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Comparing Methyl Bromide Alternatives for Strawberry 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* x *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/acreand dimethyl disulfide (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, Picand DMDS+Pic did not differ from that with MBr+Pic.

Key words: Soil fumigant, 1,3-dichloropropene, chloropicrin, propylene oxide, dimethyl disulfide

INTRODUCTION

Spain is the leading strawberry-growing country in Europe, producing more that 350,000 tons of fresh fruit annually, whereas in the USA 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 and 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-dichloropropane (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 and 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) increases 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, Florida, 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

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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 VIF.

Six treatments were organized in a randomized complete block design with five and three replications in Florida and both Spaniard 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 Dec. and Jan. in Florida and Jan., Feb. and Mar. in Spain. Marketable yield was obtained by adding the fresh weights of 25 and 26 harvests in the Spaniard locationsand 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

Table 1: Effects of soil fumigants on early and total marketable strawberry yields in Florida, USA and Huelva, Spain, 2004-05

Fumigants*	Rate per treated acre	Florida, USA Early yield	Florida, USA Total yield**	Huelva, Spain Early yield	Huelva, Spain Total yield
		ton/acre			
Control	----	2.8b	9.2b	7.0b	21.0c
MBr+Pic	270lb	6.7a	17.1a	10.6a	30.0a
1,3-D+Pic	24gal	5.5a	16.3a	10.4a	31.6a
Pic	268lb	5.4a	14.7a	10.4a	31.0a
PO	71gal	5.9a	16.6a	10.7a	27.0b
DMDS+Pic	223lb+223 lb	6.5a	15.4a	9.1a	32.2a

*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

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 ith 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.

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