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# The influence of foliar applied silicic acid on N, P, K, Ca and Mg concentrations in field peas*

Einfluss von blattapplizierter Kieselsäure auf die N, P, K, Ca und Mg Gehalte von Felderbsen

## Abstract

Silicon (Si) is the second most abundant element after oxygen in soil. However, many field studies have shown that supplying crops with extra Si in form of finely dispersed $SiO_2 \cdot n\,H_2O$ (= silicic acid "dissolved" in water) suppresses plant disease, reduces insect attack, improves environmental stress tolerance, and increases crop productivity.

The purpose of this investigation was to look at the influence of foliar applied silicic acid on the chemical content of field peas of variety Mehis. Silicic acid was applied as an aqueous spray applied in different concentrations from the 2–3 true leaf stage at two-week intervals from 21 May to 2 July 2014, in total 108 g $ha^{-1}$ Si. Silicic acid partially improved the quality of field peas of variety Mehis by increasing phosphorus and potassium concentrations in the peas. It is suggested that foliar applied silicic acid may improve root growth through an improved phosphorus supply and also the water status of the plants through an improved potassium supply.

**Key words:** Calcium, magnesium, nitrogen, pea, *Pisum sativum*, phosphorus, potassium, silicic acid

## Zusammenfassung

Silizium (Si) ist nach Sauerstoff das zweithäufigste Element in der Erdkruste. Dennoch belegen viele Feldversuche, dass eine zusätzliche Zufuhr von Si in Form von fein dispersem $SiO_2 \cdot n\,H_2O$ (= in Wasser „gelöster“ Kieselsäure) Pflanzenkrankheiten und Schädlinge unterdrücken und die Wirkung von Umweltstress lindern und die Produktivität von Pflanzen steigern kann. Ziel dieser Untersuchung war es, den Einfluss ballapplizierter Kieselsäure auf die Versorgung von Erbsen der Sorte Mehis mit den Nährstoffen N, P, K, Ca und Mg als möglichen Wirkungspfad zu prüfen. Die Kieselsäure wurde in wässriger Dispersion in unterschiedlichen Konzentrationen zweiwöchentlich beginnend mit dem 2 bis 3-Blattstadium der Pflanzen appliziert. Die Behandlung verbesserte die Qualität der Erbsen und erhöhte deren Gehalte an Phosphor und Kalium. Eine verbesserte Phosphor- und Kaliumversorgung könnte daher eine der Ursachen für positive Wirkungen von Kieselsäureapplikationen sein.

**Stichwörter:** Erbse, Kalium, Kalzium, Kieselsäure, Magnesium, Phosphor, Stickstoff

## Introduction

Silicon (Si) is the second most abundant element after oxygen in soil. Silicon dioxide comprises 50–70% of the soil mass. All plants rooting in soil contain some Si in their cells and tissues (Olle, 2014).

Plant available silicon is often deficient in soils, ground water and the food chain, ultimately affecting animal and human health. It is reported that about 50–300 kg $ha^{-1}$ of silicon is removed each year from arable soils during harvesting, cleaning and processing of crops (Bent, 2014).

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However, many field studies have shown that supplying crops with adequate plant-available Si suppresses plant disease, reduces insect attack, improves environmental stress tolerance, and increases crop productivity (HECKMAN, 2013). Silicon as a bioregulator has a potential to help many crops grow more naturally in conditions of stress. Silicon plays important roles in mitigating both biotic (insects, pests, pathogens) and abiotic (metal, salinity, drought, chilling, freezing) stresses (BENT, 2014; OLLE, 2014). Plants, if Si treated, become stronger, sturdier and naturally more tolerant to dryness and drought, mineral imbalance and extremes of temperature (BENT, 2014). Silicon application could therefore improve crop production under extreme climatic conditions (SCHNUG and FRANCK, 1984; SHAKOOR, 2014). Bioactive silicon claims to help plants to take up more nutrients and utilize water and minerals more efficiently, reducing their requirements for water fertilizers and plant protection chemicals during cultivation (BENT, 2014).

Several reports have reviewed the benefits of silicon application on crop growth, but the mechanisms of silicon action have not been systematically discussed (SCHNUG and FRANCK, 1984; ZHU and GONG, 2014).

As silicon nutrition reverses the succulence induced by high nitrogen and enhances crop growth and yield, silicon fertilizers based on silicate minerals, ashes and slags have come into vogue (OLLE, 2014).

