THE EFFECT OF SELECTED CHELATING AGENTS, GROWTH REGULATORS, RESPIRATORY INHIBITORS AND ANTIBIOTICS ON THE LIFE OF CUT FLOWERS, WITH SPECIAL REFERENCE TO ANTIRRHINUM MAJUS

By

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AN ABSTRACT

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JAMES D. KELLEY ABSTRACT

The effect of chelating agents, growth regulators, respiratory inhibitors, antibiotics, and cathode radiation on the keeping quality of cut flowers, especially Antirrhinum majus, has been studied.

Seven varieties of Antirrhinum majus and two varieties of Rosa hybrida as well as Lilium speciosum rubrum and Gerbera jamesonii were used in these experiments.

Of the 20 chelating agents tested, Cupferron (Ammonium salt of N-nitroso-N-phenyl-hydroxylamine) was the most effective. Cupferron increased the cut life of Antirrhinum majus four to nine days, and Rosa hybrida one and one-half days, but had no effect on the life of Lilium speciosum rubrum and Gerbera jamesonii. A number of other chelating agents prolonged the life of Antirrhinum majus two to four days.

In trials using sucrose and Cupferron it was found that two percent sucrose and 200 parts per million Cupferron in distilled water was as effective in extending cut life of Antirrhinum majus as any commercial floral preservative tested, but when sucrose and Cupferron were added to tap water, cut life was shortened.

Foliar applications of 1000 parts per million Cupferron at pH 3.0 and 7.0, one and three days prior to harvest, and foliar applications of 1000, 2000

and 4000 parts per million maleic hydrazide one and three days before harvest did not affect the cut life of Antirrhinum majus, variety Snowman. Maleic hydrazide, when added to the keeping water at a concentration of 250 and 500 parts per million, increased the life of Antirrhinum majus two and one-half to four days. A number of other growth regulators were tested, but maleic hydrazide was the only one found to be effective in extending cut life of Antirrhinum majus.

Respiratory inhibitors added to the keeping water proved to be ineffective in extending the cut life of flowers.

Two antibiotics, Actidione and Endomycin, at 100 parts per million extended cut life of Better Times roses one and one-half to two and one-half days.

Cathode radiation shortened the cut life of Better Times roses at dosages between ten and 1500 reps. Radiation resulted in premature bluing and crinkling of petals, and at higher concentration petal burn and leaf abscission occurred.

The effectiveness of Cupferron and other chelating agents in extending cut flower life is attributed to a possible reduction in respiration, an inhibition of auxin synthesis and a reduction of bacterial growth. The effect of maleic hydrazide in prolonging cut life is believed due to a reduction in respiration and the acceleration of indoleacetic acid destruction within the plant.

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INTRODUCTION

More than 80 percent of the retail florist business consists of the sale of cut flowers. Although considerable emphasis in research work has been placed on improving varieties, increasing production and reducing production cost, little emphasis has been placed on extending the life of the cut flower once it is in the hands of the consumer. Since much time and effort go into the production and marketing of cut flowers, it is only natural that the consumer be allowed to gain the maximum amount of enjoyment and pleasure from them, as it is the cut life of the flower that determines its value.

Most studies for extending cut flower life have concerned environmental factors previous to cutting, stage of development at harvest, time of day for cutting, depth of holding water, inhibiting with chemicals, fungal and bacterial growth in water and daily cutting of stems.

It was decided that the most fruitful area of study of this problem would be in attempting to find a chemical or chemicals that would effect the metabolic process within the flower after cutting. The effect of chelating agents, respiratory inhibitors, growth regulators, antibiotics and cathode irridation of roses (Rosa hybrida), snapdragons (Antirrhinum majus) and several other flowers was studied.

The purpose of this investigation was to study the effectiveness of some of these newer and untried compounds in prolonging the life of cut flowers at room temperature.

Chelating agents were used, since it has been recognized that these substances effect growth (Heath and Clark, 1956; Beiler and Martin, 1954; Weinstein et al., 1956). A large number of respiratory inhibitors are also known to effect plant metabolism and thus a number were used in the work with Antirrhinum majus.

Growth regulators have played a major part in the development of agriculture in the last 20 years. Compounds such as indole-3-acetic acid, 2, 4-dichlorophenoxyacetic acid, maleic hydrazide, 2, 4, 5-trichlorophenoxy-acetic acid and others have found application in fruit setting, weed control, plant propagation and flower induction. It is believed that this type of compound may also be effective in extending cut flower life.

Antibiotics have been shown by Nickell and Finlay (1954) to effect plant growth. They found several antibiotics that significantly reduced the growth of Lemma minor. Also Hamner (1957) has found the antibiotic Neomycin to affect plant development.

Irradiation also effects plant development. Skoog (1935) has reported that X-rays partially inactivated the growth hormones normally present in plants.

REVIEW OF LITERATURE

General

In 1906 the first published work appeared concerning the prolongation of the life of cut flowers by the use of chemicals being added to the water in which stems of the flowers were placed. Fourten and Ducoment (1906) reported that potassium hydroxide, calcium hydroxide, potassium chloride and sucrose were favorable in extending the life of some cut flowers, such as primula, asperula and silene, to 9 days from a normal life of 4 days. Knudson (1914), however, was unable to substantiate the favorable results of Fourten and Ducoment.

Laurie (1928) found that one-tenth of one percent boric acid increased the keeping time of carnations 3 to 7 days, and obviated the need for cutting the stems or daily changing of water. He also found that one-half of a tablet of aspirin added to two quarts of water prolonged the life of chrysanthemums and dahlias. The life of asters was doubled with the use of a one percent sugar solution.

Later work by Laurie (1936) indicated that copper wire in glass containers affected the life of several cut flowers, including aster, stocks, snapdragons and marigold. These plants lasted 1 to 2.7 days longer than controls.

Copper proved detrimental to carnations. He also showed that of all cut flowers tested, depth of water in the container was not a factor in determining cut life.

Hitchcock and Zimmerman (1929) using 50 chemicals, including aspirin, found that none were noticeably effective in prolonging the life of cut flowers.

Bossard and Verdier (1951) conducted tests to determine the effect of a number of chemicals on the keeping quality of dahlias. They added to the water in which the cut flowers were standing such materials as sodium chloride, potassium permanganate, silver nitrate, ortho-oxyquinoline sulfate, etc. A proprietary substance containing silver nitrate was the most successful, prolonging the life of dahlias for 3 to 4 days.

Tincker (1942) states that no highly effective harmless chemical has yet been satisfactorily used to prolong the cut life of flowers, and that the most certain way to prolong life of flowers is to lower the temperature of the rooms which they decorate.

Low temperature is very effective in prolonging the cut life of flowers and is now a commercially accepted practice. It was reported by Perret (1907) that a low temperature was a very effective means of preserving cut flowers, and he considered relative humidity to be an important factor also, with limits of 60 to 90 percent of saturation being most favorable.

Low temperature was beneficial in practically all cases on the more important commercial flowers, according to Hitchcock and Zimmerman (1929).

They reasoned that since low temperature (3° to 10° C) will retard the maturing processes in flowers, attempts were made to find a chemical treatment which would produce similar results at room temperature.

Hardening of carnations for 24 hours at 40° F and no refrigeration after cutting showed no significant differences in the keeping life of the flowers, according to Knappenberger (1954).

Time of cutting has been shown to also affect cut life. Howland (1945) found that greenhouse roses, variety Better Times, cut in the afternoon kept longer than those cut in the morning. During the winter and spring, those cut at 4:30 p. m. kept 7 percent (7. 4 hours) longer than those cut at 8:00 a. m. But Knappenberger (1954) was unable to find significant differences in cut life of carnations, whether cut during the morning or afternoon.

Chelating Agents

Chelating agents have been shown to effect plant growth and naturally occurring chelates in biological systems are very common. Among the naturally occurring chelates found in most plants are the peroxidases, the cytochromes, the porphyrins and catalase. These enzymes carry on vital functions in the organism, such as the catalysis of oxidation-reduction reactions, oxygen-carrying power, hydrolysis of proteins, decarboxylation, etc.

The addition of synthetic chelating agents has a profound effect on plants and animals. A chelating agent may partially or completely inhibit a metal enzyme function if it is powerful enough to compete with the enzyme for the metal (Martell and Calvin, 1952).

Zentmyer (1943) suggested that the fungicidal action of oxines (derivatives of 8-hydroxyquinoline) was due to the inactivation of essential metal ions in the enzyme systems. Beiler and Martin (1954) have used chelating agents such as versene (ethylenediaminetetra acetic acid), diphenylthiocarbazone and tetraethylthiuran disulfide to inhibit the activity of 5-hydroxytryptophan decarboxylase. They concluded that enzyme activity depends on the presence of a metallic ion and that the inhibition obtained with chelating agents is due to the removal of this metal from the enzyme complex by these agents.

Ethylenediaminetetraacetate (EDTA) has been shown to cause injury to young tomato shoots similar to injury produced by lycomarasmin and fusaric acid (Gaumann and Naef-Roth, 1954). Again the injurious effect was believed to be due to the capacity of the chelating agent to fix metal ions essential for the metabolism of enzymes. Singh (1956) also noted the injurious effect of metal chelating agents on growth of cucumber seedlings. He obtained marked inhibition of growth of cucumber seedlings with a number of chelating agents.

Metal chelating agents have been found to stimulate as well as inhibit growth of higher plants. Heath and Clark (1956) have reported that growth

of wheat coleoptiles was increased by the use of ethylenediaminetetraacetate, 8-hydroxyquinoline, sodium diethyldithiocarbamate (DIECA) and iminodiacetic acid. Root growth was inhibited by these chemicals. Weinstein et al., (1956) obtained an increase in height, fresh weight and dry weight of soybeans by the use of disodium ethylenediaminetetraacetate (Na_2EDTA).

