STRAWBERRY PRODUCTION IN SPAIN: ALTERNATIVES TO MB, 2007 RESULTS.

J.M. López-Aranda (1)*, L. Miranda (2), F. Romero (2), B. De Los Santos (2), C. Soria (1), R. Pérez-Jiménez (1), T. Zea (1), M. Talavera (3) and J.J. Medina (2)

(1) IFAPA. CICE-Junta de Andalucía, Churriana (Málaga), Spain
(2) IFAPA. CICE-JA, Alcalá del Rio and Moguer, Spain
(3) IFAPA. CICE-JA, Granada, Spain

The National project INIA on alternatives to methyl bromide (MB) has allowed ten years of work for strawberry cultivation in Huelva (Spain). In 2000/07 a new 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 m^2/rep.) and 12 fumigant treatments was used. Strawberry cv. 'Camarosa' was cultivated following conventional cultivation practices under large plastic tunnels. As antecedents, the 2002/03 to 2005/06 results were presented in MBAO International Conference (López-Aranda et al., 2003; López-Aranda et al., 2004; López-Aranda et al., 2005; López-Aranda et al., 2006). 2006/2007 treatments in both locations were (Table 1): A: untreated control, B: MB+pic (50-50), C: sodium azide (SEP-100™), D: dazomet+dichloropropene, E: EDN (Cyanogen™), F: 1,3D+Pic (61:35) (Telopic™), G: pic alone, H: DMDS+pic, I: methyl iodide (50-50) (Midas™), J: essential oils, K: methyl iodide (33-67) (Midas™) and, L: furfural (Multiguard™). Midas™ (MI+pic), Multiguard™ and essential oils were applied for first time in our strawberry field tests. Soil shank-applications were conducted on August, 23-24, 2006 (location 2) and September, 1, 2006 (location 1). Furfural, sodium azide and dazomet+dichloropropene pre-plant drip applications were delayed to the second week of September, 2006. Plantings were done on October 13 (location 2) and 17 (location 1), 2006.

Soil samples from each orchard were evaluated for fungal presence before and after treatments. Several treatments reduced significantly fungal population (MB+pic, EDN and MI+pic (50-50)); however, other chemicals were less effective (sodium azide, essential oils and furfural). Results will be presented and discussed. Ten plants per replication were selected to study plant monthly after planting date (Table 2).

Samples from the same plants per replication used for size (diameter) evaluation were examined at the end of the growing season (May 3, 2007), five plants for soil-borne fungi and five plants for nematodes presence. *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 3). Very high isolation frequencies of *Cylindrocarpon* spp. and *Fusarium* spp. and low isolation frequencies of *Rhizoctonia spp.*, *Macrophomina* spp. and species of *Pythium* were detected. All of them are important components of black root rot complex. Results on soil-borne fungi and nematodes control will be discussed. As in precedent growing seasons (2002/03 to 2005/06), plant survival, other agronomical traits and yields were optimal in both locations (Table 4). Average fruit weight is presented in Table 5. Results and current status of MB replacement in the area of Huelva will be discussed.

References

López-Aranda, J.M., Miranda, L., Romero, F., De Los Santos, B., Montes, F., Vega, J.M., Páez, J.I., Bascón, J. and Medina, J.J. 2003. Alternatives to MB for strawberry production in Huelva (Spain). 2003 Results. En: Proceedings Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions. November 3-6, 2003, San Diego, USA, 33:1-4. URL: http://www.mbao.org/

López-Aranda, J.M., Miranda, L., Soria, C., Romero, F., De Los Santos, B., Montes, F., Vega, J.M., Páez, J.I., Bascón, J. and Medina, J.J. 2004. Chemical alternatives to Methyl Bromide for strawberry production in Huelva (Spain). 2003/04 Results. En: Proc. 2004. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions. October, 31-November, 3, 2004, Orlando, USA, 41:1-4. URL: http:// www.mbao.org/

López-Aranda, J.M., Santos, B.M., Gilreath, J.P., Miranda, L., Soria, C. and Medina, J.J. 2005. Evaluation of Methyl Bromide alternatives for strawberry in Florida and Spain. En: Proc. 2005 Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions. November, 2005, San Diego, USA, 9:1. URL: http:// www.mbao.org/

López-Aranda, J.M., Miranda, L., Romero, F., De Los Santos, B., Soria, C., Pérez-Jiménez, R., Zea, T., Talavera, M., and Medina, J.J. 2006. Strawberry production in Spain: Alternatives to MB, 2006 results. En: Proc. 2006 Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions. November, 2006, Orlando, USA, 59:1-5. URL: http:// www.mbao.org/

Table 1. Treatments applied to soils in 2006/07.

