

COST ACTION FA1204 FINAL CONFERENCE

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

19 – 21 September 2016, Pula, Croatia

PROGRAMME AND BOOK OF ABSTRACTS



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Welcome note

Dear Participants,

It is our pleasure to welcome you to the Final Conference of COST ACTION FA1204 'Vegetable Grafting to Improve Yield and Fruit Quality under Biotic and Abiotic Stress Conditions.'

Vegetable grafting is technique that has been used for a long time in vegetable production, but in the past decades has received more attention as an efficient and sustainable method to improve vegetable yield and quality under stressful conditions. Although this technique has long tradition in Croatia, it is only since recently used in commercial vegetable production, particularly in watermelon field production and tomato hydroponic crop.

The COST FA1204 activities have been aimed to stimulate cutting edge multidisciplinary collaborative research towards identifying and understanding how rootstock-mediated traits can improve vegetable crop yield and quality under biotic and abiotic adverse conditions. Until now, as a result of this action, three Annual Conferences and four Steer Committee meetings were held in the countries participating in COST FA1204.

The 1st Annual Conference 'Exploiting root-to-shoot communication for improving yield stability and fruit quality in vegetable crops' was held in Murcia, Spain pointed out importance of development of new tools targeted to roots to enhance agronomic stability and sustainability of crops under multiple and combines stress conditions.

The 2nd Annual Conference called 'Innovation in vegetable grafting for sustainability' was held in Carcavelos, Portugal. The Conference intention was to host marked opportunities for the participants to meet and build future collaboration on innovation in vegetable grafting for sustainability.

The 3rd third Annual Conference 'Vegetable Grafting and the Rhizosphere' was organised in Berlin, Germany. Although, the root environment is particularly important for rootstocks and thus scion growth, it has been mainly neglected in research. This conference was focused on rhizosphere and gave exciting presentation and discussion on the topic.

The Final (4th) Conference of COST FA1204 resulted from the four-year work throughout working groups and/or from official and un-official collaborations among members of the Action. The gained knowledge and the skills will be presented during Conference and further activities aimed on building of an international multidisciplinary research network will be discussed.

Thus, the aims of the Conference are:

- to bring together members of the COST Action FA1204 and to discuss achievements, added value of networking and future plans,
- to bring together experts, academics and practitioners in vegetable grafting to exchange knowledge and to discuss options and strategies for topic improvement,
- to strengthen connection between scientific research and practical implementation.

The program of the Conference contains: six oral presentations per each working group (24 in total); 17 poster presentations; round table including oral presentations of participants from private companies; STSMs section with six oral presentations; book presentation during closing section; technical tour within Istrian region including representative agricultural/historical sites visits.

Beside the research and expert enrichment, we hope that you will carry back home strong memories of the city Pula that is combination of ancient and modern architecture as well as Istrian peninsula nature, life, and culture.

In conclusion, an issue of vegetable grafting continues to maintain a high importance in global agriculture according to its role in the alleviation of the effects of abiotic or biotic stresses. However, there are still a lot of unanswered and unexplored topics. Thus, the Final Conference is not the end of the story, established network lines are the assurance for the future activities and challenge.

Finally, we would like to express our appreciation to all colleagues who have contributed to the organization of Conference.

So, welcome you to the COST FA1204 Final Conference and have good time

Pula, 19 September 2016

On behalf of the Local Organizer Committee

Smiljana Goreta Ban and Katja Žanić

19-21 September 2016, Pula, Croatia

Committees

Local Organizing Committee (Croatia)

Dean Ban, Institute of Agriculture and Tourism
Marko Černe, Institute of Agriculture and Tourism
Smiljana Goreta Ban, Institute of Agriculture and Tourism
Klara Trošt Lesić, Institute of Agriculture and Tourism
Katja Žanić, Institute for Adriatic Crops and Karst Reclamation

Scientific Committee

Guiseppe Colla, *Chair of the COST FA1204*, University of Tuscia, Italy
Francisco Pérez Alfocea, *Vice-chair of the COST FA1204*, CEBAS-CSIC, Spain
Roni Cohen, ARO, Newe Ya'ar Research Center, Israel
Ian C.Dodd, Lancaster University, United Kingdom
Carmina Gisbert, COMAV-Polytechnic University of Valencia, Spain
Smiljana Goreta Ban, Institute of Agriculture and Tourism
Cherubino Leonardi, University of Catania, Italy
Dimitrios Savvas, University of Athens, Greece
Dietmar Schwarz, Institute of Vegetable and Ornamental Crops, Germany
Andrew J.Thompson, University of Cranfield, United Kingdom
Jan Henk Venema, University of Groningen, The Netherlands
Halit Yetisir, University of Erciyes Kayseri, Turkey
Katja Žanić, Institute for Adriatic Crops and Karst Reclamation

Working Group Leaders and Co-Leadres

WG 1 – Genetic resources and rootstock breeding
Andrew J.Thompson, University of Cranfield, UK
Halit Yetisir, University of Erciyes Kayseri, Turkey

WG 2 - Rootstock-scion interactions and graft compatibility
Jan Henk Venema, University of Groningen, The Netherlands
Ian C.Dodd, Lancaster University, United Kingdom

WG 3 – Rootstock mediated resistance to biotic and abiotic stresses
Dietmar Schwarz, Institute of Vegetable and Ornamental Crops, Germany
Roni Cohen, ARO, Newe Ya'ar Research Center, Israel

WG 4 – Rootstock mediated improvement of fruit quality
Cherubino Leonardi, University of Catania, Italy
Carmina Gisbert, COMAV-Polytechnic University of Valencia, Spain

STSm section

Dimitrios Savvas, University of Athens, Greece

Programme

18 September, Sunday

All day Arrivals

19 September, Monday

08:00 – 09:00 Registration

09:00 – 09:30 Official opening

09:30 – 11:00 Session 1: WG 1 Oral presentations

Chairs: Andrew J. Thompson and Halit Yetisir

09:30 – 09:45 Vegetable rootstock breeding: genetic variation and selection strategies
Thompson A.J., Bebeli P.J., Gisbert C., Belén Picó M., Yetisir H.

09:45 – 10:00 Screening of various gourd genotypes and watermelon cultivars for alkalinity tolerance under different pH levels
Ulas F., Yetisir H., Ulas A.

10:00 – 10:15 A new pepper rootstock to overcome salt stress
Penella C., Gisbert R., López-Serrano L., San Bautista A., López-Galarza S., Calatayud A.

10:15 – 10:30 Interspecific hybridization and hybrid seed yield of *Solanum Melongena* and *Solanum Aethiopicum* Lines for rootstock breeding
Saribas S., Balkaya A., Kandemir D., Secim A.

10:30 – 10:45 Citron: a promising rootstock for watermelon grafting
Belén Picó M., Pérez-de-Castro A., Cebolla-Cornejo J., Roselló S., Sorribas F., Gisbert C.

10:45 – 11:00 Breeding of rootstocks appropriate for cucumber grafting
Velkov N., Rodeva R., Markova D., Yankova V., Masheva S.

11:00 – 11:30 Coffee break

11:30 – 13:00 Session 2: WG 2 Oral presentations

Chairs: Jan Henk Venema and Ian C. Dodd

11:30 – 11:45 Rootstock – scion signaling: factors that mediate scion performance and graft compatibility
Venema J.H., Pina A., Dodd I.C.

11:45 – 12:00 Hormonal and nutritional responses regulate rootstock-mediated vigour under low-potassium nutrition in tomato
Martínez-Andújar C., Albacete A., Martínez-Pérez A., Pérez-Alfocea F.

12:00 – 12:15 Evaluating the role of root-to-shoot jasmonate signalling
de Ollas C., Arbona V., Gomez-Cadenas A., Dodd I.C.

12:15 – 12:30	Proteome analysis of grafted melon response to drought stress <u>Vítámvás P.</u> , Kosová K., Smirnova T., Prášil I.T.
12:30 – 12:45	Changes in the xylem sap metabolite profiles induced by the rootstock genotype in tomato <u>Albacete A.</u> , Martínez-Andújar C., Pérez-Alfocea F.
12:45 – 13:00	Early detection of graft incompatibility in an apricot intraspecific population <u>Irisarri P.</u> , Errea P., <u>Pina A.</u>
13:00 – 14:30	Lunch
14:30 – 16:00	Session III: WG 3 Oral presentations Chairs: Dietmar Schwarz and Roni Cohen
14:30 – 14:45	Physiological wilting of grafted melons: A phenomenon related to genetic material, rootstock-scion interaction and high temperatures <u>Cohen R.</u> , Edelstein M., Freeman S., Omari N., Pivonia S., Koren A., Soteriou G., Papayiannis L., Kyriacou M., Schwarz D.
14:45 – 15:00	Crop management affects success of grafted beans against plant parasitic nematodes <u>Costa S.R.</u> , Mourão I., Rodrigues J.R., Moura M.L., <u>Brito L.M.</u>
15:00 – 15:15	Cutting grafting method (RPSG) provides better stand establishment and nutrient uptake rate in salt-stressed cucumber seedlings <u>Balliu A.</u> , Sallaku G.
15:15 – 15:30	Effect of grafting on photosynthetic activity during dehydration and rehydration of tomato plants <u>Georgieva K.</u> , Mihailova G., Balacheva E., Rodeva R.
15:30 – 15:45	Grafting onto different rootstock genotypes alleviates salt stress in aubergine plants by activating antioxidative enzyme defense system <u>Talhouni M.</u> , Sönmez K., Ellialtıoğlu Ş.Ş., Kuşvuran S.
15:45 – 16:00	Population dynamics of <i>Bemisia tabaci</i> (Gennadius) and tomato leaf anatomy as affected by rootstock <u>Žanić K.</u> , <u>Dumičić G.</u> , Mandušić M., Vuletin Selak G., Jukić Špika M., Urlić B., Bočina I., Goreta Ban S.
16:00 – 16:30	Coffee break

16:30 – 17:30

Poster session (I, II, III)

- 1a Selection of low temperature tolerant *Cucurbita* spp. hybrid rootstocks for cucumber (*Cucumis sativus* L.)
Karaağaç O., Dođru S.M., Kar H., Yetişir H.
- 1b Contribution of grafting to nitrogen use efficiency among different solanum species
Ulas A., Yetisir H., Ulas F., Dogancı E.
- 2a Mechanisms associated with tolerance of grafted bell pepper rootstock to low root zone temperature
Aidoo M.K., Sherman T., Fait A., Rachmilevitch S., Lazarovitch N.
- 2b The hypocotyls morphology of promising salt tolerant winter squash and pumpkin rootstock lines and grafting compatibility, survival rates with grafted cucumber
Yıldız S., Balkaya A.
- 2c Antioxidant responses to arsenic stress in grafted melon plants
Stazi S.R., Allevato E., Marabottini R., Rita Paolacci A., Ciaffi M., D'Annibale A., Giuffrida F., Leonardi C.
- 2d Effects of rootstock type and grafting-healing duration on un-rooted grafted cuttings for eggplant transplant production and shipping
Sabatino L., Iapichino G., D'Anna F.
- 3a Host reaction of bean cultivars to the root knot nematode *Meloidogyne javanica*
Pires D., Costa S., Mourão I., Almeida M.T.
- 3b Effect of tomato grafting on virus infections
Petrov N., Dikova B., Balacheva E., Stoyanova Z., Rodeva R.
- 3c Melon growth, yield and resistance against soil borne diseases as affected by grafting under un-controlled greenhouse conditions
Al-Abed A., Naser Z., Qaryouti M.
- 3d Bell Pepper Response to Low Root Zone Temperature
Aidoo M.K., Sherman T., Fait A., Lazarovitch N., Rachmilevitch S.
- 3e Effect of partial root-zone irrigation on grafted tomato mineral content and fruit quality
Urlić B., Dumičić G., Runjić M., Vuletin Selak G., Jukić Špika M., Mandušić M., Žanić K.
- 18:00 – 21:00 Social event and networking (<http://www.pulacitytour.com/hr/>)

20 September, Tuesday

09:00 – 10:30

Session IV: WG 4 Oral presentations

Chairs: Cherubino Leonardi and Carmina Gisbert

09:00 – 09:15

How herbaceous grafting influences vegetable quality

Gisbert C., Kyriacou M., Oztekin G.B., Mourão I., Roupheal Y., Leonardi C.

