PERFORMANCE OF METHYL BROMIDE ALTERNATIVES FOR STRAWBERRY PRODUCTION IN FLORIDA AND SPAIN

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Abstract. Three field trials were conducted to compare the effect of selected methyl bromide (MBr) alternatives on strawberry (Fragaria × ananassa Duch.) yield and soilborne pest control in Spain and Florida. Fumigant treatments were MBr + chloropicrin (MBr + Pic; 67:33 and 50:50 v/v, in Florida and Spain, respectively) at a rate of 270 lb/acre, 1,3-dichloropropene (1,3-D) + Pic (65:33 v/v) at 24 gal/acre; Pic at 268 lb/acre, propylene oxide (PO) at 71 gal/acre, and DMDS (DMDS) + Pic (50:50 v/v) at 223 lb + 223 lb/acre. A non-treated control was also included. In both locations, use of fumigants resulted in higher early and total marketable yields than in the non-treated control plots. Yield in plots treated with 1,3-D + Pic, Pic, and DMDS+ Pic did not differ from that with MBr + Pic.

Spain is the leading strawberry-growing country in Europe, producing more that 350,000 tons of fresh fruit annually, whereas Florida is second only to California in planted area and value with 7,100 acres and $178 million, respectively (U.S. Department of Agriculture, 2004, 2005). In both locations, strawberry is transplanted in polyethylene-mulched beds with drip irrigation and the soil is treated with methyl bromide + chloropicrin (MBr + Pic) to control soilborne diseases, nematodes and weeds. However, the Montreal Protocol phases out MBr because it is an ozone-depleting molecule (Hildebrand, 2004).

Several fumigants have been proposed as MBr replacements. Among those alternatives, 1,3-dichloropropene (1,3-D) + Pic has been indicated as an effective means to reduce the incidence of soilborne diseases in tomato (Lycopersicon esculentum Mill.) (Gilreath and Santos, 2004; Gilreath et al., 2004; Jones et al., 1995). De Cal et al. (2004) testing various alternatives to MBr in Spanish strawberry nurseries, found that Pic and 1,3-D were comparable to MBr for soilborne disease control. However, 1,3-D + Pic activity against troublesome weeds, such as nutsedge (Cyperus spp.), has been somewhat inconsistent. Locascio et al. (1999a, b) reported that several MBr-alternative treatments, including 1,3-D + Pic, were as effective as MBr + Pic suppressing nutsedge. However, Noling and Gilreath (2002) have found that nutsedge control could be erratic with 1,3-D + Pic.

Other potential alternatives to MBr are propylene oxide (PO) and dimethyl disulfide (DMDS). The former is an all-purpose fumigant that has provided broad-spectrum control against soilborne diseases, nematodes, and weeds in preliminary tests (Belcher et al., 2004; López-Aranda et al., 2004; Norton, 2004). After soil application, it is microbially-decomposed and transformed to propylene glycol, a food additive (Warren, 2004). Similar activity has been observed in preliminary trials for DMDS, which is combined with Pic at different ratios to improve soilborne disease control and to reduce price.

Using highly-retentive mulches is also an important component for improving fumigant activity against soilborne pests. For instance, virtually impermeable films (VIF) increase duration under the mulch of relatively high fumigant concentrations, consequently allowing more time for exposing soilborne pests to lethal rates and for lateral distribution in the soil (Gilreath et al., 2005; Minuto et al., 1999; Santos et al., 2005). The objective of this study was to compare the effect of selected MBr alternatives on strawberry yield and soilborne pest control in Spain and Florida.

Materials and Methods

During fall 2004, three field trials were conducted in two locations in Huelva, Spain, and one experimental site near Ruskin, Fla., USA. In Florida, planting beds were 28 inches on top and spaced 4 ft apart, whereas in Spain these were 20 inches on top and 3.6 ft between beds. Planting beds were pre-formed and fumigated with three and four chisels per bed in Florida and Spain, respectively, which delivered the fumigant 6 inches deep. Beds were covered with black high-density polyethylene mulch in the non-treated control plots, whereas the rest of the treatments were covered with virtually impermeable film (VIF).

Six treatments were organized in a randomized complete block design with five and three replications in Florida and both Spainiard locations, respectively. Fumigant treatments were MBr + Pic (67:33 and 50:50 v/v, in Florida and Spain, respectively) at a rate of 270 lb/acre, 1,3-D + Pic (65:33 v/v) at 24 gal/acre, Pic at 268 lb/acre, PO at 71 gal/acre, and DMDS + Pic (50:50 v/v) at 223 lb + 223 lb/acre. A non-treated control was also included. Experimental plots were 30 and 75 ft long in Florida and Spain, respectively. Four weeks after treatment (WAT), bare-root ‘Camarosa’ transplants were established in double rows (12 inch apart) on the bed tops. In Spain, both trials were conducted under passively-ventilated polyethylene tunnels, whereas in Florida open fields were used. Crop management followed local practices.