Treatment	Rate (kg/ha of treated area)	Method of application	Mulch type
Control	Untreated	-	Black LDPE
MB+pic (50-50)	400	Shank, 4 chisels in bed	Black LDPE
Sodium azide (SEP-100)	120	Pre-plant drip irrigation	Black VIF
Dazomet+1,3-D	60+300	Pre-plant drip irrigation	Black VIF
EDN (Cyanogen)	400	Shank, 4 chisels in bed	Black VIF
1,3-D+pic (Telopic)	300	Shank, 4 chisels in bed	Black VIF
Pic alone	300	Shank, 4 chisels in bed	Black VIF
DMDS+pic	250+150	Shank, 4 chisels in bed	Black VIF
MI+pic (50-50) (Midas)	300	Shank, 4 chisels in bed	Black VIF
Essential oils	300	Shank, 4 chisels in bed	Black VIF
MI+pic (33-67) (Midas)	300	Shank, 4 chisels in bed	Black VIF
Furfural (Multiguard)	40 ml a.i.[1]/m^2 +2.5 ml/m^2	Pre-plant drip irrigation + monthly drip irrigation	Black VIF
[1]a.i. = active ingredient			

Table 2. Plant diameter in cm: 3, 5 and 7 months after transplant (mat).

	Loc. 1: Occifresa			Loc. 2: C. Malvinas			Two loc. average		
Treatments	3mat	5mat	7mat	3mat	5mat	7mat	3mat	5mat	7mat
Control	18.5 d	24.6 c	31.7 a	23.9 cd	26.8 c	32.4 e	21.2 d	25.7 e	32.0 e
MB+pic (50-50)	22.6 ab	29.0 ab	38.8 a	27.4 a	30.9 a	41.1 ab	25.0 ab	30.0 ab	39.9 a
Sodium azide	19.0 cd	25.6 c	36.9 a	25.3 bc	29.6 ab	39.6 abcd	22.1 cd	27.6 cd	38.2 abc
Dazomet+1,3-D	21.5 abc	27.3 abc	35.9 a	26.1 ab	29.5 ab	38.9 abcd	23.8 bc	28.4 bc	36.4 bcd
EDN	23.7 a	29.8 a	37.7 a	27.4 a	31.2 a	40.9 ab	25.6 a	30.5 a	39.3 ab
1,3-D+pic	22.1 ab	28.6 ab	38.6 a	26.5 ab	29.7 ab	40.1 abc	24.3 ab	29.2 abc	39.4 ab
Pic alone	24.3 a	29.7 ab	38.1 a	26.8 ab	30.1 ab	39.1 abcd	25.5 ab	29.9 ab	38.6 ab
DMDS+pic	22.4 ab	29.5 ab	38.1 a	27.3 ab	31.3 a	42.6 a	24.8 ab	30.4 a	40.4 a
MI+pic (50-50)	22.5 ab	26.7 bc	36.9 a	26.6 ab	29.4 ab	38.9 abcd	24.6 ab	28.0 c	37.9 abc
Essential oils	18.9 cd	25.2 c	33.0 a	23.6 cd	27.1 c	34.5 de	21.2 d	26.2 de	33.8 de
MI+pic (33-67)	22.0 ab	27.1 abc	38.2 a	26.2 ab	30.4 a	41.0 ab	24.1 ab	28.7 abc	39.6 ab
Furfural	19.9 bcd	27.3 abc	34.8 a	2.4 d	28.0 bc	32.3 cde	21.2 d	27.6 cd	35.0 cde

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 3. Nematode populations at the end of the growing season.

