

UC Davis

The Proceedings of the International Plant Nutrition Colloquium XVI

Title

Chloride improves fruit yield and quality of strawberry (*Fragaria* × *ananassa* Duch.)

Permalink

<https://escholarship.org/uc/item/9ck8q8n2>

Authors

Bellof, Svenja
Schubert, Sven

Publication Date

2009-03-16

Peer reviewed

Introduction

Chlorine has been known as an essential plant nutrient since 1954 (Broyer et al. 1954) and fulfills several important functions in plant growth and photosynthesis. Chloride has osmotic functions (Clarkson and Hanson 1980) and stimulates the tonoplast H^+ -ATPase (Churchill and Sze 1984), thus playing an important role in cell elongation. In photosystem II, chloride binds to positive binding sites, thus organizing the protein surface and enabling the catalytic mechanism (Coleman and Govindjee 1987, Homann 1988). Nevertheless, strawberry is characterized as a chloride-sensitive species with a toxicity threshold at a chloride concentration of 1% of leaf dry weight and an EC value of the soil solution of 2 dS m^{-1} (Martínez Barroso and Alvarez 1997).

Hypotheses

Due to the role of chloride in photosynthesis and cell elongation a moderate chloride nutrition improves the yield of strawberry. As an anion, chloride competes with organic anions in phloem transport. Thus moderate chloride nutrition leads to a reduced acid concentration in strawberry fruits.

Materials and Methods

In order to investigate these hypotheses two experiments were conducted. In the first experiment, strawberry plants were raised in small Mitscherlich pots with one plant per pot containing 3 kg soil and 3 kg sand each, soil pH was adjusted to 5.9 with CaCO_3 . Macronutrient fertilization was carried out with 5.48 g NH_4NO_3 , 4.64 g $\text{CaHPO}_4 \times 2 \text{ H}_2\text{O}$, and 1.62 g $\text{MgSO}_4 \times 7 \text{ H}_2\text{O}$ per pot. Potassium was applied in seven different treatments with 0, 0.5, 1.0, or 2.0 g K per plant, given either as KCl or K_2SO_4 .

In the second experiment, strawberry plants of cv. Elsanta were raised as described for the first experiment, but K fertilization was carried out in seven different treatments with 0, 0.25, 0.5, or 1.0 g K per plant, given either as KCl or K_2SO_4 . In addition to the macronutrient fertilization all plants were fertilized with micronutrients resulting in 5 mg Cu, 20 mg Zn, 6 mg B, 10 mg Mn, and 0.26 mg Mo per plant.

In both experiments, each treatment was carried out with ten replicates. After fruit harvest, number of fruits per plant, single fruit weight, fruit yield, shoot fresh and dry weight, nutrient concentrations of shoots and fruits, as well as titratable acid, glucose, fructose, and sucrose concentrations of the fruits were analyzed.

Arithmetic means and standard errors were calculated using excel, ANOVA ($P = 5\%$) and Bonferroni Multiple Comparisons were carried out using SPSS.

Results and Discussion

In the first experiment, chloride nutrition had a positive effect on the number of fruits per plant, resulting in a higher fruit yield (Tab. 1). Single fruit weight was not affected by chloride nutrition. Fruit quality was also improved by chloride nutrition regarding glucose, fructose, and sucrose concentrations (Tab. 1). As the chloride concentration of the soil was sufficient at a micronutrient level the plants of the K_2SO_4 treatments were also supplied with chloride. The question arises why additional chloride nutrition had a positive effect on fruit yield and quality.

Table 1: Results of the first experiment. Arithmetic means and standard errors of number of fruits per plant, fruit yield, as well as glucose, fructose, and sucrose concentrations of strawberry fruits in relation to type (K_2SO_4 , KCl) and amount of K-fertilizer (0 - 1 g K / plant). None of the treatments received any additional micronutrient fertilization.

