SOME TESTS WITH SOIL FUMIGANTS

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In October 1954, a root, basal stem-rot and wilt disease of *Chrysanthemum morifolium* in the Fort Myers area of Florida was brought to the attention of the Plant Pathology Laboratory, State Plant Board of Florida. Isolations made over a four month period from plants showing these symptoms yielded a number of fungi known to be pathogenic to chrysanthemums including *Pythium* spp., *Rhizoctonia* spp., *Sclerotium rolfsii* and also a fungus of unknown pathogenicity, *Fusarium oxysporum.*

Although the nature of this disease is not completely understood, it is apparent that it is caused by a complex of soil-borne organisms. Hence, soil fumigation tests using various chemical materials have been conducted in the Fort Myers area with the primary object being to determine the effectiveness of these soil treatments in the control of the disease and of root-knot nematodes. Secondary objectives have been to observe the control of weeds and the plant tolerance to the materials tested.

Materials and Methods

The chemicals included in the test were Vapam (sodium-n-methyl dithiocarbamate), Crag 974 (dimethyl tetrahydrothiadiazine thione), methyl bromide as Dowfume MC-2 (98% monobromomethane, 2% chloropicrin) and a mixture of commercial formalin, allyl alcohol, and Shell D-D (dichloropropene-dichloropropane), which is referred to as F. A. D. mixture. Chemicals and their rates of application are shown in Table 1.

The ground bed plots measured 105 square feet. The entire test involved some 3600 square feet.[2] Each plot was bordered by wood strips sunk into the ground to a depth of approximately 3 inches. The soil in the test area was a sandy-loam type to which about 30% organic matter (German peat) had been added and rototilled in the previous fall.

Because of the difficulties involved in obtaining a large area planted to one crysanthemum variety, it was necessary to use four varieties: Blue Chip, White Top, Orange Beauregard and Shasta. Thus the experiment was a split-plot design with treatments as the main-plot effects and varieties as the sub-plot factors. Treatments were replicated four times and were randomized within a single replicate. Varieties were not randomized within each treatment.

Table 1. - Chemicals and rates of application used in soil fumigation plots to control a root and stem-rot disease of Chrysanthemum morifolium.

Chemical	Rate of application	Amount/sq. ft.	Amount/plot
Vapam	200 lbs. per acre	4.33 ml	454.6 ml
"	300 " " "	6.50 "	682.0 "
"	400 " " "	8.65 "	909.3 "
Methyl bromide	4 lbs. per 100 sq. ft.		
F. A. D. mixture			
Formalin	100 gal. per acre	8.7 ml	912.5 ml
Allyl alcohol	25 " " "	2.17 "	227.3 "
D-D	20 " " "	1.74 "	182.7 "
Crag 974	100 lbs. per acre (actual)	1.1 gm	110 gm
" "	200 " " "	2.2 "	220 "
" "	300 " " "	3.3 "	330 "
Control (not treated)			

Vapam, a water soluble, liquid material, in sufficient quantity for one plot was added to 50 gallons of water and applied to the soil with a power sprayer. Crag 974, a wettable powder, was applied in like manner. In both cases, a watering rose was used on the hose to insure even distribution of the chemicals.

A sufficient amount of the F. A. D. mixture for one plot was prepared in six gallons of water (two 3 gallon watering cans) and applied with watering cans.

Following the application of Vapam, Crag 974 or F. A. D. mixture to a plot, approximately 44 gallons additional water was sprinkled on to distribute the chemicals to a depth of 6-8 inches.

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[2]/The cooperation of Povia Brothers Farms, Fort Myers, Florida, who made available the necessary space, and the able assistance of Mr. W. J. Messmer is gratefully acknowledged. All plants were supplied through the courtesy and cooperation of Yoder Bros., Barberton, Ohio.

Methyl bromide (MC-2) was liberated under a gas-tight "tent" of Sisalkraft paper from 1 pound cans with a "Jiffy" applicator. The end of the applicator hose was placed in a clean quart can to prevent the methyl bromide from running directly into the soil. Sisalkraft cover was secured with wood strips nailed to boards forming the plot.

Twenty-one days elapsed between soil treating and planting to allow ample time for the chemicals to diffuse from the soil.

Weed control records were made immediately prior to planting. In some plots the total number of weeks were counted, in others the weeds were so numerous that a count was impossible. Although the weeds were pulled from the plots at the time of planting, a weed count was made three weeks after planting to determine the effective longevity of the chemical treatments.

An attempt was made to determine the cause of the root and basal stem rot disease by making isolations from representative diseased plants at periodic intervals during the course of the experiment.

