RESPONSE OF *Sinapis nigra* L. AND *Sinapis alba* L. TO THE PRESENCE OF NaCl AND SILICON IN NUTRIENT SOLUTION

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Abstract
Stress caused by salt is one of the most important abiotic stresses for plants. It is well known that silicon can alleviate this abiotic stress in some plant species. In this experiment we analyzed *Sinapis nigra* and *Sinapis alba* growing in the presence of 50 and 100 mM NaCl and influence of Si on tolerance of this two species to salinity. The results showed that salinity had significant effect on growth, concentration of photosynthetic pigments and free proline. The smallest effect of NaCl and NaCl combined with Si was on transpiration intensity.

Introduction
Soil salinity is a problem that is growing in many regions where irrigation is a regular agro-technical measure, as well as in arid and semiarid regions. Stronger mineralized water and reclaimed water utilities are often used for irrigation [1]. Cultivated plants react to increased concentrations of salt and salinity may significantly affect the quality and the yield [2].
Silicon (Si) is the second most abundant element in Earth crust. It is well known that although Si is not usually considered to be an essential element it could be beneficial for plant growth and production [3]. Many studies show that the addition of Si increases the resistance of plants to biotic and abiotic stress [4].
Black and white mustard are grown for seeds that are used as spices. Oil of black mustard has strong antibacterial activity and white mustard is also used as feed and green manure. They are very important for the production of honey, too. The diverse purposes and unexplored possibilities of mustards for analyzing those species with respect to excessive NaCl and role of silicon.
The aim of experiments was to examine the influence of different concentrations of NaCl and and the effects of silicon on growth, physiological and chemical properties of black and white mustard.

Experimental
In this paper, we studied how the continious presence of 0 (control), 50 and 100 mM NaCl and NaCl combined with silicon (2 ml/L) affects on fresh weight (leaf, stem, root), concentration of free proline (shoot and root) and photosynthetic pigments, and transpiration intensity, in white mustard (*Sinapis alba* L.) and black mustard (*Sinapis nigra* L.). All treatment were set in five repetitions, eight plants per repetition. Plants were grown in semi-controlled conditions of a greenhouse, in water cultures, using one half strength Hoagland solution [5] as nutritive medium. Fifty days after sowing analises were done. Fresh weight were measured, the intensity of transpiration was measured gravimetrically, free proline were analized spectrophotometrically (*Beckman, USA Duferies 60*) [6], as well as concentration of photosynthetic pigments (following procedures [7] [8]).

Statistical analysis of data was performed by Statistica 13. Significance of obtained differences between means was established by LSD test for all parameters.

Results and discussion

Salinity caused a reduction of growth of above-ground parts of plants, contributed to reduction of the leaf surface, which further effect was the reduction of photosynthesis intensity. The obtained results are in accordance with this experiment. White mustard didn't show significant differences in the FW leaf between treatments, while in the black mustard there were significant differences in plants grown in the presence of 100 mM NaCl+Si (Figure 1). Significant differences were between treatments, especially in FW of stems of white mustard. FW of roots was not significant compared to the control in any plant species.

