K+S KALI GmbH

IPNI Frontiers of Potassium Conference

Potassium Sulfate as a Key to Crop Quality

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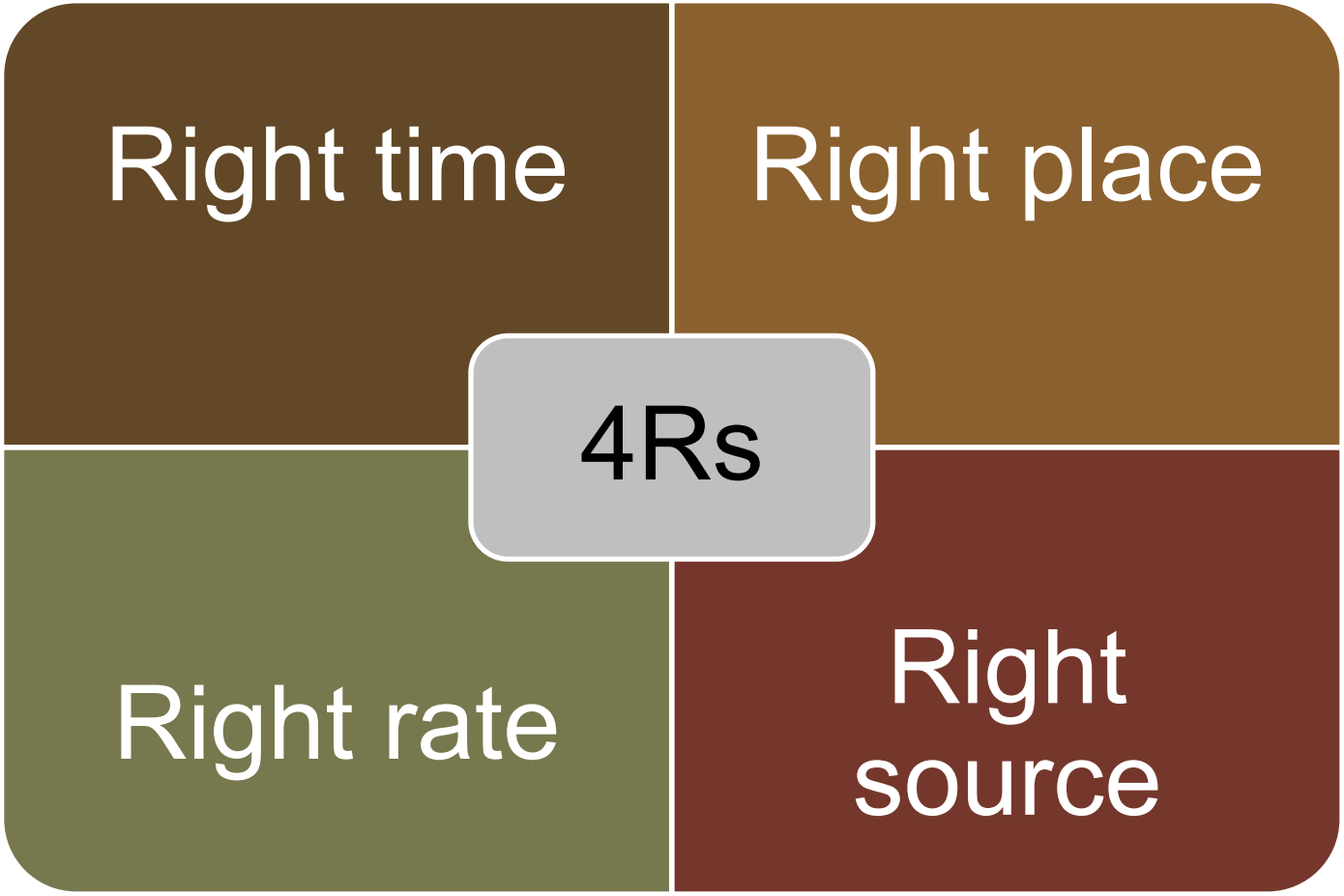
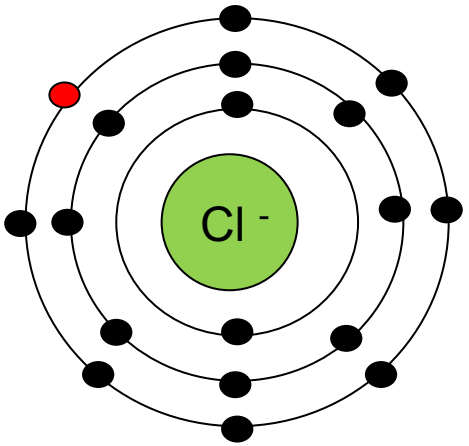
4R Nutrient Stewardship



Chloride sensitive crops

Chloride

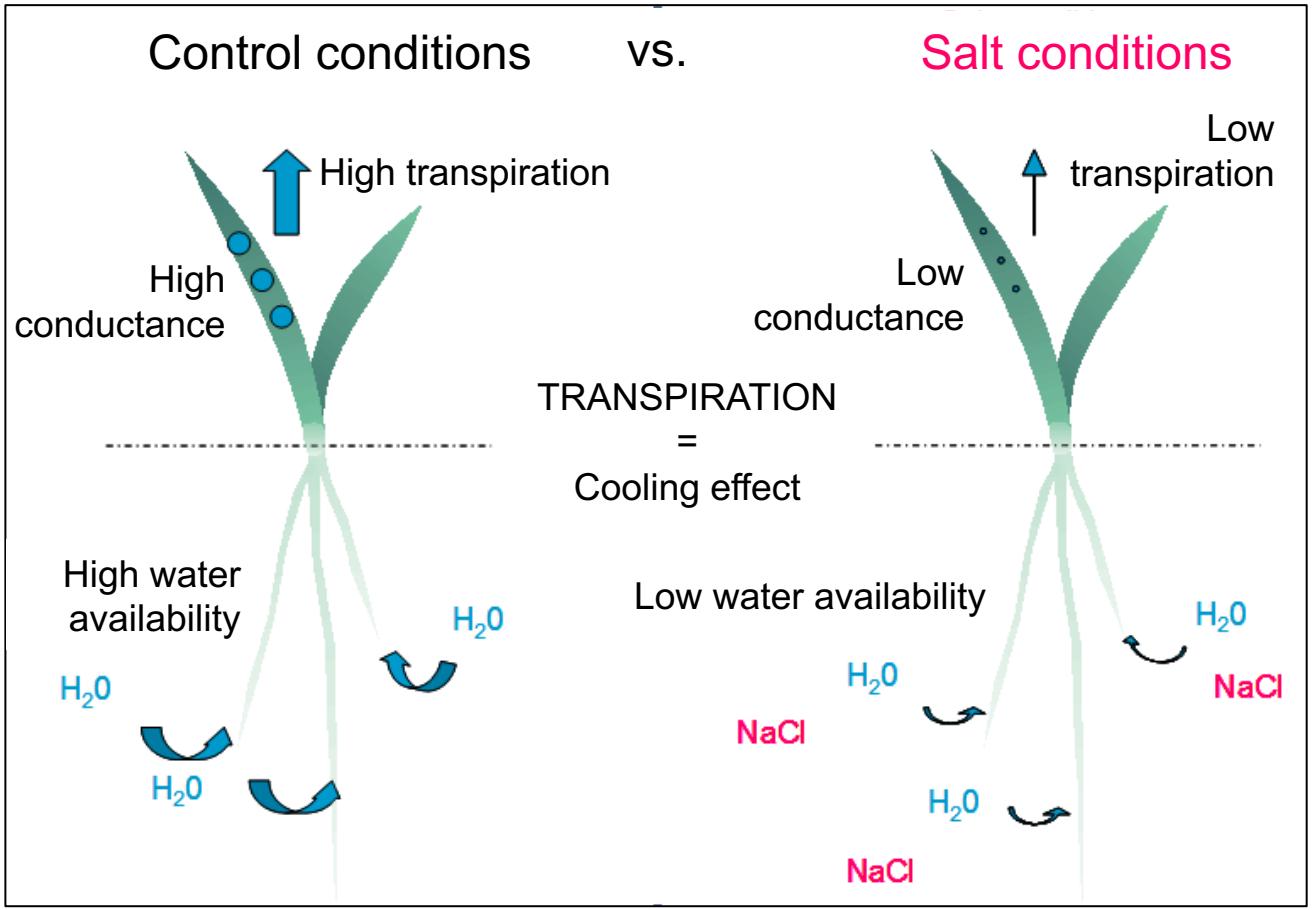
- Chloride is a micronutrient
- Minimum required: 1 g/kg $^{-1}$ DM (White and Broadley, 20111, Marschner, 1995).
- But….according to
  - Amount present on soils
  - Sensitivity of the crop, its presence may be harmful.



