of a growth-retarding chemical was absorbed by illuminated plants than by those kept in darkness.

Nitrogen Levels in Soil

The nitrogen level in the soil appears to be another possible influence on the keeping quality of cut chrysanthemums. Matstalerz (22) reports that soil nitrate had no apparent effect on the life and quality of cut carnations and chrysanthemums. A similar result was obtained by Wesenberg et al. (48). According to their study, chrysanthemum flower longevity was not affected appreciably by the method of fertilizer application during the last half of the production period. Different results were obtained by Waters (45,46). He reports that keeping quality of chrysanthemum flowers was increased sharply when nitrogen or total fertilizer was reduced during the latter part of the growing season. Woltz et al. (51) made a similar report.

II. USE OF CHEMICALS

General

Trials to prolong the keeping quality of cut flowers by use of many types of chemicals have been carried out by a number of workers. Hitchcock et al. (12) in their early work found no marked beneficial results from

the use of fifty different chemical treatments. Laurie (19) reports that copper containers extended the life of cut daffodil, snapdragon and chrysanthemum flowers from 1 to 2.7 days. Odom (32), using a formula which consisted of 0.009 per cent SO_2 - 0.0005 per cent H_3PO_4 - 0.0002 per cent H_3BO_3 - 0.0005 per cent "superol" - and 4 per cent sugar with pompon chrysanthemums, found that the foliage remained in good condition for 7 to 8 days longer than in tap water.

It is a well-known fact that the first acquaintance with growth substances by plant scientists was through studies on tropisms. The concept of growth regulation by a certain substance was perceived by Julius Sacks (1880), who deduced from his experiments on plants that special materials are responsible for the formation and growth of different organs. Recently, various kinds of growth retardants have been extensively used for maintaining post harvest quality of horticultural crops. Cathey (3) defined that the term "growth-retarding chemicals" or "growth retardant" pertains to all chemicals which slow down cell division and cell elongation in shoot tissues and regulate plant height without formative effects.

According to Wesenberg et al. (48), phosphon-D treatment of pot chrysanthemums resulted in an average longevity increase of only 0.6 days. But N^6 -benzyladenine increased the longevity of flowers considerably.

2,4-dichlorophenoxyacetic acid (2,4-D)

2,4-dichlorophenoxyacetic acid has been used as one of the most effective herbicides. Since 2,4-D at low concentration breaks down the plant's physiological processes, it might, at low concentration, have the ability to retard senescence in certain horticultural crops. Little research has been done on effects of 2,4-dichlorophenoxyacetic acid on the keeping quality of floricultural crops. But several reports are available about the effect on stored fruits. Mitchell et al. (25) found that at low concentration (200-400 ppm), 2,4-dichlorophenoxyacetic acid had an effect on greenhouse tomatoes by extending the life of the tomato flowers. In studies with lemons, Stewart (39) found that the storage life of lemons was increased as a result of the application of 2,4-dichlorophenoxyacetic acid (100 to 1,000 ppm) to the fruit. Kaufman et al. (14) reports that 50 ppm of butyl ester of 2,4-D extends marketability of cauliflower heads with about 18 days. However, this chemical shows some side effects. According to Pridham (37), after study with trees, shrubs, and perennials, delayed breaking of dormancy of 2,4-D treated plants was followed by production of distorted foliage.

N-dimethyl amino succinamic acid (B 995 or Alar)

Effects of N-dimethyl amino succinamic acid on the quality of stored horticultural crops are comparatively well known. N-dimethyl amino succinamic acid is one of the growth retarding compounds developed by Naugatuck Chemical, Division of United States Rubber Company. A number of investi-

gations show that the undesirable post-harvest physiological processes of horticultural crops often were effectively controlled by this chemical. Larsen et al. (16) report that 300-500 ppm N-dimethyl amino succinamic acid more than doubled vase-life and improved quality of cut carnations compared with a tap water control. Mean vase-life of cut snapdragons was increased 2.7 times by placing them in a solution containing 300 ppm 8-hydroxyquinoline citrate (QC), 10-50 ppm B 995 and 1.5 per cent sucrose (18). Similar studies with vegetables were made by Halevy et al. (6,8). According to them, senescence and deterioration of certain perishable crops at various temperatures were greatly reduced by post-harvest treatment with N-dimethyl amino succinamic acid.

In greenhouse studies of the effect of Alar on the early stage of Butternut squash (Cucurbita moschata Poir), Hopp (13) found that at harvest time 62 per cent of the fruits from the 5,000 ppm plots still had persistent flowers. According to a report from the United States Rubber Company (43), fall application at rates from 2,000 to 3,000 ppm has been reported to delay blooming of apples the following spring.

A recent study of Larsen et al. (17) proved that a few microorganisms related to cut flower senescence were stimulated by 500 ppm of N-dimethyl amino succinamic acid rather than inhibited. This means Alar affects directly the metabolic processes of cut flowers rather than inhibiting the activities of senescence inducing micro-organisms.

Methyl-2-chloro-9-hydroxyfluorene-(9)-carboxylate

Since methyl-2-chloro-9-hydroxyfluorene-(9)-carboxylate (Morphactin IT 3456) is a relatively new synthetic plant growth regulator, few reports are available. According to E. Merck AG. (4), Morphactins inhibit cell division in formative tissues. It can be used at a wide range of concentrations (10^{-2} to 10^{-7}) without toxic side effects. Among many symptoms in the treated plants, inhibition of flower formation and delay in flowering are included (26). Van de Werken (44) reports that on *Coleus* cuttings 40 ppm of IT 3456 inhibited root development, depressed top growth, caused leaf abscission, and caused cell proliferation at the base of the treated stems.

III. CONTROLLED ATMOSPHERE

The concept of storing fruits without oxygen has a long history. According to Parsons et al. (35), Berard published a paper in 1821 showing that the storage life of fruit could be lengthened in atmospheres devoid of oxygen. Mattus (23) reports that the technique of "controlled atmosphere storage" was developed by F. Kidd and C. West in England in order to extend the normal storage life of apples and pears. This technique was studied by R. M. Smock and A. Van Doren at Cornell University. The advantages and disadvantages of controlled atmosphere storage to Mattus are as follows:

Advantages:

1. Increased cold storage life.

2. Increased life after storage.

Disadvantages:

1. Some varieties may not benefit from controlled atmosphere storage.
2. Storage rooms must be made essentially gastight and the rooms not opened until the end of the storage period.

Asen et al. (1) suggest that there may be some benefit in using "controlled atmosphere storage" for flower crops. An early study by Thornton (40) showed that roses were benefited by carbon dioxide levels within the range of 5 to 15 per cent when the period of storage was longer than one day. He also determined the concentration of carbon dioxide in the surrounding air that various plant organs could tolerate without injury while being shipped or held in storage (14). Longley (20) observed in his study that storage at 32 and 33 degrees F. in eight to ten per cent carbon dioxide prevented opening of Briarcliff roses. Hauge et al. (10) were the first workers using waxed boxes sealed in water tight cellophane for storage of cut flowers. They attributed improved keeping quality of cut flowers to carbon dioxide increased and relatively high humidity maintained in the enclosed atmospheres of cellophane packages. They suggest that increased carbon dioxide in the storage atmosphere prolonged cut flower life as it caused reduction of available oxygen. Ohlander et al. (33) found that storage life of peonies was increased by storing them in waxed boxes sealed with cellophane.

Many investigations (9,23,40,41) proved the harmful effects of either too high carbon dioxide levels or too low oxygen levels. Hanan (9) found that carbon dioxide concentrations above 4 per cent were harmful for carnations. At 15 per cent carbon dioxide, Tailsman and Pearson rose flowers endured temperatures at freezing point seven days (41). According to Platenius (36), the critical oxygen concentration below which the tissue was injured by anaerobic respiration was from one to four per cent at 20 degrees C.

IV. PHYSIOLOGICAL PROCESS

A limited amount of study has been conducted on the physiological processes of flowers during and after storage. Cathey (3) theorized that growth retardants should be considered as antimetabolites rather than as anti-gibberellins or anti-auxins. According to Reed et al. (38) growth retardation of peas by N-dimethyl amino succinamic acid was correlated with the inhibition of the oxidation of tryptamine-2-C¹⁴ to indoleacetaldehyde-2-C¹⁴ in homogenates. This study supports Cathey's theory. In study with detached bean leaves, Halvey et al. (7) found that N-dimethyl amino succinamic acid affected preservation of chlorophyll in the leaves.

According to Halvey et al. (6), N-dimethyl amino succinamic acid depresses the respiration rate of Grand Rapids leaf lettuce at 15 degrees and 20 degrees C. But it had no effect at lower temperatures.

Light affects flowers in many ways. According to Woltz et al. (51), storage in light maintained the photosynthetic capacity and sugar content

of leaves at higher levels and for longer durations than storage in darkness or at elevated temperatures. In studies with beans, Mitchell (24) found that more 2,4-dichlorophenoxyacetic acid was absorbed by illuminated plants than by others kept in darkness. Light intensities of 100 to 900 foot-candles did not affect the rate of absorption of this chemical.

Reduction of the respiration rate by modification of the atmosphere has already been mentioned on page 8. According to Hawes et al. (11), the rate of respiration of roses and chrysanthemums was decreased because of increased carbon dioxide inside the airtight film-enclosed packages. Thus, the quality of some crops should be improved by high carbon dioxide storage. Loughheed et al. (21) found that carbon dioxide levels of 10 per cent increased fresh weight and tenderness of asparagus spears with a 15 per cent level being most effective.

A side effect of carbon dioxide was found by Mitchell (24). He found that the phenoxytype of 2,4-D was not translocated from absorbing organs to other tissues when kept in carbon dioxide free air.

One of the main objectives of this study is determination of the process and degree of maturity and senescence. Maturity is the stage at which a certain flower is in full development and is followed by senescence, which is the stage in which flowers are deteriorating. The process of senescence varies among different species and different varieties of flowers. According to Weinstein (47), the fresh weight of rose petals increased until the bloom was fully open, after which it decreased. He also reports that petal, receptacle, and leaf tissues decreased in dry weight during senescence,

presumably due to respiratory loss. In studies with chrysanthemums, Kuc et al. (15) found that the respiratory rates of the flowers of different maturities were similar. Absolute dry matter increased with maturity but not in proportion to water content, so the percentage of dry matter decreased. Neff (29) also reports that there was a correlation between weight fluctuation and keeping quality. Halevy et al. (8) found a correlation between senescence and water absorption of flowers. They report that the decrease in water supply to the flower by the stem is one of the major reasons for its rapid wilting but that growth-retarding chemicals can reduce transpiration under certain conditions.

Mold injury on flowers is also one of the causes of early failures. It is particularly severe when flowers are stored under the high humidity conditions present in tight packages. According to Fischer (5), severity of mold injury on flowers stored under high humidity conditions was dependant on temperature and was far greater at temperatures of 35 to 45 degrees F. than at 31 degrees F. Stewart (39) reports that increased life of lemon by addition of 100 to 1,000 ppm 2,4-D to the fruit resulted in decrease in the amount of fruit mold.

CHAPTER III

MATERIALS AND METHODS

General Experiment Design

Locally grown cut flowers of Chrysanthemum morifolium 'Indianapolis' were subjected to the normal procedures of cutting, grading, and cold storage before starting the experiments.

