EVALUATION OF SOME CHEMICAL AND CULTURAL ALTERNATIVES TO METHYL BROMIDE FUMIGATION OF SOIL IN A CALIFORNIA STRAWBERRY PRODUCTION SYSTEM

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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 were tested in two large field experiments near Watsonville, CA, during 1993-94 and 1994-95. Both fields had been fumigated previously prior to planting strawberries in a strawberry-vegetable rotation. Fumigants were injected at 20 cm depth (broadcast treatment) and the soil immediately covered with polyethylene tarpaulin. Tarpaulin was removed after 5 days, beds were raised, and the strawberry cultivar Selva transplanted (2 rows/bed) in November. Conventional practices for strawberry production and pest management were followed, including sprinkler irrigation initially and drip irrigation at bed centers in the production season. Berries were picked for fresh market at least twice weekly by normal grower practice starting in April and continuing into November. Relative to yields (100%) obtained following standard fumigation with Methyl Bromide/Chloropicrin (67/33% @ 325 lb/acre), total yields (1994 and 1995, respectively) 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), 109% with Telone II/Chloropicrin (30/70% @ 410 lb/acre, 1995 only), and 57 and 70% on nontreated soil. The incidence of plants with recognizable diseases (e.g., Phytophthora root and crown rots, Verticillium wilt, or collapse of unknown etiology) in all treatments was low and average growth and yield differences were due largely to overall differences in plant growth and vigor.

To measure longer-term performance and residual effects of the fumigants used, parts of the field treated in 1993 were retreated with the same chemicals or left untreated in October, 1995. On ground receiving the same repeat treatments in 1993 and 1995, berry yields to date in the 1995-96 season, relative to that on nontreated soil, are increased approximately 28% by Methyl Bromide/Chloropicrin, 40% by Chloropicrin alone, and 64% by Telone /Chloropicrin (70/30). On ground that was not treated in 1993, treatment with Methyl Bromide/Chloropicrin in 1995 increased current yield nearly 40%. On ground treated in 1993 but not retreated in 1995, all of the chemical fumigants used in 1993 decreased current yield relative to that obtained on soil not treated in both 1993 and 1995, suggesting that the residual or carryover effects of the fumigants used in 1993 are negative in the 1995-96 growing season. It is important to note that these results are being obtained in the absence of significant pressure from known soilborne pathogens.

In experiments at a separate field site near Watsonville, CA, where *Verticillium* populations are high, bed fumigation treatments were applied in early October. Two row beds were shaped, fumigated (2 shanks/bed, 15-20 cm deep), and covered with tarpaulin. Transplants

were planted through the plastic tarpaulin one month later. While none of the bed fumigation treatments gave the level of disease control or yield expected following broadcast fumigation with Methyl Bromide/Chloropicrin, all increased yield significantly relative to that in nonfumigated soil. The increases in yield for 1996 were 46% for Methyl Bromide/Chloropicrin (67/33% @ 325 lb/acre), 39% for Methyl Iodide (400 lb/acre), 32% for Telone II/Chloropicrin (70/30% @ 425 lb/acre) and Chloropicrin alone (300 lb/acre). Basamid (Dazomet, 400 lb/acre) increased yield 28% in 1995 but only 8% in 1996 because of phytotoxicity early after transplanting for the 1995-96 season. Yield results for the other treatments were similar in 1995 and 1996. All bed fumigation treatments reduced *Verticillium* populations in soil and effectively controlled weed growth through plant holes in the plastic mulch.

One full cycle of a rotation experiment has been completed on nonfumigated soil at the Watsonville site with high populations of *Verticillium* present. Strawberries were grown uniformly in 1993-94. Two crops of broccoli, a cover crop of rye, or one crop of strawberries were grown in 1994-95, all followed by strawberry in 1995-96. Relative to continuous strawberry, a one-year rotation with broccoli increased 1996 strawberry yields by 24% and one year of rye increased yield 18%. A comparison of three California strawberry varieties on nonfumigated soil containing high populations of *Verticillium dahliae* showed that there is little resistance to Verticillium wilt in the varieties Seascape, Selva, or Laguna.

The results obtained so far suggest the following: 1) Preplant fumigation of soil with Methyl Bromide/Chloropicrin consistently increases the growth and yield of strawberry very significantly, even when the soil does not contain significant populations of known pathogens; 2) Methyl Bromide/Chloropicrin, Chloropicrin alone, and Telone II/Chloropicrin can all work effectively for preplant fumigation of soil for strawberry production, but their relative performance depends on the treatment history of the soil and method of application (i.e., broadcast or bed application), among other variables; 3)In a strawberry-vegetable rotation on ground without significant pressure from known soilborne pathogens of strawberry, the residual effects (measured on the second strawberry crop planted 2 years after application) of soil fumigation with Methyl Bromide/Chloropicrin, Chloropicrin alone, and Telone /Chloropicrin were not beneficial relative to nonfumigated soil and, in some cases, were negative; 4) Preplant treatment of soil with Basamid (Dazomet) can increase strawberry yields significantly, but precautions must be taken to avoid phytotoxicity; 5) Methyl Iodide, when applied to beds at the high rates used, has effective preplant soil fumigant activity for strawberry; 6) Rotation of broccoli or rye with strawberry is beneficial, but only partly compensates for a lack of soil fumigation in strawberry production; and 7) Genetic resistance to Verticillium wilt in current California strawberry varieties is limited.

The fumigation and rotation experiments reported above are being repeated with modifications in 1996-97. In addition, mechanisms by which soil fumigation increases strawberry growth and yield and the epidemiology of Verticillium wilt are being researched.