CropLife Foundation
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# The Importance of Soil Fumigation: Nursery Crops

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*Key Points*

- Soil fumigation ensures a vigorous start to propagated orchard and vineyard stock and can reduce production costs by reducing the need for post planting pest management.
- In a nursery setting, the efficacy of any treatment is overall more important than its cost due to the possibility of inadvertently distributing plants contaminated with soilborne disease or nematodes.
- Losses of up to 100% are possible if pest free certification cannot be met due to inadequate pest control.

*Technical Summary*

Nursery producers of fruit and nut tree plants and rose bush plants provide pest-free stock to commercial growers of a wide range of crops such as apricot, peach, prune, nectarine, cherries, plums, apples, pears, almonds, walnuts, pistachios, pecans and chestnuts, and roses. The nursery industry as a whole had an estimated value of $4.65 billion in 2006 for operations with over $100,000 in sales in 17 program states. Of this, the combined value of nurseries producing fruit and nut trees and deciduous shrubs, which includes rose bushes, accounted for 20% of the total value of all nursery production, or $924 million [1]. California alone accounted for 60% of the value of fruit and nut trees and 29% of the value of deciduous shrubs (Table 1).

Nursery plants for farm planting in California must be commercially clean with respect to economically important nematodes, which ensures that plant parasitic nematodes and soilborne pathogens are not spread from infested field nurseries and that establishment and vigor of new fruit fields is not compromised [4]. California phytosanitary regulations for nursery production specify treatments that may be used to qualify nursery stock to be certified. Currently, acceptable treatments are limited to methyl bromide/chloropicrin or 1,3-D with limitations depending on soil type and moisture [5]. If certified treatments are not used and parasitic nematodes are detected in a nursery block at the end of the growing cycle, the planting stock is non-saleable which can result in complete economic loss [11]. As most roses are not planted in commercial settings, rose nurseries are not required by the state of California to meet these regulations, but other states and countries accept the California certification to meet interstate and international phytosanitary requirements [4].

Detailed estimates of the extent to which fumigants are used in the nursery industry are not readily available. Historically, methyl bromide and chloropicrin have been the preferred treatment in nursery stock production in the western U.S. Table 2 shows estimates of the area treated with methyl bromide by fruit and nut tree, raspberry, and rose bush nurseries from 1997 to 2002. Methyl bromide continues to be used by some nurseries under a critical use exemption,

while some nurseries have switched to alternatives, particularly 1,3-dichloropropene, chloropicrin and metam sodium. Table 3 shows reported fumigant use by all California nurseries for outdoor grown transplant or propagative material, which includes other nursery crops such as strawberry nursery plants, which are discussed in a separate section of this report.

Preplant soil fumigation is used to control nematodes, diseases and weeds, which are of varying importance in different crops (Table 4).

The production cycle for open field production of perennial fruit and nut crop nursery stock can vary considerably among crops and growers. However, a common nursery production rotation includes a 1 year fallow or cover crop, 1 or 2 years of rotational crops, and a 1 to 3 year nursery crop. Long growing cycles of 1 to 3 years in some cases require very effective nematode control deep into the soil profile, at soil depths of 1.5 meters or greater, to delay reinfestation before harvest. The diversity of nursery crop species, rootstock/scion combinations, and cultural practices, as well as the high value of the crop, require substantial crop safety research before growers can be expected to adopt an alternative treatment [6]. After nematode certification requirements, weed control is among the most important management issues and economic considerations in nursery pest control. The long crop cycle and associated weed management challenges mean that most California nurseries rely on extensive tillage and hand weeding, in addition to preplant fumigation, to achieve a consistently high level of weed control. Some growers also use herbicides, however, herbicide options are very limited and many growers avoid the use of herbicides due to the risk of crop injury. As alternative fumigants are phased in and labor and fuel costs continue to ride, herbicides are likely to become a more important weed management tool in perennial crop nurseries [11]. In a study uring rootstocks of peach, plum/peach hybrid and plum, application of several PRE and POST herbicides provided good to excellent weed control and caused no critical injury to rootstock cuttings. However, these herbicides, while labeled for use in production orchards, are not currently labeled for tree nursery production. Considerable work on herbicide rates, timing, and method of application are needed before these materials can be safely applied to newly planted rootstock on a more broad scale [9].

In a nut tree nursery trial in California, native and introduced nematode counts nine months after planting were highest in untreated plots. The total number of weeds was highest in the untreated plots. However, the number of total marketable trees was not significantly different in the untreated plots compared to shank-injected methyl bromide/chloropicrin treated plots.

