

# New York State Flower Growers

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## AZOBENZENE DEVELOPMENTS

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During its first year of commercial use azobenzene fumigation has become established as the principal control for red spider mite in rose ranges, and is now rapidly gaining popularity on carnations, chrysanthemums and many other crops. In the past 16 months, in spite of many production difficulties and delays, over 150,000 pounds of azobenzene fumigant have been produced and used by many hundreds of growers throughout the United States and Canada. Government scientists and growers from England, France, Belgium, Holland, Norway, Sweden, Denmark, Argentina, and other foreign countries who have visited Cornell this past year have shown great interest in azobenzene fumigation and are introducing its use in their countries. Much information has been gained from further experimentation and the experience of growers as to the best conditions for azobenzene fumigation; and two new methods, the Benzo-Fume (azobenzene) pressure fumigator and the Azofume 45 candle have been developed to the stage of readiness for commercial use.

### THE SUPPLY SITUATION

Growers have experienced considerable difficulty and delay in getting supplies of azobenzene fumigants. This was not the fault of the companies processing and distributing the fumigant powders, but was due to the continued shortage of azobenzene itself, and delays in delivery to them. Since azobenzene has no industrial uses, it has to be manufactured especially for the florists' use. The National Aniline Division has been unable to supply the processors with enough azobenzene to satisfy the demand and are not likely to be able to for some time. The reasons given are continued shortage of equipment, prior demands of other chemical products, and the difficulty of producing azobenzene of the high standard of purity desired.

Another large chemical concern (duPont)

had planned to start large scale production of azobenzene in early November. However, they decided to postpone their program pending further investigation of possible production hazards as discussed in New York State Flower Growers Bulletin No. 15. This left a number of the azobenzene fumigant processors short of anticipated supplies, and forced the Tobacco By-Products and Chemical Corporation to postpone the commercial production of Benzo-Fume (azobenzene) Pressure Fumigators.

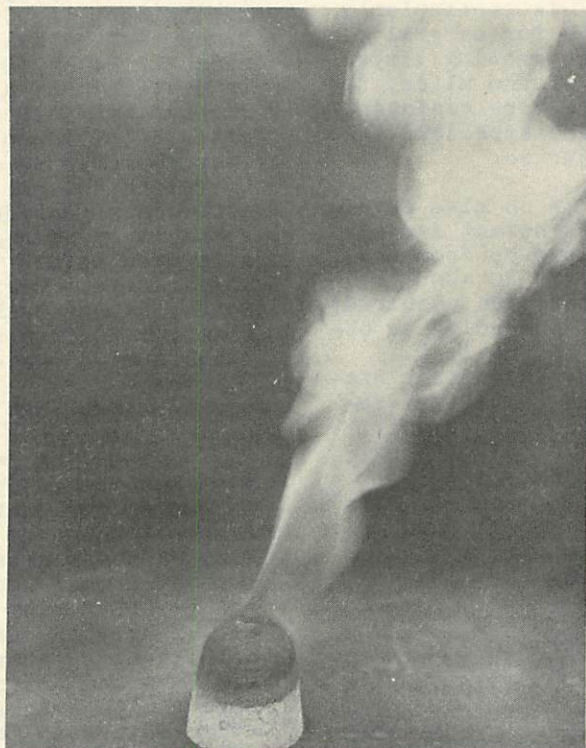
In an attempt to take care of the growers' needs the Plant Products Company has undertaken the manufacture of sizeable quantities of azobenzene for their formulations.

Production of azobenzene is now much greater than during the past year and is steadily increasing, but the demand for azobenzene fumigants and dusts has increased so rapidly that shortages are likely to continue for some time, and growers would be wise to order well in advance of their current needs.

### AZOBENZENE MATERIALS AND SOURCES

Following is a list of companies handling various azobenzene products, in order of their introduction. Some of these products are also available through various florists' supply companies throughout the country.

- 70% Azobenzene powder (for vaporizing on steam pipes).  
Azofume 70 - Plant Products Company, Blue Point, New York  
Hypozone - Hydroponic Chemical Company, New York 18, New York  
Mite-Y-Fume - Andrew Wilson, Inc., Springfield, New Jersey  
Azoide 70 - Bonide Chemical Company, Utica 4, New York  
Spider Doom 70 - J. J. Parker, 1187, East 214 St., New York 67, New York



Azofume 45 Candle gives greater convenience, greater safety on tender crops, and less discoloration of roses than lamp or steam pipe vaporization.



Azobenzene Crystals (for vaporizing by lamps or "hot plates")

Any of the above companies.