09:15 – 09:30

Scion/rootstock combinations influence yield and metabolic profile of tomato fruits (*Lycopersicon esculentum* Mill.)

Kacjan Maršič N., Šircelj H., Mikulič Petkovšek M.

09:30 – 09:45

Rootstock effect on grafted green bean yield and fruit quality

Mourão I., Moura M.L., Costa S.R., Rodrigues J.R., Brito L.M., Ferreira M.E., Coutinho J.

09:45 – 10:00

Effects of *Cucurbita* hybrid rootstocks on quality of three fruit vegetables grown under moderate saline conditions

Stefanoni W., Roupheal Y., Cardarelli M., Barbetti B., Colla G.

10:00 – 10:15

Preventing entry of pharmaceuticals (carbamazepine) into the food chain by using grafted plants

Edelstein M., Ben-Hur M., Ju-Young Y., Bernstein N., Nasser A., Baumkoler F., Gerstl Z.

10:15 – 10:30

Grafting as a tool to enhance tomato fruit quality

Aktas H., Schwarz D.

10:30 – 11:00

Poster session (IV)

4a

Simultaneous determination of heavy metals (Cr, Ni, As, Cd, Pb, Hg) in Pachino cherry tomatoes grafting on different rootstock

Cincotta F., Verzera A., Condurso C., Bua G.D., Annuario G., Dugo G., Paratore A.

4b

Yield and quality of grafted mini watermelon [*Citrullus lanatus* (Thunb) Matsum & Nakai] cultivars

Soteriou G.A., Kyriacou M.C.

4c

The implications of grafting for watermelon and melon fruit quality

Kyriacou M.C., Soteriou G.A.

4d

Technological features and elements of economic efficiency regarding the semi-automatic grafting of vegetables

Bogoescu M., Vintila M.

4e

Grafting influences the fate of arsenic in melon plants

Allevato E., Marabottini R., Stazi S.R., Giuffrida F., Leonardi C.

11:00 – 11:30

Coffee break

11:30 – 13:00	Session V: Round table - (<i>connection of science and industry</i>) Chairs: Jan Henk Venema, Francisco Pèrez Alfocea, and Smiljana Goreta Ban
11:30 – 11:45	Grafted vegetable transplants and viral threats: effective solution or emerging complication <u>Koren A., Klein E.</u>
11:45 – 12:00	Our international grafting venture: current challenges and future opportunity <u>Causarano G.</u>
12:00 – 12:30	<i>Discussion on practical implementation and transfer of knowledge</i>
12:30 – 13:00	<i>Presentations of current projects, plans for future research and networking</i>
13:00 – 14:30	<i>Lunch</i>
14:30 – 16:00	Session VI: STSMs – Achievements and outcomes Chair: Dimitrios Savvas
14:30 – 14:45	Contribution of Short Term Scientific Missions to the scientific objectives of COST FA1204 <u>Savvas D.</u>
14:45 – 15:00	Alleviating aluminium toxicity and adverse effects of low pH in vegetables by grafting onto suitable rootstocks <u>Rouphael Y., Colla G., Cardarelli M., Bitterlich M., Porras M.E., Kläring H.P., Schwarz D.</u>
15:00 – 15:15	Interactions of grafting and shading in a greenhouse pepper crop <u>Sabatino L., Ropokis A., Bernabei G., Ntatsi G., D'Anna F., Katsoulas N., Savvas D.</u>
15:15 – 15:30	Response of some cucurbit genotypes to salinity stress <u>Topalova E., Břhm V., Tüzel Y., Öztekin G.B., Velkov N., Petkova V., Kappel N.</u>
15:30 – 15:45	Is cadmium tolerance root- or shoot-controlled in grafting pea plants? <u>Sanoubar R., Orsini F., Gianquinto G., Dodd I.</u>
15:45 – 16:00	The COST Action FA1204 database: A simple and effective tool for vegetable growers and the scientific community <u>Celli T., Rouphael Y., Ntatsi G., Fiorillo A., Colla G.</u>
16:00 – 16:30	<i>Coffee break</i>
16:30 – 17:30	Conclusions and closing Book presentation Closing remarks
18:00 – 22:00	Social event and networking (http://www.histriaaromatica.hr/index.php?ln=EN)



19-21 September 2016, Pula, Croatia

21 September, Wednesday

All day technical visit

09:00 – 20:00

Leaving Pula

Visit to vegetable nursery – owner Ivan Dušan

Visit to IPTPO vinery: <http://www.iptpo.hr/>

Visit to cabbage processing facility

<http://www.ciburiproduct.hr/>

Networking at Agroturizam „Ograde”

<http://agroturizam-ograde.hr/>



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

ABSTRACTS OF ORAL AND POSTER PRESENTATIONS



SESSION I WORKING GROUP 1

Genetic resources and rootstock breeding

ORAL PRESENTATIONS

Vegetable rootstock breeding: genetic variation and selection strategies

Andrew J. Thompson¹, Penelope J. Bebeli², Carmina Gisbert³, María Belén Picó³ and Halit Yetisir⁴.

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Abstract

The key challenge in plant breeding is the combination of multiple beneficial traits from different sources into a single elite cultivar. Grafting allows this complex task to be broken down into two more manageable breeding tasks, for example disease resistance genes can be stacked in a rootstock line without altering the carefully selected combination of genes that gives high fruit quality in the scion. Early benefits of vegetable rootstocks were realized through rootzone disease resistances and the enhancement to scion vigour; now the increasingly widespread use of grafting and associated infrastructure is stimulating genetic and breeding research to deliver a greater diversity of traits through the rootstock genotype. Different grafted vegetable crop species have contrasting bottlenecks in the breeding process such as availability of useful germplasm, barriers to hybridization, identification of gene-trait associations for marker assisted selection, and choice of trait screening strategy, but genotyping no longer limits progress since the emergence of next generation DNA sequencing, reference genomes for all grafted vegetable crops, and robust, inexpensive genotyping platforms.

Currently, a small number of F₁ hybrid vegetable rootstocks dominate commercial seed sales, but the reasons for their selection are poorly understood at the genetic and genomic levels; partnerships between academic researchers and commercial breeders have the potential to provide a scientific basis for future breeding strategies. Here we will report the findings of Working Group 1 of COST action FA1204 in relation to rootstock breeding, and will give examples from current research projects of COST action members in each of the key grafted vegetable crops.

Keywords: Working Group 1, rootstock breeding, genetic diversity, rootstock selection.

Screening of various gourd genotypes and watermelon cultivars for alkalinity tolerance under different pH levels

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Abstract

The aim of the present study was to determine genotypic differences in alkalinity tolerance among different gourd genotypes and watermelon cultivars, and to screen the plants based on the physiological and morphological response mechanisms under different pH levels. Under greenhouse conditions, two watermelon cultivars (Crimson Tide and Crisby) and 20 different gourd (*Lagenaria siceraria* landraces *Cucurbita maxima*) genotypes were grown in 8 L pots filled continuously aerated nutrient solution under three different pH levels (8.5, 6.5 and 4.5) with three replications. The results indicated that shoot (stem and leaf fresh and dry matter, leaf area) and root (root fresh and dry matter, root length) growth significantly ($P<0.001$) affected by different levels of pH supply. Highly significant ($P<0.001$) genotypic variation in shoot and root growth was found among genotypes and cultivars. Growth response to supplied pH, i.e. the interaction between pH and genotype, was also highly significant ($P<0.001$) in some shoot and root growth parameters. Also, shoot mineral element composition (P, K, Ca, Mg, Fe, Mn, Zn, B) was also significantly affected ($P<0.001$) by different levels of pH supply. Highly significant interaction ($P<0.001$) between pH and genotype was found in shoot mineral element composition.

Keywords: genotypic difference, pH tolerance, nutrient solution, gourd genotypes

A new pepper rootstock to overcome salt stress

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Abstract

Pepper is one of the most important crops in Mediterranean area, which is usually classified as a salt-sensitive species, even though it has been observed that salt tolerance can vary amongst pepper genotypes. The salinity of water and soil, can induce the appearance of physiological disorders in peppers as the Blossom-end rot (BER) and cracking, induce plant senescence and decrease not only production, but also the quality of the fruits. A promising perspective to improve pepper resistance to salinity is the use of grafting of commercial cultivars onto salt-tolerant rootstocks. The main objective of using rootstocks is to increase scion growth and development rate, yield and fruit quality. Tomato and melon are the two commonest herbaceous species in which the grafting practice has been efficiently applied to obtain salt-tolerant plants. As far as we know, very few studies on grafted pepper plants have been conducted to elucidate whether or not salt tolerance might be conferred by rootstocks. The screening of wild pepper accessions has been performed in our previous works to assess naturally-occurring genetic variation when plants are grown under salinity conditions, and salt-tolerant accessions to be used as rootstocks were selected. Recently, these selected tolerant accessions have been used as a source of variation in breeding programmes to obtain new hybrids to be used as rootstocks more tolerant against abiotic stresses. One of these hybrid (code H2) has been tested to agronomical and physiological behavior and economical profitability during three years under salinity conditions in Valencia area (Spain). To study H2 used as rootstock in responses under salinity, we have compared the performance of commercial cultivar “Adige” (A) plants (Lamuyo pepper, Sakata seeds) grafted onto H2 (A/H2), ungrafted plants (A) and A grafted onto one of the most important commercial rootstock used in Mediterranean-Spain area, Antinema (Sakata seeds) (A/ANT). The economic profitability for three plants combination (deduct the seeds cost and labor costs included the grafted) was always higher for A/H2 plants, although the profitability was dependent of the climatic conditions of each year. For 2014 the economical profitability was 2,50; 0,70 and 2,11 €/m² for A, A/ANT and A/H2 respectively; during 2015, due to the fact that the mean temperature was lower, a decrease of the number of flowers was observed. Nevertheless, the yield rate was higher for A/H2 and also the benefits, with 1,47 €/m² compared with 0,38 €/m² for A plants and 0,25 €/m² for A/ANT. Similar results were obtained in 2016 with a 45% more of economic profit for A/H2 (2,11€/m²) compared with ungrafted or ANT/A). The higher profit for A/H2 was due mainly to the lowest number of BER fruits. The physiological mechanisms which explain the higher tolerance to salinity in terms of productivity of A/H2 plants were: its capacity to maintain higher biomass through of preserve photosynthetic rate, higher proline content in the roots that allow a better water use efficiency which makes easier to maintain the metabolic functions in A/H2 grafted plants and its production. This work was financed by INIA (Spain) through Project RTA2013-00022-C02-01 and the European Regional Development Fund (ERDF). L.P.S. is a beneficiary of a doctoral fellowship (FPI-INIA).

Interspecific hybridization and hybrid seed yield of *Solanum melongena* and *Solanum aethiopicum* lines for rootstock breeding

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Abstract

The use of grafted seedlings in *Solanaceae* has increased in recent years as interspecific hybrids between *S. melongena* x *S. aethiopicum* has become the preferred rootstock for eggplant. In this study, different interspecific hybridization combinations were evaluated to obtain *S. melongena* x *S. aethiopicum* rootstocks. The field experiment of this study was carried out in Antalya province, Turkey in 2015-2016 years. The initial genetic materials were inbred and purified up to the S5 generation. A total of 1800 pollinations each of different combinations between 6 *S. melongena* lines and 10 *S. aethiopicum* lines were performed. These genotypes were selected based on resistant to Fusarium and Verticillium wilt, fruit set ratio, and seed yield traits. The fruit set number, fruit set percentage, and seed yields per fruit were detected. 921 interspecific hybrid fruits were obtained from these hybridizations. The most hybrid fruit ratios were determined in the combinations of FS9 x SA11 (% 80.0), FS6 x SA14 (% 76.7), FS6 x SA13 (% 73.3), FS9 x SA17-1 (% 73.3) and FS12 x SA17-2 (% 73.3). FS9 x SA6, FS6 x SA6, FS12 x SA6 and FS11 x SA6 interspecific hybrids were determined to be promising ones for hybrid seed yield. At the end of this study, these selected combinations will be used in the development of promising new eggplant rootstock cultivars.