Herr et al. (1956) have found EDTA has a slight activating effect on aconitase activity, and Weinstein et al. (1956) showed EDTA stimulated polyphenol oxidase activity. Altmann (1953) attributed the activating effect of some chelating agents to their ability to remove heavy metals from the reacting system.

Chelating agents can also inhibit enzyme activity. Herr (1956) has reported that ortho-phenanthroline, pyrophosphate, 8-hydroxyquinoline and alpha, alpha-dipyridyl inhibit aconitase activity. Increasing concentrations of Na_2EDTA have been shown to decrease the activity of cytochrome oxidase and ascorbic acid oxidase (Weinstein et al., 1956). They suggested that the decrease in cytochrome oxidase activity may be due to successful competition by EDTA with porphyrin for iron, resulting in decreased synthesis of the enzyme or direct inhibition of protein synthesis.

In working with chelating agents it is often difficult to determine which metal ion is being chelated. Ethylenediamine tetraacetate (EDTA) strongly chelates most of the metals and has a high water solubility both as

salts and chelates (Martell and Calvin, 1952). Albert and Gledhill (1947) have shown that few chelating reagents show true specificity for a metal and that a very large number of reagents will chelate copper. They also found that a given chelate reagent will chelate the different metal ions in various degrees. The chelates in their study were divided into hydrophobic and hydrophilic chelating agents. Hydrophobic ones being those that produce an insoluble precipitate in water and hydrophilic ones producing a water soluble compound.

Growth Regulators

Maleic hydrazide has been one of the more promising growth regulators in regard to possible use in extending the life of cut flowers (Griesel 1954; Lougheed 1954). Other growth regulators have been used with some success.

Maleic hydrazide has been shown to be an antiauxin by Leopold and Klein (1951). It was shown that auxins have the capacity to overcome maleic hydrazide inhibition completely over a wide range of concentrations of the inhibitor. Indoleacetic acid and naphthaleneacetic acid were the auxins capable of relieving maleic hydrazide inhibition.

Isenberg (1954) found that maleic hydrazide was stimulatory to respiration of Sweet Spanish onions at lower concentrations and inhibitory at high

concentrations. He attributed the decrease in respiration of stored onions treated with maleic hydrazide to an inhibition of succinic dehydrogenase.

The aging processes in the intact flower of Magnolia grandiflora were retarded by spraying at anthesis with maleic hydrazide (Griesel, 1954). It was found that starch reserves did not decrease as rapidly in the treated as in the untreated flowers, and it was suggested that the retardation of starch digestion may account in part for lowered respiration, observed by other investigators, in maleic hydrazide treated plants.

Lougheed (1954) has reported that when cut roses were dipped in a 0. 3 percent solution of maleic hydrazide (MH-30) they could be kept for up to two weeks.

Kalin (1955) has reported that 0. 03 percent maleic hydrazide was not effective in prolonging the life of cut daffodil flowers held at room temperatures.

Growth regulators are also effective in preventing bud and flower dropping. Warne (1947) found that by spraying inflorescences of lupines 4 or 5 hours after cutting with 400 to 800 parts per million alpha-naphthylacetic acid (NAA) or beta-indolylacetic acid (IAA) there was a great reduction in the amount and rate of shedding buds and flowers in the first three days.

Whiteman (1949) found that sodium alpha-naphthyl acetate, a growth substance used to prevent fruit drop, prevented shattering of peony petals when the cut flowers were placed in a 50 parts per million solution. One year the

life of the cut flowers was extended from 4 to 8 days by this treatment, but in the subsequent two seasons, although shattering was prevented, life was not prolonged. The keeping quality of lilies of the valley was considerably improved by 25 parts per million of the hormone in solution. Tests with carnations, gladoli, Iris reticulata, German iris, roses and perennial pea were ineffective.

One of the first compounds found to act as an anti-auxin was gamma-phenylbutyric acid. Other anti-auxin like substances which have been found to inhibit growth are 2, 3, 5-triiodobenzoic acid and coumarin (Galston, 1947; Thimann and Bonner, 1949). Andreae and Andreae (1953) have shown the lactone, methyl umbelliferone, to be effective in increasing the enzymatic destruction of indoleacetic acid and that this excessive destruction of indoleacetic acid may inhibit growth.

Respiratory Inhibitors

The term plant respiration has been defined as "all those material changes undergone by complex cellular substances" (James, 1953). Respiration is thus a complex sequence of chemically reversible and irreversible reactions. The respiration rate of plants is measured by their oxygen consumption or carbon dioxide production, or both.

The rate of respiration of plant material is dependent upon a number of environmental factors, such as temperature, carbon dioxide concentration, and light intensity, as well as age of the tissue and genetic constitution of the plant.

Here we are concerned primarily with temperature as it effects respiration. As early as 1874 it was shown that a rise of temperature is likely to accelerate the respiration rate. At temperatures near 0° C, respiration is usually measurable, but very slow, but as temperature is increased up to 40-50° C the respiration rate increases. Numerous investigators have shown that the Q_{10} for plant material is usually between 2 and 4, depending on the plant and the temperature range. Because of this effect of temperature on respiration, plant products when harvested are kept at reduced temperatures until used. Cut flowers are no exception. Flowers, after cutting, are kept under refrigeration to prevent rapid development and subsequent death. Through refrigeration enzymatic activity of the cells is reduced, and this, in turn, reduces the rate of respiration. In apples, the relationship between respiration rate and duration of storage life has been demonstrated by Kidd and West (1930). They showed that approximately equal amounts of carbon dioxide will have been liberated at the time when apple tissues collapse, regardless of the temperature at which they have been stored. The same may

be true for cut flowers, that is, only a certain amount of respirable material may be in the cut flower and once this material has been used the flower parts start to decompose. The length of time the respirable material will last may thus be directly related to the temperature of the plant.

Assuming that the foregoing is true, the author has attempted to prolong life of cut flowers by not only placing more respirable material at the plant's disposal, but also by slowing down the inherent respiration rate of the plant.

As stated previously, plant respiration is a complex series of chemical reactions occurring within the plant cell. As in all chemical reactions, the rate of the reactions is controlled by substances called catalysts. The organic catalysts occurring in plants are known as enzymes. Since respiration is the sum total of a number of complex chemical reactions, we find that enzyme activity determines the rate of respiration. In turn, enzyme activity is dependent upon a number of factors. The principal factors which determine the activity of an enzyme are temperature, pH of the solution, concentration of the substrate, and concentration of the enzyme.

Laurie (1936) was one of the first to approach the problem of cut flower life by attempting to slow down plant respiration. He ran respiration studies on several types of cut flowers, and concluded that low respiratory

rate was correlated with longevity of the cut flower stem, while high respiratory rate was related to a short life. Three materials were effective in cutting down the respiratory rate, according to Laurie (1936). They were "hydrozene sulphate, fluroglucinol and resinol", but it is not stated if these chemicals prolonged cut life.

Carbon dioxide output of rose and gardenia flowers has been studied by Siegelman (1952). He found that long life and low respiration rate was induced by low temperatures.

Many research papers have been written dealing with chemicals that inhibit enzyme activity, but a specific inhibitor, acting upon a single enzyme is at present unrealized (James, 1953). The principal types of respiratory inhibitors used in this present work are the weak organic acids and other compounds shown to effect respiration.

Antibiotics and Cathode Radiation

Using Lemna minor as a test plant Nickell and Finlay (1954) have reported that the use of such antibiotics as Actidione, Aureothricin, Catenulin, Chlortetracycline, Neomycin, Patulin, Polymyxin or Thiolutin resulted in a 90 to 98 percent decrease in weight over the control plants after three weeks of

growth at a concentration of 20 parts per million. A possible mechanism for inhibition was not presented. Bacitracin, Isonicotinic hydrazide and Penicillin G all stimulated growth.

Cathrode rays are electron beams. When the negatively charged electron from the cathode ray machine passes through or close to a molecule, the electron loses a portion of its energy and leaves the molecule in a state of disturbance.

Gamma rays differ from cathode rays in that they are electromagnetic radiations emitted by naturally occurring and artificial radioactive elements. Cathode ray dosage is measured in reps (roentgen - equivalent - physical).

Irradiation has been found to be very effective in inactivation of micro-organisms at dosages of he order of 2×10^6 rep. (Hannan, 1956) and this has been the principal area in which it has been applied. But radiation also has been found to kill insects and to be effective in destroying certain enzymes. Because of its effect on enzymes it was thought that it may be effective in slowing down the respiration rate of cut flowers.

Skoog (1935) has reported that X-rays partially inactivate the growth hormone normally present in plants. He believes the mechanism involves the destruction and inhibition of formation of the growth hormone with a corres-

ponding inhibition of internodal elongation and reduced formation of new tissues in the apex of the plant.

Gamma irradiation has also been shown to be effective in inhibiting the activity of some enzymes. Respiratory gas exchange in potato tubers was shown by Sussman (1953) to be enhanced by dosages of gamma radiation as low as 1000 r. Carbon dioxide evolution was also increased and the peak of this increase occurred 24 hours after that of the oxygen uptake. Cytochrome oxidase and tryosinase activities were not affected by dosages as high as 400, 000 r, but tyrosinase activity was reduced by 50 percent at 3, 200, 000 r.

MATERIALS AND METHODS

Since the primary purpose of this work was to find chemicals that would influence the life of cut flowers, it was decided to limit the work primarily to one kind of flower. Antirrhinum majus was chosen because it could be easily grown in a short time, a large amount of uniform material could be obtained at one time, it has a medium cut life and since it has an inflorescence and not a single flower per stem, it was possible to study the effect of the chemicals on florets that had fully developed and on ones which were considerably undeveloped.

In all experiments using snapdragons (Antirrhinum majus) the following procedure was used unless otherwise noted. The spikes were cut in late afternoon, when between 10 and 14 of the lower florets had fully opened. They were then placed in tap water in a 40° F refrigerator for the next 24 hours to harden. After the 24 hours of hardening, the most uniform spikes were selected, cut to a length of about 30 inches, and placed in individual pint milk bottles containing the appropriate chemical solution. All chemicals were in distilled water and the stems were not recut or removed from the solution at any time during the experiment.