Field experiments in walnut and almond nurseries in CA to assess the effects of alternative fumigants on weed seed viability, seasonal weed densities and the time required for hand removal of weeds. Fumigants reduced the viability of weed seeds between 4 and 90% across weed species and treatments, compared to the non-fumigated control, and at three of four locations, it took less time to hand weed the fumigated plots than the non-fumigated control plots [10].

Raspberry nurseries choose production fields without a history of dangerous pathogens (e.g. Phytophthora rubi, causing raspberry root rot) and select for well-drained soil types that are less favorable for disease development. Nurseries generally practice crop rotation, keeping a three to five year interval between raspberry nursery plantings [5].

In a comparison of productivity and economics of fumigants in raspberry nurseries in Washington and California, Telone C-35 at 433 lbs/acre was found to be at least as effective as methyl bromide for disease and nematode control, and substantially less expensive (Table 5) [7]. Estimates of income based on cane and root yield indicate that the non-fumigated controls performed well, primarily due to the savings in fumigation cost [7]. However, without fumigation, the pathogens *Phytophthora rubi*, *Agrobacterium tumefaciens* and *Pratylenchus penetrans* were significantly higher than in fumigated plots [8]. Infestation with Pratylenchus penetrans alone could lead to a non-saleable crop.

Nursery roses are grown in open field plots. A typical crop rotation for a two year rose crop includes one year fallow, followed by one or two years of rotational crops and then a two year rose crop. Roses have deep roots, which require pest control to a depth of 1.5 meters. Rose growers may use 1,3-D if there is no history of nematode problems and soil moisture levels are not higher than 12%. In addition, township caps in California restrict the amount of 1,3-D that can be used in a given area. This issue is especially important for nursery rose growers, as most production of this crop is concentrated in two townships where other crops that also use 1,3-D such as almonds and carrots, are grown [2].

In a garden rose nursery trial in California, nematodes (i.e. root-knot nematode and stunt nematode) were detected at planting and in rose roots at harvest 2 years later in the untreated plots. In addition, *Pythium* populations, weed infestation and plant vigor were all lower in the untreated plots compared to plots treated with fumigants [4].

*Estimated Impacts*

Given pest free certification standards, losses of 100% are estimated for nursery growers if fumigants were no longer available and no alternative pest management is adopted. Net revenues have been estimated at $53,679 per acre for fruit and nut tree nurseries and $6,157 per acre for rose nurseries. Total impacts across areas currently using fumigants are estimated at $14.7 million for fruit and nut tree nurseries and $9.8 million for rose nurseries.

**References**


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**Photo Credits:**

Walters, Thomas, Michael Particka, Inga Zasada and John N. Pinkerton, 2011, "Productivity and economics of methyl bromide alternatives for raspberry nurseries," Methyl Bromide Alternatives Outreach Conference.

Top: tarped fumigation; Bottom: volunteer potato in fumigation trial

**Table 1. Gross Sales of Deciduous Shrubs and Fruit and Nut Nursery Plants in 2006 (Operations with $100,000+ sales)**

| State | Deciduous Shrubs ($1000) | Fruit and Nut Plants ($1000) |
|---|---|---|
| Alabama | 11,872 | 771 |
| California | 187,499 | 165,154 |
| Connecticut | 29,985 | 1,364 |
| Florida | 103,358 | 22,082 |
| Georgia | 14,228 | 1,063 |
| Illinois | 19,662 | 1,101 |
| Michigan | 24,452 | 3,282 |
| New Jersey | 27,922 | * |
| New York | 8,624 | 5,513 |
| North Carolina | 26,474 | 1,564 |
| Ohio | 42,529 | * |
| Oregon | 81,925 | 31,682 |
| Pennsylvania | 6,949 | * |
| Tennessee | 12,284 | 7,725 |
| Texas | 31,163 | 5,416 |
| Virginia | 12,101 | 2,570 |
| Washington | 6,953 | 22,684 |
| Other Program States | | 4,425 |
| Total | 647,980 | 276,396 |

* Included in Other States to avoid disclosure of individual operations.
Deciduous shrubs includes buddleias, hibiscus, hydrangeas, lilacs, roses, and other deciduous shrubs.
Fruit and nut plants includes citrus and subtropical fruit trees, deciduous fruit and nut trees, grapevines, other small fruit plants, and other fruit and nut trees.
Source: [1]

**Table 2. Historic Pattern of Methyl Bromide Use Area Treated (hectares)**

| Crop | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|
| Western Raspberry Nurseries | 100 | 83 | 103 | 111 | 103 | 131 |
| California Deciduous Fruit and Nut Tree Nurseries | 652 | 632 | 698 | 639 | 633 | Not reported |
| California Nursery Roses | 611 | 600 | 609 | 647 | 645 | 584 |

Source: [2]