Keywords: interspecific hybridization, *Solanum melongena*, *Solanum aethiopicum*, rootstock, breeding

Citron: a promising rootstock for watermelon grafting

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Abstract

Cucurbita ssp. interspecific hybrids (*C. moschata* Duchesne x *C. maxima* Duchesne) and bottle gourd accessions (*Lagenaria siceraria* Standl) are the most common commercial rootstocks for watermelons. These rootstocks are resistant to many of the soilborne fungi affecting this crop, but are susceptible to root-knot nematodes (RKN, *Meloidogyne* spp.). As consequence of the withdrawal of methyl bromide as soil fumigant, nematode populations in field have increased worldwide. Therefore, new rootstocks RKN-resistant are necessary for their management. We are assaying the usefulness of the taxon *Citrullus lanatus* var. *citroides* (citron) as new rootstock for watermelons. We have selected one citron accessions highly RKN resistant and tested its agronomical behavior as watermelon rootstock. Watermelon plants developed onto Citron rootstock were more vigorous than those self- or non-grafted, whereas no effect on flowering time or fruit set was observed. The citron rootstock seems to affect less negatively fruit quality than *Cucurbita* hybrids. All these results indicate that citron is a promising rootstock for watermelon.

Keywords: *C. lanatus*, nematode, quality

Breeding of rootstocks appropriate for cucumber grafting

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Abstract

Grafting technique is more frequently applied as horticultural practice to *Cucurbitaceae* crops and in particular to cucumber during the last decade. The reasons are related to intensive use of arable land, multiplication of soil-borne pests and prohibition of methyl bromide usage. Grafting is an adequate solution to this problem. The most commonly used rootstocks in the production are *Cucurbita maxima* x *C. moschata* F₁, *C. maxima*, *C. moschata* and *Lagenaria siceraria*. An important moment at the initiation of a breeding program is to establish certain parameters as germination rate of the rootstock seeds, compatibility between scion and rootstock, productivity after grafting, fruit quality, resistance to Fusarium wilt, Pythium root rot and nematodes (*Meloidogine* spp). The aim of this study was to investigate local and introduced germplasm of *Cucurbitaceae* family in relation to these parameters and to breed new rootstocks appropriate for cucumber grafting. The results showed that germination rate of rootstock seeds varied greater in *L. siceraria* and *C. ficifolia* in comparison to the other cucurbits. All of tested rootstocks were compatible with cucumber but survival rate varied from 80 to 90 percent for *C. maxima* x *C. moschata* F₁, *C. maxima*, *C. moschata* and *L. siceraria*; 40-50% for *Luffa cylindrica*; 70-80% for *C. ficifolia*. The yield variations of cucumber varieties were influenced in a greater extent by the rootstock compared to the scion but the influence of the environmental factors was greatest. The highest yield was reported in cucumber cultivars grafted on *C. maxima* x *C. moschata* F₁, *C. maxima* and *L. siceraria*. The total sensory evaluation could vary depend on scion, rootstock and harvest time and their interactions. The tested breeding material to Fusarium wilt and Pythium root rot revealed that *L. siceraria* (landrace) and cv. Muskatna 51-17 (*C. moschata*) possessed the lowest index of infestation (10% and 30%, respectively). The lowest index of nematode infestation from 15 to 30% was established in CM 720 x Carotina F₁, Turban x Muskatna 51-17 F₁ (*C. maxima* x *C. moschata* F₁), PI 560946, Carotina (*C. moschata*) and AMB (*C. pepo*). Summarizing the results it could pointed interspecific hybrid as the most appropriate rootstock for cucumber grafting. In order to develop new interspecific hybrid combinations fifteen *C. maxima* genotypes were cross-pollinated with five *C. moschata* genotypes. Three new hybrids were developed between Turban x Muskatna 51-17 F₁, CM 720 x Carotina F₁ and CM 720 x Afrodita F₁. The last two hybrids were developed on the basis of male sterility line (CM 720), which allow to reduce the cost for additional work for pollination.

Keywords: *Cucurbitaceae*, interspecific hybrid, compatibility, yield, resistance



POSTER SESSION I



1a. Selection of low temperature tolerant *Cucurbita* spp. hybrid rootstocks for cucumber (*Cucumis sativus* L.)

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Abstract

The low temperature is one of the most important abiotic stress factors inflicting heavy economic relevant yield losses by reducing plant growth and development. Cucumber is one of the most sensitive vegetable species to low temperature. Because of this reason, cucumber growing periods are limited to the low temperature conditions in Turkey. Grafting is a promising tool to enhance plant performance of Cucurbitaceae family against to abiotic stress conditions. Pumpkin is recommended as rootstocks in low temperature conditions for grafted cucumber growing. In previous studies, 52 *Cucurbita* spp. lines were screened to low temperature tolerance. Eight *C. moschata* and one *C. maxima* parental lines that identified as low temperature tolerant were crossed as half diallel among themselves. 28 *C. moschata* x *C. moschata* and 2 *C. maxima* x *C. moschata* hybrids were obtained. The commercial rootstocks Maximus F₁ (*C. maxima* x *C. moschata*), New Super Unryu (*C. moschata* x *C. moschata*), and Triumph F₁ (*C. ficifolia*) were used as control. *Cucumis sativus* L. ‘Gordion F₁ and Termessos F₁’ cucumber cultivar was used as a scion. Cucumbers were grafted onto the 33 rootstocks using the procedure of splice grafting method. Grafted plants were grown at air temperatures of 12°C / 8°C day /night under 16 / 8 h photoperiod during 40 days. The experiment was arranged in a randomized complete block design with three replicate and 10 plants used in each replicate. Root dry weight (g), total root length (cm), root volume (cm³), root surface area (cm²), damaged leaf ratio, plant height (cm), electrolyte leakage ratio (%), total chlorophyll content, and leaf relative water ratio (%) parameters were examined. H24, H11 and TM1 hybrids were selected as superior rootstock against low temperature.

This research was founded by TÜBİTAK (Project Number: TOVAG COST 114O843)

Keywords: root, cucurbita, rootstock, breeding, low temperature

1b. Contribution of grafting to nitrogen use efficiency among different *Solanum* species

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Abstract

The objective of the present study was to determine the grafting compatibility among different *solanum* species and contribution of grafting to Nitrogen Use Efficiency (NUE; dry matter production per unit crop N supply). In the study pepino (*Solanum muricatum*) was used as scion and grafted onto rootstocks of tomato (*Solanum lycopersicum*) and eggplant (*Solanum melongena*). Plants were grown in a hydroponic nutrient solution system in controlled climate chamber. Nitrogen was applied at two doses (High-N: 3.0 mM, Low-N: 0.3 mM) with three replications. The measured parameters were; plant height, leaf number, internodes number, shoot and root fresh and dry matter, shoot/root ratio, leaf area, leaf chlorophyll content (SPAD), root length, root diameter and root volume. In terms of growth and development, the graft combinations (pepino/tomato and pepino/eggplant) differed significantly. Significantly positive effects of nitrogen supply were recorded on the plant height ($P<0.05$), leaf number ($P<0.01$), leaf area ($P<0.001$) and internodes number ($P<0.05$). Also, shoot fresh ($P<0.001$) and dry ($P<0.001$) matter were significantly affected by nitrogen supply. Root length ($P<0.001$) and shoot/root ratio ($P<0.001$) were significantly affected by N supply, whereas no effect was recorded either on root diameter or root dry matter. Compared to non-grafted pepino (control), pepino/tomato graft combination showed a highest NUE at both low-N and high-N supply. However, lowest growth performance and hence lowest NUE was found in pepino/eggplant combination at low-N supply.

Keywords: grafting, pepino, *solanum*, nitrogen, root

SESSION II

WORKING GROUP 2

Rootstock-scion interactions and graft compatibility

ORAL PRESENTATIONS

Rootstock – scion signalling: factors that mediate scion performance and graft compatibility

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Abstract

During this presentation an overview will be given on the progress that has been made in rootstock-scion signalling: factors that mediate scion performance and graft compatibility, the two working fields of COST Action FA1204 Working Group 2. Results of reciprocal grafting studies will be presented that were aimed to elucidate the root-derived signals that facilitate improved rootstock and scion performance, mainly in tomato. Investigations have focused on the roles of the phytohormones abscisic acid (using the ABA-deficient mutants *notabilis* and *flacca*, and the ABA overproducing transgenics *sp5* and *sp12*), jasmonic acid (using the JA-deficient mutant *JL5*), cytokinin (using cytokinin overproducing *IPT* transgenics) and ethylene (using the partially ethylene insensitive mutant never-ripe, NR). The main focus will be on signalling responses to abiotic stresses such as drought, salt and non-optimal temperatures. In addition, rootstock-scion interactions responsible for determining success in rootstock-scion compatibility will be presented to identify anatomical, physiological and molecular markers for graft incompatibility. Different lines of research have focused on defining the cellular and molecular mechanisms involved in the incompatible reaction and the development of a test to predict (early) compatibility success. During the last 10 years, remarkable progress has been made in the field of graft incompatibility. Important innovative and technical information have been developed to assess levels of graft compatibility by scanning electron microscopy (SEM), electrical impedance measurements, by analysis of reactive oxygen levels (ROS) and chlorophyll *a* fluorescence imaging (F_v/F_m ratio). The role of secondary metabolites, plant growth regulators, cell to cell communication and differentially expressed genes between compatible and incompatible combinations will be discussed in terms of the incompatibility reaction between grafting partners. Finally, examples of deliverables will be discussed that might be useful for nurseries, vegetable growers or rootstock breeders.

Keywords: working group 2, abiotic stress, rootstock-scion communication, graft compatibility

Hormonal and nutritional responses regulate rootstock-mediated vigour under low-potassium nutrition in tomato

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Abstract

The underlying physiological traits of the tolerance to low nutrient supply are still largely unknown. Sixteen contrasting RILs derived from the wild tomato species *S. pimpinellifolium* were used to evaluate the rootstock-mediated induction of low (L) or high (H) vigour to a commercial F1 hybrid grown under control (6 mM, c) and low-K (1mM, k). A model is proposed to explain the rootstock effect on shoot performance under low-K, with the ethylene precursor ACC playing a pivotal negative role. The ACC concentration was higher in the low vigour Lc and Lk combinations while it was reduced in the high vigour Hk plants. Low ACC levels would activate the transport of K vs Na in the Hk grafted plants. Along with K, Ca and S, micronutrient uptake and transport were also activated in the Hk combinations under low-K. Additionally, an interconversion of trans-zeatin into trans-zeatin riboside decreases ACC in the tolerant LcHk plants. The high vigour induced by the Hk plants can also be explained by an interaction of ACC with other hormones (cytokinis and salicylic, abscisic and jasmonic acid). Therefore, Hk rootstocks convert an elite tomato F1 cultivar into a (micro) nutrient-efficient phenotype, improving growth under reduced K fertilization.

Keywords: tomato, grafting, micronutrients, phytohormones, potassium.

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Evaluating the role of root-to-shoot Jasmonate signalling

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Abstract

Previous reciprocal and self grafting experiments in near isogenic wild type Castlemart (CST) and jasmonic acid deficient (JL5) tomato plants under water stress conditions showed that JL5 scions constitutively displayed lower stomatal conductance (gs) due to over accumulation of the JA precursor OPDA, which acts as an antitranspirant. A CST rootstock partially reversed the diminished gs of JL5 scions, which correlated with a decrease in foliar OPDA concentration and increased JA transport from WT roots. To prove that xylem-borne jasmonates could reverse the JL5 phenotype of OPDA accumulation and hence increase transpiration, detached whole tomato shoots of CST and JL5 were fed with artificial xylem sap supplemented with JA. Gravimetric transpiration and gs were monitored for 5 hours and at the end of the experiment, leaf tissue and xylem sap was collected to analyze hormonal content (ABA, OPDA and JA). In CST plants, 1 μ M JA is quickly transported to the shoot and transiently decreased transpiration (12-18% decrease compared to control plants). In the same system, 1 μ M ABA consistently decreased transpiration by 35-45% during the same period. However, JL5 detached shoots showed the opposite response as 1 μ M JA increased transpiration (10-15% compared to JL5 fed with control artificial xylem sap) but similar response to fed 1 μ M ABA although JL5 showed less sensitivity to ABA. Hormonal analyses showed that JA transported via transpiration stream decreased leaf OPDA levels and increased both JA and ABA levels in tissue. Transpiration was negatively correlated with OPDA levels. Thus JA transport via the transpiration stream partially restored the WT transpiration phenotype in JL5 scions via feedback hormonal regulation of the Jasmonates biosynthesis pathway.