In Spain, weed densities were determined at 6, 10, and 16 WAT, whereas nematode populations were obtained at 10 and 20 WAT. The number of plants per treatment was counted at 4, 8, and 14 WAT, whereas at 20 WAT five plants per plot were selected to isolate and identify fungal species on the plant roots and crowns. In Florida, plant number, weed densities, and nematode populations were examined at 4, 6, and 8 WAT; 6 and 10 WAT; and 20 WAT, respectively. Early marketable yield comprised harvests during December and January in Florida, and Jan., February and March in Spain. Marketable yield was...
Table 1. Effects of soil fumigants on early and total marketable strawberry yields in Florida, USA, and Huelva, Spain, 2004-05.

<table>
<thead>
<tr>
<th>Fumigants</th>
<th>Rate per treated acre</th>
<th>Early yield</th>
<th>Total yield</th>
<th>Early yield</th>
<th>Total yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>-</td>
<td>2.8 b</td>
<td>9.2 b</td>
<td>7.0 b</td>
<td>21.0 c</td>
</tr>
<tr>
<td>MBr + Pic</td>
<td>270 lb</td>
<td>6.7 a</td>
<td>17.1 a</td>
<td>10.6 a</td>
<td>30.0 a</td>
</tr>
<tr>
<td>1,3-D + Pic</td>
<td>24 gal</td>
<td>16.3 a</td>
<td>10.4 a</td>
<td>31.6 a</td>
<td></td>
</tr>
<tr>
<td>Pic</td>
<td>268 lb</td>
<td>14.7 a</td>
<td>10.4 a</td>
<td>31.0 a</td>
<td></td>
</tr>
<tr>
<td>PO</td>
<td>71 gal</td>
<td>5.9 a</td>
<td>16.6 a</td>
<td>10.7 a</td>
<td>27.0 b</td>
</tr>
<tr>
<td>DMDS + Pic</td>
<td>223 lb + 223 lb</td>
<td>6.5 a</td>
<td>15.4 a</td>
<td>9.1 a</td>
<td>32.2 a</td>
</tr>
</tbody>
</table>

*Abbreviations: MBr = methyl bromide; Pic = chloropicrin; 1,3-D = 1,3-dichloropropene; PO = propylene oxide; DMDS = dimethyl disulfide.
Values followed by the same letter within each fruit category do not differ at the 5% significance level.

Obtained by adding the fresh weights of 25 and 26 harvests in the Spaniard locations, and 18 harvests in Florida. Data were submitted to analysis of variance and treatment means were compared with Fisher’s protected least significant difference test at the 5% significance level (SAS Institute, 2000).

**Results and Discussion**

Experiments in each country were analyzed separately, because of the different growing conditions. However, there was no significant treatment by location interaction in the two Spaniard sites. Therefore, their results were combined for further analysis. In both locations, all fumigated treatments resulted in higher early and total marketable yields than the non-treated control (Table 1). In Florida, early and total marketable yields with 1,3-D + Pic, Pic, PO, and DMDS + Pic were comparable to the MBr + Pic. Strawberry early yield in the fumigated plots ranged between 5.4 and 6.7 ton/acre, whereas the strawberry production in the non-treated control was 58% less than the industry-standard MBr + Pic. Total marketable yield followed a similar pattern as for early yield, with strawberry yield of 9.2 ton/acre in the non-treated control plots, which was approximately 46% less than the yield in the MBr + Pic plots. In the Spaniard locations, early and total marketable yield declined by 34 and 30%, respectively, in comparison with the yields obtained in the industry-standard MBr + Pic plots. With the exception of the propylene oxide-treated plots, strawberry yields in plots treated with all other fumigants did not differ from those in MBr + Pic plots.

Throughout the experimental sites, pressure from weeds, nematodes, and fungi was not significant. Similarly, plant survival was unaffected by the treatments, which suggests that the benefit of soil fumigation not always reflect on soilborne pest populations. It is widely known that the tested soil fumigants do not have stimulatory effect on the crop. Therefore, this beneficial effect could be due to the cumulative action on minuscule populations of fungi, nematodes, and weeds, which measured individually, are too small to cause significant yield reductions.

**Literature Cited**