**Table 3. Fumigant use in Nurseries for Outdoor Grown Transplants or Propagative Material in California in 2010**

| Fumigant | Acres Treated |
|---|---|
| 1,3-Dichloropropene | 649 |
| Chloropicrin | 1379 |
| Metam Sodium | 553 |
| Methyl Bromide | 1517 |

Source: [3]

**Table 4. Key Diseases and Weeds for Western Raspberry Nurseries, California Fruit and Nut Tree Nurseries and California Nursery Roses**

| Use | Key Pests |
|---|---|
| Western Raspberry Nurseries | Pathogens: *Agrobacterium tumefaciens*, *Phytophthora fragariae* var. *Rubi* (root rot), *Verticiliium* spp. (wilt), *Phythium* spp., *Rhizoctonia* spp.<br>Nematodes: *Pratylenchus penetrans* (lesion)<br>Weeds: perennial weeds (e.g. yellow nutsedge and quackgrass) |
| California Stone Fruit Tree Nurseries | Nematodes: *Helicotylenchus dihystera* (spiral), *Tylenchus mexicanus* (Tylenchus), *Tylenchorhynchus* spp. (stunt), *Trichodorus* spp. (stubby root) |
| California Nut Tree Nurseries | Nematodes: *Pratylenchus vulnus* (root lesion), *Meloidogyne* spp. (root knot), *Helicotylenchus dihystera* (spiral), *Xiphinema americanum* (dagger) |
| California Nursery Roses | Nematodes: *Meloidogyne hapla* (root knot), *Pratylenchus penetrans* (lesion), *Paratylenchus hamatus* (pin)<br>Pathogens: *Verticillium dahlia*, *Pythium* spp., *Agrobacterium tumefaciens*<br>Weeds: including *Cyperus* spp. |

Source: [2][7]

**Table 5. Raspberry nursery cane and root production, estimated income and fumigation costs, and income less fumigation costs relative to methyl bromide fumigation**

| Treatment, rate (lb/acre) and tarp type | Shoot weight (kg/m) | Canes (no. /m) | Root weight (kg/m) | Estimated fumigation cost ($/acre) | Income less fumigation cost relative to MB:pic ($/acre) |
|---|---|---|---|---|---|
| *Burlington, WA* | | | | | |
| Non-fumigated, V | 5.6 a | 21.5 | 1.5 | $676 | $7,468 |
| Telone C-35, 433, V | 7.2 ab | 19.5 | 1.6 | $2,172 | $4,231 |
| Midas 50:50, 225, V | 6.6 bc | 21.9 | 2.0 | $3,389 | $3,230 |
| Pic-Clor 60, 366, V | 7.1 bc | 22.0 | 1.7 | $2,337 | $6,027 |
| MB:pic, 67:33, 350, H | 5.5 d | 17.9 | 1.5 | $2,814 | |
| *Lynden, WA* | | | | | |
| Non-fumigated, V | 2.1 | 20.6 | 0.32 | $676 | -$324 |
| Telone C-35, 433, H | 3.1 | 22.3 | 0.37 | $1,750 | $1,848 |
| Telone C-35, 433, V | 2.8 | 22.0 | 0.29 | $2,173 | -$320 |
| Midas 50:50, 350, H | 2.5 | 21.4 | 0.27 | $4,826 | -$4,160 |
| Midas 50:50, 225, H | 2.8 | 19.9 | 0.29 | $3,811 | -$3,713 |
| Midas 50:50, 225, V | 2.5 | 21.1 | 0.26 | $3,389 | -$4,500 |
| Pic-Clor 60, 366, V | 3.1 | 19.6 | 0.38 | $2,337 | -$2,208 |
| MB:pic, 67:33, 350, H | 2.7 | 23.2 | 0.24 | $2,814 | |

Income estimates based upon wholesale price of $0.75/cane and $9.46/kg roots.
H=high density polyethylene film; V=virtually impermeable film
No significant differences among treatments for shoot weight, harvested cane number, cane weight, or root weight in Lynden, WA
Results from Macdoel, CA not shown because non-fumigated control was not included in trial
Source: [7]

**Table 6. Estimated Benefits of Fumigants in Fruit and Nut Tree, Raspberry and Rose Nurseries with No Alternative Pest Management**

| Crop | Area (acres) | Net Revenue (per acre) | Total |
|---|---|---|---|
| California Fruit and Nut Tree Nurseries | 274 | $53,679 | $14,708,031 |
| Western Raspberry Nurseries | 1578 | | |
| California Rose Nurseries | 1598 | $6,157 | $9,838,886 |
| Totals | | | |

Area based on methyl bromide use in 2000 [2]

Revenue losses for California Fruit and Nut Tree Nurseries and California Rose Nurseries assumes total loss of net revenues using 1,3-D+Chloropicrin [12]