Keywords: JA, OPDA, transpiration, root-to-shoot, ABA.

Proteome analysis of grafted melon response to drought stress

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Plant exposure to stress induces a dynamic proteome response aimed at an establishment of a new homeostasis. The two-dimensional differential gel electrophoresis (2D-DIGE) analysis enables protein relative quantification leading to an identification of the protein spots revealing an enhanced abundance in stress-treated or stress-tolerant varieties which could be further tested as potential markers of stress tolerance. Proteomic experiments aimed at grafted melon proteome response to drought were analyzed. The aim of the study was to evaluate the effect of vegetable grafting on melon response to drought treatment at protein level. Unsurprisingly, the majority of differently abundant proteins belongs to energy-, stress- and defence-related proteins. We were able to find differences in protein abundances between grafted and ungrafted plants also. The results of proteomic analyses were interpreted with respect to other physiological data such as parameters related to photosynthesis (chlorophyll fluorescence), water regime-related characteristics (water saturation deficit, osmotic potential), and others. Dehydrin accumulation was analysed by hybridization of samples with anti-dehydrin polyclonal antibody. The role of identified proteins in understanding of the grafted plant stress response and acquisition of plant stress tolerance is discussed.

Acknowledgement: The work was supported by the Ministry of Agriculture of the Czech Republic (MZe RO0415), EU COST action FA1204 and by the Ministry of Education, Youth and Sports (LD14087).

Keywords: melon, drought, proteome, dehydrin, grafting

Changes in the xylem sap metabolite profiles induced by the rootstock genotype in tomato

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Abstract

Identifying root-derived chemical signals and understanding their specific effects in shoot tissues could open new strategies to improve crop yield stability under abiotic stress conditions. Therefore, a commercial tomato cultivar (*Solanum lycopersicum* cv Boludo F1, Monsanto) was either self-grafted (L/L) or grafted onto the interspecific commercial tomato rootstock Maxifort (Monsanto) obtained from a cross between *S. lycopersicum* and *S. habrochaites* (L/H), and onto a recombinant inbred line obtained from a cross between *S. lycopersicum* and *S. pimpinellifolium* from AVRDC (L/P). Grafted plants were cultivated under commercial greenhouse conditions during autumn season in Mazarrón (Spain). Xylem sap, collected by root pressure, was injected into a U-HPLC-MS system (EXACTIVE, ThermoFisher Scientific). The metabolite signature of the '*pimpinellifolium*' L/P graft combination was strongly associated to the first principal component (PC1), which explained 47% of the total chemical variance, while the '*lycopersicum*' L/L combination was linked to PC2, explaining 31% of the variance. The metabolite profile of the '*habrochaites*' L/H plants clustered between the other two combinations. Additionally, we identified 81 putative compounds of both the primary and secondary metabolism. We have shown that the metabolite profile of the xylem sap can be qualitatively and quantitatively modified by changing the root system (rootstock), as a genotypic source of chemical variability. Xylem sap profiling is likely to provide physiological markers to assist root-targeted breeding for resistance to individual or combined stresses.

Keywords: tomato, grafting, xylem, LC-MS, metabolite profile

Acknowledgments: ROOTOPOWER Project funded by the European Commission, Theme [KBBE.2011.1.2-05].

Early detection of graft incompatibility in an apricot intraspecific population

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Abstract

In the last years, it has been reported that not only anatomical changes take place during graft union formation but also molecular ones that might be involved in generating different behavior between compatible/incompatible combinations at early stages of development. In this sense, the content and nature of the callus cells implicated in the first step of graft formation can play an important role in triggering the response that lead to the formation of a strong and successful union. In this study, cell proliferation, cell arrangement, cell shape and photosynthetic pigment contents, were observed in a F1 apricot intraspecific population ('Moniqui' female parent_incompatible and 'Paviot', male parent_compatible) segregating for the graft compatibility trait. 66 apricot seedlings were grafted on the rootstock 'Marianna 2624' and evaluated one month after grafting. Compatible grafts exhibited an organized and homogeneous cell arrangement at the contact surface, strongly stained with calcofluor. On the contrary, it was displayed a disorganized arrangement in some areas of the contact surface, showing no additional development in incompatible descendants. Pearson correlation showed a significant a strong correlation between cell proliferation and cell arrangement (0,802**), cell shape (0,521**), as well as cell arrangement and cell shape (0,573**). A negative correlation was obtained between the presence of photosynthetic pigment contents at the graft interface and the rest of the parameters studied. All the characteristics of the descendants spread between the compatible and incompatible parents, and we observed a normal distribution of these traits in the population. Neither of the descendants was lower or higher than the progenitors and all these traits related to graft compatibility were transmitted to the descendants. The behavior of the grafts growth at one month after grafting was correlated to that of the same combinations one year after grafting. These differences at the cellular levels may govern compatibility and incompatibility, and may provide valuable information for determining the affinity of grafted seedlings at an early stage in other progenies and new cultivars to be released into the market.

Keywords: cell behavior, graft compatibility, histological analysis, Pearson correlations, *Prunus armeniaca* L.



POSTER SESSION II



2a. Mechanisms associated with tolerance of grafted bell pepper rootstock to low root zone temperature

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Abstract

The goal of this study was to investigate the effects of low root zone temperature on the growth and development of plants and to identify the mechanisms associated tolerance to cold stress. Two grafted bell pepper varieties rootstocks (ROM/ROM and ROM/CTR1) and non-grafted bell pepper (ROM) were evaluated in the winter season in a commercial growth net house. Minirhizotron tubes and in-growth cores were used to investigate grafted bell pepper root tolerance/response to low root zone temperatures. Shoot phenology, fruit yield and root dynamics as well as soil profile properties were investigated. The biomass of ROM grafted on CTR1 significantly increased compared to ROM non-grafted and ROM grafted on its own rootstock. In comparing root volume obtained by the in-growth core at the soil profile depth from 0 to 35 cm sampled at two different time point ROM grafted on CTR1 demonstrated a fast root growth rate. ROM/CTR1 had more number of root tips at this depth relative to the other plants. With the minirhizotron we observed more CTR1 rootstock number of roots at the soil profile between 45 and 75 cm compared to other grafted plants. CTR1 rootstock showed tolerance to low soil temperature linked not only to its deep rooted root morphology but also able to grow more root tips close to the surface of the soil and significant increase yield. With this tolerance, CTR1 has the potential to be used as a commercial rootstock for many varieties of pepper response to low root zone temperature areas.

Keywords: rootstock, low temperature stress, minirhizotron, in-growth core

2b. The hypocotyls morphology of promising salt tolerant winter squash and pumpkin rootstock lines and grafting compatibility, survival rates with grafted cucumber

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Abstract

Grafted seedlings recently are being used widely for vegetable grown in many countries of the world. Winter squash and pumpkins were recommended for use of rootstocks for the grafted watermelon, melon and cucumber growing in the saline soils. In this study, the promising salt tolerant winter squash and pumpkin rootstock lines were used and grafting compatibility, survival rates for grafted cucumber was evaluated. Gordion cv. (cucumber) was used as a scion. Emergence rate, hypocotyl morphology, survival were determined. Grafting success of these rootstocks were found between 33.0-87.0%. It was determined that the grafting success of G31 (87%) and G29 (50%) pumpkin genotypes, G15 (70%) and G14 (63%) interspecific genotypes with Gordion cucumber cultivar is the highest. The grafted cucumber genotypes gave the highest vegetative growth compared to ungrafted control seedlings. To conclude, G31, G15 and G14 rootstock candidates were found to be the first local salt-tolerant rootstocks for cucumber breeding studies. These findings showed that selected promising salt tolerant rootstock genotypes will be used for grafted cucumber seedling production in near future.

Keywords: winter squash, pumpkin, rootstock, resistance, cucumber, grafting, salt

2c. Antioxidant responses to arsenic stress in grafted melon plants

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Abstract

The toxic effects of arsenic (As), on plants and humans, have originated a series of studies aimed to understand the mechanisms involved in its uptake from the environment and its transport and partitioning in the plants.

The reactive oxygen species (ROS) generation is the primary response of the plants exposed to high concentrations of metalloid: As(III) and As(V) generates conditions of oxidative stress in tissues, inducing the production of ROS such as superoxide anion ($O_2^{\bullet-}$), hydroxyl radical ($\bullet OH$) and H_2O_2 (Mallick et al. 2011. Ecotoxicol Environ Saf 74, 1316–1324).

One of the most deleterious effect induced in a plant exposed to As is the lipid peroxidation, this affects cellular function and leads also to the production of radicals derived from lipids (Moller et al. 2007. Annu. Rev. Plant Biol. 58, 459–481). The malondialdehyde (MDA), one of the decomposition products of polyunsaturated fatty acids of the membrane, is considered as a reliable indicator of oxidative stress. As answer to oxidative damage, plants have evolved a large pool of antioxidant enzymes such as superoxide dismutase (SOD), peroxidase, ascorbate peroxidase, glutathione (GSH) reductase and catalase. The expression levels of these enzymes in plants, is deeply influenced by the concentration of As (Duman et al. 2010 Ecotoxicol 19, 983-993). Another answer of the plant to the presence of the toxic metalloid came from a group of non-enzymatic antioxidants, such as GSH, phytochelatins (PCs), ascorbate, carotenoids and anthocyanins (Song et al. 2010 PNAS 107, 21,187 to 21,192).

The aim of this research is to study the biochemical, metabolic and molecular response of melon (cv. Proteo) grafted onto different rootstocks ('Proteo', 'RS841' and 'Strongtosa') and exposed to a nutrient solution with two different concentrations of As: 0.002 and 3.8 mg/l.

The preliminary result will be presented.

Keywords: arsenic, plant, ROS, abiotic stress, grafted melon plants.

2d. Effects of rootstock type and grafting-healing duration on un-rooted grafted cuttings for eggplant transplant production and shipping

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Abstract

Herbaceous grafting of fruiting vegetables is one of the most important techniques to overcome pests and soilborne diseases in modern cropping systems. Even though large-scale commercial production of vegetable seedlings is expanding rapidly in many developed and less-developed countries, there are many issues associated with cultivating grafted vegetable seedlings. Major problems are the large labor and high skilled technique required for the grafting operation and post-graft handling of grafted seedlings for rapid healing (7 to 10 days), and the high transportation costs associated to long distance delivery. In many areas of the world, due to the high cost of skilled manpower, the use of grafted plug plants is still limited causing a relatively slow development of the grafting nursery industry. Our objective was to test the use of un-rooted grafted cuttings as means of propagation and distribution of eggplant transplants. Un-rooted eggplant grafted cuttings ('Birgah' eggplant scion with *Solanum torvum* or *Solanum aethiopicum* rootstocks) harvested after diverse healing time [0 (DIH 0), 1 (DIH 1), 3 (DIH 3), 5 (DIH 5), or 7 (DIH 7) days after grafting] were exposed to 20°C 'simulated transportation temperature' and dark condition in a growth chamber for 72 hours. After the simulated transportation time, all un-rooted grafted cuttings were transferred into the greenhouse for rooting. The results showed that both *S. torvum* and *S. aethiopicum* are suitable rootstocks for applying the un-rooted grafted cutting propagation technique. However, plants grafted onto *S. torvum* showed better results in terms of leaf number after shipping, leaf number after rooting and number of leaves after 7 days of growth as compared to those grafted onto *S. aethiopicum*. Furthermore, *S. torvum* grafted plants showed higher rooting percentage, leaf area, root fresh and dry weight than those grafted onto *S. aethiopicum*. Regardless of the rootstock used, the treatment DIH 0 gave the best results in terms of rooting, growth and development rates of the finished plug transplants. This innovative production/shipping method might be successfully used in areas where local nurseries do not have high grafting efficiency.

Keywords: shipping, un-rooted grafted cutting, eggplant, *S. torvum*, *S. aethiopicum*.

