Serbian Plant Physiology Society

Institute for Biological Research „Siniša Stanković", University of Belgrade

1st International Conference on Plant Biology

20th Symposium of the Serbian Plant Physiology Society

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20th Symposium of the Serbian Plant Physiology Society
Subotica, June 4-7, 2013

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PROGRAMME

1st International Conference on Plant Biology
20th Symposium of the Serbian Plant Physiology Society

Tuesday, June 4th, 2013

Until 13.00 — The arrival of participants and registration, placement of posters (Sections 1, 2, 3, 4, 5, 6)

13.30-13.35 — Conference opening

Section 1. Plant Growth and Development – Plenary lectures and Oral presentations

13.35-13.55 — Václav Motyka, Petre I. Dobrev, Lenka Záveská Drábková: **Cytokinins of *cis*-zeatin-type: their role for plant development and in the evolution of hormonal homeostatic mechanisms in plants**

13.55-14.20 — Brigitte Mauch-Mani, Chantal Planchamp, Dirk Balmer: **Induced resistance in cereals**

14.20-14.45 — Sándor Kovács, Ágnes Nagy, Brigitta Végh, Brigitte Mauch-Mani, Gábor Jakab: ***Pathogenesis Related LIPase 2 (PRLIP2)* deficiency alters basal resistance and BABA induced priming in Arabidopsis**

14.45-15.00 — Branka Uzelac, Dušica Janošević, Snežana Budimir: **Ultrastructural analysis of mesophyll cells during natural leaf senescence of *Nicotiana tabacum***

15.00-15.15 — Martin Raspor, Václav Motyka, Slavica Ninković, Ivana Dragićević: **Tuberization dynamics in *AtCKX* transformed potato plants grown *in vitro***

15.15-15.30 — Jelena Milojević, Jelena Savić, Milan Dragićević, Ljiljana Tubić, Nina Devrnja, Snežana Zdravković-Korać: **SoRIP2 gene might be a good marker for somatic embryogenesis in spinach**

15.30-16.00 — *Coffee break*

Section 2. Plant Metabolism and Nutrition – Plenary lectures and Oral presentations

16.00-16.25 — Hrvoje Fulgosi, Lea Vojta, Snježana Jurić, Ana Tomašić Paić, Lucija Horvat, Renata Hanzer, Jasminka Antunović, Vera Cesar, Bernd Zechmann, Hrvoje Lepeduš: **New alleys in regulation of photosynthetic energy conversion**

16.25 - 16.40 — Milan Dragićević, Milica Bogdanović, Milica Milutinović, Biljana Filipović, Slađana Todorović, Ana Simonović: **Differential regulation of glutamine synthetase and glutamate synthase genes by plant growth regulators in *Arabidopsis***

16.40-16.55 — Marija Vidović, Filis Morina, Sonja Milić, Jana Barbro Winkler, Andreas Albert, Sonja Veljović-Jovanović: **Combined effect of UV-B irradiation with high or low light on photosynthesis in variegated plant species**

17.00-18.00 — **Poster presentation (Sections 1, 2)**

18.00 — *Free time*

Wednesday, June 5th, 2013

7.30-9.00 — *Breakfast*

Section 3. **Plant Genome and Inheritance and Section 4. Plant Biotechnology – Plenary lectures and Oral presentations**

9.00-9.25 Borut Bohanec: **Regulatory approaches of novel transgenic technologies related to plant breeding with emphasis on development in European Union**

9.25-9.50 Zlatko Šatović, Zlatko Liber, Marija Jug-Dujaković, Ivan Radosavljević, Danijela Greguraš, Mihailo Ristić, Dejan Pljevljakušić, Zora Dajić-Stevanović, Jerko Gunjača: **An association mapping approach to identify molecular markers associated with essential oil components in natural populations of Dalmatian Sage (*Salvia officinalis* L.)**

9.50-10.15 Alena Gajdošová, Miroslava Súkeníková, Radoslava Matúšová, Tatjana Vujović, Gabriela Libiaková: **Advances in genetic transformation of selected small fruit species**

10.15-10.40 Dragan Vinterhalter, Jovanka Miljuš-Đukić, Živko Jovanović, Vladimir Orbović, Branka Vinterhalter: **Circadian regulation of photo- and gravitropism in potato shoot cultures**

10.40-10.55 Aleksandar Cingel, Jelena Savić, Tatjana Ćosić, Martin Raspor, Jelica Lazarević, Ann Smigocki, Slavica Ninković: **Development of Colorado potato beetle larvae (*Leptinotarsa decemlineata* Say) fed on potato co-expressing rice cystatins I and II plants**

11.00-11.30 *Coffee break*

11.30-11.45 Ana Simonović, Biljana Filipović, Saša Malkov, Nikola Tanić, Vedrana Milinković, Milan Dragićević, Angelina Subotić: **Arabinogalactan protein gene family from *Centaurium erythraea* Rafn.**

