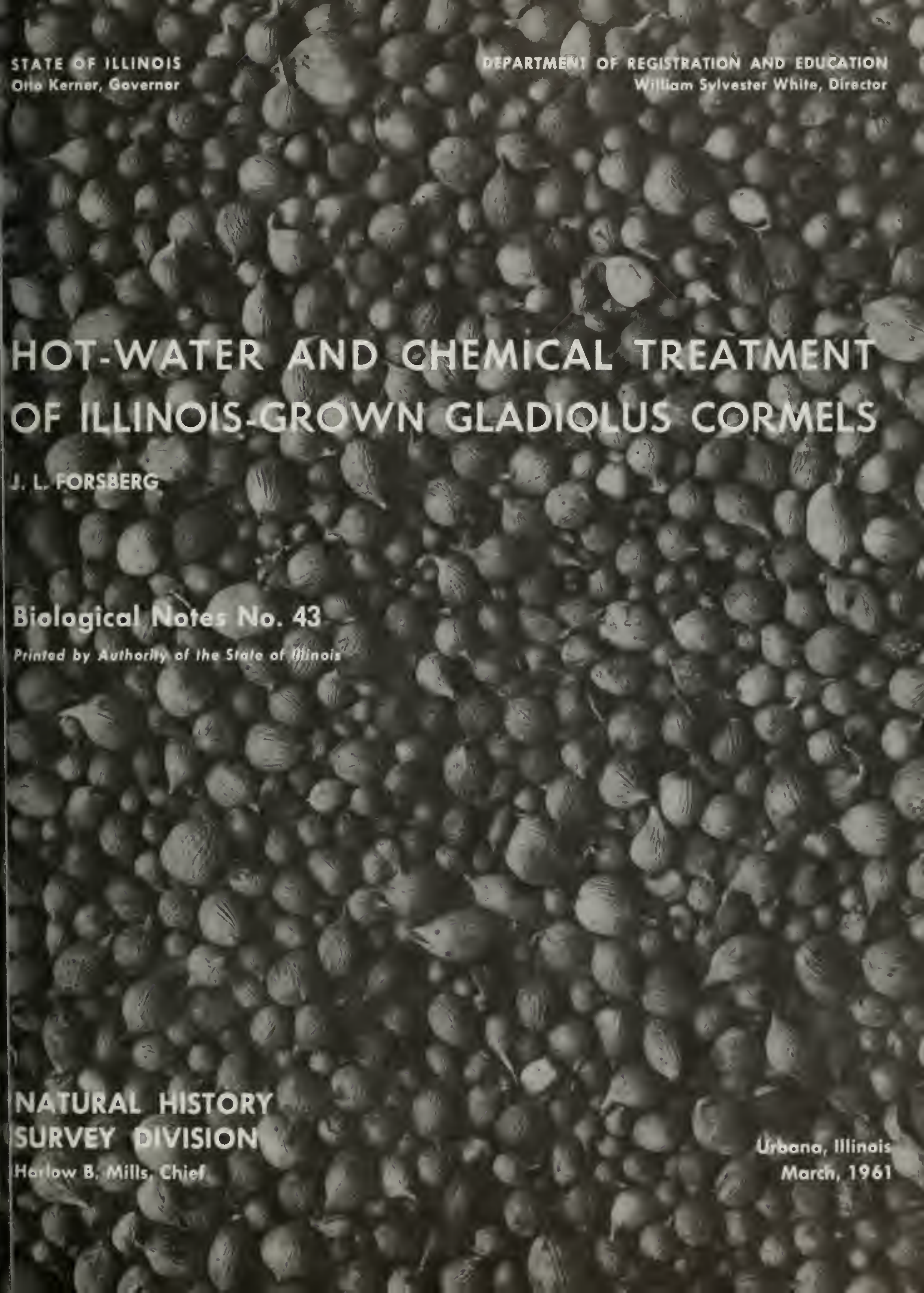

STATE OF ILLINOIS
Otto Kerner, Governor

DEPARTMENT OF REGISTRATION AND EDUCATION
William Sylvester White, Director

HOT-WATER AND CHEMICAL TREATMENT OF ILLINOIS-GROWN GLADIOLUS CORMELS

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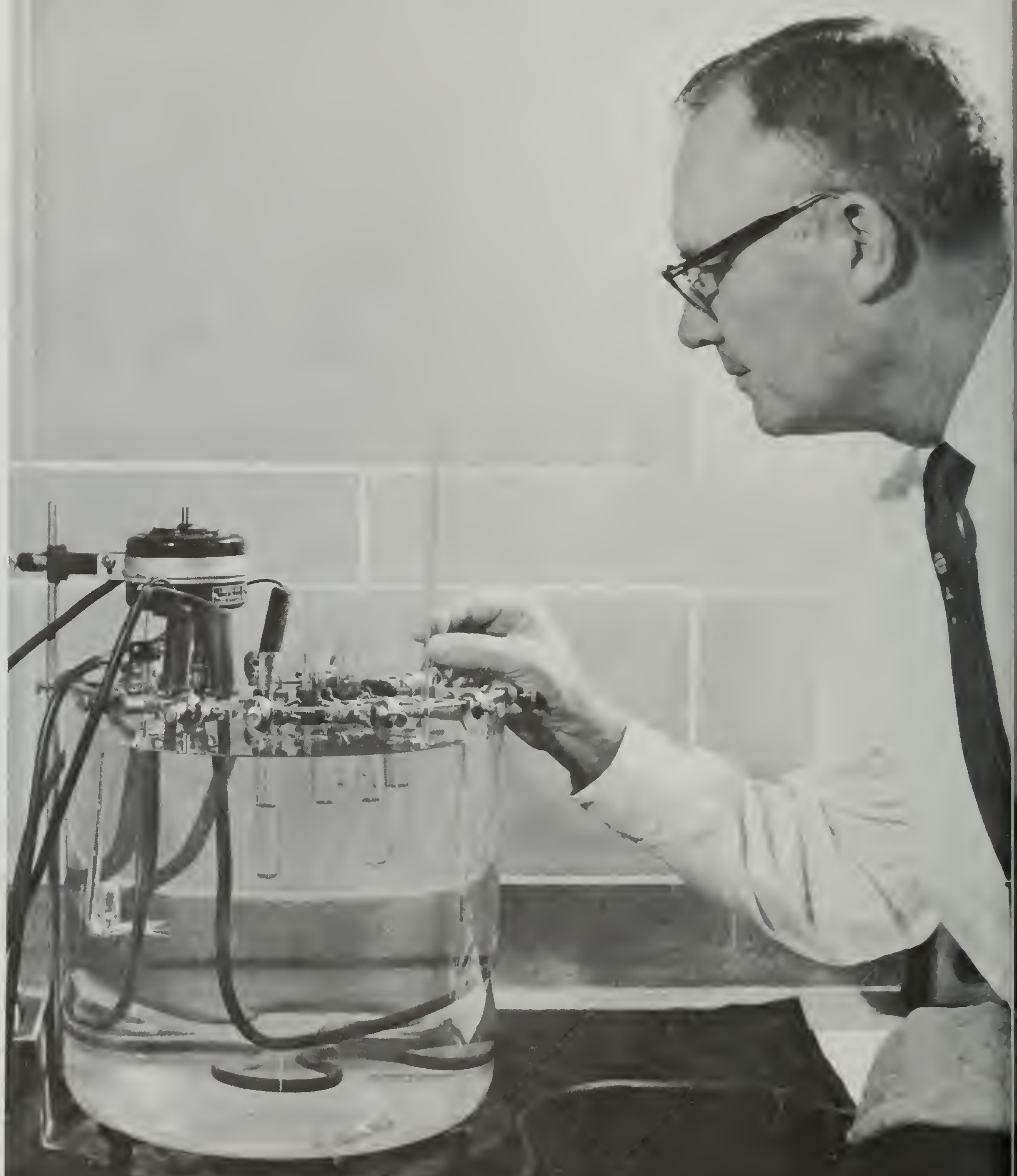

Fig. 1.--Fisher constant temperature bath used in tests on heat tolerance of gladiolus pathogens. This apparatus was used also for most of the hot-water treatments on gladiolus cormels.

HOT-WATER AND CHEMICAL TREATMENT OF ILLINOIS-GROWN GLADIOLUS CORMELS

J. L. FORSBERG*

The hot-water treatment of gladiolus cormels as a method of eliminating certain fungus pathogens has received considerable attention recently from plant pathologists and commercial gladiolus growers. The first report on the use of this method was made by Roistacher (1951), who treated semidormant cormels of six gladiolus varieties for 30 minutes at temperatures between 131 and 140 degrees F. In semidormant cormels subjected to the hot-water treatment at 135 degrees, germination was 40 per cent less than in untreated cormels; in similar cormels subjected to the treatment at 137 degrees, germination was 75 per cent less than in the untreated checks. Preliminary tests to determine the thermal death point of Fusarium oxysporum var. gladioli in gladiolus cormels indicated that this point "is close to the temperature that critically reduced germination of the cormels."

Bald & Markley (1955) reported that control of Fusarium and other diseases was attained on a field scale when the hot-water treatment was applied to growers' lots of gladiolus cormels. They cautioned, however, "For successful treatment, cormels had to be harvested from warm soil after growth during summer."

The hot-water treatment was recommended with reservations by Bald (1956), who stated, "Cormels that have withstood treatment undamaged have so far been from plants grown in a warm dry climate during summer, and matured and harvested before the onset of cold weather. Cormels grown in cooler climates, or grown and harvested during the cooler season in a warm climate, have not yet survived the required temperature."

Bald, Ferguson, & Markley (1956) gave detailed instructions on use of the hot-water treatment and cited a case in which a badly diseased lot of Spotlight gladiolus cormels was so successfully treated that the disease appeared in less than 0.5 per cent of the resulting plants.

Magie (1956) reported that the hot-water treatment of gladiolus cormels had been tested in Florida since 1953. He stated further that "A 30-minute soak at 53.5^{o} C killed the following fungi in cormel-size pieces of diseased tissue cut from corms: Fusarium oxysporum Schlect. f. gladioli (Massey) Snyd. & Hans., Stromatinia gladioli (Drayt.) Whet., and Curvularia lunata (Wakk.) Boed."

