EFFECTS OF FUNGICIDES AND INSECTICIDES ON FLOWER QUALITY OF COMMERCIAL CHRYSANTHEMUMS IN FLORIDA

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ABSRTACT

Three cultivars of commercial chrysanthemums were sprayed with five fungicides and two fungicide-insecticide combinations from the time buds began to show color to the time the petals were completely unfurled. Dithane M-45, Dithane Z-78 and Orthocide were safe to blooms and foliage. Daconil was safe to foliage but slightly injured blooms with repeated applications. Botran was injurious to blooms and foliage. Dieldrin-fungicide combinations were safe to blooms and foliage when the fungicides alone were safe. Lannate-fungicide combinations were safe to the blooms but injured leaves with all fungicide combinations.

INTRODUCTION

The chrysanthemum industry in Florida, represented by cut flowers, potted plants and cuttings, had a wholesale value of 18 million dollars in 1968. This value is greater than for any other herbaceous ornamental crop produced in the state (5). Under the subtropical climate, where chrysanthemums are produced, diligent disease and insect control practices must be utilized (5). Current information on the phototoxicity of fungicides, insecticides and their combinations is needed to make pesticide applications with minimum risk of reducing quality to the crop.

In 1967, Engelhard (2) showed the phytotoxicity of some fungicides was influenced by weather. Meta-Systox-R injured open flowers under certain conditions but was not injurious when tank-mixed with some fungicides. In Ohio (1), single applications of many fungicides and insecticides were made to three cultivars of potted chrysanthemums. Injury was noted with relatively few materials.

The objectives of this research were to determine limits of tolerance (safety margins) and the phytotoxicity of selected fungicides and fungicide-insecticide mixtures applied to chrysanthemums under a wide range of weather conditions.

Florida Agricultural Experiment Stations Journal Series No. 3374.

METHODS AND MATERIALS

Chrysanthemum plants are grown in ground beds, 3.5 ft wide and 72 ft long, under natural saran cloth. The Leon fine sand was fumigated under black polyethylene with 2 lb/100 ft^2 of methyl bromide. Rooted cuttings were set in an 8- by 6-inch grid spacing on February 11, 1969. They were lighted 4 hours at 10 ft-c for 17 nights, pinched on February 27, pruned to three stems on March 20 and center buds removed on April 22. Insect control was maintained with Guthion and Meta-Systox-R; insecticide applications were stopped when the buds began to show color. The plants were fertilized at the rate of 30 lb N and K/acre/week with NH_4NO_3 plus KNO_3 watered over the plants and beds followed by overhead irrigation. Dry fertilizer, 6-6-6 30% organic plus trace elements, was incorporated at 500 lb/acre preplant and placed between the plants after six weeks.

Treatments were started when the flower buds began to show color. Chemicals were applied directly into the blooms and on the leaves with a knapsack sprayer at 40-55 psi until the suspensions ran off the plants. Formica boards were placed on each side of a plot to control drift of chemicals to adjacent plots. The successive applications were generally applied alternately in the mornings and afternoons to increase the range of weather conditions under which the pesticides might induce injury. Sprays were applied 1) when the blooms were wet, 2) when the blooms were dry, 3) when the spray suspensions dried slowly (72 hours after one application), 4) with temperatures ranging from 26 C (78 F) to 34 C (93 F), 5) from the time the buds showed color to the time the petals were unfurled (blooms were considered mature), 6) on both spray and pot cultivars, 7) with relative humidity ranging from 45 to 80 per cent, 8) on overcast and on sunny days, and 9) at rates close to those recommended to rates much higher than those recommended. Rain followed

several of the sprays within two hours after application.

Experiment I. Fungicide and fungicide-insecticide mixtures on 'Yellow Delaware'.—Botran 75W was applied at 0.75 and 1.5 lb/100 gallons of water. Daconil 75W, Dithane M-45 80W, Dithane Z-78 75W and Orthocide 50W were each applied at 1.5 and 3.0 lb/100. In addition each of the fungicides was tank-mixed with the insecticide Dieldrin 50W or Lannate 90WD. Dieldrin was used at 1.0 and 2.0 lb/100 and Lannate at 0.5 and 1.0 lb. With the fungicide-insecticide combinations, the low and high rates of each chemical were always tank-mixed. Applications were made on May 13, 16, 20, 23, 27, 30, June 3, 6, 1969. The treatments were applied in a randomized block design with two replications. Each treatment unit contained 28 plants pruned to three stems.

Experiment II.—Fungicides on 'Bright Golden Ann' and 'Yellow Iceberg'. Daconil 75W, Dithane M-45 80W and Orthocide 50W were each applied at 2, 4 and 6 lb/100. Botran 75W was applied at 1, 2 and 3 lb/100. Applications were made on May 14, 16, 20, 23, 27 and 30, 1969. They were applied in a randomized block design with two replications in each cultivar. Eech treatment unit contained 28 plants pruned to three stems.

