THE OHIO JOURNAL OF SCIENCE

VOL. XLV JULY, 1945 No. 4

THE EFFECT OF CHEMICAL SOIL TREATMENTS ON THE DEVELOPMENT OF WHEAT MOSAIC

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INTRODUCTION

Wheat mosaic virus, *Marmor tritici* H.[2], is unique in the fact that it is transmitted from one generation of wheat to another through the soil. Both winter and spring wheat are susceptible to infection when planted in the fall, but usually the symptoms are not noticeable until the following spring when the plants make rapid growth. In a previous communication (4) the writer reported results on the study of certain insects and nematodes with regard to their ability to act as virus vectors. Neither the insects nor nematodes considered transmitted the virus. Thus far the vector of wheat mosaic virus occurring east of the Mississippi River has not been found, and the method of inoculation when plants are grown in virus-infested soil is open to conjecture.

It is known that a soil treatment with a solution of formaldehyde in water will control wheat mosaic, as will steam sterilization (5). It also has been shown (3) that control of the disease can be obtained by heating infested soil at a temperature of 60° C. for ten minutes.

From our general knowledge of the disease it is believed that a soil-borne organism is responsible for transmission of the virus. In an attempt to elucidate this point a study was made to determine what effect certain chemicals used as insecticides and nematocides would have on the development of the disease when applied to virus-infested soil. The present paper discusses some of the results obtained.

MATERIAL AND METHODS

The soil used in these tests was collected from localities in Indiana where mosaic had seriously affected wheat over a period of many years. When treated, the soil was at a moisture content of 25 per cent and gave a pH reading of 4.8. By analysis the soil contained 25 per cent clay, 59 per cent silt, and 16 per cent sand and fine gravel.

[1]This work was conducted while the writer held the Muellhaupt Scholarship, Department of Botany, Ohio State University, Columbus, Ohio. Grateful acknowledgement is made to Dr. R. M. Caldwell of Purdue University, and Dr. Benjamin Koehler of the University of Illinois, who supplied the soil for investigational purposes. Without their aid this study could not have been undertaken. The writer is also indebted to Dr. E. N. Transeau, Dr. W. G. Stover, and Dr. C. C. Allison, of Ohio State University, for their assistance in the preparation of the manuscript. Paper from the Department of Botany, the Ohio State University, No. 478.

[2]The Latin name of the virus follows the system of nomenclature in the Handbook of Phytopathogenic Viruses (2).

Eighteen air-tight metal containers, with a capacity of 490 cubic inches, were filled to one inch from the top with virus-infested soil which previously had been passed through a screen of one-fourth-inch mesh. Six chemicals were studied at different concentrations. Calcium cyanide (granulated) was used at 1, 3, and 5 gms.; carbon disulphide at 2, 5, and 10 cc.; while chloropicrin, ethyl chloride, ethylene dichloride and methyl bromide each were used at 0.3, 1, and 3 cc. Each sample of chemical was placed in one of the metal containers, approximately equidistant from the bottom and the surface of the soil; then water was sprinkled over the surface to create a partial seal. A close-fitting, cardboard disc, which previously had been given three coats of animal glue on each side, was next inserted over the soil; and glue was used as a seal between the disc and container. This procedure was followed since the work of Godfrey (1) showed that the gases of chloropicrin and carbon disulphide do not readily diffuse through membranes of animal glue. As a check on the effect of the chemicals on the development of the plants, non-infested soil was treated in the manner described above, except that only six containers were used, one for each of the six chemicals. In each case the check soil was treated with a dosage equal to the largest amount of chemical applied to the infested soil.

At the beginning of the experiment all soil was at a temperature of 16° C., and after the containers were sealed they were placed in a greenhouse where the temperature was approximately 27° C. After seven days the discs were removed and the soil from each can spread out on separate paper sheets and placed outdoors to facilitate aeration. Strong odors of carbon disulphide, calcium cyanide, chloropicrin, and methyl bromide could easily be detected as the discs were removed from their respective containers.

The wheat was sown in No. 10 tin cans. The bottoms of the cans were perforated with holes to permit drainage of excess water. The required number of these cans were first half filled with composted soil known to be free from virus. To this was added a three-inch thick layer of the chemically treated soil in which the wheat was planted four days after the discs were removed. The treated soil from each container was placed in five of the tin cans and fifteen seeds of Purdue No. 1 wheat, a variety highly susceptible to mosaic, were planted in each can. This method has been shown by Webb (7) and confirmed by the writer to give about as much infection as when infested soil was used exclusively without the underlying non-infested soil.

After the wheat was planted all cans were placed outdoors over winter in soil trenches about eight inches deep and each series of five cans was placed in one row. There was a space of four inches between the cans in each row and sixteen inches between each row of five cans. As a control, wheat was also planted in virus-infested and non-infested soil which had not been treated with the chemicals. The outside soil was firmly pressed around each can and drainage of surface water was cared for by providing ditches in order that the soil within the cans should not become mixed.

