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Effect of chemical fumigation on soil fungal communities in Spanish strawberry nurseries

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Abstract

Strawberry runners are a high-value cash crop in Spain that requires vigorous transplants free of pathogens. Pre-plant soil fumigation with methyl bromide (MB), or with mixtures of MB and chloropicrin (Pic), are standard practices for controlling soil-borne diseases. However, use of MB will be forbidden in European Union countries by the year 2005; for this reason several soil fumigants have been tested as chemical alternatives to MB in Spanish strawberry nurseries. Because of the known broad activity of these compounds, their effects on strawberry soil fungal communities were studied. Experiments were conducted over a 5-year period, with pre-plant applications at two different locations each year. Soil fungal populations were estimated in each plot before and after treatments on potato-dextrose agar amended with 0.5 g l^{-1} streptomycin sulphate and selective media for *Fusarium* spp., *Pythium* spp., *Verticillium* spp., *Phytophthora* spp., and *Rhizoctonia* spp. Soil fungal populations in Spanish strawberry nurseries were clearly reduced in number and composition after pre-plant soil fumigation. Differences in the level of reduction was obtained with some treatments. *Penicillium* sp., following by *Alternaria* sp., *Fusarium* sp., *Morteriella* sp., *Cladosporium* sp., *Pythium* sp., and *Verticillium* spp. were usually presented in Spanish nursery soils from March to April, whereas *Phytophthora* spp. and *Rhizoctonia* spp. were only sporadically isolated. All the fumigants reduced the soil fungal population quantitatively, but only MB:Pic and dazomet caused a clear change in their fungal genera composition. A total reduction was observed on *Pythium* and *Morteriella* populations after application of all the fumigants, except for DMDS. Populations of *Verticillium* spp. were also reduced by the applied fumigants in the strawberry nursery soils tested; the lowest reductions were obtained with 1,3-D:Pic + Virtually Impermeable Film, metam sodium, metam potassium and DMDS.

Keywords: Fumigation; *Fusarium* spp.; Methyl bromide; *Pythium* spp.; *Phytophthora* spp.; *Rhizoctonia* spp.; *Verticillium* spp.

1. Introduction

Application of methyl bromide (MB) to agricultural soils before planting has been the basis to control nematodes, soil-borne pathogens (such as

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Phythophthora cactorum, *Verticillium* spp., *Rhizoctonia* spp., *Pythium* spp., and *Fusarium* spp.) and weeds for many years in strawberry nurseries in Spain (Duhart et al., 2000; De Cal et al., 2004). The chemistry and air pollution potential of this fumigant (Ibekwe et al., 2001a) as well as its ability to destroy stratospheric ozone have been extensively documented (Yung et al., 1980; Prather et al., 1984). MB utilization is being phased out in the European Union (Anon., 2000), and indeed in 2005, MB will be forbidden in EU countries (Batchelor, 2002). 1,3-Dichloropropene (1,3-D), chloropicrin, dazomet, metam sodium (both of them methyl isothiocyanate precursors), metam potassium and dimethyl disulphide in combination with different films have been tested as chemical alternatives to MB in Spanish strawberry nurseries (De Cal et al., 2004). Most of these fumigants show a wide activity range (Elliott and Des Jardin, 2001; Ibekwe et al., 2001a; 2001b) but their effects on strawberry soil fungal communities are largely unknown (Mark and Cassells, 1999; Martín and Bull, 2002). Soil fumigants usually have damaging effects on beneficial microorganisms; therefore, identification of new alternatives to methyl bromide should be based on the efficiency against pathogens but minor side effects on beneficial microorganisms.

Soil fungi, such as other soil microorganisms, are critical to soil environment (Dalal, 1998). They can act as both sources and sinks for many elements and as agents of nutrient transformation and pesticide degradation (West, 1986; Elliott and Des Jardin, 2001; Imberger and Chiu, 2002). They also associate to strawberry plant roots in beneficial or harmful modes (Menge, 1982; Robertson et al., 1988; Mark and Cassells, 1999; Elliott and Des Jardin, 2001). Even in absence of known pathogens, strawberry crops have exhibited an improved growth response when planted into soil fumigated with MB. One of the possible reasons for this evidence is that fumigation may alter the microbial composition of the soil, either enhancing beneficial colonizers or reducing populations of damaging rhizosphere colonizers (Martín and Bull, 2002). For that reason, it is critical to know the effects of biocides such as MB and its chemical alternatives have on fungal communities, both beneficial and detrimental, of strawberry nursery soils.

In this paper, we have evaluated the effect of MB and some alternatives to MB, together with different films, on beneficial and detrimental soil fungal communities in Spanish strawberry nurseries.

2. Materials and methods

2.1. Treatments and experimental design

Experiments were carried out during 5 years (1998–2002). Two different experimental fields located in Navalmanzano (Segovia, Spain) (A) and Arévalo (Avila, Spain) (B) were used for the experiments. In years 2000, 2001 and 2002, the fields had not been fumigated with MB for at least 6 years prior to the experiment. Strawberry or horticultural crops, and strawberry or cereal were cultivated at Navalmanzano and Arévalo fields, respectively, in former years. A randomized complete block design with three replications (three blocks) was used in each field, and the size of each treatment plot was 400 m^2 (5.5 m wide by 72 m long). Treatments were applied when soil temperature was higher than 7 °C and soil moisture content about 60%. If necessary, soil was water sprayed before treatments. Treatments were applied on 30 March 1998, 9 April 1999, 5 April 2000, 30 March 2001, and 3 April 2002 at Navalmanzano fields and 24 March 1998, 26 April 1999, 22 March 2000, 30 March 2001, and 4 April 2002 at Arevalo fields. Fumigants applied were methyl bromide, 1,3-dichloropropene, trichloronitromethane (chloropicrin), tetrahydro-3,5-dimethyl-2H-1,3,5-thiadiazine-2-thione (dazomet), sodium *N*-methyldithiocarbamate (metam sodium), potassium *N*-methyldithiocarbamate (metam potassium), and dimethyl disulphide. These fumigants were applied alone or combined with other compounds at several doses under plastic films and different years as shown in Table 1. All fumigants except dazomet were applied to the soil at 20 to 25 cm depth, using eight injection chisels spaced 33 cm apart. Dazomet was applied to the soil surface and incorporated to 14 to 15 cm depth with a rototiller. Transparent, low-density polyethylene (PE) (Reyenvas S.A., Spain) or co-extruded three-layer virtually impermeable films (VIF) (Reyenvas S.A., Spain) were used after fumigations and left in place for at least 14 days. Hand weeding was used to control weeds.