Chloride sensitive crops

Chloride

- “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).

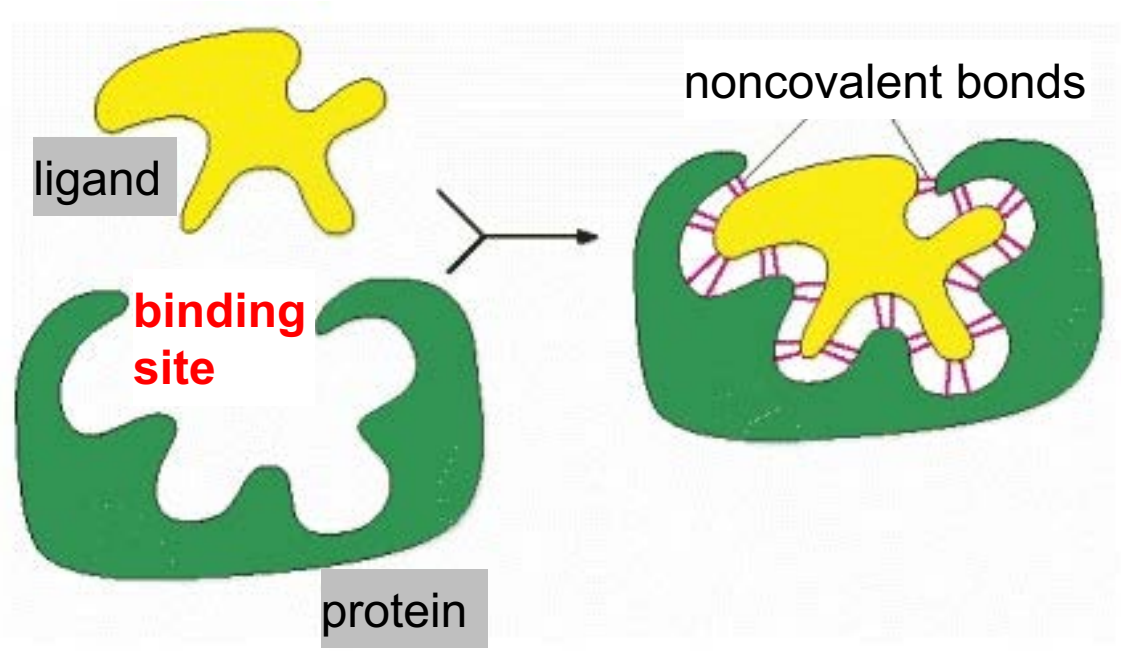


Source: Berry 2010

Chloride sensitive crops

Chloride

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

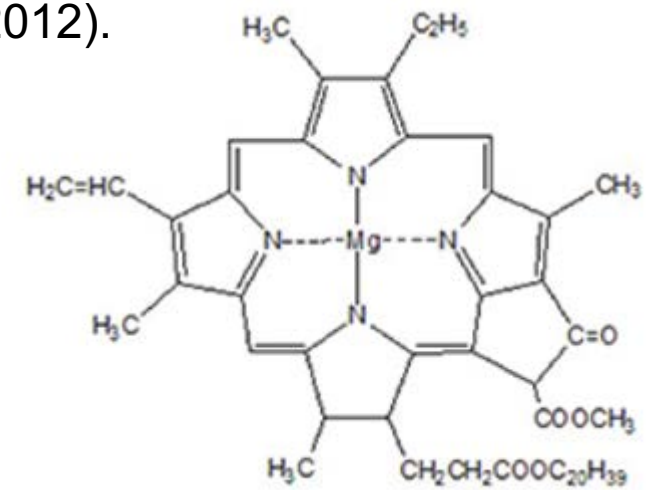


Source: Alberts et al. 2002; NCBI n.d

Chloride sensitive crops

Chloride

- 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

Chloride sensitive crops

Chloride

- 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.

Chloride tolerance of various crops

Classification	Crop
Chloride - loving:	Coconut, celery, sugar beet, Swiss chard and fodder beet
Chloride based fertilisers are preferred	

Chloride tolerance of various crops

Classification	Crop
Chloride tolerant:	Cereals, maize, oilseed rape
Chloride based fertilisers can be used but most vegetables prefer sulphate based fertilisers because of their sulphur demand.	

