ceptable with dichlobenil, noticeable leaf burn was observed nine months after the second consecutive yearly application (table 4). Since all plots were left untreated during the second season, it is not known whether a single application would be adequately safe.

Twenty and 34 months after application (second season, following second application) typical chlorosis and leaf burn was very evident in these treatments. Incorporating dichlobenil at 6 and 12 lbs per acre increased foliage damage (table 5).

In another test, dichlobenil 50 WP was applied as a spray 3 to 4 inches under the soil surface from the trailing edge of a weed knife in April 1969. Rates were 0,3,8,13, and 18 lbs per acre. Commercial season-long control was attained at all but the 0- and 3-lb rates seventeen months after one treatment. However, foliar symptoms on the vines were apparent at rates higher than 3 lbs per acre.

A second trial was made using this spray blade at a low rate of dichlobenil 50 WP (March 1970). MCPA and 2,4-D.O.S. amine treatments were also included (table 6).

In this trial 1.5 and 3.0 lb per acre rates of dichlobenil alone, applied with a spray blade, did not give commercial bindweed control. When used in conjunction with MCPA or 2,4-D, commercial control was achieved without vine toxicity.

In these tests, the oil-soluble or water-soluble amine formulations of 2,4-D and a formulation of MSMA which included a surfactant as a single treatment or a repeated application failed to safely control field bindweed for the growing season. One mid-season spray containing either of these materials after an application of dichlobenil of at least 3 lbs per acre gave commercial season-long control of bindweed.

Dichlobenil is a volatile herbicide requiring incorporation for maximum results, particulary when using the 50% wettable-powder formulation. Phytotoxicity from dichlobenil above a 3-lb per-acre rate was apparent, and was enhanced when the herbicide was incorporated with a spray blade or rotovator. Dichlobenil is long lasting in the soil when incorporated. Other studies have shown that few, if any, crops are resistant to dichlobenil when grown on sandy soils that are low in organic matter.

The application method of spraying a herbicide barrier under the ground to prevent weed growth is new and shows some promise for bindweed control. Treatments of 2,4-D did not produce residual 2,4-D activity in the soil or long-term effects in grape vines.

Needs for bindweed control have been redefined. Bindweed control is necessary in the vine row in new plantings for the first three years, or until vine growth shades it out. Eradication of bindweed from the total vineyard area is considered to be too costly in most areas as well as unsafe, and impractical at this time.

New work in bindweed control is being directed to layering a chemical barrier in the vine row, 3 to 4 inches under the soil surface, to prevent bindweed shoot emergence. The search is still continuing for a safe surface-applied herbicide. Also, expansion of the program for insect predators of bindweed is planned by University of California researchers in biological control to help reduce this weed pest.

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Wente Vineyards, Livermore, cooperated.

What happens to soil fumigants after nematode control?

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The results of research on nematicides, in addition to demonstrating remarkable yield increases of agricultural crops brought about by nematode control, have also shown that EDB, DBCP and 1,3-D have no significant persistent adverse effects on the physical and biological composition of soil, or on the nutritional value of crops grown on treated soil. These successful nematicides are physically and/or biologically degradable.

THREE SOIL FUMIGANTS, 1,2 dibromoethane (EDB), 1,3 dichloropropane (1,3-D), and 1,2 dibromo-3-chloropropane (DBCP) have been used extensively for nematode control in California soils for 15 to 25 years. These nematicides have been used at dosages ranging from 8.6 lbs per acre (0.5 gal per acre of DBCP) to 2000 lbs per acre (200 gal per acre of D-D). The chemicals are injected in well tilled, moist soils to depths of 8 to 20 inches and normally persist in the soil at nematicidal dosages for several days or weeks without need for special covers on the soil surface. (1,3 dichloropropene (1,3-D) is sold under the trade name Telone, and a 1,2 dichloropropane mixture is sold under the trade names D-D and Vidden D).