11.45-12.00 Milica Bogdanović, Slađana Todorović, Milan Dragićević, Katarina Cankar, Jules Beekwilder, Harro Bouwmeester, Ana Simonović: **Vector construction for promoter analysis in chicory and fluorescence evaluation by agroinfiltration**

12.00-12.15 Daniela Đikanović, Aleksandar Kalauzi, Milorad Jeremić, Jianmin Xu, Miodrag Mićić, Jeffrey D. Whyte, Roger M. Leblanc, Ksenija Radotić: **Application of CdSe nanoparticles in plant biology research**

12.15-12.30 Sanja Treskić, Slaven Prodanović, Ankica Kondić-Špika, Borislav Kobiljski, Ljiljana Brbaklić, Dragana Trkulja, Nada Grahovac, Aleksandra Nastasić: **The role of DIMBOA in maize biotic stress resistance – presence of DIMBOA biosynthesis *bx1* gene in NS inbred lines**

13.00-14.30 *Lunch*

Section 5. **Biotic Plant Interactions and Section 6. Secondary Metabolite Production – Plenary lectures and Oral presentations**

14.30-14.55 Eleni Tsantili: **Increases in phenolic compounds during cold storage of temperate fruits**

14.55-15.10 Vladan Jovanović, Jasmina Nestorović Živković, Slavica Dmitrović, Mihailo Ristić, Suzana Živković, Danijela Mišić: **Allelopathic potential of *Nepeta rtanjensis* Diklić & Milojević and *Nepeta cataria* L. essential oils on selected weeds**

15.10-15.35 Kalina Danova, Yuliana Markovska, Vaclav Motyka, Petre Dobrev, Evelyn Wolfram: **Understanding plant-environment interactions is a key to successful yield of phytopharmaceuticals form medicinal species *in vitro***

16.00-16.15 Jelena Dragišić Maksimović, Vuk Maksimović: **Qualitative evaluation of different antioxidative compounds present in propolis originating from different locations of Serbia**

16.15-16.30 Gordana Tovilović, Đurđica Ignjatović, Jelena Živković, Zoran Maksimović, Mirko Tomić, Katarina Šavikin: **The influence of methanol and aqueous-acetone extracts from three *Veronica* species on wound healing process**

16.30-18.00 **Poster presentation (Sections 3, 4, 5, 6)** + *Coffee break*

18.00-19.00 Placement of posters (Sections 7, 8, 9)

20.00 *Galla Dinner*

Thursday, June 6th, 2013

7.00-9.00 *Breakfast*

Section 7. **Environmental Stress and Ecophysiology – Plenary lectures and Oral presentations**

9.00-9.25 Zsófia Bánfalvi: **Implication of stress tolerance and tuber yield in potato**

9.25-9.50 Achim Kunz, Michael M. Blanke: **Six misconceptions about climate change – from a biologist's viewpoint: Effects of recent climate change on temperature pattern, precipitation, risk of frost and apple phenology – based on 55 years of meteorological and phenological data at Campus Klein-Altendorf, University of Bonn**

9.50-10.15 Judit Dobránszki, Ildikó Hudák, Nóra Mendler-Drienyovszki, Mária Hevesi: **Evaluation of biotic stress tolerance using tissue culture systems**

10.15-10.35 Dominik Vodnik, Klemen Eler: **How to study the dynamics of stomatal response?**

10.35-11.00 Zorica Jovanović, Radmila Stikić, Ljiljana Prokić, Slađana Savić, Milena Marjanović, Slaviša Đorđević: **Deficit irrigation as a strategy to save water: challenge for research in stress physiology**

11.00-11.30 *Coffee break*

11.30-11.45 Živko Jovanović, Nemanja Stanisavljević, Aleksandar Mikić, Svetlana Radović: **The expression of DREB2A related gene from pea (*Pisum sativum* L.) as affected by water stress**

11.45-12.00 Nemanja Stanisavljević, Aleksandar Zdravković, Marija Ilić, Živko Jovanović, Jovanka Miljuš-Đukić, Aleksandar Mikić, Svetlana Radović: **Variations in antioxidative defense parameters in *Pisum sativum* var. arvense during vegetation period in field conditions**

12.00-12.15 Iva Pavlović, Hrvoje Lepeduš, Jutta Ludwig-Müller, Branka Salopek-Sondi: **Stress response of *Brassica rapa* plants to salt treatment**

12.15-12.30 Ljiljana Prokić, Filis Morina, Marija Vidović, Dejana Panković, Sonja Veljović-Jovanović: **Proposed mechanisms for drought acclimation in two *Verbascum thapsus* L. populations differing in metal tolerance**

12.30-14.00 *Lunch*

14.00-15.00 **Poster presentation (Section 7)**

Friday, June 7th, 2013

7.00-9.00 Breakfast

Section 8. Biodiversity and Conservation – Plenary lectures and Oral presentations