Chloride tolerance of various crops

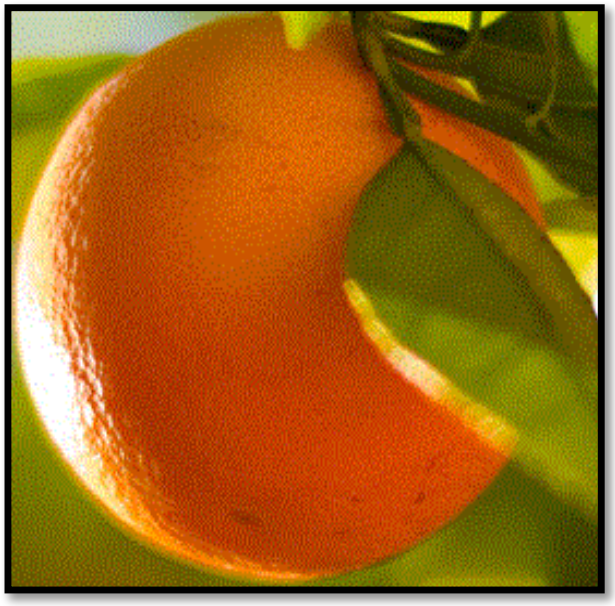
Classification	Crop
Partly chloride tolerant:	Sunflower, stone fruits, grape vines
Chloride based fertilisers can be used if they are applied on time before the start of vegetative growth.	

Chloride tolerance of various crops

Classification	Crop
Partly chloride tolerant:	Pineapple, coffee and tomatoes
Chloride based fertilisers can be used if they are applied on time before the start of vegetative growth.	

Chloride tolerance of various crops

Classification	Crop
Chloride sensitive: Only fertilisers containing potassium in the form of sulphate should be used	Starch potatoes, potatoes for processing, citrus, pomes and fruit stones (especially cherries)



Chloride tolerance of various crops

Classification	Crop
Chloride sensitive: Only fertilisers containing potassium in the form of sulphate should be used	Berries, tobacco and all crops under glass

PINEAPPLE

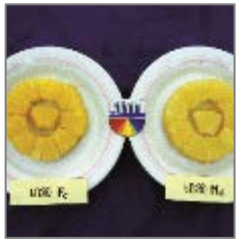
Role and quantitity of K demanded in pineapple

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)

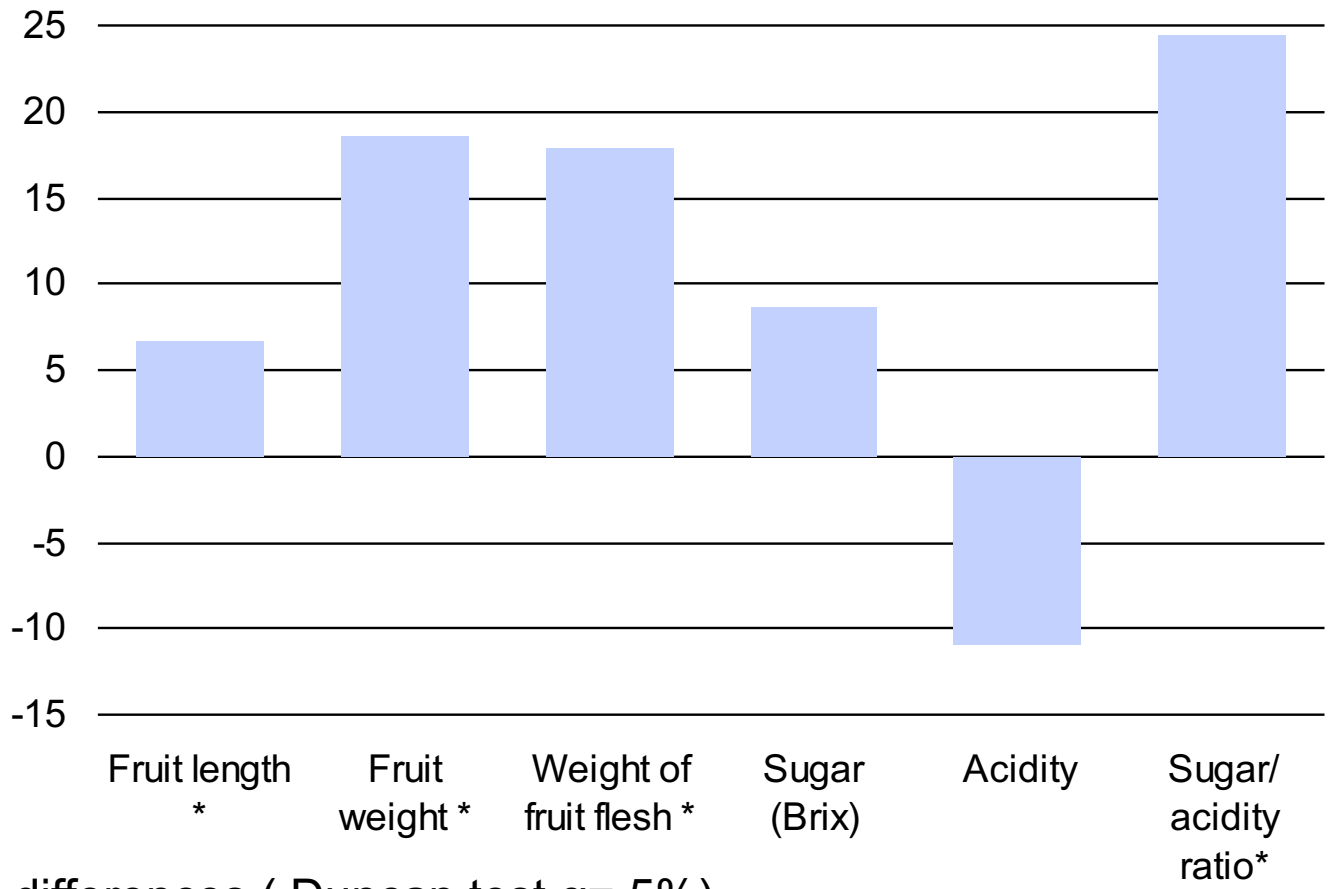


Fosters the formation of ascorbic acid → fruit color of the pulp is intensified (SOPIB 2015)

K required by pineapple increases the N demanded (SOPIB 2015)

Pineapple: quality parameters

Effect of replacement of potassium chloride by potassium sulphate on size, weight and quality aspects of pineapple