	0 g K plant ⁻¹ control	0,5 g K plant ⁻¹ K ₂ SO ₄ KCl	1 g K plant ⁻¹ K ₂ SO ₄ KCl	2 g K plant ⁻¹ K ₂ SO ₄ KCl
fruits plant ⁻¹	24,67 ± 1,49	30,40 ± 3,04	38,80 ± 2,78	25,40 ± 2,00 28,90 ± 2,42
fruit yield plant ⁻¹ (g)	369,30 ± 17,90	441,38 ± 36,21	526,73 ± 26,60	381,79 ± 34,32 421,44 ± 24,66
glucose (mg (g DW) ⁻¹)	56,71 ± 4,19	89,18 ± 4,39	96,48 ± 3,68	98,25 ± 2,61 105,08 ± 4,30
fructose (mg (g DW) ⁻¹)	108,44 ± 4,93	117,39 ± 4,49	122,36 ± 3,11	123,93 ± 3,93 124,34 ± 4,90
sucrose (mg (g DW) ⁻¹)	21,61 ± 5,96	32,69 ± 4,14	47,22 ± 5,79	56,01 ± 5,37 44,64 ± 8,81
				62,45 ± 6,39 79,81 ± 7,90

In the second experiment in which plants were supplementarily fertilized with micronutrients Cu, Zn, B, Mn, and Mo, the KCl and K_2SO_4 treatments did not differ in number of fruits and fruit yield (Fig. 1 A). Glucose, fructose, and saccharose concentration (Fig. 2) as well as titratable acid concentration were not affected by chloride fertilization. Thus fruit yield and quality of strawberry fruits were not improved by chloride fertilization when additional micronutrient fertilization was applied. But plants of KCl and K_2SO_4 treatments differed in Mn concentration in the shoot, the Mn concentration of the KCl treatment at the highest K-level being significantly higher than the Mn concentration of the K_2SO_4 treatment (Fig. 1 B).

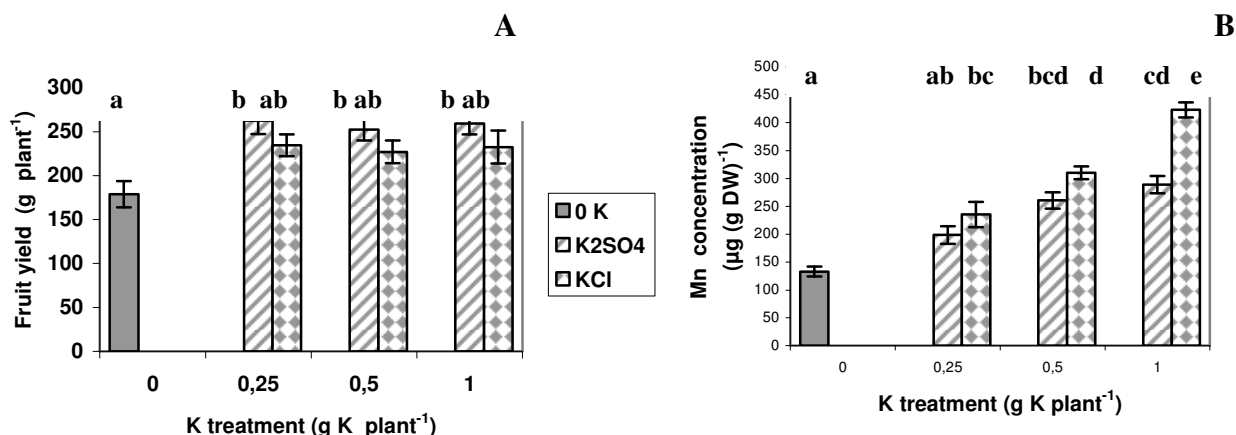


Figure 1: Fruit yield of strawberry plants (A) and Mn concentration of shoots of strawberry plants (B), both in relation to type (K_2SO_4 , KCl) and amount of K-fertilizer (0 - 1 g K / plant). Columns show the arithmetic mean of each treatment including standard error. Values marked with the same letter (a or b) do not differ significantly according to Bonferroni-Test ($P = 5\%$).

