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Plant sap analysis: Monitoring plant health

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Who we are?

- Independent crop consulting
- Laboratory specialised in plant sap testing
  - Started in 2008
  - Active in 200 different crops *(organic, sustainable, conventional)*
    - Fruit (strawberry, raspberry, blueberry, red currant, apple, pear, cherry)
    - Greenhouse vegetables (tomato, pepper, cucumber, eggplant)
    - Fieldgrown vegetables (lettuce, leek, beans, carrot, potato)
    - Agricultural crops (wheat, corn, barley, grass)
    - Nursery crops (trees, flower bulbs, cutting flowers)
  - Active in 15+ countries
  - Results within 24 hours after arriving of samples for an up to date advice
  - Cost effective
- Independent research
  - Fertilisation trials
- Study groups
  - Teaching growers, consultants

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Why testing the plant sap?

- The final result of soil interactions
- Management tools during growing season
- Complete overview of current mineral plant uptake
- Every sample 20 parameters
  - Sugars (Brix), pH, conductivity
  - Nutrients:
    - Calcium
    - Magnesium
    - Potassium
    - Sodium
    - Nitrogen (Nitrate, Ammonium, Total Nitrogen)
    - Phosphorous
    - Chloride
    - Sulphur
    - Silica
    - Manganese
    - Iron
    - Zinc
    - Copper
    - Boron
    - Molybdenum
    - Aluminium

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What a plant sap sample tells you

- Current uptake of nutrients
- Mineral deficiencies and / or excesses
  - before visible appearance
- Nutrient imbalance in soils
- Plant reserves
- The nutrients which the plant is able to use for its growth at that moment
  - Different than dry matter test (total)
- Reflects plant health and vitality
- Fruitquality
- "Like a blood test of a plant"

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Sampling

- Crop specific manuals
- Young and old leaves separately
- Sample in the morning (leaf tension)
- Poor vs good plants
- Leaves without petioles
- Avoid rain of dew on the samples
- Avoid evaporation of sample

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Why measuring in the plant?

Factors which determine mineral uptake

- pH of the soil, irrigation water
- Imbalance in minerals (Albrecht, BS)
- Release of fertilisers (organic vs minerals)
  - Moment of application vs plant available
- Soil structure / root quality
- Soil life
- Climate, temperature, light, moisture
- Etc, etc, etc….

Looking into the plant will show you the final result of all of the above!

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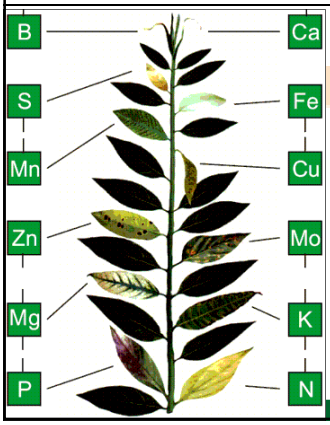
Mineral mobilisation within the plant



Mobile minerals:
Deficiency appears first in older leaves

- Nitrogen (N)
- Potassium (K)
- Magnesium (Mg)
- Phosphorous (P)

Medium immobile minerals:

- Sulphur (S)
- Iron (Fe)
- Manganese (Mn)
- Zinc (Zn)
- Copper (Cu)
- Molybdenum (Mo)

immobile minerals:
Deficiency appears first in young parts

- Calcium (Ca)
- Boron (B)

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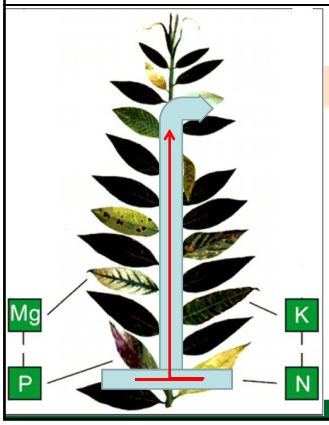
Mineral mobilisation within the plant



When roots can't deliver N,P,K or Mg, the plant will use its reserves.

Older leaves are storehouse for mobile elements (N, P, K, Mg)

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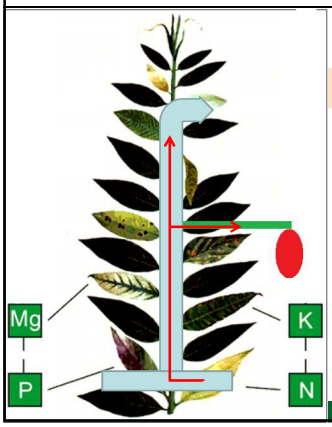
Mineral mobilisation within the plant



Example:
When fruit starts to develop, potassium demand raises.

