CONTROL OF ANTHRACNOSE SCALE ROT ON LILIUM LONGIFLORUM THUNB. ('GEORGIA')[2]

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ABSTRACT

Anthracnose scale rot or black scale caused by *Colletotrichum lilii* makes lily bulbs unmarketable. Experiments carried through 1963-66 showed that Daconil 2787 applied to bulbs as a post-harvest dust or a pre-planting soak (30 minutes) was most effective in controlling the disease and promoting good production of large, white bulbs. Phaltan was less effective than Daconil 2787 but better than captan dust and the standard ferbam-penb soak. The addition of Botran to Daconil 2787 improved bulb production.

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INTRODUCTION

The "black scale" disease incited by *Colletotrichum lilii* damages Easter lily bulbs grown in Florida and reduces their vigor. Since 1958, the disease has increased in severity, especially

Table 1.- Materials and concentrations used on Easter lily bulbs in tests for control of Colletotrichum lilii scale infection.

Material	Concentrations		Used alone or with
	Dust (%)[1]	Dip	
Puratized Agricultural Spray (PAS)		1 pt/100	Parathion
Captan 50W	7.5, 12.5	4, 12 lb/100	Terraclor
Phaltan (folpet) 50W	8.0	5, 12 lb/100	Botran
Botran (dicloran) 50W	4, 8, 21	1.5, 6 lb/100	Daconil, Phaltan
Daconil 2787, 75W	4, 7.5, 20	3, 8, 12 lb/100	Botran,DMSO
Demosan 65W		4, 8 lb/100	
Actidione		5 ppm	
Cycloheximide oxime		25, 40 ppm	
Fermate (ferbam) 76W	7.5	5 lb/100	Terraclor
Terraclor (PCNB) 75 W	7.5	5 lb/100	Fermate
Cyprex 65 W		4 lb/100	
Arasan (thiram) 75W	7.5		
Dexon-Terraclor	2.5 - 10.0		
Mycostatin	10.0		
Griseofulvin	5.0		
Parathion 4EC		1 pt/100	Dip fungicides
DMSO (dimethyl sulfoxide)		2, 6%	Dip fungicides
Pyrax (pyrophyllite talc diluent)			Dust fungicides

[1]Percent active ingredients

on organic soils and peat-amended sands. Plakidas (3) in 1944 reported that the disease was serious in Louisiana after 1937 and named the fungus pathogen *C. lilii.*

Soaking of bulbs in Puratized Agricultural Spray solution, recommended as a control measure in Louisiana by LeBeau and Reynolds (1), reduced flower and bulb production in Florida. The object of these trials was to improve on presently used methods of controlling scale rot. The results obtained during a 5 year period are herein reported.

Methods and Materials

Pre-storage treatments. — Florida - grown 'Georgia' lily bulbs, 3-4 or 4-5 inches, were used in all experiments. Freshly harvested bulbs with roots removed were dusted with fungicides by tumbling the bulbs in closed paper bags with an excess of the dust mixture. Two cups of the mixture were used per bushel of bulbs. The bulbs were rolled from end to end of the bag six times. Bulbs were then packed in air-dry sawdust in plastic lined or wax-impregnated cardboard boxes and held at 75° F for nine weeks.

Pre-planting treatments were usually made by soaking the bulbs for 30 minutes or overnight in the chemical solutions. In-furrow drenches were tested to protect newly developing bulbs from soil-borne fungus infection. Drenches were applied at the rate of 2.5 gallons per 100 feet of furrow after bulbs were planted and before covering them. All plantings were made in late September or early October. Dip-treated bulbs were planted the day after treatment. Each experimental unit contained 50 bulbs per 17 feet of row and was replicated 4 times on a sandy muck soil.

The ability of some fungicides to eradicate the Colletotrichum fungus in bulb scales was tested by soaking diseased bulbs for 2-18 hours in fungicidal preparations. Infected scales were then removed and isolated aseptically on agar plates to determine whether the pathogen was eradicated.

Table 2.- Fungicides tested during 1961-63 on Easter lily bulbs for controlling infection by Colletotrichum lilii.

Treatment[1]	Results
PAS 1 pt/100 gal, 18 hour soak	Controls disease but reduces yields.
Captan, 7.5% dust at 4 cups/bu of bulbs[2]	Injures roots produced in storage; ineffective.
Demosan, one-half hour soak	Ineffective
Cycloheximide oxime, one-half hour soak	Ineffective
Fermate, one-half hour soak	Ineffective
Fermate-Terraclor dust, 7.5-7.5%	Ineffective and injurious
Terraclor, 5 lb/100 gal	Ineffective
Arasan dust, 7.5%	Ineffective
Dexon-Terraclor dust, 2.5-10%	Ineffective and injurious
Mycostatin dust, 10%	Ineffective
Griseofulvin dust, 5%	Ineffective

[1] Dusts were applied to bulbs before packing and storing; soak treatments were made one day before planting the bulbs.