	Loc. 1: Occifresa: *Pratylenchus penetrans*	Loc. 2: C. Malvinas *Meloidogyne hapla*		
Treatments	individuals/g of roots	Severity Index[1]	Nº eggs+ J_2/g of roots	females/g of roots
Control	32.33 cd	2.13 b	4337.33 c	39.37 c
MB+pic (50-50)	5.00 ab	0.07 a	2.80 a	0.03 a
Sodium azide	20.97 bcd	1.67 ab	866.67 bc	6.90 bc
Dazomet+1,3-D	10.00 abc	1.00 ab	305.10 bc	2.50 ab
EDN	15.30 abcd	0.40 ab	35.00 ab	0.30 ab
1,3-D+pic	11.00 abcd	0.20 a	116.67 ab	0.60 ab
Pic alone	24.83 cd	0.53 ab	55.33 ab	0.37 ab
DMDS+pic	7.67 abc	0.67 ab	86.67 ab	0.43 ab
MI+pic (50-50)	2.50 a	0.13 a	24.00 ab	0.13 ab
Essential oils	43.13 d	1.13 ab	333.33 bc	2.33 ab
MI+pic (33-67)	18.63 abcd	0.13 a	5.67 a	0.10 ab
Furfural	15.50 abcd	0.87 ab	96.33 ab	0.70 ab

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. Transformation log (1+x).
[1]Severity Index Scale: 0 (No symptoms) to 4 (all roots attacked).

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

	Loc. 1: Occifresa		Loc. 2: C. Malvinas		Two loc. average	
Treatments	Total yield[1]	Relative yield[2]	Total yield[1]	Relative yield[2]	Total yield[1]	Relative yield[2]
Control	814 c	75.5	795 d	71.6	804	73.4
MB+pic (50-50)	1078 a	100	1111 a	100	1095	100
Sodium azide	1044 ab	96.8	1074 a	96.7	1059	96.7
Dazomet+1,3-D	1042 ab	96.7	1021 ab	91.9	1031	94.2
EDN	1127 a	104.5	1123 a	101.1	1125	102.7
1,3-D+pic	1105 a	102.5	1018 abc	91.6	1062	97.0
Pic alone	1121 a	104.0	1118 a	100.6	1120	102.3
DMDS+pic	1118 a	103.7	1110 a	99.9	1114	101.7
MI+pic (50-50)	1038 ab	96.2	1012 abc	91.1	1025	93.6
Essential oils	835 c	77.5	889 bcd	80.0	862	78.7
MI+pic (33-67)	1022 ab	94.8	997 abc	89.7	1010	92.2
Furfural	932 bc	86.5	844 cd	76.0	888	81.1

[1]Cumulated up to May 22nd, 2007; [2]Relative yield 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.

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

	Loc. 1: Occifresa		Loc. 2: C. Malvinas		Two loc. average	
Treatments	g/fruit	Relative weight[1]	g/fruit	Relative weight[1]	g/fruit	Relative weight[1]
Control	24.2 c	89.3	24.5 a	88.1	24.4 d	88.7
MB+pic (50-50)	27.1 a	100	27.8 a	100	27.5 a	100
Sodium azide	27.1 a	100	25.2 a	90.6	26.2 abc	95.3
Dazomet+1,3-D	26.7 a	98.5	26.0 a	93.5	26.4 ab	96.0
EDN	26.9 a	99.3	27.6 a	99.3	27.3 ab	99.3
1,3-D+pic	26.5 a	97.8	27.1 a	97.5	26.8 ab	97.5
Pic alone	26.7 a	98.5	26.7 a	96.0	26.7 ab	97.1
DMDS+pic	26.1 a	96.3	27.0 a	97.1	26.6 ab	96.7
MI+pic (50-50)	25.8 ab	95.2	26.5 a	95.3	26.1 abc	94.9
Essential oils	24.3 bc	89.7	24.8 a	89.2	24.6 cd	89.5
MI+pic (33-67)	26.1 a	96.3	25.4 a	91.4	25.8 bcd	93.8
Furfural	24.6 bc	90.8	24.2 a	87.1	24.4 d	88.7

[1]Relative 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.