Plant Stress Physiology

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Effects of foliar Fe application on chlorophyll concentration, mineral composition and Fe distribution in sugar beet leaves

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Introduction

Iron chlorosis is a widespread physiological disorder affecting many crops that clearly reduces yield. Foliar Fe fertilization is a common agricultural strategy to control this disorder. The effects of Fe application to the whole leaf on structure, chlorophyll concentration and nutrient concentration were previously investigated in several works. In this work an iron-containing solution was applied to a portion of an Fe-deficient leaf of sugar beet and the effects of this application on both treated and untreated side of the leaf were studied.

Material and methods

Sugar beet plants (*Beta vulgaris* L. cv Orbis) were grown in a growth chamber with a photosynthetic photon flux density of 350 μmolm^{-2}s^{-1} PAR, 80% relative humidity and 16 h at 23 °C / 8h at 18°C light/dark regime. Sugar beet plants were grown for 2-week period in a half-strength Hoagland nutrient solution with 45 μM Fe(III)-EDTA, and then for 2 weeks in a half-strength Hoagland nutrient solution without iron.

After that a solution including $FeSO_4$, $7H_2O$ (2 m*M*) was applied to one half of the leaf (in the adaxial and abaxial side) using a paint brush (Fig. 1). The application was made twice, the first one at the beginning of the experiment and the second one two days later.

Two experiments were made:

Experiment 1: treatment was applied to the upper side of the leaf. Chlorophyll evolution was studied. Eight days after the first application leaves were detached and the mineral element concentration (P, K, Ca, Mg, Fe, Mn, Cu and Zn) of treated and untreated leaf areas was analyzed according to standard laboratory procedures.

Experiment 2: treatment was applied to the left side of the leaf. Chlorophyll evolution was followed and Fe transversal foliar distribution was studied by scanning electron microscopy and energy-dispersive X-ray microanalysis (SEM/EDX) .

The leaf chlorophyll concentration evolution was estimated with a SPAD Chlorophyll meter daily (Minolta 502, Osaka, Japan), using 4 measurements in treated and untreated parts of the leaf.

Fig. 1. Iron solution application by paint brush

Results

Chlorophyll concentration evolution

In both experiments, in the treated leaf section the Fe-solution application led to significant chlorophyll increases, whereas the untreated section showed only a slight re-greening (Fig. 2, Fig .3 and Fig. 4).