Potassium in old leaves will be mobilised and transported to younger leaves and fruit.

Deficiencies of mobile minerals will appear first in older leaves.

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Young vs old leaves

- Sample young and old leaves separately
  - Young, but fully developed leaves
  - Oldest, but still vital leaves



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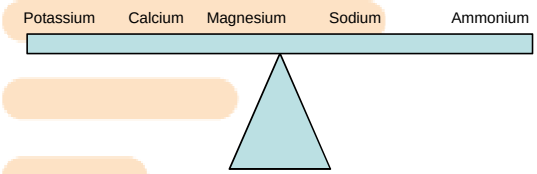
Antagonistic interactions

Cation balance

Potassium Calcium Magnesium Sodium Ammonium



Sufficient numbers in the soil is no garantee for a balanced uptake.
It's the balance what counts for the uptake

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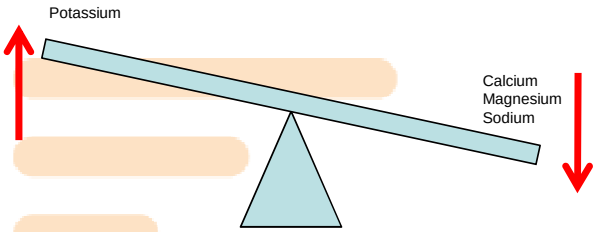
Antagonistic interactions



When 1 cation increases, 1 or more will decrease in the plant sap.

When 1 cation decreases in availability, 1 or more will increase in the plant sap

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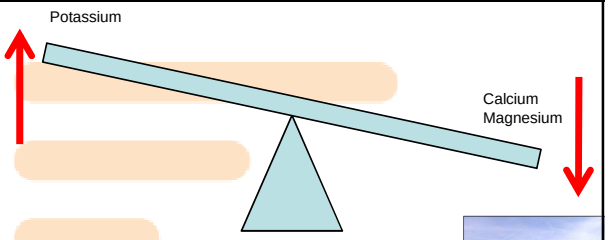
Antagonistic interactions



Example:
- Due to high applications of manure, potassium availability will raise
- Decreased uptake of calcium and magnesium
- Results →Decreased plant growth
  →smaller fruit, misshapen
- Advice: Apply manure or compost not only based on organic matter and soil life, but also take mineral content in mind.

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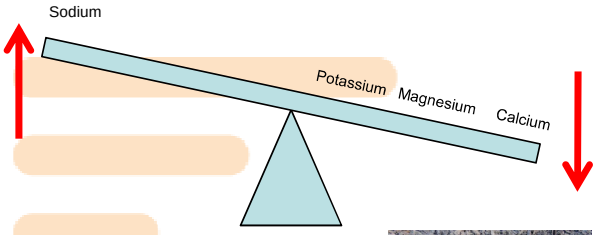
Antagonistic interactions



Plants need very little sodium.
Sodium is easy uptakeable
Sodium uptake directly decreases uptake of calcium, magnesium and sodium

Causes:
- Waterquality
- Ballast with fertilisers (poor compost)

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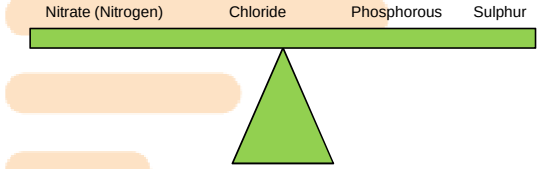
Antagonistic interactions

Anion balance



Anions have the same interactions
When 1 is high, others will decrease

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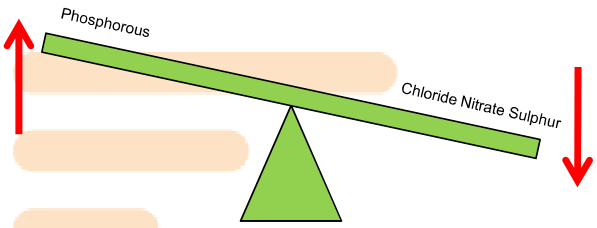
Antagonistic interactions



Nitrate reduction will result in a better uptake of phosphorous and sulphur.

