DOSAGE REDUCTION OF METHYL BROMIDE FUMIGATION IN THE SPANISH MEDITERRANEAN COAST

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Abstract

An important dosage reduction on MBr fumigation can be achieved by combination with soil solar heating during summer in the Mediterranean coast of Spain.

This technique allows a significant action over fungi, weeds, plant health and harvest production, at least at the same level than fumigation with MBr at a normal dosage (about 60g/m2 of soil).

Controlled fungi include Phytophthora cactorum, P. parasitica, Pythium spp., Fusarium oxysporum f.sp. dianthi and Rhizoctonia solani. Crops include carnations, tomatoes, carrots and strawberries. Spontaneous flora is also controlled.

1. Introduction

Soil solar heating (Solarization) in mild areas presents an alternative method to control a number of soil borne biological agents, with proven efficacy in the control against nematodes, pathogenic fungi, and adventitious weeds (Katan 1976).

In the geographical latitude of valencia the limitations presented by solarization are basically the meteorological unsteadiness which produces uncertain results, and the long period of treatment which does not adapt always to the crop calendar. The possibility of combining solarization with fumigants at very low dosages has been put forward by a number of authors (Cebolla and García, 1984, Malathrakis 1987, Martinez et al. 1987) and their results evaluated both in health and in yield of crops, have been comparable to the conventional treatment with fumigants.

A method of fungal management is suggested here, which allows their exact location in the soil, and the subsequent recovery from the exact point in which the inoculum was placed, in order to study the direct effect on the overall structures.

In order to check the small dosage techniques for Methyl Bromide (MBr), several crops conducted on naturally infested soils are set to confirm the practical application to the most common cultures in the area.

2. Material and Methods

2.1. Pathogens

2.1.1. Inoculum

Phytophthora parasitica, P. cactorum both isolated from strawberry, Pythium spp. and Rhizoctonia solani isolated from melon, and Fusarium oxysporum f.sp. dianthi isolated from carnation were used for preparing artificial inocula. Fungi were grown in PDA Petri dishes until complete colonization.

Simultaneously, small balls of expanded clay (ARLITA) with a size between 6 and 10 mm diam., which are extremely porous, are autoclave sterilized in a nutrient broth consistent in potato extract plus 40g/l glucose, in order to introduce nutrient medium into the ball cavities. Upon exit from autoclave the air contained in the cavities of the expanded clay has been substituted by the nutrient medium.

Subsequently, the balls were asepticaly transferred to the Petri dishes colonized by fungi, and were incubated until micellia covers completely the surface and cavities of the balls. In such a way the fungal structures were placed inside the clay ball cavities.

Mesh bags containing 20 balls were attached by fastening them to rigid plastic mesh pieces ensuring correct separation between three different depths, 4, 8 and 24 cm. under soil surface.

After treatment, the bags content are recovered by unearthing most carefully, and transferring to the following selective media, Ponchet for Pythium and Phytophthora (Ponchet 1972), Komada for Fusarium (Komada 1975), SEIA for Rhizoctonia (Menzies 1967). A record is made of the number of balls within which the fungi has succeeded to survive treatment, and grow in the medium.

2.1.2. Treatments

Normal fumigation with MBr (2% Chloropicrine) at a dosage of 56g/m2 (56) was compared with Solarization (Mulch), consisting in mulching with standard PE 50 micron thick, Solarization under plastic Tunnel (Tu) plus mulching, mulching plus 14g/m2 MBr (14A), mulching plus 28 g/m2 MBr (28), Tunnel plus mulching plus 14 g/m2 MBr (14T), uncovered soil was left as control (Check).

Experimental plots (6 x 3 m) were prepared with the ground in season, by cross tilling with a cultivator followed by another with rotovator.

Application of treatments was done at the end of July. the plastic sheets were left on place during 15 and 30 days for the treatments (Mulch),(Tu),(14A),(14T) and (28) in order to study the effect of exposure time to the sun radiation. For all these treatments the plots were irrigated under the plastic sheet one day after application of MBr.

The experimental design was completely randomized with two replicates of each treatment and exposure time. Test was repeated during two years. Comparison of results was made through the Duncan multiple test.

2.1.3. Weeds

The effect of treatments, previously described, on weeds was studied by visual observation of spontaneous flora development, and comparison with control. In all instances soil samples were collected and incubated under optimal conditions in greenhouse to study the effects on seed of adventitious weed (Carretero 1977).

2.1.4 Temperatures

Soil temperatures for Check, Mulching and Tunnel were measured continuously at depths of 4, 8, 16, 32, and 64 cm by means of platinum probes Pt-100, calibrated and connected to a data logger.

