NovaCropControl

Masterclass
Monitoring plant health

By:
Eric Hegger

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Introduction:

NovaCropControl

Eric Hegger:
Consultant at NovaCropControl

- Graduated from the HAS University in 'Horticulture and Business management'
- 5 years experience in Greenhouse cultivation
- Now working for 3 years at NovaCropControl
- Email: E.hegger@novacropcontrol.nl

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History NovaCropControl:

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2003
HAND METERS
START IN STRAWBERRY AND OPEN FIELD

2009
ESTABLISHMENT
BY BART VROMANS AND SJOERD SMITS

2017
NEW OFFICE
LOCATED IN OISTERWIJK

2018
TEST LOCATION
1000M2 INDEPENDENT INVESTIGATION

2019
10 YEARS
CELEBRATED WITH COLLEAGUES

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Introduction:

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Plant sap analyzes

- Also water samples on nutrition.
- Every sample 21 parameters

Fast results

- Results within 24u after arriving

Located in Oisterwijk

- 35 employees
- New facility since 2017

Worldwide

- Active +30 landen
- Shipping from all countries is possible within 5 days.

Test location

- 1000m2 plastic tunnel for independent research
- In 2020 tests for Strawberry, Tomato, Pepper

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Subjects

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Session 1:

- Why Plant sap Measurements?
- Mobility of elements
- Nutrient balance and the interactions in the plant
- Factors that influence mineral uptake

Session 2:

- Interpreting analyses
- Using bemesting-online
- Nutrition and plant health
- Research on plant health

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Plant sap in which crops?

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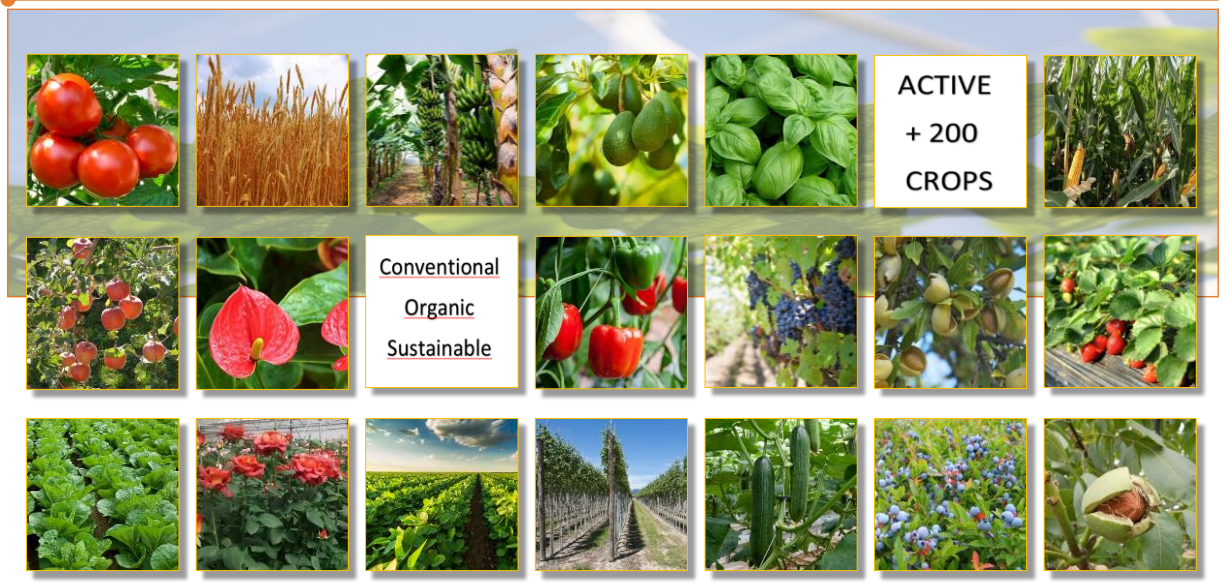

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The benefits of Plant Sap measurements?

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- ***Manage nutriënt uptake***
- ***Improve fertilizer efficiency***
- ***Avoid nutrient deficiencies or toxicities***
- ***Improve plant health and vitality***
- ***Better leaf and fruit quality***
- ***Improve fruit taste***

_____=

Cost saving through optimum plant growth / health / fruit quality

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Which nutrients?

