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Sustainable Alternatives to Methyl Bromide in Romanian Horticulture

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Abstract. Soilborne pathogens are very destructive in vegetable crops and one of the most limiting factors to farmer's income. Their management worldwide has been based on pre-plant soil fumigation with methyl bromide, a compound whose phase-out procedure was initiated in the Montreal Protocol (1992) due to its hazardous effects on the environment.Since the adhesion to the Montreal Protocol, Romania government decided to phase out methyl bromide use beginning with 2005. During the last seven years, the research was focused on investigating methyl bromide alternatives for controlling soilborne pathogens, mainly in protected area vegetable crops. These substitutes have been based on using other registered chemical compounds, and non-chemical methods (soil steaming, solarization, cultural practices, plant resistance). All the current methyl bromide substitutes and control measures for controlling soilborne pathogens in protected area vegetables crops have limitations, compared with methyl bromide. The aim of this paper is to describe the current methyl bromide alternatives for controlling soilborne pathogens in Romania horticulture.

Keywords: nematodes, soilborne, alternatives, greenhouses, metham sodium, grafted plants

INTRODUCTION

In Romania, the glass greenhouses cover about 480 ha (280ha heating greenhouses and 200 ha not heating) and the total greenhouses with plastic film are over 5000ha. Since crop rotation is rarely adopted, the reduction of yield, both in quantity and quality, progressively affects the crops, thus making necessary the adoption of soil disinfestations practices or, other methods(Gullino *et al.,* 2003). Before 2002 the most frequent methods for soil disinfections in Romanian greenhouses were sterilization with steam and the use of methyl bromide (107.72 methyl bromide tons in 2003), (Bogoescu *et al.,* 2005). Traditionally, greenhouses were built around the power plants of the main towns in order to use the hot water produced by them both for soil treatment and heating. Since 1995, following the liberalization of the energy market, the cost of steaming increased and its use for soil treatment was no more economically sustainable. At present, energy alone accounts 75% of production costs for protected and heated crops. Because of the increase in energy cost, the greenhouses area disinfections by steam and heated has been drastically reduced. In the same time according to Montreal Protocol (1997), methyl bromide, as an ozone-depleting compound, is banned for plant protection(fumigation applications) starting January 2005 (Gov. Ordinance no. 89/1999, approved by Law No. 159/2000, art. 9).

The researches have been focused on finding effective alternatives to this fumigant in order to control soil borne pathogens and nematodes. The aim of this work was to establish some alternatives to the use of methyl bromide in protected area vegetables crops from Romania.

MATERIALS AND METHODS

The demonstrative plots were organized in 2004 – 2010 period on tomatoes, cucumbers and watermelons cultivated in demonstration trials for testing some alternatives to methyl bromide, in specifically Romanian conditions, to control the pathogenic fungi on roots and root knot induced by nematodes, at the Horting Institute (Bucharest).

The efficacy of the chemical alternative, metham sodium (100ml/m²- commercial dose) – and the non-chemical method, grafting plants, were tested and compared to that of methyl bromide(75g/ m²- commercial dose)used as standard control. Metham sodium represents a suitable and transferable alternative to methyl bromide, particularly for its application that can be done throughout the drip irrigation.The adoption of grafted plants onto resistant rootstocks was selected as an interesting solution not only to reduce the use of fumigants, but also to improve the quality, the quantity and the duration of the harvest. Echevarría *et al.* (2003), show that grafting is one of the most promising techniques used for the substitution of methyl bromide.

V1= metham sodium(MS)

V2=grafted plants(GP)

V3= methyl bromide(MeBr) – standard control variant

The plots, with an average surface of 900 m^2, were organized after the method of random blocks, each experimental variety having three replicates.

The chemical methods (metham sodium and methyl bromide) were applied through a drip irrigation system. Soil disinfection was done according to the specific climate conditions, to over 15ºC in the soil at 10cm depth. Before the products were applied into the soil, it has been covered with a plastic film (width 4 m, thickness 0.11 mm, impervious to gas). The waiting time was 8 days for methyl bromide and 21 days for metham sodium.

The tomato hybrid Mondial F1(Enza Zaden) was grafted on the resistant rootstocks Beaufort(De Ruiter Seeds), the cucumber hybrid Mathilde F1 (Royal Sluis, Holland) was grafted on the resistant rootstock Shintoza *(Curcubita maxima x Cucurbita moschata)* and the watermelon hybrid Cicerio F1 (Ergon Seed) was grafted on the resistant rootstock ES30900 (Ergon Seed). The density of grafted plants was:

Tomatoes = 13500 plants/ha with 2 stems(reduced with 50%)

Cucumber = 28.000 plantsha(normal density)

Watermelons = 3500plants/ha(reduced with 50%)

There were done observations and determinations regarding the influence of soil disinfections treatments and the use grafted plants, about:

- marketable production
- appearance of the first harvest
- fruits' quality
- nutritional value of fruits
- frequency of soil borne diseases and pests:
  - corky root induced by *Pyrenochaeta lycopersici* - tomatoes
  - *Fusarium oxysporum* f. sp. *Cucumerinum* – cucumbers and watermelons
- incidence of nematode attack on the roots (after Lamberti, 1971 and Di Vito, 1979).

