Water Volume as Related to Effectiveness of 1,3-Dichloropropene and Chloropicrin Mixture by Drip Application for a Strawberry Crop in Spain

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Abstract

The most commonly used chemical alternatives to methyl bromide for large field strawberry production in Spain are applied by shank injection in open air. For small plots or glasshouses, which must be disinfested we used drip irrigation with an emulsifiable mixture of 1,3-dichloropropene and chloropicrin. This mixture was applied in two water volumes (18 and 36 L/m^2) and at two dosages (35 and 50 g/m^2). We also tested the effect of applying irrigation before treatment and of adding wash water after treatment, and the volumes added were measured with a volume counter. Efficacy of treatments was compared by evaluating the control of plant pathogenic fungi and the disease they caused, populations of weeds, assessing plant vigour, yield and product quality. All treatments gave control of fungi and weeds, vigour of plants and quality of fruits, comparable to or better than that of plants grown in methyl bromide treated soil. The best marketable yields were found in treatments that utilized high water volumes during application of fumigant. A high degree of variability was found when the volume of the liquid used for application was less than 18 L/m^2. Low marketable yield was found when the wash water volumes were below 3 L/m^2. The fumigant concentration varied between 0.68 and 2.5 g/L for the treatment that produced the highest values of marketable yield.

INTRODUCTION

Methyl bromide (MB), a highly effective fumigant, is widely used for control of soilborne diseases in the strawberry crops of Spain. With its impending phase out there is a need for alternative disinfestation methods that are technically and economically viable. The mixture of 1,3-dichloropropene (1,3-D) and chloropicrin (Pic), which combines nematocidal and fungicidal action, is so far the best chemical alternative to MB. However, some erratic results (Cebolla, 2002) have been found and suggest the need for improvements in the application technique of 1,3-D-Pic to provide consistent results. In large fields 1,3-D-Pic is applied by shank injection but in small plots or glasshouses drip irrigation, with an emulsifiable mixture, may be the optimal route of application.

Strawberry production in Spain starts with the application and incorporation of manure to soil with a roto-tiller, followed by the formation of beds. Drip irrigation pipes are placed on the beds and they are then covered with a plastic sheet. After this an emulsified formulation of 1,3-D-Pic is applied with the irrigation water through a venturi device. The use of the venturi device generally results in an uncontrolled amount of water being applied and sometimes in an uneven distribution of the fumigant and hence a loss in efficacy. It is obviously essential that the fumigant and the water come into contact with as much soil as possible for optimal disinfestation to occur. The amount of water recommended in a sandy soil (Ajwa and Trout, 2000) is at least 43 mm, but 61 mm gave better results.

The goal of the experiment described is to compare the efficacy of drip applications using different amounts of water during (delivery) and after application (wash) in clay loam soils.

MATERIALS AND METHODS

The soil was roto-tilled and beds each 50 cm wide and m apart were formed, and covered with black low density PE (75 µm thickness).

About 20 root pieces, 5 mm long, cut from strawberries infected with *Fusarium oxysporum* were buried at 10, 20 and 30 cm depth before treatment. These tissues were recovered after the treatment and plated on Komada selective medium Petri dishes (Komada, 1975) to monitor the effect on fungal inoculum.

The fumigant used was an emulsifiable formulation of 55.5% 1,3-dichloropropene with 32.7% chloropicrin w/w (Agrocelhone NE). Methyl bromide 98% w/w was applied under transparent LDPE (75 μm thickness) and untreated plots were used as a control. Beds in MB plots were formed after the treatment.

Several days before treatment the soil in the beds was moistened by drip irrigation with 18 L/m^2 of water. The emulsifiable mixture was applied by injection through a Venturi device at two dosages (35 and 50 g/m^2) and two volumes of water of about 18 and 36 L/m^2. The former (18 L/m^2) is the calculated amount of water needed to increase the moisture from a 60% to 100% of field capacity in the upper 20 cm of soil. After treatment additional water was used to wash the drip pipes and to move the fumigant down in the soil profile. The volumes of water used were measured with a volume counter.