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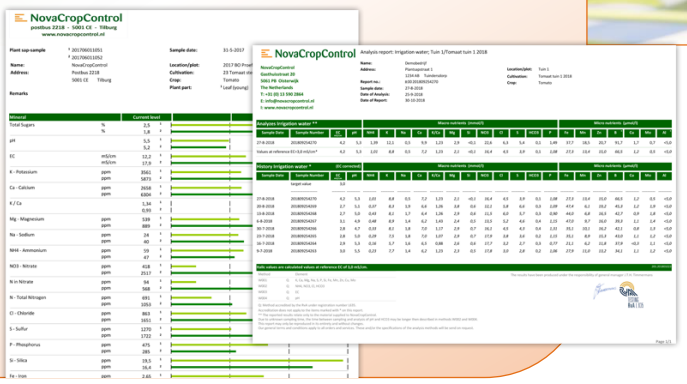
Every sample: 21 parameter.

- Total Sugars
- EC
- pH
- Calcium
- Potassium
- Magnesium
- Sodium
- Nitrogen (Nitrate, Ammonium, Total Nitrogen)
- Chloride
- Sulphur
- Phosphorus
- Silica
- Iron
- Manganese
- Zinc
- Boron
- Copper
- Molybdenum
- Aluminium



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Difference plant sap and dry matter test

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Minerals in the plant:

- Mineral / dissolvable salts (current uptake for plant development)
- Fixed minerals (in organic compounds, hardly available for plant development)

- **Plant sap measurement** measures mostly dissolved salts and a small part of the fixed minerals. The current situation of nutrition the plant can use for growth.
- **Dry matter test** counts the total of both (total uptake by plant). Deficiency is not directly visual in the analyze

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Difference plant sap and dry matter test

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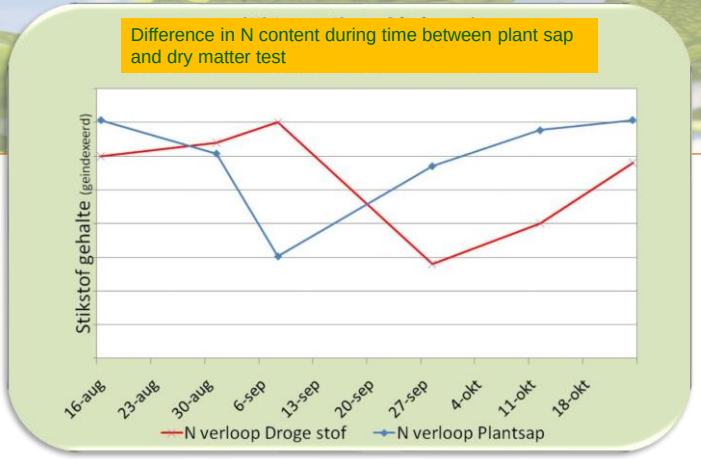
Plantsap: N deficiency in a earlier stage visual. 2/3 weeks later visual in the dry matter.

Dry matter test: In a dry matter test it takes longer to determinate lower numbers



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Find the cause of a deficiency

