

STRAWBERRY PRODUCTION IN SPAIN: CHEMICAL ALTERNATIVES TO MB, 2009 RESULTS.

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The Spain's Methyl Bromide Alternatives Project (INIA) has allowed 12 years of work for strawberry in Huelva (Spain). In 2008/09 a series of field trials has been conducted in two locations of the coastal area. On each orchard: "Occifresa" (Moguer) and "Cumbres Malvinas" (Palos de la Frontera), a complete randomized block design with 3 replications (78 m²/rep. & 500 plants/rep.) and 12 fumigant treatments was used. Strawberry cv. 'Camarosa' was cultivated following conventional cultivation practices under high-tunnels. As antecedents, the 2002/03 to 2007/08 results were presented each year in MBAO International Conference (see MBAO web site www.mbao.org). 2008/09 treatments in both locations, applied under pre-formed beds mulched with standard black LDPE films were (Table 1): A: untreated control; B: MB+pic (50-50); C: sodium azide (SEP-100TM); D: dazomet+(1,3D+Pic); E: 1,3D+Pic (61:35) (InLineTM); F: 1,3D+Pic (61:35) (TelopicTM); G: chloropicrin alone (TripicrinTM); H: DMDS+pic; I: methyl iodide+pic (33-67) (MidasTM); J: DMDS+metam sodium; K: acrolein; and, L: furfural (Multiguard ProtectTM).

Soil shank-applications (treatments B, F, G, H, I & J) were conducted on August 14, 2008 (location 2: Cumbres Malvinas) and September 5, 2008 (location 1: Occifresa). Pre-plant drip applications (treatments C, D, E, K & L) were delayed to August 27-28, 2008 (location 2) and September 5 to 11, 2008 (location 1), respectively. Plantings were done on October 14, 2008.

Soil samples from each orchard were evaluated for fungal presence before (August, 2008) and after (October, 2008) treatments. Most part of treatments reduced significantly initial fungal population; however, other treatments were less effective (location 1: treatments A & L and location 2: treatments A, F & J). Results will be presented and discussed.

Samples from 10 plants per replication used for size (diameter) evaluation were examined at the end of the growing season (May 6-7, 2009); five plants for soil-borne fungi and five plants for nematodes presence. Additionally, symptomatic plants that indicated different aerial symptoms (in particular collapsed, wilt, or very small plants) were taken (19 samples from location 1, treatments A, B, D, K and L; 12 samples from location 2, treatments A, B, D, E, K and L).

Pratylenchus penetrans was detected in samples from “Occifresa” (location 1) and *Meloidogyne hapla* was observed in samples from “Cumbres Malvinas” (location 2) at the end of the cultivation period (Table 2). Results will be presented and discussed.

In samples of 5 plants/replication, high isolation frequencies of *Fusarium spp.*, *Cylindrocarpon spp.* and *Rhizoctonia spp.*, were detected in location 1 and 2. Presence of *Pythium* was increased in location 2 and not detected in location 1 at the end of the growing season. All of them are important components of black root rot complex. For the case of additional symptomatic plants samples taken, *Macrophomina phaseolina* and *Phytophthora cactorum* were isolated in location 1 and 2. Results will be presented and discussed.

Weed control assessment was done on December, 12 and 15, 2008 in location 2 and 1, respectively. Fumigant efficacy on weeds was assessed by three ways: 1) biomass of the native weed population; 2) time needed to remove the weeds; 3) number of weed removed (Table 3). These controls were focused on the weeds growing on the bed tops mulched with black PE F film. Results will be presented and discussed.

As in precedent growing seasons (2002/03 to 2007/08), plant survival, other agronomical traits and yields (Table 4) were optimal in both locations. Average fruit weight is presented in Table 5. Results and current status of MB replacement for strawberry cultivation in the area of Huelva will be discussed.

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Table 1. Treatments applied to soils in 2008/09.