Chemical treatments of cormels had been used in Illinois for many years, but all of the experimental work on, as well as commercial use of, the hot-water treatment had been in California and Florida, and no information was available on effects of using hot-water treatments on Illinois-grown cormels. Because gladiolus growers in Illinois suffer losses every year from the Fusarium, Curvularia, and Stromatinia diseases, it seemed desirable to determine if the hot-water treatment could be used successfully in this state. It also seemed desirable to compare the effectiveness of hot-water treatments with a standard chemical treatment and to obtain some fundamental information on heat tolerances of the gladiolus pathogens. Results of tests designed to obtain this information are reported in this paper.

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PRELIMINARY TEST

A preliminary test on survival of hot-water-treated Illinois-grown cormels was made in 1956 on a commercial gladiolus grower's farm in Kankakee County, Illinois. The cormels were treated in a specially built insulated treating tank with temperatures of circulating water thermostatically controlled within 0.5 degree F. of the desired temperature. Because the equipment was not ready to use until after mid-June, the treatments were not made as early as had been intended. Cormels were treated June 20 and 22 and planted June 22. The following treatments were used on cormels of the gladiolus varieties Debonair, Spic and Span, and Margaret Fulton: hot-water at 131 degrees for 30, 45, and 60 minutes; hot-water at 125 degrees for 4 hours; hot-water at 135 degrees for 10, 20, and 30 minutes; New Improved Ceresan, one-half pound in 25 gallons of water at air temperature for 1 hour. An additional treatment in water at 110 degrees for 23 hours was used on one variety. One 1-pound coffee can, level full, of cormels was used as a treatment lot. Sixteen feet of row were used for planting each lot of cormels. Results of this test are shown in tables 1, 2, and 3.

Although germination was reduced by the heat treatments and there was a progressive reduction in germination as temperatures and treating times were increased, in none of the lots were all of the cormels destroyed by the hot-water treatments. Since the cormels were probably far out of their dormancy at the time of treatment, the results were not discouraging. As the cormels were planted in a field where diseased gladioli had been present, little significance can be attached to the amount of rot which developed in the various lots.

HEAT TOLERANCES OF GLADIOLUS PATHOGENS

In the winter of 1956-57 laboratory tests were conducted on heat tolerances of gladiolus pathogens. These tests were carried out with the help of Raymond E. Wilken, then Technical Assistant, Illinois Natural History Survey. Cultures of *Fusarium oxysporum* f. *gladioli* (Massey) Snyd. & Hans., *Curvularia trifolii* (Kauffm.) Boed. f. *gladioli* Parm. & Lutt., and *Stromatinia gladioli* (Drayton) Whet., which had been isolated originally from diseased tissues of gladiolus corms, were subcultured on potato dextrose agar in petri dishes and incubated at 24 degrees C. *Fusarium* and *Curvularia* cultures were incubated 10 days and *Stromatinia* cultures 2 weeks before being used in the heat tolerance tests. Twenty-six isolates of *Fusarium*, 12 isolates of *Curvularia*, and 3 isolates of *Stromatinia* were used in the tests. Altogether 270 individual tests were made.

The various isolates of the three organisms were subjected to a series of heat treatments in which the following procedure was used for each test: Six test tubes, each containing 7 ml. of distilled water, were suspended in an automatic Fisher constant temperature bath, fig. 1. All tubes were allowed to reach a preselected temperature before inoculum was added. The petri dish subculture of the organism to be tested was dispersed for 30 seconds in a Waring Blendor containing 200 ml. of distilled water. Five drops of the dispersed culture were then added to each of the six tubes in the water bath. At the end of each of three periods, (15, 30, and 60 minutes) one pair of test tubes was removed from the water bath and the contents of each tube was poured into a petri dish containing potato dextrose agar. After the dishes had stood for a few seconds to allow the solid particles to settle, the water was poured off. Checks were prepared by adding five drops of the dispersed culture to 7 ml. of water in a test tube, shaking the tube for a few seconds, and then pouring the contents into a petri dish containing potato dextrose agar. After the solid parti-

Table 1. --Effect of hot-water and New Improved Ceresan treatments of Debonair cormels, as indicated by number of corms produced and per cent of corms rotted.

Treatment	Corms Produced	Per Cent of Corms Rotted
131°F., 30 minutes	820	43.9
131°F., 45 minutes	532	33.8
131°F., 60 minutes	388	14.2
125°F., 4 hours	122	0.0
135°F., 10 minutes	828	11.2
135°F., 20 minutes	459	1.8
135°F., 30 minutes	146	4.1
New Improved Ceresan	1,032	14.3
No treatment	1,203	26.1

Table 2. --Effect of hot-water and New Improved Ceresan treatments of Spic and Span cormels, as indicated by number of corms produced and per cent of corms rotted.

Treatment	Corms Produced	Per Cent of Corms Rotted
131°F., 30 minutes	612	11.8
131°F., 45 minutes	700	8.6
131°F., 60 minutes	649	3.2
125°F., 4 hours	172	0.0
135°F., 10 minutes	1,248	0.9
135°F., 20 minutes	670	3.3
135°F., 30 minutes	459	1.5
110°F., 23 hours	1,490	0.7
New Improved Ceresan	1,260	6.3
No treatment	1,240	3.9

Table 3. --Effect of hot-water and New Improved Ceresan treatments of Margaret Fulton cormels, as indicated by number of corms produced and per cent of corms rotted.

