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Potassium Sulfate as a Key to Crop Quality

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4R Nutrient Stewardship

Right time
Right place
Right rate
Right source

4Rs
Chloride is a micronutrient

Minimum required: 1 g/kg $^{-1}$ DM (White and Broadley, 2011; Marschner, 1995).

But according to:
- Amount present on soils
- Sensitivity of the crop, its presence may be harmful.
“Salinity reduces water availability in the soil and affects stomatal conductance” (Berry 2010).

Excessive concentration of chlorine in the root zone may cause osmotic stress by low water availability (Lamond & Leikam 2002; Marschner 2012).

Source: Berry 2010
High Cl in the cytoplasm may shift other ions from the binding site of enzymes compromising the cellular functioning (George et al. 2012).

Source: Alberts et al. 2002; NCBI n.d.
Chloride sensitive crops

- May interfere with
  - translocation and accumulation of assimilates
  - synthesis of chlorophyll
  - photosynthesis (Beckerman and Lerner, 2015)
  - uptake of other nutrients (George et al. 2012).

Chlorophyll a
Reaction to Cl accumulation varies according to the plant species (Bernstein, 1965).

In saline sensitive plants, even low concentrations of salt may limit growth and produce leaf necrosis (Skykes, 1992; Maas 1993; George et al. 2012).

This kind of response is divided into four categories

- “chloride loving”
- “chloride tolerant”
- “partly chloride tolerant”
- “chloride sensitive” crops.
<table>
<thead>
<tr>
<th>Classification</th>
<th>Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride - loving:</td>
<td>Coconut, celery, sugar beet, Swiss chard</td>
</tr>
<tr>
<td></td>
<td>and fodder beet</td>
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<tr>
<td>Chloride based fertilisers are preferred</td>
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Chloride tolerance of various crops

K+S KALI GmbH
Chloride tolerance of various crops

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<tr>
<td>Chloride tolerant:</td>
<td>Cereals, maize, oilseed rape</td>
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Chloride based fertilisers can be used but most vegetables prefer sulphate based fertilisers because of their sulphur demand.
### Chloride tolerance of various crops

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<td>Partly chloride tolerant:</td>
<td>Sunflower, stone fruits, grape vines</td>
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Chloride based fertilisers can be used if they are applied on time before the start of vegetative growth.
# Chloride tolerance of various crops

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<td>Partly chloride tolerant:</td>
<td>Pineapple, coffee and tomatoes</td>
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# Chloride tolerance of various crops

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<tr>
<td>Chloride sensitive:</td>
<td>Starch potatoes, potatoes for processing,</td>
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<td></td>
<td>citrus, pomes and fruit stones (especially</td>
</tr>
<tr>
<td></td>
<td>cherries)</td>
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<tr>
<td>Only fertilisers</td>
<td>Only fertilisers containing potassium in</td>
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<td>containing potassium</td>
<td>the form of sulphate should be used</td>
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<tr>
<td>Chloride sensitive:</td>
<td>Berries, tobacco and all crops under glass</td>
</tr>
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</table>

Only fertilisers containing potassium in the form of sulphate should be used.
PINEAPPLE
K+S Group

Role and quantity of K demanded in pineapple

Positive effects for plant growth

Increases fruit yield and improves fruit quality

Boosts the synthesis of sugars and acids (Lacoeuilhe 1978, 1984; Teixeira et al. 2011)

Increases total acidity → Prevents internal browning during storage at chilling temperatures (Marchal et al. 1981)

Fosters the formation of ascorbic acid → fruit color of the pulp is intensified (SOPIB 2015)

K required by pineapple increases the N demanded (SOPIB 2015)
Effect of replacement of potassium chloride by potassium sulphate on size, weight and quality aspects of pineapple

* Significant differences (Duncan test α= 5%)

Dry matter mass of pineapple plants as affected by leaf chloride content resulting when KCl is applied at a rate of 700 kg K$_2$O ha$^{-1}$.

Significant at P<0.01

Y = 472.72 - 17.3 X

R$^2 = 0.53$

(Ref. Teixeira, L.A.J, Quaggio, J.A. and E.V.Mellis, 2011)
Fruit yield as influenced by rates and sources of potassium

MOP: $Y = 51.18 + 3.44 \times 10^{-2} \, \dagger \, X - 2.98 \times 10^{-5} \, \dagger \, X^2 \quad R^2 = 0.53$

SOP: $Y = 52.48 + 2.01 \times 10^{-2} \, \dagger \, X \quad R^2 = 0.64$

SOP + MOP: $Y = 52.48 + 1.64 \times 10^{-2} \, \dagger \, X \quad R^2 = 0.73$

†, ‡ significant at $P<0.05$ and $P<0.01$, respectively

(Rezaei, L.A.J, Quaggio, J.A. and E.V. Mellis, 2011)
POTATO
Potassium is crucial for high potato yield and the risk management in unfavorable conditions such as drought.

Potassium decreases the incidence of discolorations such as internal blackening and blackspot.

Increases citric acid, vitamin C of the tuber.

Potassium decreases reducing sugar content → important for processing.

An optimum supply of potassium improves harvest and storage characteristics. This results in a reduced susceptibility to bruising.

Increases starch content of the tuber.
Factors influencing black spot incidence of potato tubers

Cultivation:
- Site
- Fertilisation
- Water supply

Variety

Harvest conditions

Post harvest treatment

Storage conditions

Ripeness of tubers

In the tuber:
- Free phenolic amino acids
- Organic acids (pH)
- Other phenolic compounds
- Enzyme activities
- Mineral nutrients (K, Ca, Fe, Mg)

(after Pawelzik, Delgado 1999)
Effect of K Supply on Black Spot of Potato at Harvest and after 3 and 6 Months in Storage

(Mochełek, Poland, 2001/2002 + 2003/2004, n = 6)
Effect of the K source on potato tuber yield in India

Source: Bansal, 2003
Role of K in citrus

- Increases water use efficiency under saline conditions
- Involved in the production and transport of sugar, starch and protein
- Synthesis Vitamin C (influenced by sugar metabolism)
- Improves fruit size and yield
- Increases content of juice in fruit
- Enhances coloration of fruits
Effect Influence of SOP supply on water use efficiency of citrus tress under saline conditions in Turkey

Source: Marchand 2007

Citrus: water use efficiency

Potassium application (g/tree)

Water use efficiency

Troyer citrange

Poncirus trifoliata

- Fresh water
- 3.5 dS/m
- 6.5 dS/m

Source: Marchand 2007
Effect of foliar K fertilization on color of citrus clementine var. *Cadoux* (low density, 6 x 3.5 m)

Control

5% - KNO₃ x 2

5% - KNO₃ x 3

8% - KNO₃ x 2

8% - KNO₃ x 3

2.5% - K₂SO₄ x 2

2.5% - K₂SO₄ x 3

4% - K₂SO₄ x 2

4% - K₂SO₄ x 3

Source: Hamza et al. 2012
Effect of potassium source on fruit yield

Source: Hamza et al. 2012
Citrus: total soluble sugars (TSS)

Effect of potassium source on total soluble sugars content (TSS)

Source: Hamza et al. 2012
Conclusions

- For Cl sensitive crops the application the form of K applied plays an important role both for yield and especially quality.
- S as an essential nutrient has an additional yield effect under conditions of low S supply.
- Under saline conditions chlorine free forms of Potassium can help to mitigate the unfavourable growth conditions.
- The fourth “R” (right form) needs more attention in sophisticated fertilizer management systems.
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