A total of two-hundred and sixteen chrysanthemums having stems 32 inches in length were used. These flowers were bright, fairly tight with the centers closed, and free from injury. Flower quality was of Blue Grade (2,31). Mean flower diameter was 6.05 inches and did not vary significantly between treatments. Since three experiments were done with different chemicals, seventy-two flowers were used for each experiment.

The chrysanthemum stems were cut to ten, twelve and one-half, and fifteen inches in length for convenience to arrange them upright in quart containers. Three flowers with different stem length were placed in each container. Each group of three flowers had a total of eighteen leaves. Each experiment consisted of six different treatments, including one control, and four replications were used in all cases.

The six treatments in all three experiments were as follows:

1. Check (distilled water - open air).
2. Distilled water - Controlled atmosphere with 15 per cent oxygen plus 95 per cent nitrogen.

3. Distilled water - Controlled atmosphere with 5 per cent carbon dioxide in air.
4. Solution of growth retardant - Open air.
5. Solution of growth retardant - Controlled atmosphere as in 2.
6. Solution of growth retardant - Controlled atmosphere as in 3.

Different chemicals were used for different experiments. The chemicals were: methyl-2-chloro-9-hydrofluorene-(9)-carboxylate; N-dimethyle amino succinamic acid; and, 2,4-dichlorophenoxyacetic acid. For the first series, methyl-2-chloro-9-hydroxyfluorene-(9)-carboxylate (Morphactin IT 3456) was used at 40 ppm in the flower containers during cold storage from April 18 to May 12, 1968. N-dimethyl amino succinamic acid (Alar or B 995) was used for the second series at 300 ppm from April 18 to May 21, 1968. The last experiment was done with 2,4-dichlorophenoxyacetic acid (2,4-D) at 50 ppm in the flower containers during cold storage from May 17 to June 10, 1968. These particular concentrations of growth retardants were chosen after preliminary testing which was carried out during the previous winter.

The flowers, not more than 24 hours from cutting, were held in the growth chamber (E-57 Environator) at a temperature of 32 to 34 degrees F. with a 1,000 foot-candles light intensity for six days. After removal from the environator, all flowers were placed in tap water in open air at a temperature of 67 to 69 degrees F. The room was lighted with fluorescent lamps which provided about 20 foot-candles of light to the chrysanthemums throughout the experiment.

Techniques

Seventy-two flowers, with cut stems as mentioned on page 13, were arranged at random in six different treatment groups of three flowers each. Four replications were used for each series of six treatments.

Air-tight bags were made with DuPont's heat-sealing cellophane. The open ends of 16 x 24 inch cellophane sleeves were folded together and sealed by passing a hot sealing iron over this surface. Two port holes, one on the upper part of the bag and the other on the lower, were made to permit flushing, filling and sampling of the enclosed atmosphere. Rubber tubes with clamps prevented the escape of gas. A wire support inside the bags reduced contact of the bags with the flowers.

Carbon dioxide, oxygen, nitrogen, and breathing air were obtained in compressed gas cylinder. To obtain an atmosphere composition of 5 per cent oxygen plus 95 per cent nitrogen, the cellophane bags, which contained three flowers, were flushed with nitrogen long enough to reduce the oxygen level to 2 per cent. Then pure oxygen was added until the oxygen level reached 5 per cent (36). The oxygen concentration was determined with a Beckman D-2 oxygen analyzer. To obtain an atmosphere composition of 5 per cent carbon dioxide plus air, the cellophane bags were flushed with carbon dioxide until the carbon dioxide level reached the desirable level (41). When the carbon dioxide level became too high, excess gas was flushed out with breathing air. The levels of carbon dioxide were determined with a Fyrite Carbon Dioxide Indicator. After a little practice, the desirable air concentrations could be obtained in less than 10 minutes with a difference of less than 0.1 per cent. During the first six days of cold

storage, the atmospheric composition in the sealed packages was determined every other day and the level of carbon dioxide or oxygen readjusted as necessary.

A total of twenty-four quart jars were used for one experiment. These jars were filled with 500 milliliter of either a solution of growth retardant or distilled water. After six days storage in controlled atmosphere and chemical treatment the flowers were placed in tap water and exposed to temperatures of 66 to 70 degrees F. At the sixteenth day of the second series of experiments (with B 995), the temperature rose to 76 degrees F. for eighteen hours because of outside interference with the air conditioning. For the third series, flowers were sprayed with Captan and set in a Systox solution for twenty-four hours at the beginning of the experiment to prevent damage by Botrytis and aphids.

Data Collection

Data were collected during the experiment on flower diameter, fresh weight of flowers, petal turgidity, fresh and dry weight of petals, the amount of water absorbed, the process of flower senescence, the degree of opening of the flower center and number of days it took for the flower center to open fully.

Measurements were taken on all flowers. Flower diameters were measured at the first day of each experiment. Fresh weight of the flowers was taken at six day intervals. Flower petals were harvested at six day intervals from the five outer layers on the receptacle to determine turgidity, fresh and dry weight of the flower petals. The petals were

bent down to a 90-degree angle on the scales for measuring the resistance of the petal which was used as criterion for determination of petal turgidity. Turgidity of those petals which had dehydrated was treated as zero. Then the petals were oven dried for six hours at 90 degrees C. for dry weight determination. The water absorption was measured at six-day intervals and recorded in milliliters per 100 grams of flowers on the basis of initial fresh weight. The data of senescence of the first petal, tenth petal, and 10 per cent of the petals (40 to 45 petals) was recorded. The size of the unopened flower center was measured at six day intervals. Also the number of days it took for each flower to open fully was recorded.

CHAPTER IV

RESULTS AND DISCUSSION

Total Fresh Weight

Fluctuation of the total fresh weight is shown in Tables I and II. There were no significant differences in total fresh weight during cold storage between different treatments. Flowers in all treatment gained in weight during cold storage, and reached a maximum weight six days from the beginning of the experiment.

Total fresh weight of the IT3456 treated flowers was greater than that of other treatments from the twelfth to the twenty-fourth day (LSD @ 1 per cent). On the eighteenth day, total fresh weight of the IT 3456 treatment was similar to both the distilled water and B 995 treatment (LSD @ 1 per cent). Total fresh weight of the IT 3456 treated flowers was the same on the twenty-fourth day as the weight of the 2,4-D treated ones at the twelfth day. Fresh weight of the B 995 treated flowers was not significantly different from that of distilled water treated flowers during the experiment (LSD @ 5 per cent). This suggests IT 3456 affected preservation of the fresh weight of the flowers for a longer period than the other chemicals.

Effects of controlled atmosphere storage on the total fresh weight of chrysanthemum flowers were not evident. From the twelfth to the twenty-fourth day of the experiment, the fresh weight of the flowers stored in

TABLE I

GREEN WEIGHT OF FLOWERS THAT ABSORBED
VARIOUS GROWTH REGULATORS

Treatment	Green Weight of flowers in grams ¹				
	Treat. ² & Storage ³			Holding ⁴	
	Days from Start				
	0	6	12	18	24
No Chemical	34.03	39.09	34.52	31.95	23.82
IT 3456 ⁵ , 40 ppm	34.13	41.12	39.14	36.84	32.10
B 995 ⁶ , 300 ppm	33.95	39.96	36.91	33.46	24.30
2,4-D ⁷ , 50 ppm	34.13	39.98	30.98	27.46	20.18
LSD @ .01	NS	NS	3.22	3.88	5.21
LSD @ .05	NS	NS	2.41	2.90	3.90

¹Green weight of flowers, stems, and leaves as described under methods.

²Treatment: Distilled water containing the specified amount of each chemical.

³Storage: At 33 $\pm$ 1 degree F. at 1,000 foot candles.

⁴Holding: At 68 $\pm$ 2 degrees F. at 20 foot candles.

⁵IT 3456: 2-chloro-9-hydroxyfluorene-(9)-carboxylate.

⁶B 995: Trade name for a commercial formulation of N-dimethyl amino succinamic acid and other materials for wetting, spreading, and suspending the active ingredient in water. 300 ppm of N-dimethyl amino succinamic acid was used.

⁷2,4-D: 2,4-dichlorophenoxyacetic acid.

TABLE II

GREEN WEIGHT OF FLOWERS STORED IN
SEVERAL ATMOSPHERES

Treatment	Green weight of flowers in grams				
	Treat. & Storage			Holding	
	Days from Start				
	0	6	12	18	24
Air ¹	34.48	39.83	37.13	34.83	38.22
5% O ₂ ² in N ₂	33.81	39.99	34.98	31.69	22.98
5% CO ₂ ³ in air	33.89	39.59	34.05	30.77	24.11
LSD @ .05	NS	NS	2.09	2.51	3.37

¹Unmodified natural atmosphere.

²Gas proof containers flushed with nitrogen, and 5%, approximately, of the nitrogen replaced with oxygen.

³Carbon dioxide was introduced into gas-proof containers of natural air until there was 5% of CO₂ present in the air in the containers.

air was greater than that of the 5 per cent oxygen and the 5 per cent carbon dioxide stored flowers. Decreases in fresh weight of the air treatment were a week behind those of the 5 per cent oxygen and 5 per cent carbon dioxide treatment during the last part of the experiment (LSD @ 5 per cent).

Petal Turgidity

Degree of petal turgidity was affected by both chemical treatment and atmospheric modification (Table III and IV). The maximum petal turgidity was recorded at the sixth day in all cases. At the sixth day, petal turgidity of IT 3456 treated flowers was greater than either that of the distilled water or 2,4-D treated ones, but was no greater than that of the B 995 treated ones (LSD @ 5 per cent). Petal turgidity of the distilled water treatment was less at the twelfth day than that of the IT 3456, B 995, and 2,4-D treatments (LSD @ 5 per cent). Petal turgidity of the IT 3456 treatments was greater at both the eighteenth and twenty-fourth day than that of all other treatments (LSD @ 1 per cent). At the eighteenth day, the petal turgidity of the B 995 treated flowers was greater than that of both the distilled water and 2,4-D treated ones, but was not different at the twenty-fourth day (LSD @ 1 per cent). At both the sixth and twelfth day, petal turgidity of the flowers in air was greater than that of those in the 5 per cent oxygen treatment, but was no greater than those in air contains 5 per cent carbon dioxide (LSD @ 5 per cent). From the eighteenth to the twentieth-fourth day, petal turgidity was greater for air treatment than for either the 5 per cent

TABLE III

TURGIDITY OF PETALS TREATED WITH DIFFERENT
GROWTH RETARDING SUBSTANCES.

Treatment	Turgidity of Petals in Grams ¹				
	Treat. ² & Storage ³		Holding ⁴		
	Days from Start				
	0	6th	12th	18th	24th
No Chemical	.309	.353	.270	.111	.049
IT 3456, ⁵ 40 ppm	.309	.412	.342	.217	.104
B 995, ⁶ 300 ppm	.307	.391	.371	.171	.063
2,4-D, ⁷ 50 ppm	.312	.376	.356	.079	.035
LSD @ .01	NS	.042	.034	.045	.030
LSD @ .05	NS	.032	.026	.034	.023

¹Turgidity of petals as described under methods.

