TOMATO GRAFTING AS AN ALTERNATIVE TO METHYL BROMIDE IN MOROCCO

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Tomato production characteristics

In Morocco, early tomato for export is grown mainly under plastic cover (tunnels and greenhouses). There has been, with the introduction of this new production system, a revolution in the greenhouse production technology: Greenhouse type, quality of the plastic cover, ferti-irrigation, plastic mulch, new high yielding cultivars, specific pesticides, soil fumigation particularly with Methyl Bromide etc…However, the intensification of the protected crops production has created new optimal conditions for the development of many pests. Soil-borne diseases problems were relatively simple in the early years, but they increased in importance as intensive cultivation continued. Soil fumigation with Methyl bromide to control soil borne fungi and root knot nematodes is considered as one of the main factors for the production success in greenhouses. Tomato is grown from July to may (10 months) and most of the production is exported.

Main tomato soil borne pathogens

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 ramosa)* , root knot nematodes (*Meloidogyne* spp.) . However, the key soil-borne pathogens are *Fusarium* , *Verticillium* and root knot nematodes (*Meloidogyne* spp.). These pathogens are used to be controlled by Methyl Bromide (98 % Methyl Bromide and 2% Chloropicrin). At the moment, tomato represents about 58% of the total area fumigated by this chemical. The utilization rate varies from 750 kg/ ha to 1000 kg /ha

Use of Methyl Bromide

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. Soil disinfection cost with Methyl Bromide is very low and represents only 2.03 % (1,250 US $/ha) of the total investment (61,585 US $/ha). The low price, the low part of the product in the total investment and also the high efficacy of the fumigant to control soil borne pests explain why this fumigant is very popular and is widely used in tomato covered cultivation. In addition, between two tomato crops, 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 in the planting rows by specialized

companies, is injected into the soil, which is covered by a plastic tarp to contain the pesticide. The tarps are then used as mulch for the plant and are removed at the end of the season

Tomato grafting

Grafting, which was considered at one time too expensive, is now widely used at a commercial level in Morocco and in many other countries. Resistant rootstocks, provide excellent control of many tomato soil borne pathogens and particularly of *F.oxysporum* f. sp. *lycopersici*., *F. oxysporum* f. sp. *radicis-lycopersici*, *P. lycopersici* and *Meloidogyne* spp. In addition to the soil borne pathogens control, tomato grafting has also many other purposes such as growth promotion and yield increase, low temperature tolerance, growth period extension and fruit quality.
The non grafted and grafted tomato plant population per ha are respectively about 20,000 (one stem per plant) and 10,000 plants/ha (2 stems/plant). When grafted plants are used, the same yield or a higher one could be obtained with this half plant population (table 1). In 2002, the total production of grafted plants was significantly higher than the non grafted ones. The quality, expressed as % of exported production was also higher (table 1)

Table 1
Total and exported production of grafted and non grafted tomato (Daniella / Beaufort KNVF)

Tomato (*)	Plants/ha	Total Production		Exported production	
		2001	2002	T/ha	%
Non grafted	20.000	121 a	151 a	105,7 a	70
Grafted	10.000	134 a	174 b	130,5 b	75

(*): non grafted tomato: 20,000 plants/ha (one stem/plant), grafted tomato : 10,000 plants/ha (2 stems/plant)

At the moment, 25 % (950 ha) of the protected tomato area (3,800 ha) are planted with grafted plants. In 2002, about 9,5 millions of tomato grafted plants (10,000 plants, double stem/ha)
Tomato is commonly grafted on KNVF interspecific *Lycopersicon hirsuum* x *L.esculentum*. The most popular rootstocks used at the moment in Morocco are Beaufort (De Ruiter), Hé-Man (Sluis and Gruit), and Brigeor (Gautier). The KNVF rootstocks are resistant to the key soil borne pathogens: *F. oxysporum* f.sp.l*ycopersici* (race 1 and 2), *V.dahliae*, and *Meloidogyne* spp and to others (*Pyrenochaeta lycopersici*, *F.oxysporum* f.sp.*radicis lycopersici* and Tobacco mosaic virus) .

Root knot severity on grafted and non grafted tomato is reported in table 2

Table 2
Root knot nematodes severity on grafted and non grafted tomato

Plant	Gall Index (GI)	Resistance
Non Grafted (Daniella)	4.73	Susceptible
Grafted (Daniella/Beaufort)	1.2	Resistant

Daniella: VFTMV, Beaufort: KVNF. Nematodes soil population before planting:: 173larvae/ l
GI: 1 (1-2 Galls), 2 (3-10), 3 (11-30), 4 (31-100), 5 (› 100)

The comparative cost of grafted and non grafted plants are reported in table 3.Compared to the non grafted plants, the extra cost of grafted plants is of 2,590 US $ and only 1,290 US$

after deduction of the Methyl Bromide application cost (1,300 US$). The extra costs represents only 2 % of the total costs per hectare (61,585 US$). This low extra cost explains why grafting is more and more popular among the farmer. However, the extra costs are largely covered by the profits generated by the grafting technology. (Table 4).The global profit is about 5,610 US$

Table 3
Comparative costs of grafted and non grafted plants (US $ /ha)

Non grafted plants	Grafted plants
Seeds: (80 g x 16 US$)= 1,280 Peat : 270 Alveolar plates: 230 Black plastic: 20 Watering cans: 20 Workers: 40	Grafted plants (*): 3,800 Seeds of the tomato hybrid (**): 40gx16= 640
Total: 1,860	4,440

(*) 10.000 grafted plants x 0.38 US $ = 3,800 US $. The grafted plants are not produced in the farm, but bought from specialized nurseries.
(**) seeds of the root stocks are supplied by the nursery

Table 4
Compared profits of grafted and non grafted tomato plants (2002 experiment)

Tomato	Extra cost of grafted tomato (US $)	Extra production (T)	Profits (US $)
Non grafted	0	0	0
Grafted	1,290	23	5,610

23 T x 300 US $ = 6,900 US $, Global profit: 6,900 – 1,290 = 5,610 US $

Conclusion

Tomato grafting is a non chemical alternative to methyl bromide. In Morocco, grafting is applied at a wide commercial level: 25 % (950 ha, 9.5 Millions of grafted plants) of the tomato protected area (3,800 ha). Grafting should be considered as a component of an IPM program which includes other control methods such as sanitation, pathogens free seeds and seedlings, weed control, improvement of plant growing conditions etc…

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