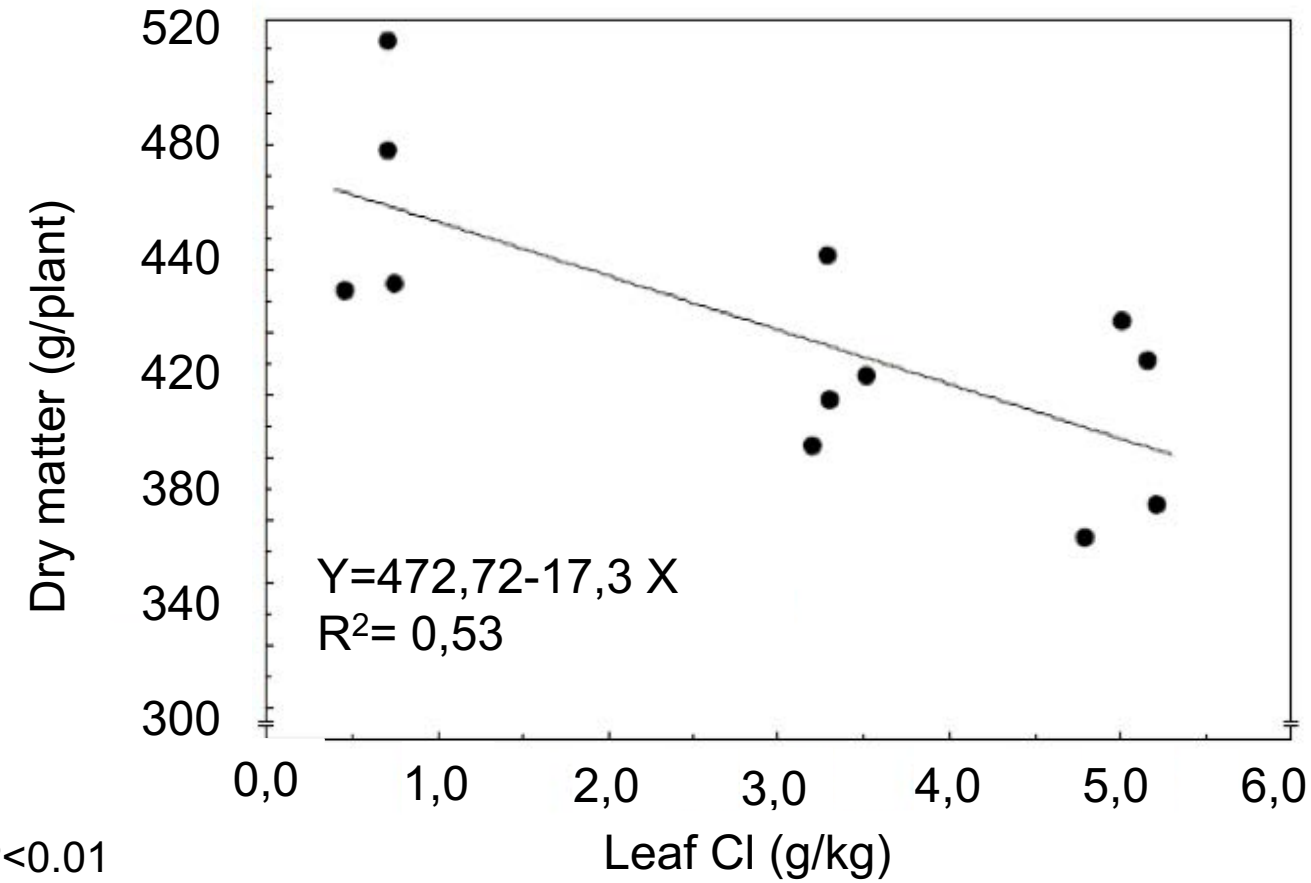


* Significant differences (Duncan test α= 5%)

Source: K+S KALI GmbH, 2014. After Manica et al., 1984.

Pineapple: dry matter

Dry matter mass of pineapple plants as affected by leaf chloride content resulting when KCL is applied at a rate of 700 kg K_2O ha^{-1}

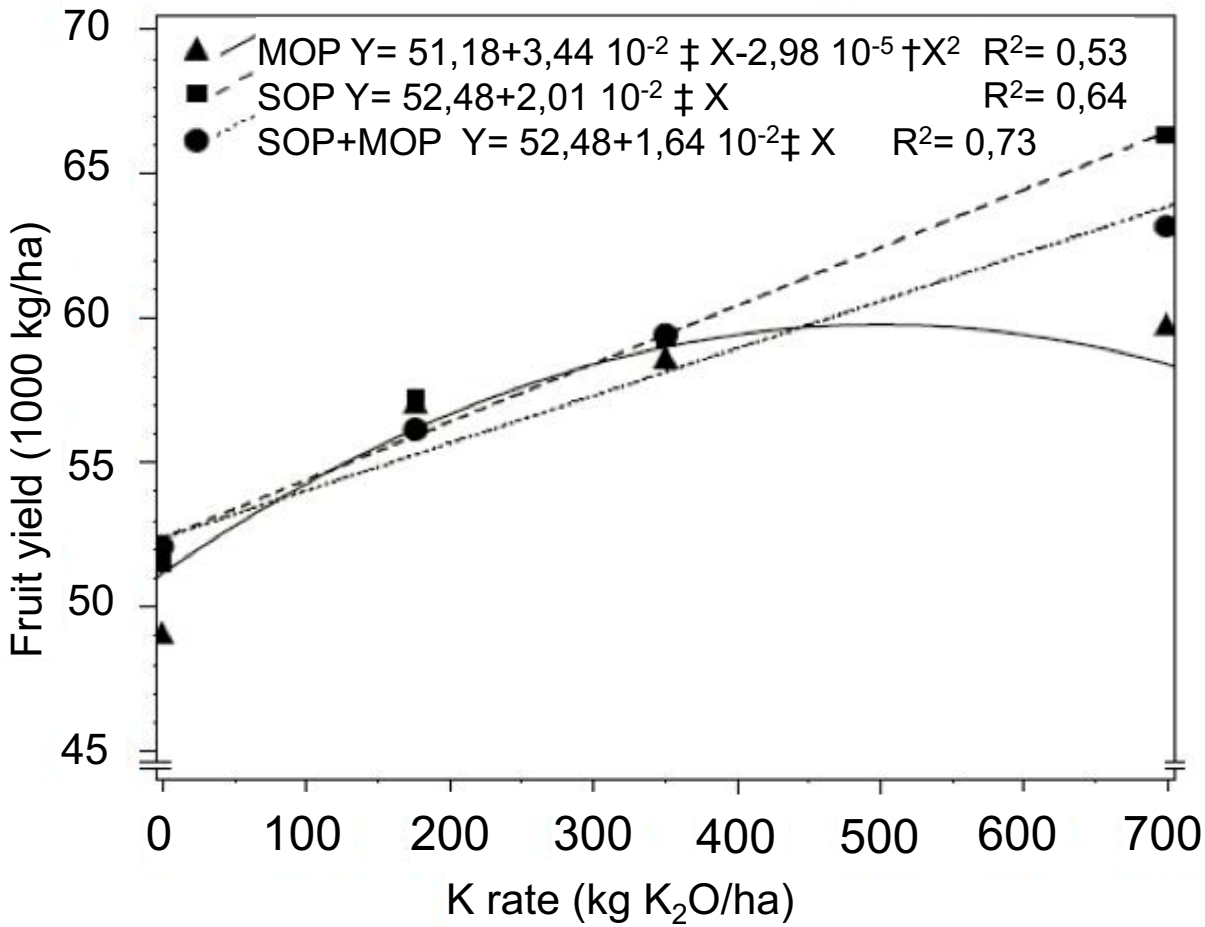


Significant at P<0.01

(Teixeira, L.A.J, Quaggio, J.A. and E.V.Mellis, 2011)

Pineapple: fruit yield

Fruit yield as influenced by rates and sources of potassium



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

(Teixeira, L.A.J, Quaggio, J.A. and E.V.Mellis, 2011)

POTATO

Role of K in potato

Potassium is crucial for high potato yield and the **risk management** in unfavorable conditions such as drought.