²Treatment: Distilled water containing the specified amount of each chemical.

³Storage: at 33 $\pm$ 1 degree F. at 1,000 foot candles.

⁴Holding: at 63 $\pm$ 2 degrees F. at 20 foot candles.

⁵IT 3456: 2-chloro-9-hydroxyfluorene-(9)-carboxylate.

⁶B 995: Trade name for a commercial formulation of N-dimethyl amino succinamic acid and other materials for wetting, spreading, and suspending the active ingredient in water. 300 ppm of N-dimethyl amino succinamic acid was used.

⁷2,4-D: 2,4-dichlorophenoxyacetic acid.

TABLE IV

TURGIDITY OF PETALS STORED IN DIFFERENT ATMOSPHERE

Treatment	Turgidity of Petals in grams ¹ Treat. ² & Storage ³ Days from Start Holding ⁴				
	0	6th	12th	18th	24th
Air ⁵	.319	.401	.354	.170	.082
5% O ₂ in N ₂ ⁶	.303	.370	.319	.131	.048
5% CO ₂ in Air ⁷	.306	.378	.332	.133	.059
LSD @ .01	NS	NS	NS	NS	.026
LSD @ .05	NS	.027	.022	.029	.020

¹Turgidity of petals as described under methods.

²Treatment: Distilled water containing the specified amount of each chemical.

³Storage: At 33 + 1 degree F. at 1,000 foot candles.

⁴Holding: At 68 + 2 degrees F. at 20 foot candles.

⁵Unmodified natural atmosphere.

⁶Gas proof containers flushed with nitrogen, and 5%, approximately, of the nitrogen replaced with oxygen.

⁷Carbon dioxide was introduced into gas-proof containers of natural air until there was 5% of CO₂ present in the air in the containers.

carbon dioxide in air treatment or 5 per cent oxygen in nitrogen treatment.

Fresh Weight of Petal

Table V indicates the effect of chemicals on the fluctuation of petal fresh weight. Effects of atmospheric composition on the petal fresh weight are shown on Table VI.

The maximum petal fresh weight of the IT 3456 and B 995 treatment was found on the twelfth day. This did not parallel the total fresh weight which reached its maximum at the sixth day. The maximum petal fresh weight of the 2,4-D treatment fell on the sixth day. This suggests that 2,4-D accelerated the physiological processes in the flower petals rather than inhibiting them. The maximum weight of fresh petals was considered as the time when the flowers fully matured (47). IT 3456 and B 995 treated flowers reached full maturity six days later than those treated with 2,4-D or distilled water.

At both the twelfth and the eighteenth day, the petal fresh weight of the IT 3456, B 995, and distilled water treatments was greater than that of the 2,4-D treated flowers (LSD @ 1 per cent). On the twenty-fourth day, petal fresh weight of the IT 3456 treatment was the greatest followed in sequence by the B 995, distilled water, and 2,4-D treatments (LSD @ 5 per cent).

At both the thirteenth and the nineteenth day, the petal fresh weight of flowers in air was greater than that of those in 5 per cent oxygen in nitrogen or the 5 per cent carbon dioxide in air treated

TABLE V

GREEN WEIGHT OF PETALS OF FLOWERS RECEIVING
DIFFERENT CHEMICAL TREATMENTS DURING STORAGE

Treatment	Green Weight of Petals in grams ¹				
	Treat. ² & Storage ³	Days from Start Holding ⁴			
	0	6th	12th	18th	24th
No Chemical	.873	.963	.960	.886	.543
IT 3456, ⁵ 40 ppm	.848	.931	1.025	.930	.756
B 995, ⁶ 300 ppm	.862	.928	1.041	.906	.673
2,4-D, ⁷ 50 ppm	.868	.936	.885	.705	.426
LSD @ .01	NS	NS	.073	.072	.110
LSD @ .05	NS	NS	.055	.054	.082

¹Green weight of petals as described under methods.

²Treatment: Distilled water containing the specified amount of each chemical.

³Storage: At 33 ± 1 degree F. at 1,000 foot candles.

⁴Holding: At 68 ± 2 degrees F. at 20 foot candles.

⁵IT 3456: 2-chloro-9-hydroxyfluorene-(9)-carboxylate.

⁶B 995: Trade name for a commercial formulation of N-dimethyl amino succinamic acid and other materials for wetting, spreading, and suspending the active ingredient in water. 300 ppm of N-dimethyl amino succinamic acid was used.

⁷2,4-D: 2,4-dichlorophenoxyacetic acid.

TABLE VI

GREEN WEIGHT OF PETALS PLACED IN DIFFERENT
ATMOSPHERES DURING STORAGE

Treatment	Green Weight of Petals in grams ¹				
	Treat. ² & Storage ³		Holding ⁴		
	Days from Start				
	0	6th	12th	18th	24th
Air ⁵	.856	.931	1.024	.912	.626
5% O ₂ in nitrogen ⁶	.862	.942	.944	.824	.582
5% CO ₂ in air ⁷	.871	.945	.956	.835	.591
LSD @ .05	NS	NS	.047	.046	NS

¹Green weight of petals as described under methods.

²Treatment: Distilled water containing the specified amount of each chemical.

³Storage: At 33 $\pm$ 1 degree F. at 1,000 foot candles.

⁴Holding: At 68 $\pm$ 2 degrees F. at 20 foot candles.

⁵Unmodified natural atmosphere.

⁶Gas proof containers flushed with nitrogen, and 5%, approximately of the nitrogen replaced with oxygen.

⁷Carbon dioxide was introduced into gas-proof containers of natural air until there was 5% of CO₂ present in the air in the containers.

ones (LSD @ 5 per cent). At the twenty-fourth day, there were no differences in petal fresh weight between atmospheric treatments.

Dry Weight of Petals in Percentage of Initial Fresh Weight

The relative petal dry weight increased until the sixth day in all treatments except in the IT 3456 treatment (Table VII). The relative petal dry weight of IT 3456 treatment increased through the twelfth day. This suggests that IT 3456 slowed down the physiological processes and, perhaps, meristematic development of the flower.

At the sixth day, the relative petal dry weight of flowers of the IT 3456 treatment was less than either the distilled water and B 995 treatments (LSD @ 1 per cent). At the twelfth day, the relative petal dry weight of IT 3456 treated flowers was greater than that of petals from any other treatments (LSD @ 5 per cent). The percentage of petal dry weight of both the IT 3456 and B 995 treatment was greater than that of either the distilled water or 2,4-D treatment on the eighteenth day. At the twenty-fourth day, the relative petal dry weight of 2,4-D treatment was smaller than that of all other chemical treatments. This indicates that 2,4-D stimulated the physiological processes in the flowers rather than inhibiting them.

Different atmospheric compositions did not affect the relative percentage of petal dry weight during the experiment (Table VIII).

TABLE VII

PERCENTAGE OF FLOWER PETALS DRY WEIGHT
RECEIVING DIFFERENT CHEMICAL
TREATMENTS DURING STORAGE

Treatment	Petal Dry Weight Percentage ¹ Treat. ² & Storage ³ Holding ⁴ Days from Start				
	0	6th	12th	18th	24th
No Chemical	9.13	9.99	9.72	8.32	7.54
IT 3456, ⁵ 40 ppm	9.20	9.29	10.54	9.33	8.17
B 995, ⁶ 300 ppm	9.13	10.24	9.41	9.07	7.92
2,4-D, ⁷ 50 ppm	9.23	9.67	8.26	6.89	6.65
LSD @ .01	NS	.67	1.04	.77	.91
LSD @ .05	NS	.50	.78	.58	.68

¹Petal dry weight percentage as described under methods.

²Treatment: Distilled water containing the specified amount of each chemical.

³Storage: At 33 ± 1 degree F. at 1,000 foot candles.

⁴Holding: At 68 ± 2 degrees F. at 20 foot candles.

⁵IT 3456: 2-chloro-9-hydroxyfluorene-(9)-carboxylate.

⁶B 995: Trade name for a commercial formulation of N-dimethyl amino succinamic acid and other materials for wetting, spreading, and suspending the active ingredient in water. 300 ppm of N-dimethyl amino succinamic acid was used.

⁷2,4-D: 2,4-dichlorophenoxyacetic acid.

TABLE VIII

DRY WEIGHT PERCENTAGE OF FLOWER PETALS STORED IN
DIFFERENT ATMOSPHERES

Treatment	Petal Dry Weight Percentage ¹				
	0	Treat. ² & Storage ³		Holding ⁴	
		Days from Start			
	0	6th	12th	18th	24th
Air ⁵	9.05	9.86	9.72	8.74	7.66
5% O ₂ in N ₂ ⁶	9.14	9.75	9.41	8.20	7.67
5% CO ₂ in air ⁷	9.33	9.79	9.33	8.27	7.38
LSD @ .05	NS	NS	NS	NS	NS

¹Petal dry weight percentage as described under methods.

²Treatment: Distilled water containing the specified amount of each chemical.

³Storage: At 33 $\pm$ 1 degree F. at 1,000 foot candles.

⁴Holding: At 68 $\pm$ 2 degrees F. at 20 foot candles.

⁵Unmodified natural atmosphere.

⁶Gas proof containers flushed with nitrogen, and 5%, approximately, of the nitrogen replaced with oxygen.

⁷Carbon dioxide was introduced into gas-proof containers of natural air until there was 5% of CO₂ present in the air in the containers.

Amount of Water Uptake

Water uptake by chrysanthemum flowers was affected by chemical treatment and atmospheric composition (Table IX and X). There was a marked difference in water absorption during the first six days and the second six days due to temperature. At both the sixth and the twelfth days, the amount of water absorbed by the IT 3456 treatment was greater than that of all other treatments (LSD @ 1 per cent). The 2,4-D treatment showed the least water absorption ability among chemical treatments throughout the experiment. There was no significant difference in water absorption among IT 3456, distilled water, and B 995 treated flowers after the flowers were out of storage one week.

Because of the air-tight environment, the amount of water absorbed by both the flowers in 5 per cent oxygen in nitrogen and those in 5 per cent carbon dioxide in air was smaller than that of those in air during six days of cold storage. During the second six days, right after removal from cold storage, the amount of water absorbed by both the 5 per cent oxygen in nitrogen and the 5 per cent carbon dioxide in air treatment was greater than that of the air treatment. No differences were found due to atmospheric composition after the flowers were out of storage one week.

Degree of Senescence

Since senescence follows maturity, determining the day of senescence is important in this study. It was decided to consider the flowers as

TABLE IX

WATER UPTAKE BY FLOWERS TREATED WITH DIFFERENT
GROWTH RETARDING SUBSTANCES

Treatment	Water Uptake in Milliliters ¹ Days from Start			
	6th	12th	18th	24th
No Chemical	64.86	128.36	80.46	70.69
IT 3456, ² 40 ppm	96.98	156.36	114.82	106.72
B 995, ³ 300 ppm	64.97	140.80	79.98	77.81
2,4-D, ⁴ 50 ppm	42.73	73.56	40.48	34.97
LSD @ .01	14.82	15.50	57.93	NS
LSD @ .05	11.07	11.58	43.30	59.73

¹ Amount of water uptake as described under methods.

² IT 3456: 2-chloro-9-hydroxyfluorene-(9)-carboxylate.

