GRAFTED TOMATOES – ECOLOGICAL ALTERNATIVE FOR CHEMICAL DISINFECTION OF SOIL

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ABSTRACT

This study aimed to identification of an ecological alternative for the chemical disinfection of soil in the greenhouses from Romania. Tomato (*Solanum lycopersicum* L.) is one of the most popular vegetable crops in the world. The carbohydrate, vitamins, salts of important mineral elements and organic acids content of tomato fruits is very important. Tomato crops are very sensitive to climatic vagaries, so fluctuation in climatic parameters at any phase of growth can affect the yield and the fruit quality. Grafting on *Solanaceae* is a method which has improved and spread quickly during the past years, a similar approach to crop rotation, a practice meant to increase productivity, resistance or tolerance to biotic and abiotic stress factors and at increasing fruit quality. The research was conducted in a glass greenhouse of the Horting Institute, Bucharest, Romania. The biological material used was a Romanian tomato hybrid (Siriana F1), a Dutch tomato hybrid (Abellus F1) and four rootstocks, a Dutch tomato hybrid (Emperador F1) and three Romanian tomato cultivars (L_{542}, L_{543} and L_{544}) obtained from the Research and Development Station for Vegetable Growing, Buzău, Romania. The rootstocks have had resistance to biotic stress factors (soil diseases and pests) and the chemical disinfection of soil has was eliminated. The result of this research are presented in this paper.

Keywords: *Fusarium, grafted plants, Meloidogyne, resistance, Solanum lycopersicum*

INTRODUCTION

Methyl bromide is a broad-spectrum soil fumigant. Mixtures of these two fumigants, methyl bromide and cloropicrin, work synergistically in controlling a wide range of plant pathogens and pests, including fungi, nematodes, insects, mites, rodents, weeds, and some bacteria. Methyl bromide was listed in 1993 by the Parties of the Montreal Protocol as an ozone-depleting compound. According to the Montreal Protocol, the import and manufacture of methyl bromide in the United States of America (USA) and other developed countries will be banned by 2005, after stepwise reductions in 1999, 2001 and 2003. Currently, there is a need for environmentally sound and economically feasible alternatives [1].

In Romania the use of methyl bromide in soil treatments for plant protection (fumigation applications) is banned from 2002 January 1st and the use of methyl bromide in storage applications is banned from 2005 January 1st (Gov Ordinance no. 89/1999, approved by Law no. 159/2000, art. 9) [4].

Farmers often use perilous chemicals to overcome the loss due to disease and pests. Though Various other environment friendly methods like using resistant varieties or cultivars produced by conventional method of breeding or by using biotechnological tools are also available but they are too much time consuming and require a huge input on research and trials on and off field [10].

Grafting on *Solanaceae* is a similar approach to crop rotation [3].

It is a practice meant to increase productivity, a method which has improved and spread quickly during the past years. This method of tomato vegetative multiplication is aimed at producing plants with higher resistance or tolerance to soil diseases (*Fusarium* and *Verticillium*) and pests (nematodes).

Grafting is a promising tool to enhance plant performance of *Solanaceae* under growth conditions in which the fruiting vegetables are exposed to salinity, water stress, alkalinity, heavy metals contamination, and excessive amounts of trace elements. Several effective rootstocks are already in practical use, or used in breeding programs. Augmentation of this knowledge may help to select and breed appropriate rootstocks which improve the adaptability of fruit vegetable crops to salinity, water stress, alkalinity, heavy metals contamination, and trace element toxicity [6].

Research focus currently relies on combinations of environmentally friendly approaches among which is grafting for pathogen management. Grafting has potential to provide resistance to multiple soilborne pathogens, for example, nematodes, after a susceptible plant (scion) is united with resistant rootstocks. Sources of resistant rootstocks include species from the same family or closely related species, hybrids, and weeds. Farmers select rootstocks with desirable genetic properties, for example, resistance to nematodes, flooding, salinity, extreme temperatures, and increased yield production. Tomato are the most grafted plants in the Solanaceous family [8].

