ALTERNATIVES TO MB FOR STRAWBERRY PRODUCTION IN HUELVA (SPAIN). 2003 RESULTS.

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The first National project INIA SC 97-130 on alternatives to Methyl Bromide (MB) was finished in 2002. Results for strawberry in Huelva have been presented in MBAO Conference (López-Aranda et al., 2000, 2001, 2002). After one year on demonstration stage (2002), we started a three-year (2003-2005) new National project INIA entitled: "Optimization and new implementation in Methyl Bromide alternatives. Strawberry fields and High-elevation nurseries. Critical uses". In 2002-2003, two private farms were selected: Occifresa Inc. (Avitorejo, Moguer) and Cumbres Malvinas Inc. (Malvinas, Palos de la Frontera). Cv. 'Camarosa' was cultivated following conventional cultivation practices under large plastic tunnels. The experimental design on each orchard was in complete randomized blocks with 3 replications (78 m^2/rep.) and 10 fumigant treatments (Table 1). New chemical alternatives incorporated for the first time in Spain, in the 2003 strawberry experiments, were MB-pic (33-67), DMDS (Dimethyldisulfide) and Propylene oxide (Propozone^{TM}) shank applied under preformed raised-beds mulched with VIF or PE films. As new implemented alternatives the applications of VIF technology to MB-pic (33-67), Dazomet (Basamid^{TM}), 1,3D-pic (Telopic^{TM}), Pic alone and DMDS, with 50% of dosage were used. Shank application of MB-pic (50-50) under preformed beds (40 g/ m^2 of treated area) was employed as standard MB use in the area. Fumigations were conducted on September 26-27, 2002, and planting dates were October 17-18, 2002.

Soil samples from each orchard were evaluated (Table 2) for fungal presence before and after treatments. No lethal soil-borne fungi were present at the moment of planting, either in soil or plants. In the case of nematodes, only plant samples were examined before planting. No phytoparasitic nematodes were detected. Samples from the same plants per replication used for size (diameter and number of leaves) evaluation were examined at the end of the growing season for soil-borne fungi and nematodes presence. In spite of the absence of phytoparasitic nematodes in plants before planting, *Pratylenchus penetrans* was detected in plant samples from Occifresa (location 1) and *Meloidogyne hapla* was observed in several plant replications of C. Malvinas (location 2) at the end of the cultivation period (Table 3). These results suggest that with Dazomet-dir-VIF, MB-pic (33-67) and Propozone LDPE treatments an adequate control of *Meloidogyne hapla* in C. Malvinas (location 2) was not achieved. Moreover, an adequate control of *Pratylenchus penetrans* in Occifresa (location 1) was not achieved with Dazomet-dir-VIF, Chloropicrin VIF and Propozone LDPE treatments. Plant samples that were examined for presence of soil-borne fungi at the end of the growing season showed presence of black root rot complex, particularly in location 2. *Cylindrocarpon* sp. and *Rhizoctonia* spp. were detected in all treatments in both locations. In spite of the presence of soil-borne pathogens (fungi and nematodes), at the end of the growing season, plant survival, yields, and other agronomical and morphological traits were optimal in both locations. In fact, plant survival, just after plantation dates and at mid growing season (April 1, 2003), was optimal for every treatment including Controls without fumigation. Plant diameter (cm) and number of leaves followed similar tendencies to the yields in the experiments. Table 4 shows total commercial yield per plant and relative yield in relation to the standard MB-pic (50-50) (40 g/m^2 of treated area). Average fruit weight is presented in Table 5. Herbicide treatments, located on the soil between beds, were applied in November 1st, 2002 (Glufosinate 15%-Finale™) and three times during the growing season (Paraquat-Gramoxone Plus™) in location 1 (Occifresa), and only one time, November 30, 2002 (Paraquat-Gramoxone Plus™) in location 2 (C. Malvinas). To assess the control of weed emerged on the top of beds (a real problem on this issue), weeding operations in both orchards (December 2, 2002) were registered as time of operating and fresh weed biomass eliminated (Table 6).

