STRAWBERRY NURSERIES IN SPAIN: ALTERNATIVES TO MB, 2006 RESULTS.

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The National project INIA on alternatives to methyl bromide (MB) has allowed nine years of work for high-elevation strawberry nurseries in Spain. The activities reported herein, corresponding to 2006 (named experiments), were carried out in two nurseries: Viveros California Inc. (Vinaderos, Avila) and Viveros Rio Eresma Inc. (Navalmanzano, Segovia) in Castilla-Leon (Northern-Central part of Spain), locations 1 and 2, respectively. The experimental design on each nursery was a 10 fumigant treatment complete randomized blocks with 4 large replications of 137.5 m^2 each. To emphasize differences between 2003, 2004, 2005 and 2006 experiments, treatments are presented in Table 1. Summaries of 2003 to 2005 results were presented in MBAO International Conference (De Cal et al., 2004, 2005; García-Méndez et al., 2006). A part of alternative treatments incorporated on 2006 experiments (all of them under VIF film) were similar to those applied on 2003 to 2005; as new stand-alone chemicals and new mixtures were: sodium azide (SEP-100™), essential oils, Midas™ (Methyl iodide: chloropicrin 50:50 w/w), metam sodium in combination with an experimental biofungicide developed by SGIT-INIA team (before planting mother plant roots were submerged in a suspension of *Penicillium oxalicum*, 10^7 conidia/ml) and mixture of chloropicrin plus dichloropropene. Preceding crops were cereals and sugar beet in both locations. Fumigation dates were April 5-6, 2006, with averaged 7-8ºC soil temperature and good weather. Essential oils application was delayed 2-3 days on each location. Cv. 'Camarosa' mother-plants from Californian nurseries were planted in May 3-4, 2006. Commercial daughter runner plants were estimated in September 19-20, 2006.

Beside these experiments, similarly to 2003-2005 period, a field demonstrations program has been carried out by this National project INIA in two different locations (named demonstrations): Viveros Grufresa Inc. (Cabezas de Alambre, Avila) and Viveros Herol Inc. (Mudrián, Segovia). Field demonstrations are presented in Table 2. Preceding crops were cereals in both locations. Fumigation

and planting dates were similar to those utilized for experiments; but in this case, commercial runner plants were machine-harvested from the whole demonstration field (1,000 m^2/demonstration), and trained crews sorted and counted the total number of marketable plants (i.e., > 9-10 mm diam. crown) in October, 2-3, 2006 (Segovia, Mudrián) and in October 19-20, 2006 in (Avila, Cabezas de Alambre).

Soil samples from each field experiment were evaluated before and after soil fumigant treatments in selective media. Total colony forming units per gram of dry soil (CFU/g) of *Fusarium, Phytophthora, Pythium*, *Rhizoctonia,* and *Verticillium* were estimated in each replication. Two times (July and September) during the strawberry growing period (medium and full running activity), 20 runner plants were randomly chosen in each replication and analyzed to calculate the incidence of diseased plants (%) per each treatment. Results on soil borne fungi control and disease incidence (%) in experiments will be discussed. All the fumigants (except untreated control) reduced quantitatively the soil fungal and nematode population and compared well with MB+pic (50/50) fumigation. The incidence of diseased plants during running activity showed that more than the 50% of death plants were no caused by soil borne pathogens, and only less than 5% of plants was lost due to soil fungal and nematode population; it means difficulties to point out statistic differences between treatments on control of strawberry nursery diseases.

To monitor weed populations at each location, areas of 3.5 m^2 were left unweeded in each plot of experiments throughout the duration of each study. Weeds were sampled and removed on five dates, from early-July until mid-September. At each sample date, weed species present, total weed density and total fresh weight were measured for each treatment. In the case of demonstration fields, two areas of 15 m^2 per demonstration were left unweeded. The most common weeds in the experimental and demonstration plots were common purslane (*Portulaca oleracea)*, common lambsquarters *(Chenopodium album)* and mallow (*Malva* spp.) in Avila locations and *Chenopodium album*, Italian ryegrass (*Lolium* spp.) and pigweeds *(Amaranthus retroflexus)* in Segovia locations. The presence of weeds is summarized in Tables 3 and 4. Results on weed control will be discussed.