Special Azobenzene Fumigating Products

Azofume 45 Candles - Plant Products Company, Blue Point, New York

Benzo-Fume Pressure Fumigators - Tobacco By-Products & Chemical Corp., Louisville, Kentucky, (Not yet available)

Azobenzene Dusts (for dusting, not fumigating)

Hypozone 20 (contains 20% azobenzene and 10% DDT), Hydroponic Chemical Company, New York 18, New York

Azofume 10 (contains 10% azobenzene and 80% "mike" sulfur), Plant Products Company, Blue Point, New York

MITES HARDER TO CONTROL ON ROSES

The most extensive experimentation, discussion, and use of azobenzene has been on roses because the need was most urgent on this crop.

Red spider mite control is particularly difficult on greenhouse roses for several reasons. The relatively high growing temperatures cause rapid increase of the mites; the mites developing on roses are more resistant to insecticides; and roses are especially sensitive to insecticide injuries.

The effect of temperature on mite development is remarkable. At a constant average temperature of 80°F. mites develop from newly laid eggs to the adult stage in about a week's time, at 70°F. two weeks are required, and at 60°F. about a month. According to observations and calculations of Dr. W. D. Whitcomb of the Massachusetts Experiment Station, the progeny of a single fertilized female mite in 30 days' time amounts to only about 20 mites at 60°F., about 13 thousand mites and eggs at 70°F., and well over 13 million at 80°F. constant temperature. This explains why red spider mites are so much more difficult to control in the summer and on warm-house crops such as roses.



One mite in 30 days' time gives rise to 13,000 mites and eggs at 70° and over 13,000,000 at 80°. High kills are necessary for control.

Red spider mite on roses is much harder to kill than the same species on other crops, probably due to more favorable nutrition. As one example of this, Dr. C.C. Compton (Jour. Ex. Ent. 30(3):515, 1937) reported results of careful laboratory experiments in which the same insecticide at the same concentration killed 89% of the mites on chrysanthemum, 70% on carnation, and only 32% on rose. The writer, and other research workers have had similar results with other insecticides.

Roses are notoriously sensitive to various types of injury from insecticides, such as burn of soft growth, yellowing and dropping of mature leaves, and chronic "hardening" and stunting of growth.

Before the development of azobenzene fumigation many insecticides had been tested extensively for control of red spider mite on roses and found either lacking in effectiveness or too injurious. These included many rotenone sprays, thiocyanates, cyclohexylamine derivatives, dinitro-phenol compounds, polysulfide and seleno-sulfide compounds, oil sprays, and fumigants such as naphthalene, liquid fulex, and methyl bromide. Names such as Selocide, Karaya gum, Spidercide, R. S. - 380, Formula 157, and Cyclonox, to mention only a few, will recall to rose growers many memories of the "battle with the mites." Although the development of more effective rotenone spray formulas such as NNOR, Energized Rotogreen, and Liberty Rose Special afforded a considerable degree of control, syringing remained the principal control measure even before the war made rotenone sprays unavailable. Syringing involves high labor costs, causes much foliage damage and crooked stems, and often results in heavy losses from black spot disease.

THE YEAR'S RECORD ON ROSES

During the past year azobenzene fumigation has been adopted as the principal method of red spider control in the majority of rose ranges throughout the country. Reports from many of these growers have emphasized both the advantages and shortcomings of the method and afforded much additional experience with the effects of various fumigation conditions. Results have varied a good deal. Some growers have had uniformly high kills of red spider mite with little or no plant injury other than some "bleaching" of flowers, while others have reported quite a few instances of either poor kill or considerable foliage injury or sometimes both. Most of this variation appears to be due to differences in conditions and methods of use, as discussed later. So far as the writer knows, all of the azobenzene used by the processors listed above has been of a satisfactory degree of purity. Differences in color of the powder fumigant have been due mainly to differences in fineness of grind and moisture content.

Increased Production - Reduced Costs

The benefits from azobenzene fumigation on roses are now so generally known that they do not require much discussion here.



Reports from many commercial ranges indicate a large increase in production and stem length from azobenzene fumigation compared with syringing under similar conditions.

Harold Koenig, United States Cut Flower Company, reported a 25 per cent increase in cut for the entire range for January 1946 compared with January 1945, together with a reduction in culls and crooks in Talisman from 10 per cent down to 1 per cent.

Charles Butler, of George B. Hart, Inc., reported an increase in cut of 68,000 roses or 25 per cent for December 1945-January 1946 compared with the previous year, and 44,000 or 13 per cent increase above a 7-year average.

Increase in stem length has been equally striking. Charles Butler reported an increase of 180,150 inches in total stem length of cut from a house of 4600 Pink Delight for 3 months (Oct. through Dec. 1945) compared with the same plants for the same period in 1944. Following regular fumigation of the entire range, started in October 1945, the 9-inch grade for his entire crop for a 7 months' period, November through May, dropped to 13.1 per cent, compared with the previous 7 years' average of 29.2 per cent for the same months under syringing. This is a difference of 16.1 or a decrease of 55 per cent in the 9-inch grade (16.1 divided by 29.2). For the months of January and February there was over 80 per cent decrease in 9 inch compared with the 7-year average. Five fumigations were made as follows: October, January, March, April, and May. No syringing was done during the entire period.