In location 1 (Table 4), results showed very significant differences ($P = 0.01$) in yield among treatments; however, statistical and practical differences in location 2 were not detected. As in previous years, average yield and fruit weight (Table 5) obtained with Telopic and Pic alone were satisfactory and similar to those obtained with the standard MB treatment: MB-pic (50-50). In general, VIF applications are efficient solutions to improve the performance of chemical alternatives but dosage should be increased to 65-70% of the standard dosage applied under LDPE films. It is clear that in the case of DMDS treatments, DMDS VIF (400 kg/ha) performed much better than DMDS LDPE (800 kg/ha). In this case combinations of DMDS-Pic under black VIF films would be a good alternative. The different techniques used to incorporate Dazomet (Basamid™) into the soil showed small agronomical differences. Results regarding to the use of Propylene oxide (Propozone™) under LDPE film have evidenced that a dose of 30 gallons/acre is not enough to achieve a good performance in our field conditions. Dosage should be incremented to 40 gallons/acre (LDPE film) or 25-30 gallons/acre (under black VIF film). Finally, application for critical use exemption for the Spanish strawberry industry has been presented and recommended by MBTOC in 2003.

References

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Table 1. MB Alternatives. Strawberry trials 2003. Huelva.

Treatments	Description
Control	Control without fumigation
MB-pic (50-50)	Shank applied, preformed beds, black PE 40 microns, 400 kg/ha
MB-pic (33-67) VIF	Shank applied, preformed beds, black VIF 50 microns, 200 kg/ha
Dazomet-rot-VIF	Broadcast incorporated rotovator, black VIF 50 microns, 125 kg/ha
Dazomet-dir-VIF	Incorporated, preformed beds, black VIF 50 microns, 125 kg/ha
Telopic VIF	Shank applied, preformed beds, black VIF 50 microns, 200 kg/ha
Chloropicrin VIF	Shank applied, preformed beds, black VIF 50 microns, 200 kg/ha
DMDS VIF	Shank applied, preformed beds, black VIF 50 microns, 400 kg/ha
DMDS LDPE	Shank applied, preformed beds, black PE 40 microns, 800 kg/ha
Propozone LDPE	Shank applied, preformed beds, black PE 40 microns, 30 gal./acre

Table 2. MB Alternatives. Total number of propagules per g of dry soil, before/after treatments.

Treatments	Loc. 1 Occifresa		Loc. 2 C. Malvinas	
	Before	After	Before	After
Control	5379.5	4917.5	5709.5	528.0
MB-pic (50-50)	8096.8	1188.1	2871.3	0
MB-pic (33-67) VIF	4895.4	0	2607.3	0
Dazomet-rot-VIF	4785.5	330.3	3201.3	0
Dazomet-dir-VIF	6006.6	1958.2	5104.4	528.0
Telopic VIF	4939.5	0	3509.3	1518.1
Chloropicrin VIF	4950.5	0	4774.5	2288.2
DMDS VIF	6062.0	6097.6	2970.3	858.1
DMDS LDPE	9417.0	5192.5	3971.4	2486.2
Propozone LDPE	5665.5	4939.5	3124.3	2508.2

Table 3. MB Alternatives. Presence of nematodes at the end of the growing season[1].

Treatments	Loc. 1 Occifresa			Loc. 2 C. Malvinas		
	Meloidogyne hapla		*Pratylenchus penetrans*	*Meloidogyne hapla*		*Pratylenchus penetrans*
	Severity Index[2]	? /g of roots	Individuals per g roots[3]	Severity Index[2]	? /g of roots	Individuals per g of roots
Control	0.0	0.0	161.5 ab	0.07	0.0	0.0
MB-pic (50-50)	0.0	0.0	23.2 bc	0.00	0.0	0.0
MB-pic (33-67) VIF	0.0	0.0	21.8 bc	0.27	9.3	0.0
Dazomet-rot-VIF	0.0	0.0	65.3 bc	0.00	0.0	0.0
Dazomet-dir-VIF	0.0	0.0	124.3 ab	1.00	24.8	0.0
Telopic VIF	0.0	0.0	5.5 c	0.00	0.1	0.0
Chloropicrin VIF	0.0	0.0	110.0 bc	0.00	0.4	0.0
DMDS VIF	0.0	0.0	2.8 c	0.00	0.0	0.0
DMDS LDPE	0.0	0.0	93.5 bc	0.00	0.0	0.0
Propozone LDPE	0.0	0.0	320.9 a	0.27	3.3	0.0

[1] Sample size: 5 plants/replication; [2] Severity Index Scale: 0 (No symptoms) to 4 (all roots attacked); [3] P = 0.10

Table 4. MB Alternatives. Total commercial yield (g/plant) and total relative yield.