9.00-9.25 Marina Stanilova: **Conservation of endemic and endangered plant species by means of biotechnology - applicability of the results and social impact in Bulgaria**

9.25-9.50 Irina Holobiuc: **Stress-induced somatic embryogenesis in some threatened plant taxa**

9.50-10.15 Dejan Pljevljakušić: **Influence of planting time, fertilization and propagation type on yield and quality of arnica (*Arnica montana* L.)**

10.15-10.30 Branislav Šiler, Tijana Banjanac, Jasmina Nestorović Živković, Jelena Cvetković, Ana Simonović, Stevan Avramov, Danijela Mišić: **Genetic diversity among *Centaurium erythraea* Rafn Balkan Peninsula populations as revealed by TRAP markers, highly correlated to secondary metabolite profiles**

10.30-10.45 Tatjana Vujović, Đurđina Ružić, Radosav Cerović: **Cryopreservation of autochthonous plum genotypes using droplet vitrification technique**

Section 9. Evolutionaty Plant Biology – Plenary lectures and Oral presentations

10.45-11.10 Aleksej Tarasjev: **Evolutionary biology in biomonitoring, plant population conservation and environmental protection**

11.10-11.25 Uroš Živković, Stevan Avramov, Danijela Miljković, Nataša Barišić Klisarić, Danijela Prokić, Aleksej Tarasjev: **Phenotypic variation in physiology and morphology of *Iris variegata* in response to different light conditions**

11.25-11.40 Vukica Vujić, Luka Rubinjoni, Sara Selaković, Dragana Cvetković: **Geometric morphometric study of leaf shape variation in *Mercurialis perennis***

11.40-11.55 Luka Rubinjoni, Sara Selaković, Vukica Vujić, Dragana Cvetković: **A matter of taste: the consequences of having separate sexes on plant-herbivore interactions**

12.00-13.00 **Poster presentation (Sections 8, 9)** + *Coffee break*

13.00-14.00 **DFBS general assembly: reports, awards, society elections, jubille lectures**

13.00-13.20 Borivoj Krstić: **20 meetings of the Yugoslav and Serbian Plant Physiology Society**

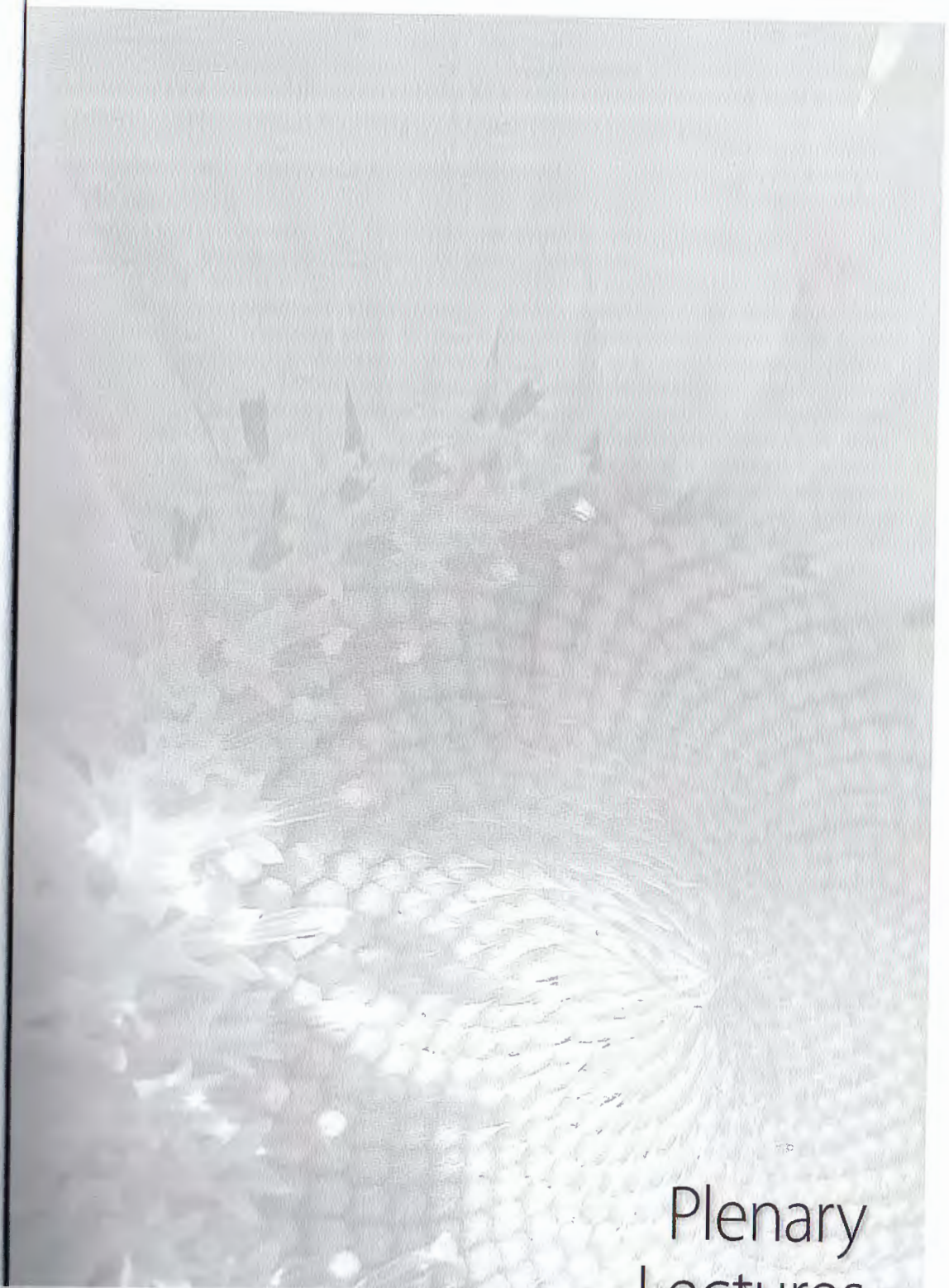
13.20-13.30 Ljubinka Ćulafić: **Dragoljub Grubišić *in memoriam***