Results regarding fresh commercial plants harvested (field experiments) are in Table 5. As in previous years, the 2006 experiments showed that agronomic results are not consistent enough. Furthermore, field demonstrations showed yield inconsistency (Table 6). Results on strawberry plant production will be discussed. So far, some inconsistency on weed control and yield stability remains for chemical alternatives to MB in strawberry nurseries.

References

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Table 1. MB Alternatives 2003 to 2006. Nursery field experiments.

2003 Experiments:		**2004 Experiments:**	
Treatments	Description	Treatments	Description
Control PE	Untreated	Control PE	Untreated
MB(50/50)[y] PE	40 g/m^2 - 8 chisels	MB(50/50)[y] PE	40 g/m^2 - 8 chisels
MB(33/67)[y] VIF	20 g/m^2 - 8 chisels	MB(33/67)[y] VIF	30 g/m^2 - 8 chisels
Dazomet VIF	35 g/m^2 - rototilled	Dazomet VIF	40 g/m^2 - rototilled
Telopic VIF	30 g/m^2 - 8 chisels	Telopic VIF	30 g/m^2 - 8 chisels
Pic VIF	30 g/m^2 - 8 chisels	Pic VIF	30 g/m^2 - 8 chisels
MS+Pic VIF	40+25 g/m^2 - 8 chisels	MS+Pic VIF	40+25 g/m^2- 8 chisels
DMDS VIF	65 g/m^2 - 8 chisels	MB(50/50)[y] VIF	30 g/m^2 - 8 chisels
DMDS+Pic VIF	20+20 g/m^2 - 8 chisels	DMDS+Pic VIF	25+25 g/m^2 - 8 chisels
Propozone PE	30 g/m^2 - 8 chisels	Propozone VIF	50 g/m^2 - 8 chisels
2005 Experiments:		**2006 Experiments:**	
Treatments	Description	Treatments	Description
Control PE	Untreated	Control PE	Untreated
MB(50/50)[y] PE	40 g/m^2 - 8 chisels	MB(50/50)[y] PE	40 g/m^2 - 8 chisels
EDN VIF	40 g/m^2 - 8 chisels	EDN VIF	40 g/m^2 - 8 chisels
DMDS+Pic VIF	40+15 g/m^2 - 8 chisels	DMDS+Pic VIF	40+15 g/m^2 - 8 chisels
Telopic VIF	30 g/m^2 - 8 chisels	Telopic VIF	30 g/m^2 - 8 chisels
MS+Pic VIF	50+15 g/m^2- 8 chisels	MS+Biofungicide VIF	50+15 g/m^2- 8 chisels
Propozone+MS	45+30 g/m^2 - 8 chisels	Sodium azide VIF	6 g a.i.[z]/ m^2 - sprinkler
Pic VIF	30 g/m^2 - 8 chisels	MI+Pic(50/50) VIF	30 g/m^2 - 8 chisels
Enzone+Pic VIF	50+15 g/m^2- 8 chisels	Essential oils VIF	30 g/m^2 - 8 chisels
Dazomet +Telopic VIF	25+20 g/m^2 - 8 chisels	Pic+DD VIF	18+12 g/m^2 - 8 chisels
[y]MB+Pic mixture; [z] a.i. = active ingredient; all treatments were broadcast applied			

Table 2. MB Alternatives 2005. Nursery field demonstrations.

Treatments	Demo surface (m^2)
MB-Pic (50:50) 300 kg/ha VIF	1,000
Pic alone 350 kg/ha VIF	1,000
Telopic 350 kg/ha VIF	1,000
Metam sodium 1,500 kg/ha VIF	1,000
Dazomet+dichloropropene (50+400 kg/ha) VIF	1,000

Table 3. Nursery field experiments. Fumigation treatments effects on weed density and fresh weed weight.