To much KCl will result in less uptake of nitrogen, phosphorous and sulphur.

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Plant sap: Improved production and fruit quality

- Potassium and calcium are important minerals for fruit quality. (size and firmness)
- Calcium for cell strenght
- Potassium for filling
- K / Ca Ratio for optimum firmness and size

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Plant sap: Improved production and fruit quality

Potassium to calcium ratio vs fruit size and quality

- Vegetative phase: plant growth, making leaves
  - Higher uptake of calcium and magnesium
  - Less uptake of potassium is needed
- Generative phase: Fruit (setting and filling)
  - When fruit starts to grow, more potassium is needed

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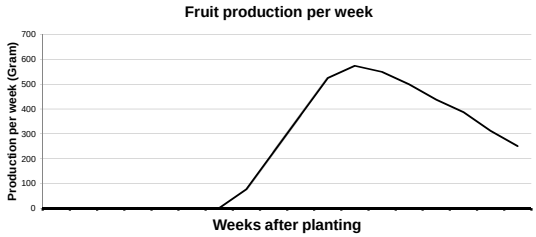
Plant sap: Improved production and fruit quality

Potassium to calcium ratio vs fruit size and quality



- When there is more fruit on the plant, potassium uptake has to be increased. (but not to much)

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Plant sap: Improved production and fruit quality

Potassium to calcium ratio vs fruit size and quality

- Young leaves vs older leaves = plant reserves of potassium
- Old leaves is storage for younger leaves or fruit. (for N, P, K, Mg)
- When demand of younger parts or fruit is high, storage of the older leaves will be used.
- Plant sap values of old leaves will drop to a level below younger parts.

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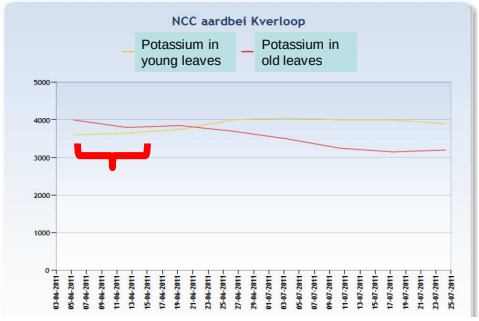
Plant sap: Improved production and fruit quality



- Starting growth : Potassium in old leaves is higher than in young leaves. (Enough reserves in storage)

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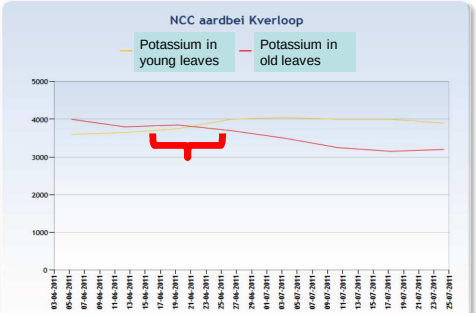
Plant sap: Improved production and fruit quality



- Beginning fruiting: Plant can't keep up with potassium uptake and starts to use storage. (Levels in old leaves will drop, young leaves stay on level)

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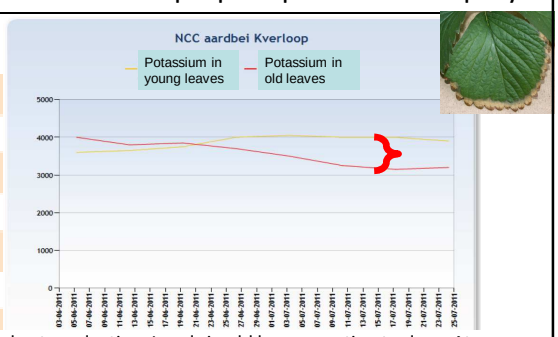
Plant sap: Improved production and fruit quality



- Highest production: Levels in old leaves continu to drop. At a certain level fruit quality will suffer.
- When potassium becomes to low, the K/Ca ratio goes wrong.

