COST ACTION FA1204

Vegetable Grafting to Improve Yield and Fruit Quality Under Biotic and Abiotic Stress Conditions

STSM Scientific Report

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STSM Topic: Interactions of grafting and shading in a greenhouse pepper crop

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1. Aim of the STSM

Bell pepper (*Capsicum annuum* L.) is an important crop in many parts of the world and is typically grown in Mediterranean area in open field or under greenhouse during the spring and summer months. The high demand for off-season vegetables and the intensive cropping systems with limited crop rotations has determined a buildup of detrimental factors (biotic or abiotic) that can substantially reduce yield and crop quality. In many cases, the pepper crop has become a monoculture, with the consequent problems of soilborne diseases that affect plant growth and yield. Due to recent policy environmental regulations, vegetable grafting is considered a feasible alternative for control of soilborne pathogens. However, very little attention has been paid to how the use of different rootstocks can affect fruit quality in grafted bell pepper.

The unfavorable environmental conditions into the greenhouse occurring in late spring and early summer, due to the increased temperatures and solar radiation, may have negative effects on bell pepper plant growth, fruit set, yield and fruit quality. Particularly, may increase incidences of fruit physiological disorders such as blossom-end rot and sunscald causing significant loss. To address the issue related with high solar radiation and high temperatures, growers reduce the incident radiation by using several shading systems such as the screen nets. The greenhouse shading equipments can reduce incoming radiation during the day, reducing the heat load in the greenhouse, assist in maintaining humidity in the plant canopy, in order to reduce plant stress. However, the shading systems have the disadvantage of limiting the exchange of air and vapor inside the greenhouse. Studies carried out in Israel report that shading increases plant growth and yield in bell pepper. Other authors report that shading reduces water requirements and increases irrigation water use efficiency in peppers.

For a better climate control the use of a movable shading system, as used in floriculture, is preferable. However, these systems increase the construction and installation costs. In this regard, the use of grafted plants onto adequate rootstocks, might provide a suitable strategy to avoid or reduce the production losses due to the environmental stresses, like the high temperatures and solar radiation intensity. On the basis of above considerations the main objectives of this STSM project were to test the impact of shading on grafted and self-rooted pepper plants in a spring-summer crop with respect to plant growth, yield, nutrient uptake, incidence of blossom-end rot, and fruit quality parameters, and to test the impact of the grafting on the antioxidant system of pepper plants grown under different levels of solar radiation intensity. The results of the STSM will be of great interest for all working groups in particular to WG3 (Rootstock-mediated resistance to biotic and abiotic stresses) and WG4 (Rootstock-mediated improvement of fruit quality) of the COST Action FA1204.

2. Carried out activities during the STSM

The experiment took place at the experimental greenhouse of the Department of Crop Science, Laboratory of Vegetable Crops - University of Athens, located in Athens (Greece). 'Sondela' and 'Orangery' F1 bell peppers self-grafted and grafted onto 'Rocal' rootstock were compared under non-shaded and shaded conditions. The experiment was conducted into two greenhouse compartments (non-shaded and shaded). In each compartment, 12 NFT (nutrient-film-technique) closed-loop hydroponic circuits (experimental plots) were used (Fig. 1). Each hydroponic circuit was an independent nutrient-film-technique (NFT) unit comprising one channel that was fed with nutrient solution (NS) from a dedicated ‘supply-tank’ via a pump. The level of NS in the supply-tank was fed by a ‘replenishment tank’ positioned above it to compensate for the NS consumed by the plants through the transpiration process. Treatments were defined by a two factorial experiment in three randomized replications. The first factor had two levels (shaded and non-shaded conditions), whereas the second factor had four levels (self-grafted 'Orangery', self-grafted 'Sondela', 'Orangery'/'Rocal', and 'Sondela'/'Rocal'). Each experimental unit consisted of nine plants.

The first activities involved the preparation of the NFT closed loop soilless system (the pest control of the soilless framework by using a 10% sodium hypochlorite solution, the preparation of the starter and replenishment concentrated and diluted nutrient solutions and the transplant of the grafted and self-grafted pepper plantlets in both shaded and non shaded compartment greenhouse).

All the basic NSs used in this experiment were prepared using water as reported in Tab.1. The pH, the electrical conductivity (EC) and the mineral composition of the starter and replenishment NSs used were reported in Tab.2. The pH and EC of the recirculating NS were measured every two days and if necessary they were adjusted.

Fig.1. NFT (nutrient-film-technique) closed-loop hydroponic circuits. Experimental plots before and after transplanting.

