AGRICULTURAL PRODUCTION IN THE EU FIVE YEARS AFTER THE END OF METHYL BROMIDE: PROBLEMS AND SOLUTIONS.

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In EU soil fumigation represents a main component for many horticultural crops, in particular for Southern Mediterranean countries and for intensive monocultural systems: small fruits and nursery (strawberry and raspberry), solanaceae (tomato, pepper, egg plant), cucurbits (melon, watermelon, cucumber and others) and cut flowers (mainly carnation and roses). In general, the use of agrochemicals in intensive agriculture has decreased in more than 30%, due to the agro-environmental EU policy and public opinion pressure. The EU regulations, increasingly, are limiting pesticides (and chemical fumigants), stimulating industries to face new challenges. The availability of chemical MB alternatives is unclear. In fact, in a different way than other international industries, the intensive agriculture in the EU has suffered two simultaneous restrictions: a) MB phase out and just immediately after, b) the non-inclusion of the most important chemical alternatives, 1,3D an chloropicrin. MB was phased out in the EU by 2008, after the compromise of the Montreal Protocol accordingly with the Regulation (EC) 2037/2000 on substances that deplete the ozone layer for soil and structural uses and 1,3D and chloropicrin by decisions taking account the Regulation (CE) 1107/2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC.

The phase-out of MB was clear and unanimously accepted by all the EU Member States accordingly with the international commitments signed on to the Montreal Protocol. However the non-inclusion (*de facto* prohibition) in the Annex I of the Regulation (CE) 1107/2009 (former Council Directive 91/414/EEC) of 1,3D and chloropicrin was a clear political decision of the qualified majority of the EU Northern and Central countries in front of EU Southern countries (also, the different way of votes from similar agro-environmental countries like The Netherlands and Belgium, was paradigmatic). Moreover, Regulation (EC) 1005/2009 prohibited after 18 March 2010 the use of MB for QPS purposes within the EU except in an emergency. For instance, this fact burns bridges to future and hypothetical utilization of MB for nurseries as QPS exemption within the EU.

The current situation of fumigants within the EU is as follows: MB absolutely banned even for QPS purposes. Dazomet authorized (included in Annex I), but allowed every three seasons and with a maximum rate of 490 kg/ha. This rate

would be OK for growers and nurserymen. Metam sodium and Metam potassium authorized (included in Annex I), but also every three seasons and with a maximum rate of 490 kg/ha. This rate would be absolutely not enough for growers and nurserymen, because current rates use to be in a range between 500 to 1000 l/ha (600 to 1200 kg/ha); the application system must be under plastic film. Currently, it is the only available list of fumigants within the EU.

However, Community regulations and agricultural reality are very different. As an example, we can consider the main chemical alternatives in the world: 1,3D and chloropicrin. *Strictu sensu* 1,3D and Pic are excluded of Annex I since 2010 and 2013, respectively. However, nowadays both are the most important MB alternatives in the EU (near 70% of utilization). This fact is due to the legal possibility of the Member States to allow temporary (120 days/year) authorizations for particular agricultural industries (sectors) (National emergency uses). This was the case for 1,3D since 2009 till 2013 (Belgium, Cyprus, France, Greece, Italy, Portugal and Spain); and right now the applications for chloropicrin temporary authorization for 2013 are underway in Italy, Spain and United Kingdom. However, the future of these limited authorizations for 1,3D and chloropicrin is very unclear in the short term. For this reason, owners of both molecules are now ongoing new requests of inclusion in Annex I. In the short and medium term the only new chemical in the EU to be included in Annex I would be DMDS (dimethyl disulfide). This legal situation of fumigants within the EU will be discussed. The utilization of fumigants based on the generation of methyl isothiocyanate is now strategic for some important agricultural sectors. In particular, "CleanStart" programme, based on Dazomet, will be summarized and discussed. The new landscape of fumigants within the EU presents new challenges in R+D: needs for lower rates of fumigants (looking back to VIF and TIF plastic technology), needs for new systems of application (e.g. Spading implements), needs for new machinery; and needs for alternation of fumigants every season of cultivation (year).

The quantities approved of MB for the UE as CUE were 4039 t in 2005 (2133 t Italy, 1059 Spain, 430.5 t France, 200 t Greece, 78.4 t United Kingdom, 50 t Portugal, 46.97 t Belgium, 40 t Poland, and 1,1 t Malta). In 2006 were 3378 t (mainly Italy with 1741 t, Spain 941.29 t, and France 416.3 t). In 2007 CUE were 633 t (Spain 318.57 t, Italy 222 t, France 68 t and Poland 24.5 t). And finally in 2008, 227 t for strawberry nurseries (Spain 215 t and Poland 12 t). These figures are in correspondence with the importance of the industries involved at world and EU level. Italy, Spain and France represent a very high percentage of production of vegetables, cut flowers, small fruits, nurseries and other sectors historically linked to the consumption of MB. In fact, within the EU-27, in 2011, Italy and Spain had the largest vegetable production among the EU Member States, with a combined share that was equal to 41.5 % of the EU-27's production.