13.30-13.40 **Annual report**

13.40-13.50 **Society awards**

13.50-14.00 **Election of the managing board for 2013-2015**

14.00-14.30 Farewell, participant departure



rameters (Fo-minimum fluorescence yield, Fm'- maximum fluorescence yield of light adapted leaves, the maximum quantum yield of PSII, Fv/Fm (Yeld (II) dark), the quantum yield of PSII, Yield (II) and the non-photochemical quenching (NPQ) were measured during the nine days. The correlation between PAR intensity and assimilation rate, so called *light curves* were obtained for both plant species. Carbon assimilation was always lower in the control compared to UV-B treated plants as the light intensity increased, especially for *P. coleoides*. In the "low PAR" experiment the carbon assimilation rate, stomatal conductance and transpiration rate were higher in UV-B exposed plants, particularly at the end of the experiment. Regarding *P. zonale* plants, CO_2 assimilation rate, stomatal conductance and transpiration rate for statistical analysis revealed more significant changes during the first half of treatment, when values for all parameters, especially for transpiration and stomatal conductance were higher in the UV-B exposed plants. Photosynthetic parameters measured were correlated with changes in the secondary metabolism induced by different light regimes in these specific model systems.

This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (project No. III43010). The experimental part was done in Helmholtz Zentrum München, Neuherberg, Germany supported by the COST Action: FA0906 UV4growth.

Silicon mediates iron acquisition by Strategy 1 plants

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Silicon (Si) and iron (Fe) are respectively the second and the forth most abundant minerals in the earth's crust. While the essentiality of Fe is discovered at the middle of the 19th century, Si is still not fully accepted as an essential element for higher plants. However, Si is proved to alleviate multiple environmental stresses in plants (e.g. metal excess, drought, salt, lodging, diseases and pests). Fe deficiency is considered to be one of the major limiting factors for crop production worldwide, also affecting human health in developing countries. Root responses (strategies) to a lack of Fe have mainly been studied in nutrient solution experiments devoid of Si, therefore information on the interactions between these two mineral elements in plants is still limited. Here we investigated how Si ameliorates Fe deficiency in Strategy 1 plant species (all dicots and monocots with the exception of grasses, which belong to Strategy 2), such as cucumber, sunflower, tomato and soybean, with the focus on the mechanism involved in Fe acquisition from the rhizosphere and utilization of root apoplastic Fe. A combined approach was performed including analyzes of apoplastic Fe pool, the components of reduction-based Fe acquisition machinery (using stable isotope ^{57}Fe and expression of *CsFRO2*, *CsIRT1*, and *CsHA1*) and accumulation of Fe-mobilizing compounds (carboxylates, phenolics and flavonoids), along with the expression of related genes involved in their biosynthesis, in the roots of model plant (cucumber). Our study indicates for the first time that the role of Si in alleviation of Fe deficiency stress includes: 1) increase of the apoplastic Fe pool in roots; 2) stimulation of Fe acquisition at the early stage of Fe deficiency stress through regulation of gene expression levels of proteins involved in this process; and 3) increase of the accumulation of Fe-mobilizing compounds in roots. Indeed, this work provides new evidence for the beneficial role of Si in plant nutrition and in perspective can be of practical importance in the development of new sustainable measures for controlling Fe chlorosis in calcareous soils, which in general are low in available Si.