³ B 995: Trade name for a commercial formulation of N-dimethyl amino succinamic acid and other materials for wetting, spreading, and suspending the active ingredient in water. 300 ppm of N-dimethyl amino succinamic acid was used.

⁴ 2,4-D: 2,4-dichlorophenoxyacetic acid.

TABLE X

WATER UPTAKE BY FLOWERS STORED IN
DIFFERENT ATMOSPHERES

Treatment	Water Uptake in Milliliter ¹ Days from Start			
	6th	12th	18th	24th
Air ²	100.91	116.69	77.30	74.39
5% O ₂ in N ₂ ³	52.29	128.44	80.16	70.21
5% CO ₂ in Air ⁴	48.93	129.18	79.35	73.04
LSD @ .01	12.83	NS	NS	NS
LSD @ .05	9.59	10.03	NS	NS

¹Amount of water uptake as described under methods.

²Unmodified natural atmosphere.

³Gas proof containers flushed with nitrogen, and 5%, approximately, of the nitrogen replaced with oxygen.

⁴Carbon dioxide was introduced into gas-proof containers of natural air until there was 5% of CO₂ present in the air in the containers.

starting senescence when 10 petals were decolorized. These few decolorized petals did not appreciably affect the value of the flower. But when 10 per cent (38 to 42 petals) of the petals were decolorized, the form and texture of the flower became undesirable.

On the IT 3456 treated flowers, the first decolorized petals appeared more than a day later than on the flowers treated with the other chemicals. Decoloration of 10 petals on both the IT 3456 and B 995 treated flowers was reached nearly two days later than on flowers treated with the distilled water and the 2,4-D treatment. Decoloration of 10 per cent of the petals on both the IT 3456 and B 995 treatment was reached more than two days later than on the rest of treatments. Table XI shows the more immediate response to IT 3456 compared with the response to B 995.

The flower petals reached senescence in a shorter time after the flowers were stored in 5 per cent carbon dioxide in air or 5 per cent oxygen in nitrogen than when stored in air (Table XII). On the flowers which were stored in air, the first brown petal appeared a day later, the tenth petal four days later, and 10 per cent of the petals had reached senescence nearly three days later than occurred on either the 5 per cent oxygen in nitrogen or 5 per cent carbon dioxide in air treated flowers.

At the twenty-fourth day, only 25 per cent of the flowers of both the IT 3456 and B 995 in open air treatments had more than half of their petals turned brown, while on the 2,4-D treated flowers more than 83 per cent of the flowers had turned brown (Table XIII). Air storage resulted in the least Botrytis damage (Table XIV). When stored in air treated with IT 3456

TABLE XI

NUMBER OF DAYS REQUIRED FOR PETALS TO FADE
WHEN TREATED WITH DIFFERENT GROWTH
CONTROLLING SUBSTANCES

Treatment	Numbers Indicate in Day		
	1st Petal	10th Petal	10% Petals
No Chemical	7.79	13.65	18.06
IT 3456, ¹ 40 ppm	9.25	16.25	20.14
B 995, ² 300 ppm	7.81	15.25	20.09
2,4-D, ³ 50 ppm	7.66	12.44	16.86
LSD @ .01	1.15	2.15	1.83
LSD @ .05	.86	1.60	1.37

¹IT 3456: 2-chloro-9-hydroxyfluorene-(9)-carboxylate.

²B 995: Trade name for a commercial formulation of N-dimethyl amino succinamic acid and other materials for wetting, spreading, and suspending the active ingredient in water. 300 ppm of N-dimethyl amino succinamic acid was used.

³2,4-D: 2,4-dichlorophenoxyacetic acid.

TABLE XII

NUMBER OF DAYS REQUIRED FOR PETALS TO FADE
WHEN STORED IN DIFFERENT ATMOSPHERE

Treatment	Numbers Indicate in Day		
	1st Petal	10th Petal	10% Petals
Air ¹	8.89	17.22	20.74
5% O ₂ in N ₂ ²	7.68	12.87	17.42
5% CO ₂ in Air ³	7.80	13.11	18.19
LSD @ .01	1.01	1.91	1.58
LSD @ .05	.74	1.42	1.18

¹Unmodified natural atmosphere.

²Gas proof containers flushed with nitrogen, and 5%, approximately, of the nitrogen replaced with oxygen.

³Carbon dioxide was introduced into gas-proof containers of natural air until there was 5% of CO₂ present in the air in the containers.

TABLE XIII

PERCENTAGE OF FLOWERS MORE THAN HALF WILTED
ON THE 25TH DAY

Treatment	Numbers in Per Cent		
	Open Air	5% O ₂	5% CO ₂
No Chemical	47.22	77.78	77.78
IT 3456, ¹ 40 ppm	25.00	58.33	41.67
B 995, ² 300 ppm	25.00	50.00	41.67
2,4-D, ³ 50 ppm	91.67	83.33	83.33
Chemical Mean			
LSD @ .01		32.66	
LSD @ .05		21.56	
Air Mean			
LSD @ .01		39.99	
LSD @ .05		26.40	

¹IT 3456: 2-chloro-9-hydroxyfluorene-(9)-carboxylate.

²B 995: Trade name for a commercial formulation of N-dimethyl amino succinamic acid and other materials for wetting, spreading, and suspending the active ingredient in water. 300 ppm of N-dimethyl amino succinamic acid was used.

³2,4-D: 2,4-dichlorophenoxyacetic acid.

TABLE XIV

PERCENTAGE OF FLOWER DAMAGED BY BOTRYTIS

Treatment	Open Air ¹	5% O ₂ ²	5% CO ₂ ³
No Chemical	11.11	36.11	30.56
IT 3456, ⁴ 40 ppm	0.00	0.00	8.33
B 995, ⁵ 300 ppm	0.00	50.00	41.67
2,4-D, ⁶ 50 ppm	16.67	25.00	16.67

¹Unmodified natural atmosphere.

²Gas proof containers flushed with nitrogen, and 5%, approximately, of the nitrogen replaced with oxygen.

³Carbon dioxide was introduced into gas-proof containers of natural air until there was 5% of CO₂ present in the air in the containers.

⁴IT 3456: 2-chloro-9-hydroxyfluorene-(9)-carboxylate.

⁵B 995: Trade name for a commercial formulation of N-dimethyl amino succinamic acid and other materials for wetting, spreading, and suspending the active ingredient in water. 300 ppm of N-dimethyl amino succinamic acid was used.

⁶2,4-D: 2,4-dichlorophenoxyacetic acid.

or B 995, none of the flowers were damaged by Botrytis, however, from 8 to 42 per cent of the flowers were damaged by Botrytis in the 5 per cent carbon dioxide in air treatment. This appears to be caused by high humidity during controlled atmosphere storage in cellophane bags.

Opening of the Flower Center

IT 3456 served to cause delay in opening of the center of the flowers. IT 3456 treatment held the flower centers closed almost a week longer than the other chemical treatments and two weeks longer than the distilled water treatment (Table XV). It appears evident that IT 3456 affected younger tissues rather than mature tissues. IT 3456 did not affect the degree of senescence of the outer layer of flower petals, any more than B 995 (Table XVI).

2,4-D treatment showed good results in holding the flower center closed. Since water use by 2,4-D treated flowers was so small, it may be that petals of the younger parts of the flower were unable to extend.

The opening of flower centers was not affected by different atmospheric compositions (Table XVII).

Total Fresh Weight versus Amount of Water Uptake

Total fresh weight fluctuations did not follow the trends in water absorption of the flowers (Figure I and II). In all cases, the maximum water absorption was recorded during the second six-day period, while the maximum total fresh weights were reached at the sixth day. These results

TABLE XV

OPENING OF FLOWER CENTER FOLLOWING CHEMICAL TREATMENTS

Treatment	Opening of Flower Center in inches ¹				
	Treat. ² & Storage ³	Days from Start Holding ⁴			
	0	6th	12th	18th	24th
No Chemical	1.31	1.02	.68	.38	.02
IT 3456, ⁵ 40 ppm	1.27	1.21	1.00	.90	.70
B 995, ⁶ 300 ppm	1.26	1.06	.93	.62	.20
2,4-D, ⁷ 50 ppm	1.28	1.15	.93	.80	.61
LSD @ .01	NS	.13	.21	.25	.29
LSD @ .05	NS	.10	.16	.18	.22

¹Opening of flower center as described under methods.

²Treatment: Distilled water containing the specified amount of each chemical.

³Storage: At 33 ± 1 degree F. at 1,000 foot candles.

⁴Holding: At 68 ± 2 degrees F. at 20 foot candles.

⁵IT 3456: 2-chloro-9-hydroxyfluorene-(9)-carboxylate.

⁶B 995: Trade name for a commercial formulation of N-dimethyl amino succinamic acid and other materials for wetting, spreading, and suspending the active ingredient in water. 300 ppm of N-dimethyl amino succinamic acid was used.

⁷2,4-D: 2,4-dichlorophenoxyacetic acid.

TABLE XVI

OPENING OF FLOWER CENTER DURING AND AFTER STORAGE
IN DIFFERENT ATMOSPHERE

Treatment	Opening of Flower Center in inches ¹ Treat. ² & Storage ³ Holding ⁴ Days from Start				
	0	6th	12th	18th	24th
Air ⁵	1.28	1.12	.93	.77	.41
5% O ₂ in N ₂ ⁶	1.28	1.09	.89	.61	.39
5% CO ₂ in Air ⁷	1.27	1.12	.84	.64	.34
LSD @ .05	NS	NS	NS	NS	NS

¹Opening of flower center as described under methods.

²Treatment: Distilled water containing the specified amount of each chemical.

³Storage: At 33 $\pm$ 1 degree F. at 1,000 foot candles.

⁴Holding: At 68 $\pm$ 2 degrees F. at 20 foot candles.

⁵Unmodified natural atmosphere.

⁶Gas proof containers flushed with nitrogen, and 5%, approximately, of the nitrogen replaced with oxygen.

⁷Carbon dioxide was introduced into gas-proof containers of natural air until there was 5% of CO₂ present in the air in the containers.

TABLE XVII

NUMBER OF DAYS TO MAXIMUM FLOWER EXTENSION FOLLOWING
TREATMENT WITH DIFFERENT GROWTH REGULATORS, AND
STORAGE IN DIFFERENT ATMOSPHERES

Treatment	Dist. Water	IT3456	B995	2,4-D
Air	19.97	23.33 ³	18.87 ⁶	20.37 ⁵
5% O ₂ + N ₂	18.89	24.00 ²	21.33 ³	20.50 ⁴
5% CO ₂ in Air	18.69 ¹	23.75 ⁴	19.50 ⁶	20.00 ⁴

¹Two flowers out of thirty-six did not fully open until 25th day.