At the beginning of the experiment the leaves, the stems and the roots fresh and dry weight, the number of leaves and the leaf area were recorded on 8 plantlets per scion/rootstock combination used. The plant tissues were dried in a forced-air oven at 80 °C for 72 hours. Leaf area was measured with an electronic area miter. Dried plant tissues were ground in a Wiley mill, and 0.5 g of the dried tissues was analyzed for the content of the following: N, P, K, Ca, Mg, Fe, Cu, Zn, Mn, and B. The N concentration was determined by Kjeldahl method, while P, K, Ca, Mg, Fe, Cu, Zn, Mn, and B were determined by dry ashing at 400 °C for 24 hours, dissolving the ashing in HNO_3 and assaying the solution obtained by an inductively coupled plasma emission spectrophotometer. At the beginning of the experiment and every month 100 mL of recirculating nutrient solution was collected per each channel, in order to measure the nutrient concentrations. Every 30 days, 1 plant per channel was removed in order to record the total plant length, the number of leaves, the number of immature fruits, the leaves, stems, roots and immature fruits fresh and dry weight, and the leaf area. From the removed plants, stem, leaf and fruit tissue metal analysis were performed. Furthermore, from April month a weekly green pruning, as recommended by the best practices for pepper crop cultivation, was conducted. In order to understand the biomass produced, the fresh and dry weight of the leaves, stems and fruits removed biomass was recorded.

Finally, solar radiation intensity, temperature, and relative humidity inside and outside the greenhouse were measured in real-time by sensors and recorded in a data-base.

Currently, the experiment is still underway. Consequently, will be recorded all the planned measurements.

Tab.1. Characteristics of the water used for NSs preparation.

Water characteristics		
EC	0.32	dS/m
pH	7.30	
Ca^{2+}	0.90	mmol/l
Mg^{2+}	0.30	mmol/l
K^{+}	0.00	mmol/l
NH_4^{+}	0.00	mmol/l
Na^{+}	0.60	mmol/l
SO_4^{2-}	0.20	mmol/l
NO_3^{-}	0.00	mmol/l
$H_2PO_4^{-}$	0.00	mmol/l
HCO_3^{-}	2.20	mmol/l
Cl^{-}	0.40	mmol/l
Fe	0.00	μmol/l
Mn^{++}	0.00	μmol/l
Zn^{++}	2.15	μmol/l
Cu^{++}	0.00	μmol/l
B	0.00	μmol/l
Mo	0.00	μmol/l
Si	0.00	mmol/l

Tab.2. Starter and replenishment diluted solution characteristics.

	NSs characteristics			
	Starter NS		Replenishment NS	
EC	2.60	dS/m	2.10	dS/m
pH	5.60		5.60	
[K]	6.00	mmol/l	7.60	mmol/l
[Ca]	6.50	mmol/l	3.50	mmol/l
[Mg]	2.00	mmol/l	1.50	mmol/l
[NO3]	15.60	mmol/l	12.80	mmol/l
[NH4]	0.50	mmol/l	1.00	mmol/l
[$H_2PO_4^{-}$]	1.20	mmol/l	1.20	mmol/l
[Fe]	20.00	μmol/l	15.00	μmol/l
[Mn]	12.00	μmol/l	10.00	μmol/l
[Zn]	7.00	μmol/l	6.00	μmol/l
[Cu]	0.80	μmol/l	0.70	μmol/l
[B]	50.00	μmol/l	30.00	μmol/l
[Mo]	0.50	μmol/l	0.50	μmol/l
[Si]	0.00	mmol/l	0.00	mmol/l

3. **Future collaboration with the host institution (if applicable):**

The research work conducted within the framework of this STSM is considered a good basis for future collaboration between the home and the host institution on topics related to grafting of vegetables. Discussions about this possibility have resulted in some plans for joint research activity and joint submission of research projects in the near future.

4. **Foreseen publications/articles resulting from the STSM (if applicable):**

After completion of the experiment and the laboratory analyses, the data are expected to be used for writing a paper on the responses of grafted vs. non-grafted pepper plants to thermal stress in greenhouses.

5. **Confirmation by the host institution of the successful execution of the STSM:**

This is to certify, that the STSM applicant, Dr. Leo Sabatino has worked successfully on the experimental plan he presented in his STSM application. Dr. Sabatino effectively contributed to the establishment of the experiment and carried out a major part of the experimental work and the measurements thereafter. He participated in many discussions about the ongoing experimental work and attended some lectures related to vegetable production and grafting. Although the experiment is going on, the first findings are promising and we expect that they can be a sound basis for a good publication in a reputable international scientific journal.

The host scientist

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