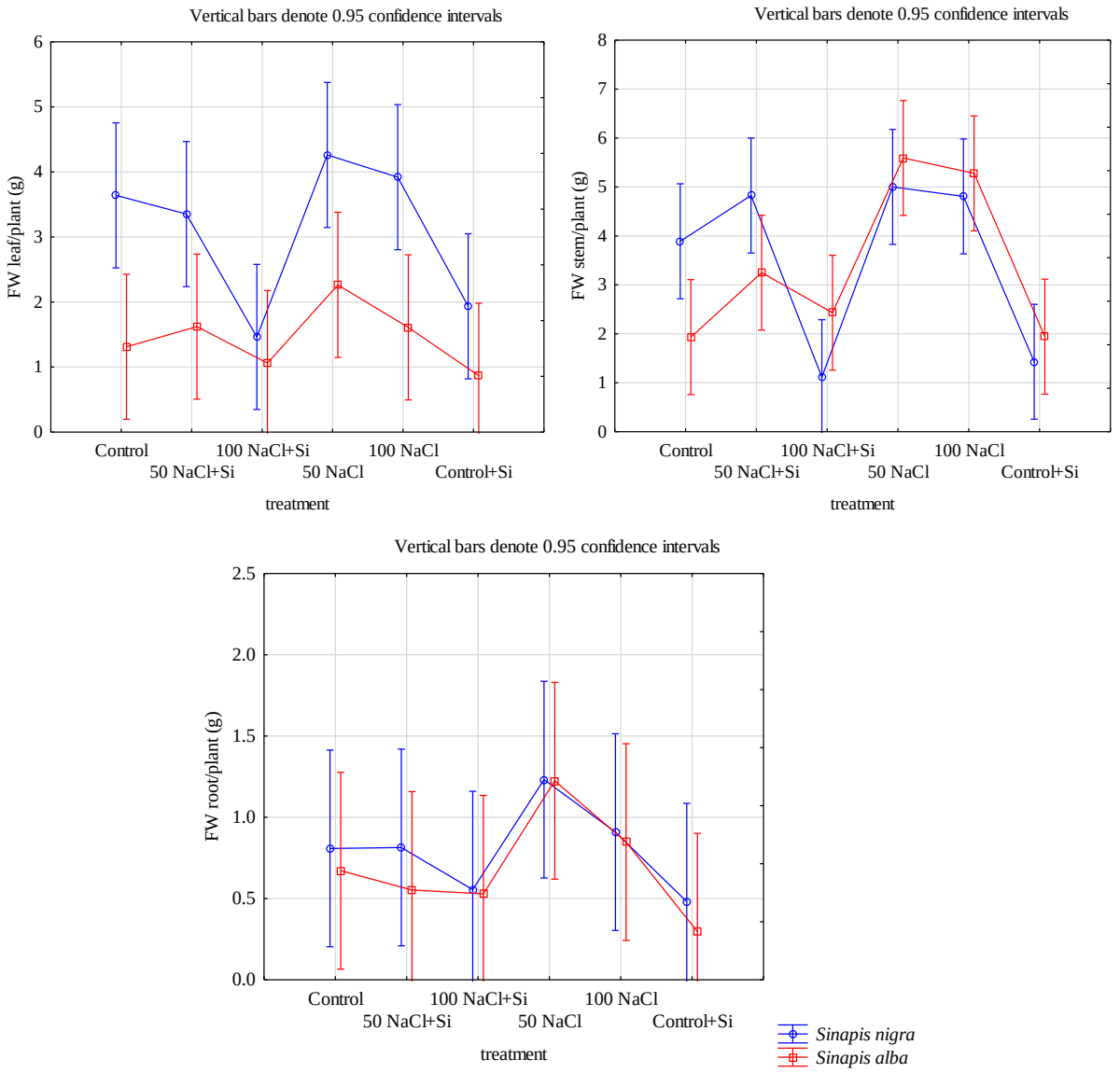

Figure 1. Fresh weight (FW) of *Sinapis nigra* and *Sinapis alba* under NaCl and Si treatment

According to previous studies (Blohina et al., 2003) Si may affect the recovery of the chlorophyll content of rapeseed caused by salinity, which suggested that Si had a positive

influence on the oxidative stress, the concentration of the photosynthetic pigments does not change significantly compared to the control. Treatment by Si in this experiment is enabled that the concentration of the pigments remained at the control level (Figure 2). The concentration of all analyzed pigments in both plant species was significantly different compared to the control, for example in treatment with 50 NaCl, concentration of Chl a was 45% higher than in the control. Quite opposite results are obtained from two varieties of corn [4] where the use of Si lead to an increase of chlorophyll, compared to plants grown in presence of NaCl, and it was defined a positive effect of Si on reduction of chlorophyll degradation.