By industries, the most significant MB CUE consumers were: tomato protected (1158 t, 823.5 t and 80 t, in 2005, 2006 and 2007, respectively. Mostly in Italy, 80% of these quantities). This is in contrast with Spain (Almeria area) one of the

biggest acreage of protected vegetables in the EU that did not applied never for MB CUN. Strawberry fruit production under plastic tunnels (1121 t and 960 t, in 2005 and 2007, respectively. Mostly in Spain (Huelva area) the biggest strawberry producer within the EU (50% of these quantities). Strawberry and other berry (raspberry) nurseries (444 t, 491 t, 319 t and 227 t, in 2005, 2006, 2007 and 2008, respectively. Cut-flower (mainly carnation and roses) with 451 t, 319 t and 83 t, respectively, (Italy with 55-60% of these quantities). Pepper protected (360 t, 313 t and 118 t, respectively), significant in Campo de Cartagena (Spain) and, finally, cucurbits protected (229 t, 217 t and 22 t in 2005, 2006 and 2007, respectively. The case of Mediterranean Almeria area (biggest plastic concentration in the world), very significant, with acreage of greenhouses ranking between 27,000 to 30,000 ha without MB, will be presented and discussed as a case-study.

So far, the transition to the new situation has been rather peaceful. The possibility of National Emergency temporary authorizations for 1,3D has been a good instrument for industries depending of chemical fumigants for production. The new situation for Pic will be a new challenge; but we expect the same behavior of the National Authorities of Southern EU countries. This apparent peaceful situation is significant in spite the different National restrictions for some chemicals. For instance, Pic has been historically banned in France, the mixture 1,3D:Pic is not authorized in Poland, and Metam (curiously), now just approved within the EU, is not allowed for strawberry in Italy. Some industries have point out losses of unitary yields; for instance the strawberry industry in Huelva and the high-elevation nurseries in Castilla-León (Spain). But the total production in Huelva has growth since 2005 and the acreage too; from an initial level of 6,200 ha (in 2008) until near 7,000 ha (in 2013). Also the raspberry industry in this area continuously increases till the current 1,200 ha under protected plastic tunnels. The high elevation nurseries in Spain (very dependent in the past of MB) have increased the acreage from a level of 1,300 ha (2005) till 1,600 ha (2013). This apparent decline of the unitary yields could be related with the cultivar renovation, with new varieties improved on fruit quality but less productive (fruit and runners) than the standard cv. 'Camarosa' during the beginning of this century. The strawberry acreage of Italy and France is slowly decreasing but these phenomena started much before than 2005.

In fact, for the Mediterranean industries the main challenges and targets are: Offer concentration, traceability of production, food safety, and cultivar renovation. And, of course, to combat the economic crisis effects (e.g. impact in the consumer's behavior with significant drops in domestic consumption), particularly in Southern Mediterranean countries. The MB issue is not a prioritary key-point right now. In fact, we are in the times of the alternatives to the alternatives to MB. Our main fumigant controls in works of R+D are 1,3D:Pic applications. The main challenges on this issue would be the improvement and extension of non-chemical practices for soil fumigation (solarization, biosolarization) and the control of emerging and re-emerging pest and disease

problems. The development of acreages and yields in the Mediterranean countries of strawberry and nurseries, tomato, pepper, cut flowers, and cucurbits will be presented and discussed.

Our EU project (Alterbromide) on adoption of alternatives in different EU Countries found that the most important alternatives to MB in 2008/2009 were chemical (70%): 1,3D:Pic (31%), MS (16%), Dazomet (9%), 1,3D alone (8%), MS+Pic (3%), Pic alone (3%); the other 30% were non chemical: Soil solarisation (8%), soilless substrates (7%), grafting onto resistant rootstock (6-7%), and Biofumigation (1%), being the rest (6-7%) crop rotations and steam; these trends have changed today in general and for specific countries and sectors. For instance, in the case of the strawberry production in the EU, around 70% of the total acreage is disinfested with chemical fumigants, mainly 1,3D:Pic, MS and some dazomet. Soilless systems for strawberry production are widely adopted in Belgium, France, Ireland, Italy, and Spain; and also used in Austria, Denmark, Finland, Germany, Greece, Hungary, Netherlands, Poland, Portugal and Sweden. Several other non-chemical alternatives have also been applied in strawberry fruit production, such as crop rotation (used widely in Denmark, Germany, Netherlands, Poland), steam (used for protected strawberry in Belgium, France and Germany), solarization (used in Cyprus), and in Sicily), and biofumigation (small-scale use in the Netherlands and Slovenia). In addition, the Netherlands (70% of growers) and some locations in Germany and Poland use of a catch crop (*Tagetes patula*) to manage nematodes as a non-chemical alternative to MB. In more detail, in Spain, currently (2012/2103) our estimations are: for 8,200 ha for fruit production (7,000 ha strawberry+1,200 ha raspberry), 1,3D:Pic (75%), Pic alone (10%), Dazomet (10%), MS (2.5%), soilless cultivation and organic production (2.5%). Also for high-elevation strawberry nurseries in Spain, our estimations for 2013 are: for 1,600 ha (1,500 ha strawberry + 100 ha raspberry), 1,3D:Pic (55%), MS (34%), Dazomet (10%), Pic alone (1%), complete details will be presented and discussed.

