In the propagation bed, infected stem cuttings take on a water-soaked, greasy-green color that eventually develops into a dark brown mushy rot. Under favorable conditions for disease development, complete collapse of a standard 3-5 cm stem cutting may occur within 3 to 7 days. Generally, the inner portion of the stem becomes completely decayed after several weeks, leaving only the outer cortical shell.

This disease is unnamed, but symptoms are typical of the disease syndrome often referred to as a blight (8). For these reasons, it is proposed that henceforth, this disease be designated as 'Bacterial Blight of *Syngonium*'.

## Discussion

*Erwinia chrysanthemi* was found to be abundant in infected *Syngonium* tissue from all five nurseries surveyed. Isolation, identification and reinoculation into *S. podophyllum* along with its omnipresence indicate it to be a serious pathogen of this host plant. The fact that the pathogen is present within the plant tissue, as shown by culture-indexing of *Syngonium* stems, suggests that it moves internally within the host and spreads to non-infected tissue during vegetative propagation.

The pathogen evidently may be present in other foliage plant species as is evidenced by this research and that of Miller and McFadden (6). The fact that other species act as reservoirs for *E. chrysanthemi* and its pathogenicity to *Syngonium* should be considered in the overall planting design of new areas with *S. podophyllum*.

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# CONTROL OF BOTRYTIS CINEREA DISEASES ON CHRYSANTHEMUM, CARNATION, ROSE, SNAPDRAGON, PETUNIA AND PHALAENOPSIS FLOWERS

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## Abstract

Carnation plants were sprayed three times with various fungicides at four day intervals, then inoculated with *Botrytis cinerea* Fr. Eighteen hours after inoculation another spraying of the test fungicides was made. The three applications of Morsodren were the most effective in protecting against infection of petals, but the best control was the post-inoculation Tutane application, although Tutane was ineffective as a protective spray.

Carnations, roses, and petunia flowers were also protected most effectively by Morsodren applied before inoculation or by Tutane applied 5 to 18 hours after inoculation. Daconil 2787 and Botran sprays were less effective. Termil "thermal dust" was as effective as the Daconil spray.

Snapdragon and Phalaenopsis flowers sprayed after harvest, then inoculated with *B. cinerea*, were protected well by captan, Botran and Daconil 2787, but their appearance was spoiled by the spray residues. Tutane gave better control and Termil gave as good control as the fungicidal sprays, but with no visible residue.

Natural infections of 'Indianapolis White' chrysanthemum flowers were controlled more effectively by early morning spraying with Tutane three times weekly than by more frequent captan spray/zineb dust applications.

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## Introduction

A serious disease of the important field and greenhouse grown flower crops is gray mold, petal spot, and stem rot caused by *Botrytis cinerea* Fr. Flowers may be damaged before harvest but generally the disease is most damaging during the flowers' post-harvest life (i.e. packing, shipping, storing) (3). The disease is especially damaging where flower crops are grown outdoors in winter in humid areas such as Florida. The outdoor production of standard chrysanthemums has been limited in Florida partly because of *Botrytis*.

The control of the disease has depended primarily on sanitation and on the application of fungicidal sprays such as zineb, maneb, captan, dicloran (Botran), Daconil 2787, and mercurials, and copper-containing formulations (6,9), which either damage flower petals or leave unsightly residues. Furthermore, such protective sprays have failed to give adequate control during epiphytotic conditions (2,3). A non-staining, volatile fungistat, 2-aminobutane, carbonated, was found to be promising as a post-harvest treatment to arrest further development of incipient *Botrytis infections* (3). The fungistat is recommended for use on gladiolus (5) and on chrysanthemums (1) and is available as the 26% liquid formulation, Tutane.

These experiments report on the effectiveness of some promising spray, dust, and dip treatments for controlling *Botrytis* diseases on certain flowers grown commercially in Florida.

## Methods and Materials

Spray fungicides used (in pounds/100 gallons water) are captan 50W, 1 to 2/100; Botran, ¾ to 1½/100; and Daconil 2787, ¾ to 1/100. Tutane was used at 3 or 4 ounces/gallon as a spray or at ½ to 4 ounces/gallon as a dip. The soluble mercury fungicide, Morsodren, was used at 3 or 4 ounces/100 gallons and Termil was sublimed on a hot-plate (400-500 F) at the rate of 1 or 1½ grams per 1000 cubic feet of enclosed space. Flowers were treated with fungicides before or after harvest. In the field, fungicides were applid by knapsack sprayer or high pressure equipment. In the laboratory, an aspirator-atomizer and air pump were used to spray flowers to the point of run-off. To apply Tutane, the inoculated flowers were removed from the plastic bags and sprayed or dipped in the solutions. After being partly dried for 30 minutes, the treated flowers were returned to their plastic bags.