Some results treating pea plants with silicon are available also from previous research. For example silicon treated pea plants showed reduced damage due to infection of *Pisum sativum* seedlings by blight disease (*Mycosphaerella pinoides*). Silicon treatment promotes formation of nodules (for N fixation) in the roots of legumes (BENT, 2014).

The application of stabilized silicic acid is called the ‘silicic acid agro technology’ (SAAT). This technology was developed by Dr. Henk-Maarten Laane (BENT, 2014). SAAT claims to be effective on almost every crop with increases of root system, longer stem/tillers, leaf area and chlorophyll content and nutrient uptake resulting in 15–50% more yield and higher quality (BENT, 2014). SAAT also decreases biotic and abiotic stresses. Due to a (much) lower infection rate, pesticide use can be reduced by (at least) 50%. The product is safe (for the plant, the soil, the farmer and the consumer) and ecologically friendly.

The purpose of this investigation was to look at the influence of silicic acid on the chemical content of field peas of variety Mehis.

## Materials and Methods

The experiment was carried out at the Estonian Crop Research Institute in 2014, in an experimental field geographically located at N 58°769' E 26°400'.

The field pea variety Mehis was used. Seeds were sown on 28 April 2014 and plants were harvested on 6 August 2014. Plot size was 10 m². A completely randomized experimental design was used in 4 replications. Sowing rate was 120 seeds per m² and sowing depth was 4 cm. Plant spacing was 12.5 × 6.7 cm.

A conventional cropping system was used. Ploughing was done in autumn 2013 and soil was cultivated twice before sowing. The preceding crop was winter rye.

Soil humus content was 3.15 g $kg^{-1}$ and pH was 5.76. Soil type was soddy-calcareous podzolic soil, soil texture sandy-clay.

There were two treatments: 1. stabilized silicic acid treatment (AB Yellow, REXIL-AGRO, 2015), 2. untreated control. The silicic acid was applied as an aqueous spray applied from the 2–3 real leaf stage at two-weekly intervals on 21 May, 4 June, 18 June and 2 July 2014. The amounts sprayed were as follows: first spray 1.5 L $ha^{-1}$ silicic acid and 750 L $ha^{-1}$, second 3 L $ha^{-1}$ silicic acid and 1500 L $ha^{-1}$ water, third 4.5 L $ha^{-1}$ silicic acid and 2250 L $ha^{-1}$ water, fourth 4.5 L $ha^{-1}$ silicic acid and 2250 L $ha^{-1}$ water. In total an amount of 108 g $ha^{-1}$ Si was applied. The water used was demineralised with a neutral pH; the pH of the spray solution was 5.5. Control plants were untreated. Fertilization was done before sowing with Yara Mila 7–12–25 (300 kg $ha^{-1}$). Weeds were controlled with Activus 330 EC (pendimethalin) 1.5 l $ha^{-1}$ + Basagran 480 (bentazone) 1.5 l $ha^{-1}$, 21.05.2014. No pest or disease control chemicals were used.

The disease ascochyta blight (*Ascochyta* spp.) was present at a low level. Disease damage was assessed at plant development stage 224–240 (decimal code for the growth stages for pea by UPOV – International Union for the Protection of New Varieties of Plants). In late growth phases attack by pea weevils was also seen (*Sitona* spp.).

Weather conditions are sown in Fig. 1. Seeds emerged slowly due to the cold spring, which was 3–4 $^0$C colder than normal at the end of June. Summer was close to the local average with a mean temperature around 18$^0$C in July. Precipitation was more than usual, although quite dry in July, but despite this plants grew well.

The samples for chemical analyses were taken from already dried peas in the autumn of 2014. The contents of nitrogen, phosphorus, potassium, calcium and magnesium were determined. Nitrogen content was determined according to the Copper Catalyst Kjeldahl Method (984.13). Phosporus determination was carried through in Kjeldahl Digest by Fiastar 5000 (AN 5242; Stannous Chloride method, ISO/FDIS 15681). Potassium determination was by the Flame Photometric Method (956.01). Calcium determination was by the o-Cresolphthalein Complexone method (ISO 3696, in Kjeldahl Digest by Fiastar 5000). Magnesium determination was by Fiastar 5000 (ASTN90/92; Titan Yellow method). Analyses of variance were carried out on the data obtained using the program Excel.

