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

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The experiments reported here are part of a project supported largely by the California Strawberry Commission and University of California Statewide IPM Project to research chemical and nonchemical alternatives to methyl bromide for preplant fumigation of soil in strawberry production. Chemical alternatives to methyl bromide have been tested in replicated field experiments at a coastal site near Watsonville, CA. Strawberry was grown every year, *Verticillium dahliae* was present in the soil, and bed fumigation treatments were applied in early October of each year. Unless stated otherwise, two-row beds were shaped, fumigated (three shanks/bed, 15-20 cm deep, rates given per unit of treated bed area which was 58% of the total area), and covered with standard black polyethylene mulch. Selva was transplanted through the plastic mulch one month later. 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.

All of the fumigation treatments used consecutively on the same ground in 5 years of experiments increased yield significantly in comparison to nonfumigated soil. For example, yields in 1998 and 1999, respectively, relative to those obtained following standard bed fumigation with methyl bromide/chloropicrin (MBC, 67/33% @ 325 lb/acre), were 77 and 98% for chloropicrin alone (300 lb/acre), and 45 and 50% for nontreated soil. Broadcast fumigation with MBC (315-330 lb/acre total area) gave relative yields of 93 and 90%. The effects of a virtually impermeable plastic film (VIF) (Bromotec, Lawson Mardon Packaging, U.K.), fumigant applications to beds in water emulsion through drip lines, and lower fumigant rates were tested during 1998-99 in a replicated field experiment on soil containing significant populations of *V. dahliae* and *Phytophthora* spp. Shank fumigation of beds with MBC and VIF mulch increased berry yields 4.5 fold relative to nontreated soil, and MBC with standard mulch was only slightly less effective. Shank applied chloropicrin at 200 and 300 lb/acre gave yields nearly equivalent to those obtained with MBC, but drip-applied chloropicrin at 200 lb/acre was somewhat less effective; VIF mulch did not improve yields in the chloropicrin treatments. Results with Telone/chloropicrin (C35) were more variable, but shank applications to beds at 283 and 425 lb/acre with standard mulch gave yields nearly equivalent to MBC, and there was no benefit of VIF in these treatments. Drip applications of Telone/chloropicrin were slightly less effective, but VIF mulch improved yields with drip-applied Telone/chloropicrin. These results differ somewhat from those obtained in 1997-98 when VIF mulch improved yields significantly in a variety of shank-applied bed fumigation treatments. Disease incidence was variable in this experiment, but both Verticillium wilt and Phytophthora root rot were controlled adequately in most treatments. All fumigation treatments effectively controlled weed growth through plant holes in the plastic mulch. 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 of application need further research to be optimized.

Cultural methods for the management of Verticillium wilt are also under investigation. Four experiments on a broccoli-strawberry rotation on nonfumigated soils have been completed, and a rotation experiment with strawberry, broccoli, Brussels sprouts, and rye is in progress. At the Watsonville site with high populations of *V. dahliae* present, one-year rotations with broccoli increased subsequent strawberry yields by 24-38% and one year of rye increased yield 18-44%, relative to continuous strawberry. None of the rotations reduced the incidence of Verticillium wilt in the subsequent strawberry crop, but physical removal of residues from the preceding strawberry crop did reduce disease incidence in the subsequent strawberry crop significantly. High-nitrogen organic amendments were incorporated into nonfumigated soil 7 weeks before planting to test their effects on Verticillium wilt. Blood, feather, and fish meal (8, 4, and 8 tons/acre, respectively) all reduced the incidence of Verticillium wilt in Camarosa strawberry. However, they also caused phytotoxicity and, therefore, did not give increases in yield proportional to levels of disease reduction. Chicken manure and mature compost (8 and 12 tons/acre, respectively) did not reduce Verticillium wilt significantly. 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. Yield losses due to Verticillium wilt in Camarosa and Selva were measurable before the onset of visible symptoms in 1999.

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 (1, 2). A number of fungi isolated from roots growing in nonfumigated soils were damaging to strawberry in greenhouse tests. These same fungi were isolated less frequently from roots in fumigated soils. 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. The results suggest that reductions in deleterious fungi and increases in beneficial fluorescent Pseudomonads contribute to the enhanced growth response of strawberry to soil fumigation with methyl bromide/chloropicrin.

References Cited

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