Treatment	Rate (kg/ha of treated area)	Method of application	Mulch type
A: Control	Untreated	-	Black LDPE
B: MB+pic (50-50)	400	Shank, 2 chisels in bed	Black LDPE
C: Sodium azide (SEP-100™)	160 a.i. ¹	Pre-plant drip irrigation	Black LDPE
D: Dazomet+1,3-D	80+400	Pre-plant drip irrigation	Black LDPE
E: 1,3-D+pic (InLine™)	400	Pre-plant drip irrigation	Black LDPE
F: 1,3-D+pic (Telopic™)	400	Shank, 2 chisels in bed	Black LDPE
G: Pic alone (Tripicrin™)	400	Shank, 2 chisels in bed	Black LDPE
H: DMDS+pic	400+130	Shank, 2 chisels in bed	Black LDPE
I: MI+pic (33-67) (Midas™)	400	Shank, 2 chisels in bed	Black LDPE
J: DMDS+metam sodium	400+1000	Shank, 2 chisels in bed	Black LDPE
K: Acrolein	240	Pre-plant drip irrigation	Black LDPE
L: Furfural (Multiguard™)	600 a.i. ²	Pre-plant drip irrigation	Black LDPE
¹ a.i. = active ingredient; ² = 60 ml/m ²			

Table 2. Nematode populations at the end of the growing season.

	Loc. 1: Occifresa: <i>Pratylenchus penetrans</i>	Loc. 2: C. Malvinas <i>Meloidogyne hapla</i>		
Treatments	individuals/g of roots	Gall Index: Severity Index ¹	N° eggs+ J ₂ /g of roots	females/g of roots
A: Control	197.49 cd	1.33 ab	2,421.68 cd	35.79 b
B: MB+pic (50-50)	9.35 a	0.13 a	24.67 a	6.81 ab
C: Sodium azide	162.76 cd	2.07 b	3,198.96 d	48.56 b
D: Dazomet+1,3-D	81.99 c	1.00 ab	631.01 c	19.92 ab
E: 1,3-D+pic (InLine)	237.29 d	0.80 ab	1,907,00 cd	28.38 ab
F: 1,3-D+pic (Telopic)	45.81 bc	0.00 a	91.71 ab	0.36 a
G: Pic alone (Tripicrin)	148.75 cd	1.33 ab	2,574,11 cd	35.47 ab
H: DMDS+pic	97.05 c	0.40 ab	186.52 bc	2.47 ab
I: MI+pic (33-67) (Midas)	11.08 ab	0.07 a	17.02 a	0.70 a
J: DMDS+metam sodium	81.88 c	0.47 ab	192.87 bc	3.18 ab
K: Acrolein	192.32 cd	1.67 b	2,786.65 cd	45.86 b
L: Furfural	150.32 cd	0.73 ab	2,540,65 cd	50.81 b

Values are means of three replicates. Means followed by the same letter in each column were not significantly different ($0.05 \leq P$) by the LSD test. Transformation $\log(1+x)$.
¹Severity Index Scale: 0 (No symptoms) to 4 (all roots attacked).

Table 3. Weed control under the various fumigant treatments.

Treatments	Location 1: "Occifresa"			Location 2: "Cumbres Malvinas"		
	Time ¹	Biomass ²	N° weeds ³	Time ¹	Biomass ²	N° weeds ³
A: Control	66.7 a	33.3 a	17.0 a	61.0 a	73.3 a	13.0 a
B: MB+pic (50-50)	28.9 b	0.7 b	0.3 b	35.7 c	18.0 a	2.3 b
C: Sodium azide	38.4 b	26.7 ab	4.7 b	41.3 bc	61.7 a	4.0 b
D: Dazomet+1,3-D	29.1 b	1.3 b	1.7 b	35.3 c	17.3 a	2.7 b
E: 1,3-D+pic (InLine)	29.3 b	1.3 b	0.7 b	36.3 c	32.3 a	2.0 b
F: 1,3-D+pic (Telopic)	28.4 b	0.0 b	0.0 b	36.3 c	16.7 a	1.7 b
G: Pic alone (Tripicrin)	33.8 b	18.0 ab	3.3 b	32.3 c	0.7 a	0.3 b
H: DMDS+pic	30.9 b	18.3 ab	2.7 b	34.3 c	4.0 a	2.0 b
I: MI+pic (33-67) (Midas)	29.1 b	2.0 b	1.3 b	37.3 c	25.0 a	3.7 b
J: DMDS+metam sodium	36.0 b	16.3 ab	4.0 b	34.7 c	2.3 a	1.7 b
K: Acrolein	30.9 b	2.3 b	1.7 b	38.7 c	38.3 a	3.7 b
L: Furfural	35.1 b	6.7 ab	4.0 b	51.0 ab	61.7 a	11.0 a

¹Time: seconds/rep.; ²Biomass: g of weed eliminated/rep.; ³N° weeds: eliminated/rep.
 Values are means of three replicates. Means followed by the same letter in each column were not significantly different ($0.5 \leq P$) by the LSD test.