The plots were planted May 18, 1955 and harvested August 29-31, 1955. Because it was not possible to bring the plants into flower and thus rate the various treatments on an actual production basis, green weight was used as a measure of plant response to the various treatments. Green weight should relate directly to flower quality as well as productivity. Plants were harvested by cutting the basal stem approximately 2" above the ground. Each variety in a plot was cut separately, the stems and leaves were bundled, weighed on a milk scales, and the weight recorded.

An index to disease control was obtained by subtracting the total number of surviving plants of any one variety in any one plot from the total initially planted minus the plants removed for examination during the test period. The difference was considered loss due to "disease".

The effectiveness of the various materials in controlling root-knot nematode (in this case *Meloidogyne incognita*) was determined at the end of the experiment by harvesting twelve plants from each variety sub-plot in a prescribed manner. Roots were washed free of adhering soil and assigned to one of 4 classes depending upon the degree of root-knot galling present: O-no visible root-knot galls; 1-slight root-knot galling evident; 2-moderate root-knot; 3-severe root-knot. The mean index for each variety sub-plot was obtained by the following formula:

$$\text{Mean Index} = \frac{\textit{Sum (Class No. x number in class)}}{\textit{Total number plants indexed.}}$$

Experimental Results

WEED CONTROL: pre-planting (Table 2).

Since counts of weeds in all plots were not made before planting, only general statements can be made regarding pre-planting weed control.

Table 2. - Effect of the different soil treatments on weed control.

Treatment	Pre-planting control rating[a]	Post-planting control total weeds/470 sq. ft.[b]
Vapam 200 lbs/acre	1.0	872
" 300 lbs/acre	1.3	538
" 400 lbs/acre	1.3	633
Crag 974 100 lbs/acre (actual)	2.0	671
" " 200 lbs/acre	1.0	761
" " 300 lbs/acre	1.3	536
F. A. D. Mixture (100-25-20 gals/acre)	2.5	630
Methyl bromide 4 lbs/100 st. ft.	0.0	194
Control (not treated)	3.0	1334

[a] 0.0 = No weeds surviving treatment.
1.0 = 1-100 weeds/plot surviving treatment
2.0 = 101 - too numerous to county weeds/plot surviving treatment
3.0 = weeds surviving treatment too numerous to count.
The rating given is an average rating of the four replicates of each treatment. Actually all plots fell in one of two catergories: less than 100 weeds/plot or weeds per plot too numerous to county.

[b] Total of four replicates.

Vapam at 200, 300 and 400 pounds per acre gave good control of all weeds. Crag 974 gave fair control at 100 pounds per acre and good control at the 200 and 300 pound per acre level. Methyl bromide at 4 pounds per 100 square feet gave excellent weed control; no weeds germinated in these plots up to planting time. F. A. D. gave poor weed control.

WEED CONTROL: post-planting.

All treatments gave significant post-planting weed control when compared with the

untreated. No particular treatment was significantly better than another treatment, although methyl bromide at 4 lbs/100 square feet approached significance.

EFFECT OF TREATMENTS ON GREEN WEIGHT

Based on mean green weight every treatment resulted in a highly significant increase in green weight when compared to that of the untreated (Table 3). There were no significant differences between treatments with the exception that some of the treatments were significantly better than Vapam at 200 lbs/acre.

NEMATODE CONTROL (Table 3).

Examinations for the presence of parasitic nematodes were made twice during the growing season. Three plants were chosen at random from each plot and the roots and surrounding soil examined. In every instance only the Southern root-knot nematode, *Meloidogyne incognita,* was found in roots of plants exhibiting root-knot galls. No ectoparasitic nematodes were found in the soil.

Analysis of the data[a] indicates that methyl bromide at the rate used gave very highly significant (0.1% level) nematode control when compared to the remainder of the treatments or the check plots. There was no difference evident among the Vapam, Crag 974 or F. A. D. treatments nor between these treatments and the check plots.

Table 3. - Effect of soil treatments on the green weight of Chrysanthemum morifolium and on the control of the Southern root-knot nematode, Meloidogyne incognita.

Treatment		Mean green weight (lbs.) per plant (variety and replicate totals)	Mean Nematode rating
Vapam	200 lbs/acre	5.75**	1.87
"	300 lbs/acre	6.24**	1.99
"	400 lbs/ acre	6.26**	2.11
Crag 974	100 lbs/acre	6.14**	1.67
" "	200 lbs/acre	6.40**	2.04
" "	300 lbs/acre	6.38**	2.07
F. A. D.	(100-25-20 gal/acre)	6.46**	1.4'
Methyl bromide (4 lbs/100 sq. ft.)		6.9***	0.61***
Control (not treated)		4.24	2.0'

** Significant at the 1% level.

*** Significant at the 0.1% level.

5/The assistance of Mr. Victor Chew of the Statistics Laboratory, University of Florida, in the analysis of this and other data in the experiment is appreciated.