Treatment	Corms Produced	Per Cent of Corms Rotted
131°F., 30 minutes	1,504	21.5
131°F., 45 minutes	1,324	19.8
131°F., 60 minutes	1,312	21.6
125°F., 4 hours	466	2.8
135°F., 10 minutes	1,443	10.4
135°F., 20 minutes	1,108	1.6
135°F., 30 minutes	712	1.7
New Improved Ceresan	1,742	5.6

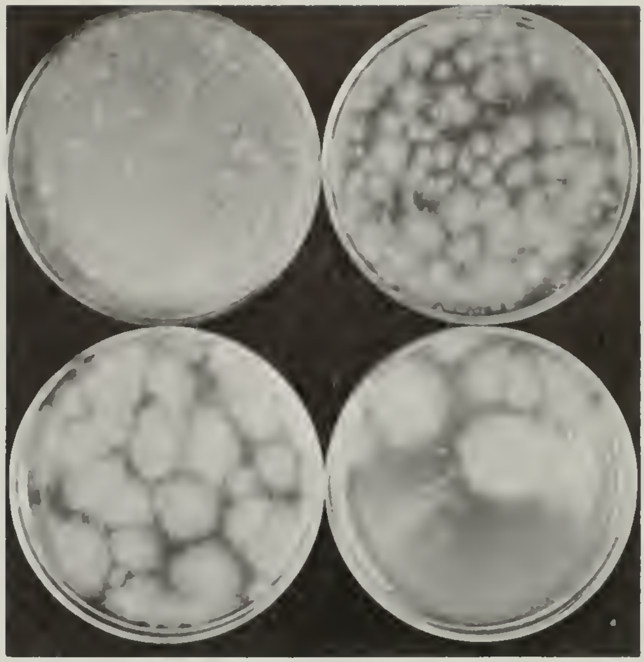


Fig. 2. --Colonies of *Fusarium oxysporum* f. *gladioli* isolate 55-31 developed from inoculum exposed to room temperature (upper left), 135 degrees F. for 15 minutes (upper right), 135 degrees for 30 minutes (lower left), and 135 degrees for 60 minutes (lower right).

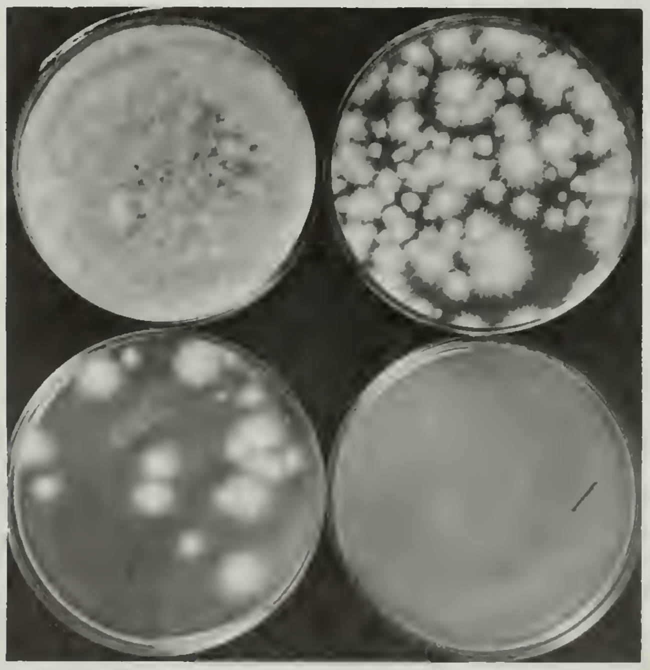


Fig. 3. --Colonies of *Fusarium oxysporum* f. *gladioli* isolate 55-28 developed from inoculum exposed to room temperature (upper left), 137 degrees F. for 15 minutes (upper right), 137 degrees for 30 minutes (lower left), and 137 degrees for 60 minutes (lower right).

Table 4.--Effect of various temperatures on six *Fusarium* isolates grown on potato dextrose agar, as indicated by number of colonies developed after being heated 15, 30, or 60 minutes.

Isolate	Temperature in Degrees F.	Exposure Time 15 Minutes	30 Minutes	60 Minutes
55-8	135	*	30	3
	136	70	8	0
	137	0	0	0
55-12	135	*	75	12
	136	*	42	2
	137	*	40	7
	138	8	2	0
	139	2	1	0
55-15	130	14	3	1
	131	0	0	0
55-31	135	*	81	11
	136	75	57	1
	137	16	1	0
	138	22	3	0
	139	2	0	0
55-52	137	30	30	1
	138	0	0	0
55-69	135	42	17	0
	136	57	9	0
	137	2	0	0
	138	2	0	0

*Colonies too numerous to count.

cles had settled, the water was poured off. The cultures were incubated at 24 degrees C. for 6 days, and the colonies growing on each plate were counted, figs. 2 and 3. Later, similar tests were made in which heat periods of 1, 2, 3, 4, 5, 6, 24, and 48 hours were used.