Most growers have reported that the fumigated plants are "softer", "break" more quickly, and make more rapid and vigorous growth. Whether increased growth is due entirely to better red spider control or partly to some other effect is not certain.

Reduction in labor cost is one of the major advantages of azobenzene fumigation. Since labor costs of syringing are as great as for surface watering, this is a large saving and particularly important with rising wages. Charles Butler at Hart's reports a 90 per cent reduction in labor cost for fumigation compared with syringing and states that the cost of the azobenzene has actually been less than the cost of the water previously used in weekly syringing.

Azobenzene fumigation by replacing syringing has practically eliminated the costly black spot disease from many ranges, and eliminated the need for fungicide treatment other than for mildew. This has resulted in a renewed interest in certain otherwise excellent varieties such as Golden Rapture which has lost favor because of susceptibility to black spot.

Some growers have felt that syringing was necessary to keep plants "soft" especially in hot summer weather. This is apparently not the case. The writer has seen a number of houses of various varieties that have had no syringing for over a year and have remained in excellent condition throughout. If humidifica-



Azobenzene kills both mites and eggs. Above small section of rose leaf with adult mites and two eggs greatly magnified.

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tion is desirable in hot weather to lower temperature, it can be done much more cheaply and effectively by other means than syringing.

#### Loss of Color in Flowers Main Disadvantage

The main disadvantage in azobenzene fumigation on roses has been loss of color in flowers of red and pink varieties, and of the red color in varieties like Talisman.

This is not a bleaching of color already present, since fully developed flowers are not affected. It is an interference with color formation in the developing buds, usually showing first in third or fourth day's cut following fumigation.

Reduction in color varies greatly in amount and duration. Under favorable conditions it is often hardly noticeable and lasts for only a few days. Under the most unfavorable condition Better Times red becomes a Happy Days or Briarcliff pink, and Briarcliff is nearly white. When severe it may take one to two weeks or even longer to get back to full color.

Cloudy weather seems to be the most important factor affecting loss of color following azobenzene fumigation. Color loss is greatest during the cloudy fall and winter months when sunlight is limiting for carbohydrate production, and generally slight or absent in summer when there is plenty of sunlight for photosynthesis. Since an abundant supply of carbohydrates is needed to produce the anthocyanin or red color in the buds, this indicates that azobenzene fumigation probably reduces color by reducing the carbohydrate supply. It may do this both by reducing carbohydrate production through injury to the chloroplasts in the leaf cells, and by increasing carbohydrate consumption through the increased rate of growth that often follows fumigation.



### Color Loss Can Be Reduced

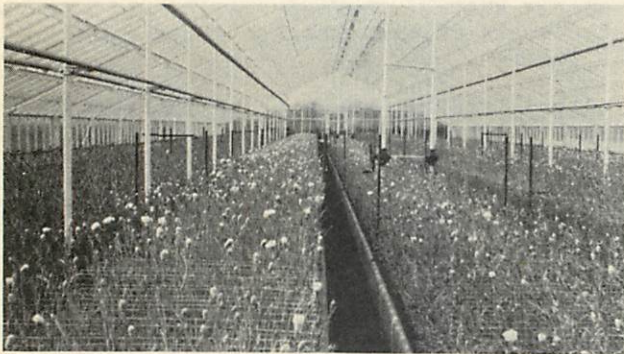
More research is needed on the causes and prevention of color loss in roses from azobenzene fumigation. However, a number of helpful suggestions can now be made, and new developments show promise of greatly reducing or avoiding this trouble.

Where periodic cropping through pinching is practiced, loss of color in the crop can readily be avoided in most ranges by fumigating individual houses when the plants are off crop. In winter the treatments should be made three weeks or more before cropping to be entirely safe.

Where plants are under more or less regular production, color loss can be reduced by making fall and winter fumigations following several days of sunny weather. Joe Wiltjen, Manager of the Premier Rose Company ranges in Illinois, reported little color loss from extensive fumigations last winter where this practice was followed.

New methods of azobenzene fumigation, one of which is now available to growers, show promise of markedly reducing the discoloration of roses. In tests to date, the Benzo-Fume Pressure Fumigator has given considerably less, and the Azofume 45 Candle much less color loss than the pipe vaporizing method even under severe winter conditions. This is discussed further under the reports on these materials.