Pavlovic J et al. (2013): Silicon alleviates iron deficiency in cucumber by promoting mobilization of iron in the root apoplast. New Phytol, doi: 10.1111/nph.12213.

The mechanisms of Si-mediated alleviation of P deficiency in wheat grown in acid soils polluted by mine tailings

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Pollution from industrial activities is increasingly creating marginal conditions for crop production worldwide. Nutrient deficiency, and in particular phosphorus (P) deficiency is an often overlooked factor which can be a severe constraint for plant growth in soils affected my mining activates (Nikolic et al., 2011). The root exudation of carboxylates (mainly citrate and malate) has been considered as the major root response to mobilize sparingly soluble P in the rhizosphere. Therefore the enhanced activity of phosphoenolpyruvate carboxylase (PEPC) appears to be a key P-independent metabolic bypass reaction of malate/citrate biosynthesis in P deficient plants. Although the beneficial role of silicon (Si) on plant growth has been reported on several plant species grown under P deficient conditions the underlying mechanism is still unknown.
The pot experiments were conducted with winter wheat, including Si fertilizers in addition to the conventional reclamation amendments (e.g. cow manure, NPK and lime) in the acid soil polluted by sulphidic mine tailings (collected form the Timok floodplain). The main focus of this study was on the dynamics of P pools in wheat rhizosphere, and on the molecular mechanism of root response to P availability in the rhizosphere (expression of *TaPT1* and *TaPT2*, encoding P_i transporters, *TaPEPC* encoding PEPC, and *MATE*-family genes encoding Al-activated citrate efflux transporter). All the amendments induced a significant change in the rhizosphere P fractions (readily available, Al- and Fe-bound P). For instance, Si supply has caused significant increase in readily available P, and reduction in Al-P and Fe-P. This can be attributed to synergetic effect of pH increase and reduction of P sorption by Al- and Fe-oxides. The leaf P concentration in wheat plants treated with Si significantly increased and was in the range of leaf P concentration in P-fertilized plants. While the expressions of the root *TaPT2* and *TaPEPC* were down-regulated by P availability in the rhizosphere and plant P status, *TaPT1* and *TaMATE* showed different pattern with markedly enhanced expression at Si treatment irrespectively of the P supply. In conclusion, Si nutrition effectively alleviates P deficiency in wheat by 1) increased P availability in rhizosphere, most probably due to MATE-mediated citrate exudation, and 2) enhanced P acquisition as a consequence of Si-promoted expressions of PT1 transporter in root plasma membrane.

Nikolic N., Kostic L., Djordjevic A., Nikolic M. 2011. Phosphorus deficiency is the major limiting factor for wheat on alluvium polluted by the copper mine pyrite tailings: a black box approach. Plant Soil 339: 485-498.

Interveinal chlorosis phenomenon and nitrogen metabolism in subsstrate-grown strawberry cv. Nyoho

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Substrate-grown strawberries (*Fragaria x ananassa* Duch. cv. Nyoho) often suffer interveinal chlorosis of

practice, we hypothesized that the cause of this phenomenon could reasonably be due to drastic changes in plant nitrogen (N) nutrition in strawberries just after planting into peat bags. In Nyoho plants, the most conspicuous feature of the diurnal pattern was the sharp increase in foliar ammonium (NH_4-N) concentrations during the first half of the light period, more acute in mature leaves. Foliar NH_4-N concentrations peaked between 12.00 and 15.00 h suggesting that the midday should be recommended time for sampling in experimental work. After treatments with high dose of glutamine synthetase (GS) inhibitor or nutrient solutions rich in NH_4-N, NH_4-N accumulation and interveinal chlorosis were more pronounced in newly expanding leaves than in mature ones. This indicates a possible connection between foliar interveinal yellowing and excess NH_4-N accumulation found in immature leaves of strawberry plants. The symptoms of foliar yellowing increased with exposure to increased light intensity and air temperature in plants treated with solutions containing NH_4-N. Regardless of the concentration of the supplied solution, foliar NH_4-N concentration followed a uniform pattern in the post-planting period. The concentration in mature leaves was peaked between 6 and 10 days after planting (DAP), before dropping steadily. However, GS activity didn't responded accordingly and started to continuously elevate after day-9 in all treatments. Increase in NO_3-N started 6 (in plants treated with 90% and 150% 'Ohtsuka A' nutrient solution) to 10 (in plants treated with 30% and 60% nutrient solution) DAP. The increase was accompanied with interveinal chlorosis in about one third of plants treated with 90% and 150% nutrient solution. Nitrate reductase activity in all treated plants reached constant levels after 6 DAP. With the absence of interveinal chlorosis in leaves that showed low foliar NH_4-N concentration regardless to treatment, it was concluded that high foliar NH_4-N concentrations and excess NH_4^+ accumulation play an important role in triggering interveinal chlorosis.

This research was supported by Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT).