Fig. 2. Treated and untreated leaf area 8 days after first treatment

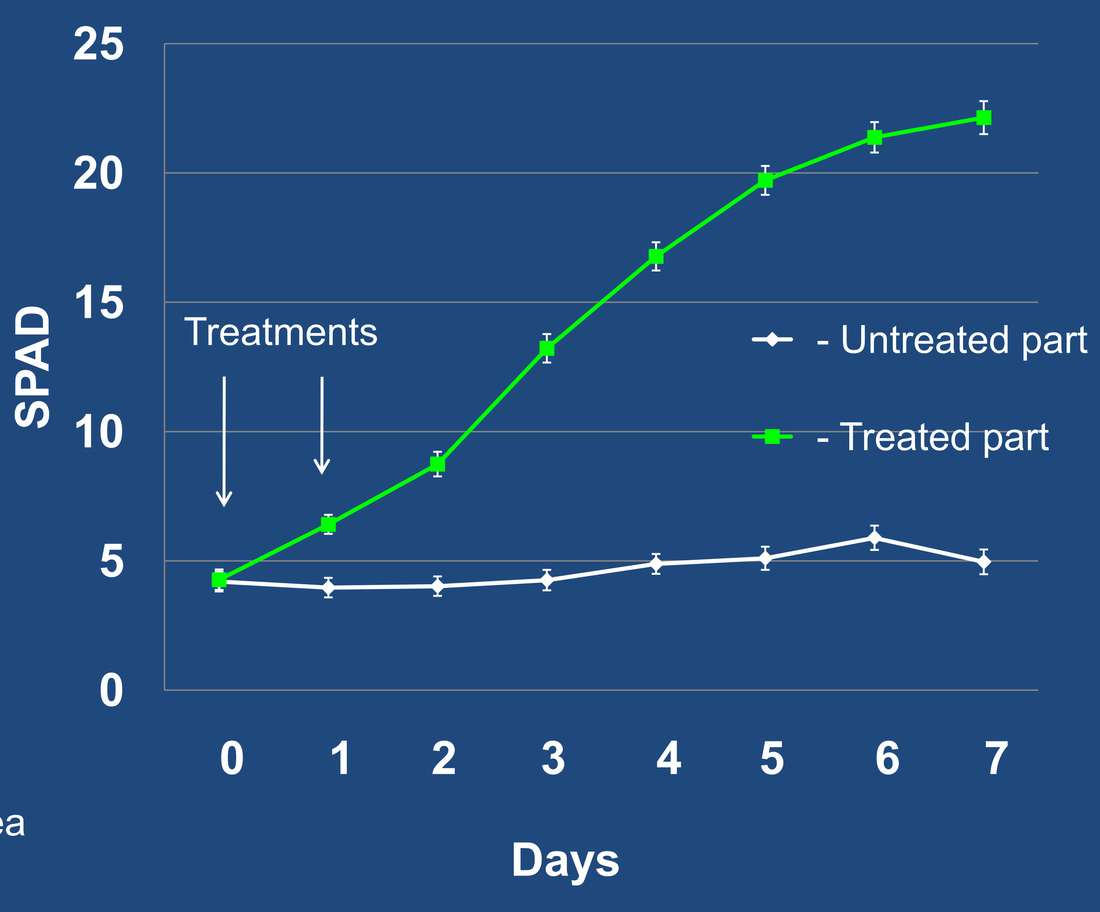

Fig. 3. Chlorophyll evolution after Fe application in the treated and untreated leaf parts

Mineral elements concentration

Figure 5 shows the change in concentration of the mineral elements in both treated and untreated parts in experiment 1, compared to reference values found in chlorotic leaves. Treated leaf areas (green bars) had major increases not only in Fe, but also in P, K, Mg and Mn. Remarkably, leaf parts not treated with Fe solution (white bars) showed also increases in Fe and Mn.

Fe transversal foliar distribution

Areas tested were adaxial epidermis, pallisade parenchyma, xylem vessels, spongy parenchyma and abaxial epidermis on leaves from experiment 2 (Fig. 4). Microanalysis showed that there was a lower Fe signal in spongy parenchyma in treated part, while it seems that Fe signal increased in the leaf transversal section from adaxial to abaxial side in non treated leaf part.