The percentage of annual cut affected by discoloration can be greatly reduced by a thorough clean-up of red spider in early fall, so that few fumigations are needed during the cloudy winter months when discoloration is greatest. During the winter of 1945-'46 many growers reported control of red spider with only one fumigation between November and April. A few growers, for example John S. Giles of Reading Flowers, Reading, Pa., reported control without syringing through the Easter crop from a single fumigation in November. The experience this past winter was less satisfactory due to high fall temperatures favor-



Azobenzene fumigation is safe and highly effective for red spider control on carnations. Several methods are available.

able to the rapid increase of mite populations, together with a shortage of azobenzene. However, the writer has reason to believe that the need for winter fumigations can be largely avoided by more frequent fumigations in early fall, together with greater care in selecting proper conditions to get maximum effectiveness.

A new combination fumigation treatment, using 70 per cent azobenzene powder together with HETP (Hexaethyl tetraphosphate) vaporized on steam pipes in the usual way, is now being developed and shows great promise of reducing the number of fumigations needed by markedly increasing the effectiveness. This will be discussed later.

### Foliage Injury Due to Unfavorable Conditions

In general azobenzene fumigation has a good record of plant safety on roses in comparison with other materials and methods including syringing. Thousands of rose house fumigations have been made without foliage injury of any importance and many growers have consistently reported little or no injury. On the other hand a good many growers have occasionally had some injury, and some have had rather frequent and sometimes rather severe injury.

Foliage injury from azobenzene fumigation has been mainly of three types: (1) tipburn or crinkling of developing leaves, or "soft growth", (2) bleaching of mature leaves similar to cyanide injury, and (3) dropping of green leaves.

Tipburn of young leaves is the most common type of injury, but in the majority of cases it is rather slight and of little importance. It may show up almost immediately or it may develop following a clear sunny day as much as four or five days after fumigation. In such cases it would seem to be due to increased sensitivity to water loss or wilting and drying rather than direct chemical burn. Slight crinkling or puckering of new leaves is also fairly common but is usually temporary and unimportant.

Under unfavorable fumigation conditions, however, there have been quite a few instances of moderate to severe tipburn and "crippling" of soft growth, occasionally necessitating pinching back the crop.

Bleaching of mature or middle-aged leaves varies from a slight marginal bleaching to whitening of most of the leaf surface. Only an occasional leaf or a large number may be affected. It results from the killing of the chloroplasts in the upper layer of leaf cells and shows up about the third day after fumigation when the chlorophyll or green coloring matter already present has disappeared. Affected leaves generally stay on the plants.

Dropping of green leaves has been rare and reported mainly with Starlight and Snow White. Leaves drop three to five days after fumigation, sometimes whole compound leaves, sometimes leaflets first and leaf stems later.



The large proportion of azobenzene fumigations made without foliage injury of any importance indicates that injury must be due to unfavorable conditions. So many variable conditions and factors are involved in widespread commercial fumigation practice that it is often difficult to determine the cause or causes of injury in particular cases. However, the results of many experimental fumigations under various conditions and study of many growers' fumigation records indicate quite clearly that most cases of injury have resulted from one or more of the following conditions: (1) too low temperature during fumigation or too rapid drop in temperature afterward, (2) local concentration of vapor due to wind drift and pocketing, and (3) vaporizing the azobenzene too rapidly and over too short a period. Many other factors enter in but these seem to be the most important. All of these factors probably cause injury principally thru excessive condensation of vapor on the plants.

#### Preventing Foliage Injury

The important factors in safe and effective use of azobenzene fumigation will be discussed in some detail later, but the following suggestions are emphasized here for the benefit of growers who have had particular trouble with foliage injury on roses. They are based both on experimental results and growers' experience.

Temperature: Get the temperature up to 75 degrees F. before starting fumigation and keep it at 75 or above for the entire 6-hour period. Select a time to fumigate when outside temperatures are such that you can be sure of doing this. In cold weather fumigation may be done on sunny days. Temperatures have often gone to 85 or 90 degrees or even higher without injury; while a drop to 70 degrees or below is risky.

Rate of Vaporization: If injury has resulted with the usual method of turning on the second set, vaporizing of pipes 1 1/2 hours after the first set - lengthen the interval to 2 or even 3 hours; - or operate in 3 sets about 1 1/2 hours apart. It appears that there has been more injury with high pressure than with low pressure steam systems. With pressures of 8 pounds or above it is apparently helpful to only partly open the valves on the fumigation lines to reduce the rate of vaporization.

Ventilation: Too rapid ventilation following fumigation is a common cause of injury. Cold draughts and sharp drop in temperature cause condensation of vapor on the plants before it can be removed from the house. Vents should only be cracked and the temperature dropped gradually. In night fumigation in cold weather it is often safer as well as easier to delay ventilation until rising temperatures in the morning, holding the temperature around 70 degrees following the six-hour period at 75 degrees.