Activity and distribution of superoxid dismutases and peroxidases in different organs of common ragweed (*Ambrosia artemisiifolia* L.)

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The common ragweed (*Ambrosia artemisiifolia* L.) is an invasive alien species from North America, reported in Bosnia and Herzegovina in 1940 for the first time. This species inhabits variety of habitats and is considered as the most noxious invasive weed in Europe. It is a highly successful pioneer species found in frequently disturbed habitats such as road sides, waste places and agricultural fields. Although there are so many studies about common ragweed as source of allergens there is not a lot of data about its antioxidative system. The aim of this work was to explore differences in activity and distribution of enzymes superoxide dismutase (SOD, 1.15.1.1) and peroxidase (POD, 1.11.1.7) in leaves, roots and inflorescence of common ragweed. Plant material was collected in a single population near the town of Srbac (NW Bosnia and Herzegovina) where common ragweed is widespread. We analysed isoenzyme profiles of SOD and POD by using the native gel electrophoresis. The obtained results showed different distribution of SOD and POD isoforms in inflorescence in comparison with leaves and roots of common ragweed. The highest protein content and peroxidase activity, with pyrogallol as substrate, was measured also in inflorescence.

The theoretical prediction of interactions between soluble silicon, iron (III) and carboxylate anions in plant fluids

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Recently, we proposed the presence of iron (Fe)-polysilicate chelate-like complexes as one of the possible mechanism involved in silicon (Si)-mediated alleviation of Fe deficiency in plants (see Pavlović et al., this volume). The presence of metals and organic ligands (e.g. oxalate and citrate) in aqueous solution can result in the complexation with dissolved silica. In aqueous solutions with low dissolved silica concentration (<10 mM) the principal species are monomeric (e.g. H_4SiO_4(aq), $H_3SiO_4^-$, $H_2SiO_2^{2-}$), and polymeric forms to various extent. The anionic species SiL_3^{2-} which is formed according to the reaction:

$$Si(OH)_4 + 3H_2L = SiL_3^{2-} + 2H^+ + 4H_2O,$$

is a hexacoordinated charge-transfer complex in which the ligands (L) are bidentately bound. A likely assumption is that the main interactions between Si and polycarboxylates do not take place in the aqueous phase, but rather on the surface of the dissolved particles (such as the surface of plant cell walls).

As a strong Fe chelator, citrate (Cit^{4-}) has been considered as the most likely major candidate for Fe transport in plants via xylem and apoplastic fluids. Ferric-citrate chemistry is complicated and a definitive description of its aqueous speciation at the neutral or weakly acidic pH values (typical for plant fluids) remains elusive. The predominant Fe(III)-citrate species at the physiological pH values are the mononuclear biologically relevant dicitrate $[Fe(Cit)_2]^{5-}$ complex and multinuclear species of low nuclearity, in particular trinuclear complexes. The $[Fe(Cit)_2]^{5-}$ complex predominates in the Fe : citrate molar ratio range 1:100 to 1:10 (the normal range found in the apoplastic fluids of Fe-adequate plants).

Aqueous silica forms stable complexes with polymeric ferric oxy-hydroxide species, which may be formed in the root apoplast. Structure of the Fe-Si complexes appears to be similar at both acid and alkaline pH. The presence of single corner Fe-O-Si bonds is expected in the monomer complex $FeOSi(OH)_3^{2+}$ in the acidic solutions. Silica substitutes for double-corner FeO_6-octahedra in Fe oxy-hydroxide polymeric complexes existing at the early stages of Fe(III) hydrolysis, likely by forming 2C-type (double corner) complexes with small Fe oxy-hydroxide polymers whose structure consists of FeO_6-octahedra linked together by common edges. In low activities aqueous silica solutions, Fe^{3+} remains essentially hexa-coordinated.

Aluminium tolerance variability in Serbian winter wheat cultivars

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Seventeen winter wheat (*Triticum aestivum* L.) cultivars widely grown in Serbia were tested to aluminium (Al) tolerance by using fast screening method. Two contrasting wheat cultivars, Atlas-66 (Al-tolerant) and Egret (Al-sensitive) were used as the reference. Wheat seedlings were grown in microelement-free nutrient solution without or with a total Al supply of 50 μM, at pH 4.2. The activity of Al^{3+} in nutrient solution was 25.9 μM, and the Al^{3+} concentration 44.2 μM (calculated by the software GEOCHEM-EZ, Version 1.0). The relative root length (RRL; a proportion of central roots length at Al-free NS) was used as the main parameter for ranking of Al tolerance. Al treatment reduced the total length by 71% in the Al-sensitive and only by 10% in the

Pobeda were ranked as sensitive, whereas the cultivars Etida, Rapsodija, Gordana, Arabeska and Ljiljana were tolerant to Al toxicity. The majority of the tested cultivars (Milijana, Zvezdana, Gora, NS 40S, NS Enigma, NS Dika, Arija, Dragana, Natalija, Simonida) were moderately tolerant to Al toxicity. The lowest root Al concentration (up to 1000 μg g^{-1} dry weight) was found in Al-tolerant Ljiljana and Arabeska, and in moderately tolerant Simonida, as well as in the referent Al-tolerant cultivar. On the other hand, root Al concentrations in all the other cultivars were significantly higher, in the range of the referent Al-sensitive cultivar. The Al tolerant cultivars selected in our study need further inspection focusing on the molecular mechanisms of Al tolerance prior to be recommended for the field trials in the regions with acid soils.