The presence of galls induced by nematodes from the *Meloidogyne* genus, were visually assessed at the end of the trials on 15% of the plants harvested from the middle of the plots.

The following index descriptors were used:

- 0 = no galls;
- 1 = slight infection, not widespread galls, presence of 1-5 galls located only on few roots;
- 2 = slight infection, widespread galls, presence of no more than 20 galls well spread on root system;
- 3 = infection with widespread galls, more than 20 galls evident and well spread on root system;
- 4 = strong infection, root system cut down and deformed due to the presence of big galls on the main roots;
- 5 = very strong infection, root system cut down and totally deformed due to the presence of big galls, absence capillary roots.

The root index (0-5) was calculated as follows: $\frac{\Sigma \text{ nematode index of all plants}}{\text{Number of plants}}$

For pathogens determined there were calculated the frequency, intensity and level of pest attack in the experimental variants.

$F\% = \frac{Nx100}{Nt}$, where:

N – no. attacked plants

Nt – total plants analyzed

$I(\%) = \frac{\sum(ixf)}{n}$, where:

i = % index

f = number of plants attacked

n = total number of plants

$GA\% = \frac{F\% x I\%}{100}$

Data analysis was performed on the average recorded data for the examined species examined (tomatoes,cucumbers,watermelon).

Statistical analysis was performed by Duncan's test.

RESULTS AND DISCUSSION

Marketable production

In order to reveal the influence of different methyl bromide alternatives (metham sodium (MS) and grafted plants (GP)), marketable production dates were collected (Tab. 1).

Tab.1

The efect of methyl bromide alternativeson the marketable production (t/ha)

Species	Metham Sodium	Grafting Plants	Methyl Bromide
Tomatoes	114b*	124a	128a
Cucumbers	47n	51mn	55m
Watermelons	48t	82p	53r

* Within a row, the values noted with the same letter do not present significant difference after the Duncan test for p = 5%

If the marketable production of tomatoes and cucumbers was lower for the proposed alternatives comparativ with the use of methyl bromide, at grafting watermelons was identificat a significantly positive effect (the marketable production higher with over 54%).The results showed a significant difference between grafted plant method and metham sodium fumigation method, where there has been a difference between 8 and 59% . At the same time, there were no registered significant differences of the marketable production between the grafted plants method and the soil disinfection using methyl bromide, at the crops of tomatoes and cucumbers

Appearance of the first harvest

As an expression of early production degree, the influence of alternatives methods on the occurrence of the first harvest was established. The observations and determinations followed the first harvest date, respective the number of days from planting to first harvest. Data recorded and presented in Table 2 show a delay of the first harvesting to the grafted plants with an average of 7 days, as compared with the first harvesting of the non-grafted plants.

Tab.2

The efect of methyl bromide alternatives on the appearance of the first harvest (days)

Species	Metham Sodium	Grafting Plants	Methyl Bromide
Tomatoes	81a*	88b	80a
Cucumbers	32m	37n	32m
Watermelons	78p	85r	77p

* Within a row, the values noted with the same letter do not present significant difference after the Duncan test for p = 5%

The differences of time for the first harvest between fumigation methods and grafted plants are statistically significant.

Fruits' quality

In Table 3 there are presented data which refers to the influence of alternatives methods on the percentage of Class I fruits. Fruit quality was assessed according to the quality standards for fresh fruits and vegetables:SR.1421/2001for tomatoes,SR.1416/2003 for cucumbers and SR 3654/2003 for watermelons.

Tab.3

The efect of methyl bromide alternatives on the percentage of Class I fruits (%)

Species	Metham Sodium	Grafting Plants	Methyl Bromide
Tomatoes	80,7b*	84,6a	81,1b
Cucumbers	78,4n	84,4m	78,3n
Watermelons	69,9r	93,1p	78,8r

* Within a row, the values noted with the same letter do not present significant difference after the Duncan test for p = 5%

The data analysis showed an improvement of commercial quality at the grafted plants of over 84% up to 93% Class I fruits; the non -grafting plants has an percentage of Class I of only 78 -81% for methyl bromide disinfestation method, respective of 70-80% Class I fruits for metham sodium alternative. The differences between fumigation methods and grafted plants are statistically significant.

Nutritional value of fruits

There were made determinations on soluble dry matter content and soluble carbohydrate from tomatoes, cucumbers and watermelons. Determinations were made on standard samples: 6 melons /sample and 3 kilograms/sample of tomatoes and cucumbers.

Samples were taken from mass product in two harvests. Analyses were performed under laboratory methodology, respectively; refractometry method (STAS 5956/71) to determine dry matter and soluble Bertrand method for determining the soluble carbohydrate. The results presented represent the average of the both harvest (Tab. 4).