2.2. Crops

The experiments were set in different sites along Valencian coast. In all the experiments MBr was applied using the cold technique, at the dosages specified for each crop, under a plastic PE sheet that remained covering the soil at least for 1 day. On the treatments of Solarization + MBr, the soil was covered with a PE plastic sheet, then the gas was dosed under the plastic, and 1 day afterward the soil was irrigated under the plastic sheet. PE sheet remained the period specified in each paragraph.

2.2.1. Strawberries

The experiment was set in a soil in which Verticillium dahliae was isolated from artichokes on several plants from the crop before but along the actual crop this fungi was not isolated, including check plots. The phytopathologycal problem consisted on a soil complex where R. solani was the most frequently isolated pathogen. Experimental design consist in plots of 37m2 big, 4 replicates per treatment. Treatments were Check, Fumigation with MBr (33% Chloropicrine) at dosage 70 gr/m2 and combination of soil solarization with fumigation Mbr 17,5g/m2. Solarization started on end of June and remained up to middle August. Yield was recorded from 5th March to 9th June.

2.2.2. Carrots

The experiment was set in a soil naturally infested with Pythium spp. isolated from many plants from the preceding crop. Experimental design consist in plots of 200 m2 big, 3 replicates per treatment. Treatments were Check, Solarization and Solarization + 7g/m2 Mbr. Solarization sheets remained from middle of July up to end August. Yield was recorded at the end of the crop.

2.2.3. Tomatoes

The experiment was set in a greenhouse without any special pathogen in soil, but in which a tomato var Cobra F1 crop was repeated along two years. Experimental design consist in plots of 130 m2 big, 2 replicates per treatment. Treatments were Check, Fumigation with MBr 56g/m2, Solarization and Solarization + 14g/m2 MBr. Solarization started beginning of July and remained up to middle of August. Yield was recorded along the crop, from 6th November to 9th January.

2.2.4. Carnations

Carnation crop (var Lena) was accomplished on big containers (40x40x80 cm) filled with a substrate made with a blend of sandy soil and 30% peat and inoculum, consistent in 2Kg per container of carnation stems infected with F.o. dianthi. Experimental design consistent in 6 replicates per treatment, 45 cuttings per container, each replicate. Treatments were Check non disinfested, Standard fumigation with MBr at 70g/m2, soil solarization, solarization with the addition of MBr at 28g/m2 and the same with MBr at 14 g/m2. Solarization consisted on mulching under closed greenhouse, started on 27th July and remained up to September 3rd.

A preliminar crop was started on 6th October and a second crop on 2nd July. Flowers were collected and recorded up to 11 July. At the end of the crop plants were cut by the first knot and the necrotic vessel ratio was recorded.

3. Results

3.1. Pathogens

As Pathogens concerns, the Duncan test (p=0.05) applied within each fungus, treatment and duration of mulching, does not suggest significant differences in any case among fumigation treatments 56, 28, 14A and 14T which appear as the best, from just 15 exposure days, up to the greater depth studied (Table 1, 2).

Tunnel+Mulching (Tu) proves significantly better than the Check in all instances. Differences of (Tu) with fumigant treatments are significant for F. oxysporum and R. solani when studying that of the values from 0-24cm, on the superficial layer 0-4cm (Tu) proves as efficient as the treatments with fumigants for P. parasitica, P. cactorum and Pythium, but for F.o. dianthi and R. solani, although Tu shows a better control than Check, it is not as efficient as the fumigation treatments.

3.1.1 Weeds

The best results (table 4) are provided by MBr 56g/m2, mulching and mulched tunnel with low dose of MBr, the poorest result was obtained with mulching. The rest of treatments give intermediate efficacy.

From samples incubated in greenhouse (table 5) weeds apear with significant differences just for Check, mulching does not show significant differences with fumigation treatments.

3.1.2 Temperatures

Temperatures reached under mulching (table 3) are higher than naked soil at any depth, but the highest increment is given by mulching under tunnel which arrives at 47 h above 43§C at a depth of 32cm.

3.2. Crops

The addition of small amounts of Mbr to solarization improves its efficacy (table 6) giving a yield at the same level than MBr at normal dosage, while solarization has an intermediate level between check and fumigation treatments. Solarization + 7g/m2 of MBr produces a significant increment on carrots yield with such a extremely reduced dosage when compared with solarization or Check.
The abnormal figure for MBr disinfestation on Tomatoes could be explained by foreign incidences.

Crop health monitoring on tomatoes and strawberries did not show special phytopathologycal problems, check treatments on carrots and carnation, were seriously diseased along the crop. Necrotic vessel ratio at the end of the crop for carnations showed good control with fumigation treatments, and intermediate health ratio for solarization.

4. Discussion

Solarization with plain mulching does not seem sufficient to control fungi in our geographical area; the efficiency is substantially improved with mulching under tunnel. The improvement is doubtless attributable to higher thermal levels reached (Table 3) as well as to a longer exposure to lethal temperatures. These results show a direct lethal effect on the surviving fungal structures even at the greatest depth studied (24 cm).