A criteria for useful life was established. Since floret abscission is very uncommon with the varieties used, it was thought that the best criteria

for the length of time of useful or cut life would be the number of days until the leaves had wilted or the number of days until the lower ten (the oldest) florets had wilted. This method of measuring cut life proved very useful for snapdragons.

In order to test as many chemicals as possible, a floret test was used also. Florets between one and three days old were removed from the growing spikes and hardened for about 12 hours at 40° F. They were then placed over the edge of a Petri dish containing the appropriate solution. The pedicel was in the solution and the rest of the floret hung over the edge of the dish. Five to eight florets were placed in each dish and the number of days until wilting was measured. The florets were allowed to remain in the original solution for their entire life span.

Roses were not hardened but used immediately upon arrival from the commission house. For roses, the criteria of life was the number of days until the petals had either fallen, wilted, or severely blued.

In none of the experiments was any attempt made to control relative humidity. Temperatures for all experiments ranged from 70 to 80° F, and in all experiments adequate checks were run.

Flowers used in these experiments include Antirrhinum majus, varieties Barbara, Jackpot. Navajo, Rockwood's Summer Pink, Snowman, Spartan

Rose, and Spartan White; Rosa hybrida, varieties Better Times and Red Delight; Gerbera jamesonii and Lilium speciosum rubrum.

The cathode ray machine was used as the source of radiation in the radiation studies.

Varying concentrations of the chemicals were used depending upon the chemical and results obtained from previous experiments. The commercial floral preservatives used were Floralife, Bloomlife and Petalife*.

Table 1 lists the chelating agents used in this study, Table 2 the growth regulators used, and Table 3 the respiratory inhibitors. Antibiotics used are listed in Table 4. The antibiotics were obtained through the courtesy of the Upjohn Company, Kalamazoo, Michigan.

All experiments were arranged in either a randomized block or split-plot design with generally from four to six replicates. The statistical treatment of the data is according to Cochran and Cox (1950).

All the flowers, except roses, used in these experiments were grown at the Plant Science Greenhouse during 1955 and 1956. The roses used were grown at Mount Clemens, Michigan.

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*Floralife (U. S. Patent No. 2, 230, 931) is manufactured by Floralife, Inc., 1435 South Wabash Avenue, Chicago, Illinois, with a composition of 97.6 percent sugar, 2.1 percent aluminum sulfate, and 0.3 percent hexamethylene tetramine.
Bloomlife is manufactured by Flower Foods, Inc., Maywood, Illinois.
Petalife is distributed by Park-Elitch Company, 1444 Wazee Street, Denver, Colorado.

TABLE 1. List of Chelating Agents and the Metals they Chelate Used in Various Experiments.

Chelating Agent	Metals Most Commonly Chelated
Benzotriazole	Cu
Cupferron (Ammonium salt of N-nitroso-N-phenyl-hydroxylamine)	Fe, Cu
Diethyldithiocarbamic acid (Na salt)	Cu
2, 4-Dihydroxyacetophenone	Fe
2, 3-Dihydroxyquinoxaline	Ca
Dimethylglyoxime	None
2, 4-Dinitrosoresorcinol	Co, Cu
Diphenylamine	Fe
Diphenylglyoxime	Ni
Diphenylthiocarbazone	Co, Cu, Pb, Zn
Ethylenediaminetetraacetic acid	Fe
Hexamethylenetetramine	Fe
2, 2', 4, 4', 6, 6'-Hexanitrodiphenylamine	K
8-Hydroxyquinoline	Cd, Cu, Co, Mn, Pb, Zn
1-Nitroso-2-naphthol	Co, Cu, Pb
1-Nitroso-2-naphthol-3, 6-disulfonic acid (di sodium salt)	Co, Cu, Fe
Phenolphthalein	Co
delta-Phenyl-gamma-thiohydantoic acid	Cu
Quinalizarin (tetrahydroxyanthraquinone)	B, Co, Fe, Mn, Pb
Resorcinol	Co, Cu, Ni

TABLE 2. Growth Regulators and Growth Regulator-like Chemicals used in the Various Experiments.

para-Aminobenzoic acid
Biuret
5-Chloro-salicylic acid
Coumarin
2, 4 Dimethoxybenzoic acid
Esculin
Furil dioxine
beta-Hydroxyethylhydrazine
2-Hydroxy-3-methylbenzoic acid
1-Hydroxy-2-naphthoic acid
3-Hydroxy-2-naphthoic acid
Indole-3-acetic acid (IAA)
Maleic hydrazide
beta-Methyl umbelliferone
1-Naphthoic acid
2-Naphthoic acid
Picolinic acid
Quinaldic acid
6-Quinoline carboxylic acid
Salcicylic acid
2, 3, 5 Triiodobenzoic acid (TIBA)
2-Thiobarbituric acid

TABLE 3. Respiratory Inhibitors used in Experiments.

Benzoin-alpha-oxime
Hydroxylamine hydrochloride
Iodoacetic acid
Maleic acid
D-L Maleic acid
Malonic acid
Mesaconic acid
para-Nitrophenol
ortho-Phenanthroline
Quinoline-8-carboxylic acid
Salicylaldoxime
Semicarbazide hydrochloride
Sodium azide

TABLE 4. Antibiotics used in These Experiments.

Actidione
Amicetin
Antibiotic bacitracin
Antibiotic D-45, free acid
Antibiotic D-45, sodium salt
Antibiotic fumagillin
Antibiotic U-5956
Celesticetin or Antibiotic D-52 (free base)
Endomycin
Neomycin sulfate
Penicillin G
Penicillin O
Salicylate D-52
Streptothricin sulfate
Tetracycline hydrochloride

The results are divided into five sections; preliminary trials, chelating agents, growth regulators, and growth regulator-like substances, respiratory inhibitors and antibiotics and cathode radiation but it is of importance to note that the tables in any of these sections do not indicate that this table contains exclusively chemicals of this type.

Chelating agents were used as a comparison in many of the experiments which were predominantly growth regulators or respiratory inhibitors. Reference to Tables 1, 2, 3 and 4 indicates the type material of any specific chemical.

EXPERIMENTAL RESULTS

Preliminary Trials

It is well known that cutting a flower definitely shortens its life but nowhere in the literature was information found as to how much life is actually shortened. An experiment using three varieties of Antirrhinum majus was designed to determine how much life is shortened by cutting.

Pairs of Antirrhinum majus of equal maturity were selected, one spike was cut and one allowed to remain on the plant. The cut one was handled in the regular commercial manner and then placed in a bottle of distilled water directly beside the spike with which it had been paired.

The results in Table 5 indicate that cutting definitely shortened the life of the lower ten florets. On spikes that were cut the lower ten florets lasted 8.2, 10.6 and 12.2 days for the varieties Barbara, Navajo and Spartan Rose respectively. The lower ten florets on uncut varieties lasted as many as 35 days.

Several factors contribute to this shortening of flower life after cutting. One principal factor is the lack of carbohydrates. Photosynthesis in the cut stem is probably reduced but lack of carbohydrates can be compensated for in part by the addition of sucrose or other sugars to the water.

Cut flowers often wilt even in distilled water and this is due to water being lost faster from the leaves and stem than can be absorbed through the xylem of the stem. The xylem very often becomes blocked by growth of fungal and bacterial organisms at the cut surface and also within the xylem vessels. Lack of mineral elements coming from the soil is also believed to be a factor contributing to an upset metabolism.

TABLE 5. Effect of Cutting on the Life of the Lower Ten Florets of Antirrhinum majus, Varieties Barbara, Navajo and Spartan Rose.

Treatment	Average Number of Days before Wilting of Ten Lower Florets under Greenhouse Conditions*		
	Barbara	Navajo	Spartan Rose
Spikes cut	8.2	10.6	12.2
Spikes not cut	25.8	35.8	30.5
L.S.D. at 5% level	3.1	5.0	7.0
L.S.D. at 1% level	4.9	7.9	11.0

*Each variety is an average of six replicates and one spike per plot.

Since florets on the uncut spike lasted about three times as long as those on cut ones, it can be seen that the goal in extending the life of cut Antirrhinum majus is yet to be achieved.

In order to study the effect of the presence of unopened florets on ones that had already opened and the presence of opened florets on ones about

to open the experiment summarized in Table 6 was conducted. The four treatments were, no florets removed from spike, all opened and unopened florets removed except ten lower ones, rachis removed above tenth floret, and a control in distilled water. The results indicate that by removing all the opened and unopened florets above the tenth one, the lower ten lasted one to two days longer and that by removing the rachis above the tenth floret, the remaining lower ten florets lasted two to three days longer. The results were significant at the 1 percent level for the varieties Barbara and Jackpot, and at the 5 percent level for the variety Spartan Rose.

TABLE 6. Effect of Removing Florets on the Life of the Lower Ten Florets of Antirrhinum majus, Varieties Barbara, Jackpot, and Spartan Rose.

Treatment	Days from Treatment until Lower Ten Florets Wilted*		
	Barbara	Jackpot	Spartan Rose
Distilled water (control); no florets removed	4.0	4.6	6.3
2% Floralife; no florets removed	4.7	6.4	7.8
2% Floralife; all opened and unopened florets removed except ten lower ones	6.1	8.4	8.2
2% Floralife; rachis above tenth floret removed	6.8	9.3	10.2
L. S. D. at 5% level	1.2	1.4	2.3
L. S. D. at 1% level	1.6	1.8	N. S.

*Each variety is an average of six replicates and one spike per plot.

Chelating Agents

The effect of a number of chelating agents on the life of three varieties of Antirrhinum majus is shown in Table 7. These particular chelating agents are capable of chelating one or more such metals as boron, calcium, cobalt, copper, iron and nickel. The results indicate significant differences in the keeping qualities of varieties, but in most instances the chelating agents at the concentrations used were of little or no benefit in prolonging cut life.