Stromatinia cultures grew poorly after they had been dispersed in the Waring Blendor. Because of this poor growth whole oats were tried as media for the subcultures of *Stromatinia*. Later *Curvularia* and *Fusarium* also were grown on oats.

Table 5.--Effect of various temperatures on two *Fusarium* isolates grown on whole oat grains, as indicated by number of grains in which fungus survived after being heated 15, 30, or 60 minutes.

Isolate	Temperature in Degrees F.	Exposure Time 15 Minutes	30 Minutes	60 Minutes
55-52	140	8	6	1
	142	3	0	2
	143	0	0	0
55-62	134	8	8	0
	135	7	8	6
	136	5	6	1
	137	0	0	0

In the preparation of the oat cultures the oats, in Erlenmeyer flasks, were soaked for several hours and then autoclaved 1 hour. After cooling, the oats in the flasks were inoculated with the disease organisms and the cultures incubated 10 to 14 days. During this period the flasks were shaken daily to prevent the oats from clumping.

Four infested oat grains were dropped into 7 ml. of preheated distilled water in each of several test tubes, placed in the water bath, and removed after specified periods of time, as described for treatment of subcultures on potato dextrose agar. After the heat treatments the four oat grains in each tube were embedded in agar and incubated. The dishes were examined for fungus growth after 4 to 6 days.

When Fusarium cultures grown on potato dextrose agar were kept in the water bath for 30 minutes, the temperature necessary to completely destroy the organisms varied from 131 degrees F. for isolate 55-15 to over 139 degrees for isolates 55-12 and 55-31, table 4. When grown on whole oat grains, isolate 55-52 was not completely destroyed by treatments below 143 degrees, table 5. Only two isolates were subjected to heat treatments for 24 and 48 hours. Isolate 55-52 was destroyed by a treatment at 125 degrees F. in 24 hours. A 48-hour exposure to 120 degrees weakened the culture but did not destroy it. Isolate 55-62 was weakened when subjected to 120 degrees for 24 hours and killed at 120 degrees F. in 48 hours.

Curvularia cultures were more uniform in their tolerance to heat than were Fusarium cultures. All isolates of Curvularia tested were killed in 30 minutes at 132 to 134 degrees F. Only two isolates were treated for longer periods and both were killed in 24 hours at 123 degrees, but not at 122 degrees.

All three isolates of Stromatinia tested were killed in 30 minutes at 124 degrees F. The three isolates reacted similarly to long-time exposures, being killed in 24 hours at 105 degrees F.

CORMEL TREATMENTS

Bald (1956) stated, "Tolerance to high temperatures seems to arise from the initiation of full dormancy by warm growing conditions. Cormels maturing under cool conditions become only partially dormant." He stated further, "The most favorable time for treatment of cormels is about 2 to 4 months after digging."

In the winter of 1956-1957 a test was made to determine if there was a time at which Illinois-grown cormels could withstand the hot-water treatment. Cormels of six varieties which had been dug in early October were divided into lots, the cormels of each variety into six lots. Each lot of a variety contained approximately the same number of cormels. No attempt was made to use the same size lots for all varieties. One lot from each variety was treated in hot water at 135 degrees F. for 30 minutes on November 30. This treatment was selected because it is recommended in some gladiolus-growing areas of California and Florida. Subsequent lots were treated December 22, January 31, February 27, and March 27. One lot was left untreated to serve as a check. The cormels were kept in the laboratory at a temperature of about 75 degrees F. from November 1 until treated. They were kept at 40 degrees F. from the time they were treated until May 13, when they were removed to a commercial gladiolus grower's warehouse and kept there until planted on May 23.

Results of this experiment are shown in table 6. The varieties varied considerably in their tolerance to the heat treatments. As indicated by yields of corms from the cormels, none of the varieties withstood the November 30 heat treatments well. If gladiolus cormels can best withstand heat treatments when the cormels are nearest complete dormancy, the results of this experiment show that cormels of all varieties do not become dormant at the same time. The period of greatest dormancy in Mother Fischer and Spic and Span was reached by December 22, in Beacon, Nancy, and Spotlight by January 31, and in Benjamin Britten by March 27. In Mother Fischer and Nancy the period of greatest dormancy had passed by February 27, in Spic and Span by January 31, and in Spotlight by March 27. The period of greatest dormancy in Beacon and Benjamin Britten had not passed by March 27. Results of this experiment agree, at least in part, with the observation of Roistacher, Bald, & Baker (1953), who stated that capacity for germination, that is, breaking of dormancy, may be rapid or slow, depending on the variety and the conditions of storage or treatment.

When yields of corms from treated cormels were compared with yields from the untreated checks it was found that the amount of rot in 17 of 25 treated lots was

Table 6. --Effect of date of hot-water treatment of cormels, as indicated by number of corms produced and per cent of corms rotted.