Potassium decreases **reducing sugar** content → important for processing

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

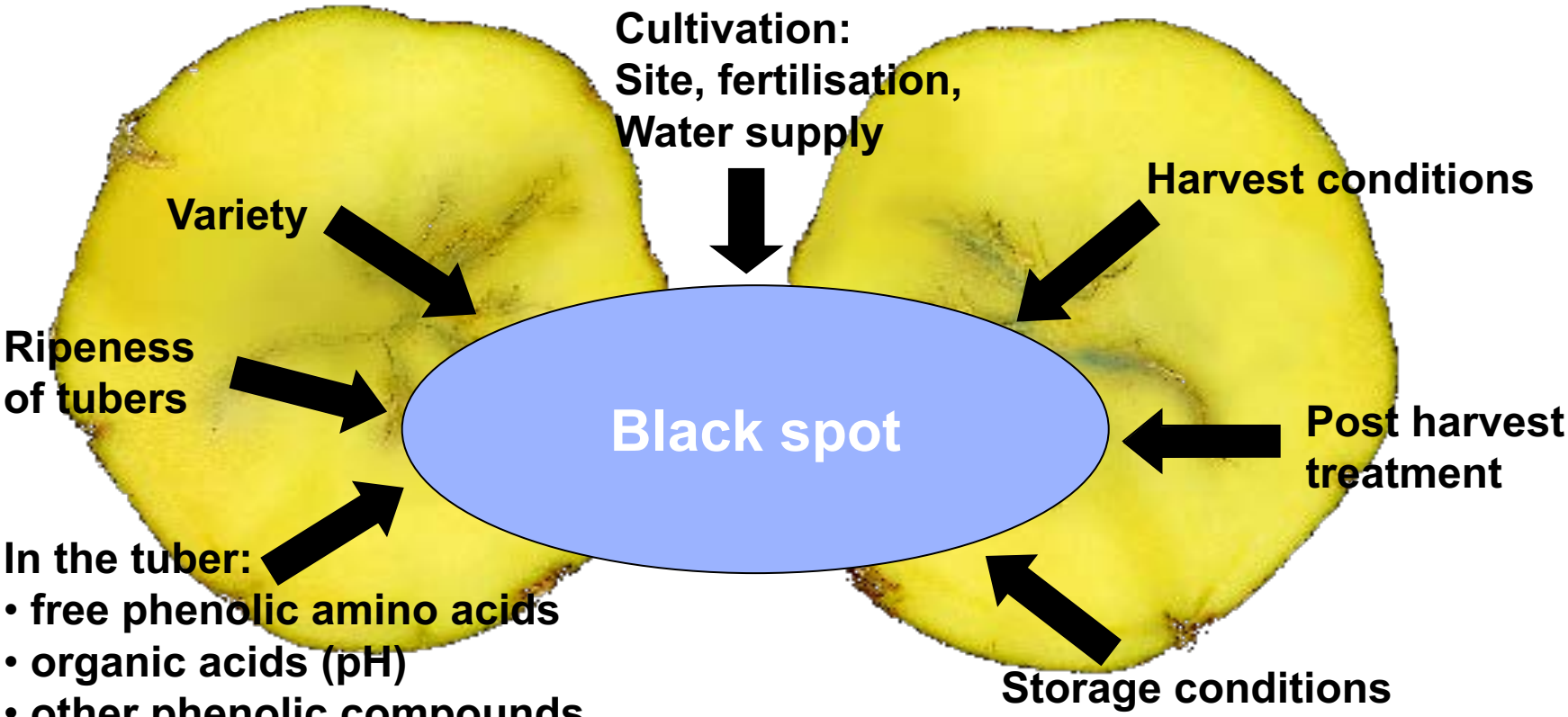
An optimum supply of **potassium** improves harvest and storage characteristics. This results in a reduced susceptibility to bruising

Increases citric acid, vitamin C of the tuber

Increases **starch content** of the tuber

Potato: black spot

Factors influencing black spot incidence of potato tubers



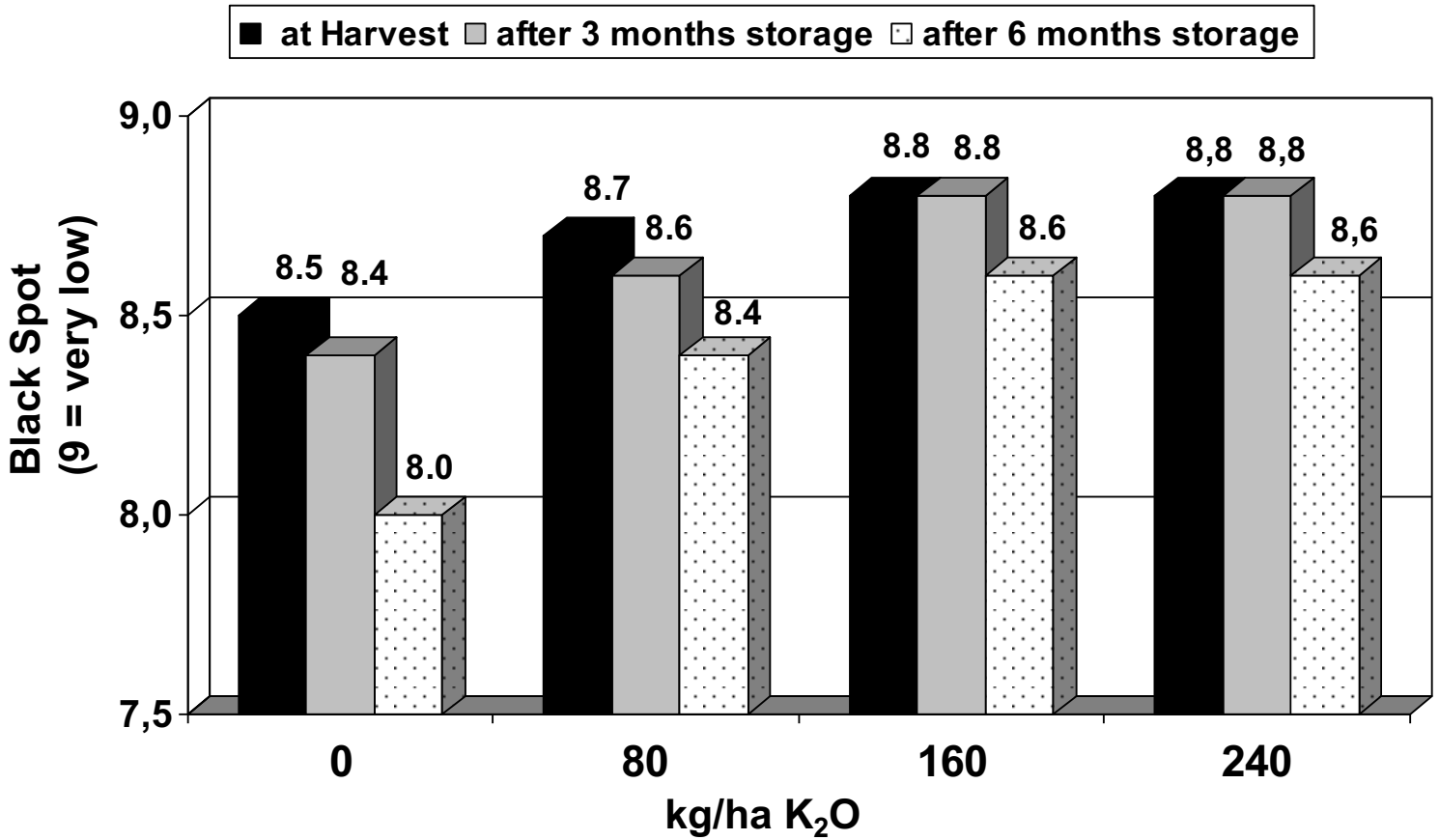
In the tuber:
- free phenolic amino acids
- organic acids (pH)
- other phenolic compounds
- enzyme activities

