THE SPANISH NATIONAL PROJECT ON ALTERNATIVES TO MB: THE CASE OF STRAWBERRY.

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The experiments on strawberry reported in this communication are part of a much larger project (SC 97-130) supported by the Ministry of Agriculture to find out short term chemical and nonchemical alternatives to MB for pre-planting fumigation in several model crops: carrots, cut- flowers, sweet pepers, citrus and strawberry, the major problems in relation with the MB issue in Spain. For insteance, the 40% of the Spanish MB market is dedicated to the strawberry industry with 1,725 mt of consumption in 1995. Alternatives have been tested in two experiments at real scale (Moguer and Cartaya) at Huelva (the main strawberry area in Europe) during 1997-1998 and 1998- 1999; in addition, chemical alternatives have been tested in two experiments (Arévalo and Navalmanzano) at Castile-Leon (the main strawberry nursery area in Europe) during 1998 and 1999. In 1999, the strawberry area cultivated in Huelva was 8,200 ha with near 320,000 mt of production, while the strawberry surface cultivated in Castile-Leon was 1,100 ha with 500-550 millions of commercial runners harvested. The high elevation strawberry nurseries with continental climatic conditions are annual cultivation systems between mid-April and October; generally, the sanitary satus of the culture is well solved since the Spanish regulations require pre-planting soil desinfection. In strawberry nurseries, a permanent problem is *Phytophtora cactorum*. The strawberry sector in Huelva uses the annual winter planting system with fresh plants. Planting month is October. Also, the general sanitary status of the culture is usually well solved. Permanent problems in strawberry production are *Botrytis cinerea* and *Sphaeroteca macularis*.

The short term conditions permit to work in three lines of alternatives based in our own "art of technology": a) non chemical alternatives; b) new chemical alternatives and recovery of old ones; c) dosage reductions of MB. In two collaborating farms at Huelva, there are two permanent randomized blocks with three replications each. The initial treatments (1997-1998) begun in the summer (July) of 1997 and they were: controls without pre-planting desinfection; standardized injection of MB (67-33), 40 g/sm; solarization alone, 6 weeks; solarization with simultaneous injection of 10 g/sm MB (67-33); or simultaneous injection of 50 cc/sm Metam Sodium; or simultaneous biofumigation (additional incorporation of mushroom compost, 5 kg/sm); injection of MB (67-33), 40 g/sm, on preformed beds (50% total surface), below black PE sheet; injection of MB (67-33), 20 g/sm, to all treated surface, below VIF transparent sheet; injection of MB (67-33), 20 g/sm, on preformed beds, below VIF black sheet; injection of Telone C-17, 60 cc/sm; injection of chloropicrin, 40 g/sm. In two collaborating nurseries at Castile-Leon there was one permanent randomized block with three replications. The initial treatments (1998) begun in the winter (March) of that year and they were: control without pre-planting desinfection; standardized injection of MB (67-33), 40 g/sm; injection of MB (67-33), 20 g/sm, below VIF transparent sheet; injection of Telone C-17, 40 cc/sm; injection of Telone

C-35, 35 cc/sm; injection of chloropicrin, 40 g/sm.
In 1997-1998, including controls, a good sanitary status of plant material (cv. “Camarosa”) was evident. Only in some plots of Cartaya (Huelva) presence of *Meloidogyne* spp. was dectected. Chemical alternatives (chloropicrin and Telone C-17) gave the higest yield results but at the same significance level than dose reductions and stardand injection (40 g/sm) of MB; however, solarization combined with chemical treatments was situated in a lower level of productivity but not significantly different than the former treatments. Alternatives with solarization alone or in combination with biofumigation and not pre-planting desinfection gave significantly the poorest results (Table 1). These 1997-1998 results point out the possible chemical alternatives with clear potential to keep productivity, fruit quality and sanitary status levels, similar to MB standard utilization (40 g/sm) in the area. However, this observation must be verified over several seasons. Moreover, solarization treatments in combination with chemical support give agronomical results similar to chemical alternatives but the "art of technology" must be improved. The first results point out no differences between MB treatments to all treated surface and below preformed beds and the good adjustment of 50% reduction hypothesis below VIF plastic. This idea opens the door to a 90% dosage reduction demonstration. The 1998 results point out the difficulty to easily find alternatives to MB in the case of strawberry nursery (Table 2). These figures need cautious explanation; a good sanitary status of both nurseries before and after pre-plant treatments was found; but mother-plants infected in origin with *Phytophtora cactorum* were also detected. With all kind of cautions our 1998 data show better agronomical protection with MB in the presence of biotic (contaminations in mother plants) or abiotic (flooding) stresses.