Results

Experiment I. Fungicide and fungicide-insecticide mixtures on 'Yellow Delaware'. On blooms (Table 1). No injury occurred on the plots sprayed with either the low or high rates of Dithane M-45, Dithane Z-78 and Orthocide or when these fungicides were tank-mixed with the low and high rates of Dieldrin or Lannate.

No injury occurred on plots sprayed with Daconil at 1.5 lb. At 3 lb, necrotic spotting became evident after the seventh spray and increased with the eighth. With Daconil at 1.5 lb plus Dieldrin 1.0 lb, necrotic spotting of petals occurred by the seventh spray. The injury was greater at the higher rate combination than the lower rate combination but was not evident any earlier. No injury occurred with the Daconil-Lannate mixtures.

Botran at both the 0.75 and 1.5 lb rates was injurious to flower buds and open blooms. Botran injury to blooms was increased in combination with Lannate at 0.5 and 1.0 lb, but not in combinations with Dieldrin at 1.0 and 2.0 lb.

On leaves (Table 1). No injury occurred to the foliage on plots sprayed with 1.5 and 3.0 lb. Daconil, Dithane M-45, Dithane Z-78 or Orthocide, or when these fungicides were tank-mixed with Dieldrin at 1.0 or 2.0 lb. When the initial rating was made after two weeks (four sprays), all plots to which fungicide-Lannate combinations were applied showed injury on the leaves.

Plots sprayed with Botran at 0.75 lb showed a small amount of leaf injury whereas at 1.5 lb the injury was severe. When Lannate was added to Botran the amount of injury increased considerably whereas no change occurred when Dieldrin was added.

Experiment II. Fungicides on 'Bright Golden Ann' and 'Yellow Iceberg'. On blooms (Table 2). 'Bright Golden Ann' was more susceptible to fungicide injury than 'Yellow Iceberg'.

No injury was present on the plots of 'Yellow Iceberg' plants sprayed six times with Dithane M-45 and Orthocide at 2, 4 and 6 lb./100. The same was true with the more susceptible 'Bright Golden Ann', except that a small amount of injury was present with Dithane M-45 at 6 lb. Botran was injurious at 1 lb/100. Daconil at 2, 4 and 6 lb did not injure 'Yellow Iceberg'. However, with the more susceptible 'Bright Golden Ann' injury appeared after 5 applications at 2, 4 and 6 lb.

On leaves (Table 2). No injury was present on plots sprayed six times with Daconil, Dithane M-45 and Orthocide at 2, 4 or 6 lb/100. After four applications of Botran, necrotic spotting appeared on the leaves of 'Bright Golden Ann' at 1 lb/100 and on 'Yellow Iceberg' at 2 lb/100.

Description of Injury

Botran. Injury on the blooms always occurred as necrotic tips and as necrotic spots on the petals. The early symptoms appeared as small, tan, water-soaked-appearing spots which became dark brown with age. Botran also burned tips of petals on buds just beginning to show color. Injury on the leaves occurred as necrotic spots. Leaf tips generally were not injured. Marginal and interveinal chlorosis also occurred.

Daconil. Dark brown necrotic spotting on the blooms occurred mainly on and along the side margins of the petals, but not at the tips. As the injury became more severe, the entire petal became involved. The petals most frequently injured were located between the outer petals and the center of the bloom. Injury was present only

Table 1. Test I. Effect of fungicides and fungicide-insecticide mixtures on the blooms and leaves of 'Yellow Delaware' chrysanthemums.

Treatment	Rate lb/100 gal fung.	insect.	% of exposed flower tissue necrotic 5/22(3)[2]	6/3(6)	6/6(7)	6/11(8)[3]	% of leaf surface affected[1] 5/27(4)[2]	6/3(6)	6/6(7)	6/11(8)[3]
CONTROL - WATER	-	-								
Botran 75W	.75	-	20	5	5	5		3	5	5
" + Dieldrin 50W	"	1.0	20	5	8	8			3	3
" + Lannate 90WD	"	0.5	20	8	10	15	5	28	33	33
"	1.5	-	35	18	18	18		13	18	15
" + Dieldrin 50W	"	2.0	25	13	13	18		14	18	18
" + Lannate 90WD	"	1.0	40	15	20	25	18	40	45	45
Daconil 75W	1.5	-								
" + Dieldrin 50W	"	1.0			2	6				
" + Lannate 90WD	"	0.5					4	10	10	10
"	3.0	-			1	5				
" + Dieldrin 50W	"	2.0			4	18				
" + Lannate 90WD	"	1.0					8	15	20	20
Dithane M-45 80W	1.5	-								
" + Dieldrin 50W	"	1.0								
" + Lannate 90WD	"	0.5					2	5	5	5
"	3.0	-								
" + Dieldrin 50W	"	2.0								
" + Lannate 90WD	"	1.0					4	10	13	13
Dithane Z-78 75W	1.5	-								
" + Dieldrin 50W	"	1.0								
" + Lannate 90WD	"	0.5					5	15	10	10
"	3.0	-								
" + Dieldrin 50W	"	2.0								
" + Lannate 90WD	"	1.0					8	18	18	18
Orthocide 50W	1.5	-								
" + Dieldrin 50W	"	1.0								
" + Lannate 90WD	"	0.5					2	8	8	8
"	3.0	-								
" + Dieldrin 50W	"	2.0								
" + Lannate 90WD	"	1.0					10	20	20	20

