Chemical Weed Control

soil sterilants and translocated herbicides have their advantages and problems according to their special uses

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Three major fields of chemical weed control are open for further development: the uses of temporary soil sterilants, permanent soil sterilants, and translocated herbicides.

Carbon disulfide, sodium chlorate, and borax are three typical temporary soil sterilants. The first is effective in the soil for a few days, or weeks at the most; the second is effective usually for a few months, depending on soil type and precipitation; the third is effective for a year or more. All three are toxic against most plants and are required in relatively large quantities.

Arsenic is the most persistent of the soil sterilants in use and under ordinary conditions a dosage of white arsenic—sufficient to render a soil sterile—will maintain that sterility for five years. A reapplication at less than the initial rate will re-establish the sterility.

In the use of translocated herbicides the chemical—to be effective in killing the roots of herbaceous and woody perennials—must penetrate the waxy cuticle of the stems and leaves, migrate through living cells of the plant tissues and accumulate to toxic levels. Consequently formulation of the spray materials is extremely important and can not be neglected.

Temporary Soil Sterilants

One outstanding example of temporary soil sterilants is IPC—isopropyl N-phenyl carbamate. This chemical, at two to five pounds per acre, is used to control winter annual grasses—bluegrass, wild barley, ripgut, soft chess—and chickweed in forage and vegetable crops in the West. Alfalfa, ladino clover, trefoil, flax, onions, strawberries, and asparagus are other crops being protected by the use of IPC.

Effectiveness of temporary soil sterilants depends either on accurate localization of the chemical in the soil or on a biochemical selectivity that enables the crop to survive the treatment.

Only a few cases are known where selectivity can be relied on to give satisfactory control with no injury to the crop. Repeated instances of 2,4-D injury to wheat, oats, barley, rice, corn, and flax prove that complete reliance can not be placed on the selectivity of this chemical.

Where localizaiton of a chemical is desirable—either for crop protection or for concentration of the toxic effects—2,4-D acid or the slightly soluble calcium salt may be used. Some of the amides also are low in solubility. These materials may be mixed in the topsoil by disking and harrowing and will remain localized longer than water-soluble salts.

A new compound, Chloro IPC, is being tested as a temporary soil sterilant. Preliminary tests indicate it may prove to be superior against quackgrass, Bermudagrass, Johnsongrass, and other pests that grow mainly during the summer months.

In evaluating chemicals—as temporary soil sterilants—the effects of soil moisture, precipitation, soil colloids and general cultural conditions are important with soil moisture and rain immediately following application probably the most important factors determining their effectiveness.

Permanent Soil Sterilants

Permanent soil sterilants find use on railway ballast, irrigation canals, industrial sites, airfields, arsenals, and other areas amounting to hundreds of thousands of acres. Weed control on such areas reduces the fire hazard and is essential in any comprehensive pest control program because those areas grow weed seeds and harbor insect, fungus, and virus pests for all adjacent agricultural lands.

Sodium arsenite, once the standard soil sterilant, currently is used less frequently because of the tremendous hazards involved in its use. It is extremely toxic and is attractive to livestock, hence doubly dangerous where animals have access to the treated areas.

In California, dry white arsenic is being tested as a soil sterilant. Apparently it is not attractive to livestock; it can be handled with relative safety by men equipped with proper clothing and dust masks; it is easy to apply; and, it is very persistent in the soil. Much of the difficulty inherent in applying the dust is eliminated by mixing the material with a small amount of a liquid wetting agent. This reduces dustiness, and hazards to the operator and to adjacent land from blowing of the dust are largely eliminated.

In using organic materials for soil sterilization, breakdown in the soil may largely determine the persistence of a given treatment. Dinitro compounds and 2,4-D breakdown rapidly; pentachlorophenol is somewhat longer lasting; Chloro IPC is more persistent than plain IPC. Recently CMU was introduced as a soil sterilant and at rates of 20 to 80 pounds per acre is effective against Bermudagrass, quackgrass, Johnsongrass, and bindweed; soil treated with 40 pounds per acre has remained free of vegetation for a year.

One great advantage of the organic chemicals is their high toxicity; carbon disulphide is required at 3,000 pounds per acre to kill bindweed to a depth of six feet; chlorate is commonly applied at 500 to 1,000 pounds per acre, borax at 1,000 to 2,000 pounds, and arsenic at 500 to 1,500 pounds. Use of 2,4-D, IPC, PCP, and CMU at from 10 to 50 or even 100 pounds per acre represents a tremendous saving in hauling and cost of application.

Translocated Herbicides

The practical problem in the use of translocated herbicides is that of providing the chemical in a form which will penetrate and translocate. The chemical and the spray formulations are important with respect to these two processes.

Carbo-wax formulations of 2,4-D are more effective than the salts against perennials; the ammonium and amine salts are more effective than the sodium salts; the alkyl esters—in spite of their high contact toxicity—failed to translocate.

Probably the 2,4-D acid molecule most nearly meets the requirements for translocation. Its greatest drawback is its low solubility in water and oil. This can be overcome by using a finely suspended product in oil or oil emulsion, or by using an emulsifiable form of the acid.

The low solubility may be of advantage as it regulates the entry of the chemical to such a rate that injury to the treated leaf is negligible or developes only slowly, allowing time for much translocation and accumulation in the plant.

Another possibility is the use of a co-solvent to make a usable spray solution or emulsion of the acid. Carbo-wax tends to thicken and can not be handled through spray equipment. Butyl cellosolve is less objectionable from this standpoint.