*Botrytis* spores for all inoculations, regardless of plant species, were obtained from 'Indianapolis' or 'Albatross' chrysanthemum and 'Friendship' gladiolus flowers, artificially inoculated and rotted by *B. cinerea*. Test flowers to be inoculated were dipped in a water suspension of 20,000 to 200,000 spores per ml. "Tween 20" surfactant was added at 75 ppm to help spread the suspension on petals. The inoculated flowers were placed in plastic bags and held moist until disease counts were made two to five days later, with the exception that flowers to be treated with Tutane were removed from bags temporarily.

The identity of the fungus causing lesions in these tests was established by re-isolation of the fungus. In all cases *B. cinerea* was identified.

## Experimentation

### Experiment 1

*Methods and materials.*—While in the bud stage, 18 flowers of 'Indianapolis White' chrysanthemum were covered with waxed paper bags to protect them from fungicidal sprays and dusts. Uncovered flowers were sprayed with captan, 1½/100, three times per week and dusted with zineb 6½% dust on alternate days, except Sunday, during December, 1965. Covered and uncovered flowers were cut on January 4, 1966 and inoculated on Jan. 6, using 20,000 spores/ml. On Jan. 4, all but six of the covered flowers were sprayed, three with captan, 1½/100, three with Botran, 1/100, and six with Tutane, 4 oz/gallon. On Jan. 6, two hours after the inoculation, Tutane at 4 oz/gal was sprayed on three of the remaining covered flowers and three were left as controls.

*Results.*—Tutane was relatively ineffective when applied to dry or wet flowers before inoculation, but one delayed application of Tutane spray was better than a month of almost daily fungicidal applications in the field and better than the post-harvest applications of captan or Botran (Table 1). Botran was more effective than captan or the field applications of captan/zineb.

Table 1. Effectiveness of fungicides in controlling Botrytis disease on 'Indianapolis White' chrysanthemum flowers cut on January 4 (am) and inoculated on January 6, 1966

| Fungicidal sprays | Date applied | Number diseased ray flowers per 3 stems |
|---|---|---|
| Inoculated control | | 190 e3/ |
| Field sprayed, captan 1/ | Dec. 2 - Jan. 3 | 50 c |
| Sprayed once in laboratory | | |
| Captan 50W, 1 1/2 lb/100 gal | Jan. 4 (pm) | 49 c |
| Botran 75W, 1 lb/100 gal | Jan. 4 (pm) | 27 b |
| Tutane, 4 oz/gal | Jan. 4 (pm) | 128 d |
| Tutane, 4 oz/gal (wet) 2/ | Jan. 4 (pm) | 124 d |
| Tutane, 4 oz/gal (2 hours after inoculation) | Jan. 6 | 5a |

1/ Flowers sprayed with grower's power equipment using captan 50W at 2 lb/100 gal three times weekly and zineb 6 1/2% dust applied between sprays.
2/ Flowers moistened before application of Tutane spray.
3/ Numbers followed by a common letter are not significantly different at the 5% level.

Experiment 2

*Methods and materials.*—Botran 75W at ¾/100, Daconil 2787 at ¾/100, and Termil at 1 g/1000 cu ft were compared in two tests for controlling the disease on 'Elegance' carnations, 'American Beauty' rose, and petunia flowers. Five cut flowers of carnation and rose and two pots of petunias were used for each treatment per test. In the second test, two Tutane spray treatments at 4 oz/gallon were applied, one at five hours and one at 18 hours after inoculation. All other materials were applied four hours before flowers were inoculated with a suspension of 200,000 spores/ml. Spores were obtained from chrysanthemum flowers. Fungicides and spores were applied with an aspirator-atomizer and air pump.

*Results.*—Tutane sprayed up to 18 hours after inoculation gave better disease control on these flowers than Botran, Daconil 2787, or Termil applied before inoculation (Table 2). The protective spray of Morsodren was less effective than Tutane applied five hours after inoculation but was statistically as good as the 18-hour Tutane spray. Morsodren was better than Botran and Termil but not consistently better than Daconil spray.