Silicon modulates compartmentation of B in wheat and sunflower under B toxicity

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Boron (B) and silicon (Si) are elements with many similar chemical properties; both are week, undissociated acids in aqueous solution and can complex readily with polyhydroxy compounds. Plants take up Si and B as uncharged monosilicic acid and boric acid, respectively. Due to these similarities, the interactions between B and Si are possible, however there is little information available regarding this aspects. Although B is an essential microelement for higher plants, its toxicity also limits crop production worldwide, mostly in arid and semiarid regions. Beside natural occurrence in the soil, B-contaminated irrigation water and mining pollution can also be a source of high soil B.

Our research was focused on Si-affected shoot accumulation and compartmentation of B in wheat and sunflower grown at toxic B conditions (500 μM). Two major B pools widely accepted in compartmentation studies were determined: 1) water insoluble residue (WIR), representing wall-bound B, and 2) soluble B, representing symplastic fraction including vacuole. There was no difference between +Si and –Si treatments in total root B concentration, whereas in the leaves with both severe and moderate toxicity symptoms total B concentration was almost 2-fold higher at –Si treatment in wheat and sunflower, indicating Si-decreased shoot B translocation. In addition, the proportion of leaf WIR-B significantly increased in both species treated with Si, being 6-fold higher in wheat. Interestingly, there was no experimental evidence for concomitant binding of B and Si to the cell wall structures. Soluble B determined directly in the freshly prepared cell sap was only slightly decreased in the +Si wheat plants, however with no differences in the +Si sunflower plants.

Our results indicate that the main mechanism of detoxification excess B in plants involving Si-enhanced cell walls binding potential of B. Under high B supply, a possible replacement of Si with B during polymerization processes in the cell walls, as well as the formation of Si-B-polyhydroxy complexes in cell sap can also be considered.

Zn concentrations in wheat grains along the gradient of native Zn soil availability in Serbia

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Zinc (Zn) is an essential microelement for plants and also an important nutritional and health factor in humans. As a consequence of low Zn availability in soils, nearly half of the world's population suffers from Zn malnutrition. Zn deficiency has serious implications for human health (e.g. impairments in physical development, immune system, brain function and learning ability) and thus for the overall economy of a country; it is most severe in nations who depend on cereals as the main staple food. A critical Zn concentration in the whole grain for humans that depend on cereal-based diets is 24 mg kg^{-1} dry matter. Research focused on increase of Zn content in cereals (biofortification), is the strategic priority in many countries. In Serbia however, the awareness of this problem is lacking, and no systematic survey of Zn availability in soils and concentrations in cereal grains has been undertaken so far.

Our study included 156 grain samples of the two major bread wheat varieties (Simonida and NS 40S) collected at 89 localities throughout Serbia. We analyzed soil pH, available Zn and grain Zn concentration together by principle component analysis and multiple linear regression. Wheat varieties did not differ in ability to accumulate Zn in grains. Both soil pH and available Zn concentration were the nominally significant predictors for grain Zn concentration and explained about 12 and 9% of the encountered variation, respectively. Zn concentration below the critical limit (24 mg kg^{-1}) was found in 58% of grain samples (values in the range 11-61 mg kg^{-1}, median only 21.3 mg kg^{-1}), while in only 14% of soil samples the available Zn was below the critical value (0.5 mg kg^{-1}).

The most severe lack of Zn in grains (below 18 mg kg^{-1}) was observed in samples from the major production regions of bread wheat (e.g. Pančevo, Vrbas and Sremska Mitrovica). The alarming results of this survey indicate that Serbia urgently needs a strategy for Zn biofortification, primarily through a breeding program to enhance Zn efficiency as a sustainable alternative to application of Zn fertilizers.