The method is based on the contact between a crop variety (scion) and a wild variety (rootstock), the last one possessing a robust root system, a high resistance to the soil pests and diseases; the result of the grafting process is the increase of the resistance against soil diseases such as *Fusarium* ssp., *Verticillium* ssp. and nematodes [5].

Commercial susceptible varieties grafted on rootstocks resistant to soilborne pathogens is one technique used as an alternative method to methyl bromide [Bogoescu, 2007, 4].

The most common rootstocks used for commercial tomato grafting are hybrids (F1) or inter-specific hybrids, which have been specifically bred for resistance against pathogens and other diseases such as nematodes, *Verticillium* wilt, and *Fusarium* wilt. Hybrids are produced by crossing selected tomato varieties with other wild *Solanum* species with the genetic ability to offer resistance to specific diseases and pathogen infection. In Europe, tomato hybrids are used as rootstocks compared to other *Solanum* spp., because of their high level of genetic improvements. There are other plants that share the same family with tomato (*Solanum torvum*, *S. aethiopicum*, and *S. macrocarpon*); these can serve as

rootstocks for their tolerance to *Fusarium* wilt and root knot nematode infestation [8].

Tomato are very popular crops in Romania, but its are very sensitive to climatic vagaries, so fluctuation in climatic parameters at any phase of growth can affect the yield. The tomato grafting is useful in Romania. Sensivity to diseases and pest has imposes introduction grafting onto resistant rootstocks. The rootstocks have a big resistance to *Meloidogyne* spp. and *Fusarium* spp. attack, compared to the ungrafted tomatoes.

This study regarding grafting of some tomatoes is important to highlight some resistances to biotic stress factors. The researches in the tomato grafting domain began at Horting Institute, Bucharest, Romania in 2002 and have continued up to now.

MATERIALS AND METHODS

The experience was carried out in a glass greenhouse on soil without chemical or thermal disinfection from Research and Development Institute for Processing and Marketing of the Horticultural Products – Horting, Bucharest, Romania.

The biological material used was a Romanian tomato hybrid (Siriana F1), a Dutch tomato hybrid (Abellus F1) and four rootstocks, a Dutch tomato hybrid (Emperador F1) and three Romanian tomato cultivars (L_{542}, L_{543} and L_{544}) obtained from the Research and Development Station for Vegetable Growing, Buzău, Romania.

This research was implemented in a randomized complete block design with two grafting combinations and the ungrafted control for each cultivar used. 30 plants were used in 3 replications of 10 plants each for every combination and control, in the following experimental scheme (variants):

V1–Siriana×Emperador;
V2–Siriana×L_{542};
V3–Siriana×L_{543};
V4–Siriana×L_{544};
V5–Siriana, control (ungrafted);
V6–Abellus×Emperador;
V7–Abellus×L_{542};
V8–Abellus×L_{543};
V9–Abellus×L_{544};
V10–Abellus, control (ungrafted).

Siriana F1 is a creation from the germplasm bank of Research and Development Station for Vegetable Growing, Buzău, Romania and is tested as grafted and ungrafted plants cultivated in greenhouses at Horting Institute.

It has great vigor, spherical shaped and slightly flattened fruit, red in color, with an up to 150 g in weight, the height of 5 cm, diameter of 6.5 cm and 4-5 seminal lodges. The plant is early (110-115 days), indeterminate and well adapted to field conditions and protected areas.

Abellus F1 (the seed source is the Rijk Zwaan company in the Netherlands) is a Dutch hybrid, very frequently cultivated in Romania and tested as grafted and ungrafted plants cultivated in greenhouses at Horting Institute Bucharest.

It has great vigor, spherical shaped and slightly flattened fruit, red in color, with up to 150-180 g in weight. The plant has indeterminate growth, with early maturation and well adapted to field, greenhouse and solarium conditions.