[2] Treatment applied to bulbs as they were packed in sawdust or peat after harvest.

The fungicides and other chemicals applied to bulbs during the course of the project are listed in Table 1. Ten experiments were conducted over the 5 year period and only the data from representative experiments are presented for illustrative purposes. Data were obtained on plant emergence when earliest plots were about 90% emerged. Data were also obtained on number and earliness of flower buds, number and size of bulbs harvested, and degree of bulb scale discoloration by disease.

Experimental Results

1961-1963 tests.—The systemic and other fungicides tested before 1963 were ineffective against anthracnose scale rot or injurious to bulbs and to the roots initiated in storage (Table 2). An excess of captan dust injured roots produced in storage and was ineffective against the disease.

Isolations were then made from *C. lilii* infected bulbs which had been soaked 2-18 hours in chemical solutions. To obtain more systemic fungicidal action, dimethyl sulfoxide and acetone were added to the fungicides. Some of the infected scales from treated and untreated bulbs were removed and 15 scales from each treatment were isolated aseptically on ager plates to determine whether the pathogen was eradicated. The results of one test are shown in Table 3. All treatments were superior to control. Treatments containing Puratized Agricultural Spray, Daconil 2787, and cycloheximide oxime were most effective against *C. lilii* but only Daconil 2787 was non-toxic, allowing vigorous growth from the remaining scales.

Table 3. - Effect of certain fungicides in eradicating Colletotrichum lilii and other fungi in 4-5 inch Easter lily bulbs as shown by scales isolated on agar plates.

Fungicidal mixture used for bulb treatment	Soak period (hrs)	No. of scales showing[1]			Vigor of growth from scales[2]
		Coll.	Pen.	Fus.	
Control, none	--	13	9	6	+
PAS, 1 pt/100 gallons	18	0	5	1	+
PAS, 1 cup/100 gal + 2% DMSO	18	1	3	0	+
Daconil 2787, 3 lb/100 gal + DMSO 2% + acetone 1%	18	0	0	0	+++
Daconil 2787 (tech.), 1 1/2 lb/100 gal + DMSO 2% + acetone 1%	18	0	0	1	+++
Daconil 2787, 10 lb/100 gal + DMSO 6% + acetone 3%	2	0	1	2	+++
Actidione 25 ppm + DMSO 2% + acetone 1%	18	4	7	3	+
Cycloheximide oxime 50 ppm + DMSO 2% + acetone 1%	18	1	6	3	++
Phaltan + Botran, 1 1/2 + 1 1/2/ 100 gal + DMSO 2% + acetone 1%	18	3	5	0	++
Phaltan + Botran, 5 + 5/100 gal + DMSO 6% + acetone 3%	2	4	7	2	++

[1] Colletotrichum, Penicillium, and Fusarium fungi growing from 15 scales per treatment.

[2] Scales used for planting test were not those used for fungus determinations

The more promising fungicides were tested as dust mixtures and applied to freshly harvested bulbs just before they were packed in sawdust. Nine weeks later, after storage at 75° F, captan and captan + Botran treated bulbs showed root retardation and injury but root growth on Phaltan + Botran and Daconil 2787-dusted bulbs was normal. Daconcil 2787 treatments were superior to the other treatments in controlling the disease (Table 4). Phaltan + Botran was more effective than captan (dusted in bag) or captan + Botran. Bulb and flower production with Phaltan + Botran and the 4% Daconil 2787 dust treatments were as good or better than the production from other treatments.

1964-1965 tests.—To control infection from the soil-borne fungus, fungicidal drenches made in the open furrow over planted bulbs were tested in comparison with bulb dip treatments. The results of one test given in Table 5 indicate that drenching Daconil 2787 at .25 lb/2.5 gal/100 ft is promising in disease control but not as effective as soaking the bulbs in Daconil 2787 at 8 lb/100 gal. Daconil 2787 was the most effective treatment. In producing large bulbs Daconil 2787, cycloheximide oxime, Demosan, and captan were similarly effective.

Pre-storage dusting.—Results of a pre-storage dust experiment are given in Table 6. Daconil 2787 + Botran dusts were superior to Phaltan + Botran dust mixtures in flower and bulb production, and all treatments including Daconil 2787 alone were superior to no treatment. The Daconil 2787 plus Botran dusts were better in bulb and flower production than Daconil 2787 alone. Bulbs treated with Daconil 2787 produced whiter bulbs than those treated with Phaltan + Botran. The addition of Botran to Daconil 2787 did not affect bulb whiteness.