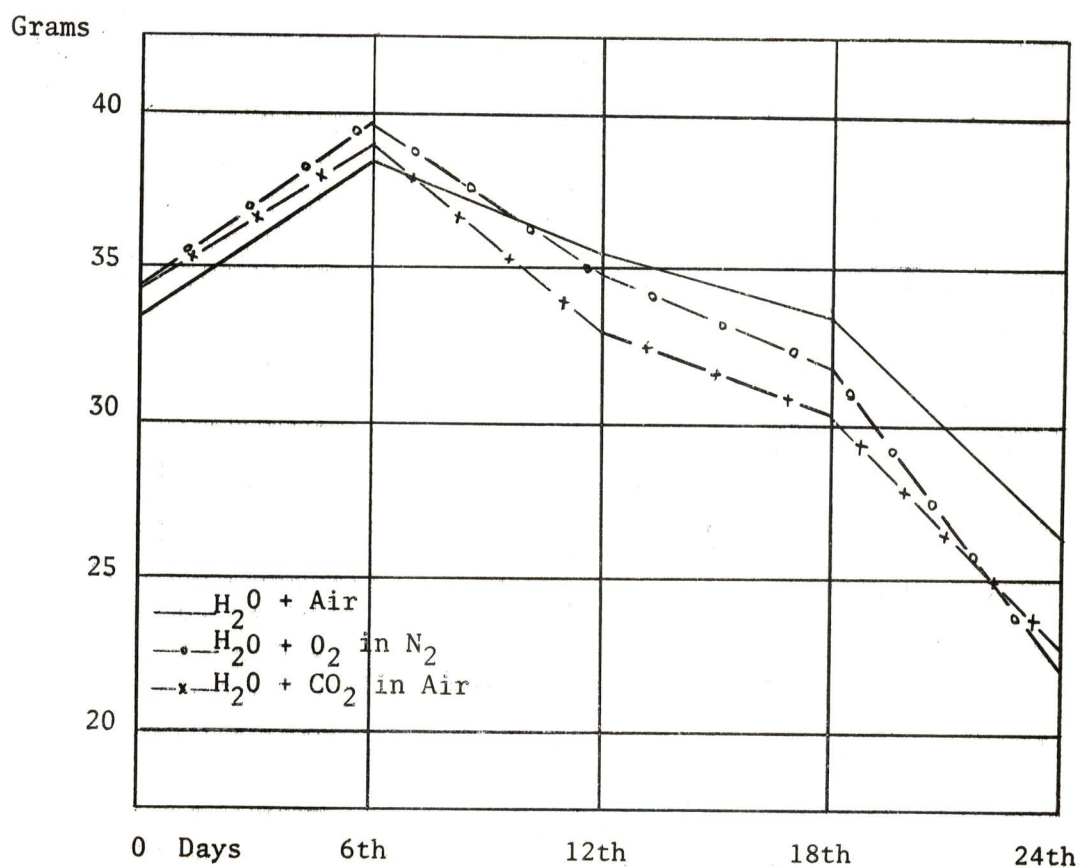
²Two flowers out of twelve opened at 25th day.

³Three flowers out of twelve opened at 25th day.

⁴Four flowers out of twelve opened at 25th day.

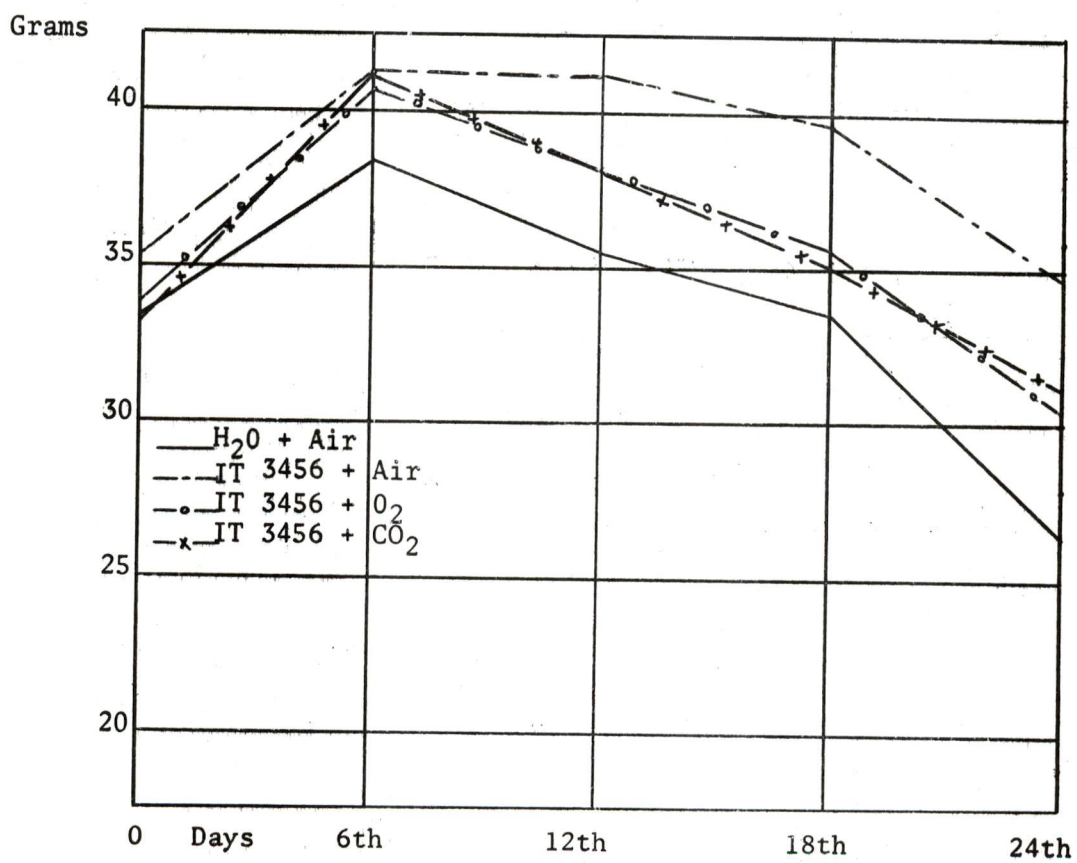
⁵Five flowers out of twelve opened at 25th day.

⁶Six flowers out of twelve opened at 25th day.



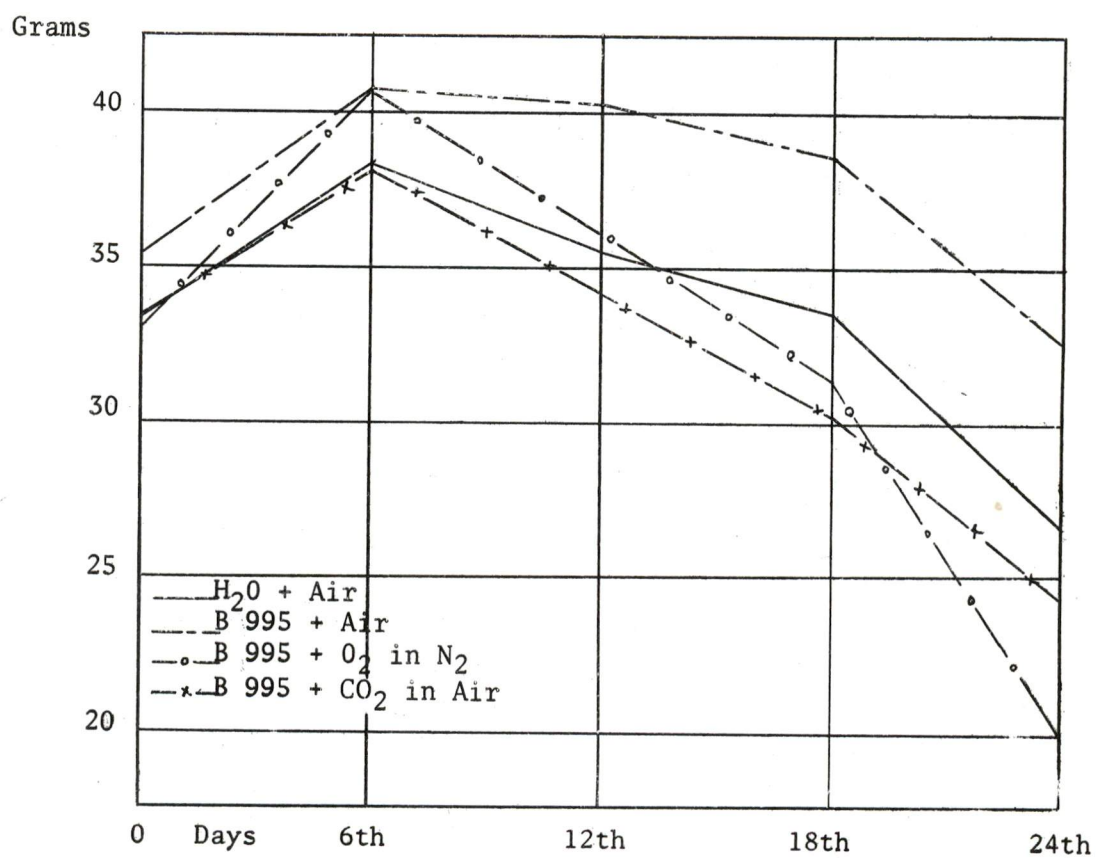
(a) Distilled water

Figure I. Fluctuation of Total Fresh Weight.



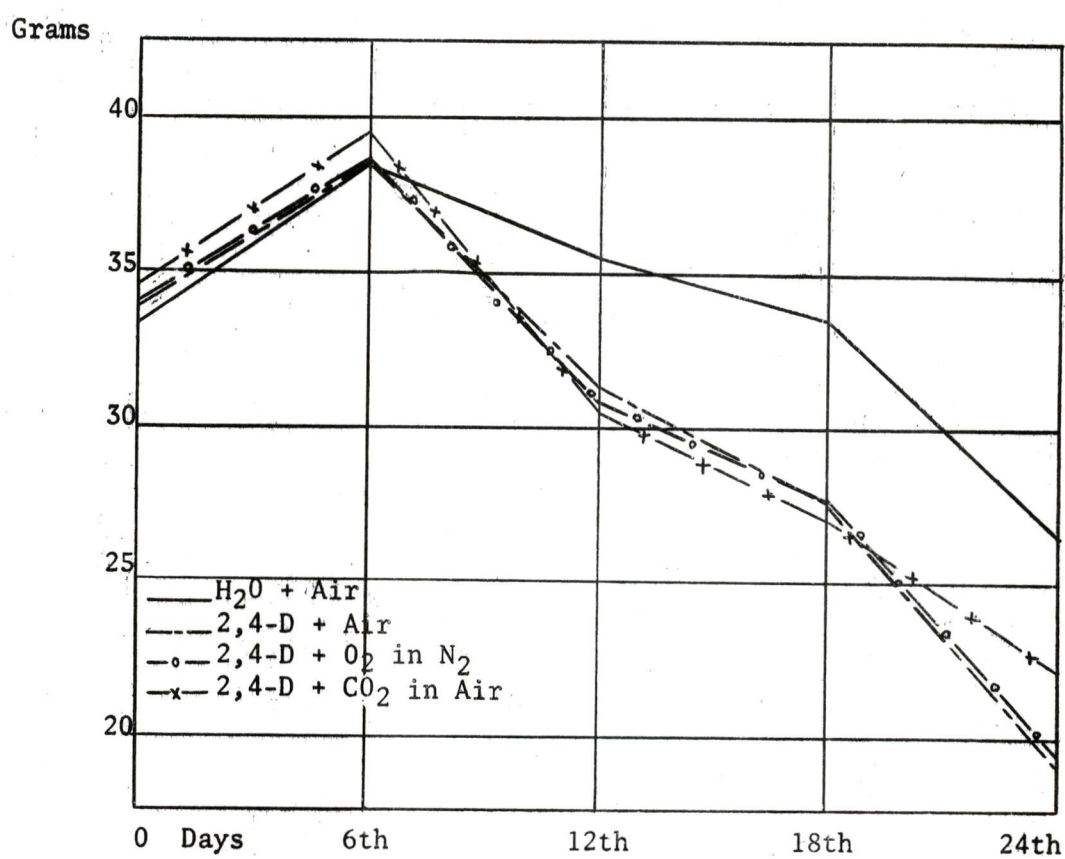
(b) IT 3456

Figure I. (continued)