Chelating agents significantly increased the length of cut life of the variety Rockwood's Summer Pink (Table 8). The results show that Cupferron, a ferric iron chelating agent, was especially effective in extending the cut life of this variety two to three times that of the check. Diphenylthiocarbazone and delta-phenyl-gamma-thiohydrantoic acid, both copper chelates, and 2, 2', 4, 4', 6, 6'-hexanitrodiphenylamine, a potassium chelate, doubled the cut life of this variety. The remaining chelating agents had little or no effect in extending cut life.

Since it was found that Cupferron, an iron chelating agent, improved the keeping of Rockwood's Summer Pink as well as other varieties of snapdragons, it was decided to try the effect of other iron chelating agents on the life of snapdragons. As is shown in Table 9, diphenylamine and 2, 4-dihydroxyacetophenone, both iron chelating agents were effective in prolonging life.

TABLE 7. Effect of Chelating Agents on the Life of Three Varieties of Antirrhinum majus.

Treatment	Average Life in Days*		
	Spartan Rose	Barbara	Navajo
Distilled water (control)	5.8	3.0	6.0
2% Floralife	6.5	5.6	6.2
100 ppm 1-nitroso-2-naphthol	8.1	4.8	3.8
100 ppm diethyldithiocarbamic acid (sodium salt)	7.7	7.8	6.2
100 ppm 2, 3-dihydroxyquinoxaline	7.0	6.0	6.2
100 ppm benzotriazole	7.1	5.3	7.0
100 ppm resorcinol	7.1	5.6	6.8
100 ppm 2, 4-dinitrosoresorcinol	6.1	5.5	6.4
100 ppm quinalizarin	7.7	5.6	5.8
L.S.D. at 5% level	N.S.	0.9	1.9
L.S.D. at 1% level	N.S.	1.1	N.S.

*Average of six replicates and one spike per plot.
Life was considered ended when either leaves or the lower ten florets wilted.

TABLE 8. Effect of Chelating Agents on Life of Antirrhinum majus, variety Rockwood's Summer Pink.

Treatment	Average Life in Days*
Distilled water (control)	4.7
2% Floralife	3.3
200 ppm hexamethylenetetramine	3.5
200 ppm phenolphthalein	4.8
200 ppm dimethylglyoxime	4.8
200 ppm diphenylthiocarbazone	5.8
200 ppm delta-phenyl-gamma-thiohydantoic acid	6.0
200 ppm 2, 2', 4, 4', 6, 6'-hexanitrodiphenyl-amine	6.2
200 ppm Cupferron	10.0
L.S.D. at 5% level	1.2
L.S.D. at 1% level	1.7

*Average of three replicates and two spikes per plot.

TABLE 9. Effect of Chelating Agents on Life of Antirrhinum majus, variety Jackpot.

Treatment	Average Life in Days*
Distilled water (control)	5.2
2% Floralife	6.8
100 ppm diphenylglyoxime	7.4
100 ppm 2, 4-dihydroxyacetophenone	7.8
100 ppm diphenylamine	9.6
100 ppm Cupferron	10.4
L. S. D. at 5% level	1.2
L. S. D. at 1% level	1.7

*Average of five replicates and one spike per plot.

Table 10 also shows the effect of iron chelating agents on the life of two varieties of snapdragon, Barbara and Jackpot. In this experiment 200 parts per million hexamethylenetetramine, 1-nitroso-2-naphthol-3, 6-disulfonic acid or Cupferron in 2 percent Floralife significantly increased the life of these two varieties and the increased time was two to three times that of the control.

Since several iron chelating agents were found effective in extending life, it was decided to try a combination of the more promising chelates. The results of using hexamethylenetetramine, 1-nitroso-2-naphthol-3, 6-disulfonic acid and Cupferron singly and in combination are shown in Table 11. With the variety, Rockwood's Summer Pink, hexamethylenetetramine and 1-nitroso-2-naphthol-3, 6-disulfonic acid were not effective alone, or in combination with Cupferron in prolonging cut life. The three chelating agents at 70 parts per million (in distilled water) did double cut life, as compared to the control.

Table 12 shows the results of three commercial floral preservatives with and without Cupferron on cut life of two varieties of snapdragon, Spartan Rose and Spartan White. Petalife alone was far superior to the two preservatives, Floralife and Bloomlife, but when 200 parts per million Cupferron was added to the floral preservatives a considerable improvement was shown in cut flower life, except with Petalife. When Cupferron was added to Bloomlife, the life of Spartan White was increased from an average of 3.4 days to

TABLE 10. Effect of Iron Chelating Agents on the Life of Antirrhinum majus, Varieties Barbara and Jackpot.

Treatment	Average Life in Days*	
	Barbara	Jackpot
Distilled water (control)	3.2	3.8
2% Floralife	6.7	6.8
200 ppm hexamethylenetetramine	6.8	8.7
200 ppm 1-nitroso-2-naphthol-3, 6-di-sulfonic acid	8.5	10.3
200 ppm Cupferron	11.0	9.8
L. S. D. at 5% level	1.3	2.8
L. S. D. at 1% level	1.7	3.8

*Average of six replicates and one spike per plot.

TABLE 11. Effect of Chelating Agents on the Life of Antirrhinum majus, Variety Rockwood's Summer Pink.

Treatment	Average Life in Days*
Distilled water (control)	3.3
2% Floralife	5.2
210 ppm hexamethylenetetramine (A)	3.8
210 ppm 1-nitroso-2-naphthol-3, 6-disulfonic acid (di sodium salt) (B)	5.2
210 ppm Cupferron (C)	8.2
105 ppm A and 105 ppm C	5.7
105 ppm A and 105 ppm B	4.5
105 ppm C and 105 ppm B	7.7
70 ppm A, 70 ppm B, 70 ppm C	5.8
70 ppm A, 70 ppm B, 70 ppm C in distilled water	6.3
L. S. D. at 5% level	1.2
L. S. D. at 1% level	1.6

*Average of six replicates and one spike per plot.

TABLE 12. Comparison of Several Commercial Floral Preservatives with and without Cupferron on the Life of Antirrhinum majus, Varieties Spartan Rose and Spartan White.

Treatment	Average Life in Days*	
	Spartan Rose	Spartan White
Distilled water (control)	5.8	3.6
2% Floralife	5.6	6.4
2% Bloomlife	4.4	3.4
2% Petalife	8.8	11.8
2% Floralife and 200 ppm Cupferron	7.6	8.4
2% Bloomlife and 200ppm Cupferron	8.2	13.6
2% Petalife and 200 ppm Cupferron	8.8	12.4
2% Sucrose	2.0	3.4
2% Sucrose and 200 ppm Cupferron	10.0	13.2
2% Sucrose and 350 ppm Aluminum Sulfate	2.2	2.6
2% Sucrose and 350 ppm Aluminum Sulfate and 200 ppm Cupferron	7.4	8.2
L.S.D. at 5% level	1.6	1.9
L.S.D. at 1% level	2.1	2.5

*Average of five replicates and one spike per plot.

an average of 13.6 days. Cupferron was effective in improving the quality of both Floralife and Bloomlife, but not Petalife.

Two percent sucrose shortened the life of both varieties, but when 200 parts per million Cupferron was added to the sucrose solution, life was extended four to five times. The addition of 350 parts per million aluminum sulfate to the Cupferron-sucrose solution shortened the cut life of both varieties.

The life of the snapdragon variety, Barbara, was also shortened by the addition of 2 percent sucrose to the water (Table 13). This experiment indicated that a 2 percent Floralife and Cupferron mixture when used in tap water was as effective in prolonging life as when used in distilled water (Table 10).

Since Cupferron was so effective in extending cut life, it was decided to determine when this chelating agent was most effective. Snapdragons, variety Rockwood's Summer Pink, were placed in a Floralife-Cupferron solution for various lengths of time, for entire life, first three days after cutting, and first six days after cutting. The results (Table 14) indicate that the Cupferron was necessary the first few days only, and after this time its presence or absence was neither beneficial or harmful to the cut life of this variety.

TABLE 13. Effect of Cupferron with Sucrose and Floralife on the Life of Antirrhinum majus, Variety Barbara.

Treatment	Average Life in Days*
Tap water (control)	5.1
2% Sucrose	2.8
2% Sucrose and 125 ppm Cupferron	2.6
2% Floralife	5.6
125 ppm Cupferron	5.6
2% Floralife and 125 ppm Cupferron	10.0
L.S.D. at 5% level	2.3
L.S.D. at 1% level	3.1

*Average of five replicates and one spike per plot.

TABLE 14. Effect of Cupferron for Various Lengths of Time on Life of Antirrhinum majus, Variety Rockwood's Summer Pink.

Treatment	Average Life in Days*
Continuous in Solution** (Control)	8.2
Solution for first 3 days	7.4
Solution for first 6 days	8.2

*No significant differences. Average of five replicates.

**Solution was 2% Floralife plus 200 ppm Cupferron after 3 and 6 days the spikes were placed in solution minus the Cupferron.

TABLE 15. Effect of Various Concentrations of Cupferron on Life of Antirrhinum majus, Varieties Jackpot and Navajo.

Treatment	Average Life in Days*	
	Jackpot	Navajo
2% Floralife	5.6	6.2
50 ppm Cupferron	8.6	6.8
100 ppm Cupferron	9.6	6.2
500 ppm Cupferron	12.6	10.0
1000 ppm Cupferron	9.4	--
L.S.D. at 5% level	2.9	N.S.
L.S.D. at 1% level	3.9	N.S.

*Average of five replicates and one spike per plot.

In order to ascertain what level of Cupferron was best for snapdragons the experiment shown in Table 15 was designed. The results indicate that between 100 and 500 parts per million Cupferron were the most desirable range for the variety Jackpot. For the variety Navajo the differences were not significant.