Storage temperature.—In the 1965 tests Botran dust treatments (Botran mixed with

Table 4.- Effect of pre-storage dust treatment of Easter lily bulbs (4-5 inch) on control of Colletotrichum lilii.

Dust formulation	No. of flower buds[1]	Bulb production index[2]	Disease index[3]
Control, none	2479^{c}	1996^{cd}	4.5^{de}
Captan 7.5% dusted over bulbs as packed	2610^{bc}	1820^{d}	3.5^{bc}
Captan 7.5% dusted on bulbs by shaking together in bag	2940^{a}	2112^{bc}	5.0^{e}
Captan 7% + Botran 21%	2740^{abc}	1856^{d}	4.0^{cd}
Phaltan 7% + Botran 21%	2982^{a}	2331^{a}	3.0^{b}
Daconil 2787, 4%	2803^{ab}	2257^{ab}	2.0^{a}
Daconil 2787, 20%	2584^{bc}	2278^{ab}	1.5^{a}

[1] Values within a column followed by the same letter are not significantly different at the 5% level as determined by analysis of variance.

[2] Bulb production index is sum of products (X 0.1) obtained by multiplying the number of bulbs in each size class by the average bulb circumference (inches) of the class (bulbs smaller than 3 inches not included.)

[3] Anthracnose scale rot symptoms rated 1 for slight (1 scale affected) to 6 for severe (all outer scales affected).

Phaltan or Daconil 2787) discolored bulb scales at storage temperatures of 75-80° F. At temperatures of 80-95° bulbs were injured more severely, small bulbs being severely injured at the higher temperature. Botran dust alone was not tested.

Pre-planting dip treatment tests were made on 3-4 inch bulbs dusted with Phaltan + Botran after harvest. The pre-plant dips with Phaltan plus Botran, Daconil 2787, or Terraclor plus Fermate improved bulb production over the dip of Puratized Agricultural Spray (PAS) and control lot (Table 7). Bulbs dipped in Phaltan plus Botran also emerged earlier than PAS or control lots. The addition of DMSO and acetone to Daconil 2787 did not improve flower or bulb production.

Discussion and Conclusions

Phaltan and Daconil 2787 alone or in combination with Botran or DMSO controlled *C. lilii* infection of lily scales without reducing flower and bulb production. Phaltan and Daconil 2787 were also outstanding in producing white bulbs whereas the bulbs in other treatments tended to be yellow. Daconil 2787-treated bulbs were whiter than those treated with Phaltan. McWhorter (2) stated that there may be an association between the yellowing of bulbs and the presence of *Rhizoctonia* (*Corticium*) *solani*.

Since wetting of harvested bulbs by fungicidal dip treatment is detrimental as far as packaging and storing are concerned, fungicidal dusts are preferred for the pre-storage treatment which is made to control the rotting of

Table 5. Comparison of pre-planting bulb dip treatments and furrow drenches for controlling infection of Easter lily bulbs by Colletotrichum lilii.[1]

Treatment[2]	No. early flowers	No. large bulbs[3]	Disease index[4]
Check[5]	2060	237^{c}	4.00^{cd}
Captan 12 lb/100, 30 min. soak	1857	272^{abc}	3.50^{c}
Phaltan 12 lb/100, 30 min. soak	1832	252^{bc}	1.75^{b}
Daconil 2787, 8 lb/100, 30 min.	1878	306^{a}	1.00^{a}
Demosan 8 lb/100, 30 min. soak	2055	254^{bc}	4.50^{d}
Demosan 4 lb/100 DMSO 2%, 30 min.	1803	294^{ab}	3.75^{cd}
Cycloheximide oxime 40 ppm + DMSO 2%, 30 min. soak	1770	297^{a}	4.50^{d}
Demosan drench in furrow (30 lb/A)[6]	1795	275^{abc}	4.50^{d}
Daconil 2787 drench in furrow (30 lb/A)[6]	1850	251^{bc}	2.00^{b}

[1]Values within a column followed by the same letter are not significantly different at the 5% level as determined by analysis of variance.
[2]All bulbs were dusted with 7.5% captan pre-storage.
[3]7-8 inch and larger
[4]Anthracnose scale rot symptoms rated 1 for slight (1 scale affected) to 6 for severe (all outer scales affected).
[5]Soaked 30 minutes in parathion EC4, 1 pint/100 gallons.
[6]12,000 feet of furrow/A.

packed bulbs by various fungi including *Rhizopus* spp. Further treatment of bulbs before planting by soaking them in Daconil 2787 or Phaltan dip preparations resulted in higher bulb quality and greater flower and bulb production.