Plots were randomly distributed in three blocks and two replicates per block. Each plot consisted of two parallel rows of about 20 m long. Strawberry cv. 'Pajaro' was planted on the bed in a double row 25 cm apart. Only the central 300 plants were used to calculate yield.

Plant vigour was determined by measuring the plant height and plant diameter of 20 plants at the end of the growing season. The number and type of the most common weed species were enumerated and used to predict the cost of weeding from the time it took to remove these. Yield of first and second quality fruits were taken separately. Debris was not considered. Marketable yield was considered as the combination of both the first and second quality fruit produced.

The differences between treatments were analysed by Duncan multiple range test. In order to determine which variables are important and to explain the effectiveness of the application, a multiple regression (backward selection) model was used, in which the dependent variable was the marketable yield, and the independent variables were washing volume of water, delivery volume, concentration of fumigant, dosage, and their quadratic and cubic terms; where "delivery volume" means the amount of water with the emulsified fumigant in L/m^2; "washing volume" means the volume of water used to wash and to push down the fumigant into the soil; fumigant "concentration" of the delivery water is expressed in (g/L); and "dosage" is the amount of fumigant applied (g/m^2). In order to complete the regression analysis, some additional plots with higher and lower volumes of water were included in the study. Both statistics were calculated using Statgraphics program (Statistical Graphics Corp. Rockville, MD, USA).

RESULTS

All treatments completely killed Fusarium in buried stem pieces to a depth of 20 cm (Table 1). Treatments with low dosage of fumigant (Table 1) did not destroy completely the inoculum at 30 cm depth and 20% (DicPic2) and 8% (DicPic4) respectively of root pieces yielded fungal colonies.

Rhizoctonia solani was identified affecting stunted plants from non-disinfested check treatments. Only one plot of the MB treatment was severely affected by *Phytophthora cactorum* after a persistent fall flood.

The most common weeds were *Poa annua* L., *Sonchus oleraceus* L., *Sonchus asper* L. Hill, *Chenopodium album* L., *Geranium rotundifolium* L., *Malva sylvestris* L., *Senecio vulgaris* L., *Diplotaxis erucoides* (L.) D.C., *Urtica dioica* L., *Chenopodium vulvaria* L., *Fumaria officinalis* L., and *Portulaca oleracea* L. Significant differences among treatments were found as to reduction in weed numbers (Table 2), but in general the incidence of weeds was very low. The cost of weeding was found to be reduced between 50% and 70% by the fumigant treatments Br60PE, DicPic1, DicPic2, DicPic3 and DicPic4, compared with the check (Table 2), with no significant differences among them.

Literature Cited

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Tables

Table 1. The influence of volumes of dosages of various fumigants and the amounts of water used to deliver the chemicals during and post application. Percentage of survival at three depths.[1]

Treatments	Dosage of fumigant g/m²	Delivery volume L/m²	Percent of tissue pieces with fungal growth		
			10 cm	20 cm	30 cm
Check	-		100	100	100
Br60PE			0	0	0
DicPic1	50	18	0	0	0
DicPic2	35	18	0	0	20
DicPic3	50	36	0	0	0
DicPic4	35	36	0	0	8

Table 2. Effect of fumigant treatments on time spent on weeding, the number of weeds per plant and dead strawberry plants (%) at the end of the season.

Treatments	Weeding min/plant	Number of weeds per plant	Dead plants %
Check	0.063 a	0.149 a	0.67 b
Br60PE	0.032 b	0.119 a	0.64 b
DicPic1	0.022 bc	0.051 b	0.11 b
DicPic2	0.020 bc	0.019 b	0.44 b
DicPic3	0.019 bc	0.024 b	0.11 b
DicPic4	0.018 c	0.028 b	0.22 b

Table 3. The effect of applications of fumigants on the productivity of strawberry plants as based on mean plant height and diameter, and early marketable and first quality yield (g/plant).