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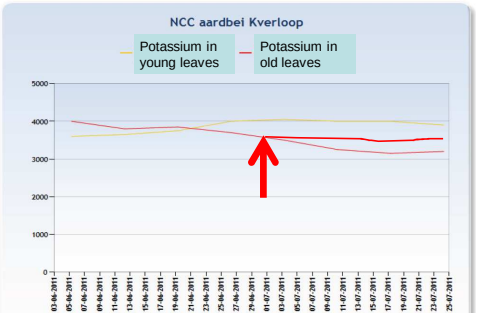
Plant sap: Improved production and fruit quality



- Apply potassium fertilisation at the right moment.
- To early: competition with calcium and magnesium in starting phase
- To late: fruit will become soft and poor shelflife

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Plant sap: Improved production and fruit quality

- Build fruit and quality with calcium as the basis
- "pump" it up with potassium, but don't let it "pop"

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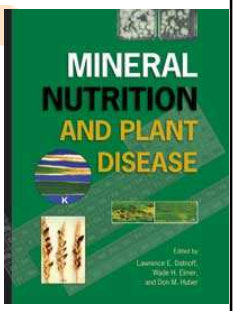
Mineral uptake and plant disease

- A balanced mineral uptake:
  - Constant growth
  - Less receptive for diseases
    - Aphids
    - Fungal (mildew, botrytis etc)
    - Bacterial
  - Flower quality
  - Fruit quality
    - Shelf life
    - Firmness
    - Taste



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Mildew and nutrition

Strawberry propagation
- 1 field
- Same fertilisation
- Same soil
- 2 varieties

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Mildew and nutrition

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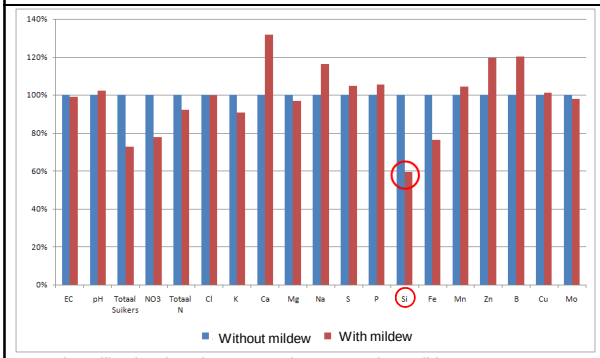
Mildew and nutrition



Monitor silica levels to improve resistance against mildew.

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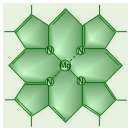
Nitrogen management and aphids

- Plant can take up nitrogen in nitrate or ammonium form
- Nitrates need to be converted (amino-acids and proteins)
- Accumulation of nitrates stimulate insects and fungal diseases.
- High nitrates → luxurious growth → large weak cells → low sugar production (Brix) → sensitive for insects (aphids)

- Key is to keep nitrate-accumulation low and convert nitrates into amino-acids and proteins
  - Optimise photosynthesis
  - Magnesium, Iron, Manganese, Zinc
  - Molybdenum
  - Biology and soil-life!



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Nitrogen management and aphids

Monitoring nitrate conversion:

Plant sap determination of: Total N, Nitrate, Ammonium

In plant sap:

Nitrate
Ammonium
Aminoacids and proteins (converted Nitrogen) +
Total Nitrogen

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Nitrogen management and aphids

- Example: organic sweet pepper glasshouse

Sap test:

Total Nitrogen = 2500 ppm
Nitrate = 1100 ppm -
Converted N = 1400 ppm

Nitrate conversion: 1100 / 2500 = 44% of N is Nitrate.
Periods with 55% and more Nitrate→ aphids

Solutions: decrease N, increase Mg, Mn, Fe, Zn
Stimulate soil-life (innoculation)

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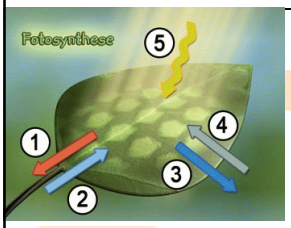
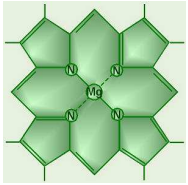
Nitrate conversion



Simplified photosynthesis
- 5: Sunlight
- 4: CO2 uptake
- 3: O2 production
- 2: Uptake of water and minerals
- 1: Sugar, energy and converted nutrients

Manage leaves as the "energy factory"
And keep them "GREEN"