Parathion was added to some of the fungicidal dips because of its significant growth stimulation reported by Overman (3). In some tests, however, emulsifiable parathion was incompatible with Daconil 2787, including root injury from the pre-planting treatment.

Although the pathogen is carried in the soil as well as on bulbs, the bulb dip treatments were generally more effective than drenching fungicides over bulbs in the open furrow. However, the furrow drenches were promising and should be tested further.

Summary

Experimental results indicate that flower and bulb production and anthracnose control

Table 6.- Production of lily bulbs and control of brown scale disease as affected by fungicidal dusts applied to 3-4 inch bulbs after harvest, 1965.

Dust mixtures[4] (percent by weight)	No. of plants emerged 11/18			No. of flower buds			Bulb production index[2]		
	A[1]	B[1]	Sum[3]	A[1]	B[1]	Sum	A[1]	B[1]	Sum
Control, Pyrax only	42	42	84[e]	235	274	509[d]	45	57	102[d]
Phaltan 8% + Botran 12%	84	98	182[d]	748	776	1524[b]	100	95	195[c]
Phaltan 4% + Botran 6%	97	129	226[c]	674	864	1538[b]	87	102	189[c]
Phaltan 12% + Botran 4%	65	92	157[d]	553	735	1288[c]	102	111	213[bc]
Daconil 2787 15%	119	139	258[bc]	661	744	1405[bc]	96	109	205[c]
Daconil 2787 7.5%	138	157	295[ab]	773	662	1435[bc]	110	101	211[bc]
Daconil 2787 7.5% + Botran 10%	146	153	299[a]	914	934	1848[a]	121	112	233[b]
Daconil 2787 15% + Botran 5%	130	162	292[ab]	968	1011	1979[a]	148	130	278[a]
Phaltan 6% + Botran 4%	108	--	--	712	--	--	112	--	--

[1] A series - amount of dust applied was in excess of that retained by bulbs.
B series - amount of dust applied was one-half the amount used in A series.

[2] Bulb production index is sum of products obtained by multiplying the number of bulbs in each size class by the average bulb circumference of the class (bulbs smaller than 3 inches not included).

[3] Values within a column followed by the same letter are not significantly different at the 5% level as determined by analysis of variance.

[4] Dusts containing over 5% active Botran (dicloran) were toxic to bulbs during 9 week storage at a temperature of 75°F, causing discoloration of scales. At summer temperatures (75° - 95°F) dusts containing 3% dicloran shrivelled and destroyed small bulbs in shed storage.

Table 7. Production of lily bulbs and control of C. lilii by fungicidal dips applied to 3-4 inch bulbs before planting, 1965.[1,2]

Treatment[3] (Amt/100 gal water)	Period of dip (hrs)	Plants emerged 11/18	No. of flower buds	Bulb production index[4]
Control, pre-stor. dust only	--	172[abc]	810[bc]	105[b]
PAS, 1 pint	18	151[c]	822[abc]	104[b]
PAS, 1 pint + parathion	18	167[bc]	759[bc]	107[b]
Terraclor + Fermate, 5 lb + 5 lb	0.5	174[abc]	739[c]	138[a]
Phaltan + Botran, 5 lb + 5 lb	0.5	193[a]	862[abc]	140[a]
Daconil 2787, 12 lb	0.5	178[abc]	943[a]	133[a]
Daconil 2787 + DMSO + acetone, 12 lb + 5.5 gal + 5.5 gal	0.5	190[ab]	888[ab]	146[a]

[1]Values within a column followed by the same letter are not significantly different at the 5% level as determined by analysis of variance.

[2]All bulbs were dusted with Phaltan + Botran + Pyrax (3-2-20) after harvest (pre-stor.)

[3]All treatments except control and Puratized Agricultural Spray (PAS) alone received 1 pint parathion 4EC per 100 gallons water.

[4]Index obtained by multiplying the number of bulbs in each size class by 1/10 the average bulb circumference of the class; bulbs smaller than 3 inches were not included.

may be improved by thoroughly dusting Easter lily bulbs after they are harvested and cleaned, using a slight excess of 7.5% Daconil 2787 dust mixture. A pre-planting soak treatment of 30 minutes is also suggested, using 8 pounds of Daconil 2787 (75 W) plus 6 pounds Botran (50 W) per 100 gallons of water without wetting agent or sticker.

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