## Results

Treatment with silicic acid partially improved the quality of field peas, variety Mehis, in terms of nutrient concen-

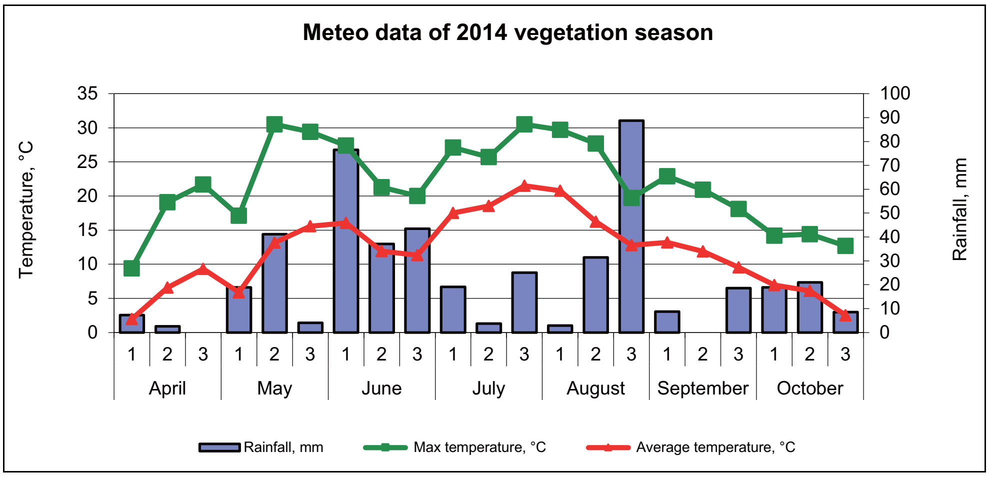

**Fig. 1.** Weather conditions during the field pea vegetation period in 2014 according to Jõgeva Meteorological Station.

tration. The content of phosphorus in field pea dry matter was significantly higher (5.4%) in the silicic acid treatment than in the control treatment (Tab. 1). The content of potassium in field pea dry matter was significantly higher (5.7%) in the silicic acid treatment than in the control treatment (Tab. 1). However, the content of nitrogen, calcium and magnesium in the field pea dry matter did not differ significantly between treatments (Tab. 1).

## Discussion

Treatment with silicon has been reported to increase nutrient uptake generally (Bent, 2014). However, in the present investigation Phosphorus and Potassium contents were increased by treating pea plants with silicic acid solution compared to the untreated control. At the same time Phosphorus is needed especially for good root growth (Durner, 2013). Potassium is very important in stomatal function and water relations of plants (Durner, 2013). The contents of Nitrogen, Calcium and Magnesium in field pea dry matter were not significantly increased by Si treatment in our experiment. This was probably due to unfavourable growing conditions in spring. It is very important that plants establish well in their initial growth phases in order to get normal growth thereafter. Pea seed germination in spring 2014 was slow (18 days), resulting in poorly developed small plants for silicic acid treatment. Later plant quality can also be negatively influenced by poor early development. It is very important to point out that the weather conditions were bad before the silicic acid treatment.

**Tab. 1. The contents (%) of nitrogen, phosphorus, potassium, calcium and magnesium in dried peas treated with foliar applied silicic acid**

| Nutrient | Treatment | | p |
|---|---|---|---|
| | Silicic acid | Control | |
| N% | 4.16 | 4.07 | 0.592 |
| P% | 0.624 | 0.590 | < 0.001 |
| K% | 0.944 | 0.891 | 0.025 |
| Ca% | 0.156 | 0.156 | 0.869 |
| Mg% | 0.132 | 0.133 | 0.882 |

Silicon additions to potted alfalfa plants have increased shoot Phosphorus content (Liu and Guo, 2011) and increased Calcium and Potassium contents in wheat (Mali and Aery, 2008). Similarly Bent (2014) reported that silicon increased the content of minerals in plants. These results are contrary to our results, but this may be due to our weather conditions. A higher Ca content is beneficial, suppressing insect and disease attack and increasing transportability and storage quality (Olle, 2013). A higher Mg content reduces the incidence of insect pests and diseases (Cakmak, 2013).

## Conclusions

Silicic acid partially improved the quality of field peas of variety Mehis: the content of Phosphorus and Potassium in field pea dry matter was higher in the silicic acid treatment than in the control treatment. The content of Nitrogen, Calcium and Magnesium in field pea dry matter did not differ significantly between treatments.

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