SOME CHEMICAL, CULTURAL, AND BIOLOGICAL ALTERNATIVES TO METHYL BROMIDE FUMIGATION OF SOIL FOR STRAWBERRY

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Chemical alternatives to methyl bromide are being tested in replicated field experiments at a coastal site near Watsonville, CA. Strawberry was grown each year, *Verticillium dahliae* and *Phytophthora* spp. were present in the soil, and bed fumigation treatments were applied to the same ground in early October of each of the last 2 years. Two-row beds were shaped, drip lines installed, and small cloth pouches containing soil with known populations of *V. dahliae* or vermiculite pieces of cultured *Phytophthora cactorum* were buried under plant row locations at depths of 15 and 50 cm. Beds were subsequently fumigated and covered with standard black polyethylene mulch or black virtually impermeable plastic film (VIF) (Hytibar, Klerk=s Plastics). Shank-applied treatments (three shanks/bed, 15-20 cm deep, rates given per unit of treated bed area which was 58% of the total area) included methyl bromide/chloropicrin (MBC) 67/33 at 325 lb/a, chloropicrin at 200 and 300 lb/a, and Telone C-35 at 283 and 425 lb/a. Treatments applied to beds under plastic in water emulsions through drip lines were chloropicrin at 200 lb/a and Telone C-35 at 283 and 425 lb/a. Inoculum pouches were recovered and Selva was transplanted through the plastic mulch one month after fumigation. Conventional practices for annual strawberry production and pest management for the area were followed, including sprinkler irrigation initially and drip irrigation in the production season. Berries were picked for fresh market at least weekly for several months by normal grower practice.

MBC killed all inoculum buried at 15 and 50 cm. With the exception of Telone C-35 at the lower rate, other shank-applied treatments reduced buried *V. dahliae* inoculum to very low or undetectable levels. The same treatments killed most of the *P. cactorum* buried at 15 cm but were only effective in doing so at the 50 cm depth where VIF plastic was used. With the exception of chloropicrin at 200 lb/a, all drip-applied treatments killed both fungi at a depth of 15 cm but not at 50 cm. This survival probably occurred because the volume of water used to deliver fumigants was insufficient for movement to the 50 cm depth. Disease incidence in the growing crop was variable, but both Verticillium wilt and Phytophthora root rot were controlled adequately in most fumigation treatments. All fumigation treatments effectively controlled weed growth through plant holes in the plastic mulch.

Shank fumigation of beds with MBC and VIF mulch more than doubled berry yields relative to nontreated soil, and MBC with standard mulch was only slightly less effective. With standard plastic mulch, chloropicrin at 200 lb/a and Telone C-35 at 283 and 425 lb/a, when shank- or drip-applied, gave yields as high as or higher than those obtained with MBC. Use of VIF plastic mulch, however, increased yields significantly in all chloropicrin treatments and in some Telone C-35 treatments. These results are similar to those obtained in 1997-98 when VIF mulch improved yields significantly in a variety of shank-applied bed fumigation

treatments, but differ from those obtained in 1998-99 when VIF effects were small. The results show that bed fumigations with the materials and methods used can be effective in the presence of significant disease pressures from soilborne pathogens, but the specific methods and rates of application need further research to be optimized.

We are continuing to research microbiological differences associated with the enhanced growth and productivity of strawberries in fumigated soils where the response is not due to control of known, major pathogens. Populations of fluorescent Pseudomonads in soil increased quickly following fumigation and several isolates of *Pseudomonas fluorescens*, *P. putida* and *P. chlororaphis* from strawberry rhizospheres in fumigated soils were beneficial when inoculated to strawberry transplanted into natural soils in the greenhouse (1). Bare-root runner plants (Selva) were inoculated with some of these bacteria in the fall of 1999 and transplanted into field plots treated with MBC, chloropicrin (200 lb/a), or not treated. None of the inoculations increased strawberry yields in MBC-treated soil, and some actually decreased yield significantly. While only one isolate increased yield in nontreated soil, three isolates increased yields significantly in chloropicrin treated soil. Periodic reinoculations during crop growth did not increase growth or yields over those obtained following one inoculation at transplanting.

Cultural methods for the management of Verticillium wilt are also under investigation. Five experiments on strawberry rotations with broccoli, Brussels sprouts, and/or rye have been completed on nonfumigated soils. At the Watsonville site with high populations of *V. dahliae* present, none of the rotations reduced the incidence of Verticillium wilt in the subsequent strawberry crop significantly, but physical removal of residues from the preceding strawberry crop did reduce disease. One-year rotations out of strawberry, however, increased subsequent strawberry yields by 18-44% relative to continuous strawberry. High-nitrogen organic amendments were incorporated into nonfumigated soil several weeks before planting to test their effects on Verticillium wilt. Feather meal applied to beds (4 tons/a of treated area) reduced disease incidence in Camarosa during both 1999 and 2000, while blood meal (4 and 8 tons/a), fish meal (8 tons/a), and compost (8-12 tons/a) reduced disease in only one of the two years. Amendments applied to beds, however, also caused phytotoxicity and, therefore, did not give increases in yield proportional to levels of disease reduction. Broadcast applications of blood or fish meal at 4 tons/a or feather meal at 2 tons/a before bed shaping reduced Verticillium wilt development during 2000 without causing phytotoxicity in the variety Aromas. Although current California strawberry varieties are all susceptible to Verticillium wilt, some (e.g. Camarosa) were significantly more susceptible than others (e.g. Selva, Chandler) when compared over several years in naturally infested soil.

Reference Cited: 1. Xiao, C. L., and Duniway, J. M. 1998. Bacterial population responses to soil fumigation and their effects on strawberry growth. Phytopathology 88:S100 (Abstract).
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