(c) B 995

Figure I. (continued)



(d) 2,4-D

Figure I. (continued)

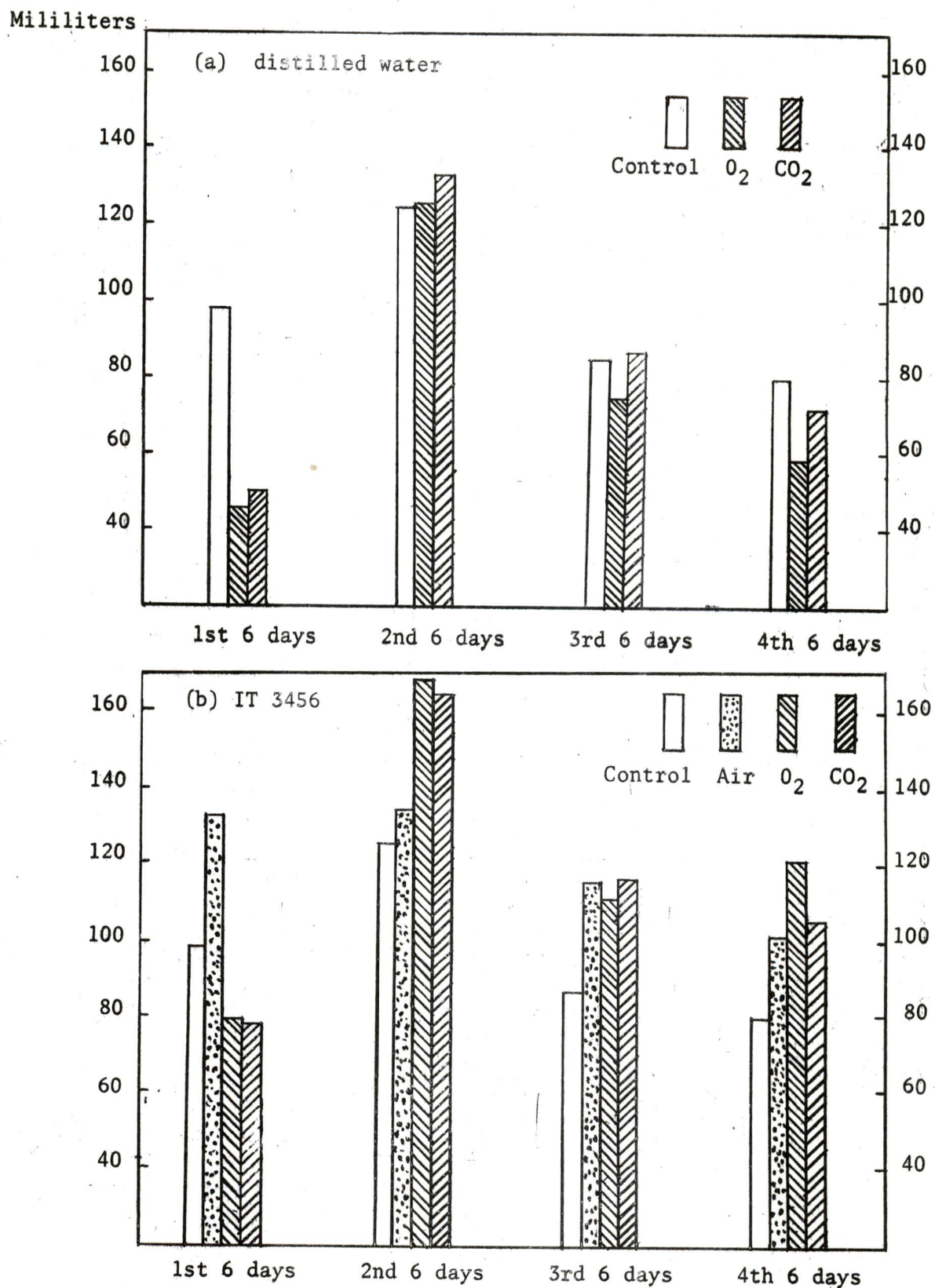


Figure II. Amount of Water Uptake

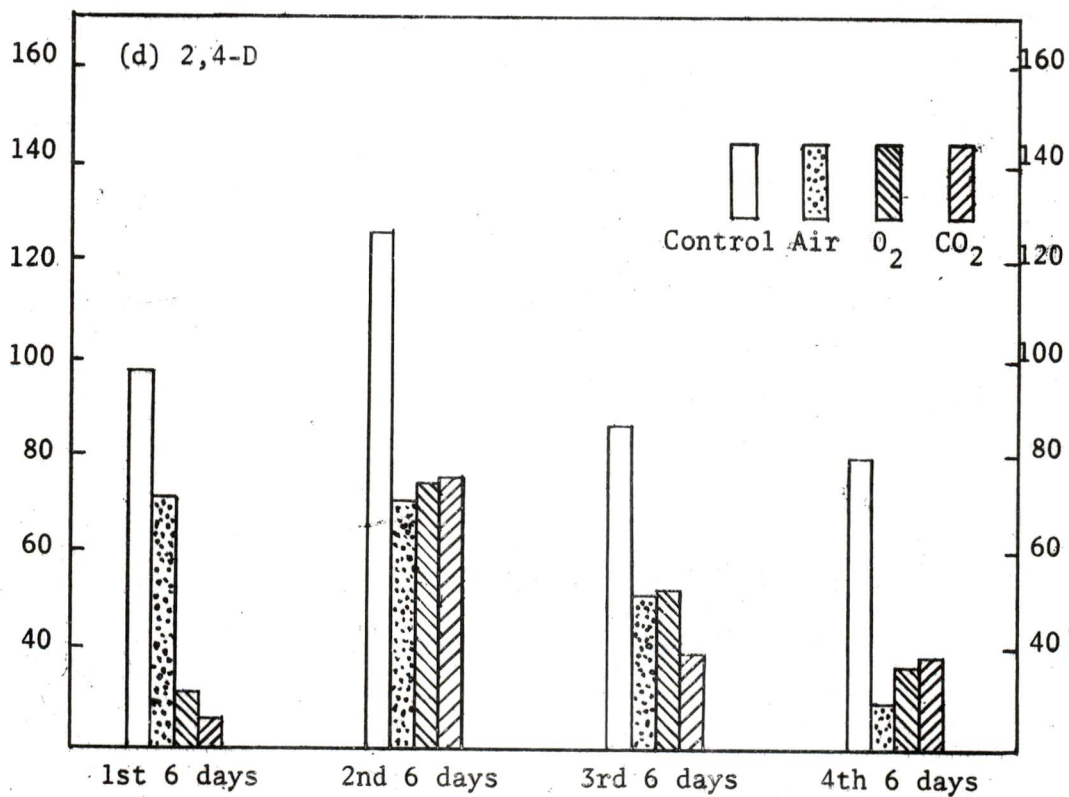
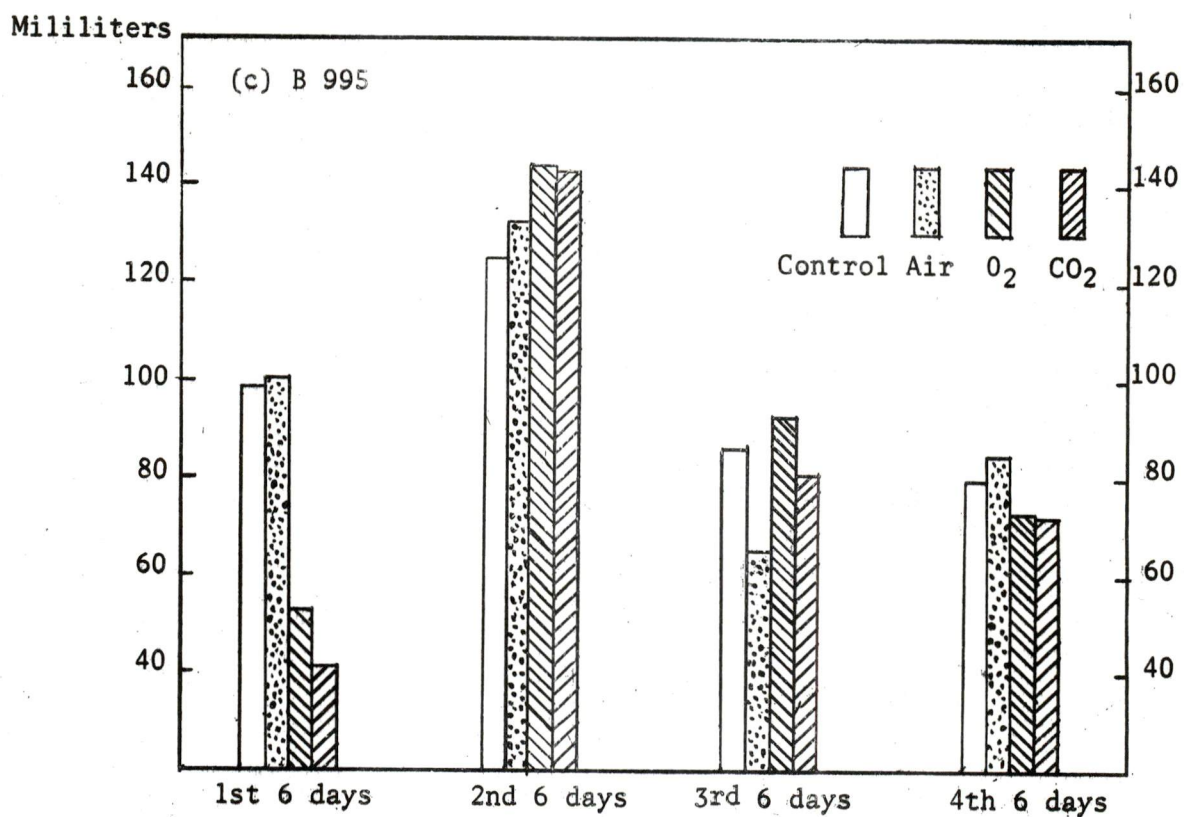


Figure II. (continued)

do differ from those of Halevy et al. (8). These investigators reported that there was a correlation between the maximum water absorption and the maximum total fresh weight.

The total fresh weight fluctuation of the flowers stored in air and treated with either IT 3456 or B 995 were similar. These were quite different from the 2,4-D treated flowers (Figure I-B, I-C, and I-D). This trend indicates that 2,4-D had opposite effects on the flowers than the other two chemicals. Both the IT 3456 and the B 995 treated flowers maintained their maximum fresh weight from the sixth to the twelfth day, and then followed the trend of the control (Figure I-A, I-B, and I-C). The IT 3456 treated flowers absorbed more water than those of the other treatments (Figure II-A, II-B, II-C, and II-D). The ability to maintain a high water absorption rate seemed related to good holding quality. These results support the report of Halevy et al. (8). This was also evident with the 2,4-D treated flowers. The flowers in the 2,4-D treatment absorbed the least amount of water and remained useable the least amount of time.