Azofume 45 candles have shown much less tendency to foliage injury as well as less discoloration of buds in roses, and are suggested for trial to those who have had difficulty

with the pipe vaporization method.

#### AZOBENZENE ON OTHER CROPS

The thorough testing of a new fumigant for plant safety on the great number of species and varieties of florist crops is a long, difficult, and expensive undertaking. Different kinds of plants vary greatly in their tolerance to different insecticides, as do different stages of development of the same plant. The method and conditions of fumigation are often as important as the material itself in determining the safety of the treatment, with the result that that one experimenter or grower may report a material as safe on a particular crop while another may report injury. No material is entirely safe on all plants under all conditions. Final judgment on the degree of safety to particular crops can often be made only after a considerable period of commercial use.

During the past three years, many experimental fumigations have been made in the college greenhouses to determine the safety of azobenzene fumigation to a wide variety of florist crops. This work has been made possible by the active cooperation of the Department of Floriculture. Many additional tests have been made on various crops through the cooperation of growers in commercial ranges. Further information has been obtained from reports of greenhouse operators in various parts of the country, and from other investigators.

The experience to date indicates that azobenzene fumigation under proper conditions has a good margin of safety on a wide range of florist crops. Only a few very tender crops, notably sweet peas and Schizanthus, have rather commonly shown objectionable injury from the treatment. Even these have often been treated both experimentally and commercially without injury under favorable conditions, particularly when Azofume 45 Candles were used.

In the treatment of relatively sensitive plants and mixed houses, the most important safety precautions are maintaining a temperature of 75 degrees F. or above and vaporizing the azobenzene over a period of two to three hours. The slow, even vaporization from Azofume 45 Candles makes them the safest method of fumigation for tender crops.

Following is a brief summary of the experience on the safety of azobenzene fumigation for the various crops.

#### Carnations

Azobenzene fumigation has proved safe on all common commercial varieties of carnations in extensive commercial use as well as in numerous experimental fumigations. No reports of sensitive varieties have been received.

Dr. Harold W. White of the Massachusetts Experiment Station, reporting on the Proceedings of a joint meeting of seven New England Florists' associations in the December issue of Northeastern Florists' News stated "Experi-



ences related by many growers who have used azobenzene on carnations were that it was highly effective as an insecticide fumigant when properly used."

Harry T. Harlow of Denver, Colorado, Secretary of the American Carnation Society, stated in a recent letter, "Here in Denver the growers have used azobenzene very successfully in their carnation ranges."

William E. Gunesch of the Research Department, Park-Elitch Company, Denver, has reported excellent control of red spider on carnations without foliage or crop injury in extensive trials in members' ranges with azobenzene fumigation by pipe vaporization, lamps, pressure fumigators, and candles, at temperatures ranging from 70 degrees to over 100 degrees F.

Reports from numerous growers indicate that there has been little or no bleaching of color in red and pink varieties, either in the open blooms, or the developing buds. Blossoms of white varieties show a light yellow color due to condensation of azobenzene vapor during fumigation, but this disappears within 24 hours. The keeping quality of the flowers has not been affected.

#### Chrysanthemums

No injury to chrysanthemums and pompons has been experienced in a considerable number of fumigations at the college and in commercial ranges during the past two years. Over 100 varieties were involved in these tests. In two experiments, fumigations made during the period of bud initiation did not cause blind buds as commonly occurs with many varieties from naphthalene fumigation at this stage of development. No injury resulted to the blooms of chrysanthemums and pompons of various varieties and colors fumigated in full bloom on several occasions.

An unusual opportunity was afforded for obtaining information on the effect of azobenzene fumigation on different varieties at different stages of development by the experimental work on year-around production of chrysanthemums at the college. Through the cooperation of Kenneth Post, several fumigations have been made in a house of 30,000 cubic feet which contained 26 varieties of chrysanthemums and pompons in four plantings a month apart, ranging from newly set cuttings to plants in full bloom. No injury resulted to any of the varieties in any state of development in these tests. The varieties involved were as follows: Albatross, Apricot Valencia, Arcadia, Barcarole, Brocade, Cassandra, Dark Pink Orchid Queen, Detroit News, Golden Jane, Goldsmith, Good News, Indiannapolis Bronze, Ind. White, Ind. Yellow, Lakme, Linda Lou, Matchless, Marie DePetris, Marketeer, Nevada, October Pink, Pinocchio, Silver Sheen, Sunnyside, Vesper, White Mensa.

#### Gardenias

Gardenias have shown very good tolerance to azobenzene fumigation in widespread commercial use as well as in experimental fumigations.

