RESPONSE OF STRAWBERRY TO SOME CHEMICAL AND CULTURAL ALTERNATIVES TO METHYL BROMIDE FUMIGATION OF SOIL UNDER CALIFORNIA PRODUCTION CONDITIONS

J. M. Duniway*, W. D. Gubler, and C.-L. Mao
Department of Plant Pathology, University of California, Davis CA 95616

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 for 4 years in replicated field experiments just inland from Watsonville, CA. Both fields used had been fumigated previously with methyl bromide/chloropicrin in a strawberry-vegetable rotation. Fumigants were injected at 20 cm depth (broadcast treatment) and the soil immediately covered with polyethylene which was removed after 5 days. Beds were raised, and the strawberry cultivar Selva transplanted (two rows/bed) in November. 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 twice weekly for several months by normal grower practice. In the initial experiments, total yields (1994 and 1995, respectively), relative to those (100%) obtained following standard fumigation with methyl bromide/chloropicrin (67/33% @ 325 lb/acre), were 94 and 96% with chloropicrin alone (300 lb/acre), 98 and 108% with Telone II (1,3-dichloropropene) /chloropicrin (70/30% @ 454-461 lb/acre), and 57 and 70% on nontreated soil.

To measure longer-term performance and residual effects of the fumigants used, half of each experimental unit treated in the initial experiments was retreated or left untreated in a continuing, 2-year, strawberry-vegetable rotation. On ground receiving the same repeat treatments, berry yields (1996 and 1997, respectively), relative to those (100%) following consecutive fumigation with methyl bromide/chloropicrin, were 107 and 104% with chloropicrin alone, and 119 and 106% with Telone/chloropicrin (70/30 or 65/35%). Sequential use of Telone/chloropicrin in a ratio of 30/70% (409 lb/acre) followed by 40/60% (430 lb/acre) gave relative yields of 109 and 93% in 1995 and 1997, respectively. Methyl bromide/chloropicrin fumigation for the second cycle of strawberries gave slightly higher yields (relative yields of 113 and 104% in 1996 and 1997, respectively) where the soil was not fumigated for the previous strawberry crop. Berry yields on soil not fumigated for the second cycle of strawberries varied somewhat with prior treatment history and ranged from 62 to 76% in 1996 and 73 to .83% in 1997 relative to yields obtained when methyl bromide/chloropicrin was used for both years of strawberry production. The results suggest that the residual or carryover effects of the fumigants used were small in the second cycle of strawberry production in a 2-year, strawberry-vegetable rotation. The incidence of plants with recognizable diseases (e.g., Phytophthora root and crown rots, Verticillium wilt, or collapse of unknown etiology) was low in all treatments and yield differences in each year were due largely to overall differences in plant growth and vigor. It is important to note that this lack of long-term benefits from earlier soil fumigations was observed in the absence of significant pressure from known soilborne pathogens. Furthermore, the results should be interpreted with caution because the total yields and yield responses to fumigation in these experiments were less than is typical for strawberry production in the Watsonville area.

In experiments at a coastal field site near Watsonville, CA, where strawberry was grown every year and *Verticillium dahliae* populations are high, bed fumigation treatments were applied in early October. Two-row beds were shaped, fumigated (two shanks/bed, 15-20 cm deep, rates given per unit of treated bed area), and covered with tarpaulin. Selva was transplanted through the plastic tarpaulin one month later. All of the bed fumigation treatments used in 3 years of experiments increased yield significantly relative to that on

nonfumigated soil. For example, the increases in yield for 1997 were 51% for methyl bromide/chloropicrin (67/33% @ 325 Ib/acre), 76% for chloropicrin alone (300 lb/acre), and 59% for Telone/chloropicrin (65/35% @ 425 lb/acre). Application of the Telone/chloropicrin mixture to beds at the same rate in a water emulsion through drip lines increased yield 54% relative to that obtained on nontreated soil, while the standard method of broadcast fumigation with methyl bromide/chloropicrin (67/33%, 315 lb/acre total area) increased yield 70%. 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.

Three 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 that 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% and one year of rye increased yield 18%, relative to continuous strawberry, all on nonfumigated soil. A comparison of four California strawberry varieties on nonfumigated soil containing high populations of V. *dahliae* showed that there is little resistance to Verticillium wilt in the varieties Seascape, Selva, or Laguna, and that the variety Camarosa is highly susceptible.

We are researching 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. Relative to nonfumigated soils, total numbers of fungi are low for several months following fumigation,' with the exception of one site where *Trichoderma* populations were high. Total numbers of bacteria in soil remain high after fumigation with a heavy representation of *Pseudomonas* species. These differences in soil populations also occur, with some modifications, in the rhizosphere of growing strawberries. We are currently testing the effects of rhizosphere and root-associated microbes from fumigated and nonfumigated soils on the growth and root health of strawberries.