Petal Fresh Weight versus Amount of Water Uptake

In general, the maximum petal fresh weights were recorded when the water absorption reached its maximum (Figure II and III). Petal fresh weights of IT 3456 treated flowers stored in air showed very similar trends. Petal fresh weight of 2,4-D treated flowers also showed similar trends, but the weight losses at the eighteenth day were far greater than those of IT 3456 or B 995 treated flowers (Figure III-D, III-C, and III-D).

Petal Fresh Weight versus Relative Dry Weight of Petal

Except for the control and the IT 3456 treatments, relative petal dry weight reached its maximum at the sixth day (Figure IV). The control and the IT 3456 treated flowers reached maximum relative dry weight the twelfth day. This suggests less carbohydrate utilization by the IT 3456 treated flowers, and considerable utilization by the flowers treated with the other chemicals. This also suggests that IT 3456 inhibited the physiological processes (Figure III and IV).

The stage of maximum maturity, in most cases, was reached at the sixth day. The flowers began to age immediately following storage because the maximum total fresh weight and maximum petal dry weight percentage were reached as the storage period ended. The stage of maximum maturity was delayed several days with IT 3456, since the highest petal dry weight percentage recorded was on the twelfth day.

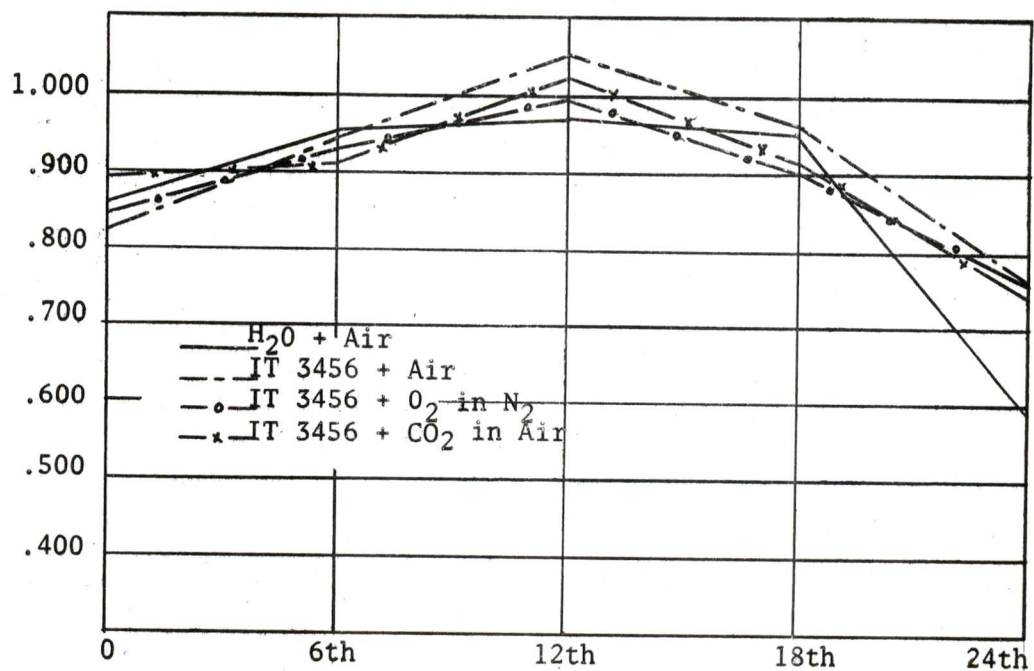
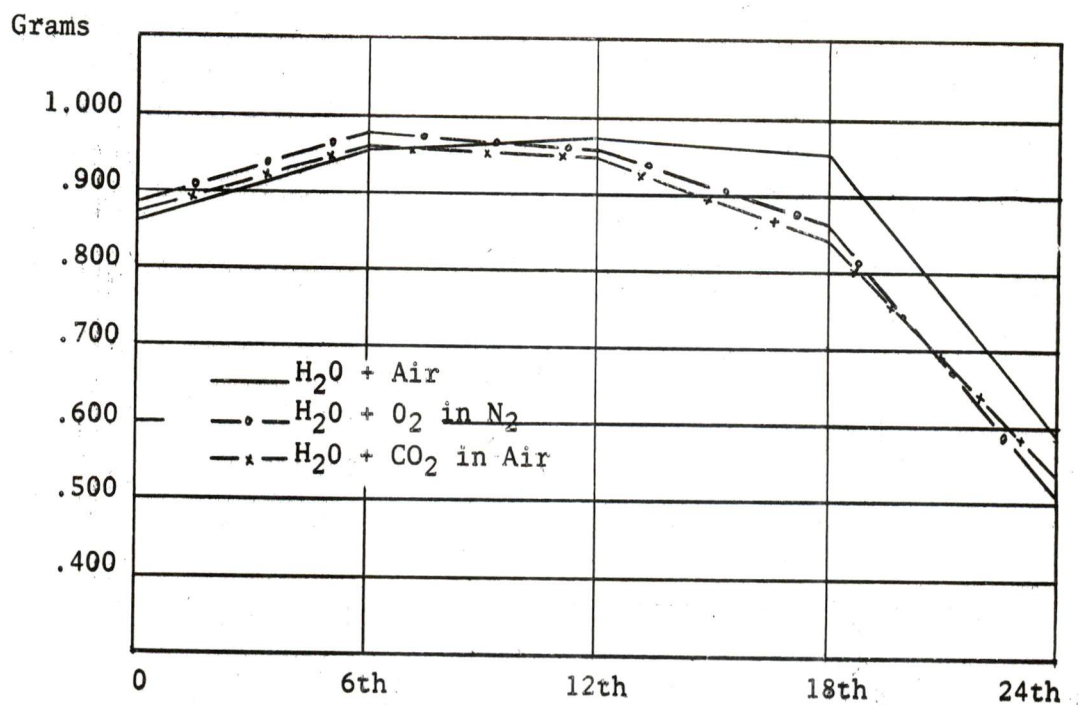


Figure III. Fluctuation of Petal Fresh Weight

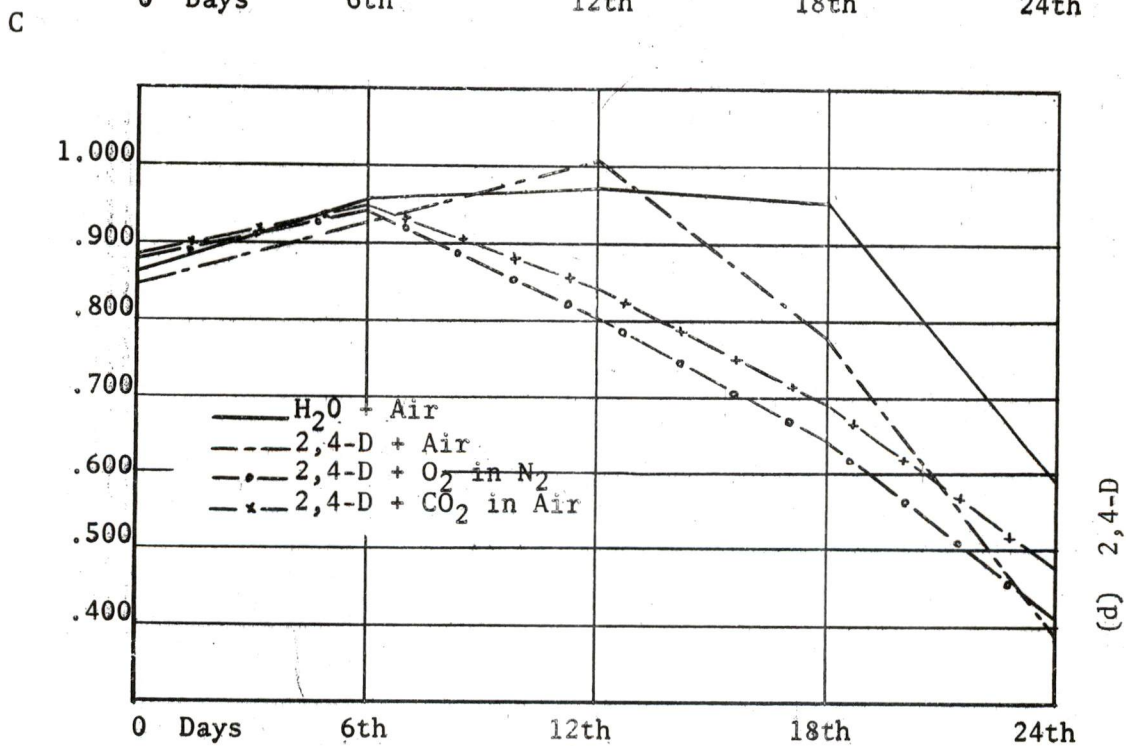
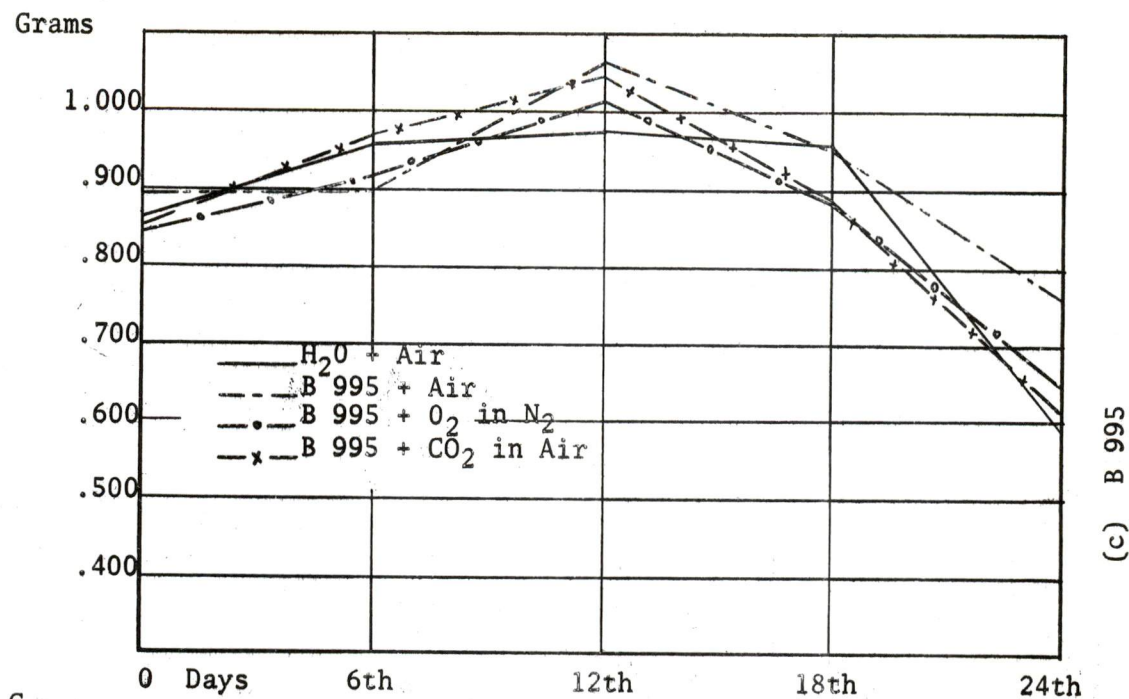
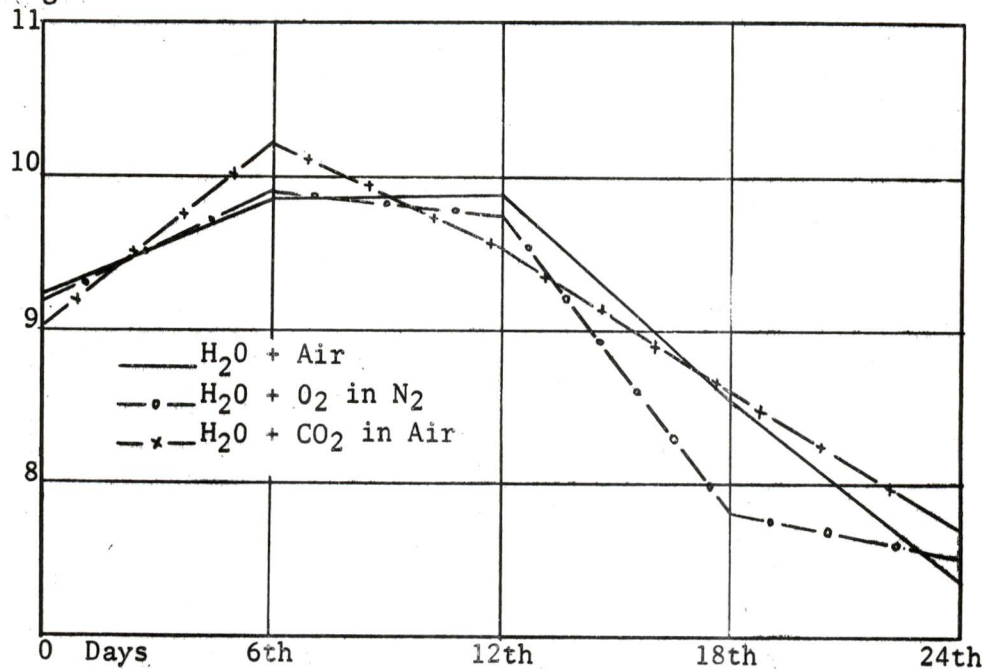
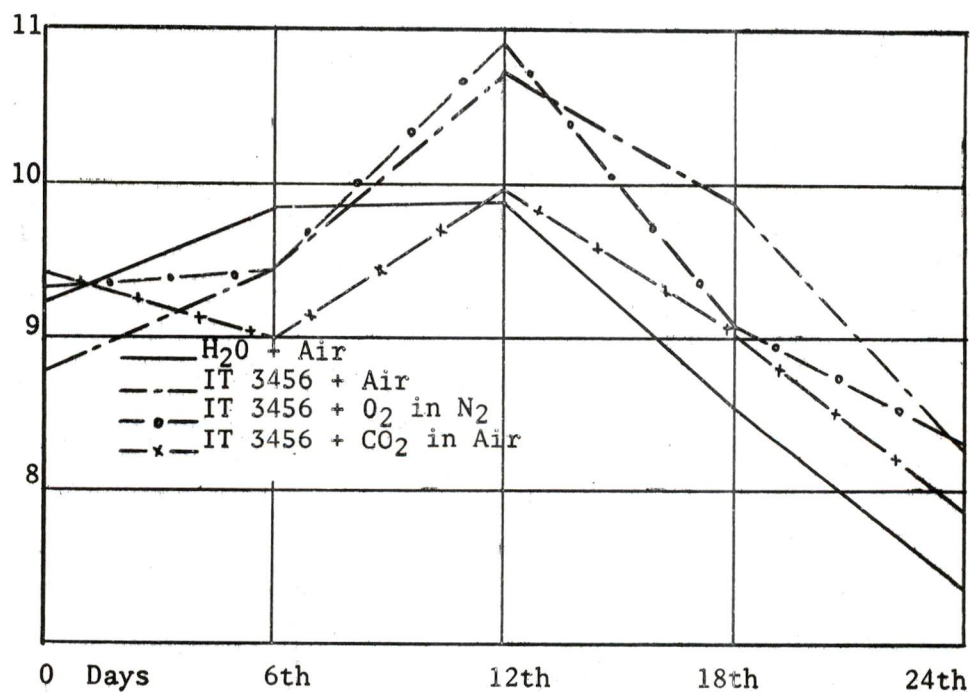