Emperador F1 (the seed source is the Rijk Zwaan company in the Netherlands) is a very vigorous tomato rootstock which impacts the grafted plant with a harmonious growth. This rootstocks is very resistant to the attack of the nematodes and to *Fusarium* sp., *Verticillium* sp. and *Tomato Mosaic Virus*, recommended for protected areas and field.

L_{542}, L_{543} and L_{544} are three tomato genotypes obtained by amelioration works performed by some horticultural researchers from VDRS Buzău and tested in experimental fields in the Horting Institute, Bucharest for homologation as rootstocks for tomato grafting.

The efficiency of the tomato grafting method was assessed by severity of attack induced by *Fusarium oxysporum* f. sp. *lycopersici*, severity of root galls induced by *Meloidogyne incognita*, a 0–5 scale (0 = no galls; 1 = 1–5 galls), after Di Vito [7].

The 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:

Σ nematode index of all plants / Number of plants

For pathogens determined there were calculated the frequency, intensity and level of pest attack:

- F% = Nx100 / Nt
  where: N – no. attacked plants, N_t – total plants
- I(%) = $\sum$(ixf) / n
  where: i - % index, f – no. of attacked plants, n = total number of plants
- GA% = F%xI% / 100

RESULTS AND DISCUSSION

In comparative analysis, the recorded results are presented as average / variant on combinations of rootstock x scion, for grafted plants, comparative with the average result of the ungrafted plants (Table 1).

Table 1. Incidence of soil pathogens and pests in tomato plots

Variants	GA%	
	F. oxysporum	*M. incognita*
V1	0,04	0,05
V2	0,02	0,06
V3	0,03	0,07
V4	0,05	0,08
V5 (control)	1,5	1,10
V6	0,01	0,04
V7	0,02	0,06
V8	0,02	0,07
V9	0,04	0,07
V10 (control)	1,1	0,5
Average		
grafted	0,03	0,06
ungrafted	1,3	0,8

The grafting influence on the resistance of tomatoes to soil-borne pathogens and nematodes at identified species of *F. oxysporum* f.sp. *lycopersici* and *M. incognita*: the grafted plants showed resistance to attack of *F. oxysporum* (0,03%) and *M. incognita* (0,06%) comparing with ungrafted tomato plants where the level of *F. oxysporum* attack was 1,3% and the level of *M. incognita* attack was 0,08%.

When plants were challenged with *Meloidogyne*, all rootstocks tested showed a significantly lower number of galls and egg masses in comparison to the control. Information on the response of nematode-resistant tomato rootstocks to root-knot nematode species and populations is still limited to few studies that show increased variability in terms of nematode infectivity and reproduction among the rootstocks. For instance, the resistant rootstock Big Power displayed high resistance in soils naturally infested with *M. javanica* and *M. incognita*. In the same study, Maxifort and Beaufort showed partial resistance to the Southern root-knot nematode compared to non- and self-grafted controls. The effect of growing resistant tomato rootstocks aiming at nematode suppression and tomato yield increase in nematode infested fields could vary depending on the tomato rootstocks and the Meloidogyne populations present in an area, thus limiting their resistance value as an efficient nematode management tool [9].

Nematode reproduction on resistant tomato cultivars was similar or higher than on resistant rootstocks for all tested *Meloidogyne* isolates in the short period experiment, but not in the long period experiment. The response of tomato cultivars and rootstocks to *Meloidogyne* isolates varies depending on the isolates of *Meloidogyne* or the length of the growing period [2].

Grafting used for a long time ago to increase resistance to biotic stresses of vegetatively propagated plants. The primary purpose of grafting vegetables worldwide has been to provide resistance to soil borne diseases (corky root, fusarium wilt, verticillum wilt, bacterial wilt) and nematodes; these are some of the biotic stress cause, damages in vegetable production and especially in continuous cropping in greenhouses [11].