[1]Average of two replications, 28 plants per replication, 3 stems per plant. Blank spaces indicate no plant response
[2]Date plants were rated followed by the number of sprays that had been applied.
[3]Blooms with petals complete open.

Table 2. Test II. Fungicides on the blooms and leaves of 'Bright Golden Ann' and 'Yellow Iceberg' chrysanthemums.

Treatment	Rate lb 100 gal	% of exposed flower tissue necrotic[1] 5/22(3)[2] BGA-YI		5/27(4) BGA-YI		5/30(5) BGA-YI		6/3(6)[3] BGA-YI		% of leaf surface affected[1] 5/22(3)[2] BGA-YI	5/27(4) BGA-YI		6/3(6)[3] BGA-YI	
Control	-													
Botran 75W	1	15	3	13	3	25	5	28	5		1		3	2
"	2	40	10	30	18	-	8	28	10		1	1	5	4
"	3	70	25	35	18	-	13	35	13		2	1	5	4
Daconil 75W	2					3		8						
"	4					3		10						
"	6					8		20						
Dithane M-45	2													
"	4													
"	6							3						
Orthocide 50W	2													
"	4													
"	6													

[1]Average of two replications, 28 plants per replication, 3 stems per plant. Blank spaces on table indicate no injury occurred.
[2]Date plants were rated followed by the number of sprays that had been applied.
[3]75% of blooms with petals completely unfurled.

on open blooms, not on young developing buds as with Botran. The leaves were not injured.

Lannate. Injury occurred only on the leaves, not on the blooms. Initially marginal chlorosis developed. As the symptoms progressed there was a lack of chlorophyll development so the leaf margins turned from yellow to white. Necrosis of the tips of the leaves was also common. These symptoms were similar to those previously reported (3).

Daconil plus Dieldrin. Necrotic spotting, marginal necrosis and tip necrosis developed on the petals. No injury occurred on the leaves.

Discussions and Conclusions

Dithan Z-78 and Orthocide at rates up to 6 lb/100 induced no injury to the blooms or foliage. No injury was present on the foliage of plots sprayed with up to 6 lb/100 Dithane M-45 but a small amount of injury occurred on the blooms on one cultivar after six applications at 6 lb/100. Similar safe performance was reported previously for these materials (2). The safety, especially in hot weather, of zinc ion plus maneb (Dithane M-45) which was reported to cause injury on chrysanthemums (4) was again demonstrated (Table 1, 2). Daconil, Dithane M-45, Dithane Z-78 and Orthocide may be applied safely to the foliage of chrysanthemums (Table 1, 2). These same fungicides, except Daconil, may be used repeatedly on blooms. With repeated applications, Daconil has a lessened safety margin on the blooms and could induce injury on susceptible cultivars (Table 1, 2). Botran, recommended (4) for control of Botrytis rot was not safe to either the blooms or the foliage at the rates used (Table 1, 2).

The insecticide Dieldrin was safe to foliage and blooms in combination with Dithane M-45, Dithane Z-78 and Orthocide. Repeated applications of Daconil plus Dieldrin resulted in flower injury after seven applications (Table 1). This injury suggests using a limited number of applications of this combination on blooms.

Lannate was safe to the blooms when tank-mixed with Daconil, Dithane M-45, Dithane Z-78 and Orthocide. However, the same mixtures were injurious to the foliage. Lannate was reported to be injurious to the foliage of chrysanthemums and was suggested for use no more frequently than once per week and at the lower suggested label rate of 0.25 lb/100 (3). In the research reported herein, Lannate was used at 0.5 and 1.0 lb/100 in the Lannate-fungicide mixtures.

Table 3. Safety margins[1] of pesticides on chrysanthemums.