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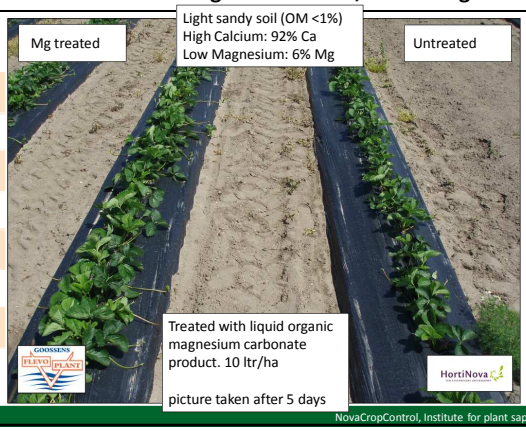
Magnesium effect, like Nitrogen:



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Comparison potato fertilisation strategies

- 6 potato fields
- Northern of The Netherlands
- Comparison of different fertilisation strategies

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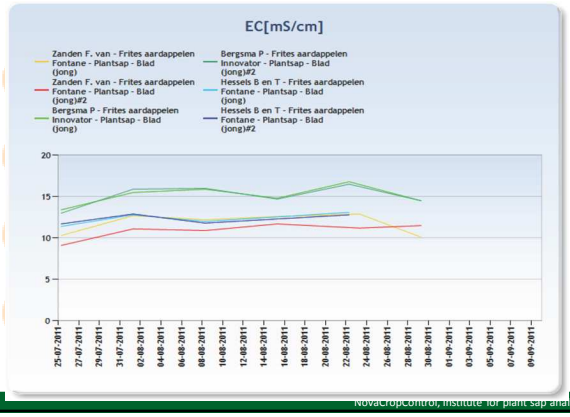
Comparison potato fertilisation strategies



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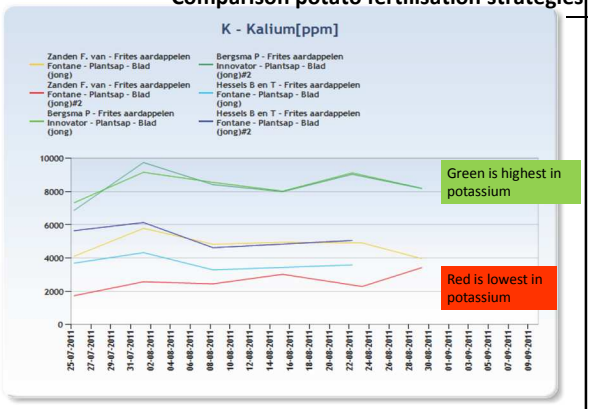
Comparison potato fertilisation strategies



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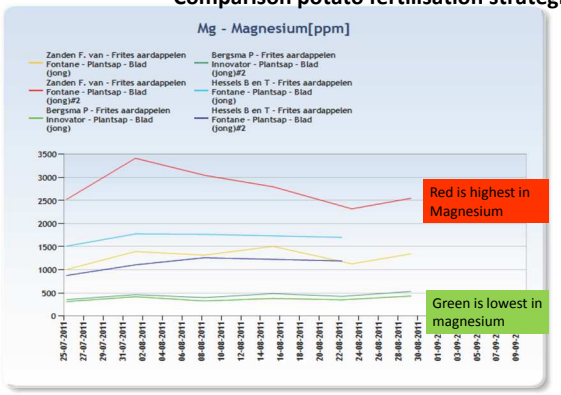

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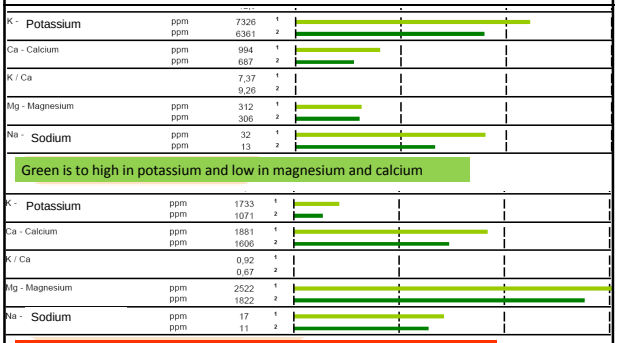

Green is to high in potassium and low in magnesium and calcium

Red is potassium deficient due to excessive magnesium applications.
Potassium deficiency has resulted in more blue spots (quality, firmness)

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Thank you for your attention

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