Variety	Date Treated	Corms Produced	Per Cent of Corms Rotted
Beacon	----	375	9.6
	Nov. 30	186	2.7
	Dec. 22	387	5.4
	Jan. 31	602	2.7
	Feb. 27	551	5.3
	March 27	594	5.7
Benjamin Britten	----	105	12.4
	Nov. 30	52	3.9
	Dec. 22	160	7.5
	Jan. 31	235	11.9
	Feb. 27	290	2.1
	March 27	423	4.3
Mother Fischer	----	230	11.3
	Nov. 30	128	20.3
	Dec. 22	240	15.8
	Jan. 31	240	14.6
	Feb. 27	125	6.4
	March 27	133	8.3
Nancy	----	415	25.1
	Nov. 30	35	0.0
	Dec. 22	128	17.2
	Jan. 31	282	13.1
	Feb. 27	120	4.2
	March 27	105	1.9
Spic and Span	----	---	----
	Nov. 30	112	23.2
	Dec. 22	385	10.1
	Jan. 31	207	18.4
	Feb. 27	164	5.5
	March 27	151	5.3
Spotlight	----	551	18.3
	Nov. 30	424	32.6
	Dec. 22	626	21.6
	Jan. 31	784	36.0
	Feb. 27	776	24.9
	March 27	543	37.8

less than that in the corresponding untreated checks. As the corms from the untreated check of Spic and Span were lost, no comparison could be made in this variety.

Because some growers had been treating cormels at 110 degrees F. for 24 hours, a comparison of the effectiveness of 110-degree and 135-degree treatments was made. Cormels of four varieties were divided into three lots each. The first lots were not treated, the second lots were treated at 135 degrees for 30 minutes on March 15, and the third lots were treated at 110 degrees for 24 hours on May 9.

Results of this test are shown in table 7. The hot-water treatments reduced the yields of corms in all cases; the 135-degree treatment reduced the yields much more than did the 110-degree treatment. In all varieties the percentage of rot was less in corms from cormels treated at 135 degrees than in those treated at 110 degrees. The 110-degree treatment had little or no effect upon the disease.

In 1958 an attempt was made to find out to what extent storage conditions before treatment affect cormel dormancy and thus affect results obtained with the hot-water treatment. Also, an attempt was made to find out if a chemical treatment would be as satisfactory as the hot-water treatment. Cormels of nine varieties in a commercial warehouse were divided into lots, the cormels of each variety into six lots. Lots 1 and 2 of each variety were taken from the warehouse to the laboratory on January 7. Lot 1 was given the hot-water treatment, 135 degrees F. for 30 minutes, on January 16. Lot 2 was kept in the laboratory at a temperature of 75 to 80 degrees F. until February 12, when it was given the hot-water treatment. Lot 3 was taken from the warehouse on February 11 and hot-water treated on February 13. After the treated cormels were dried they were stored at 40 degrees F. until 1 week before being planted. Lots 4, 5, and 6 were kept in the warehouse until May 8. On that date lot 4 was soaked 2 1/3 hours in Emmi 1:400 at 50-54 degrees F. Lot 5 was soaked 2 hours in Emmi 1:400 at 105 degrees F. Lot 6 was not treated. All cormels were planted May 8.

Results of this test are shown graphically in figs. 4, 5, and 6. In all nine varieties fewer corms were obtained from lot 3 than from lot 2. In eight of the nine varieties fewer corms were obtained from lot 1 than from lot 2. Lot 2 was the only

Table 7.--Effect of 135 and 110 degrees F. treatments on cormels, as indicated by number of corms produced and per cent of corms rotted.

Variety	Treatment	Date	Corms Produced	Per Cent of Corms Rotted
Hans Van Meegrin	None	----	896	18.1
	135°F., 30 minutes	March 15	146	4.1
	110°F., 24 hours	May 9	800	37.5
Harry Hopkins	None	----	224	11.2
	135°F., 30 minutes	March 15	12	0.0
	110°F., 24 hours	May 9	54	9.3
Lady Jane	None	----	858	23.0
	135°F., 30 minutes	March 15	102	2.0
	110°F., 24 hours	May 9	556	16.4
Sans Souci	None	----	652	24.9
	135°F., 30 minutes	March 15	84	2.4
	110°F., 24 hours	May 9	318	33.3

lot which was kept in a warm, dry room before treating. These results indicate that cormels kept in a warm, dry room generally withstand the hot-water treatment better than cormels kept in the cool, moist atmosphere of a commercial warehouse.

In six of the varieties both lots of Emmi-treated cormels produced more rot-free corms than any of the hot-water-treated lots. Also, Emmi-treated lots produced more diseased corms than the hot-water-treated lots. The hot-water treatment reduced the amount of disease, but it also reduced germination of the cormels.

In seven of the nine varieties cormels given the cold Emmi treatment produced more rot-free corms than did the cormels given the warm Emmi treatment. In the varieties Benjamin Britten and Elizabeth the Queen more rot-free corms were obtained from cormels given the warm Emmi treatment than from cormels given the cold Emmi treatment.

In another experiment the hot-water treatment was compared with cold and warm Emmi treatments on cormels of six gladiolus varieties. The following treatments were used on each variety: (1) hot water at 135 degrees F. for 30 minutes; (2) Emmi 1:400 at 50-54 degrees F. for 2 1/3 hours; (3) Emmi 1:400 at 105 degrees F. for 2 hours; (4) untreated check.