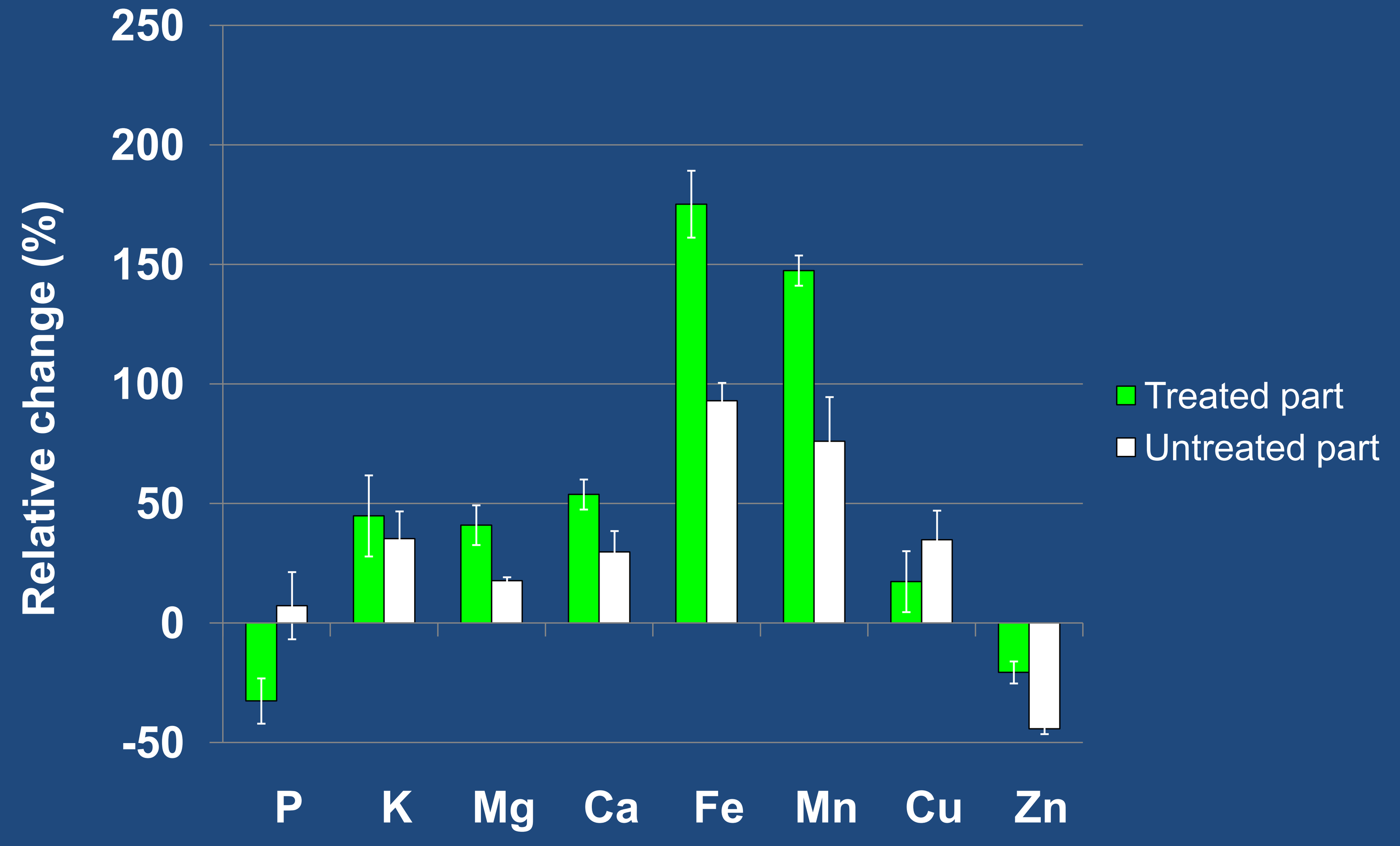

Fig. 5. Mineral element changes resulting from foliar Fe application, as compared to the elemental concentrations found in Fe-deficient leaves

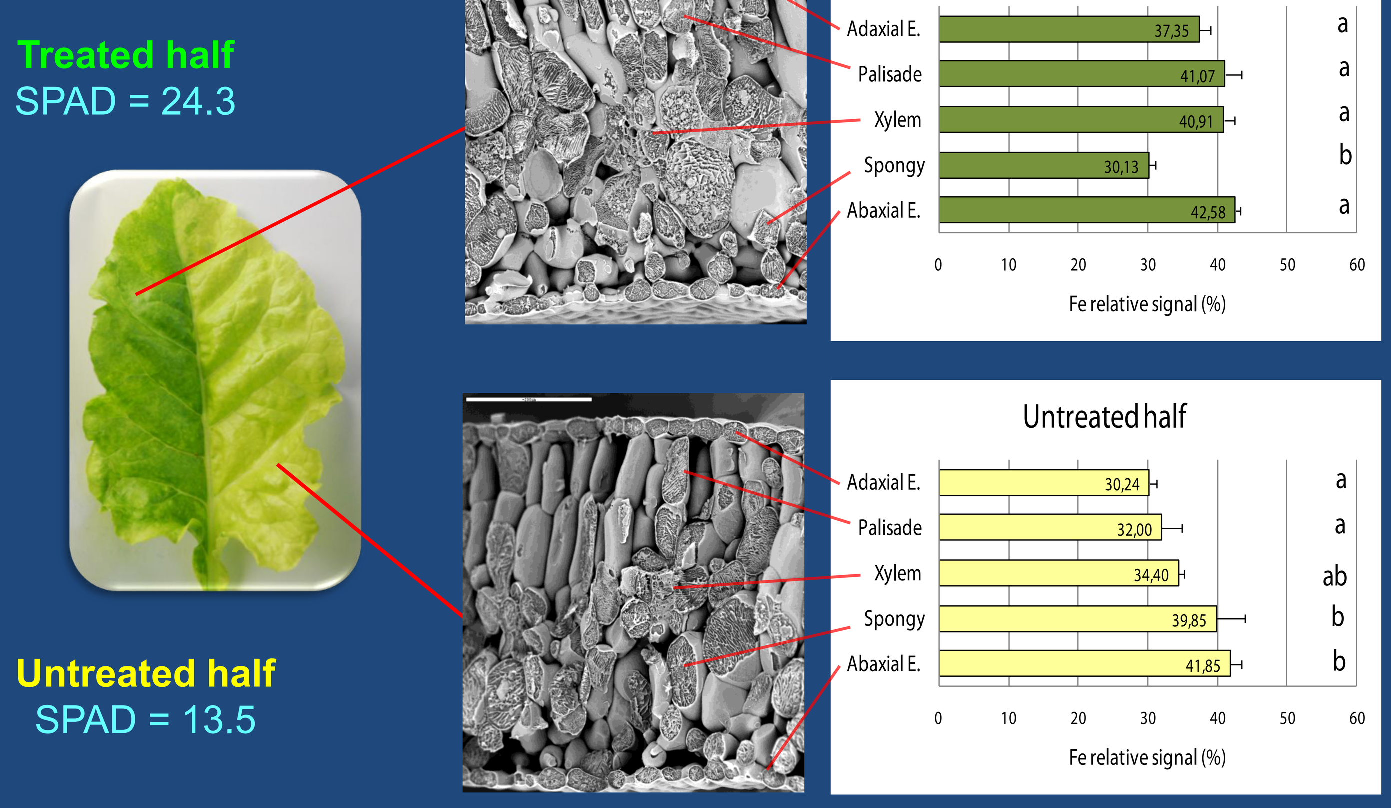

Fig. 4. Fe transversal foliar distribution by scanning electron microscopy and energy-dispersive x-ray microanalysis (SEM/EDX) after treatment

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Conclusion

Foliar Fe application increased Fe concentrations both in treated and untreated areas, whereas re-greening occurred preferentially in treated versus untreated areas. Iron application changed the mineral composition of Fe-deficient leaves, both in Fe-treated and untreated areas. Further experiments will be necessary to confirm these data.

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