SESSION III

WORKING GROUP 3

Rootstock mediated resistance to biotic and abiotic stresses

ORAL PRESENTATIONS

Physiological wilting of grafted melons: A phenomenon related to genetic material, rootstock-scion interaction and high temperatures

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Abstract

Wilting of grafted melons toward the harvest (physiological wilt, PW), was evident in growing areas and seasons in which the plants are exposed to heat and fruit load stresses. The wilting occurred in soils that were disinfested prior to planting, thus this phenomenon cannot be related to soil-borne diseases. Attempts to re-produce the PW in the winter failed, strongly indicating that the phenomenon is related to high soil or air temperatures. The PW was first evident in trellised grafted melons but recently it was recorded also in mid-summer melons grown prostrated in the open field. The incidence of the PW varied within the same melon scion cultivar when grafted onto different rootstock and different scions grafted onto the same rootstock.

For improving rootstock tolerance to PW, it is necessary to search within collections of *Cucurbita* accessions for new traits, particularly tolerance to high soil temperature. We expect this will contribute to a better performance of grafted melons in areas with high risk of PW.

Crop management affects success of grafted beans against plant parasitic nematodes

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Abstract

In Portugal, green beans (*Phaseolus vulgaris*) are grown intensively in greenhouses and so the incidence of diseases, including plant parasitic nematodes (PPN) increased as well as soil salinity caused by fertilizer applications. With the aim of suppressing soil-borne diseases and alleviating abiotic stress whilst improving green bean yield and quality, beans have been grafted in Portugal since 2010. Although PPN resistant rootstocks have been developed for some crops, they are not available for common bean. With this aim, we tested three *Phaseolus coccineus* cultivars as rootstocks for two widely used common bean cultivars (commercial hybrid ‘Oriente’ and standard Portuguese traditional ‘Vagem Rajada’): the commercially-available ‘Aintree’ and ‘White Emergo’ (TozerSeeds) and the Portuguese landrace ‘Feijão 7 anos’. Plants grafted onto each rootstock, and ungrafted or self-grafted plants (controls) were grown in two separate greenhouse trials: site Ponte de Lima (PL) under low-input management and site Póvoa de Varzim (PV) under conventional commercial management. Plants were grown for a full cropping cycle, in completely randomized plots, replicated 3 times in PL and 4 in PV. Soil samples were collected to extract, identify and quantify PPN genera. In site PV, populations of the most abundant PPN *Pratylenchus* and *Heterodera* were significantly smaller in grafted than in control plants, with minimal numbers in the rhizosphere of plants grafted onto ‘Feijão 7 anos’ ($p < 0.05$). In site PL, the most abundant PPN genera were *Tylenchorhynchus*, *Pratylenchus* and *Xiphinema*. Population densities of these nematodes were not always significantly smaller in grafted plants. The most successful rootstock differed depending on the grafted cultivar and PPN genus considered. Yield could not be correlated with nematode density in either site. Grafting is a promising technique for sustainably granting PPN resistance to crops, but the biotic and abiotic factors that modulate its success in field conditions needs further research.

Keywords: *Phaseolus coccineus*, *Phaseolus vulgaris*, *Pratylenchus* spp., rootstock, protected culture

Cutting grafting method (RPSG) provides better stand establishment and nutrient uptake rate in salt-stressed cucumber seedlings

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Abstract

The objective of the study was to assess the influence of different grafting methods (RPSG vs. SG) of cucumber seedlings on the establishment rate and nutrient absorption rate of plant's root system under normal and saline conditions. Graded seeds of *Cucurbita maxima* x *C. moschata* were sown in transplant trays filled either with vermiculite and cucumber seedlings were grafted onto them by two different grafting methods; common root intact method (SG) and cutting grafted method (RPSG). A similar number of self-rooted (NG) cucumber plants were kept as control plants. At DAG 14, the seedlings were transplanted into 200 cm³ plastic pots filled with vermiculite. At this time, two different levels of salt-stress (0 and 80 mM NaCl) were established by the addition of different amounts of sodium chloride (NaCl) to the nutrient solution. RGR_{Plant} and RGR_{Root} were used to assess the growth rate of non-grafted (NG) and grafted (SG, RPSG) seedlings and component production rate (CPR; g g⁻¹ d⁻¹) to indicate the contribution of one plant component (root, stem or leaves) to the whole plant growth. Nutrient contents of leaves (K, Ca, Mg, Mn, P, Na, Fe, Al and S) at DAG14 and DAG24 were analyzed and based on that, total uptake of each nutrient accumulated in the plant was calculated as the product of leaf dry matter and nutrient concentration. Following that, the specific absorption rate (SAR; g mg⁻¹ d⁻¹) was calculated to assess root absorption efficiency of non grafted and grafted seedlings. The results of the study proves that cutting grafted (RPSG) method offers considerable advantages over root intact grafting method (SG), in terms of grafting union formation, stand establishment and specific absorption rate of grafted cucumber seedlings after transplanting. The mechanism of advantage is related with significantly higher rate of root component production due to which a higher proportion of absorptive fine roots is present in RPSG grafted cucumber plants.

Key word; grafting, salinity, RGR, CPR, SAR

Effect of grafting on photosynthetic activity during dehydration and rehydration of tomato plants

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Abstract

The effect of drought stress on the photosynthetic activity of grafted tomato plants was investigated. Two Bulgarian tomato accessions (cultivar Kalina F1 and breeding line C19 with erectoid leaves) were used as scions. They were grafted onto three tomato rootstocks of Enza Zaden vegetable seed breeding company (Formamino, Estamino and Efialto). Drought stress was applied 25 days after grafting. The photosynthetic activity was evaluated by chlorophyll fluorescence measurements of well-watered (control), moderately and severely dehydrated plants and 24 hours after rehydration. The maximum efficiency of photosystem II (PSII), estimated by the ratio F_v/F_m , was similar in all grafted tomato plants and was not significantly affected by drought stress. In contrast, the quantum efficiency of PSII electron transport (Φ_{PSII}) and especially the ratio of fluorescence decrease to the steady state fluorescence (R_{fd} – indicating the vitality of plants) were more altered by the dehydration. The most sensitive to drought stress was line C19 grafted onto rootstock Estamino. Six days after water stress application the values of Φ_{PSII} and R_{fd} were reduced by 10 and 30%, respectively. The decline in the photochemical efficiency of these grafted plants was accompanied with increased thermal energy dissipation. The highest tolerance to drought stress showed plants of Kalina F1 grafted onto rootstocks Fortamino and Efialto. The photosynthetic activity of dehydrated grafted plants was fully recovered after 24 h of rehydration, reaching the control values.

Keywords: drought tolerance, chlorophyll fluorescence, photochemical efficiency

Grafting onto different rootstock genotypes alleviates salt stress in aubergine plants by activating antioxidative enzyme defense system

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Abstract

Antioxidant enzymes such as SOD, CAT, and APX are known to substantially reduce the levels of stress induced-reactive oxygen species (ROS) in plants increasing their tolerance level against stress factors like salinity, thus improve their growth and productivity under such harsh conditions. Grafting is known to alleviate the negative effects of biotic and abiotic stress factors by increasing the level of the antioxidant enzymes activity.

In this study a hydroponic experiment was carried out in Antalya-Turkey in 2014 under greenhouse conditions to see if grafting raise eggplant seedlings tolerance level under 15 dS/m NaCl-salinity conditions by inducing higher antioxidant enzymes activity in these plants. Five commercial genotypes (AGR 703 (*S. aethiopicum*), Vista, Köksal F₁, Yula F₁ (*S. incanum* x *S. melongena* hybrids) and Hawk (*S. torvum*)), in addition to two Turkish genotypes Burdur and Mardin (*S. melongena* L.) were used as the rootstocks. For scion two cultivars were used (Artvin and Naomi F₁). Self-grafted and non-grafted seedlings were used as control. As a result 18 rootstock/scion combinations were obtained.

It was found that SOD, CAT, and APX activity levels were higher in the grafted seedlings compared to the self- and non-grafted seedlings which resulted to better tolerance and growth. In conclusion, antioxidant enzymes activities play a protective role against abiotic stress and they are effective in providing resistance to stress in plants. Also it can be said that grafting onto the suitable rootstock increase plant tolerance level by their higher antioxidant enzymes activity induced by these rootstocks.

Keywords; aubergine, grafting, SOD, CAT, APX, hydroponic system

Population dynamics of *Bemisia tabaci* (Gennadius) and tomato leaf anatomy as affected by rootstock

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Abstract

The vegetable grafting has received more attention in past years as a sustainable practice for mitigation of abiotic and biotic stresses. The successful management of hydroponic crops assumes minimal use of pesticides and the new approaches for mitigation of pest damage have been tested. The aim of this study was to determine the effect of tomato rootstocks (Arnold, Buffon, Emperador and Maxifort) on incidence of tobacco whitefly *Bemisia tabaci* (Gennadius) in hydroponic tomato crop. Cultivar Clarabella was used as a scion, and the control was non-grafted Clarabella or grafted on its own roots. The plants were artificially infested with adult instars of *B. tabaci* at 20 October 2015. Population density of large nymphs (4th instar to pupae) was assessed on 4th, 5th and 6th leaf, 37 days after infestation. Number of individuals was counted and expressed per cm². Leaf anatomy characteristics (the thickness of the lamina, adaxial and abaxial epidermis and leaf mesophyll) of all treatments were measured. The large nymphs population density of *B. tabaci* was lower in tomato plants grafted onto different rootstocks, compared to non-grafted Clarabella plants, or grafted on its own roots regardless of leaf position. Total leaf thickness was the highest in non-grafted cv. Clarabella plants compared to plants grafted on tested rootstocks or on its own roots. Non-grafted plants of cv. Clarabella, that were more attractive to the pests, were characterized by the 12.1 µm thickness of lower epidermis and 145.2 µm thickness of mesophyll. It seems that reduction of *B. tabaci* density on leaves of grafted plants could be at least partially connected to changes in leaf anatomy induced by rootstock. The results can be applied in an integrated tomato protection against *B. tabaci*.

Keywords: *B. tabaci*, large nymphs, IPM, leaf anatomy



POSTER SESSION III



3a. Host reaction of bean cultivars to the root-knot nematode *Meloidogyne javanica*

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Abstract

Among the numerous pests and diseases that affect common bean (*Phaseolus* spp.), root-knot nematodes (RKN), *Meloidogyne* spp., are the ones that stand out for their devastating effects on horticultural crops. The main control strategy is based on the application of nematicides, which have been progressively restricted. Alternative nematode management methods have been considered, such as vegetable grafting using resistant cultivars. The objectives of this study were: 1) to know the reaction of nine cultivars of common bean (*Phaseolus vulgaris* and *P. coccineus*) to *Meloidogyne javanica*, considering their degree of susceptibility and resistance; 2) to assess the severity of damage to the roots; and 3) to infer on the potential use of these cultivars as commercial bean rootstocks. A pot experiment was done under controlled conditions in a culture room, and each treatment consisted of five replicates. Plants were inoculated with 5000 eggs and second stage juveniles of *M. javanica*, with uninoculated plants serving as negative control and susceptible tomato plants cv. Tiny Tim being used as positive control. Sixty days after inoculation, roots were observed to determine the number of galls and egg masses. None of the tested cultivars was completely resistant to the nematode. However, through a comparative analysis, a potential for resistance was detected in Bencanta and Oriente cultivars, with levels of nematode-induced galls and egg masses comparable to those of cultivars classified as resistant. The Bencanta and Oriente cultivars showed promising results regarding their use as resistant rootstocks to RKN, justifying further research to test and assess the feasibility of their use in bean grafting, under controlled conditions and in the field, and in the presence of other species of RKN.

Keywords: control, phytopathology, resistant cultivars, root-knot nematode, vegetable grafting.