Treatments	Loc. 1 Occifresa		Loc. 2 C. Malvinas		Two loc. average	
	Total[1]	Relat.[2]	Total[1]	Relat.[2]	Total[1]	Relat.[2]
Telopic VIF	1081 a	104.3 a	1038 a	97.0 a	1059 a	100.6 a
MB-pic (50-50)	1036 ab	100 ab	1070 a	100 a	1053 a	100 a
Chloropicrin VIF	1008 ab	97.3 ab	1068 a	99.8 a	1038 a	98.6 a
MB-pic (33-67) VIF	1009 ab	97.4 ab	1062 a	99.3 a	1036 a	98.4 a
Dazomet-dir-VIF	965 abc	93.2 abc	1084 a	101.3 a	1025 a	97.3 a
Dazomet-rot-VIF	994 ab	96.0 ab	1034 a	96.6 a	1014 ab	96.3 ab
DMDS VIF	930 abcd	89.7 abcd	1071 a	100.1 a	1000 abc	95.0 abc
Propozone	916 bcd	88.4 bcd	1055 a	98.6 a	985 abc	93.6 abc
DMDS LDPE	812 cd	78.3 cd	986 a	92.2 a	899 bc	85.4 bc
Control	791 d	76.4 d	989 a	92.4 a	890 c	84.5 c
P = 0.01; [1]Total: yield cumulated until May 21st, 2003; [2] Relat: MB-pic (50-50) =100%						

Table 5. MB Alternatives. Average fruit weight (g/fruit).

Treatments	Loc. 1 Occifresa		Loc. 2 C. Malvinas		Two loc. average	
	up-to-end of:					
	March	May	March	May	March	May
Telopic VIF	29.6 a	25.9 a	35.2 a	28.8 a	32.4 a	27.4 a
Dazomet-rot-VIF	28.2ab	25.9 a	32.7 a	28.9 a	30.5 ab	27.4 a
MB-pic (50-50)	29.2 a	26.7 a	31.5 a	27.1 a	30.3 ab	26.9 ab
Dazomet-dir-VIF	26.3 abc	24.7 abc	32.5 a	28.6 a	29.4 abc	26.6 abc
DMDS VIF	27.0 abc	25.0 abc	31.2 a	27.8 a	29.1 bcd	26.4 abc
Chloropicrin VIF	28.4 ab	25.6 ab	31.8 a	26.9 a	30.1 abc	26.3 abc
MB-pic (33-67) VIF	26.7 abc	24.4 abc	31.6 a	27.9 a	29.2 bcd	26.1 abc
Propozone	26.3 abc	24.6 abc	30.4 a	26.3 a	28.3 bcd	25.5 bc
DMDS LDPE	24.3 bc	23.3 bc	29.7 a	26.6 a	27.0 cd	25.0 c
Control	23.6 c	23.1 c	28.8 a	26.6 a	26.2 d	24.8 c
P = 0.01						

Table 6. MB Alternatives. Weeding on the top of raised beds .

Treatments	Loc. 1 Occifresa		Loc. 2 C. Malvinas		Two loc. average	
	Biomass[1]	Time[2]	Biomass[1]	Time[2]	Biomass[1]	Time[2]
Control	211 a	8.3 a	256 a	14.7 a	234 a	11.5 a
DMDS LDPE	161 ab	6.2 ab	128 ab	11.6 ab	144 ab	8.9 ab
Dazomet-dir-VIF	33 bc	1.8 c	90 b	9.6 ab	62 bc	5.7 bc
DMDS VIF	68 bc	3.7 bc	36 b	6.7 b	52 c	5.2 bc
Dazomet-rot-VIF	1 c	1.9 c	59 b	6.6 b	30 c	4,3 c
MB-pic (33-67) VIF	36 bc	2.5 c	25 b	4.7 b	31 c	3.6 c
Chloropicrin VIF	20 c	2.7 c	32 b	4.3 b	26 c	3.5 c
Propozone	30 bc	2.5 c	13 b	4.4 b	21 c	3.4 c
MB-pic (50-50)	13 c	2.1 c	10 b	4.5 b	12 c	3.3 c
Telopic VIF	4 c	1.9 c	5 b	4.3 b	5 c	3.1 c
P = 0.01; [1] Weed biomass (g/rep.) [2] Time of weeding (min/rep.)						