Experiment 3

*Methods and materials.*—With the exception of Morsodren the same fungicides as used in Experiment 2, plus captan 50W, were tested on cut flowers of 'Golden Spike' snapdragon, four stems per treatment. The wettable powders and Termil were applied three hours before inoculation with a suspension containing 100,000 spores/ml obtained from chrysanthemums. Tutane was sprayed five hours after inoculation. Fungicides and spores were applied with an aspirator-atomizer and air pump. Diseased florets were counted five days after inoculation.

*Results.*—Tutane was more effective than Botran or captan sprays but not significantly better than Daconil 2787 spray or Termil dust application (Table 3). Flower quality was reduced by captan, Botran, and Daconil because of disfiguring spray residues on petals, but not by Termil or by Tutane since no residue was visible.

Experiment 4

*Methods and materials.*—Tutane solutions of ½ to 4 oz/gal were used as instantaneous dips and compared with sprays of captan 50W and

Table 2. Effectiveness of fungicides in controlling Botrytis disease on flowers of 'Elegance' carnation, 'American Beauty' rose and red petunia ($F_1$ parent) by spraying before or after inoculation 1/

| Spray and dust treatments on flowers | Number of Botrytis lesions | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Carnation petals diseased | | Rose petal spots | | Petunia flower spots | | Sum | |
| Test: | I | II | I | II | I | II | I | II |
| Control, inoculated | 89 | 124 | 129 | 192 | 87 | 142 | 305c5/ | 460d5/ |
| Botran, 75W, 3/4/100 2/ | 14 | 22 | 30 | 24 | 12 | 16 | 56b | 62c |
| Daconil 2787, 3/4/100 | 13 | 21 | 21 | 21 | 15 | 18 | 49ab | 60c |
| Termil (Daconil) 3/ | 22 | 16 | 31 | 20 | 11 | 14 | 64b | 50c |
| Morsodren 4 oz/100 4/ | 7 | 7 | 16 | 18 | 4 | 4 | 27a | 29b |
| Tutane 4 oz/gallon 5 hrs after inoculation | | 3 | | 1 | | 3 | | 7a |
| Tutane 4 oz/gallon 18 hrs after inoculation | | 10 | | 5 | | 1 | | 16ab |

1/ For each treatment 5 cut flowers each of carnations and roses and 2 pots of petunias were used.
2/ Pounds of formulation per 100 gallons water.
3/ 1 gram active ingredient of Daconil sublimed per 1000 cubic feet of enclosed space before inoculation of flowers.
4/ 50 ppm Triton X-100 surfactant added.
5/ Numbers within a column followed by a common letter are not significantly different at the 5% level.

Daconil 2787 in controlling *Botrytis* disease on Phalaenopsis cut flowers. The wettable powders at 1½/100 were sprayed one day before flowers were inoculated with a suspension containing 100,000 spores/ml. Spores were obtained from gladiolus. Phalaenopsis were dipped in Tutane solutions seven hours after inoculation. Six flowers were used for each treatment. The number of petal lesions were counted four days after inoculation.

*Results.*—Tutane at 4 oz/gal injured flowers. Daconil and captan sprays disfigured the petals because of insoluble residues. Tutane dips of 2, 1, and ½ ounce/gallon controlled the disease as well as the sprays without leaving a residue or causing injuries.

Experiment 5

*Methods and materials.*—Potted carnation plants were used to compare disease control by two spray schedules: 1) three sprayings applied at 4-day intervals before inoculation and 2) the same three sprayings plus a fourth applied 18 hours after inoculation. The suspension used for inoculations contained 150,000 spores/ml, obtained from chrysanthemums. Eight pots of three 'White Elegance' plants each were used for each treatment. Four spray materials, captan, Botran, Tutane, and Morsodren, and a control lot were used, or a total of 80 pots in the two schedules. Diseased petals were counted six days after inoculation.

*Results.*—All treatments except Morsodren at 3 oz/100 reduced disease development when applied the fourth time. This was especially true with Tutane (Table 5). Morsodren was the most effective treatment with three applications, but with four applications, best control was obtained with Tutane spray at 3 oz/gallon. When applied before inoculation, Tutane was the least effective of the fungicidal treatments. Captan at 1/100 and Botran at ¾/100 disfigured the flowers because of spray residues.