Figure III. (continued)

Percentage



(a) Distilled water



(b) IT 3456

Figure IV. Petal Dry Weight Percentage Based on Initial Fresh Weight.

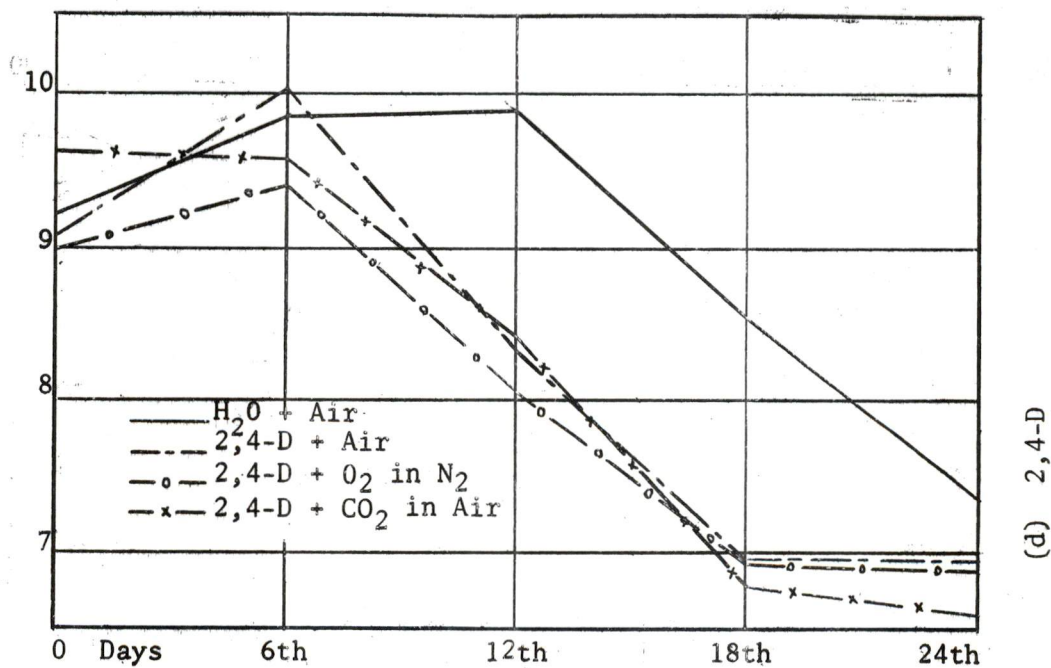
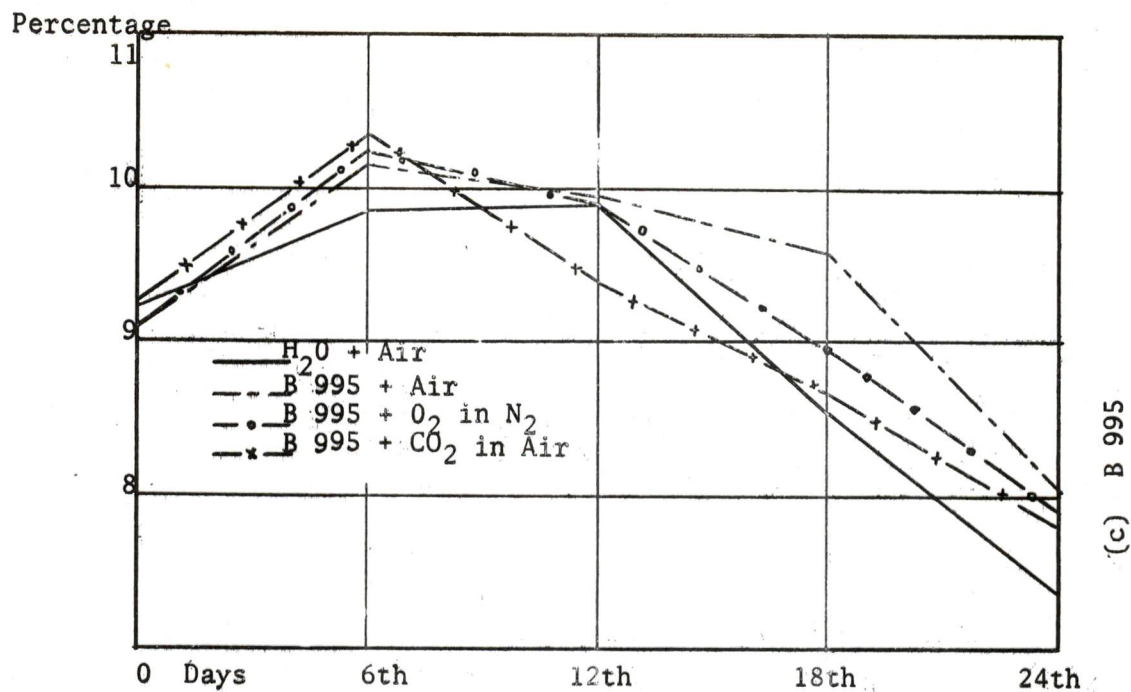


Figure IV. (continued)

CHAPTER IV

SUMMARY

The effect of three growth retardants and controlled atmosphere storage on shelf life of cut Chrysanthemum morifolium 'Indianapolis' was studied during the winter and spring of 1968 at the University of Tennessee in Knoxville.

A total of two-hundred and sixteen locally grown cut Chrysanthemum morifolium 'Indianapolis' of Blue Grade quality were used. The flower stems were cut to ten, twelve and one-half, and fifteen inches in length for convenience to arrange them upright in quart containers. The stems were submerged in various chemical solutions and the entire flowers subjected to various atmospheric compositions. The flowers were held in the growth chamber (E-57 Environator) at a temperature of 33 ± 1 degree F. at 1,000 foot-candles of light intensity for six days. After removal from the environator, all flowers were placed in tap water in open air at 68 ± 20 degrees F. under a light intensity of 20 foot-candles.

The study showed that Morphactin IT 3456 is effective in preserving the quality of cut chrysanthemums. Flowers with an IT 3456 treatment stored in air showed that the maintenance of maximum total fresh weight, petal turgidity, petal fresh weight, and relative dry weight of petal, for six days and delayed petal senescence for two and one-half days compared with the control. Flowers treated with B 995 and stored in

air reached senescence two days later than the control, but they were not better than the control in any other aspect. 2,4-D slowed down the opening of the flower centers, however, it stimulated physiological processes of chrysanthemum flowers causing early senescence.

Neither decreased oxygen levels or increased carbon dioxide levels were of benefit.

Storage quality of cold stored cut chrysanthemum flowers was maintained best by storing the flowers in air and submerging the stems in 40 ppm solution of Morphactin IT 3456.

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