Since Cupferron was found to prevent the wilting of leaves and to delay the wilting of florets, it was decided to study the effect of various levels of Cupferron on snapdragon florets. Results of this experiment are shown in Table 16. Cupferron was effective in prolonging life when used at a minimum of 100 parts per million. Concentrations of 400 parts per million were not harmful and prolonged life about one day. When 1 percent Floralife was added, the life of the florets was reduced by one or two days (Table 16). Results indicate that low amounts of Cupferron, less than 50 parts per million, may shorten the life of Snowman snapdragon florets.

The data shown in Table 17 are results of an experiment designed to study the interaction between various levels of maleic hydrazide and Cupferron. Maleic hydrazide at a concentration of 250 or 500 parts per million was very effective in prolonging cut life of the snapdragon, variety Spartan Rose, while high concentrations (3000 and 4000 parts per million) of maleic hydrazide shortened cut life appreciably. Cupferron was not significantly effective in extending life even at 500 parts per million but a concentration

TABLE 16. Effect of Cupferron on the Life of Antirrhinum majus Florets, Variety Snowman.

Treatment	Average Life in Days*
Tap water	6.3
1% Floralife	5.3
1% Floralife and 50 ppm Cupferron	6.5
50 ppm Cupferron	6.0
Distilled water	7.4
1% Floralife	5.2
1% Floralife and 50 ppm Cupferron	5.7
12.5 ppm Cupferron	6.7
25 ppm Cupferron	6.9
50 ppm Cupferron	7.3
100 ppm Cupferron	8.5
200 ppm Cupferron	8.2
400 ppm Cupferron	8.7
L.S.D. at 5% level	1.0
L.S.D. at 1% level	1.3

*Average of four replicates and six florets per plot.

TABLE 17. Effect of Various Concentrations of Maleic Hydrazide and Cupferron Singly and in Combination on the Life of Antirrhinum majus, Variety Spartan Rose.*

Maleic Hydrazide (ppm)	Average Life in Days**			
	Cupferron (ppm)			M-H mean (days)
	0	100	500	
0	7.0	8.0	8.0	7.7
250	9.5	10.5	8.3	9.4
500	11.3	9.8	9.7	10.3
1000	7.8	7.2	12.7	9.2
2000	4.2	3.7	4.3	4.1
4000	2.0	2.2	3.3	2.5
Cupferron mean (days)	7.0	6.9	7.7	

Cupferron: No significant differences between means.

Maleic Hydrazide: Difference required for significance at 5% level, 1.2 days; at 1% level, 1.6 days.

Two maleic hydrazide means for a given level of cupferron: Difference required for significance at 5% level, 2.0 days; at 1% level, 2.7 days.

Two Cupferron means for a given level of maleic hydrazide: Difference required for significance at 5% level, 2.1 days; at 1% level, 2.8 days.

*All treatments contained 2 percent Floralife.

**Average of six replicates and one spike per plot.

of 500 parts per million maleic hydrazide increased cut life almost 6 days over the control. Concentrations of Cupferron as high as 500 parts per million were not harmful, however. Results indicated that moderate levels of (between 250 and 500 parts per million) maleic hydrazide with or without Cupferron were most effective in prolonging life of this variety.

Since both Cupferron and maleic hydrazide proved effective when added to the keeping water, it was decided to test the effect of these two chemicals in addition to 8-hydroxyquinoline, when used as a foliage spray one and three days before harvest. Results (Table 18) showed no significant differences among treatments. Cupferron as high as 1000 parts per million and maleic hydrazide up to 4000 parts per million neither lengthened nor shortened the cut life of Snowman snapdragon.

Since the rose is a flower having a rather short cut life, it was thought that Cupferron might extend the life of cut roses. Table 19 shows that 200 parts per million Cupferron plus 2 percent Floralife extended the life of Better Times roses two and one-half days, while 200 parts per million Cupferron extended life one day over Floralife.

Lilium speciosum rubrum was not effected by Cupferron (Table 20) nor was Floralife of any benefit in extending cut life.

Table 21 shows the effect of three iron chelates on Gerbera jamesonii. The chemicals had no effect on the cut life of this flower and Floralife was of no value.

TABLE 18. Effect of Pre-harvest Foliage Sprays on the Life of Antirrhinum majus, Variety Snowman.

Treatment	Average Life in Days	
	Sprayed 1 day before harvest*	Sprayed 3 days before harvest**
Control	7.5	6.9
200 ppm Cupferron pH 3.0	7.5	7.3
200 ppm Cupferron pH 7.0	7.2	6.9
1000 ppm Cupferron pH 3.0	7.1	7.0
1000 ppm Cupferron pH 7.0	7.7	6.9
1000 ppm maleic hydrazide	7.3	7.0
2000 ppm maleic hydrazide	7.0	7.0
4000 ppm maleic hydrazide	7.2	7.0
100 ppm 8-hydroxyquinoline	7.7	7.0
200 ppm 8-hydroxyquinoline	7.4	7.0

*Significant at 1% level. L. S. D. at 5% level, 0.4 days; at 1% level, 0.6 days.

**No significant differences.

TABLE 19. Effect of Cupferron on Life of Rosa hybrida, Variety Better Times.

Treatment	Average Life in Days*
Distilled water (control)	4.0
2% Floralife	5.5
2% Floralife and 200 ppm Cupferron	6.6
L.S.D. at 5% level	0.9
L.S.D. at 1% level	1.4

*Average of four replicates and two flowers per plot.

TABLE 20. Effect of Cupferron and Floralife on Life of Lilium speciosum rubrum.

Tap water	5.3
Distilled water (control)	5.0
2% Floralife	4.3
2% Floralife and 200 ppm Cupferron	5.0
2% Sucrose and 200 ppm Cupferron	5.0

No significant differences.

*Average of three replicates and one flower per plot.

TABLE 21. Effect of Chelating Agents on Cut Life of Gerbera jamesonii.

Treatment	Average Life in Days*
Distilled water (control)	5.2
2% Floralife	5.5
100 ppm 2, 4-dinitroresorcinol	4.7
100 ppm diphenylamine	5.3
100 ppm Cupferron	5.2

No significant differences.

*Average of four replicates and four flowers per plot.

When browning of the lily petals started, cut life was considered ended. Gerbera cut life was completed when the heads wilted. Both of these flowers were hardened 24 hours before placing in the various solutions.

Growth Regulators

Growth regulators as well as chelating agents were used in attempting to prolong cut life of flowers. The effect of several growth regulators on two varieties of snapdragon is shown in Table 22. These chemicals when used at 100 parts per million in a 2 percent Floralife solution had no effect on cut life. Differences in extremes were one and one-half days for Jackpot and one day for Spartan Rose. Since the chemicals listed in Table 22 had no apparent physiological effect on snapdragons, it was decided to try some chemicals known to exert considerable physiological effect, such as indole-3-acetic acid, 2, 3, 5-triiodobenzoic acid, and beta-methyl umbelliferone.

The effect of a number of these chemicals is summarized in Table 23. Indole-3-acetic acid at 175 parts per million reduced the life of this variety by one-half, as did 600 parts per million beta-hydroxyethylhydrazine and 200 parts per million 2, 3, 5-triiodobenzoic acid. Coumarin, esculin or 2-thiobarbituric acid had no effect on cut life. No treatment was as good as the distilled water control.

The results of four organic acids on four varieties of snapdragon are shown in Table 24. Salcicylic acid, 2-hydroxy-3-methylbenzoic acid, 3-hydroxy-2-naphthoic acid and 1-hydroxy-2-naphtoic acid all shortened the life of these four varieties when used at 100 parts per million in a 2 percent

TABLE 22. Effect of Several Growth Regulators on the Cut Life of Antirrhinum majus, Varieties Jackpot and Spartan Rose.

Treatment	Average Life in Days	
	Jackpot*	Spartan Rose**
Distilled water (control)	5.4	5.0
2% Floralife	5.0	5.8
100 ppm 1-naphthoic acid	5.7	5.5
100 ppm 2-naphthoic acid	6.0	6.0
100 ppm 6-quinoline carboxylic acid	6.5	5.8
100 ppm quinaldic acid	6.0	5.3
100 ppm 5-chloro salicylic acid	5.6	5.0
100 ppm picolinic acid	5.6	5.8

No significant differences.

*Average of seven replicates.

**Average of four replicates.

TABLE 23. Effect of Several Growth Regulators on the Life of Antirrhinum majus, Variety Rockwood's Summer Pink.

Treatment	Average Life in Days*
Distilled water (control)	6.3
2 1/2% Floralife	5.5
200 ppm beta-hydroxyethylhydrazine	6.0
600 ppm beta-hydroxyethylhydrazine	3.7
17.5 ppm indole-3-acetic acid	5.2
175.0 ppm indole-3-acetic acid	3.2
14.6 ppm coumarin	5.8
146.0 ppm coumarin	5.3
35 ppm esculin	6.2
200 ppm beta-methyl umbelliferone	5.5
200 ppm 2, 3, 5-triiodobenzoic acid	4.0
400 ppm 2-thiobarbituric acid	6.2
L. S. D. at 5% level	1.4
L. S. D. at 1% level	1.9

*Average of three replicates and two spikes per plot.

TABLE 24. Effect of Growth Regulator-like Substances on the Life of Antirrhinum majus, Varieties Barbara, Jackpot, Navajo, and Spartan Rose.

Treatment	Average Life in Days*			
	Barbara	Jackpot	Navajo	Spartan Rose
Distilled water (control)	3.3	4.7	6.3	6.8
2% Floralife	5.8	7.0	6.2	5.7
100 ppm salcicylic acid	3.3	4.0	3.5	4.5
100 ppm 2-hydroxy-3-methyl-benzoic acid	3.6	4.7	4.2	5.7
100 ppm 3-hydroxy-2-naphthoic acid	3.3	4.7	4.0	6.0
100 ppm 1-hydroxy-2-naphthoic acid	3.3	5.0	4.0	6.3
L.S.D. at 5% level	0.7	1.6	0.9	1.1
L.S.D. at 1% level	1.0	N.S.	1.3	N.S.

