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The effect of foliar applied silicic acid on growth and chemical composition of tomato transplants

Einfluss von blattapplizierter Kieselsäure auf Wachstum und chemische Zusammensetzung junger Tomatenpflanzen

Abstract

Silicon (Si) is not an essential element for plant growth but considered as beneficial for the growth and development of most plants. The objective of this investigation was to investigate the effect of an extra supply of Si with foliar applied finely dispersed $SiO_2 \bullet n\,H_2O$ (= silicic acid "dissolved" in water) on early growth and elemental composition of tomato transplants. Silicic acid was applied as an aqueous spray applied in different concentrations from the first true leaf stage three times at two-week intervals in total 108 g/ha Si. Tomato transplants were taller with larger stem diameters when treateted with Si and NO_3, N, P, K and Ca concentrations enhanced.

Key words: Calcium, magnesium, nitrate, nitrogen, phosphorus, potassium, silicic acid, tomato

Zusammenfassung

Silizium (Si) ist ein für das Wachstum zahlreicher Pflanzen nicht essentielles, aber dennoch nützliches Element. Ziel der Untersuchungen war es, den Effekt einer zusätzlichen Si Zufuhr über das Blatt in Form von fein dispersem $SiO_2 \bullet n\,H_2O$ (= in Wasser „gelöster" Kieselsäure) auf das Wachstum und die chemische Zusammensetzung junger Tomatenpflanzen zu prüfen. Die Kieselsäure wurde in wässriger Dispersion in unterschiedlichen Konzentrationen dreimal im Abstand von zwei Wochen beginnend mit dem Erscheinen des ersten Vollblattes auf die Pflanzen appliziert. Insgesamt wurden 108 g/ha Si verabreicht. Die Behandlung erhöhte das Längen- und Dickenwachstum der Stängel und führte zu erhöhten Gehalten an NO_3, N, P, K und Ca.

Stichwörter: Kalium, Kalzium, Kieselsäure, Nitrat, Magnesium, Phosphor, Stickstoff, Tomatenpflanzen

Introduction

Although Si is present in every tissue plants complete their life cycle without the need of Si. However, in a large number of crop plants, like for instance rice, wheat, sugarcane and barley positive effects of an additional Si supply are reported (Rodrigues and Datnoff, 2015). Si accumulates in plants through the roots in the form of monosilicic acid, and thereafter it gets deposited in different types of plant cells and intercellular spaces which are called "phytoliths" (Tripathi et al., 2014). An impressive number of field studies have shown that supplying crops with adequate plant-available Si can suppress plant disease (Cogliati et al., 2011; Huang et al., 2011; Mohseni and Sabbagh, 2014), reduce insect attack, improve environmental stress tolerance and increase crop productivity. Si plays important roles in mitigating the biotic (insects, pests, pathogens) and abiotic (metals, salinity, drought, chilling, freezing) stress (Rodrigues and Datnoff, 2015). Silicon application is therefore supposed to

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be a means for improving crop production under extreme climate conditions. Several reports reviewed the benefits of silicon application on crop growth, but the mechanisms of silicon action have not been systematically discussed (Olle, 2014; Schnug and von Franck, 1984; Zhu and Gong, 2014).

The foliar application of stabilized silicic acid is called the 'silicic acid agro technology' (SAAT) (Bent, 2014). SAAT has been shown to be effective on a number of crops and their growth parameters like for instance an increased root system, promoted growth of stems and tillers, enlarged leaf areas and leaf chlorophyll content and nutrient uptake all in all resulting in up to 15–50% more yield and improved quality (Bent, 2014).

Bent (2014) has shown that there are lots of experiments done to see whether Silicon has an effect also on tomato plants. He reported that SAAT technology can increase the yield of tomatoes up to 31% based on research done in Asia and Europe in 2012–2013. Similarly Toresano-Sánchez et al. (2012) found that a Si treatment increased the yield of tomatoes. For tomatoes Bent (2014) recommended to use the SAAT technology from transplant age to full production of fruit after every 8–12 days. Still there are missing experiments which are testing the hypothesis of positive effects of Si to tomato transplants and its quality.

Material and Methods

The experiments were conducted under greenhouse conditions at the Estonian Crop Research Institute. Test plant was the tomato variety Malle. Three week old seedlings were transplanted once into individual pots (9 cm diameter) with Novarbo B2 Organic Biolan substrate (lime content 6 kg/m^3, fertilizer content 1.0 kg/m^3, fertilizer N-P-K 12–6–22, pH neutral). There were two treatments: 1. stabilized Si acid treatment (AB Yellow, ReXil, 2015), 2. untreated control. The Si was applied dispersed in water (1.5 L product in 750 L water used on one ha) from the first true leaf stage three times at two-week intervals in total 108 g/ha Si with three applications. The experiment had four replications per treatment and was repeated in total twice.

The greenhouse lighting at a plant level was approximately 12000 lux from high pressure sodium lamps. The plants were additionally lighted in the period of 18 hours (23.00–16.00). All plants were grown with a minimum day and night temperature of 20°C and 18°C, respectively.

After 6 weeks, yield, height and stem diameter were recorded and the content of total N, nitrates, Ca, Mg, K and P analyzed after Kjeldahl digestion.

Results and Discussion

Compared to control the Si treatment increased the height of tomato transplants significantly by 20% (Fig. 1), and gave the plants a darker green appearance (Fig. 5).