EDB and 1,3-D are used only for preplant treatments and are applied 14 days to three months prior to treatment, depending on the dosage, soil texture, and temperature. DBCP can be used as a preplant nematicide or can be applied to tolerant living plants for the control of established nematode populations.

The recommendations for the use of these three nematicides are based on performance and residue data developed by scientists in the pesticide industry, the USDA, and state agriculture experiment stations, including the University of California Agricultural Experiment Station.

Regulation

In 1959, the Federal Insecticide, Fungicide, and Rodenticide Act was amended to include *nematicides,* plant growth regulators, desiccants, and defoliants. The combination of all Federal laws regarding food purity, agricultural chemical safety, and residue tolerances made it necessary for the manufacturers of nematicides not only to demonstrate their usefulness but to prove that no toxic residues persisted in food for humans and feeds consumed by livestock and poultry. Within the University of California Agricultural Experiment Station, Communication 18 charges staff members making recommendations for the use of pesticides on California crops to develop their own performance and residue data.

To meet the requirements of Federal laws and regulations and University policy, and to ascertain the potential for environmental pollution, an integrated program on nematicides has been carried on in the Department of Nematology, University of California, Riverside since 1960. This program focuses on obtaining performance and residue data, on the physical and biological degradation of nematicides in soil, on the influence of nematicides on beneficial organisms in soils, and on the influence of soil fumigants on the nutritional value of crop plants. Some highlights of these research efforts are reviewed.

The search for residues

As indicated previously, nematicides are generally injected into soil prior to planting. Being volatile chemicals they diffuse through the soil mass, and are present at planting time in relatively low concentration. Concentrations are reduced through (1) loss by diffusion at the soil surface, (2) adsorption by organic matter, and (3) degradation.

Efforts to find the parent molecule (EDB, 1,3-D or DBCP) in the edible portions of crop plants grown on treated soil have not been successful. Further research indicated the absence of any bromine- or chlorine-containing organic molecule. Increased amounts of the bromide and chloride ion were found in plants. Bromide is considered to have some physiological effect in humans if consumed in massive amounts. The FDA therefore ruled that bromide residue levels found in food crops grown on EDB and DBCP treated soils would have to be determined and tolerances established before EDB and DBCP could continue to be used.

To facilitate these efforts, researchers adapted direct elemental analysis of plant parts for total bromide by instrumental neutron activation. As an example, raw carrots are washed, ground, and a sample weighed into plastic vials. The sample is then exposed to a high uniform neutron flux in a reactor such as the General Atomic TRIGA reactor. The bromine is converted to a radioactive form (Br^{82}). Highly energetic gamma rays are emitted by the neutron-induced radioactive bromine in the sample. The radioactivity is measured by a gamma ray spectrometer and the data converted to concentration of bromide ion in ppm (parts per million) of the plant part. Large numbers of samples can be done quickly, accurately and relatively inexpensively by this means. Data on bromine and chlorine residues from numerous crops, including citrus, beans, carrots, melons, potatoes and tomatoes, grown on EDB, DBCP and 1,3-D treated soil, have been developed in this research utilizing neutron activation analysis. No organic halide has been detected. Safe bromide residue levels have been set based upon these studies. Organophosphate and carbamate nematicides have not been recommended for use in California to date, but if and when they are. data on residues in crops will be developed.

Degradation in soil

If EDB, BDCP and 1,3-D or organic molecules containing bromide or chloride ions do not occur in plants grown on treated soil, what has happened to the nematicides? The total bromine content does increase in some plants grown on DBCP and EDB treated soil. This suggests that chemicals of this kind might break down in soil to simple molecules and/or ions.

