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OBSERVATIONS OF CERTAIN FACTORS GOVERNING EFFICACY OF SOIL FUMIGANTS

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Compared with efforts expended in foliage problems, control of below-the-ground pests and pathogens has been a neglected field. Although little is yet known regarding the nature of organisms causing damage through plant roots, the enormous extent of crop losses from such organisms has been strikingly demonstrated by the use of soil fumigants. Soil fumigation appears to offer a logical and practical means of controlling harmful and undersirable soil organisms and increasing crop yields and quality. There are now four or five manufacturers of fumigants carrying on an intensive screening program with volatile chemicals. Literally hundreds of fumigants have been tested against various soil fungi, insects, nematodes and weed seeds and many promising ones have been found. Also much fundamental knowledge is gradually being acquired regarding factors affecting the performance of fumigants. There is a great need for intensive work along these lines by local experiment station workers, and it is hoped that the following generalized discussion will be a thought provoker and research stimulator.

The fumigants now being used commercially in Florida are chlorpicrin (Larvacide), methyl bromide (Iscobrome), dichloropropene-dichloropropane mixture (D-D) and ethylene dibromide (Soilfume 60-40, Soilfume 80-20 and Dowfume W-40). Their respective merits have been discussed in other papers. All of these fumigants are relatively insoluble in water, but vary considerably in their molecular weights, boiling points and vapor pressures. They are all applied beneath the soil surface as liquids and function in the soil as gases.

Spacing and Depth of Applications—Studies of fumigant diffusion in soil have shown that the diffusion pattern is ordinarily like a bottle or a flask with a tapering neck. It can be readily understood that the spacing of application points or rows should be close enough and the depth of applications be shallow enough so that the point at which the pattern begins to taper be as close to the soil surface as possible; also so that the various diffusion patterns meet or preferably overlap at all points. With the flask picture in mind, it can be understood that the upper inch or two of soil is the most difficult area to fumigate effectively. Spacing can be wider in sandy soils (say, 12 to 14") than in clay and muck soils (say, 8 to 10"). It is advisable to make applications as shallow as possible and still retain the fumigant in the soil. Depth of application should be increased, particularly in sandy soils, when soil temperatures are high and/or soil moisture contents are low.

Penetration—From the point of application the fumigant must penetrate throughout the soil mass to the desired depth, into rotting roots and other organic debris, and then be retained long enough to kill various forms of inoculum. Factors affecting diffusion, such as soil temperature, soil porosity, soil moisture content, degree of sorbtion, molecular weight and vapor pressure of the fumigant determine the degree and rate of penetration. The fumigants in use are all heavier than air so that downward penetration is usually no problem. Sometimes, as in the treatment of sandy seed beds with chlorpicrin, it is desirable to limit downward penetration of the fumigant by raising the water table. Owing to the difficulty of penetrating unrotted or partially rotted roots, it is desirable to allow such organic debris to thoroughly rot before treating the soil. The principle reason for the comparative inferiority of chlorpicrin against the root knot nematode is its inability to kill all stages of the nematode in roots that are not thoroughly disintegrated, whereas methyl bromide, D-D and ethylene dibromide have this ability when applied under favorable conditions. It is also suspected that general penetration of the fumigant is hindered by air pockets surrounding organic debris, in that the gas settles in these pockets. Penetration into surface ridges and lumps is difficult; hence the importance of having the surface thoroughly levelled following application of the fumigant.

Soil Temperature—In general soil fumigants are most effective at soil temperatures between 50° and 80° F. At low temperatures sorbtion of the fumigants by soil particles is greater, volatilization and diffusion are lessened, and the period of retention in soil is prolonged. At higher temperatures loss of the fumigant at the soil surface is more rapid. Materials with a low boiling point, like methyl bromide, are more effective at lower temperatures and less effective at higher temperatures than chlorpicrin, D-D and ethylene dibromide which have higher boiling points. At high temperatures the fumigant should be applied deeper, the soil moisture content should be higher and, in the case of chlorpicrin and methyl bromide, greater attention should be given to sprinkling the soil surface with water. Muck and clay soils can be treated more effectively at higher temperatures than sandy soils.

Soil Moisture—It is difficult to state the ideal soil moisture content levels for best results from soil fumigation. Since the fumigants are all only slightly soluble in water they are not able to penetrate a wet soil. Similarly a high water table can stop downward penetration of the fumigant, or, on rising, force it out of the soil; a heavy leaching rain can push the gas downwards; and a light rain or artificial sprinkling can help seal the fumigant in the soil and materially aid in results obtained with chlorpicrin and methyl bromide. In dry soil the loss of gas is often too rapid. Pre-conditioning of soil with moisture is known to be very important in regard to killing of weed seeds with chlorpicrin, and this may apply to other organisms and other fumigants. When soil temperatures are above, say 75°, the soil moisture content, particularly in sandy soils, should be higher. Clay soils and probably mucks, should be fumigated at lower moisture levels than sandy soils.

Soil Type — Diffusion of fumigants through more porous sandy soils is easier than through less porous clay soils. Also sorbtion of these gases, principally by the colloidal soil particles, is greatest in clay, second in muck and least in sandy soils. Although gas sorbtion is not as great in muck as in clay, it is apparently more prolonged. In general, clay and muck soils should be fumigated with higher dosages, shallower applications, in looser condition, at lower soil moisture contents and at higher temperatures than sandy soils and a longer period should be allowed for aeration.

Rates of Application—The usual rates of application are about 500 lbs. of chlorpicrin, 200 lbs. of methyl bromide, 200 lbs of D-D and 50 lbs. of Ethylene dibromide per acre. Dosages are increased somewhat when soil conditions are adverse for retention or diffusion of gas. Also heavier dosages are applied in muck and clay soils than in sandy soils.

WIREWORM CONTROL STUDIES ON THE LOWER SOUTHEASTERN FLORIDA COAST, 1946-47

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There is no question but that serious losses from wireworms have been sustained by potato growers in South Florida. The important question is how can the losses be stopped. This report records results of rather extensive experiments conducted in the 1946-47 season on the use of insecticides for wireworm control. An enumeration of three characteristics of the wireworm problem in South Florida is as follows: (1) one of the corn wireworms, *Melanotus communis Gyll*, is the insect involved, (2) most of the insects complete their life cycle in one year, as shown by Wilson[1], and (3) most of the insects are in the larval stage during the entire potato growing season. Adaptation of control measures found effective elsewhere may not be effective in South Florida, nor do the differences necessarily preclude an easier solution to the problem.

Some of the newer insecticides were tested to determine their effectiveness in wireworm control. They included DDT, benzene hexachloride, termed HCH (for 1, 2, 3, 4, 5, 6-hexachlorocyclohexane) in this report, and the fumigants dichloropropane - dichloropropylene under the proprietary names of *D-D*, and *Dowfune N*, and ethylene dibromide, or *Dowfume W-10*.

All experiments were conducted on the calcareous or marl soil in commercial fields of potatoes of South Dade County. This soil is alkaline and was found to range in pH between 7.5 and 8.7. It might be questioned, owing to the alkalinity, how DDT and benzene hexachloride could be effective in wireworm control, since both insecticides are understood to decompose in alkaline media. Some wireworm control, however, was obtained.

FIELD EXPERIMENTS

In cooperation with the Farsouth Growers Cooperative Association an experiment was conducted in which different concentrations

[1] WILSON, J. W. Present status of the wireworm in South Florida. *Proc. Fla. State Hort. Soc.* for 1946: 103-106.