NEW DEVELOPMENTS OF ALTERNATIVES TO METHYL BROMIDE FOR THE CONTROL OF TOMATO SOIL BORNE PATHOGENS IN COVERED CULTIVATION IN A DEVELOPING COUNTRY : MOROCCO.

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Use of Methyl Bromide in Morocco

The attitude that Methyl Bromide is the universal panacea to control soil-borne pathogens, nematodes, bacteria and weeds is still prevailing among many protected crops growers. For soil fumigation , Methyl Bromide is used in combination with chloropicrin (respectively 98% and 2%). Chloropicrin is used as a detector because the Methyl Bromide is an odorless gas.

Methyl Bromide use on soils is related to export crops grown under plastic cover (except banana which is grown only for the local market). Tomato , Melon, Strawberry, Banana and others represents respectively 57.85%, 13.66 %, 10.96%, 6.78% and 10.75% of the total area fumigated by this chemical. The utilization rate varies from 750 kg / ha to 1000 kg / ha

The soil disinfestation cost with Methyl Bromide is very low and represents only 2.03 % of the total tomato cost production. The low price, the low part of the product in the total investment and also the high efficacy of Methyl Bromide to control soil borne pests explain why this fumigant is very popular and is widely used in vegetables covered cultivation. Tomato is grown under cover from July till May. The farmer has only one to two months to prepare the next crop Therefore, preplant application of the fumigant permits the soil to be replanted within a short waiting period. The chemical , applied by specialized companies , is injected into the soil, which is covered by a plastic tarp to contain the pesticide. For vegetables and strawberries , only the plant rows are fumigated. The tarps are then used as mulch for the plant and are removed only at the end of the season. For bananas, all the surface of the greenhouse soil is fumigated. In this case, when the fumigation is complete, the tarps are removed from the field. Therefore , the release of Methyl Bromide into the atmosphere is higher after the fumigation of the banana soils than after the fumigation of the vegetables ones.

Main Alternatives to Methyl Bromide

Tomato is attacked by many soil-borne pathogens such as Fusarium (*Fusarium oxysporum f.sp.lycopersici,* race 1 and race2) and Verticillium wilts (*Verticillium dahliae* , races 1 and 2) , *Clavibacter michiganense (*bacterial canker) , *Pseudomonas syringae p.v tomato* (bacterial speck*)* , Orobanche *(Orobanche crenata)* , root knot nematodes (*Meloidogyne* spp.) . These pathogens are used to be controlled by Methyl Bromide. To decrease the use of Methyl Bromide, an Integrated Pest Management program (IPM) for tomato based mainly on local research results was implemented in some farms and in close collaboration with the farmers . This program is at the moment widely used in Morocco.

Crop rotation

Crop rotation includes exported crops in various combinations according to the export market: tomato- squash- beans -melon- hot pepper, or tomato-beans-melon-hot pepper-squash , or tomato-melon- hot pepper- beans- squash . It is important that the following crop should not belong to the same family as the previous one. Hot pepper could be replaced by pepper

Resistant varieties

Many tomato cultivars are resistant to various soil and air borne pathogens. However, no resistance is available for the control of some pathogens such as *C. michiganensis* subsp. *michiganensis*, *P.syringae* pv.*tomato*, *Xanthomonas campestris* pv.*vesicatoria*, *Sclerotinia sclerotiorum*, *D.lycopersici*. Even for the available resistant cultivars, the rise of new races particularly of *Fusarium* and *Verticillium* is a threat to the tomato production . Many high yielding tomato varieties used at the moment are susceptible to nematodes. No tomato variety is resistant to *Verticillium* race 2. Resistant commercial cultivars of tomato to *F.oxysporum* f.sp.*radicis* , *P lycopersici* and to *F.oxysporum* f.sp.l*ycopersici* race 3 are not available .

Plant grafting

Resistant rootstocks, such as KNVF types, provide excellent control of many tomato diseases and particularly *Fusarium oxysporum f.sp.lycopersici,F.oxysporum f.sp.radicis and Meloidogyne spp* . This technique, which was considered to be too expensive, is now widely used in Morocco at a commercial level . In general, without grafting, the tomato plant population per ha is about 18,000 plants/ha. When grafted plants are used, it has been shown that the same yield could be obtained with half plant population (9,000 plants/ha). The grafted plants are conducted with two stems instead of one for the non grafted plants.

Solarisation

Soil solarization is more and more used in Morocco. It controls many tomato pathogens such as *Colletotrichum coccodes, F.oxysporum* f. sp *.lycopersici, V. dahliae, P. lycopersici, R. solani* and *Orobanche ramosa*. Unfortunately, soil solarization do not decrease the population of *Meloidogyne* spp in the Moroccan conditions. Soil solarization efficacy may depend on weather , soil type and pests or diseases to be controlled

Soil-less culture

Soil-less culture is developing in Morocco for the control of many horticultural (vegetables and fruit trees) soil borne pathogens.

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