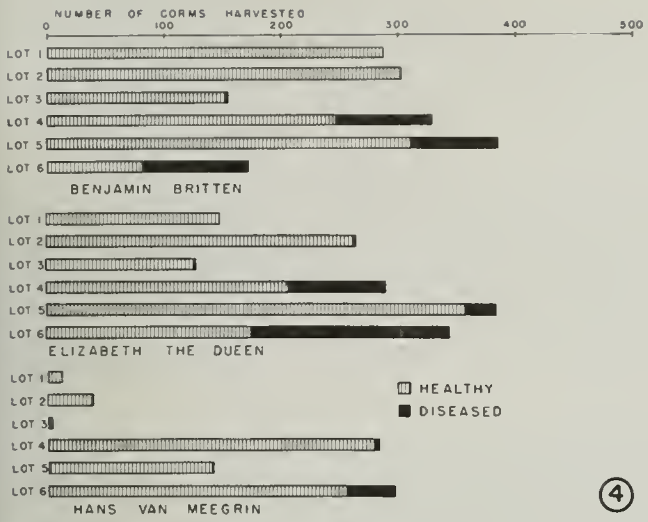
The cormels of each variety were divided into four equal parts by volume. No attempt was made to use the same number of cormels for all varieties. The hot-water treatments were made on December 19, 1957; the treated cormels were then dried and stored at 40 degrees F. until 1 week before planting. The Emmi treatments were made on May 8, 1958, the day all the cormels were planted.

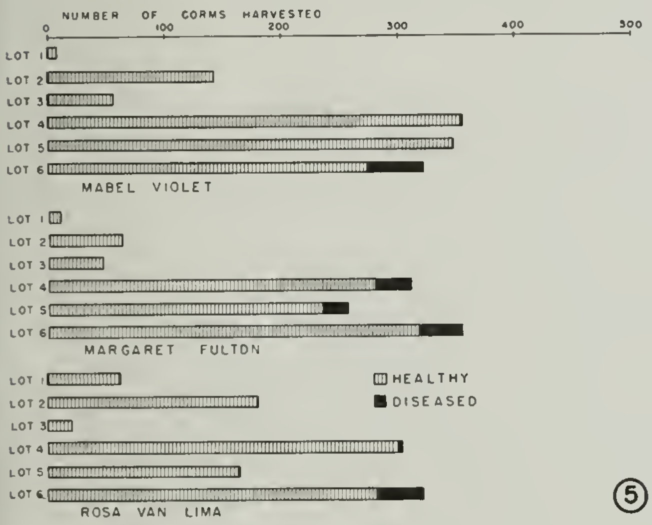
Results of this experiment are shown in figs. 7 and 8. In five of the six varieties more rot-free corms were obtained from cormels given the Emmi treatments than from cormels given the hot-water treatments. The hot-water treatments were superior to the Emmi treatments only in the variety Leif Ericson. In three of the varieties more rot-free corms were obtained from cormels treated in warm Emmi than from cormels treated in cold Emmi. In the other three varieties the reverse was true. In five of the six varieties the least amount of disease was found in corms produced from cormels that had received the hot-water treatment.

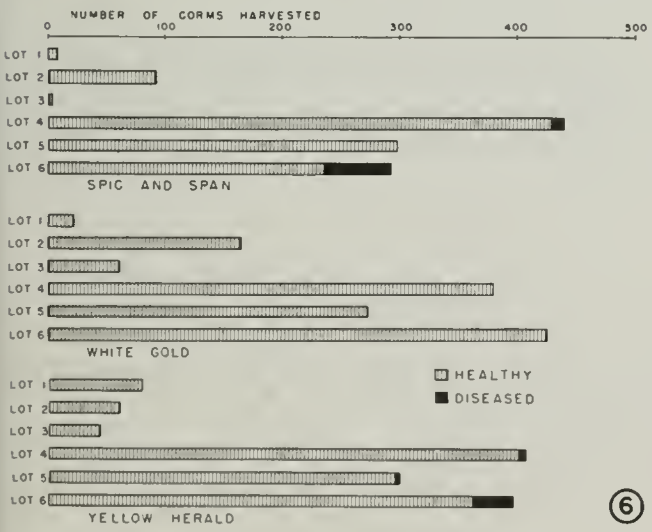
DISCUSSION

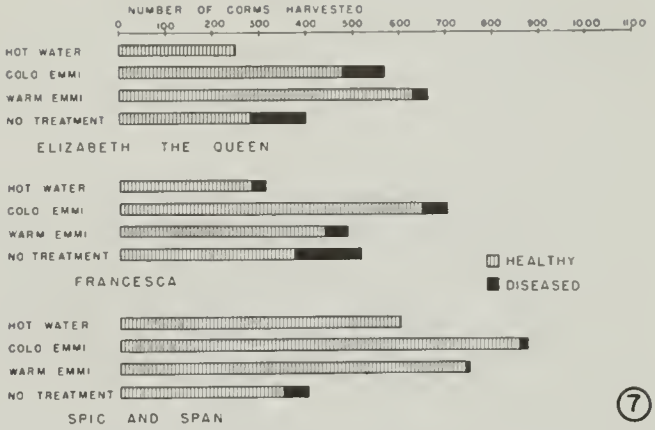
From the results obtained in the experiments reported here, it may be concluded that the hot-water treatment can be used beneficially on Illinois-grown cormels under certain conditions. The hot-water treatment will eliminate Fusarium and Curvularia from a stock of cormels to a greater extent than will a chemical treatment. However, the hot-water treatment may reduce corm yields so much that the value of the treatment becomes questionable. Use of a chemical treatment, while not reducing the amount of disease percentagewise as much as the hot-water treatment, generally will result in a greater yield of rot-free corms than would be obtained with the hot-water treatment. The hot-water treatment might be of greatest benefit in cleaning up a badly diseased lot of cormels to give the grower a new start with a small amount of relatively disease-free planting stock.