Table 3. Control of Botrytis cinerea on cut snapdragon flowers of 'Golden Spike' sprayed or dusted 3 hours before inoculation, or sprayed with Tutane 5 hours after inoculation.

| Treatment with spray or thermal dust | No. infected florets on four stems 5 days after inoculation | Presence of spray residues |
|---|---|---|
| Uninoculated control | 1ab 4/ | None |
| Inoculated control | 59 d | None |
| Captan 50W, 1 1/2/100 1/ | 12 c | Severe 3/ |
| Botran 50W, 1 1/2/100 | 6 b | Severe 3/ |
| Daconil 2787, 1/100 | 4ab | Moderate 3/ |
| Termil (Daconil) dust 2/ | 3ab | None |
| Tutane, 4 ounces/gallon | 0a | None |

1/ Pounds of formulation per 100 gallons water.
2/ 1 1/2 grams of Termil tablet sublimed per 1000 cu ft of enclosed space before inoculation.
3/ Beauty of flowers reduced by spray residues.
4/ Numbers followed by a common letter are not significantly different at the 5% level.

## Experiment 6

*Methods and materials.*—Duplicate plots of field-grown 'Indianapolis White' chrysanthemum were sprayed from bud stage to harvest to control natural infections of *B. cinerea*. Three sprays were applied per week, Tutane by knapsack sprayer lightly on flowers wet with dew, and captan by high pressure spray boom on dry flowers. Zineb 6½% dust was applied on alternate days, except Sunday. There were no unsprayed control plots. Ten flowers cut from the two plots per treatment were covered with moist plastic bags for five days after which the number of infected ray flowers was counted.

*Results.*—Natural infections of *B. cinerea* were controlled more effectively by Tutane spray than by the captan spray and zineb dust applications (Table 6).

## Experiment 7

*Methods and materials.*—To test the effect of Tutane solution, excess solution, and delay in packaging on petal injury of 'Iceberg' chrysanthemum, flowers were dipped in water and in two ounces and four ounces of Tutane per gallon, and either drained by centrifugal force or not drained of excess solution. The flowers were enclosed in moist plastic bags immediately or held for one or six hours before packaging. Flowers were held in moist plastic bags for three days, after which data on petal injury were obtained.

*Results.*—Even at two ounces per gallon, Tutane dip injured petals unless the excess solution was drained immediately (Table 7). But when drained, the flowers could be safely packaged immediately. The four ounce rate was injurious whether flowers were drained or not, unless the drained flowers were allowed to aerate and dry for six hours before packaging. The two ounce rate "not drained" was as injurious as the four ounce rate "drained"; both injured petals packaged one hour after treatment.

Table 4. Control of Botrytis infections on Phalaenopsis cut flowers inoculated with spore suspension, six flowers per treatment

| Spray or dip treatment | When applied 1/ | Number lesions | Petal damage |
|---|---|---|---|
| Uninoculated control | | 0 | |
| Inoculated control | | 83 | |
| Captan 50W 1 1/2/100 2/ | Before | 5 | Residue |
| Daconil 2787 1 1/2/100 2/ | Before | 4 | Residue |
| Tutane dip, 4 oz/gal | After | 0 | Injury 3/ |
| Tutane dip, 2 oz/gal | After | 0 | |
| Tutane dip, 1 oz/gal | After | 2 | |
| Tutane dip, 1/2 oz/gal | After | 4 | |

1/ Sprayed one day before inoculation or dipped in Tutane 7 hours after inoculation.
2/ Spray residues reduced flower beauty.
3/ Chemical injury.

Table 5. Effectiveness of fungicides in two spray schedules for controlling Botrytis disease on 'White Elegance' carnation flowers, 48 flowers per spray treatment

| Sprays applied at 4-day intervals | No. of infected petals 1/ 3 sprays before inoculation | Fourth spray 18 hrs after inoculation | Spray residue 3/ |
|---|---|---|---|
| Control, water spray | 426 h4/ | 378 g | |
| Captan 50W, 1 lb/100 gal | 218 e | 170 d | ++ |
| Botran 75W, 3/4 lb/100 gal | 161 d | 115 c | +++ |
| Tutane, 3 ounces/gallon | 258 f | 16a | |
| Morsodren, 3 oz/100 gal 2/ | 65 b | 49 b | |

1/ Botrytis infections counted 6 days after inoculation of flowers with spores from diseased 'Albatross' chrysanthemums. For each treatment per spray series there were 24 plants with 2 flowers each.
2/ 5 ppm active ingredient. 50 ppm Triton X-100 surfactant added.
3/ Spray residues: objectionable +++, moderately objectionable ++.
4/ Numbers followed by a common letter in either column are not significantly different at the 5% level.