That a varietal difference in susceptibility to the Southern root-knot nematode existed was evident at the time of indexing. This visual difference has been borne out in the analysis of the index data (Table 4). The difference between mean index values are highly significant.

The resistance to Southern root-knot nematode shown by the variety Shasta seemed to be uniform and stable under all conditions of the experiment. Orange Beauregard responded to treatment only in the methyl bromide plots. The response of Blue Chip and White Top to treatments other than methyl bromide was variable.

Table 4. - Varieties ranked in order of increasing susceptibility to the Southern root-knot nematode, Meloidogyne incognita.

Variety	Mean Index[a]	
Shasta	0.55	
Blue Chip	1.81	Differences significant at 1% level
White Top	2.26	
Orange Beauregard	2.52	

[a]Total of 432 plants of each variety examined.

DISEASE CONTROL (Table 5).

Of 1047 plants set in the untreated plots 33 were dead at the conclusion of the test. This gave a loss to "disease" of 3.1%. Although some of the treatments showed a significant decrease in disease when compared to the untreated plots, the total amount of disease was not great enough to draw conclusions regarding treatments and disease control.

Table 5. - Effect of the different soil treatments on loss of plants due to disease

Treatment		Total losses
Vapam	200 lbs/acre	23
"	300 lbs/acre	16
"	400 lbs/acre	14
Crag 974	100 lbs/acre	22
" "	200 lbs/acre	13
" "	300 lbs/acre	15
F. A. D. (100-25-20 gals/acre)		13*
Methyl bromide (4 lbs/100 square feet)		23[a]
Control (not treated)		33

*Significant at the 5% level.

[a]Total of 33 plants lost; 10 of these because of methyl bromide injury.

The losses to disease occurred for the most part at two stages in the growth of the plants. Losses first occurred 3-4 weeks after planting the plots. The majority of these young plants showed a root and basal stem-rot. Isolations yielded primarily *Rhizoctonia* spp. About eight weeks after planting a second period of plant loss occurred. The variety White Top exhibited wilt symptoms while Blue Chip showed a firing of the leaves. The vascular tissues of affected plants of both varieties showed a distinct brown discoloration and isolations yielded primarily *Fusarium oxysporum.* From a few plants exhibiting brown-black stem lesions as much as 12 inches above the ground, *Rhizoctonia* spp. was obtained.

The bacterial blight organism, *Erwinia chrysanthemi,* was not isolated from any of the diseased plants.

PLANT TOLERANCE

None of the chemical treatments caused an observable detrimental effect on the growth of the plants. In two of the methyl bromide treated plots some of the liquid methyl bromide splattered onto the soil despite precautions taken to avoid this. In such cases the methyl bromide remains in the soil for a long period and is toxic to plants set in this soil. A total of 10 plants were killed in these two plots.

CONCLUSIONS:

Since this is the first in a series of plots to test soil fumigants, no conclusions are drawn nor will recommendations be made at this time.

RECENT ADVANCES IN CONTROLLING DISEASES OF GLADIOLUS

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Interest in treating soil with chemicals to control certain gladiolus diseases has increased in the past two years. Growers as well as research people have become more interested in soil treatment for three reasons: first, new chemicals are now available at a cost per acre that may allow them to be used for some field crops. Second, moving to new land is becoming difficult and expensive. The need for replanting old land is greater each year. Third, and I believe, most important, the desire to plant corms on disease-free or chemically treated land is increasing because disease-free planting stocks are becoming available as a result of hot-water treatment of cormels. Until recently, the soil was almost certain to be contaminated by each crop of gladiolus because of the disease fungi which are carried on the corms.

Soil infestation problems have increased in importance in another way too. Ten years ago Fusarium disease was the only important soil disease of gladiolus. Then in 1947 another fungus disease caused by *Curvularia lunata* (Wakk.) Boed. spread over Florida. Recently the importance of a soil fungus called *Stromatinia gladioli* (Drayt.) Whet. was discovered and reported to you last year (3). Also, as Dr. Kelsheimer told us this morning, nematodes are becoming more important in the over-all problem of gladiolus soil infestation.

Soil diseases were usually severe in the important gladiolus-growing areas of the State in the past two years. In the Manatee County area the flower crop on 700 acres was severely reduced or completely ruined by Stromatinia root rot. In all areas a heavy toll was taken by the Fusarium disease.

STROMATINIA ROOT ROT

Much has been learned about Stromatinia root rot since early 1954 when the disease was first discovered on gladiolus farms in the Tampa Bay and Ft. Myers areas. First, the disease was found to be economically important only in well-drained land, indicating that control might be obtained by summer flooding of the land. Second, plantings made either early or late in the season escaped the effects of the disease more or less completely; but soil infestation by the production of sclerotia usually occurred regardless of the time corms were planted. Third, treatment of