Absence of significant differences between solarization with fumigants at very low doses and the conventional disinfestation with fumigants at standard doses allow to point this combined method up as excellent for pathogen control, with the advantage of lower use of toxic products, and consequently, a reduction of residues in soil; moreover, it shortens safely the exposure time to solarization in a significant way.

Tunnel with mulching had, by far, a better performance, than solarization with plain mulching, although its effect in depth is not always sufficient.

The method used is valuable for the study of efficacy, against fungi, of any kind of soil disinfestation treatment.

The results of control for adventitious weed agree with those obtained for fungi, although here plain mulching, if does not produce a total control, does appear as agronomically valuable for the following crop, since there is a reduction in competition.

The possibility of combining MBr fumigation at reduced dosages with soil solar heating while keeping or even improving the yield is clear upon practical crops.

This technique avoids uncertainty to soil solarization on middle latitudes, and would allow to reduce significantly the soil covering time up to 15 days in most instances.

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Table 1 - Surviving per cent after 15 days exposure under PE

	Check	56	28	14A	14T	Mulch	Tu
F.o.diant.	100f	6 ab	12 abc	5 a	9.8abc	100f	48d
R. solani	100f	6.7abc	0.8ab	2 abc	0 a	95f	26d
P.parasit.	38cdef	2.4ab	0 a	2.4ab	0 a	42cdef	7abc
P.cactorum	72def	8 abc	10 abc	1 a	3.6ab	45dcdef	27abcd
Pythium spp.	93f	10 ab	19 abcd	6 a	14 abc	74 f	14abcd

Table 2 - Surviving per cent after 30 days exposure under PE

	Check	56	28	14A	14T	Mulch	Tu
F.o.diant.	100f	10 abc	3 ab	10 a	1.4abc	92f	45d
R. solani	100f	14 abc	20abcd	8 a	11 ab	93f	34d
P.parasit.	92f	10 abc	0 a	15 abc	0 a	62def	4.8abc
P.cactorum	63def	20 abc	1 a	11 ab	2 a	40bcdef	2.8 a
Pythium sp.	95f	7 ab	0.5a	6 ab	0.5a	72f	3 ab

Table 3 - Exposure time (hours) above a temperature level for each treatment and depth (cm)

	Mulching					Tunnel			Check				
Level	4	8	16	32	64	16	32	64	4	8	16	32	64
>33§C	848	863	1082	1147	1134	1152	1150	1113	182	112	25	0	0
>35	644	658	754	784	300	1142	1132	1070	89	61	0	0	0
>37	502	501	445	128	0	1122	1102	883	55	11	0	0	0
>39	386	384	168	1	0	1016	996	599	24	0	0	0	0
>41	289	265	4	0	0	682	571	0	0	0	0	0	0
>43	173	138	0	0	0	383	47	0	0	0	0	0	0
>45	43	10	0	0	0	124	0	0	0	0	0	0	0

>47	0	0	0	0	0	1	0	0	0	0	0	0	0
>49	0	0	0	0	0	1	0	0	0	0	0	0	0

Table 4 - Weed control rate evolution

	Check	56	28	14A	14T	Mulch	Tu
September	0b	97a	96.3a	98.5a	99.8a	93.5a	97.5a
November	0b	95.5a	93a	99.3a	98.7a	93.7a	96.3a
May	0d	97.2c	95.8c	93.3c	96 c	69.2a	86.7b

Table 5 - Number of seedling species germinated in greenhouse

	Check	56	28	14A	14T	Mulch	Tu
Solanum nigrum	24	0	0	0	0	0	0
Sonchus spp	25	0	0	1	0	3	0
Lolium spp	48	0	0	2	0	1	0
Plantago lanceolata	4	0	0	0	0	0	0
Asphodelus fistulosus	2	0	0	0	0	1	0
Euphorbia exigua	8	0	0	0	0	0	0
Euphorbia prostrata	3	0	0	0	0	0	0
Malva spp	1	0	0	0	0	0	0
Medicago spp	0	0	0	0	0	1	0
Cruciferae spp	0	0	0	0	0	1	0
Non identified	35	5	0	4	3	13	1
Total	150b	5a	0a	7a	3	20a	1a

Table 6 - Total yield (Kg/m2) on horticultural crops and on carnation (flowers/m2).

Crop	Check	Mbr(dosage)		Solariz + MBr (dosage)	Solariz
Strawberry	2.8b	3.3a (70g)	-	3.5a (17.5g)	3.2b
Tomato	4.8bc	4.6c (56g)	-	6.6a (14g)	5.8ab
Carrot	0.85a	-	-	7.69c (7g)	4.98b
Carnation	5.2a	197b (70g)	202.6b (28g)	206.3b (14g)	177.1b