No instances of serious injury and few cases of injury of any kind have been reported. Gardenias have been fumigated extensively and successfully for the control of mealy bugs as well as red spider mite. In many cases a dosage of 1 pound to 35,000 cubic feet has been used and vaporized at one time, without causing injury, following the recommendation of D. C. Kiplinger of Ohio State University. Rodney McLellan of San Francisco reported excellent success in large-scale use of azobenzene fumigant for red spider mite control beginning in the summer of 1945. He reported that the elimination of the need for syringing solved the problem of controlling bacterial leaf spot.

Gardenia blooms turn yellow under azobenzene fumigation, but the discoloration disappears either before picking or in storage.

#### Snapdragons

Although moderately sensitive to azobenzene fumigation under unfavorable conditions, snapdragons of many varieties and in all stages of development have been fumigated many times without injury, both experimentally and in commercial practice. There were no indications that it affected the normal development of the flower spikes through bud injury as occurs with some materials. Indications are that the treatment is reasonably safe on this crop under proper conditions.

#### Cucumbers and Tomatoes

Much interest has been expressed in the use of azobenzene fumigation for red spider mite control on greenhouse cucumbers and tomatoes. The writer has had very little opportunity to carry on experimental work on these crops but has had a good many reports of successful use by commercial growers in Ohio, Indiana, and elsewhere. Mr. Keith Owen, Jr. of the J. W. Davis Co., Terre Haute, Indiana reports in correspondence that they have experimented with azobenzene fumigation on cucumbers with good success. They have made several fumigations of the entire range by steam pipe vaporization. At first they used a dosage of 10 pounds of the 70 per cent powder per acre, regardless of cubic capacity, and later reduced this to 6 pounds per acre (using 125 pounds for one treatment of the range). This would be equivalent to 1 pound to 80,000 cubic feet, or half the standard dosage, in houses of 12 feet average height. At the 10-pound rate Mr. Owen reported that "The foliage bleached some and then greened up and looked as good or better than before. The spiders were killed and foliage remained clean." He stated, "We like azobenzene and think that it is going to prove to be a fine control for red spider."

Dr. R. B. Neiswander, of the Ohio Experiment station, Wooster, Ohio, made the following statement in a letter dated December 21, 1946: "You no doubt know that a considerable demand for azobenzene is developing in Ohio for use in control of the common red spider on hothouse tomatoes and cucumbers. Also, we have recently tested Azofume-70 in control of an Eriophyid mite on tomatoes in a greenhouse



at Toledo. The mite apparently was introduced from Georgia, and it was present in tremendous numbers when it was brought to our attention. Two weeks after fumigating I was unable to find a single living mite in the fumigated area."

The azobenzene processors have reported a number of rather large and repeated orders from cucumber and tomato growers cooperatives in that area.

The experience would indicate that azobenzene fumigation is reasonably safe on greenhouse cucumbers and tomatoes, but that they should be treated under favorable conditions, and possibly with lower dosages than used with other crops. The Azofume 45 Candles should increase the margin of safety on the crop.

Gerberas

Azobenzene fumigation appears to be very promising for the control of red spider mite, and possibly also cyclamen mite and broad mite on Gerberas. This crop is very subject to infestation by these mites and very difficult to spray thoroughly due to the dense, floppy foliage.

VanBourgendien Bros. of Babylon, N. Y., probably the largest greenhouse growers of gerberas, have several times fumigated their large houses of this crop with good results against red spider mite and without any serious foliage injury. However, fumigation during the cropping period did cause marked bleaching or loss of color in the flowers which persisted for one to two weeks.

Poinsettias

Large numbers of poinsettias have been fumigated for mealy bug control both experimentally and in commercial ranges with only a few instances of light to moderate bleaching of foliage. The treatment appears to be safe on stock plants and reasonably safe on young plants. However, the crop should not be treated after bracts form as these are apt to be discolored. Also, Harold Koenig of the United States Cut Flower Company, Elmira, N. Y., has found that fumigation of poinsettia cuttings in sand prevents rooting. The new insecticide HETP (hexaethyl tetraphosphate) shows promise of being more satisfactory for mealy bug control on poinsettias than azobenzene.

Miscellaneous Crops

Tolerant Plants: The following additional florists' crops have shown no foliage injury of any importance from test fumigations with azobenzene. Each of the crops listed has been included in at least three or more fumigations, involving a considerable number of plants of various varieties and stages of development. The plants marked with a star (\*) have generally shown considerable bleaching or other injury to the blossoms and should not be fumigated when in bloom.

- |                |               |
|----------------|---------------|
| Ageratum       | Dracaena      |
| Asparagus fern | Dusty Miller  |
| Aster          | Geranium      |
| * Azalea       | Gladiolus     |
| * Begonia      | Hydrangea     |
| Boston Daisy   | Iris          |
| Calceolaria    | Ivy           |
| Calendula      | * Kalanchoe   |
| Camellia       | Lilies        |
| Centaurea      | * Narcissus   |
| Cineraria      | * Pelargonium |
| Coleus         | Petunia       |
| * Cyclamen     | Primula       |
| * Delphinium   | Saintpaulia   |

Sensitive Plants: The following plants have been fumigated safely under favorable conditions. However, they are relatively sensitive and liable to rather severe injury under unfavorable conditions. Particular care and the use of azofume candles are suggested in treatment of these crops: Larkspur, Lupine, Nasturtium, Poppy, Schizanthus, Sweet Peas, Zinnia.