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STRAWBERRY

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ticillium wilt. This holds true in most strawberry areas in California, but not in all because of strain variations in the fungus.

Infected tomato, potato, cotton and nightshade weed—*Solanum sarachoides*—are most commonly responsible for soil contamination with Verticillium. Land once infested with this fungus remains so for long periods of time, and rotations with other crops have not in general reduced the infestation significantly.

Black Root Rot

Black root rot is caused—at least in part—by a complex of soil organisms. Several different fungi, the root lesion nematode and possibly bacteria, in combination, appear to cause the roots to die.

Usually plants affected by black root rot decline sharply in their second fruiting year, rarely producing a satisfactory second year crop and almost never a third. In certain instances the plants decline rapidly during the first growing year, particularly if strawberries were grown previously on the land.

Isolations from black root rot plants have yielded many fungi. Probably significant are *Pyrenochaeta* (*Phoma*) *terrestris*—not reported previously from strawberry and known to produce a root rot of onion—*Phoma* sp. (possibly *P. radicis*) *Rhizoctonia solani*, *Pythium ultimum Stemphylium* sp. probably *S. radicinum*, *Fusarium oxysporum F. solani*, *Cylindrocarpon* spp. and several others, some of which are believed to be new to science.

In addition to the above fungi which grow readily in culture, microscopic examination of cleared sectioned roots revealed a great abundance of the endophytic fungus, *Rhizophogus*. Its presumed beneficial role in the nutrition of strawberry is strongly questioned.

Anatomical studies have yielded valuable information on the structure and potential longevity of the strawberry root system. The large, fleshy roots which arise from the crown are perennial in nature. In their first year they should be white until they develop vascular and cork cambiums. Healthy roots late in the first year and thereafter, add wood to the central xylem cylinder and cork to the outer bark tissues. Three layers should be distinctly visible in two years and older healthy strawberry roots, cut in cross section: *1*, the central cylinder of wood which is white; *2*, the inner bark which surrounds the wood and has the appearance of mother-of-pearl; and, *3*, the outer bark which is light to dark brown in color. If the central cylinder of wood is surrounded only by a loose punky dead bark, the root is diseased—black root rot—and the plant is on the decline. Specific information as to the natural longevity of the small lateral roots is not yet available.

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The above progress report is based on Research Project No. 981.

MICROELEMENTS

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mature leaves, stem bark, stem wood, root bark, root wood, and fine roots. All parts were thoroughly cleaned, dried, and the separate portions of each plant were weighed. Similar parts of the nine plants from each treatment were combined for analysis, making seven samples to be analyzed for each of the five treatments.

The seedlings in the soil containing 300 ppm of added nickel died immediately after planting. Those planted in the soil having 150 ppm of added nickel made no new growth and died soon after planting. Plants in the soil to which 75 ppm of nickel had been added, made some growth but after 11 months their total dry weight was only approximately one tenth that of the control plants. The leaves on these plants showed some mottling which resembled that caused by a zinc deficiency. They had a lower top to root weight ratio than the controls. No root injuries were apparent. The plants grown in the soil containing 25 ppm of nickel were normal in appearance but of somewhat reduced size compared to the controls.

Similar experiments with copper additions to the soil indicate that nickel is considerably more toxic to sweet orange seedlings than copper.

The leaf samples were analyzed spectrographically. The results showed that the available nickel in the soil is readily taken up by the plants and can be detected easily in the leaves.

The presence of toxic amounts of nickel appears to lower the uptake of copper by the plant but not to the extent of producing a deficiency. The amounts of chromium found in the leaves are somewhat but not significantly increased. The amount of manganese in the leaves is not altered except when large amounts of nickel are present.

Only about 30% depression in growth was caused by the 25 ppm of nickel in the soil during this first year of growth. The ultimate effect on the mature tree is not yet known.

In only a few samples of leaves from citrus orchards has nickel been found in amounts that might be regarded with suspicion. One of these trees—containing 8 ppm of nickel—came from some trees which had received an extremely large application of sulfur to the soil. In this case the pH of the top foot of soil had been lowered to 3.3. These leaves also contained an excessive amount of manganese but it is difficult to say whether the manganese was dangerously high.

The southern California soils that have been analyzed for minor components have a nickel content of from 15 to 30 ppm. Two soils fall outside this range: the soil from the Citrus Experiment Station contains only 8 ppm, and a soil from Tulare County exceeds 100 ppm of nickel. The nickel present in the average soil will normally be in the form of very insoluble compounds, but if the soil is acidified to too high a degree the nickel will be made soluble and available to the plant. Besides nickel, other elements such as copper, manganese, and zinc may be rendered soluble in toxic concentrations by excessive soil acidification.

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The above progress report is based on Research Project No. 1025.

WEED

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The alkyl 2,4-D esters of the lower alcohols are volatile and hazardous to sensitive crops. In their place a number of low volatile esters are on the market. Two of these are the butyoxyethanol ester and the propylene glycol butyl ether ester. These esters are superior to the salts and to the lower alkyl esters in controlling perennials. They approach the acid in this property.

Trials have proved repeatedly that the low volatile esters are effective wherever used on perennials.

Successful use of soil sterilants and translocated herbicides involves complex processes and requires detailed knowledge of the systems that function. Whereas contact spraying of annuals is relatively simple, use of these more involved methods requires understanding of soil-water relations, soil-plant interrelations, plant physiology and plant biochemistry.

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The above progress report, based on Research Project No. 883, is a condensation of a paper read before the session on Herbicides of the 12th International Congress of Pure and Applied Chemistry in New York.