3b. Effect of tomato grafting on virus infections

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Abstract

Virus diseases can cause serious yield losses in tomato (*Lycopersicon esculentum*). *Tomato mosaic virus* (ToMV), *Potato virus Y* (PVY), *Cucumber mosaic virus* (CMV) and *Tomato spotted wilt virus* (TSWV) have the highest economic importance among all viruses infecting tomato crop in Bulgaria. The control of virus diseases is difficult, expensive and with limited options. Grafting is a method applied in solanaceous and cucurbitaceous vegetables to solve a number of problems in the last decades. Along with increased plant vigor and yield, this technique is also highly effective in ameliorating crop losses caused by adverse environmental conditions. Grafting with resistant rootstocks is an effective strategy to manage the soil-borne diseases and root-knot nematodes but also could improve the resistance to some foliar diseases and viruses. The purpose of present investigation was to test the effect of three rootstocks (Enza Zaden seeds) on the reaction of grafted tomato plants to four important viruses. Bulgarian tomato cultivar Rosalina Rossa was used as scion. Non-grafted, self-grafted and grafted on rootstocks plants were inoculated with standard virus suspensions of ToMV, PVY, CMV and TSWV according to Noordam. Inoculated plants were daily observed for virus symptoms. The presence or absence of the viral infection in tomato plants was proved by DAS-ELISA serologic assays with specific polyclonal immunoglobulin G for the relevant plant virus according to Clark and Adams. DAS-ELISA kits (LOEWE, Germany) were used for identification of virus infection. The Cut off was three times the negative control. All samples above Cut off were positive for virus infection. The ToMV inoculated plants had local small necrotic spots only on the leaves 7 days after inoculation. The PVY and CMV inoculated plants had no visible symptoms. Despite the absence of visible virus symptoms all inoculated with PVY and CMV tomato rootstocks and scions had systemic virus infection, according to DAS-ELISA results 14 days after inoculation. Most of the tomato plants inoculated with PVY, CMV and ToMV remained symptomless except some ToMV inoculated plants. The accumulation of TSWV in grafted tomato plants in comparison with the average extinction values for non-grafted Rosalina Rossa decreased with 1.89%, 21.35%, 26.22% and 30.54 % for self-grafted Rosalina Rossa and Rosalina Rossa grafted on Estamino, Fortamino and Efialto, respectively. The Bull heart and Ideal tomato cultivars served as positive controls. Phenotypically, the reaction of grafted plants to TSWV was expressed as lack of local and systemic symptoms of virus infection i.e. the TSWV infection remained latent. The grafting experiments showed that even the presence of PVY, CMV and TSWV in the grafted plants they remained symptomless without any local or systemic symptoms. The conclusion could be drawn that the grafted plants were tolerant to PVY, CMV and TSWV and could be used for qualitative production.

Keywords: virus infection, virus tolerance

3c. Melon growth, yield and resistance against soil borne diseases as affected by grafting under un-controlled greenhouse conditions

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Abstract

Melon growth, yield and resistance against soil borne diseases of two commercial melon cultivars; Ra'anan and Raymond grafted on three melon rootstocks; Gad (53009), Shimshon (53004), and 53006 were evaluated in Jordan Valley under field conditions in un controlled greenhouse. The soil, in this region, characterize by heavy to moderate infestation of *Fusarium oxysporum* (1200 – 3000 CFU) due to heavy cultivation with tomato and melon with soil salinity about 8 dS/m. The grafted melon seedlings were transplanted on late Feb. 2016 using Randomized Complete Block design (RCDB) with four replicates. Data regarding plant growth, disease incidence, yield and fruit quality were collected during and at end the experiment. Our results showed that, plant vegetative growth was improved by grafting in both cultivars and plant fresh weight of Ra'nan cultivar was increased from 60% to 130% and in Raymond cultivar plant fresh weight increased by 30% as compared with non- grafted plants for each cultivar. Fruit yield of grafted Ra'nan increased from 23 - 71% and Raymond from 12-39% as compared with non- grafted plants for each cultivar. Furthermore, Ra'nan cultivar grafted on 53004 and 53006 rootstocks were more resistance to *Fusarium* than Raymond grafted on the same root stocks. Raymond cultivar grafted on 53009 was more resistance to *Fusarium* as compared to same cultivar grafted on 53004 and 53006. In general, our results showed that grafted melon of both cultivars improved plant growth, yield and resistance against soil borne diseases.

Keywords: Grafted melon, melon rootstock, soil borne diseases, melon growth, fruit yield.

3d. Bell Pepper Response to Low Root Zone Temperature

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Abstract

The goal of this study was to investigate the mechanisms underlying plant root tolerance/response to low root zone temperatures. We exposed two bell pepper varieties (Canon, CTR1) grown aeroponically to three levels of root zone temperatures (7, 17°C, and 27°C). Gas exchanges, shoot phenology and root dynamics were examined. Profiling of TCA cycle intermediates in the leaves were examined by GC-MS. In comparing Canon to CTR1 during treatments, we observed that Canon reduced plant height (51 and 81% at 7 and 17°C respectively) and shoot dry weight (61 and 25 at 7 and 17°C respectively). Photosynthesis was negatively affected in Canon by 16% at 7°C and 20% at 17°C compared to CTR1. TCA cycle intermediates relative content in the leaves of the varieties was higher in Canon. Canon root maximum length was reduced by 8 and 9% at 7 and 17°C compared to CTR1. The root tolerance of CTR1 can be attributed to an increase of carbon to the growth of the roots and effective regulation of stomata and cellular carbon assimilation demonstrated by the TCA cycle intermediates in the leaves. With this tolerance, CTR1 has the potential to be used as rootstock for low root zone temperature areas.

Keywords: aeroponic, low temperature stress, TCA cycle intermediates, respiration

3e. Effect of partial root-zone irrigation on grafted tomato mineral content and fruit quality

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Abstract

Alternate partial root-zone drying (PRD) irrigation is one of the water-saving strategies, while grafting onto some rootstocks is a useful tool to overcome abiotic stresses in fruit vegetables, including tomato and can enhance macronutrients uptake owing to more vigorous root system. The aim of this study was to investigate the effect of partial root-zone drying on grafted tomato leaf and fruit mineral concentrations (N, P, K, Ca and Mg) and fruit quality attributes. The tomato plants (cv. Clarabella) ungrafted, self-grafted and grafted onto He-man rootstock were soil grown in greenhouse under two irrigation regimes, partial-root zone drying (PRD) and full irrigation (FI).

There were no significant differences between treatments in leaf N, P and K concentrations while for leaf Ca and Mg significance were found. Leaves on average had more Ca and Mg under PRD. No differences were found in fruit mineral concentrations between treatments. Fruit soluble solids content (SSC) and titrable acidity were higher under PRD, but tomato juice pH was higher in FI treatment. Also, SSC was affected by grafting type and was highest in ungrafted plants.

These results show the effectiveness of PRD with respect to upgrading of fruit quality in tomato without negative influence on grafted tomato leaf and fruit mineral content.

Keywords: *Solanum lycopersicum* L., grafting, water stress, mineral nutrition

SESSION IV

WORKING GROUP 4

Rootstock mediated improvement of fruit quality

ORAL PRESENTATIONS

How herbaceous grafting influences vegetable quality

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Abstract

Vegetable grafting is at this point widespread in many horticultural area to avoid or to reduce loss in production caused by adverse growing conditions. Besides the positive effects of the grafting on plant vigour and yield level, produce quality can be affected when plants are grafted on specific rootstocks. For this reason, rootstock/scion combination is supposed to be carefully chosen for optimal fruit quality. In the presentation we will synthesise a review on recent and relevant literature concerning the effects of grafting on vegetable fruit quality. We will focus only on product-oriented quality and objective criteria. Accordingly, considering the main grafted crops the effects of grafting on the main qualitative traits will be presented and discussed.

Scion/rootstock combinations influence yield and metabolic profile of tomato fruits (*Lycopersicum esculentum* Mill.)

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Abstract

The effect of different scion/rootstock combinations on yield and metabolic profile of tomato fruit, cultivated in greenhouse, was evaluated. Four tomato cultivars were assessed as scions: 'Belle F1', 'Corvinus F1', 'Marteze F1' and 'Roque F1', and were grafted onto two rootstocks: 'Beaufort F1' and 'Optifort F1'. Self-grafted plants were used as a control. Both factors had significant impact on tomato yield. The highest yield was attained at plants grafted onto 'Optifort' (on average 175 t/ha) and at cv. 'Marteze' (on average 165 t/ha). Grafted plants onto both rootstocks significantly decreased glucose and ascorbic acid content at all tested cultivars, while citric acid was decreased at 'Corvinus F1'/'Optifort' and 'Marteze'/'Beaufort F1' combinations and increased at 'Belle F1'/'Beaufort F1' combination compared to the control. Among the primary metabolites fructose content was affected only by cultivar, with the lowest content in fruits of cv. 'Roque F1' (9.7 g/kg FW). Rootstock had significant influence on α -karoten and lutein while β -karoten was influenced only by cultivars. No significant effect of scion/rootstock combination on lycopene content was confirmed. Grafting influenced also phenolic profile of tomato fruit. Both factors significantly influenced hydroxycinnamic acids, with their highest content in fruits of 'Belle' (17 mg/kg) and the lowest content in fruits of plants grafted onto 'Optifort' (9.8 mg/kg). Grafting plants on 'Beaufort' and 'Optifort' significantly decreased the content of total flavonols in tomato fruits (2.6 and 2.1 mg/kg) compared to the control plants (4.2 mg/kg). Also fruits of cv. 'Roque' had the significantly lower total flavonol content (1.4 mg/kg) among all cultivars. Total flavanones were affected also by both factors. The lowest were in fruits of plants grafted onto 'Optifort' (0.10 mg/kg) and in the highest (0.16 mg/kg) in fruits of 'Belle F1' cultivar. Tomato grafting and the determination of compatible rootstocks is a useful technological measure striving to increase the yield and fruit quality, which are important to the growers as well as in terms of beneficial effects on human health.

Keywords: Tomato; *Lycopersicum esculentum* Mill., grafting, scion/rootstock combinations; metabolites

Rootstock effect on grafted green bean yield and fruit quality

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Abstract

Grafting of green beans (*Phaseolus vulgaris* L.) is used in Portugal to prevent biotic and abiotic stresses since 2010 and is currently an important strategy for the production of this crop grown in greenhouses both in hydroponics and soil production systems. Bean grafting is also a safe technique for the environment and easy to manage, hence well suited for organic production. This study evaluated the effects on crop yield and pod quality of grafting two commercial green beans cultivars ‘Oriente’ (Vreeken's Zaden) and standard Portuguese traditional ‘Vagem Rajada’, onto *P. coccineus* rootstocks: cv. Aintree (P1) and White Emergo (P2) (TozerSeeds) and the traditional ‘Feijão 7 anos’ landrace ‘Ponte de Lima’ (P3). The experiments were conducted in two different locations in the NW Portugal (Ponte de Lima, PL and Póvoa de Varzim, PV). Since the splice grafted plants can support two sets of stems along two tutors and the self and ungrafted plants only one, in order to maintain the same stem density, self and ungrafted control plants were planted in pairs. Plant densities were equivalent to 3.3 and 2.1 stems m⁻², respectively for PL and PV. In PL the trial was conducted with low input of soil mineral nutrients and the crop showed symptoms of the vascular wilt caused by the soil-borne fungus *Fusarium oxysporum* f. sp. *phaseoli* (Fop). In this site the highest yield (11.7 kg m⁻²) was obtained with the cv. ‘Oriente’ shoot grafted onto P3, followed by the scion/rootstock combinations cv. ‘Oriente’/P2 and cv. ‘Vagem rajada’/P2 and P3 (mean 2.7 kg m⁻²). A similar, lower yield (mean 1.3 kg m⁻²) was found in the graft combinations of both cultivars grafted onto rootstock P1 and in the control plants of both green bean cultivars. In site PV, with absence of disease symptoms, increased mineral nutrient availability and lower crop density, a comparable yield was obtained from plants of both cultivars in self-grafted, ungrafted and grafted onto P1 and P3 rootstocks (mean 4.5 kg m⁻²), which was higher than the yield from plants of both cultivars grafted onto rootstock P2. Green bean pod quality was also influenced by the root/shoot genotype. Grafting with P2 and P3 rootstocks resulted in an increased P content of the pods for both cultivars in both experimental sites, as well as increased Mg content in PL and Ca content in PV, compared to self-grafted and ungrafted plants. The higher nutrient content of the pods indicates an increased uptake and better utilization of nutrients by grafted plants with those rootstocks. Therefore, bean grafting appears to be an appropriate strategy to increase crop tolerance to important soil borne diseases and to increase nutrient uptake. Selection and breeding efforts together with a better understanding of the scion/rootstock combinations and crop management effects on plant growth and development needs further research.