Stems of Si treated plants were 31% and significantly thicker than in the untreated controls (Fig. 1). The fresh matter of the Si treated plants had a significantly (up to 75%) higher nitrate content, corresponding with an increase of the total N concentrations by up to 31% (Fig. 2).

In dry matter the P concentrations increased significantly up to 9%, K up to 24% and Ca up to 7%. No effect was detected on the concentrations of Mg (Fig. 3 and 4).

This is the first report on Si effects on young transplanted tomato plants, revealing that significant effects on growth parameters like stem length and diameter can be observed also at early growing stages. For later growing stages this has been confirmed already by Bent (2014). The experiments confirm also earlier findings from Olle and Schnug (2016) that foliar applied Si increases the plants concentration of P and K giving the plant a better supply for the higher demand in early

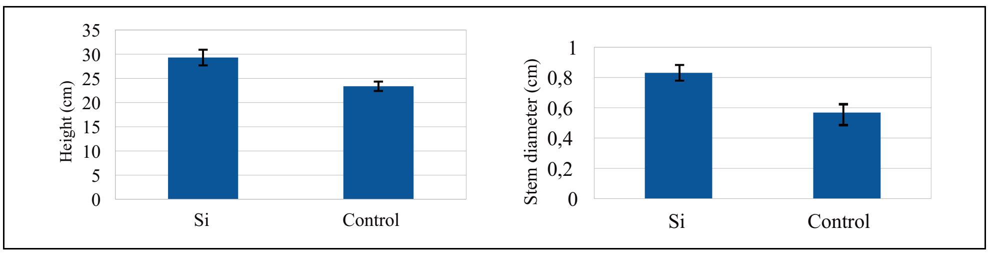

Fig. 1. Effect of foliar applied Si on height and stem diameter of tomato transplants variety Malle. Effects are significant at p < 0.5% T-Test.

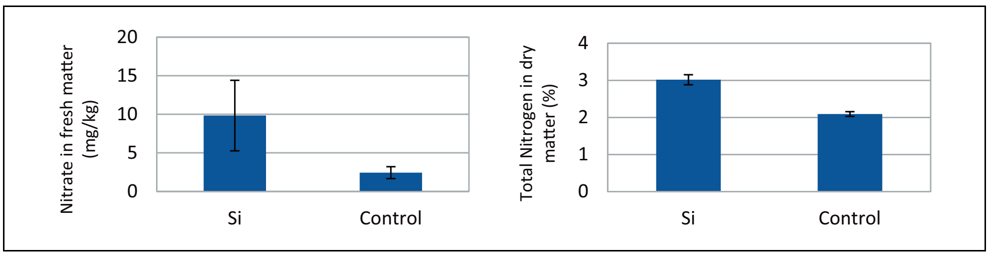

Fig. 2. Effect of foliar applied Si on nitrate and total nitrogen concentration in the fresh matter of tomato transplants variety Malle. Effects are significant at p < 0.5% T-Test.

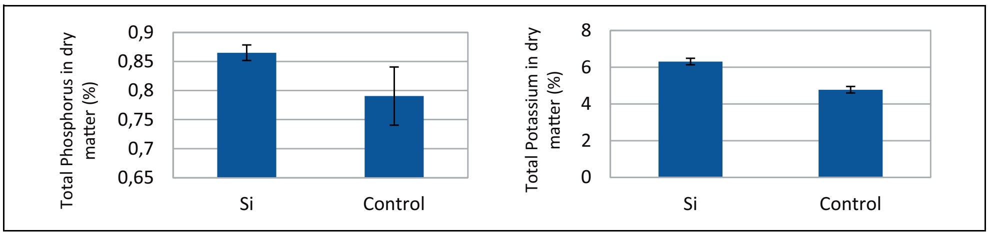

Fig. 3. Effect of foliar applied Si on phosphorus and potassium concentration in dry matter of tomato transplants variety Malle. Effects are significant at p < 0.5% T-Test.

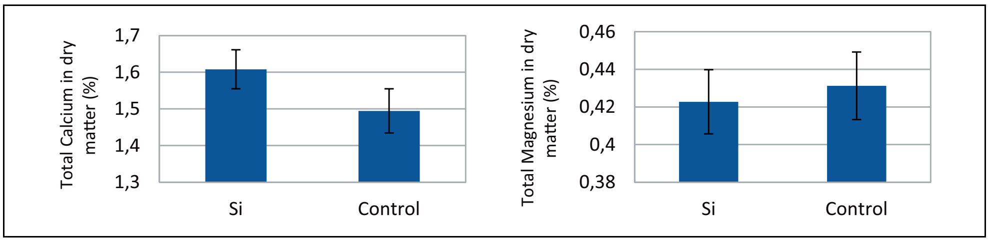

Fig. 4. Effect of foliar applied Si on calcium and magnesium concentration in dry matter of tomato transplants variety Malle. Effects for calcium are significant at p < 0.5% T-Test.

Fig. 5. Effect of 108 g/ha Si applied as aqueous solution (left) on growth and appearance of tomato transplants variety Malle.

growing stages. Similar results are reported for alfalfa by Liu and Guo (2011) and for Ca and K in wheat by Mali and Aery (2008). While Potassium is very important in stomatal function and water relations of plants (Durner, 2013). A higher Ca content is beneficial, suppressing insect and disease attack and increasing transportability and storage quality (Olle, 2013).

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