Mineral nutrients (K, Ca, Fe, Mg)

(after Pawelzik, Delgado 1999)

Potato: black spot

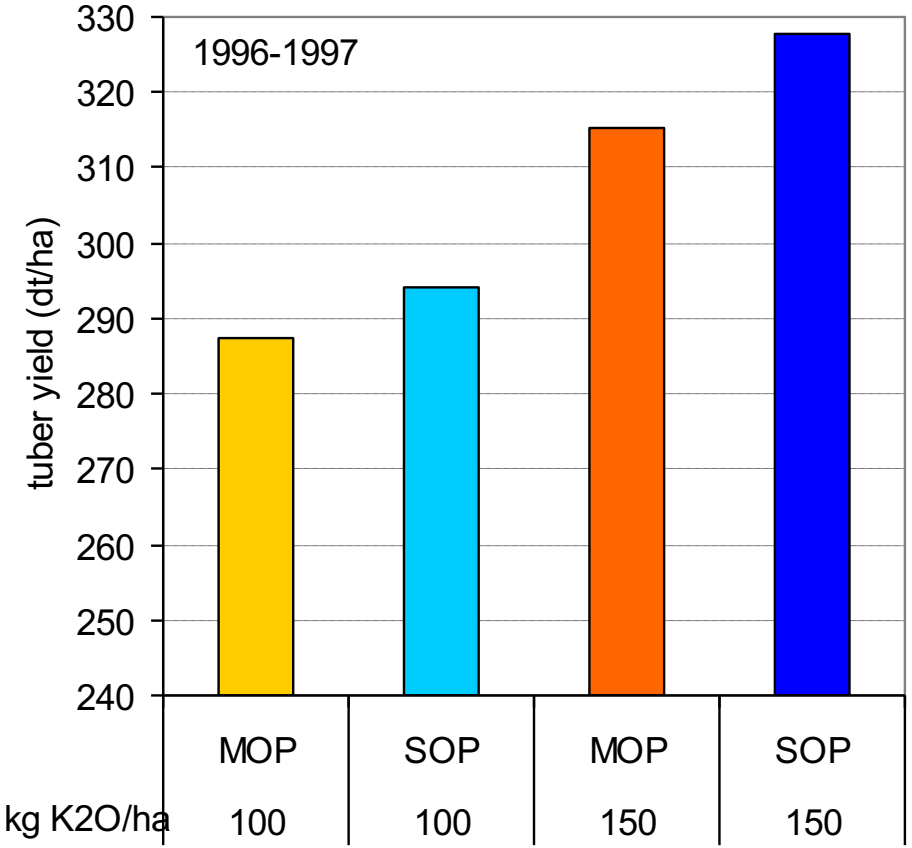
Effect of K Supply on Black Spot of Potato at Harvest and after 3 and 6 Months in Storage

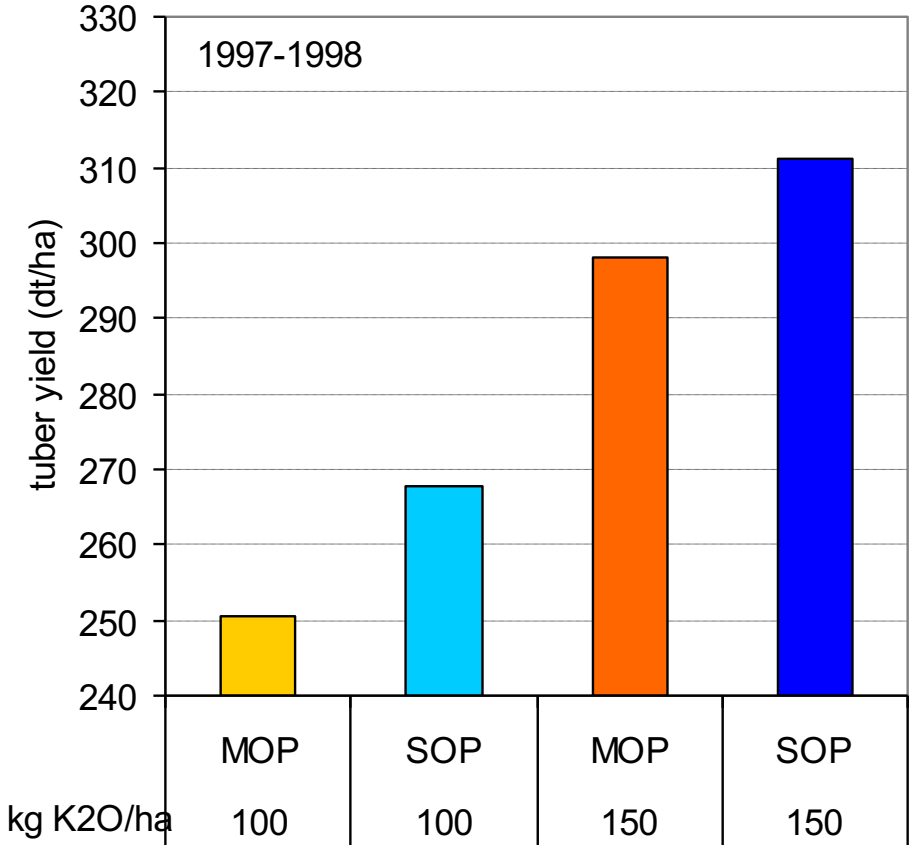


(Mochełek, Poland, 2001/2002 + 2003/2004, n = 6)