It has been demonstrated that cis- and trans-1,3-dichloropropene (i.e., Telone or D-D) chemically hydrolyze in moist soil to the corresponding 3-chloroallyl alcohols which are biocidal. In addition, it has been shown that 3-chloroallyl alcohol is capable of metabolism to carbon dioxide and water by a bacterium (*Pseudomonas* sp.) isolated from soil. The 3-chloroallyl alcohol is first converted to 3-chloroacrylic acid, the chlorine is then removed and the intermediate products are converted to carbon dioxide and water. If this is what occurs under field conditions (and this is now being studied), then the residues remaining are CO_2, chloride ion and water—none of which pose a pollution problem.

Contrast

In contrast to the 1,3-dichloropropenes, ethylene dibromide (EDB) and 1,2 dibromo-3-chloropropane (DBCP) do not readily decompose chemically (hydrolyze) in soil. A significant biological dehalogenation of EDB and DBCP does occur in soil. Under laboratory conditions DBCP is converted to n-propanol, chloride and bromide. EDB is converted to ethylene and bromide. These results are consistent with a variety of biodehalogenations studied here that are affected by soil organisms and enzymes isolated from them.

Under field conditions a number of factors combine to reduce EDB, DBCP and 1,3-D concentrations to below detectable levels. These factors include diffusion, adsorption and physical and/or biological degradation. Research is presently being conducted to determine whether physical and biological degradation play a significant role in the loss of 1,3-D, EDB and DBCP from soils under field conditions, and how long these nematicides persist in significant quantities. Results to date confirm earlier work which indicated that they were not persistent pesticides.

Effect on natural enemies

EDB, DBCP and 1,3-D are not highly selective pesticides. Depending on dosages used, they are known to be bactericidal, fungicidal and insecticidal as well as nematicidal. Questions could well be asked then about what effect they have on nematode trapping fungi and other biological control agents of nematodes that occur in soil. Investigations of the effect of 1,3-D, EDB and DBCP on nematode-trapping fungi in citrus soil, have shown DBCP was not fungitoxic under field conditions, and only temporarily inhibit growth of these beneficial fungi under laboratory conditions. Thus the use of DBCP as a treatment for the control of citrus nematodes on living trees has only a transient adverse effect on some biocontrol agents in the root zone. EDB is fungistatic but not lethal. Laboratory studies indicate that EDB used at nematicidal dosage rates is actually taken up and degraded by nematode-trapping fungi and may even be utilized as a temporary carbon source. 1,3-D on the other hand is toxic to many of the nematode trapping fungi and could have an adverse effect on biocontrol agents in soil. Predacious nematodes succumb to all nematicides, but most species are not abundant in agricultural soils and probably have a very minor influence on plant-parasitic populations.

Recently a sporozoan parasite of root-knot and other nematodes has been shown to be tolerant of a number of nematicidal chemicals. Thus, an awareness of the biocontrol agents present, and their tolerance to various nematicides, could lead to an integration of control practices for maximum effectiveness.

Effect on nutrition

Nematicides do influence the physical and biological composition of treated soil. Research had shown that neither residues of the parent compound, nor other halide containing organic compounds, were present in crops grown on treated soil. It was also of interest, however, to know whether the nutritional value of crops was affected. With the support of USDA and the cooperation of Dr. Gladys Emerson of the Human Nutrition Section, School of Public Health, University of California, Los Angeles, the nutritional components of carrots, citrus and lima beans grown on EDB, DBCP and/or 1,3-D treated soil were studied. No adverse effects on any nutritional components were noted. The only significant change that occurred was an increase in Beta carotene content. Beta carotene is a precursor of Vitamin A. Analysis of beans and citrus, showed no adverse effects of soil treatment with DBCP, EDB and/or 1,3-D.