CONCLUSION

The use grafted tomatoes, the grafting combinations (scions x rootstocks) researched in the Horting Institute, may be recommended for the vegetable crops in Romania. Development of grafted tomato that are resistant to *Fusarium* spp. and *Meloidogyne* spp. can be done more quickly than breeding.

These rootstocks (Emperador, L_{542}, L_{543} and L_{544}) are used in Romania for conventional and ecological crops; its have had good results by grafting with some scions (Siriana and Abellus).

Sensivity to diseases and pest has imposes introduction grafting onto these resistant rootstocks to some biotic stress factors (*F. oxysporum* f. sp. *lycopersici* and *M. incognita*) for tomato crops cultivated in protected spaces on the soil without chemical or thermal disinfection because in Romania the use of methyl bromide in soil treatments for plant protection is banned.

Based on the above mentioned results, it can be said that the rootstocks played a important role in plant resistance to soil disease and pest.

The results showed that tomato grafting on the suitable rootstock has positive effects on the crops compared to the ungrafted tomatoes.

The researches regarding tomato grafting at Horting Institute are in evolving for the development of the vegetable crops in Romania.

REFERENCES

[1] Ajwa H., Klose S., Nelson S., Minuto A., Gullino, M., Lamberti F., Lopez A., Jose M., Alternatives to Methyl bromide in Strawberry Production in the United States of America and the Mediterranean Region, Phytopathologia Mediterranea, vol. 42, pp 220-244, 2003;

[2] Aydınlı G., Mennan S., Resistance Response of Tomato Cultivars and Rootstocks Carrying the Mi-1.2 Gene to Isolates of *Meloidogyne arenaria*, *M. incognita*, and *M. javanica* at Two Different Growing Periods, Korean journal of horticultural science and technology, vol. 37, pp 509-519, 2019;

[3] Blestos F.A., Olympos C.M., Rootstocks and grafting of tomatoes, peppers and eggplants for soil-borne disease resistance, improved yield and quality, The European Journal of Plant Science and Biotechnology, vol. 2(1), pp 62-73, 2008;

[4] Bogoescu M., Doltu M., Iliescu L., Tănasa N., Phase-out methyl bromide in Romania horticulture – consecutive at preservative actions of the ozon layer, Bulletin USAMV, Horticulture Cluj-Napoca, Romania, vol. 64, 2007;

[5] Bogoescu M., Doltu M., Sora D., Mohora A., Iordache B., Results on establishing the technology for obtaining the watermelons grafted seedlings, Bulletin UASVM, Horticulture Cluj-Napoca, vol. 66(1), pp 397-403, 2009;

[6] Colla G., Fiorillo A., Cardarelli M., Rouphael Y., Grafting to improve abiotic stress tolerance of fruit vegetables, Acta Horticulturae, vol. 1041, pp 119-126, 2014;

[7] Di Vito M., Lamberti F., Carella A., La resistenza del pomodoro nei confronti dei nematodi galligeni: prospettive e possibilitá, Rivista di Agronomia, vol. 13, pp 313-22, 1979;

[8] Nyaku S.T., Amissah N., Grafting:An Effective Strategy for Nematode Management in Tomato Genotypes, Advances in Tomato Breeding and Production, 2018;

[9] Rumbos C.I., Khah E.M., Sabir N., Response of local and commercial tomato cultivars and rootstocks to *Meloidogyne javanica* infestation, Australian Journal of Crop Science, vol. 5(11), pp 1388-1395; 2011

[10] Sen A., Chatterjee R., Bhaisare P., Subba S., Grafting as an Alternate Tool for Biotic and Abiotic Tolerance with Improved Growth and Production of Solanaceous Vegetables: Challenges and Scopes in India, International Journal of Current Microbiology and Applied Sciences, vol. 7, pp 12-135, 2018;

[11] Yassin H., Hussen S., Reiview on Role of Grafting on Yield and Quality of Selected Fruit Vegetables, Global Journal of Science Frontier Research D:Agriculture and Veterinary, vol. 15(1), 2015.