	Weed density (number/replication[y])		Fresh weed wt. (g/replication[y])	
Fumigation treatments	Vinaderos-Avila	Navalmanzano-Segovia	Vinaderos-Avila	Navalmanzano-Segovia
Control PE	90.85 a[z]	40.50 a	487.70 ab	194.92 a
Essential oils VIF	70.45 a	23.45 b	632.00 a	92.99 a
Telopic VIF	18.60 b	20.95 bc	198.00 bc	158.11 a
Sodium azide VIF	7.55 b	12.05 bcd	57.40 c	116.55 a
MI+Pic(50/50) VIF	3.00 b	11.45 bcd	40.10 c	51.00 a
MS+Biofungicide VIF	3.15 b	9.70 bcd	33.80 c	35.36 a
DMDS+Pic VIF	3.20 b	8.30 cd	32.90 c	78.37 a
Pic+DD VIF	5.10 b	3.95 d	62.90 c	15.56 a
EDN VIF	3.85 b	4.65 d	36.30 c	104.75 c
MB(50/50) PE	1.60 b	3.50 d	13.70 c	12.17 a

[y]Average of five samplings; replication = area of 3.5 m^2
[z]Means followed by the same letter within a column each year are not significantly different according to Duncan's multiple range test ($P \leq 0.05$)

Table 4. Nursery field demonstrations. Fumigation treatments effects on weed density and fresh weed weight.

	Weed density (number/replication[y])		Fresh weed wt. (g/replication[y])	
Fumigation treatments	C. Alambre-Avila	Mudrián-Segovia	C. Alambre-Avila	Mudrián-Segovia
Pic alone 350 kg/ha VIF	36.80 a[z]	9.70 abc	619.90 a	83.35 a
MB-Pic (50:50) 300 kg/ha VIF	1.20 b	15.70 a	12.50 b	115.43 a
Telopic 350 kg/ha VIF	2.90 b	14.50 ab	25.10 b	94.64 a
Metam sodium 1,500 kg/ha VIF	1.20 b	5.80 bc	20.90 b	58.56 a
Dazomet+dichloropropene (50+400 kg/ha) VIF	1.70 b	4.70 c	11.30 b	29.30 a

[y]Average of five samplings; replication = area of 15 m^2
[z]Means followed by the same letter within a column each year are not significantly different according to Duncan's multiple range test ($P \leq 0.05$)

Table 5. Nursery field experiments. Total and relative marketable runner plant production estimation.

	Vinaderos-Avila		Navalmanzano-Segovia		Two locations aver.	
Fumigation treatments	Plants·ha^{-1}	Relative[y]	Plants·ha^{-1}	Relative[y]	Plants·ha^{-1}	Relative[y]
MI+Pic(50/50) VIF	437,500 abc[z]	96.7	552,500 a	119.5	495,000 a	108.2
Pic+DD VIF	482,500 a	106.6	437,500 abc	94.6	460,000 a	100.5
MB(50/50) PE	452,500 ab	100	462,500 ab	100	457,500 a	100
Telopic VIF	402,500 abcd	89.0	477,500 ab	103.2	440,000 ab	96.2
MS+Biofungicide VIF	435,000 abc	96.1	442,500 abc	95.7	438,750 ab	95.9
EDN VIF	427,500 abc	94.5	420,000 abc	90.8	423,750 abc	92.6
DMDS+Pic VIF	317,500 abcd	70.2	485,000 ab	104.9	401,250 abcd	87.7
Essential oils VIF	280,000 cd	61.9	382,500 bc	82.7	331,250 bcd	72.4
Sodium azide VIF	250,000 d	55.2	382,500 bc	82.7	316,000 cd	69.1
Control PE	297,500 bcd	65.7	297,500 c	64.3	297,500 d	65.0

[y]Relative plant production to standard MB:Pic (50/50) under transparent PE
[z]Means followed by the same letter within a column each year are not significantly different according to Duncan's multiple range test ($P \leq 0.05$)

Table 6. Nursery field demonstrations. Total and relative marketable runner plant machine-harvested production.

	C. Alambre-Avila		Mudrián-Segovia		Two locations aver.	
Fumigation treatments	Plants·ha^{-1}	Relative[z]	Plants·ha^{-1}	Relative[z]	Plants·ha^{-1}	Relative[z]
MB-Pic (50:50) 300 kg/ha VIF	509,000	100	519,000	100	514,000	100
Pic alone 350 kg/ha VIF	512,500	100.7	403,000	77.6	457,750	89.0
Metam sodium 1,500 kg/ha VIF	451,500	88.7	380,000	73.2	415,750	80.9
Dazomet+dichloropropene (50+400 kg/ha) VIF	451,500	88.7	352,000	67.8	401,750	78.2
Telopic 350 kg/ha VIF	406,000	79.8	383,000	73.8	394,500	76.8

[z]Relative plant production to MB:Pic (50/50) under transparent VIF