We started the second year during summer 1998, in accordance with the following criteria: a) the same treatments in the same experimental unities than 1997; b) solarization treatments during 5 weeks and a new engine prototype utilization; c) increase until 100 cc/sm of Metam Sodium dosage in simultaneous solarization treatment; d) improved biofumigation technique followed by sowing of a kind of turnip ("nabina") (*Brassica oleracea*) and green soil incorporation at the end of September; e) Metam Sodium, Telone C-35 and Dazomet as direct chemical alternatives; f) sistematic utilization of MB injected new formula 50-50 (MB-chloropicrin). As observed in 1997-1998 season, in 1998-1999 the sanitary status of the trials was normal. In all cases, including controls, a very good sanitary status of plant material was evident. Newly, in several plots of Cartaya (Huelva) there was presence of *Meloidogyne hapla*. In this second year of trials, once more, chemical alternatives (chloropicrin, Telone C-35 and Dazomet) gave the higest yields but at the same significance level than dosage reductions and stardand injection (40 g/sm) of MB; however, solarization combined with chemical treatments were situated at a lower level of productivity than the former treatments. Alternatives with solarization alone or in combination with biofumigation and not pre-planting desinfection controls gave, very significantly, the poorest total and early yield results (Table 3). In the absence of relevant pathological problems, the great differences found out only two years after initiation of the trials can be related with allelopathic and soil stress phenomena. These first figures of the national project in the Huelva's strawberry area support the idea of a global chemical alternative to MB and perhaps, as a second level, global physical alternatives like solarization always powered with chemical support would also be possible. However, we

have taken a cautious attitude; it is necessary to know the long-term effects of the lack of MB protection all along the years and the economical evaluation at real scale of new global alternatives is under way.

Table 1. Commercial yield (g/plant) in "Camarosa" strawberry. Two locations results. Huelva. 1997-1998.

Treatments	Total yield (until June,1st,98)	Early yield (until March, 31st,98)
Chloropicrin (40 g)	796 a	278 a
Telone C-17 (60 cc)	779 ab	271 a
MB (40g) preformed beds	768 ab	259 abc
MB (20g) preformed beds VIF	756 ab	261 ab
MB (40g) chem. alt.	752 ab	267 a
MB (20g) VIF	748 ab	263 ab
Solarization + MB(10g)	746 ab	265 ab
MB (40g) phys. alt.	744 ab	267 a
Solarization + Metam S(50 cc)	725 bc	264 ab
Solarization	668 cd	233 cd
Solarizatión + Biofumigat.	662 d	240 bcd
Control (no desinf.) chem.	638 d	205 e
Control (no desinf.) phys.	615 d	221 de

$P \leq 0.05$;

Table 2. Commercial yield (plants/ha) in "Camarosa" nurseries. Castile-Leon. 1998.

Treatments	Nursery in Arévalo (Avila)	Nursery in Naval-manzano (Segovia)	Average two localities
MB (40g)	529,000 a (*)	476,000 a (**)	502,000 a(**)
MB (20g) VIF	554,000 a	439,000 ab	497,000 a
Telone C-17 (40 cc)	461,000 ab	413,000 ab	437,000 ab
Telone C-35 (35 cc)	386,000 b	380,000 ab	383,000 bc
Chloropicrin (40 g)	383,000 b	354,000 b	369,000 c
Control (no desinf.)	131,000 c	184,000 c	158,000 d

(**) $P < 0.05$; (*) $P < 0.01$

Table 3. Commercial yield (g/plant) in "Camarosa" strawberry. Two locations results. Huelva. 1998-1999.

Treatments	Total yield (until May, 15th,99)	Harvest index
Telone C-35 (40 cc)	565 a	106
Chloropicrin (40 g)	551 ab	103
MB (20g) preformed beds VIF	544 abc	102
Dazomet (50 g)	535 abc	100
MB (40g) phys. alt.	534 abc	100
MB (40g) preformed beds	527 abc	99
Solarization + Metam S(100 cc)	523 abc	98
Metam S (125 cc)	513 bc	96
Solarization + MB(10g)	500 c	93
Solarization + Biofumigat.	446 d	83
Solarization	434 ef	81
Control (no desinf.) phys.	387 fg	72
Control (no desinf.) chem.	374 g	70

$P < 0.05$;