Plant sap analysis: Monitoring plant health, ACRES USA 7-12-12

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)
  - Field grown 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 arrival of samples for an up to date advice
- Cost effective
- Independent research
- Fertilisation trials
- Study groups
  - Teaching growers, consultants

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
- 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
- Fruit quality
  - “Like a blood test of a plant”

What a plant sap sample tells you
- Current uptake of nutrients
- Mineral deficiencies and/or excesses
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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

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)

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).

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.

Young vs old leaves

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

Antagonistic interactions

Cation balance

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

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

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

Causes:
- Water quality
- Ballast with fertilisers (poor compost)

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

Nitrate reduction will result in a better uptake of phosphorous and sulphur. Too much KCl will result in less uptake of nitrogen, phosphorous and sulphur.

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

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 too much)

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.

Potassium in young leaves

Potassium in old leaves

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

- 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)

- Highest production: Levels in old leaves continue to drop. At a certain level fruit quality will suffer.
- When potassium becomes too low, the K/Ca ratio goes wrong.
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- Apply potassium fertilisation at the right moment.
- Too early: competition with calcium and magnesium in starting phase
- Too late: fruit will become soft and poor shelf life

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"

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

Mildew and nutrition

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

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
• Nitrites need to be converted (amino-acids and proteins)
• Accumulation of nitrites stimulate insects and fungal diseases.
• High nitrites → luxurious growth → large weak cells → low sugar production (Brix) → sensitive for insects (aphids)
• Key is to keep nitrate-accumulation low and convert nitrites into amino-acids and proteins
  – Optimise photosynthesis
  – Magnesium, Iron, Manganese, Zinc
  – Molybdenum
  – Biology and soil-life!

Monitoring nitrate conversion:
Plant sap determination of: Total N, Nitrate, Ammonium
In plant sap:
Nitrate
Ammonium
Aminoacids and proteins (converted Nitrogen) + Total Nitrogen

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 (inoculation)

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”

Magnesium effect, like Nitrogen:

Light sandy soil (OM <1%)
High Calcium: 92% Ca
Low Magnesium: 6% Mg

Treated with liquid organic magnesium carbonate product 10 ltr/ha
picture taken after 5 days

Comparison potato fertilisation strategies

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

EC [mS/cm]

Comparison potato fertilisation strategies

K - Kalium [ppm]

Comparison potato fertilisation strategies

Mg - Magnesium [ppm]

Comparison potato fertilisation strategies

Potassium

Sodium

Red is lowest in potassium

Red is highest in magnesium

Green is lowest in magnesium

Green is highest in potassium

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

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

Thank you for your attention

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