Nursery Soil Fumigation Regime Affects Strawberry Transplant Production, Transplant Size, and Subsequent Fruit Yield

Kirk D. Larson, Associate Pomologist
U.C. Davis Dept. of Pomology
7601 Irvine Blvd., Irvine CA 92618

The California strawberry industry produces about 80% of the US strawberry crop on less than half the US strawberry hectareage, with per hectare yields 2- to 10-fold greater than yields obtained in other states (CA Processing Strawberry Advisory Board, 1995). This high productivity is the result of two factors: a unique coastal environment with consistent spring-like conditions during a 6-7 month season that favor strawberry plant reproductive growth (Larson, 1994); and a highly-evolved annual planting system. Planting system components that contribute to high yields are: annual planting of certified disease-free transplants (Strand, 1993); transplant production in high-elevation (>1,000 m), high-latitude (> 40o N latitude) nurseries, where environmental conditions result in increased transplant vegetative vigor, yield, fruit quality, and pest resistance (Larson, 1994; Strand, 1993; Voth and Bringhurst, 1990); raised beds; polyethylene bed mulch; drip irrigation; and preplant soil fumigation.

The foundation for any successful crop production programs begins with the use of pest- and disease-free seed or planting stock. For strawberry, production of clonal transplants requires multiple vegetative propagation cycles, with each cycle yielding 1,000,000 plants per hectare, or more. At any step of these propagation cycles, the presence of soilborne pathogens, weeds that host viruses and that compete for nursery resources, and strawberry seedlings (from seed produced in previous nursery propagation cycles) can compromise certification status, or affect variety trueness-to-type and nursery productivity. Presently, nursery preplant soil fumigation with mixtures of methyl bromide and trichloronitromethane (chloropicrin) effectively control weeds, nematodes, lethal soilborne pathogens such as Verticillium, Phytophthora spp, Pythium spp., Colletotrichum spp., etc., and a highly variable complex of sublethal microorganisms that stunts plant strawberry growth and reduces yield (Larson and Shaw, 1995; Shaw and Larson, 1996; Wilhelm and Paulus, 1980). The importance of nursery fumigation is universally recognized; currently, all certified organic strawberry farmers use strawberry transplants grown in methyl bromide-fumigated soil.

Given the importance of clean nursery stock in the production of horticultural crops, the impending ban on methyl bromide soil fumigation dictates that soil fumigation alternatives be investigated throughout ALL phases of the strawberry plant propagation/fruit production cycle, and not simply in fruit production fields. The dearth of scientific studies regarding nursery soil fumigation alternatives is puzzling, since virtually all tree fruit and nut crops trace their origins to fumigated nurseries in which methyl bromide currently is the fumigant of choice due to its efficacy and relative cost effectiveness.

Research in the Pomology Department at the University of California, Davis has attempted to fill in some of the data gaps regarding alternatives to strawberry nursery soil fumigation with methyl bromide. In 1993, we examined the efficacy of MeBr + chloropicrin, chloropicrin alone, and nonfumigation applied preplant to virgin strawberry ground in a high-elevation nursery (Larson and Shaw, 1995). Compared to MeBr, use of chloropicrin and nonfumigation resulted in significant reductions in nursery runner productivity and runner plant size. Furthermore, when transplants from these three nursery fumigation treatments were grown in a fruiting field in Southern California, there was a significant effect of nursery treatment on fruit production (Larson and Shaw, 1996), with the MeBr+chloropicrin nursery treatment producing the greatest yield. Throughout this study, there were no visual symptoms of root or crown disease symptoms on plants in any treatment, suggesting that differences among fumigation regimes were the result of competition from sublethal soil organisms, rather than specific, lethal pathogens.

In 1994, 1995, and 1996 we extended our nursery fumigation study to include three preplant soil fumigation regimes (MeBr + chloropicrin, chloropicrin alone and nonfumigation) in low-elevation strawberry propagation nurseries, in addition to high-elevation nursery fumigation treatments. For all of these trials, strawberry transplants were produced in soil that had never previously been planted to strawberries. In these trials, runner plants produced with various fumigation regimes at low elevation (year 1) were transplanted into high elevation fumigation regimes (year 2), and the runner plants produced at high elevation were then transplanted to fruit production fields in Southern California (year 3). The objective of these multi-year studies was to determine the extent of nursery soil treatment "carry over" when a methyl bromide alternative was used throughout the entire strawberry plant propagation cycle. Results from these studies indicate that the most immediate fumigation environment has the greatest effect on fruit production (i.e., fruiting field fumigation treatment has a greater effect than high-elevation fumigation treatment which has a greater effect than low-elevation fumigation treatment), but also that the low-elevation nursery fumigation regime can have a significant effect on fruit production two years later.

Determining that nursery fumigation treatments "carry over" into the fruiting fields is not surprising; in poorly fumigated or nonfumigated fruit production fields, strawberry growth and yield reductions due to microbial competition and infection are well-documented (Yuen et al., 1991). Under similar conditions in a nursery, runner plant propagation would be expected to result in the spread and/or propagation of competitive soil microbes. However, the extent to which nursery treatments can impact growth and production years later has not been previously documented.

The information presented in this summary regarding nursery soil fumigation alternatives reveals the complexities of present-day horticultural production systems, and indicates that a complete understanding of the impact of the loss of methyl bromide soil fumigation will only be realized when testing of MeBr alternatives is conducted throughout the propagation cycle of these crops.

Literature Cited

Larson, K.D. and D.V. Shaw. 1996. Nursery and field fumigation treatments and yield of Chandler. The Pink Sheet Strawberry News Bulletin, vol. 96, no.3. The California Strawberry Commission, Watsonville, CA..

Larson, K.D, and D.V. Shaw. 1995. Nursery soil fumigation and runner plant production. HortScience 30:236-237.

Shaw, D.V. and K.D. Larson. 1996. Relative performance of strawberry cultivars from California and other North American sources in fumigated and nonfumigated soils. J. Amer. Soc. Hort. Sci. 121:764-767.

Strand, L. 1993. Integrated Pest management for Strawberries. Regents of the University of California, Division of Agriculture and Natural Resources, Oakland, CA. 142 p.

Voth, V. and R.S. Bringhurst. 1990. Culture and physiological manipulation of California strawberries. HortScience 25:889-892.

Wilhelm, S. and A.O. Paulus. 1980. How soil fumigation benefits the California strawberry industry. Plant Dis. 64:264-270.

Yuen, G.Y., M.N. Schroth, A.R. Weinhold, and J.G. Hancock. 1991. Effects of soil fumigation with methyl bromide and chloropicrin on root health and yield in strawberry. Plant Dis. 75:416-420.