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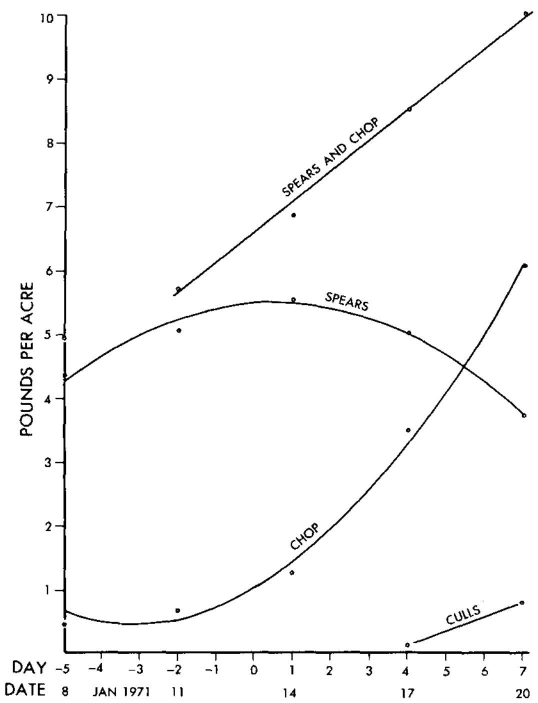
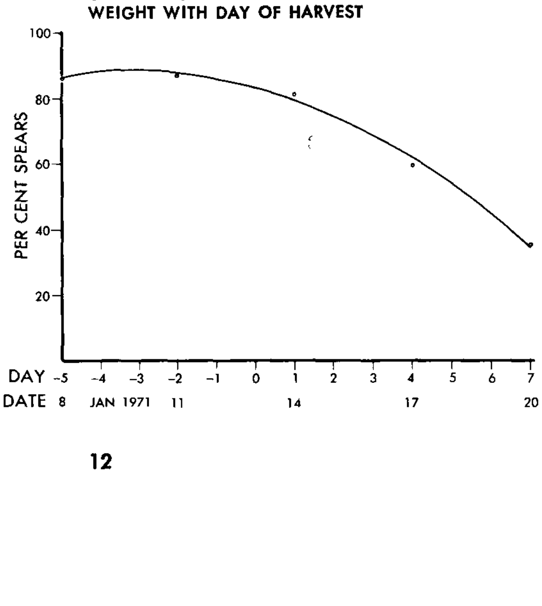
Once-over harvesting of BROCCOLI FOR FREEZING

GRAPH 1. YIELD TRENDS, GREEN DUKE BROCCOLI (5-INCH CUT)



GRAPH 2. CORRELATION OF SPEAR PERCENTAGE BY WEIGHT WITH DAY OF HARVEST



R. A. BRENDLER

With both yield and quality changes occurring rapidly from day to day, a simple objective method of field sampling broccoli is highly desirable for a once-over harvest operation by hand and is essential for machine harvesting. Studies reported here indicate the difficulty in devising such a sampling method and point out the need for good judgment by farmers and field men until a good method is developed.

BROCCOLI VARIETIES now being used in California for freezing are usually harvested two or three times because the earliest heads in the field are ready to harvest two weeks or more ahead of the latest heads. Uniformity of maturity that would allow once-over harvest would reduce the cost of hand harvesting and is essential for mechanical harvesting.

To find out what happens from day to day in a broccoli field, five small-scale single harvests were made in an eight-bed trial of Green Duke broccoli grown by Ray Swift and Louis Brucker on the Oxnard Plain. Green Duke is one of several new varieties with relatively uniform maturity.

First harvest

The first harvest was on January 8, and subsequent harvests were three days apart. Plots to be harvested were arranged in a randomized complete block design. Each block was 20 feet of a two-row bed (40-inch centers). There were five replications.

At each harvest all heads of ¾-inch or more in diameter were harvested. Quality control personnel of the Oxnard Frozen Foods Cooperative graded the broccoli from each plot into spears, chop, and culls. Before grading, all heads were cut to 5 inches in length. To be graded "spear" quality, a head of broccoli must have a minimum stem diameter at the 5-inch cut of approximately ⅝ inch and the beads must be of good quality and not overmature. "Chop" grade broccoli either