Potato: tuber yield

Effect of the K source on potato tuber yield in India





Source: Bansal, 2003

CITRUS

Role of K in citrus

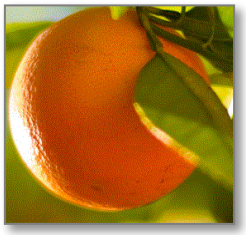
Increases water use efficiency under saline conditions

Improves fruit size and yield

Involved in the production and transport of sugar, starch and protein

Increases content of juice in fruit

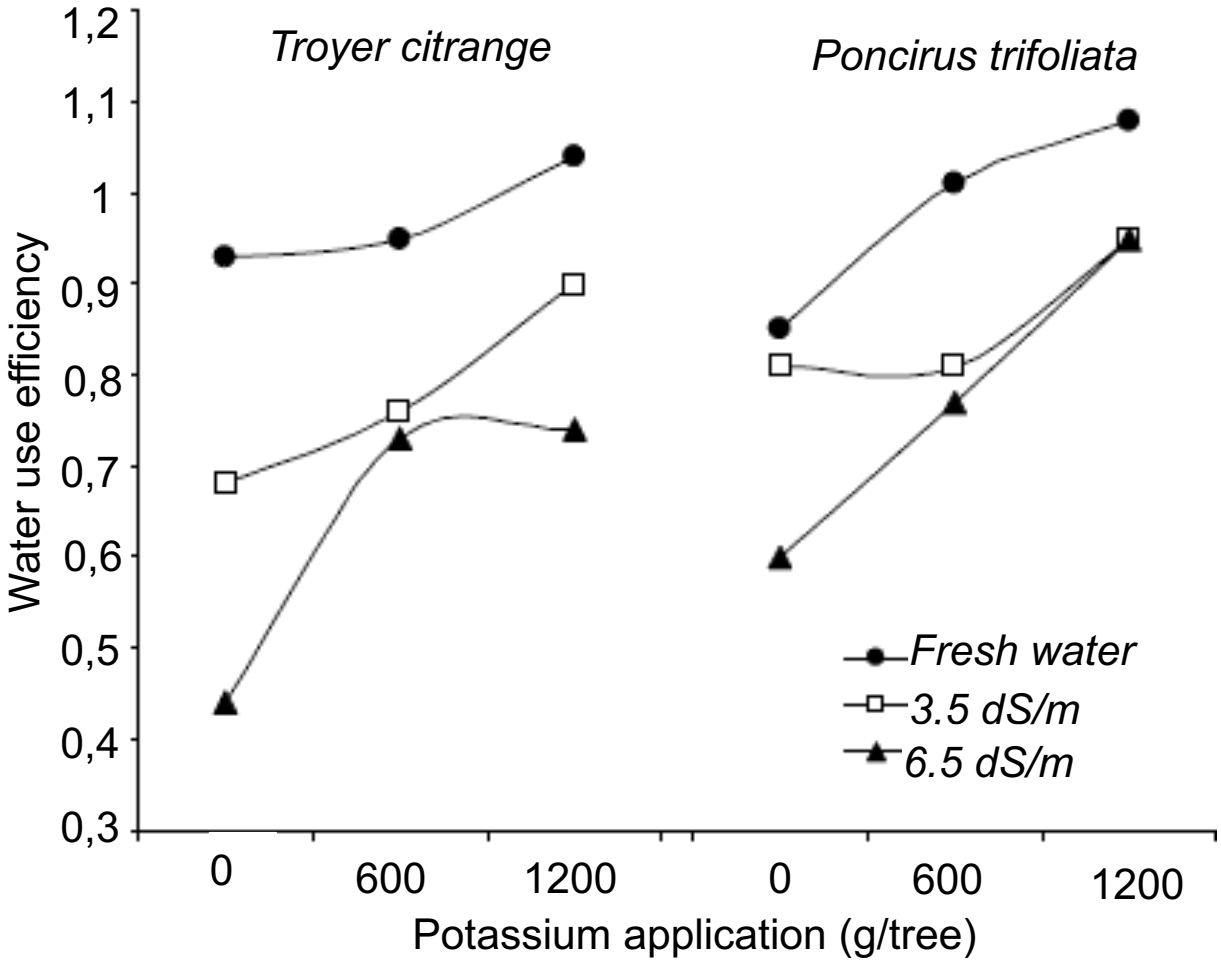
Synthesis Vitamin C (influenced by sugar metabolism)



Enhances coloration of fruits

Citrus: water use efficiency

Effect Influence of SOP supply on water use efficiency of citrus tress under saline conditions in Turkey

