THREE YEARS OF RESULTS ON CHEMICAL ALTERNATIVES TO METHYL BROMIDE FOR STRAWBERRY NURSERIES IN SPAIN.

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The surface of strawberry high-elevation nurseries in Spain is of around 1,100 ha and its productions are 500 to 550 million of commercial runner plants per year. In the recent past they have had a consumption of 500 t/year of MB-Pic (98%-2% or 67%-33%). This cultivation is one of the high-priority aims inside the National project INIA SC 97-130 on alternatives to MB. The high-elevation nurseries are located in sandy and flat areas of Castile-Leon (Central-Northern part of Spain), with elevation above see level between 800 and 1,100 m, and under continental climatic conditions. For this kind of crops it is customary to change of location from time to time by means of farm-leasing. The cultivation system is annual with plantation dates between April and May and digging of fresh commercial runner plants along October. 95% of mother plants come from big Californian nurseries. The general sanitary status of the Spanish high-elevation nurseries has been satisfactory. The biggest sanitary problems are *Phytophthora cactorum*, *Verticillium* spp., phytoplasms and weeds. These experiments are being carried out in collaboration with two big nurseries: Viveros California SAT and Viveros Rio Eresma SA, in their farms located at Arévalo (Avila) and Navalmanzano (Segovia), respectively. It has been intentionally experimented the change in locations with the aim to introduce the geographic mobility in our experiments. Details of locations, previous cultivations, dates of fumigation, plantation and digging, and existing climatic conditions in the fumigation-plantation period are attached in Table 1. It has been established randomized complete blocks design with three replications, the size of each experimental unit was 400 m^2 (5.5 m wide, with 3 rows of mother plants cv. "Camarosa" coming from Californian nurseries, and 72 m long). Fumigant treatments are summarized in Table 2.

The 1998 results pointed out the difficulty to find alternatives to MB in the case of strawberry nursery (Table 3). These figures need a cautious explanation: a good sanitary status of both nurseries before and after pre-plant treatments was found, but mother-plants infected with *Phytophthora cactorum* in the nursery were also detected. Our 1998 data showed better agronomical protection with MB-Pic (50-50) (40 g/m^2 or 20

g/m^2 VIF) in the presence of biotic (infected mother-plants) or abiotic (flooding) stresses (López-Aranda, 1999). During the winter of 1999 it was repeated the experiments with the same nurseries but at different locations. Treatments were very similar to those used in 1998 (Table 2); Telone C-17 was substituted by Dazomet (50 g/m^2) sealed with plastic film. Before planting a detailed analysis of Californian mother plants was made. In both cases presence of *Phytophthora cactorum* was evidenced (6% of the plants in Navalmanzano-2 and 4% in Arévalo). However, in 1999 trials no biotic or abiotic problems were observed; only *Verticillium* spp. was observed in the controls at Navalmanzano-2. At both locations, they were observed from the beginning of the vegetative activity (June) some episodic yellowing of runner plants in experimental units with Dazomet that could be attributed to phytotoxicity symptoms but this could not be established with certainty. The 1999 results are presented in Table 4. They showed different trends to the ones observed in 1998. Besides the exceptional comparative result of Telopic (Telone C-35) in Navalmanzano-2, a worse productive behavior was evidenced in the controls. Once again, in the winter of 2000 we have repeated the experiments with the same nurseries but at new different locations. Fumigant treatments were similar to those used in 1999 (Table 2); adding shank application of Metam Sodium (125 cc/m^2) and Metam Potassium (160 cc/m^2) sealed with plastic film. During the 2000 trials it was not observed any biotic or abiotic problems with the exception of *Verticillium* spp. and weed infestation in Navalmanzano-3 location affecting controls without fumigation. The 2000 results are presented in Table 5. Every year and location, at the moment of digging, a sample with 20 commercial runner plants per replication was taken to determine fresh and dry weight of crowns and roots and crown diameter. No differences were observed among treatments included controls without soil fumigation. Nematofauna has been abundant in all locations inside the normal limits. At Navalmanzano-1, 2 and 3, it was constituted by Rhabditidae, Dorilaimidae non parasitics, Mononquidae and a low proportion of Tilenquidae from diverse genera *(Aphelenchus* spp., *Scincura* spp., Tylenchus spp., *Tylenchorhynchus* spp., *Pratylenchus* spp., *Neotylenchus* spp.), none of them parasitic of the strawberry. At Avila locations (C. Alambre, Arévalo and Vinaderos), the populations were in consonance with the previous cereal cultivation: *Pratylenchus zeae*, *Heterodera avenae*, *Globodera* spp., and *Punctodera* spp., besides other Tilenquidae and Rhabditidae. Neither in this case no parasites of the strawberry were detected. All the chemical treatments did reduce nematode populations. The sampling at several dates did not reveal nematode damages.