EXPERIMENTAL RESULTS

There was a good stand of wheat and the plants were approximately six inches tall when the hard frosts and snows of winter settled. Considerable heaving of the soil within the cans caused some plants to die. No counts of plants were made in the fall, but one record from fifty cans selected at random made in the spring when the plants were making rapid growth gave an average of between eight and nine plants in each can. The diseased and healthy plants were not counted separately, but were critically examined three times up to the period when the wheat was in the boot stage. The results were recorded in a general way as: complete control; incomplete when both healthy and diseased plants were present; and no control.

The examinations revealed that calcium cyanide was more effective in controlling the disease when used at the higher concentrations. At 1 gm. there was no control; at 3 gms. control was incomplete; but 5 gms. completely controlled the disease. There were no diseased plants in the soil treated with carbon disulphide at each of the concentrations of 2, 5, and 10 cc. Chloropicrin and methyl bromide were similarly effective when used at 0.3, 1, and 3 cc. At the latter concentrations ethyl chloride was not effective, and ethylene dichloride gave only incomplete control at the two higher concentrations.

In another experiment virus-infested soil, of an amount equal to that used previously, was placed in a tight container and subjected to the fumes of naphthalene at room temperature for 17 days. The soil was placed in cheesecloth bags and suspended over the naphthalene flakes. After four days of aeration it was planted to wheat in the manner described above. Another similar quantity of soil was air dried, then mixed thoroughly with 500 gms. of rotenone powder with active ingredients of 0.75 per cent. Water was then added before the wheat was sown. No disease developed as a result of either of these treatments.

The plants grown in the non-infested soil remained healthy throughout the length of the experiment, while there was a very high incidence of disease in the virus-infested soil which had not been subjected to the chemicals. No evidence of any effect of these materials on the development of the plants was noticed. The results of these experiments are recorded in Table I.

TABLE I

EFFECT OF CHEMICAL TREATMENTS TO VIRUS-INFESTED SOIL ON THE DEVELOPMENT OF WHEAT MOSAIC*

CHEMICAL	AMOUNT USED	EFFECT ON DISEASE
Calcium cyanide (granulated)	1.0 gm. 3.0 gm. 5.0 gm.	No control Incomplete control Complete control
Carbon disulphide	2.0 cc. 5.0 cc. 10.0 cc.	Complete control " " " "
Chloropicrin	0.3 cc. 1.0 cc. 3.0 cc.	Complete control " " " "
Ethyl chloride	0.3 cc. 1.0 cc. 3.0 cc.	No control " " " "
Ethylene dichloride	0.3 cc. 1.0 cc. 3.0 cc.	No control Incomplete control " "
Methyl bromide	0.3 cc. 1.0 cc. 3.0 cc.	Complete control " " " "
Rotenone	500.0 gm.	Complete control
Naphthalene		Complete control

*Grateful acknowledgement is made to Innis, Speiden & Company for chloropicrin; to the Pittsburg Chemical Company for methyl bromide; and to The Dow Chemical Company for ethylene dichloride and ethyl chloride.

DISCUSSION

These experiments were not planned in order to find a means of controlling wheat mosaic as this already is accomplished in a practical way by the use of resistant varieties, but it did seem of interest to study what effect some chemicals which are toxic to certain organisms would have on the development of the disease. While these results are somewhat interesting, it must be remembered that more than one replication of this work might have yielded other data, but unfortunately not enough virus-infested soil was available for such an undertaking.

The results obtained indicate that the liquids previously used effectively as insecticides and nematocides were also effective in controlling the disease. Ethylene dichloride and ethyl chloride were not as effective, but nothing is known as to the efficiency of the animal glue membranes used as a seal over the fumigating chambers on the retention of these gases. It is interesting to point out that no disease developed in the soil with which rotenone dust had been mixed. In this case the soil had first been stored in a well ventilated room until dry before it was mixed with the rotenone, but this procedure was not considered to have affected the results obtained, since McKinney (6) has shown that the disease develops in virus infested and retained in an air-dried condition for three years.

The nature of the vector of wheat mosaic virus is still open to discussion. It is believed that a subterranean insect or nematode transmits the virus, and that the action of the materials used was on the vector rather than on the causal agent. There are many kinds of subterranean arthropods such as thrips, spring tails, garden centipedes, mites, and root aphids, to mention a few, which might pass unnoticed to the unaided eye while examining soil. However, it is somewhat unusual to expect such forms of animal life to remain dormant in air-dried soil for three years and then resume parasitic habits after this period if favorable conditions for plant growth are provided. Nematodes, on the other hand, have this capacity.

SUMMARY

A study was made on the action of certain chemicals, commonly used as insecticides and nematocides, on the development of winter wheat mosaic. Samples of a specified quantity of virus-infested soil were subjected for seven days to the gases of five volatile liquids and two solids; besides, one contact insecticide was studied in this connection.

Calcium cyanide when used in the greatest amount and carbon disulphide, chloropicrin and methyl bromide at each of the three concentrations used completely controlled wheat mosaic. Ethylene dichloride reduced the incidence of the disease at the two larger dosages, but etyhl chloride gave no control. The fumes of naphthalene and rotenone dust, when mixed with the soil, also gave complete control of the disease.

The action of these chemicals was probably on the vector rather than on the virus.

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