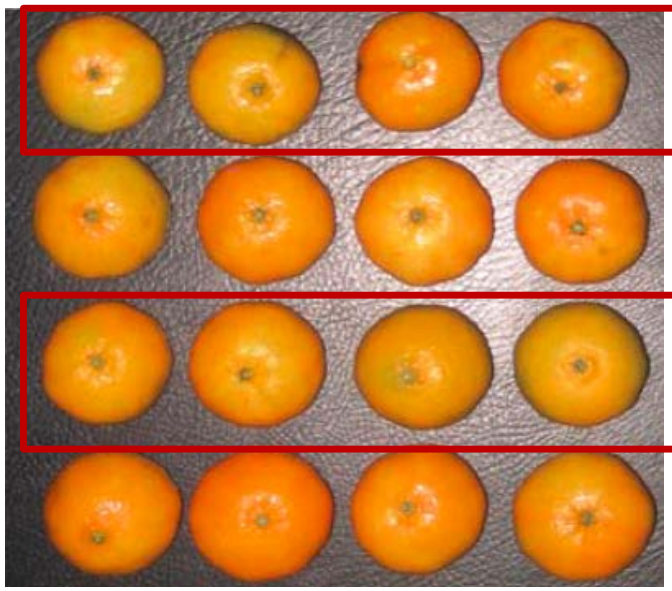


Source: Marchand 2007

Citrus: color

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

Control

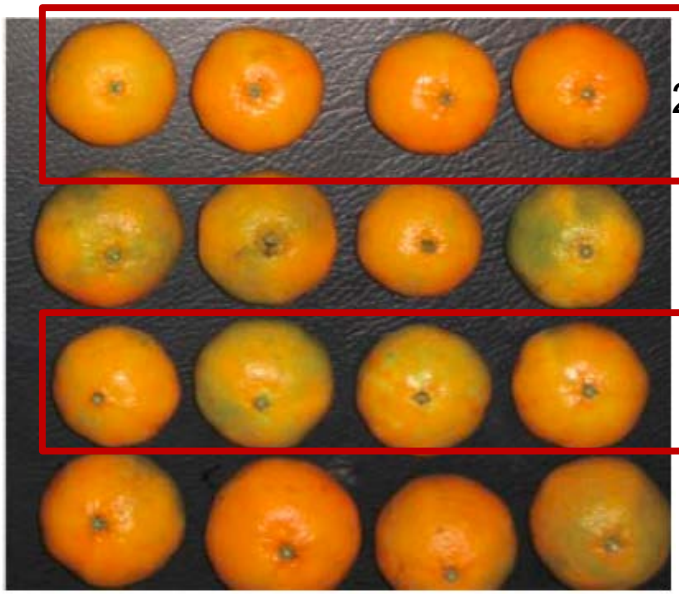


5% - KNO_3 x 2

5% - KNO_3 x 3

8% - KNO_3 x 2

8% - KNO_3 x 3



2.5% - K_2SO_4 x 2

2.5% - K_2SO_4 x 3

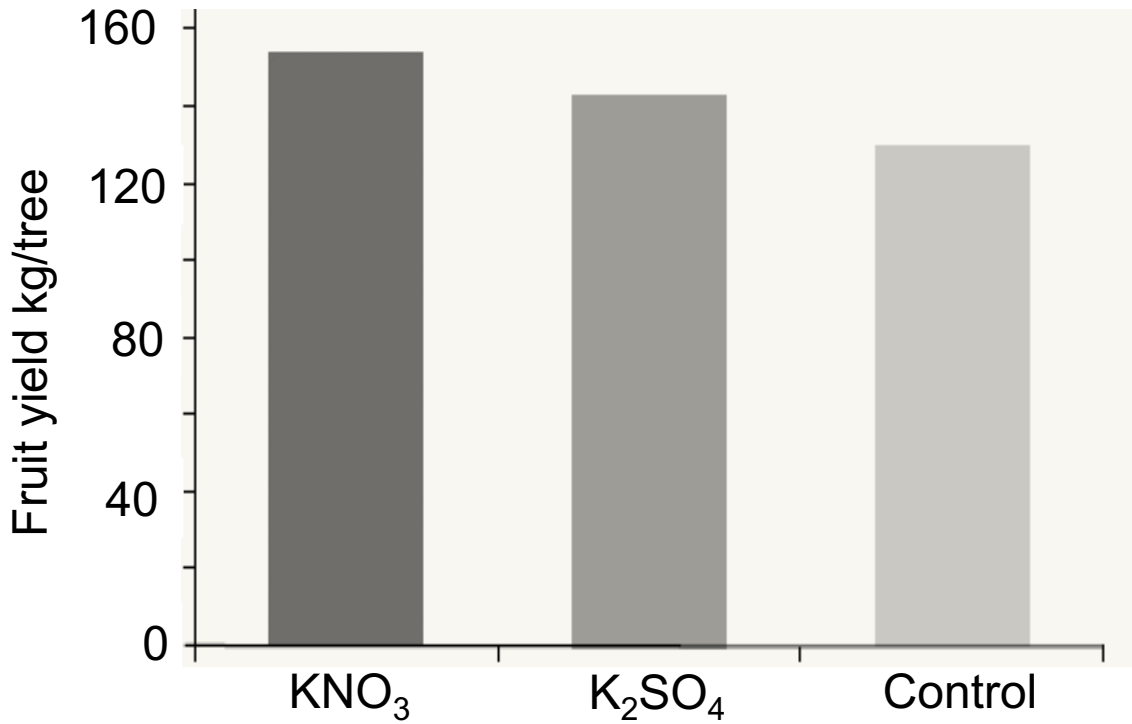
4% - K_2SO_4 x 2

4% - K_2SO_4 x 3

Source: Hamza et al. 2012

Citrus: fruit yield

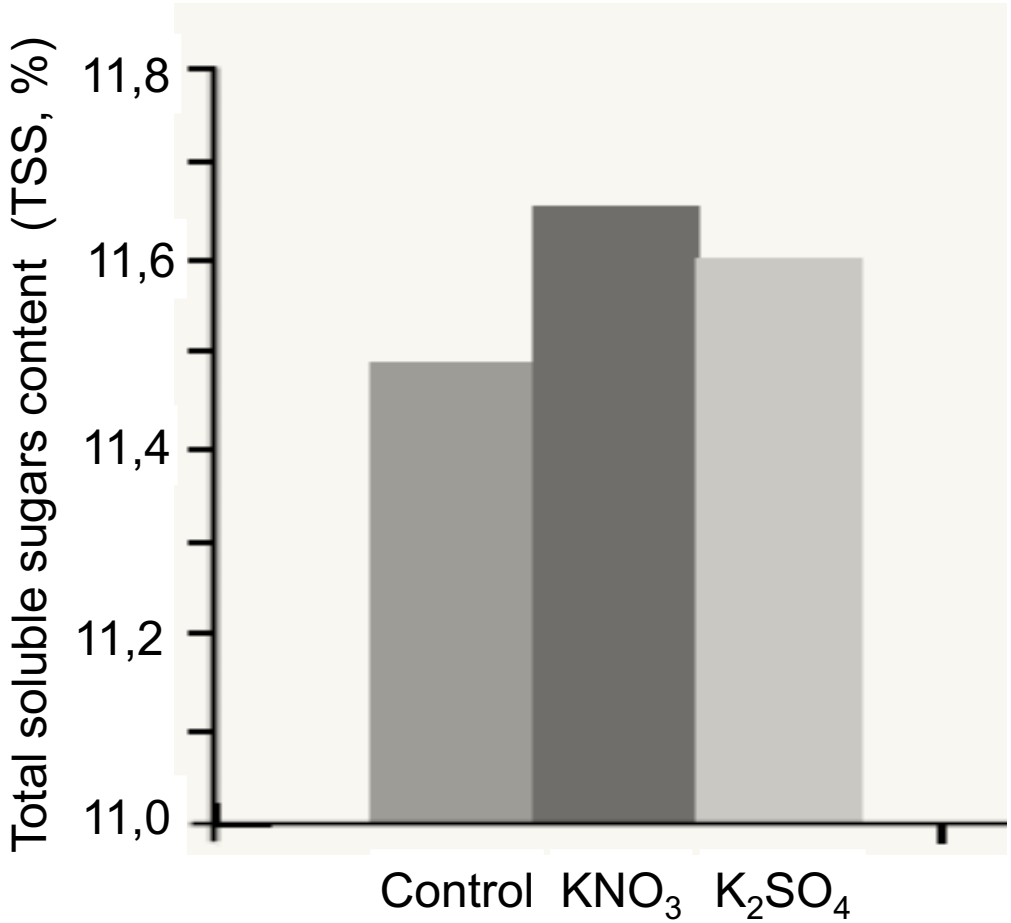
Effect of potassium source on fruit yield



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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