## Discussion and Conclusions

The importance of protecting flowers from *Botrytis* infection is obvious because one infected flower may inoculate others in the package dur-

Table 6. Control of natural infections of Botrytis cinerea on 'Indianapolis White' chrysanthemum flowers in commercial planting

| Fungicides sprayed on flowers 3 times/week after show of color | Number of infected ray flowers 5 days after cutting stems 3/ |
|---|---|
| Captan 50W, 2 lb/100 gal 1/ | 74 |
| Tutane, 3 gal/95 gal 2/ | 4 |

1/ Zineb 6 1/2% dust was applied in evening between spray applications. Captan spray applied with high pressure spray boom.
2/ Tutane at 4 oz/gal was applied while flowers were wet with dew or rain; flowers were sprayed from above only, using knapsack sprayer.
3/ Data obtained from ten flowers; five per duplicate plot.

Table 7. Injury on 'Iceberg' chrysanthemum flowers from dipping in Tutane solution in relation to removal of excess solution and delay in packaging

| Concentration of Tutane dip | Flowers drained 1/ | Injury due to delay in packaging flowers after treatment 2/ None | 1 hour | 6 hours |
|---|---|---|---|---|
| Control | No | 0 | 0 | 0 |
| 2 oz/gallon | Yes | 0 | 0 | 0 |
| (4000 ppm, ai) | No | ++ | + | 0 |
| 4 oz/gallon | Yes | ++ | + | 0 |
| (8000 ppm, ai) | No | +++ | ++ | + |

1/ Flowers held by stems and drained of excess liquid by swinging at arm's length.
2/ Severe = +++, moderate = ++, slight = +, and no injury = 0.

ing storage or while enroute to market. There are two aspects to consider in the control of *Botrytis* disease on commercial flower farms, pre-harvest and post-harvest fungicide or fungistat applications as well as sanitary practices. Both aspects are important because field spraying with present fungicides, although fairly effective in protecting the leaves, has not adequately protected flowers from rotting in transit to market, especially when cool, moist conditions exist (2,8). The use of fungicidal dips and sprays for cut flowers before packaging has been helpful but often disfigures the flowers or actually injures them (2).

Two fungicides, Termil and Morsodren, and a fungistat, Tutane, are herein reported to be both effective and non-staining on cut flowers. Termil and Morsodren effectively protected against infection but only Tutane effectively arrested infections already started, whether natural field infections or those resulting from artificial inoculation. Tutane was found to be more useful than other materials tested for post-harvest disease control, mainly because it controls incipient infections at least 18 hours old. Eighteen hours after inocultion, *Botrytis* infections began to be visible as water-soaked spots on the petals, but treatment with Tutane at that time arrested further development, preserving the usefulness and beauty of the infected flowers.

Tutane is slowly and partly volatile and at higher dosages and concentrations was toxic to petals. It was found to be rather ineffective in protecting against the disease but was generally more effective than other treatments tested when applied up to 18 hours after inoculation and incubation. Its effectiveness was found to increase markedly as volume of spray was increased (7). The hazard of toxicity was reduced without sacrificing adequate control by using enough volume of lower concentrations to obtain good coverage and by allowing the flowers to drain and aerate before packaging.

The fact that Iceberg' chrysanthemum flowers were safely dipped in Tutane and packaged wet indicates that wet flowers may be shipped safely, thereby reducing the cost of handling flowers and getting them to market as much as a day sooner (3). As now practiced, flowers wet with dew or rain are dried off before being packed because of the hazard of mold development on moist flowers. The shipment of flowers with stems held in water may be aided by post-harvest treatment with Tutane, thereby reducing the hazard of mold development in moist packages. The post-harvest control of *Botrytis* diseases by the use of Tutane is a new concept that could improve the quality of flowers grown in Florida, especially during *Botrytis* epiphytotics, and substantially reduce hand labor costs.

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