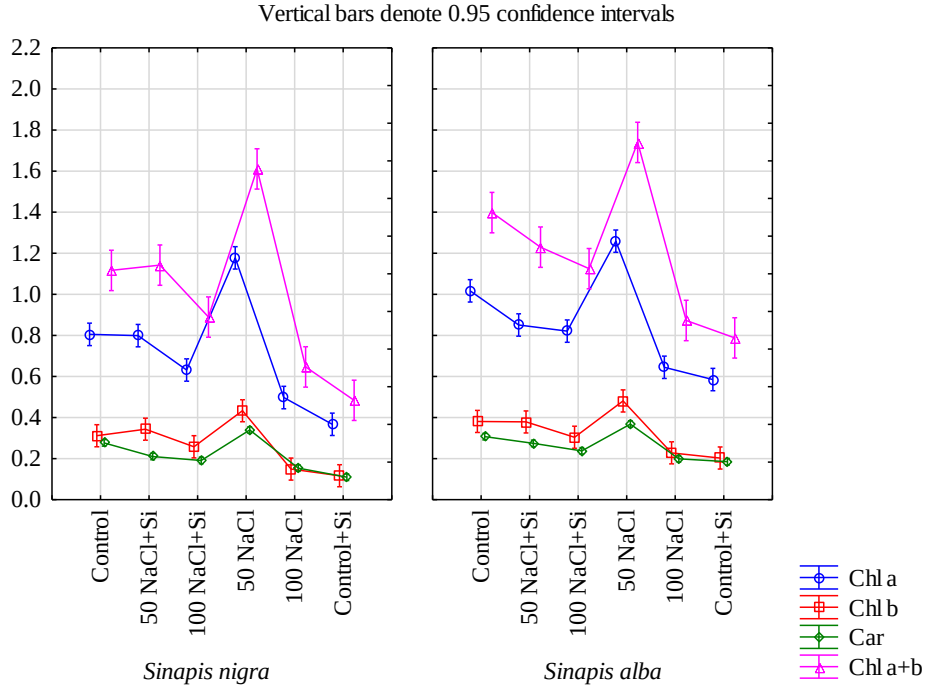

Figure 2. Photosynthetic pigments (mg/g FW) of *Sinapis nigra* and *Sinapis alba* under NaCl and silicon treatment

The content of free proline in the root was the similar in both plants species. The biggest difference compared to respective controls induced treatment 100NaCl+Si where concentration of free proline was 13 times higher in *Sinapis nigra* and about 5 times higher in *Sinapis alba* (Figure 3).

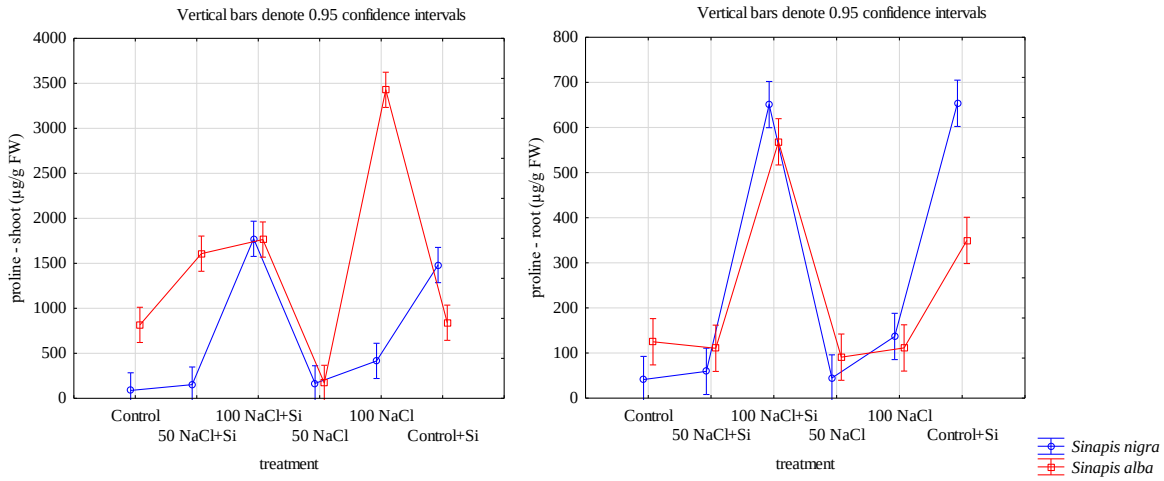

Figure 3. Concentration of free proline of *Sinapis nigra* and *Sinapis alba* under NaCl and silicon treatment

In shoots were larger differences between plant species, the difference of the concentration of free proline compared to the control was the biggest in *Sinapis alba*, 4.2 times more in the treatment of 100 NaCl, while the largest difference in *Sinapis nigra* was observed applying treatment 100NaCl+Si, 20 times higher concentrations compared to the control (Figure 3).