The results of experiments in which cormels were treated in different months indicated that, in general, the safest time to use a hot-water treatment on Illinois-grown cormels is in January. Other experiments showed that storage conditions before treatment greatly affect the results of the hot-water treatment. Because corm-









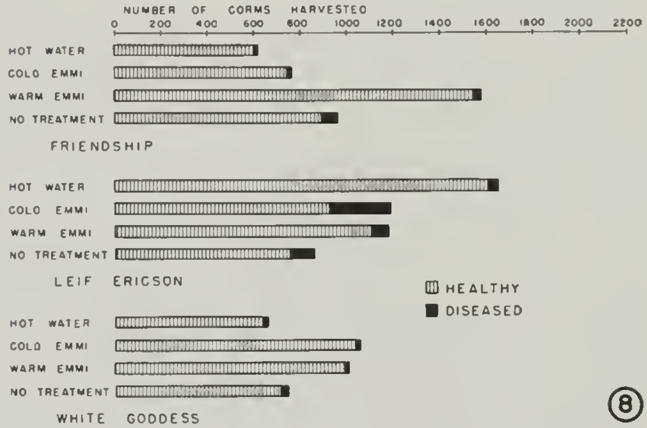


Fig. 4.--Number of healthy and diseased corms harvested from cormels of three gladiolus varieties: Benjamin Britten, Elizabeth the Queen, and Hans Van Meegrin. Lots 1, 2, and 3 were hot-water treated, lot 2 after being stored in a warm, dry laboratory; lots 4 and 5 were treated with Emmi; lot 6 was not treated.

Fig. 5.--Number of healthy and diseased corms harvested from cormels of three gladiolus varieties: Mabel Violet, Margaret Fulton, and Rosa Van Lima. Lots 1, 2, and 3 were hot-water treated, lot 2 after being stored in a warm, dry laboratory; lots 4 and 5 were treated with Emmi; lot 6 was not treated.

Fig. 6.--Number of healthy and diseased corms harvested from cormels of three gladiolus varieties: Spic and Span, White Gold, and Yellow Herald. Lots 1, 2, and 3 were hot-water treated, lot 2 after being stored in a warm, dry laboratory; lots 4 and 5 were treated with Emmi; lot 6 was not treated.

Fig. 7.--Number of healthy and diseased corms of gladiolus varieties Elizabeth the Queen, Francesca, and Spic and Span, harvested from cormels subjected to hot-water and to cold and warm Emmi treatments.

Fig. 8.--Number of healthy and diseased corms of gladiolus varieties Friendship, Leif Ericson, and White Goddess harvested from cormels subjected to hot-water and to cold and warm Emmi treatments.

els subjected to warm, dry storage conditions will withstand the hot-water treatment much better than will cormels which have been kept in the cool, moist atmosphere of a commercial warehouse, growers who wish to use the hot-water treatment should transfer their cormels to warm, dry quarters at least a month before subjecting them to the hot-water treatment.

Although treating cormels at 135 degrees F. for 30 minutes, a recommended treatment in California and Florida, may do much toward reducing the amount of disease in the subsequent crop, it is conceivable that use of this treatment year after year might eventually increase, rather than reduce, the amount of disease in gladiolus planting stock. These experiments have shown that all isolates of Fusarium are not killed in 30 minutes at 135 degrees F. Thus, if such heat-resistant strains survived the treatment they might continue to develop in a gladiolus stock until the heat treatments would become entirely ineffective.

Roistacher, Baker, & Bald (1957) do not agree with this view. They contend that "Everything considered, it is unlikely that Fusaria of such thermal tolerance as to render the treatment ineffectual will appear. However, since cormels in a proper state of dormancy can often tolerate temperatures well above 135 degrees F.... there is still some margin of safety."

Ryan (1960), quoting Dr. Robert O. Magie of the Gulf Coast Experiment Station, Bradenton, Florida, stated, "Corona and Leading Lady cormels have been treated at 135°F for several years, and a large stock of cormels has been built up. However, it was found last year that this treatment was not effective in destroying all of the Fusarium infection, and the corms began to break down when grown from planting stock or after reaching No. 1 size. Last summer, Corona and Leading Lady cormels were treated at temperatures up to 139 degrees F for 30 min. The smaller cormels tolerated the highest temperature used and are growing in the field."

The report from Magie supports the contention that heat-resistant strains of Fusarium can survive and continue to develop in a gladiolus stock until the heat treatments become ineffective. This hazard might be avoided, as Magie has suggested, by increasing the treating temperature from 135 to 139 degrees F. Such a procedure, however, would reduce germination in many stocks of gladiolus cormels so much that it would be unwise to use the method as a regular commercial practice.

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