	Foliage[2]	Blooms[2]
Botran 75W	0	0
Daconil 75W	>4X	1-2X
Dithane M-45 80W	>4X	>4X
Dithane Z-78 75W	>2X	>3X
Orthocide 50W	>4X	>6X
Dieldrin 50W-Fungicide	>2X	>2X
Lannate 90WD-Fungicide	<1X	>2X

[1] See text for definition

[2] >= greater than <= less than.

The rate at which pesticides may be applied safely to plants varies with the chemicals. The safety margins (Table 3), obtained by dividing the use-rate into the highest rate that can be used without injury, were determined for the chemicals used in this research. They were based on a use-rate on the foliage of 1.5 lb/100 for Daconil, Dithane M-45, Dithane Z-78 and Orthocide, and 1.0 lb for Botran. On the blooms the use-rate was 1 lb/100 for Daconil, Dithane M-45, Dithane Z-78 and Orthocide, and 0.75 for Botran. Dieldrin and Lannate safety margins were determined from combinations with the above fungicides. With Dieldrin, the use-rate was 1 lb and Lannate 0.5 lb/100.

The wide safety margins (Table 3) for Dithane M-45, Dithane Z-78 and Orthocide indicate these materials are safe for the blooms and foliage of chrysanthemums. Daconil was greater than 4X on the foliage but was 1-2X with repeated applications on the blooms. Botran had no safety margin on either the blooms or foliage. Dieldrin-fungicide was safe to blooms and foliage if the fungicide in the combination was safe. Lannate-fungicide was safe on the blooms but repeated applications injured the foliage with any of the Lannate-fungicide combinations.

The chemicals in these tests were applied under a wide range of weather conditions to increase the possibility of a particular chemical inducing plant response. However, it would appear that if chemical injury was to occur, it depended more on the cumulative number of sprays applied than to the particular weather conditions. It appears that a phytotoxic, cumulative factor may build up in or on plants which

at some point reaches a threshold value and plant response becomes visible. The plant response may be visible before harvest or it is possible that potential injury is short of the threshold point for damage at harvest, and reduction in quality may occur through reduced shelf life or the development of necrotic tissue after harvest. Therefore, to maintain maximal quality, it is suggested that the minimal number of chemical applications necessary for good disease and insect control be made, the number of materials and rates be kept as low as possible, the safest known materials to the plants be applied, and effective materials be *alternated in* a disease control program.

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CONTROL OF BOTRYTIS CINEREA DISEASE ON CUT FLOWERS OF GLADIOLUS BY SUBLIMATION OF FUNGICIDES

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ABSTRACT

Two "thermal dust" fungicides, Termil and Thiabendazole (TBZ), and a liquid, Tutane, were found to be promising in controlling *Botrytis* disease on cut flowers. They are not only effective; they leave no visible residues. Termil and TBZ dusts were more effective than Botran and captan sprays in protecting gladiolus cut flowers from infection. Tutane applied after initiation of infection was more effective than captan, Botran and Daconil 2787 sprays applied before inoculation. The control of *Botrytis* by Tutane spray was increased as much or more by doubling spray volume as by doubling concentration.

An out-door test of Termil applied with a Carmel fogging gun showed that flowers were protected by the dust better than by sprays of captan, Botran and Daconil 2787. The test sprays and dust were applied to mature chrysanthemum stock plant beds where cut gladiolus flowers were placed among the chrysanthemums as indicator plants and then inoculated.

INTRODUCTION

Flowers of various kinds grown during the winter in Florida are often subjected to cool, moist conditions that are ideal for the spread of the gray-mold fungus, *Botrytis cinerea* Fr. Leaves and stems as well as flowers may be rotted in the field or, more important, in the package of cut flowers and in storage. Although *B. cinerea* attacks gladiolus flower petals readily, it is not usually destructive on other parts of the plant, as is *B. gladiolorum Timm.* However, the gladiolus makes a good test plant for studying *B. cinerea* infection and control because the petal lesions are discrete and easily counted two days after inoculation.

The principal control measure for *Botrytis* diseases on flower crops grown out-of-doors is spraying or dusting with fungicides such as captan, maneb, zineb, Daconil 2787, and Botran (1, 2, 3, 6). When the weather favors *Botrytis* epiphytotics, field spraying does not always prevent incipient infections from spreading and developing in transit and storage (4). Post-harvest dip treatments with captan and Botran have been unsatisfactory in effectiveness as well as in acceptance by the trade. The chemicals often injure the flowers or leave unsightly residues. Tutane (2-aminobutane, carbonated), a water-soluble, volatile fungistat, was recommended as a post-harvest flower treatment for chrysanthemums and gladiolus (1, 5).

This paper presents the results of experiments which were carried out in 1965-1967 for the purpose of comparing "thermal dusts" made

Florida Agricultural Experiment Stations Journal Series No. 3372.