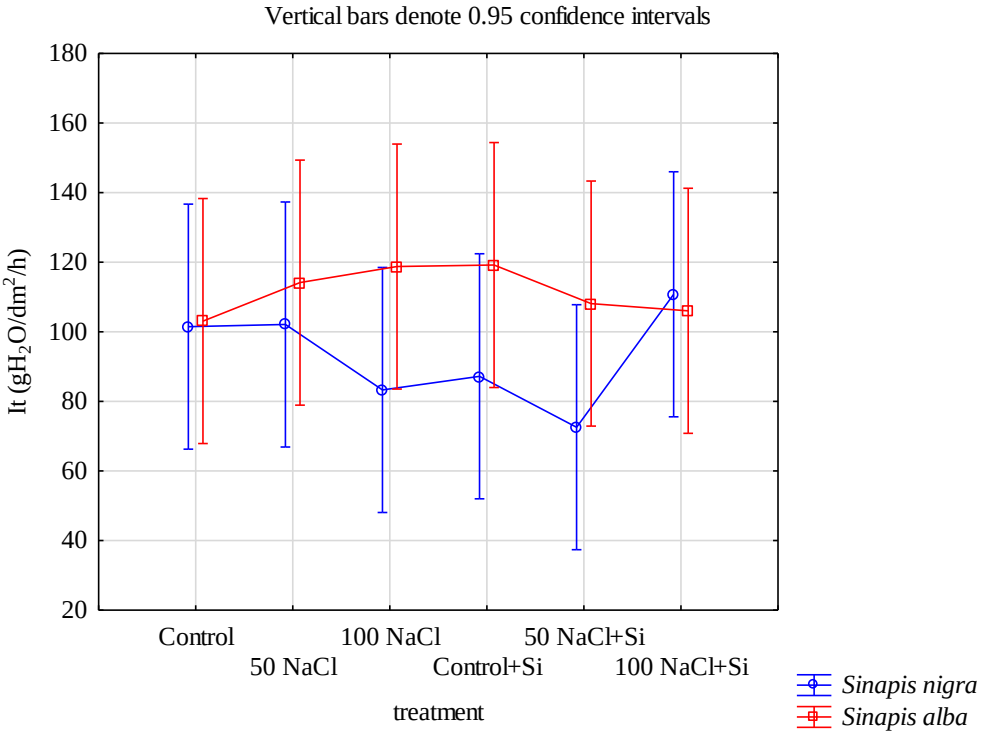

Figure 4. Transpiration intensity of *Sinapis nigra* and *Sinapis alba* under NaCl and silicon treatment

In contrast to the results of research on the oilseed rape, in which at high concentrations of salt concentration of free proline increased and upon the addition of Si proline content declined,

suggesting that Si reduced the negative effect of salinity on the concentration of proline [10]. Applied concentration of salts and of silicon had not significant influence on transpiration intensity (Figure 4). The results obtained on *Sinapis nigra* (Figure 4) are in accordance with the previous research [11] [2], which have established that salinity in peas, reduced the leaf, transpiration surface, which further reduced transpiration.

Conclusion

Salinity significantly affected growth, concentration of photosynthetic pigments and free proline in black and white mustard, whereas intensity of transpiration changed only slightly. However, applied concentration of Si alleviated negative effects of salt in plants grown at lower salt concentration (50 mM NaCl). It would be good to examine the impact of application of different concentrations of silicon on vegetative growth, grain yield and quality of *S. nigra* and *S. alba* in the future.

Acknowledgements

We thank Ministry of Education, Science and Technological Development of the Republic of Serbia (TR 31036 and TR 31016) for financial support.

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