Tab.4

The efect of methyl bromide alternatives on the content of soluble dry mater and soluble carbohydrates (%)

Species	Metham Sodium		Grafted Plants		Methyl Bromide	
	Soluble dry	Carbohy-drates	Soluble dry	Carbohy-drates	Soluble dry	Carbohy-drates
Tomatoes	5,6a*	4,18d	5,4a	3,99d	5,6a	4,09d
Cucumbers	4,6m	3,81h	4,4m	3,52h	4,7m	3,94h
Watermelons	6,5p	5,85y	6,1p	5,49y	6,4p	5,48y

* Within a row, separately for soluble dry mater and separately for soluble carbohydrates, the values noted with the same letter do not present significant difference after the Duncan test for p = 5%

The soluble dry matter content and soluble carbohydrate is expressed in percentages. The recorded results which refer to some indicators of quality nutrients (dry matter and carbohydrate content) determined on tomatoes, cucumbers and watermelons have shown a slight decrease of the content in these indicators in the fruits that come from grafted plants. The differences between fumigation methods and grafted plants concerning the nutritional value of fruit expressed by soluble dry matter content and carbohydrates are not statistically significant .

Frequency of soil borne diseases and pests

Following observations on the culture substrate, there were identified species of *Pyrenochaeta lycopersici* for tomatoes and *Fusarium oxysporum* f. sp. *Cucumerinum* to cucumbers and watermelons. The data show the efficiency of soil disinfestation treatments made with methtyl bromide and metham sodium as well as of the grafted plants towards the soil borne diseases (Table 5).

Tab.5

The efect of methyl bromide alternatives on the frequency of soilborne disease* (%)

Species	Metham Sodium	Grafting Plants	Methyl Bromide
Tomatoes	1,41a**	1,52a	1,39a
Cucumbers	2,34m	2,41m	2,29m
Watermelons	0,41p	0,47p	0,31p

*_Corky root_ induced by _Pyrenochaeta lycopersici_ on tomatoes _Fusarium oxysporum f. sp. Cucumerinum_ on cucumbers and watermelons

**Within a row, the values noted with the same letter do not present significant difference after the Duncan test for p = 5%

There were no registered significant differences concerning the frequency of the attack produced by Pyrenochaeta lycopersici and Fusarium oxysporum f. sp. cucumerinum between the analysed variants.

Regarding the effect of alternatives on nematodes attack (_Meloidogyne spp.)_ the results recorded at the break ground culture are presented in Tab. 6.

Tab.6

The efect of methyl bromide alternatives on the root index and the frequency[1] of nematode attack

Species	Metham Sodium		Grafted plants		Methyl Bromide	
	Root index[2]	Frequency (%)	Root index	Frequency (%)	Root index	Frequency (%)
Tomatoes	1,8[3]	3,1a	1,9	3,1a	0,9	1,1a
Cucumbers	1,7	2,9m	1,8	3,3m	0,8	0,6m
Watermelons	1,2	0,9z	1,2	1,1z	1,1	0,8z

[1] Average of percentage of infected plants assessed on all plants collapsed and still living at the end of the trial.

[2] Root index between the interval 0:5

[3] Within a row,the values noted with the same letter do not present significant difference after the Duncan test for p = 5%

Data showed a reduction in frequency of nematode galling for the variants where soil disinfestations were made with methyl bromide. Data analysis confirmed the tolerance effect of grafted plants to _Meloidogyne_ spp (Oda, 1993).

The data did not show significant differences according to the Duncan test, between chemical alternative by fumigation with metham sodium and the use of grafted plants method.

CONCLUSIONS

The results obtained on the demonstrative plots in the last years have revealed as a suitable soil disinfestations methods for the Romanian conditions (climatic, economics and of legislation) the following methyl bromide alternatives:

- Chemicals method: metham sodium

- Non-chemical method: grafted cucumbers

Considering the effectiveness - however - limited to these two alternatives it is necessary in the future to continue the studies and research in this field of activity in order to establish new methods of soil disinfestations with a high effectiveness and a low impact on the environment.

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REFERENCES

1. Bogoescu, M., M.L. Gullino, A. Minuto and A. Amadio (2005). Alternatives to Methyl Bromide Romanian Protected Crops. Acta Horticulturae 698:315-320.
2. Echevarría, P.H, A. Rodriguez, S.M. Vivaracho and A.D. Vallejo (2004). Influence of rootstocks and soil treatment on the yield and quality of greenhouse-grown cucumbers in Spain. Acta Horticulturae(ISHS). 663:403-408
3. Gullino, M. L., A. Camponogara, G. Gasparrini, C. Rizzov Clini and A. Garibaldi (2003). Replacing methyl bromide for soil disinfestations: the Italian experience and the implication for other countries. Plant Disease. 87: 1012-1021.
4. Oda, M.(1993). Present state of vegetable production using grafted plants in Japan. Agr. Hort.,68:442–446.
5. Gov. Ordinance no. 89/1999 published in OM nr.423/31.08.1999, approved by Law No.159/2000, art.9 published in OM nr.486/05 October 2000.