In the case of the strawberry production in France, the estimations are: for 3,200 ha, non-fumigated (80%) (crop rotation and 600 ha in clean soilless substrates), and 20% fumigated (Mostly with MS drip applied and small acreage of Dazomet and 1,3D), remember the historical prohibition of Pic in this country. For strawberry nurseries in France (280 ha) the current solutions are, MS + crop rotation (100%) (Du Fretay and Fritsch, pers.comm.). In Italy, the main alternative is 1,3D/Pic (Veneto, Emilia-Romagna, Campania, Basilicata, Calabria). For this case, the mixture of 1,3D/Pic is not registered; the application is by means of a tractor with two tanks that inject both fumigants separately into the beds while simultaneously laying out sheets of VIF (Piardi and Spotti, pers.comm.).

In the case of the successful grafting onto resistant rootstock in EU and other countries, some data of grafting (2009/2010) in EU countries were: 98% of watermelon, 10% of tomato and 3% of melon in Spain; 100% of watermelon, 40-

50% of melon, 2-3% of tomato, 5-10% of cucumber in Greece; 80% of watermelon in Cyprus; 30% of watermelon in Italy and 50% of tomato in Netherlands, without data for other crops in Italy and France. These Spanish data correspond to 12,000 ha of watermelon and 500 ha of melon in 2007 (Camacho, com. perss.), and 5,000 ha of tomato (2009) (mostly in Campo de Cartagena, Canary Islands and Almeria) (Lacasa, com.perss.). An up-date of grafting onto resistant rootstock in EU utilization, and some problems and concerns will be presented and discussed. Total production area for flowers and ornamental plants was estimated at 200 thousand hectares (in 2010). The most important production EU countries in 2011, regarding plants and flowers sector, were: The Netherlands (33%), Italy (13%), France (12%), Germany (12%) and Spain (11%), followed at distance UK, Denmark and Belgium. In general, clean soilless substrates have increased for protected cut-flowers and ornamentals in many countries. The flowers most commonly grown in substrates are roses, carnations and gerberas. Growers in the Netherlands use steam treatments on about 1000 ha of flowers and ornamentals, in particular for chrysanthemums (900 ha). Growers found that steaming provided more effective control of *Verticillium* than MB. In Southern EU countries, chemical fumigants are widely used in the cut flower sector (1,3D, Pic alone, MS and Dazomet). As non-chemical solutions it is remarkable the application of biosolarization (chicken manure + soil solarisation) in the cut-flower of the Atlantic Southern Spain (about 500 ha).

Finally a list of major emerging and re-emerging soil borne problems within the EU agriculture linked to alternatives to MB could be: Fusarium wilt (*F. oxysporum*) in some cut-flowers (Italy) and strawberry fruit (Spain); Fusarium wilt (*Fusarium* spp.) in strawberry nursery (Spain); root rot (*Phytophthora capcisi*) in pepper (Italy); root rot (*Phytophthora nicotianae)* in tomato (Italy) and pepper (Spain); black dot (*Colletotrichum coccodes*) in tomato (Italy); charcoal rot (*Macrophomina phaseolina*) in strawberry (Spain, Italy); root-kont nematode *Meloidogyne hapla* and lesion nematode *Pratylenchus penetrans* in strawberry (Spain); several species of root-knot nematode of genus *Meloidogyne* in pepper and tomato (Spain). There are different ideas about this emerging phenomena, some explanation have been given: lack of MB, subsequent increase use of Pic, important changes in soil disinfestation (from broadcast to beds, from shank to drip), and some concerns with climate change and the strong restrictions on the use of agrochemicals. Some of these emerging soil borne problems will be presented and discussed.

Some potential solutions for the unclear future of soil fumigants within the EU protected agriculture will be presented and discussed.

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