SELECTION OF METHOD

Four methods of azobenzene fumigation have been developed, as discussed below. All of these fumigants are now available except the Benzo-Fume Pressure Fumigator, which will be marketed as soon as the manufacturers can obtain adequate supplies of azobenzene. All except the 70 per cent azobenzene powder can be used in either hot water or steam heated houses.

Steam Pipe Vaporization using the 70 per cent azobenzene powder has been the standard method for use in steam heated ranges. It does not require any investment in vaporizing equipment and is also somewhat safer and more convenient than the use of lamps or hot plates. This method has proved effective and safe on most crops. The standard dosage is 1 pound to 40,000 cubic feet. The cost at present prices is 3 to 6 cents per 1000 cubic feet depending on quantity purchased.

Vaporization of azobenzene crystals by means of kerosene lamps or electric hot plates has until recently been the only method available for use in hot-water heated ranges. It has been used with excellent success by many carnation growers who already had such equipment for use with naphthalene and liquid Fulex. However, lamps are rather difficult to keep properly adjusted for a slow safe rate of vaporization. Growers will find the newer methods both more convenient and safer, particularly on tender crops and in "mixed" houses. The standard dosage for the 100 per cent crystals is 1 pound to 57,000 cubic feet. The cost at present ranges from 2 to 5 cents per 1000 cubic feet.

The Azofume 45 Candle is the most convenient and safest method now available, and is particularly good for mixed crops in hot water heated ranges. It is also gaining popularity on roses due to less loss of color in the buds. The standard dosage is 1 pound to 25,000 cubic feet. The cost at the present price is about 10 cents per 1000 cubic feet.



The Benzo-Fume Pressure Fumigator (not yet available) is a much more convenient method than either lamp or steam pipe vaporization, and somewhat safer for sensitive crops. The standard dosage is 1 pound to 10,000 cubic feet. The cost is expected to be between 4 and 5 cents per 1000 cubic feet.

#### CONDITIONS FOR FUMIGATION

The effectiveness and safety of azobenzene fumigation depend to a large degree on proper conditions and care in application. The first consideration to insure best results is to pick a time to fumigate when there is little or no wind and when you can be sure of keeping the proper house temperature during fumigation and ventilation. Fumigation may be done either at night or in the daytime depending on outside temperatures. In cold weather one can take advantage of sunny days to maintain temperature.

The best temperature is between 75 and 85 degrees F. Lower temperatures are more dangerous than higher ones. A drop to 70 degrees or below is very likely to cause injury while temperatures have often gone to 90 or even 95 degrees on sunny days without injury. Get the temperature up to 75 degrees before starting fumigation and maintain this for the entire 6-hour fumigation period.

Wind is the greatest enemy of effective fumigation especially in narrow and rather "loose" houses. Even moderate winds greatly reduce the concentration of vapor by leakage. They also create air currents in the house which may cause injury through drift and pocketing of vapor, especially in large houses. If possible, avoid fumigating when wind is over 8 or 10 miles an hour. Wet down the walks to increase humidity and help "seal" the glass laps by condensation. In small houses increase dosage.

Dosage. The standard dosage given for the various materials is the amount that has been found most satisfactory in reasonably tight houses of average width (35 to 50 feet), with little or no wind. Since loss of vapor by leakage varies greatly with tightness of the house, size of house, and wind velocity, best results are obtained by varying the dosage somewhat in accordance with conditions and previous experience. Small houses (30 to 20 feet or less in width) having a much greater glass area in relation to cubic capacity, may require a 10 to 25 per cent increase in dosage depending on relative tightness and wind. Larger houses (60 to 85 feet wide) can often stand a 10 to 20 per cent reduction without loss of effectiveness under favorable conditions.

High Humidity is not essential but may increase effectiveness somewhat and reduce tendency to tipburn of soft growth. It is most helpful in "sealing" glass against leakage from wind.

A 6-hour fumigation period with vents closed is recommended as most effective for all methods.