In conclusion, these three year of results showed the special difficulty to find viable alternatives to MB in the case of strawberry high-elevation nurseries. Their peculiarities, such as geographic mobility and winter period of fumigant treatments, they have caused in our experiments different trends in each year. Nevertheless, these results allow to clarify some elements: a) good behavior of treatments with shank application of MB-Pic (50-50) (20 g/m^2) under VIF film technology; what is a very important fact for the hypothetical case of "critical uses" in the EU territory (this cultivation could be clear exponent); b) We have started to clarify and to characterize the global behavior as chemical alternatives to MB of Telopic (Telone C-35), Dazomet and Metam Potassium. In the case of strawberry high-elevation nurseries in Castile-Leon, our results pointed out that more time for experimental work is needed.

References

López-Aranda, J.M. 1999. The Spanish National Project on alternatives to MB: The case of strawberry. En: 1999 Annual International Research Conference on Methyl Bromide alternatives and Emissions reductions. November 1-4, San Diego (California): 8-1 to 8-4.

Table 1. Summary of locations, previous crops, Dates of experiments and climatic conditions.

Year	Location A Avila	Location B Segovia	Previous crops	Date of treatments	Date of plantation	Date of harvest	Climatic conditions
1998	Cabeza de Alambre	Naval-manzano-1	Straw. nurs.	March, 24-30	April, 22-24	Octob., 8-13	Very bad
1999	Arévalo	Nava-lmanzano-2	Fallow +Straw.nurs	March, 26-April, 9	April,30(A)-May,5(B)	Octob., 14	Very good
2000	Vinaderos	Naval-manzano-3	Fallow+ Sugar beet/ cereals	March, 22-April, 5	April,18(B)-May,16(A)	Octob., 7	Good

Table 2. Fumigant treatments. 1998-2000. High-elevation nurseries.

Year	Treatments	Description
1998	Control	Control without soil fumigation
	MB(40)	MB-Pic (67/33) 40 g/m^2 shank applied, broadcast
	MB(20)VIF	MB-Pic (67/33) 20 g/m^2 shank applied, broadcast VIF transp. film
	Telone C-17	Telone C-17 40 cc/m^2 shank applied, broadcast
	Telopic	Telone C-35 35 cc/m^2 shank applied, broadcast
	Chloropicrin alone	Chloropicrin 40 g/m^2 shank applied, broadcast
1999	Control	Control without soil fumigation
	MB(40)	MB-Pic (50/50) 40 g/m^2 shank applied, broadcast
	MB(20)VIF	MB-Pic (50/50) 20 g/m^2 shank applied, broadcast VIF transp. film
	Dazomet	Dazomet 50 g/m^2 incorporation , sealed with plastic film, broadcast
	Telopic	Telone C-35 35 cc/m^2 shank applied, broadcast
	Chloropicrin alone	Chloropicrin 40 g/m^2 shank applied, broadcast
2000	Control	Control without soil fumigation
	MB(40)	MB-Pic (50/50) 40 g/m^2 shank applied, broadcast
	MB(20)VIF	MB-Pic (50/50) 20 g/m^2 shank applied, broadcast VIF transp. film
	Dazomet	Dazomet 50 g/m^2 incorporation , sealed with plastic, broadcast
	Telopic	Telone C-35 40 cc/m^2 shank applied, broadcast
	Chloropicrin alone	Chloropicrin 40 g/m^2 shank applied, broadcast
	Metam Sodium	Metam Sodium 125 cc/m^2 shank applied, sealed plastic, broadcast
	Metam Potassium	Metam Potassium 160 cc/m^2 shank applied, sealed plastic, broadcast

Table 3. 1998 Results.Yield: Commercial runner plants dug (harvested)/ha.

Treatments	Cabeza de Alambre	Navalmanzano-1	Two locations average
MB (40)	529,000 a	476,000 a (**)	502,000 a(**)
MB (20) VIF	554,000 a	439,000 ab	497,000 a
Telone C-17	461,000 ab	413,000 ab	437,000 ab
Telopic	386,000 b	380,000 ab	383,000 bc
Chloropicrin alone	383,000 b	354,000 b	369,000 c
Control	131,000 c P < 0.01	184,000 c P < 0.05	158,000 d P < 0.05

Table 4. 1999 Results.Yield: Commercial runner plants dug (harvested)/ha.

Treatments	Arévalo	Navalmanzano-2	Two locations average
Telopic	508,300 a	690,000 a	599,200 a
Chloropicrin alone	526,700 a	590,300 ab	560,200 a
MB (20) VIF	541,700 a	531,700 bc	536,700 a
Dazomet	481,700 a	561,700 bc	521,700 ab
MB (40)	521,700 a	513,300 bc	517,500 ab
Control	423,300 a P < 0.05	445,000 c P < 0.05	434,200 b P < 0.05

Table 5. 2000 Results.Yield: Commercial runner plants dug (harvested)/ha.

Treatments	Vinaderos	Navalmanzano-3	Two locations average
MB (20) VIF	633.330 a	826.670 a	730.000 a
MB (40)	670.000 a	670.000 ab	670.000 ab
Metam Potassium	683.330 a	616.670 b	650.000 ab
Chloropicrin	623.330 a	660.000 ab	641.670 ab
Metam Sodium	530.000 a	630.000 b	580.000 bc
Dazomet	550.000 a	583.330 b	566.670 bc
Telopic	526.670 a	530.000 b	528.330 c
Control	486.670 a P < 0.05	170.000 c P < 0.05	328.330 d P < 0.05