Table 4. Total commercial yield in grams/plant and relative yield.

Treatments	Loc. 1: Occifresa		Loc. 2: C. Malvinas		Two loc. average	
	Total yield ¹	Relative yield ²	Total yield ¹	Relative yield ²	Total yield ¹	Relative yield ²
A: Control	855 d	81.5 d	742 b	68.9 b	799 d	75.1 d
B: MB+pic (50-50)	1050 ab	100.0 ab	1078 a	100.0 a	1064 ab	100.0 ab
C: Sodium azide	1024 ab	97.5 ab	1015 a	94.2 a	1020 abc	95.8 abc
D: Dazomet+1,3-D	1116 a	106.3 a	1004 a	93.2 a	1060 ab	99.6 ab
E: 1,3-D+pic (InLine)	1036 ab	98.6 ab	1131 a	104.9 a	1083 a	101.8 a
F: 1,3-D+pic (Telopic)	1047 ab	99.7 ab	1110 a	102.9 a	1078 a	101.3 a
G: Pic alone (Tripicrin)	1025 ab	97.6 ab	1116 a	103.5 a	1070 ab	100.6 ab
H: DMDS+pic	1068 ab	101.8 ab	1119 a	103.8 a	1094 a	102.8 a
I: MI+pic(33-67) (Midas)	1067 ab	101.6 ab	1076 a	99.8 a	1072 ab	100.7 ab
J: DMDS+metam sodium	900 cd	85.7 cd	1003 a	93.1 a	952 c	89.4 c
K: Acrolein	971 bc	92.5 ab	1015 a	94.2 a	993 bc	93.4 bc
L: Furfural	867 d	82.6 d	831 b	77.1 b	849 d	79.8 d

¹Cumulated up to May 23rd, 2009; ²Relative yield in relation to MB standard treatment MB+pic (50-50) = 100%.
 Values are means of three replicates. Means followed by the same letter in each column were not significantly different ($0.5 \leq P$) by the LSD test.

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

Treatments	Loc. 1: Occifresa		Loc. 2: C. Malvinas		Two loc. average	
	g/fruit	Relative weight ¹	g/fruit	Relative weight ¹	g/fruit	Relative weight ¹
A: Control	26.0 e	90.7 e	22.9 c	84.3 c	24.5 e	87.6 e
B: MB+pic (50-50)	28.7 abc	100.0 abc	27.2 a	100.0 a	28.0 abc	100.0 abc
C: Sodium azide	29.2 ab	101.5 ab	26.5 ab	97.3 ab	27.8 abc	99.5 abc
D: Dazomet+1,3-D	28.7 abc	100.0 abc	26.5 ab	97.3 ab	27.6 bc	98.7 bc
E: 1,3-D+pic (InLine)	29.3 ab	101.8 ab	27.5 a	100.9 a	28.4 ab	101.4 ab
F: 1,3-D+pic (Telopic)	28.7 abc	100.1 abc	27.0 a	99.4 a	27.9 abc	99.7 abc
G: Pic alone (Tripicrin)	28.5 abc	99.4 abc	26.3 ab	96.8 ab	27.4 bc	98.1 bc
H: DMDS+pic	28.3 bc	98.5 bc	27.1 a	99.4 a	27.7 bc	98.9 bc
I: MI+pic (33-67) (Midas)	29.3 ab	101.8 ab	27.2 a	99.8 a	28.2 ab	100.9 ab
J: DMDS+metam sodium	27.9 cd	97.2 cd	26.5 ab	97.4 ab	27.2 cd	97.3 cd
K: Acrolein	29.6 a	103.0 a	27.8 a	102.3 a	28.7 a	102.7 a
L: Furfural	27.1 d	94.4 d	25.3 b	93.2 b	26.2 d	93.8 d

¹Relative weight in relation to MB standard treatment MB+pic (50-50) = 100%; $P \leq 0.05$.
 Values are means of three replicates. Means followed by the same letter in each column were not significantly different ($0.5 \leq P$) by the LSD test.