*Average of six replicates and one spike per plot.

Floralife solution. It is of interest to note that Floralife increased the life of two varieties about two and one-half days and had no effect on the life of the other two varieties.

Other growth regulators were tested using florets of the variety Barbara (Table 25). In general, all growth regulators used in this experiment shortened the life of florets. Cupferron, a metal chelating agent, increased the life span of florets approximately three days over the control. The trend was that the higher the concentration of the growth regulator, the shorter the life span.

Maleic hydrazide was most effective in extending cut life of snapdragons. Table 26 shows the effect of three concentrations of this chemical on cut life of varieties Jackpot and Navajo snapdragon. Maleic hydrazide at 2000 parts per million was most effective in prolonging life, but another experiment (Table 11) indicated that this concentration was too high. The red variety, Navajo, showed no significant differences in cut life when treated with maleic hydrazide.

TABLE 25. Effect of Various Chemicals on the Life of Antirrhinum majus Florets, Variety Barbara.

Treatment	Average Life in Days
Distilled water (control)	5.2
2.5 ppm indole-3-acetic acid	4.9
50 ppm indole-3-acetic acid	3.5
2.5 ppm sodium azide	5.0
2.5 ppm malonic acid	4.9
10 ppm biuret	5.7
5 ppm 2, 3, 5-triiodobenzoic acid	4.4
50 ppm furil dioxine	5.1
100 ppm furil dioxine	5.0
5 ppm beta hydroxyethylhydrazine	5.3
25 ppm beta hydroxyethylhydrazine	5.7
50 ppm 2, 4-dimethoxybenzoic acid	4.5
50 ppm p-aminobenzoic acid	3.7
100 ppm Cupferron	8.1
L.S.D. at 5% level	0.6
L.S.D. at 1% level	0.8

*Average of three replicates and five florets per plot.

TABLE 26. Effect of Maleic Hydrazide on the Life of Antirrhinum majus, Varieties Jackpot and Navajo.

Treatment	Average Life in Days	
	Jackpot	Navajo
Distilled water (control)	4.0	5.4
2% Floralife	6.4	4.4
1000 ppm maleic hydrazide	8.6	6.6
2000 ppm maleic hydrazide	10.2	7.2
4000 ppm maleic hydrazide	9.4	5.0
L.S.D. at 5% level	1.3	N.S.
L.S.D. at 1% level	1.8	N.S.

*Average of five replicates and one spike per plot.

Respiratory Inhibitors

During the latter part of the experimental work a number of respiratory inhibitors were selected in order to study their effect on the length of life of cut snapdragons. Table 27 shows the effect of sodium azide and malonic acid on the variety Rockwood's Summer Pink. These two chemicals shortened the life of this variety in all cases. The results indicated that the concentrations used were considerably higher than optimum.

TABLE 27. Effect of Respiratory Inhibitors on the Life of Antirrhinum majus, Variety Rockwood's Summer Pink.

Treatment	Average Life in Days*
Distilled water (control)	3.9
2% Floralife	5.6
130 ppm sodium azide	1.1
65 ppm sodium azide	2.0
200 ppm malonic acid	3.1
104 ppm malonic acid	4.1
52 ppm malonic acid	5.5
L.S.D. at 5% level	0.9
L.S.D. at 1% level	1.2

*Average of four replicates and one spike per plot.

When snapdragons were dipped for one minute in .05M malonic acid or .05M sodium azide, their cut life was shortened (Table 28). Snapdragons, variety Barbara, dipped in 20, 000 parts per million maleic hydrazide lasted approximately one day longer than undipped spikes. The variety Spartan Rose lasted two days longer when dipped for one minute in 20, 000 parts per million maleic hydrazide (Table 29), but spikes dipped in solutions of .05M malonic acid or .05M sodium azide had a shorter life than the checks. Floralife increased the life of varieties Barbara and Spartan Rose about one and one-half days (Tables 28 and 29).

In Table 30 the effect of several respiratory inhibitors and chelating agents on the florets of the snapdragon Spartan White are given. Hydroxylamine hydrochloride and quinoline-8-carboxylic acid both respiratory inhibitors appear to have no effect on floret life, but quinoline-8-carboxylic acid at 25 parts per million did extend the life of florets one day. The three chelating agents, ethylenediaminetetraacetic acid, 1-nitroso-2-naphthol-3, 6-disulfonic acid and diphenylamine had little effect on cut life. At increasing concentrations of EDTA cut life was shortened.

The experiment (Table 31) using a number of respiratory inhibitors indicates that 10 parts per million was not harmful to florets. But 50 parts per million of the chemicals, except iodoacetic acid, decidedly shortened the

TABLE 28. Effect of Respiratory Inhibitors on the Life of Antirrhinum majus, Variety Barbara.

Respiratory Inhibitors (dipped for 1 minute)	No Floralife	Floralife	Resp. Inhib. Mean* (days)
Distilled water	3.7	5.5	4.6
20,000 ppm maleic hydrazide	4.8	6.3	5.6
.05M malonic acid	3.7	4.7	4.2
.05M sodium azide	3.3	3.8	3.6
Floralife mean* (days)	3.9	5.1	

Floralife: Differences required for significance at 5% level - 0.4 days;
at 1% level - 0.7 days.

Respiratory inhibitors: Differences required for significance at 5% level - 1.0 days
at 1% level - 1.3 days

*Average of six replicates and one spike per plot.

TABLE 29. Effect of Respiratory Inhibitors on the Life of Antirrhinum majus, Variety Spartan Rose.

Respiratory Inhibitors (dipped for 1 minute)	No Floralife	Floralife	Resp. Inhib. Mean* (days)
Distilled water	5.5	7.3	6.4
20,000 ppm maleic hydrazide	7.5	9.0	8.3
.05M malonic acid	5.3	6.3	5.8
.05M sodium azide	5.3	5.0	5.2
Floralife mean* (days)	5.9	6.9	

Floralife: No significant differences between means.

Respiratory inhibitors: Differences required for significance at 5% level - 1.4 days
at 1% level - 1.9 days

*Average of six replicates and one spike per plot.

TABLE 30. Effect of Several Chemicals on the Life of Antirrhinum majus Florets, Variety Spartan White.

Treatment	Average Life of Floret in Days*
Distilled water (control)	7.0
25 ppm hydroxylamine hydrochloride	6.9
50 ppm hydroxylamine hydrochloride	6.9
100 ppm hydroxylamine hydrochloride	7.1
25 ppm quinoline-8-carboxylic acid	8.1
50 ppm quinoline-8-carboxylic acid	7.5
100 ppm quinoline-8-carboxylic acid	7.0
25 ppm ethylenediaminetetraacetic acid (EDTA)	6.0
50 ppm ethylenediaminetetraacetic acid (EDTA)	5.5
100 ppm ethylenediaminetetraacetic acid (EDTA)	4.9
25 ppm 1-nitroso-2-naphthol-3, 6-disulfonic acid	6.8
50 ppm 1-nitroso-2-naphthol-3, 6-disulfonic acid	7.1
100 ppm 1-nitroso-2-naphthol-3, 6-disulfonic acid	6.3
25 ppm diphenylamine	7.3
50 ppm diphenylamine	7.5
100 ppm diphenylamine	7.2
L. S. D. at 5% level	0.9
L. S. D. at 1% level	1.2

*Average of four replicates and six florets per plot.

TABLE 31. Effect of Respiratory Inhibitors on Life of Florets of Antirrhinum majus, Varieties Spartan Rose and Spartan White.

Treatment	Average Life in Days*	
	Spartan Rose*	Spartan White**
Distilled water (control)	5.2	6.8
10 ppm malonic acid	5.3	6.5
50 ppm malonic acid	3.7	3.8
10 ppm mesaconic acid	4.7	6.0
50 ppm mesaconic acid	3.8	3.9
10 ppm p-nitrophenol	5.9	6.5
50 ppm p-nitrophenol	5.9	4.4
10 ppm semicarbazide hydrochloride	6.0	6.9
50 ppm semicarbazide hydrochloride	4.3	5.4
10 ppm salicylaldoxime	6.3	7.4
50 ppm salicylaldoxime	4.8	5.7
10 ppm maleic acid	5.3	6.1
50 ppm maleic acid	3.9	4.0
10 ppm iodoacetic acid	4.7	4.0
50 ppm iodoacetic acid	5.6	6.8
L. S. D. at 5% level	1.6	1.6
L. S. D. at 1% level	2.1	2.1

*Average of four replicates and three florets per plot.
**Average of four replicates and four florets per plot.

life of florets of both Spartan Rose and Spartan White. In general, none of the respiratory inhibitors (Tables 31 and 32) significantly increased length of life of either florets or the whole spike.

The experiments summarized in Tables 33 and 34 show the effect of a number of respiratory inhibitors on life of two varieties of snapdragon, Spartan Rose and Spartan White. The basic solution in these two experiments was 2 percent sucrose and 200 parts per million Cupferron in distilled water. The basic solution was very effective in extending cut life, but the addition of 10 and 50 parts per million of a respiratory inhibitor gave no improvement. Para-nitrophenol and ortho-phenanthroline at 50 parts per million shortened the life of florets of both varieties.

TABLE 32. Effect of Respiratory Inhibitors on the Life of Antirrhinum majus, Varieties Spartan Rose and Spartan White.

Treatment	Average Life in Days*	
	Spartan Rose	Spartan White
Distilled water (control)	7.3	7.8
Tap water	7.8	8.0
2% Floralife	7.8	7.8
10 ppm malonic acid	8.5	7.5
50 ppm malonic acid	8.8	7.5
100 ppm malonic acid	8.0	5.5
10 ppm mesaconic acid	8.3	8.3
50 ppm mesaconic acid	7.0	7.0
100 ppm mesaconic acid	7.5	7.0
10 ppm p-nitrophenol	7.3	6.3
50 ppm p-nitrophenol	6.8	5.8
100 ppm p-nitrophenol	4.5	3.0
10 ppm maleic acid	8.0	7.3
50 ppm maleic acid	6.3	6.5
100 ppm maleic acid	5.8	6.0
200 ppm Cupferron	9.5	10.3
L.S.D. at 5% level	1.9	2.1
L.S.D. at 1% level	2.5	2.8

*Average of four replicates and one spike per plot.