Keywords: *Fusarium oxysporum*, *Phaseolus coccineus*, *P. vulgaris*, pod nutrient content

Effects of *Cucurbita* hybrid rootstocks on quality of three fruit vegetables grown under moderate saline conditions.

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Abstract

Salinity is one of the main challenges that farmers encounters in growing plants, particularly in arid and semiarid regions of the world. Negative effects on productivity of vegetables may occur in such conditions; in worst cases, cultivation can be even compromised. Grafting can represent an effective tool to reduce yield losses caused by salinity. On the other hand, there are several conflicting reports on changes in fruit quality due to grafting and whether this technique is advantageous or deleterious. Three greenhouse experiments have been conducted to determine yield and fruit quality of cucumber (*Cucumis sativus* L.), melon (*Cucumis melo* L.) and watermelon (*Citrullus lanatus* [Thunb.] grafted onto the *Cucurbita* hybrid rootstocks (*Cucurbita maxima* Duch. × *Cucurbita moschata* Duch.) 'PS1313', 'P360' and 'Ercole', respectively. Plants were grown in soilless system and supplied with two nutrient solutions: a non-salinized and a salinized solution containing, 40 mM (cucumber and melon) and 30 mM NaCl (watermelon). The marketable yield in the three cucurbits was higher in grafted than ungrafted plants. Increasing the level of NaCl in the nutrient solution improved the physical properties and the flavour compounds of the three vegetables. Concerning the effect of grafting the fruit brightness (L*), dry matter (DM) and total soluble solids contents (TSS) increased in cucumber, whereas an opposite trend was observed for titratable acidity. The nutritional qualities of grafted melons such as fruit DM, titratable acidity and TSS content were slightly inferior compared to those of ungrafted plants, whereas physical qualities such as fruit firmness and Hunter colour values (L* and a*/b*) were superior compared to those of plants grown with their own roots. In watermelon, nutritional qualities of grafted watermelons such as fruit DM, glucose, fructose, sucrose, and TSS content were similar in comparison to those of ungrafted plant. Taking all together, rootstock/scion combinations should be accurately selected for specific geographic and climatic conditions.

Keywords: *Citrullus lanatus* (Thunb.), *Cucumis melo* L., *Cucumis sativus* L., salt stress, rootstock/scion combinations.

Preventing entry of pharmaceuticals (carbamazepine) into the food chain by using grafted plants

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Abstract

The entry of pharmaceuticals into the food chain is of concern due to their increased presence in soils and water sources. It may be possible to limit their uptake into the edible portions of plants by using vegetables grafted onto appropriate rootstocks. The purpose of this study was to compare the uptake of carbamazepine, a conservative and ubiquitous pharmaceutical, by different *Cucurbita* rootstocks for identification of an appropriate rootstock to prevent carbamazepine uptake. Seven accessions of gourds were planted in perlite and drip irrigated with a 10 or 500 µg/L carbamazepine solution. The experiment was carried out for 30 days in 4 replicates. The EC, pH and carbamazepine concentration were determined in both the irrigation water and drainage and also in the plant sap exudate. At the end of the growing period, the dry weights of the shoot and roots were measured. No significant effect was found in plant development for any variety at either of the two concentrations. At the higher carbamazepine concentration, an increase in its concentration in the sap exudate was observed, i.e., carbamazepine was transported to the above ground parts of the plant. Differences in the transport of carbamazepine to the canopy were observed among the accessions tested; at 10 µg/L of carbamazepine, two accessions exhibited reduced carbamazepine transport to the shoots, whereas at 500 µg/L all accessions exhibited reduced carbamazepine transport. Hence, these cultivars can be used as potential biological barriers to prevent the penetration of carbamazepine to the edible portion of plants.

Key words: carbamazepine, fruit safety, plant uptake, rootstock.

Grafting as a tool to enhance tomato fruit quality

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Abstract

Photosynthesizing chloroplasts develop in response to light and are mediated by photomorphogenic signalling pathways. The sustained capacity of particular cells and tissues to form chloroplasts is strongly influenced by the *Golden 2*-transcription factor. Sugars, pigments, and secondary metabolites needed for ripe fruit flavour and health related attributes depend on photosynthesis in green fruit. Thus, we postulated that dark green tomato fruits containing more chloroplasts also have enhanced flavour attributes. Based on this hypothesis, we screened >50 cultivars in their fruit and chloroplast characteristics and selected cultivars with dark green tomato fruits as potential rootstocks. In the present study, we grafted a light green tomato (LA 4442) with a low fruit sugar concentration on rootstocks with dark green fruits and high in fruit sugar content (Beaufort, Cuatomo and LA 0247) and compared them with the non- and self-grafted scion. Fruit characteristics, as glucose, fructose, titratable acids, chlorophyll content and the *GLK2* gene expression were measured and resulted in significant differences. Fruit sugar was increased by the rootstocks used. Other characteristics measured, such as number of trusses, fruits, fruit dry matter percentage, total yield, and single fruit mass, showed also significant differences between the self-grafted and rootstock grafted treatments. The results indicated that cultivars with dark green tomatoes expressing more *GLK2* and containing higher chlorophyll content than light green tomatoes are able to enhance sugar concentration of scion fruits having a low concentration when they are non- or self-grafted.

Keywords: grafting, *Golden -2*, photosynthesis, tomato, fruit quality



POSTER SESSION IV



4a. Simultaneous determination of heavy metals (Cr, Ni, As, Cd, Pb, Hg) in Pachino cherry tomatoes grafting on different rootstock.

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Abstract

The contamination of agricultural product with non-nutrient heavy metals has become an important concern throughout the world do to the potential adverse effects on human health. Vegetables have the potential to accumulate heavy metals when grown on contaminated soils or when irrigated with sewage and wastewaters. Some heavy metals are toxic to plants even at very low concentrations, while others may accumulate in plant tissues up to a certain level without visible symptoms or yield reduction. One of the possible applications of grafting in commercial vegetable production is the mitigation of stress caused by adverse chemical soil conditions in the root environment. It has been demonstrated that some rootstocks are capable of reducing the uptake and/or the transport of heavy metals to the shoot moderating the stress caused by excessive external concentrations of them. Fruit vegetables, such as tomato, are characterized by rather low rates of heavy metal translocation to the fruits; thus, the impact of grafting on the uptake of heavy metals has been so far hardly investigated. Some Authors demonstrated that the use of appropriate rootstocks for tomato plants may raise Ni and Cd tolerance through limiting heavy metal uptake by roots and/or its translocation to the shoot and by detoxification. To our best knowledge, there are currently no reports concerning the determination of Ni and Cd together with other non-nutrient heavy metals, such as Cr, Ni, As, and Hg, in grafted tomato fruit. In this context, the research evaluate the influence of different rootstocks on heavy metal content in tomato fruits. Tomato samples were produced in the South-east corner of Sicily not far from two risk areas (Augusta-Priolo and Gela) where petrochemical activities are present. Cherry tomato *Lycopersicon esculentum* Mill as scion whereas Beaufort, Optifort and Blue Devil as rootstocks, were used. The rootstocks have been chosen among those normally used for cherry tomato exhibiting a good affinity with the scion. Cr, Ni, As, Cd and Pb were quantified by ICP-MS (Inductively Coupled Plasma Mass Spectrometry) after freeze drying and microwave digestion of the samples while Hg was quantified after freeze drying by the direct Hg analyser (DMA-80, atomic absorption spectrophotometer). ICP-MS include high sensitivity, a high signal-to-noise ratio and the flexibility to analyze a whole suite of elements in a single run, saving considerable time and money. The data showed a different amount of heavy metals in cherry tomatoes depending on the different rootstock. The different behavior can be attributed to a different interaction rootstock-scion that may exhibit dissimilar abilities to take up minerals from soil. The ability to select the best rootstock can be a sustainably tool to ensure safety of fruits and vegetables in areas with heavy metal contaminated soils.

Keywords: Pachino cherry tomato, grafting, contaminated soils, heavy metals, ICP-MS.

4b. Yield and quality of grafted mini watermelon [*Citrullus lanatus* (Thunb) Matsum & Nakai] cultivars

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Abstract

Over the last years, the market share commanded by mini (3-5kg) watermelon cultivars has been growing across watermelon producing countries. In Cyprus this type of watermelon has not been adopted yet by local producers, mainly because of the unfamiliarity of the local market with the product. The objectives of this study have been to evaluate the field performance of three mini watermelon cultivars (Sunday Special, Alicante, Modellino). Large fruited diploid cv. 'Pegasus' was used as the control. Yield in all cultivars was above the regional average (52 t ha⁻¹). No yield differentiation was observed among cultivars. Mini diploid cv. Modellino had the smallest fruit weight and the highest number of fruit among all cultivars examined. Mini melon cultivars had higher flesh firmness than large fruited cv. 'Pegasus'. Triploid cvs. 'Sunday Special' and 'Alicante' had higher fructose content than the two diploid cvs. 'Modellino' and 'Pegasus' but no differentiation was observed in soluble solids (SSC) and total sugar content among cultivars (G.A. Soteriou and M.C. Kyriacou).

4c. The implications of grafting for watermelon and melon fruit quality

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Abstract

Grafting on disease-resistant rootstocks is a growing practice in watermelon and melon cultivation worldwide. The current presentation provides an overview of work conducted to assess the effects of grafting watermelon and melon scions onto *Cucurbita maxima* × *C. moschata* rootstocks. The effects of grafting on yield characteristics, physicochemical quality attributes, and postharvest performance are analysed mainly for watermelon, and partly for melon. The implications and possible linkage between physiological effects such as retarded ripening in watermelon and plant decline in melon are discussed.

4d. Technological features and elements of economic efficiency regarding the semi-automatic grafting of vegetables

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Abstract

Worldwide, more than 80% of vegetable grafting is performed manually. Over the last 10 years semi-automatic and automatic mechanical devices have been developed for grafting vegetable seedlings. In this study the grafting operations were performed manually and semi-automatically by the "grafting robot": GR-800CS. The experiment was conducted using eggplants; the eggplant scions were Sharapova F1 (RijkZwaan) and Aragon F1 (HazerGenetics), and the rootstocks used were Emperor (RijkZwaan) and Hykiaku (KanekoSeeds). The difficulty consists mainly in preparing the biological material for grafting and the grafting operation itself. The operator's dynamic yield in a working day was determined which included, the average number of grafted plants/day/operator, the average number of grafted plants by a worker/hour and the specific costs for the grafting operation by both manual and semi-automatic methods. The manual grafting of 1000 pieces of eggplant required 2.4 working days/worker, while the grafting the same number by the semi-automatic method needed only 0.7 working days/worker. The semi-automatic method resulted in a 16.08% decrease of the price of seedlings compared with the manual method.

Keywords: scion, rootstock, robot, grafting, grafting rate

4e. Grafting influences the fate of arsenic in melon plants

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Abstract

Arsenic is a metalloid toxic for plants and human, classified like cancerogenic by WHO and its presence in soil and water can be a problem for crops because can enter in food chain.

Previous research showed the ability of grafted melon plants to uptake, accumulate and partition the metalloid in different plant organs. It was also observed that widespread rootstocks hyperaccumulate differently the toxic element into the roots. However, As is uptaken by roots as arsenate by phosphate transporter (the affinity is due to the structural similarity between the two compounds), once in root, arsenate is quickly reduced in arsenite with an enzymatic assisted reduction (and the oxidation of glutathione GHS in the oxidize form GSS). As (III) can follow several path: 1. It can be accumulate in vacuoles 2. Can be effluxed by root system 3. Can be organicated and volatilized.

To better understand the above aspects, adopting grafted melon plants, we carried out further researches aimed at: i) clarifying cause/effect relations under increasing amount of As in the nutrient solution (0.002, 0.1, 1, 3.8 mg/l); ii) quantifying, in root and pulp, the As in the 2 oxidation states (trivalent and pentavalent) to understand the fate of the element into the plant. Preliminary result will be presented and discussed.