Treatments	Plant height (cm)	Plant diameter (cm)	Early fruit (g)	Marketable fruit (g)*	First quality fruit (g)
Check	11.8 b	25.1 b	165.8 c	216.0 c	168.1 c
Br60PE	23.1 a	33.6 a	241.3 ab	366.6 b	254.2 b
DicPic1	23.4 a	32.7 a	242.7 b	393.2 b	333.2 a
DicPic2	22.1 a	32.5 a	296.5 ab	463.8 a	397.9 a
DicPic3	21.9 a	32.8 a	299.4 ab	472.4 a	400.6 a
DicPic4	22.2 a	32.9 a	306.4 a	474.6 a	401.3 a

* Fruits with a diameter higher than 25 mm are classified as first quality; fruits under 25 mm diameter are classified as second quality. Marketable fruits are considered both first and second quality fruits.

[1] Legend for Tables 1, 2 and 3. Treatments: Check: Non disinfested; Br60PE: MB at 60 g/m² with polyethylene sheet; DicPic1: 50 g/m² of the mixture 55.5% 1,3-dichloroprope and 32.7% chloropicrin w/w applied with 18 L/m² of delivery water; DicPic2: 35 g/m² of the same mixture applied with 18 L/m² of delivery water; DicPic3: 50 g/m² of the same mixture and 36 L/m² of delivery water; DicPic4: 35 g/m² of the same mixture and 36 L/m² of delivery water.

Figures

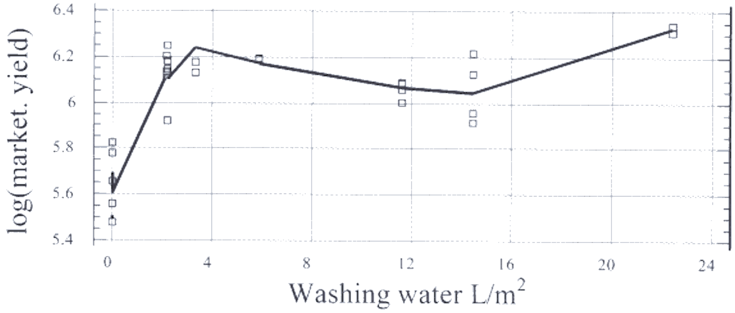

Fig. Log(marketable yield) by washing water volume with predicted values.

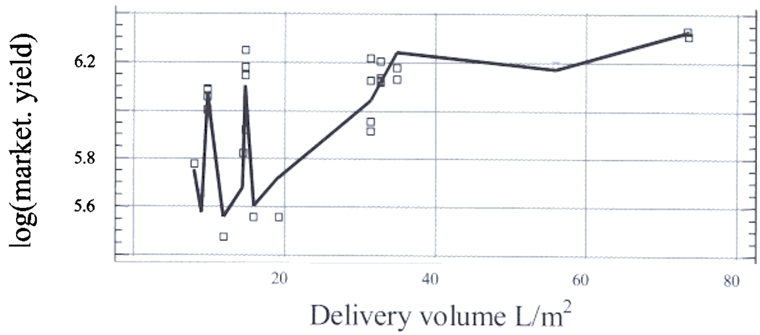

Fig. 2. Log(marketable yield) by delivery volume water with predicted values.

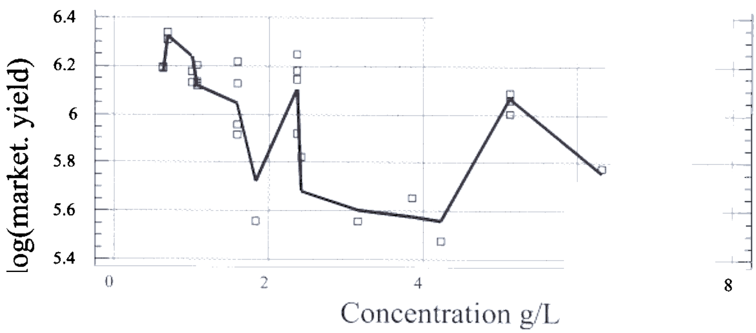

Fig. 3. Log(marketable yield) by concentration with predicted values.