RESPONSE OF STRAWBERRY TO SOIL FUMIGATION: MICROBIAL MECHANISMS AND SOME ALTERNATIVES TO METHYL BROMIDE

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The experiments reported here are part of a larger project supported by the California Strawberry Commission and ARS-USDA 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. Two-row beds were shaped, fumigated (two shanks/bed, 15-20 cm deep, rates given per unit of treated bed area which was 58% of the total area), and covered with black plastic 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 bed fumigation treatments used in 4 years of experiments increased yield significantly in comparison to nonfumigated soil. For example, yields in 1997 and 1998, respectively, relative to those obtained following standard bed fumigation with methyl bromide/chloropicrin (67/33% @ 325 lb/acre), were 117 and 76% for chloropicrin alone (300 lb/acre), 105 and 87% for Telone/chloropicrin (65/35% @ 425 lb/acre), or 66 and 45% for nontreated soil. Application of the Telone/chloropicrin mixture to beds at the same rate in a water emulsion through drip lines gave yields of 102 and 104% relative to those obtained on beds fumigated with methyl bromide/chloropicrin, while broadcast fumigation with methyl bromide/chloropicrin (67/33%, 315-330 lb/acre total area) gave relative yields of 112 and 96%. All fumigation treatments reduced *V. dahliae* populations in soil and effectively controlled weed growth through plant holes in the plastic mulch. The results show that bed fumigations with the materials used can be effective and that drip application of emulsified Telone/chloropicrin shows promise, but the specific methods of application need further research. The use of a virtually impermeable plastic mulch (Bromotec Y681B, Lawson Mardon Packaging, U.K.) in 1998 improved yields on average by 16% over those obtained with a standard black polyethylene mulch in the bed fumigation treatments above, and with chloropicrin or Telone/chloropicrin applied at rates reduced by one third.

Four experiments on a broccoli-strawberry rotation on nonfumigated soils have been completed. At Davis, CA, where *V. dahliae* is absent, one year of fallow or one year of broccoli production did not increase subsequent strawberry yields over those obtained with continuous production strawberry. Fumigation with methyl bromide/chloropicrin in the same experiment increased strawberry yields 54-69%. At the Watsonville site with high

populations of *V. dahliae* present, a one-year rotation with broccoli increased subsequent strawberry yields by 24-38% and one year of rye increased yield 18-44%, relative to continuous strawberry, all on nonfumigated soil. Yield increases following one-year rotations out of strawberry, however, were approximately half as large as those obtained by soil fumigation in the same site and years. Although current California strawberry varieties are all susceptible to Verticillium wilt, the relationship of disease incidence to initial populations of *V. dahliae* in soil differed significantly between the varieties Selva and Camarosa.

We are researching microbiological differences associated with the enhanced growth and productivity of strawberries in soils fumigated with methyl bromide/chloropicrin where the response is not due to control of known, major pathogens (1, 2). Plants in fumigated soils consistently had higher root length densities and fewer dark roots than plants in nonfumigated soils. Relative to nonfumigated soils, total numbers of fungi are usually low for several months following fumigation. *Cylindrocarpon* spp. were isolated from 0.5-cm segments of strawberry roots grown in nonfumigated soils (mean frequency 14%) but not from roots grown in fumigated soils. *Pythium* spp. were more commonly isolated from roots in nonfumigated soils, with mean isolation frequencies of 3 and 11% for fumigated and nonfumigated soils, respectively. *Rhizoctonia* spp. were frequently isolated from roots in both fumigated and nonfumigated soils. Pathogenicity of the predominant isolates of these fungi was tested on strawberry in the greenhouse. *Cylindrocarpon* spp. did not cause significant root rot, but some isolates caused significant reductions in shoot and root growth. *P. ultimum* caused root rot and growth reductions. Of the 14 binucleate isolates of *Rhizoctonia* spp. tested, four caused significant root rot and growth reductions, while three others caused only growth reductions. Total populations of bacteria in soil were not affected by fumigation, but fluorescent Pseudomonads were significantly less 5 days after fumigation. Populations of fluorescent Pseudomonads in soil, however, increased quickly following fumigation and were 10-1000 fold higher than in nonfumigated soils 10 days to 9 months after fumigation. Predominant isolates of fluorescent Pseudomonads from the rhizosphere were tested for effects on strawberry growth in natural field soil in the greenhouse. The effects of individual isolates ranged from beneficial (increased shoot and root dry weights up to 72% and 162%, respectively) to deleterious (about 20% shoot or root reduction). *Pseudomonas fluorescens*, *P. putida* and *P. chlororaphis* were among the most predominant and beneficial rhizobacteria tested. 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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