Biochemical properties and antioxidant capacity of *Pyrus amygdaliformis* VIII. fruit juice from Mt. Athos, Greece

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Limited data is available on the biochemical properties and antioxidant capacity of wild pear fruits. Recently, in general wild edible crops have gained greater attention, and research shows that many wild edible

Silicon mitigates oxidative stress in cucumber at copper excess

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Beneficial effects of silicon (Si) are well demonstrated for many crop species, although its essentiality is still not proven. Some mechanisms of Si-mediated alleviation of different stresses in plants have been proposed in the literature, however the molecular bases of these mechanisms are poorly understood. Metal toxicity is considered as an important environmental problem in many agricultural soils worldwide. Copper (Cu) is an essential microelement for plant growth and development. As a redox-active transition metal, Cu is a cofactor in many proteins involved in electron transfer chains including respiration and photosynthesis. However, in excess Cu can induce oxidative stress via several proposed mechanisms, including direct generation of reactive oxygen species (ROS) through the Fenton reaction. The aim of this study was to elucidate the molecular mechanism of Si-mediated alleviation of oxidative stress caused by excess Cu in cucumber. Hydroponically grown plants were subjected to different Cu concentrations, with or without Si supply. The high Cu-treated plants showed higher biomass and better root growth when Si was applied. The parameters of oxidative stress lipid peroxidation, total phenolics and tissue Cu concentrations were measured. Expressions of the genes involved in antioxidative defense and biosynthesis of phenolics were in accordance with the biochemical findings, clearly demonstrating the multiple role of Si in alleviation the harmful effects of ROS in cucumber.

Photosynthetic efficiency and leaf morphology of (*Pinus nigra* Arn.) under variable urban pollution conditions

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To date an unprecedented, rapid change in urban environment is observed, which is likely to exceed the adaptive potential of plants, especially that of tree species with their long reproductive cycles. Changes in chlorophyll fluorescence parameters is considered as an reliable approach for evaluating the state of plant vitality and provides a rapid and accurate technique for detecting and quantifying the tolerance of plants to stress. In order to consider the different pollution sources, photosynthetic efficiency (Fv/Fm) of Austrian pine (*Pinus nigra* Arn.) in urban areas of four cities in Serbia, characterized by different sources of pollution, was assessed. The sampling sites were urban parks in the cities exposed to airborne pollutants from industrial activities, waste disposal and heavy traffic: Belgrade (traffic), Pančevo (factory of nitric fertilizers and a refinery), Obrenovac (thermoelectric power plant and fly ash disposal site), Smederevo (iron smelter), and Košutnjak forest in Belgrade (without direct source of pollution).
Site-dependent variations were found in photosynthetic efficiency (Fv/Fm) of pine trees. A reduced vitality was observed in all the examined sites in relation to control: Pančevo ($p<0.001$), Obrenovac ($p<0.001$), Smederevo ($p<0.001$), and Belgrade ($p<0.01$) followed by toxicity symptoms in form of tip necrosis and decline of the needles, which was the most pronounced in the city of Smederevo.
The results obtained in this study demonstrate that the two-years-old pine needles expressed both physiological and morphological injuries and that the measured reductions in photosynthetic capacity can be attributable to increased uptake and accumulation of the pollutants in the examined sites.
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Effects of pollution on Norway maple (*Acer pseudoplatanus* L.): chlorophyll fluorescence and photosynthetic pigments

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Many urban areas are polluted by industrial activities and waste disposal. The role of vegetation in mitigating the effects of airborne pollution has been highlighted as one potential benefit of urban green space. Sycamore maple (*Acer pseudoplatanus* L.) is often used for urban landscaping because it is considered to be tolerant to different ecological conditions. The ecophysiological behavior of maple trees in urban areas of four cities in Serbia, characterized by different sources of pollution, was studied. The sampling sites were urban parks in the cities exposed to airborne pollutants from industrial activities, waste disposal and traffic: Belgrade (traffic), Pančevo (factory of nitric fertilizers and a refinery), Obrenovac (thermoelectric power plant and fly ash disposal site), Smederevo (iron smelter), and Košutnjak forest in Belgrade (without direct source of pollution). Site-dependent variations were found in photosynthetic efficiency (Fv/Fm) of maple trees. A reduced vitality was observed in Obrenovac ($p<0.001$), Smederevo ($p<0.001$), and Belgrade $p<0.05$) in relation to control, followed by toxicity symptoms in form of leaf chlorosis and marginal necrosis. Differences in total chlorophyll (Chla+b) levels between sites were as follows: Pančevo ($p<0.001$), Obrenovac ($p<0.001$), Smederevo ($p<0.001$), and Belgrade (ns).
The results clearly demonstrate that the individuals of maple from city parks in Obrenovac with the thermoelectric power plant in its vicinity, in Smederevo with iron smelter and Belgrade with dominance of traffic pollution have lower adaptation response to the pollution. This work highlights the possibility of using a fast and low-cost procedure to evaluate the pollution level through data obtained from plant species growing within an urban environment.
This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (grant No. 173018).

The effect of drought on photosynthesis of *Q. robur* and *Q. cerris*: Use of light response curve as indicator of stress

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Seedlings of *Q. robur* and *Q. cerris* were grown in in the greenhouse pot experiment during one vegetation period. Acorns were collected in natural populations at Mt Fruška gora National park in 2011 and sown