TABLE 33. Effect of Several Respiratory Inhibitors on the Life of Antirrhinum majus, Varieties Spartan Rose and Spartan White.

Treatment	Average Life in Days*	
	Spartan Rose	Spartan White
Distilled water (control)	5.3	7.8
Basic solutions**	14.0	10.3
10 ppm ortho-phenanthroline	10.3	8.8
50 ppm ortho-phenanthroline	7.3	5.3
10 ppm hydroxylamine hydrochloride	15.3	15.0
50 ppm hydroxylamine hydrochloride	11.3	12.3
10 ppm D-L maleic acid	10.3	12.8
50 ppm D-L maleic acid	12.7	10.0
10 ppm quinoline-8-carboxylic acid	14.3	11.0
50 ppm quinoline-8-carboxylic acid	14.0	14.0
L.S.D. at 5% level	3.9	4.0
L.S.D. at 1% level	5.6	5.5

*Average of four replicates and one spike per plot.

**Basic solution of 2% sucrose and 200 ppm Cupferron used in all treatments except control.

TABLE 34. Effect of Respiratory Inhibitors on the Life of Antirrhinum majus, Varieties Spartan Rose and Spartan White.

Treatment	Average Life in Days*	
	Spartan Rose	Spartan White
Distilled water (control)	6.8	7.0
Basic solution**	10.5	12.5
10 ppm benzoin oxime	11.8	13.0
50 ppm benzoin oxime	13.5	11.3
10 ppm malonic acid	10.8	11.8
50 ppm malonic acid	10.3	7.8
10 ppm para-nitrophenol	12.3	12.5
50 ppm para-nitrophenol	7.0	5.8
L.S.D. at 5% level	2.2	2.8
L.S.D. at 1% level	3.0	3.7

*Average of four replicates and one spike per plot.

**All treatments except control were in a "Basic Solution" containing 2% sucrose and 200 ppm Cupferron.

Antibiotics and Cathode Radiation

Florets of the snapdragon Spartan Rose were placed in White's solution (White, 1943) containing five antibiotics at two concentrations. Results (Table 35) indicated that White's solution alone shortened the life of these florets. The antibiotics used had little or no effect on length of life of this variety, but 10 parts per million Endomycin appeared to counteract the detrimental effect of White's solution.

In Table 36 the results of a number of antibiotics on the florets of the variety Barbara are presented. These antibiotics in the presence of White's solution had no significant effect on the life of the florets. Distilled water was significantly better than tap water in preserving cut life. A 1 percent solution of Floralife shortened the life of florets about two and one-half days.

Spikes of the variety Spartan Rose were not significantly affected by concentrations of 10 and 100 parts per million D-52 Salicylate, Neomycin sulfate or actidione (Table 37).

Antibiotics had no significant effect on length of cut life of Red Delight roses (Table 38). A solution of 2 percent Floralife did increase life about two days over the control (distilled water).

TABLE 35. Effect of Antibiotics in White's Solution on the Life of Antirrhinum majus, Variety Spartan Rose, Florets.

Treatment	Average Life in Days*
Distilled water (control)	4.6
Tap water	3.2
White's solution	2.5
10 ppm Endomycin	3.5
50 ppm Endomycin	2.5
10 ppm Penicillin O	2.4
50 ppm Penicillin O	2.4
10 ppm Antibiotic D-52	2.0
50 ppm Antibiotic D-52	2.6
10 ppm Streptothricin sulfate	2.5
50 ppm Streptothricin sulfate	2.9
10 ppm Antibiotic D-45, sodium salt	2.7
50 ppm Antibiotic D-45, sodium salt	2.8
L. S. D. at 5% level	0.6
L. S. D. at 1% level	0.9

*Average of four replicates and five florets per plot.

TABLE 36. Effect of Antibiotics in White's Solution on the Life of Florets of Antirrhinum majus, Variety Barbara.

Treatment	Average Life in Days*
Distilled water (control)	7.5
Tap water	3.8
Distilled water and 1% Floralife	4.9
Distilled water and 1% Floralife and 25 ppm Cupferron	8.5
White's solution	4.5
10 ppm Antibiotic bacitracin	3.7
50 ppm Antibiotic bacitracin	4.6
10 ppm Amicetin	5.0
50 ppm Amicetin	4.3
10 ppm Tetracycline hydrochloride	4.5
50 ppm Tetracycline hydrochloride	3.8
10 ppm Penicillin G	4.0
50 ppm Penicillin G	4.8
10 ppm Antibiotic D-45, free acid	4.5
50 ppm Antibiotic D-45, free acid	3.6
L. S. D. at 5% level	0.9
L. S. D. at 1% level	1.2

*Average of four replicates and five florets per plot.

TABLE 37. Effect of Antibiotics on the Life of Antirrhinum majus, Variety Spartan Rose.

Treatment*	Average Life in Days**
2% Floralife (control)	7.4
10 ppm D-52 Salicylate	6.6
100 ppm D-52 Salicylate	6.2
10 ppm Neomycin sulfate	6.4
100 ppm Neomycin sulfate	6.4
10 ppm Actidione	6.2
100 ppm Actidione	6.2

No significant differences.

*Each treatment contained 2% Floralife.

**Average of five replicates and one spike per plot.

TABLE 38. Effect of Antibiotics on the Life of Rosa hybrida, Variety Red Delight.

Treatment	Average Life in Days*
Distilled water (control)	2.0
Tap water	3.2
2% Floralife	4.4
Basic solution**	3.2
10 ppm Endomycin	3.8
100 ppm Endomycin	3.6
10 ppm Penicillin O	3.2
100 ppm Penicillin O	3.4
10 ppm Antibiotic D-52	4.0
100 ppm Antibiotic D-52	3.6
10 ppm Streptothricin sulfate	2.6
100 ppm Streptothricin sulfate	3.0
10 ppm Antibiotic D-45, sodium salt	3.0
100 ppm Antibiotic D-45, sodium salt	4.2
10 ppm Antibiotic bacitracin	4.0
100 ppm Antibiotic bacitracin	2.4
10 ppm Neomycin sulfate	4.2
100 ppm Neomycin sulfate	3.8
10 ppm Amicetin	3.4
100 ppm Amicetin	3.4

No significant differences.

*Average of five replicates and one rose per plot.

**All antibiotics were in a "Basic solution" of 1% sucrose in distilled water adjusted to pH 4 with citric acid.

Two antibiotics (Table 39) were effective in prolonging the life of Better Times roses. Endomycin at 100 parts per million and Actidione at 10 or 100 parts per million were both effective in extending the life of this variety from one and one-half to two days. The thirteen other antibiotics had no effect on cut life.

The effect of cathode rays on roses, variety Better Times, is shown in Table 40. Dosages of less than 75 reps had little effect on roses but dosages of greater than 100 reps caused anatomical differences in petals and flower opening. Outer petals of buds receiving greater than 100 reps developed crinkly areas. Crinkling developed the first day after treatment with 150 reps or greater. More than 150 reps also kept flower buds tight through the fourth day, and dosages between 500 and 1500 reps caused abscission of leaves within fifteen minutes after treatment. Peduncles broke at the end of the first day at concentrations of 1500 reps.

TABLE 39. Effect of Antibiotics on the Life of Rosa hybrida, Variety Better Times.

Treatment	Average Life in Days*
Tap water	4.4
Distilled water acidified to pH 4.5 and 2% sucrose	4.4
10 ppm Endomycin	4.6
100 ppm Endomycin	6.0
10 ppm Penicillin O	5.0
100 ppm Penicillin O	5.2
10 ppm D-52 Salicylate	5.2
100 ppm D-52 Salicylate	5.0
10 ppm Streptothricin sulfate	4.4
100 ppm Streptothricin sulfate	4.2
10 ppm Antibiotic D-45, sodium salt	4.6
100 ppm Antibiotic D-45, sodium salt	4.4
10 ppm Antibiotic bacitracin	4.2
100 ppm Antibiotic bacitracin	4.2
10 ppm Neomycin Sulfate	5.0
100 ppm Neomycin Sulfate	4.8
10 ppm Amicetin	5.0
100 ppm Amicetin	5.0
10 ppm Tetracycline hydrochloride	4.4
100 ppm Tetracycline hydrochloride	4.4
10 ppm Penicillin G	4.6
100 ppm Penicillin G	4.2
10 ppm Antibiotic D-45, free acid	4.4
100 ppm Antibiotic D-45, free acid	4.4
10 ppm Antibiotic U-5956	5.2
100 ppm Antibiotic U-5956	5.4
10 ppm Celesticetin	5.0
100 ppm Celesticetin	4.8
10 ppm Antibiotic fumagillin	4.6
100 ppm Antibiotic fumagillin	4.6
10 ppm Actidione	6.6
100 ppm Actidione	6.8
L.S.D. at 5% level	0.8
L.S.D. at 1% level	1.1

*Average of five replicates and one flower per plot.

TABLE 40. Effect of 1000-KVP Cathode Rays on the Life of Rosa hybrida, Variety Better Times.