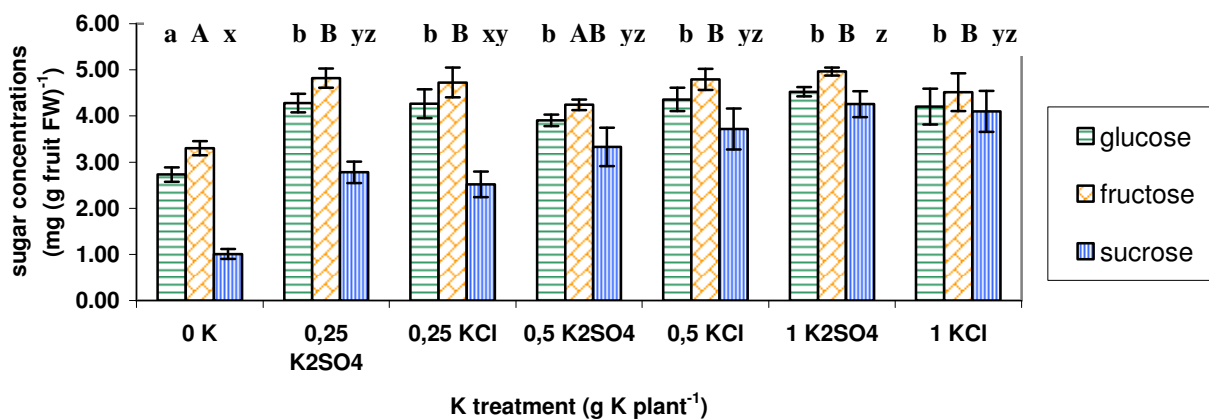


Figure 2: Glucose, fructose, and saccharose concentration of strawberry fruits in relation to type (K_2SO_4 , KCl) and amount of K fertilizer (0 - 1 g K / plant). Columns show arithmetic means of each treatment including standard errors. Values marked with the same letter (glucose a or b, fructose A or B, saccharose x, y or z) do not differ significantly according to Bonferroni-Test ($P = 5\%$).

These results indicate that chloride fertilization improves Mn availability in the soil or has a positive effect on Mn uptake by the plant. Strawberry plants in the first experiment were obviously not supplied sufficiently with Mn. While Mn availability or uptake was improved in the KCl treatments, the plants of the K_2SO_4 treatments were lacking Mn resulting in lower number of fruits and poor fruit quality. In the second experiment, Mn availability was improved by additional Mn fertilization. Thus the plants of both fertilizer treatments were supplied with sufficient amounts of Mn, resulting in equal fruit yield and quality.

Conclusions

Chloride fertilization can compensate insufficient Mn supply by either improving Mn availability in the soil or Mn uptake of the plant. Thus chloride fertilization even of chloride-sensitive cultivars can improve yield and fruit quality. The mechanisms of these processes remain to be elucidated.

References

- Broyer TC, Carlton AB, Johnson CM and Stout PR, Chlorine - a micronutrient element for higher plants. *Plant Physiol.* 1954; 29: 526-532
- Churchill KA, Sze H, Anion-sensitive, H^+ -pumping ATPase of oat roots. Direct effects of Cl^- , NO_3^- , and a disulfonic stilbene. *Plant Physiol.* 1984; 76: 490-497
- Clarkson DT, Hanson JB, The mineral nutrition of higher plants. *Annu. Rev. Plant Physiol.* 1980; 31: 239-298
- Coleman WJ, Govindjee, A model for the mechanism of chloride activation of oxygen evolution in photosystem II. *Photosynth. Res.* 1987; 13: 199-223
- Homann PH, Structural effects of Cl^- and other anions on the water oxidizing complex of chloroplast photosystem II. *Plant Physiol.* 1988; 88: 194-199
- Martínez Barroso MC, Alvarez CE, Toxicity symptoms and tolerance of strawberry to salinity in the irrigation water. *Sci. Hort.* 1997; 71: 177-188