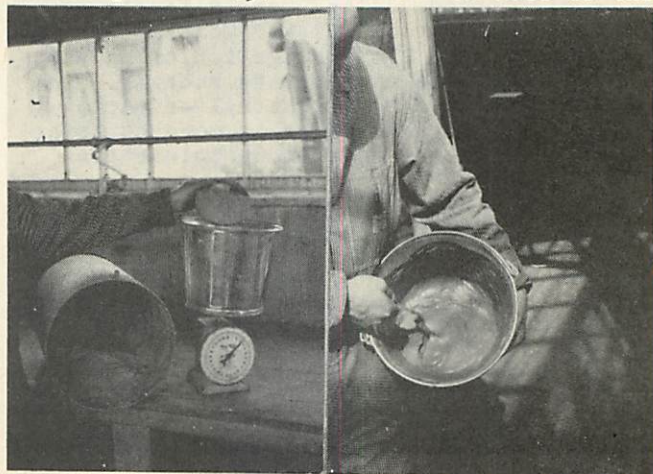
Proper Ventilation is important to avoid possible injury from condensation of vapor by cold draughts and sharp drop in temperature. Vents should only be cracked and temperature held around 75 degrees for the first hour after fumigation. In night fumigations in cold weather it is often safer as well as easier to delay ventilation until rising temperatures in the morning, meanwhile holding the temperature above 70 degrees.

#### DIRECTIONS FOR FUMIGATION

The proper conditions for fumigation as discussed above should be followed for all types of azobenzene fumigants. Calculate carefully the cubic capacity of each house to be fumigated and the amount of fumigant required at the standard dosage. Record this for future use. To calculate cubic capacity, multiply the length of the house by the width to get square feet of area, then multiply this by the average height to get cubic feet. To figure average height add the height at the eaves to the height at the peak and divide by 2. Check your figures.

#### Steam Pipe Vaporization

The standard dosage is 1 pound of 70 per cent azobenzene powder to 40,000 cubic feet. The procedure is as follows: (1) Weigh out the required amount for each house into one or more pails. Use the same container on the scales each time to save the trouble of making different adjustments and possible errors. Add water either by measure or a little at a time, and stir to a smooth, thin, paint-like paste. A pint of water per pound of powder is about right. (2) By means of a 3 or 4 inch paintbrush apply a thin coat of the paste to cold steam pipes the full length of the house. Treat one pipe for each 10 feet of width, spaced across the house. In cold weather it is best not to use the wall pipes due to excessive condensation from the cold glass and air currents. To insure even distribution, treat 4 or 5 feet of pipe, skip 2 feet, and repeat; then go back and apply any material left to blank spaces. (3) Turn steam on half of the



For steam pipe vaporization the 70 per cent Azobenzene powder is weighed into pails and mixed with water to a smooth thin paste for painting on the pipes.



treated pipes, or one over the half if an uneven number. The heat melts the azobenzene which then fumes off as an orange colored vapor. Two hours later turn on the remaining treated pipes. The first set may be left on or turned off depending on temperature.

#### Lamp or Hot Plate Vaporization

The standard dosage is 1 pound of azobenzene crystals to 57,000 cubic feet. There should be one lamp or hot plate for each 7,000 cubic feet, and they should be supported above the level of the plants. Fulex lamps with pyrex cups are commonly used and suitable. Heat should be adjusted so that the crystals melt and fume off slowly, well below the boiling point. Too rapid vaporization is very likely to cause injury, particularly near the lamps. The safest method is to put in one-half the required amount per lamp at the start, and the rest 2 hours later, adjusting the heat so that each half-dose will vaporize in 1 1/2 to 2 hours' time. The dosage should be weighed out and then apportioned among the lamps by means of a jigger of proper size. The standard dosage amounts to 1 ounce by weight to 3,500 cubic feet, or a total of 2 ounces per lamp, when using 1 lamp per 7,000 cubic feet. A 1 1/2 fluid ounce liquor jigger holds about 1 ounce of azobenzene crystals by weight when level full. Thus one of these gives about the proper amount per lamp for each half-dose.

#### Azofume 45 Candles

Directions for use of the candles are given in the following article, together with a more detailed discussion of this convenient new method.

#### Benzo-Fume Pressure Fumigator

Directions for use and full information on the azobenzene pressure fumigator are given in the following article.

#### SAFETY AND PRECAUTIONS

The question of the safety of azobenzene fumigation has been fully discussed in Bul. No. 15, Nov. 1946. There is nothing to indicate any danger in its use with reasonable precautions, and there have been no reports of ill effects from very extensive use over the past 18 months.

The following precautions are recommended to be on the safe side: (1) Do not stay in the greenhouse longer than necessary during fumigations. (2) When exposed to the vapors wear a good felt pad respirator such as the Dustfoe Respirator made by the Mines Safety Appliance Co., Pittsburg, Penna., or the Comfo Chemical Cartridge Respirator with G. M. C. cartridges, from the same company. (3) Store azobenzene in closed, labeled containers and avoid spilling any quantity in closed rooms where people are working, or where it may get into food. (4) Wash hands and face after working with the material and change clothes if they become saturated with it.

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