Treatment in Reps.	Observations
0	Normal development. Wilting of petals on 5th day.
10	Slight bluing of petals on 4th day.
20	Slight bluing of petals on 3rd day.
30	Slight bluing of petals on 3rd day.
40	Margins of outer petals crinkly at end of 1st day and moderate bluing on 3rd day.
50	Buds on "tight" side on 2nd day and bluing by 3rd day.
60	Buds on "tight" side and outer petals a little crinkly by 2nd day. Bluing of petals by 3rd day.
75	Outer petals a little crinkly at end of 1st day and buds on "tight" side on 2nd day. By 4th day buds had good form, still tight, but definite bluing. On 5th day still buds had good form.
100	Buds remained somewhat "tight" through 4th day but bluing of petals began to appear on 3rd day.
150	Outer petals are crinkly and appearance not good at end of 1st day. Buds remained "tight" through 4th day. Bluing of petals evident on 2nd day.
200	Outer petals crinkly on 1st day. Buds remained very "tight" through 4th day and petal burning appeared by 5th day.
250	Same as for 200 reps., except buds remained very "tight" through 5th day and leaves dried out on 5th day, with wilted buds.
500	Some abscission of leaves about 15 minutes after treating, with a burning of side of buds exposed to radiation on 1st day. Buds never opened and petals burned. Dead by 5th day.
1000	Bluing of petals within 15 minutes of treating. Side of bud exposed to radiation showed severe burn on 1st day. Nearly 100% leaf abscission within 15 minutes of treating. Buds never opened properly and had broken necks by 3rd day.
1500	Leaves fell immediately upon treating. Very close to 100% leaf abscission. Stem broke at peduncle by end of 1st day. Bluing of petals evident within 15 minutes of treating. Buds never opened.

DISCUSSION

It was found that some chelating agents were effective in increasing cut flower life. Cupferron, diphenylamine, hexamethylenetetramine and 1-nitro-2-naphthol-3, 6-disulfonic acid, all reported to chelate iron and in some cases copper, were effective in prolonging the cut life of snapdragons. There are several possible reasons why these chelating agents were effective in prolonging cut flower life. They could have reduced bacterial growth at the base of the cut stem, increased the mobility of minor elements in the plant, reduced respiration or acted as an anti-auxin.

Chelating agents have been shown to act as bactericides and fungicides (Zentmyer, 1943). Since the plugging of the xylem vessels by microorganisms is known to contribute to a shortened cut flower life, it is possible that the chelating agents inhibited the growth of these organisms in the xylem and thus were indirectly beneficial in prolonging cut flower life.

The mobility of the minor elements may also have been increased and thus the metabolic processes may have continued at a more normal rate. Reduced respiration could have been a factor in the prolonged life of flowers treated with chelating agents.

Chelating agents can inhibit partially or completely, the metal-enzyme function if it is powerful enough to compete with the enzyme for the

metal. Since a large number of co-enzyme are either metal-containing or metal-activated, such as iron in catalase, peroxidase and cytochromes; copper in polyphenoloxidase, ascorbic acid oxidase and tyrosinase; zinc in carbonic anhydrase and some peptidases and molybdenum in nitrate reductase, it is possible that enzyme activity was reduced and thus produced a subsequent reduction in plant respiration.

This is in partial agreement with the work of Weinstein et al. (1956) who found that cytochrome oxidase and ascorbic acid oxidase activity was reduced by the presence of the chelating agent EDTA. But at the same time they found polyphenol oxidase activity increased. Total oxygen uptake remained constant.

It is of interest to note that developing leaves on snapdragon spikes became chlorotic after six to eight days in a Cupferron solution. This chlorosis of new foliage would indicate an immobility of either iron or magnesium or both by the chelating agent. The chelating agents also may be acting as anti-auxins in that they may stimulate the activity of indoleacetic acid oxidase and thus lower the concentration of indoleacetic acid in the plant. Weinstein et al. (1956) have shown that EDTA will stimulate activity of some enzymes.

The results with maleic hydrazide suggest that the destruction of indoleacetic acid may account for prolonged life when the flowers were placed in a maleic hydrazide solution. This chemical, when used at less than 1000

parts per million, was effective in prolonging cut life. This agrees with the work of Andreae and Andreae (1953) who suggest that maleic hydrazide stimulates the oxidation of indoleacetic acid and thus inhibited growth by this excessive destruction of auxin. Leopold and Klein (1951) are also of the opinion that maleic hydrazide is an anti-auxin. Maleic hydrazide may also have contributed to a lower respiration rate. Stored onions, treated with maleic hydrazide, have been found to have lower respiration rates (Isenberg, 1954).

Although cut flower life was prolonged in a 0.1 percent solution of maleic hydrazide, a 0.4 percent foliage spray one and three days prior to cutting, did not affect cut life. It was possible that the foliage application was made too near harvest, and although high concentrations were used, there was not sufficient time for a physiological effect.

Experiments with respiratory inhibitors showed that in general these compounds shortened, or did not affect length of cut life. Sodium azide and malonic acid at concentrations above 100 parts per million shortened cut life of snapdragons. Sodium azide induced premature wilting of snapdragon leaves. Since sodium azide is a potent respiratory inhibitor, respiration may have been stopped prematurely and the necessary energy needed for water uptake was not available. The same could be true when higher concentrations of malonic acid were used. Malonic acid is an inhibitor of succinic dehydrogenase and thus can stop dehydrogenation of succinic acid.

The action of maleic hydrazide on plant respiration has been attributed also to the inhibition of the enzyme succinic dehydrogenase (Isenberg, 1954). Indoleacetic acid also shortened cut life of snapdragon florets and spikes. This is possibly due to the increase in growth and metabolism due to excess indoleacetic acid.

Two antibiotics were found to prolong the life of Rosa hybrida. Actidione and Endomycin prolonged the length of life of Better Times roses one and one-half to two and one-half days. These antibiotics were probably effective in inhibiting the growth of microorganisms in the water solution and in the xylem of the stem.

The antibiotics may also have acted as a chelate of some of the minor elements in plants, thereby reducing the metabolic processes. Nickell and Finlay (1954) demonstrated that Actidione and other antibiotics inhibited growth of Lemna minor, but gave no explanation for the decrease in growth.

Cathode radiation was found not to prolong cut life of Rosa hybrida. Treated flowers developed bluing of petals sooner than usual and at higher concentrations produced petal burn and leaf wilt.

Although it has been reported that irradiation will inactivate microorganisms (Hannan, 1956) and that X-rays partially inactivate the growth hormone of plants (Skoog, 1935), the harmful effects of irridation were greater than the beneficial effects. High concentrations must be necessary to partially destroy auxins. It is possible that if only the stems were exposed to radiation, bluing of petals would have been prevented. Some type of pretreatment also may have been useful before exposure to cathode radiation.

CONCLUSIONS

1. The effect of chelating agents, growth regulators, respiratory inhibitors, antibiotics and cathode radiation on the keeping quality of cut flowers, especially Antirrhinum majus, has been studied.

2. Seven varieties of Antirrhinum majus and two varieties of Rosa hybrida as well as Lilium speciosum rubrum and Gerbera jamesonii were used in these experiments.

3. Several chelating agents, Cupferron, dephenylamine, hexamethylenetetramine and 1-nitro-2-naphthol-3, 6-disulfonic acid were effective in prolonging the cut life of several varieties of Antirrhinum majus. Cupferron, especially, was very effective and increased cut life of some varieties of Antirrhinum majus as much as six days.

4. When 200 parts per million Cupferron was added to a two percent solution of the commercial floral preservatives Bloomlife or Floralife, the cut life of Antirrhinum majus, variety Spartan Rose and Spartan White, was increased four to ten days over the control (two percent Bloomlife or two percent Floralife).

5. The effectiveness of the commercial floral preservative Petalife was not increased by the addition of Cupferron. Petalife was superior to both Bloomlife and Floralife.

6. Two hundred parts per million Cupferron and two percent sucrose in distilled water increased cut life of Antirrhinum majus four to nine days, but when Cupferron and sucrose were added to tap water, cut life was shortened.

7. Two percent sucrose and 200 parts per million Cupferron in distilled water was as good or better in extending cut life of Antirrhinum majus than any commercial floral preservative tested.

8. The level of Cupferron for extending cut life of Antirrhinum majus was not critical, but at levels less than 100 parts per million, little response was noted and above 500 parts per million some injury was evident.

9. Cupferron at 200 parts per million extended cut life of Better Times roses one day. The life of Lilium speciosum rubrum and Gerbera jamesonii was not affected by Cupferron.

10. A foliage application of 1000 parts per million Cupferron at pH 3.0 and 7.0, one and three days prior to harvest did not affect cut life of Antirrhinum majus variety Snowman.

11. The effectiveness of Cupferron in prolonging cut life is believed to be partially due to a reduction in the respiration rate of the cut flower.

12. Of a number of growth regulators used, only maleic hydrazide at 250 and 500 parts per million added to a two percent Floralife solution,

increased cut life of Antirrhinum majus, variety Spartan Rose, two and one-half to four days over the control.

13. A foliage application of 1000, 2000 and 4000 parts per million maleic hydrazide, one and three days before harvest, did not affect cut life of Antirrhinum majus, variety Snowman.

14. Antirrhinum majus, variety Spartan Rose, dipped for one minute in 20, 000 parts per million maleic hydrazide increased cut life two days.

15. Respiratory inhibitors such as sodium azide, malonic acid, maleic acid, p-nitrophenol and others did not extend cut life of Antirrhinum majus.

16. Two of the fifteen antibiotics tested improved cut life. Actidione and Endomycin at 100 parts per million extended cut life of Better Times roses one and one-half to two and one-half days, but had no effect on cut life of Antirrhinum majus.

17. Cathode radiation of dosages between 10 and 1500 reps shortened the cut life of Better Times roses. At all dosages bluing of petals was hastened and at dosages of 50 reps and higher, crinkling developed in the petals, while at dosages above 100 reps, opening of buds was delayed, and between 500 and 1500 reps, leaf abscission occurred within 15 minutes after treatment.

18. Wide varietal differences were noted in the cut life of Antirrhinum majus, with some varieties having a cut life of three and one-half days, while others had double this cut life.

19. The lower ten florets of uncut spikes of three varieties of Antirrhinum majus, Barbara, Navajo and Spartan Rose lasted three times as long as the lower ten florets on cut spikes.

20. The removal of the upper unopened florets of cut spikes of Antirrhinum majus prolonged the life of the remaining lower ten florets.

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