Keywords: grafting, arsenic, melon, arsenic speciation

SESSION V

ROUND TABLE

Connection of science and industry

ORAL PRESENTATIONS

Grafted vegetable transplants and viral threats: effective solution or emerging complication

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Abstract

Grafting cucurbit and solanaceous crops is a common practice to improve crop tolerance to variety of diseases, abiotic stress, and to increase yields. The implication of resistant genes in rootstock and scion to improve grafted seedling tolerance to viral pathogens, was studied since the turn of the 20th century and expanded with the increased production of grafting, concurrently to intensification of viral threats. Plant tolerance to stress was affected by grafting and genetic resistance of rootstock and scion in different ways. Difference in tobacco mosaic virus (TMV) resistance level, determined by different resistant-gene composition of the scion and rootstock, has led to incompatibility and collapse of grafted tomato plots in Israel. In tomato yellow leaf curl virus (TYLCV), no interaction between the genetic resistance and rootstock-scion compatibility was found, nor transfer of resistance from resistant tomato rootstock to sensitive scion. Using vigorous combinations of tomato rootstock and scion increased grafted plant tolerance to pepino mosaic virus (PepMV) through improved plant development, despite the lack of genetic resistance of the tested varieties. Another mechanism of avoidance was found in grafted cucurbits, cucumbers and melons, which were barely infected with viruses such as cucumber mosaic virus (CMV) transferred by aphids. It was observed that darker green color of the grafted plant foliage was less attractive for the aphids than the brighter green color of the non-grafted control, hence less infestation stress occurred. The combination of cucumber green mottle mosaic virus (CGMMV) and soilborne *Pythium* spp. caused dramatic reduction in non-grafted cucumber survival and yield, while using grafted cucumber having appropriate rootstock architecture enabled lower disease severity and economical yield. During 2014, an epidemic by complex of two tobamoviruses, TMV and tomato mosaic virus (ToMV) occurred in Israel, rapidly spread by mechanical means. These days, eggplant which blocks ToMV transfer to the scion, is tested as a half-commercial rootstock to prevent yield losses. Grafting tomato prevented tomato chlorosis virus (TOC) symptoms, by a mechanism which is not yet studied. Grafting of fruit-vegetables enables effective management of viral diseases, but in certain cases, such as Tobamoviruses, additional factors should be considered. Those including incompatibility under stress conditions and mechanical distribution of virus during seedling production at the nursery and later, at the field plot. Therefore, it is essential to use high quality seeds free of virus and other pathogens, and adjusted sanitation during production and cropping processes.

Our international grafting venture: current challenges and future opportunity

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Abstract

Centro Seia owns four nurseries in Europe; two facilities are based in Italy, one in France, and one in Bosnia Herzegovina. Recently, Centro Seia established an international partnership resulting in a dedicated grafting facility in western North Carolina, on the eastern seaboard of the United States. Twenty years ago, Centro Seia implemented a strategic initiative focused on the introduction of grafting technology; as a result, the demand for grafted plants has grown every year since. In 2015 the company produced 80 million young plants for protected crops in Europe, half of which were grafted. The company's core mission is to work together with growers and stakeholders: the aim is to fulfil needs of the customer by finding solutions to improve yield and quality. Centro Seia's R&D department is mostly focused on business applications and internal implementation of research from outside sources. The progress of the company, current achievements and new challenges will be presented.

SESSION VI

STSMs section

Achievements and outcomes

ORAL PRESENTATIONS



Contribution of Short Term Scientific Missions to the the scientific objectives of COST FA1204

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Abstract

Short-term scientific missions (STSM) are exchange visits between researchers involved in a COST Action, allowing scientists to visit an institution or laboratory in another COST country. They are aimed at fostering collaboration, sharing new techniques and infrastructure that may not be available in other participants' institutions or laboratories. During COST FA1204 21 (twenty-one) exchange visits between researchers involved in a this COST Action were successfully carried out and achieved to implement the exchange and interaction between the FA1204 participants and favored young scientists (PhD students and Post-docs). From the experiments performed during these STSMs several publications are under the submission process in peer reviewed papers indicating the successful use of the resources allocated to this COST Action tool.

Alleviating aluminium toxicity and adverse effects of low pH in vegetables by grafting onto suitable rootstocks

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Abstract

Low pH and aluminium (Al) stresses are the major constraints of poor plant growth and losses in productivity in acidic soils. Al toxicity and acidity can disturb morphological, physiological and molecular process in vegetables leading to a drastic yield reductions. Grafting vegetable elite cultivars onto suitable rootstocks may be considered an effective strategy to overcome these environmental stresses. Three greenhouse experiments were conducted two on cucumber (*Cucumis sativus* L.) and one on tomato (*Solanum lycopersicum* L.) in order to evaluate the effectiveness of selected rootstocks *Cucurbita* hybrid and figleaf gourd for cucumber and interspecific hybrids for tomato to enhance Al and low pH tolerance. Cucumber plants were cultured in pots and supplied with nutrient solutions having different pH and Al concentrations: standard pH, pH 3.5 and pH 3.5 + high Al, whereas tomato was grown in an nutrient film technique (NFT) system and supplied with standard pH, pH 3.5, pH 3.5 + low Al or pH 3.5 + high Al. In all experiments, Al stress was more phytotoxic than low pH treatment. Cucumber plants grafted onto *Cucurbita* hybrid exhibited the best performance compared to plants grafted onto figleaf gourd or ungrafted ones. The better crop performance was attributed to a reduced translocation of Al from roots to shoot, better nutritional status of macro- and microelements as well as ability to maintain cell membrane stability. Grafting tomato onto specific rootstock was able to mitigate adverse effects of Al acidity and Al stress by improving nutritional status, photosynthesis, increased the capacity of antioxidant enzymes, up-regulating key genes involved in the molecular strategies to increase Al tolerance in plants.

Keywords: *Cucumis sativus* L., gene expression, photosynthesis *Solanum lycopersicum* L., selected rootstocks.

Interactions of grafting and shading in a greenhouse pepper crop

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Abstract

Know how on nutrient to water uptake ratios, which are commonly called "uptake concentrations", are particularly important in protected environment when plants are grown in closed-cycle cultivation systems. In such systems, the input ratio between the mass of a nutrient and the volume of water should be equal to the corresponding nutrient to water uptake ratio by the plants, in order to obtain a null nutrient accumulation plant balance. Therefore, if data about the mean uptake concentrations are known, they can be used to establish nutrient solutions for closed-cycle hydroponic cultivations. Preliminary remarks revealed that the nutrient-to-water uptake ratios in hydroponic crops grown in Mediterranean greenhouses may be substantially different than in north-European greenhouses, due to differences in climatic conditions. Moreover, different genotypes or different rootstocks/scion combinations in the case of grafted plants may have an impact on nutrient and water uptake. In the present study, the water and nutrients uptake was measured in 4 different pepper scion/rootstock combinations ('Orangery'/'Orangery', 'Sondela'/'Sondela', 'Orangery'/'Rocal' and 'Sondela'/'Rocal') grown in shaded and non-shaded conditions. All plants were grown in a closed NFT (nutrient-film-technique) system. Plant growth parameters such as shoot length, leaf fresh weight and leaf area were recorded. Furthermore, root-to-shoot ratio was also calculated. Fruit production, number of fruit, average fruit weight and fresh weight of the fruits with blossom end rot symptoms were recorded. Fruit quality analysis like fruit diameter, fruit length, fruit skin colour, fruit firmness, seed fresh weight per fruit and total soluble solid (°Brix) were also performed. Mean water uptake ratios (uptake concentrations) of macro- and micronutrients for five time intervals were determined through the estimation of nutrient removal from the recycled nutrient solution. The experiment is still underway and therefore, the differences that will be observed in the calculated nutrient uptake concentrations and all the above tested parameters, between the different scion/rootstock combinations and growth conditions in terms of shading, will be discussed.

Keywords: nutrient uptake, shading, grafting, bell pepper.

Response of some cucurbit genotypes to salinity stress

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Abstract

The research was conducted in order to identify the response of some cucurbit genotypes to salinity stress in an unheated PE greenhouse in the autumn season of 2013. Sixteen genotypes (*Citrullus lanatus* Thunb.: ‘Sultan F₁’, ‘Nosztalgia F₁’, and ‘Lentus F₁’; *Cucumis melo* L.: ‘Vitalia F₁’, ‘ZKİ 1112 F₁’, ‘Çeşme’, and ‘Kirkagaç’; *Cucurbita pepo* L. var. *giromontia*: ‘İzobilna F₁’; *Cucurbita maxima* L.: ‘Plovdivski 48/4’; *Cucurbita moschata* Duch.: ‘51-17’; *Luffa cylindrica* (L.) Roem.; *Cucurbita ficifolia* Bouché; *Lagenaria siceraria* Mol.: ‘Macis’; *C. maxima* L. x *C. moschata* Duch.: ‘RS 841’, ‘TZ148’, and ‘Nun 9075’) were grown as water culture. The seeds were sown in peat on 16th of September. Two weeks later after the peat on their roots were washed, the seedlings were transplanted (4 seedlings in pot on foam board) into brown plastic lateral pots filled with complete nutrient solution. Salinity was initiated two weeks after the transplantation of seedlings. Salinity level was gradually increased up to 300 mM by adding 50 mM NaCl at 2 day interval. Plants were put at 100 and 300 mM NaCl levels for 7 days. The plants in the control were fed with normal nutrient solution during the same period. Stress severity on the leaves was scored. Also stem length and diameter, leaf number, shoot and root fresh and dry weights, electrolyte leakage (EL, %) and relative water content (RWC, %) were measured. The results demonstrated that plant growth and dry matter production differed among the tested genotypes, although plant vigour was decreased with increased salinity. The performance of some genotypes was even higher at 100 mM and 300 mM.

A genotype differentiation in the response to salinity stress was revealed. On this base the studied genotypes were grouped according to their tolerance to salinity stress.

Keywords: cucurbit genotypes, salt stress, vigour.

Is cadmium tolerance root- or shoot-controlled in grafting pea plants?

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Abstract

Cadmium (Cd) is one of the most toxic heavy metals and it is readily taken up by plants, leading to disturbances in mineral nutrition and carbohydrate metabolism, and may therefore strongly reduce biomass production. The performance of different grafting combinations of two genotypes of pea (*Pisum sativum*): wild type SGE and Cd-tolerant mutant SGE^{Cd} under different cadmium concentrations was carried out in order to investigate the role of grafting in controlling cadmium toxicity by limiting the transport of cadmium to the shoot. Different measurements based on stomatal conductance, foliar Cd concentrations, shoot and root xylem ABA signalling were made in order to identify whether cadmium tolerance can be rootstock-mediated in grafted plants. The results of this work showed a greater reduction in shoot FW when mutant plants was used as a rootstock (WT/MT – 52%) compared to when wild type plants were used as a rootstock (MT/WT - 39%). Overall, there was a significant effect of rootstock on shoot biomass, although the effect of the rootstock depended on the scion (significant scion x rootstock interaction). After prolonged cadmium exposure (16 DAS) wild type non-grafted plants were more sensitive to Cd where gs decreased significantly by 61% compared to control plants. Similarly, self-grafted WT plants (WT/WT) were more sensitive to Cd treatments (64% reduction compared to control plants) than self-grafted mutant plants (47% reduction). ABA concentration in leaf tissue, root and shoot xylem sap are still require analysis.

Keywords: grafting pea, cadmium, Stomatal conductance, ABA



The COST Action FA1204 database: A simple and effective tool for vegetable growers and the scientific community

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Abstract

The COST Action FA1204 ‘Vegetable grafting to improve yield and fruit quality under biotic and abiotic stress conditions’ started in 2012 with the aims of understanding the biological basis of rootstock-mediated improvement of several vegetable crops and their compatibility. One important output of the COST Action was to create an international database with information published in the international scientific literature and generated by the COST Action. The database was created from Excel spreadsheets by collecting the following information for the main grafted crop (globe artichoke, cucumber, melon, watermelon, tomato, eggplant and pepper): disease resistance of rootstocks, abiotic stress tolerance of rootstocks, compatibility issues, sources of rootstocks, vigour effects on scion, grafting techniques, yield and quality variation in different grafting combinations. The database represents an effective and easy to use tool for the scientific community, private companies, vegetable growers, extension specialists and other institutions.

Keywords: Cucurbits, database, quality, solanaceous, rootstocks

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