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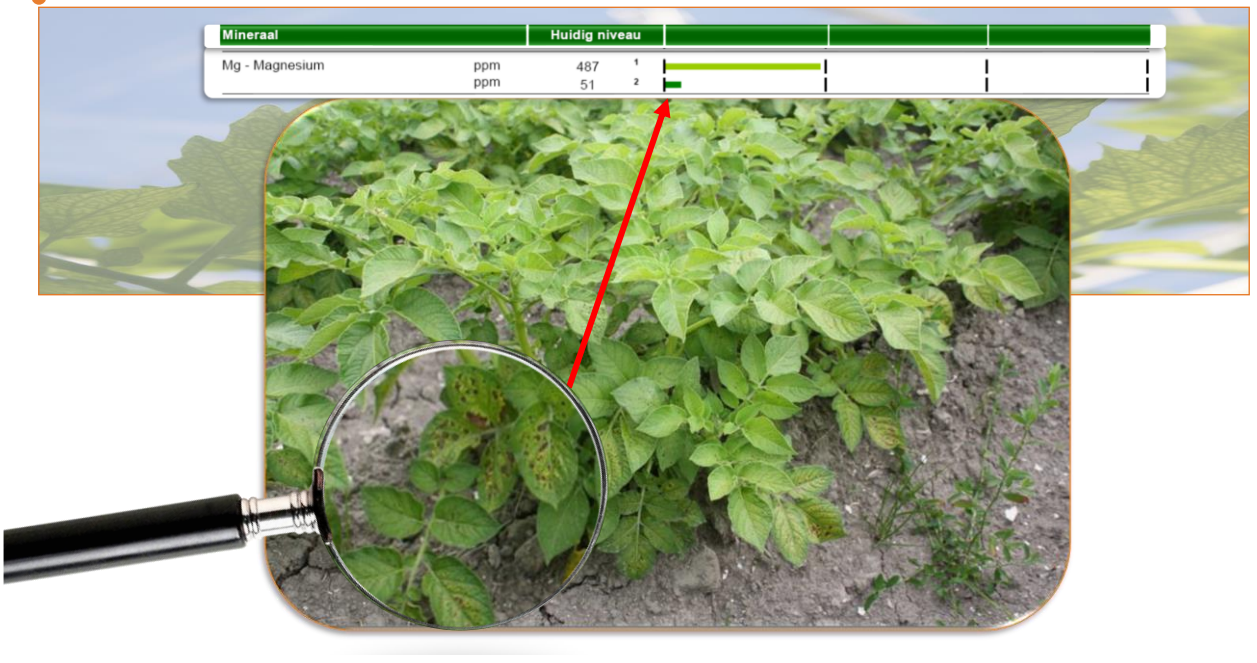

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Boron too high or Potassium deficiency?

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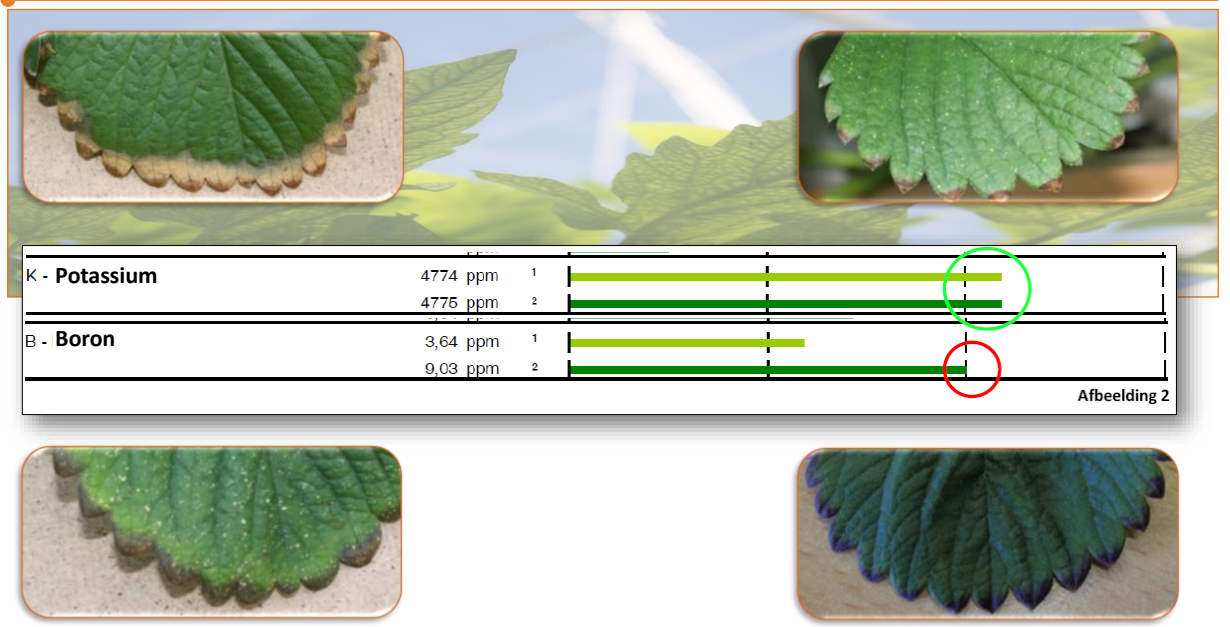

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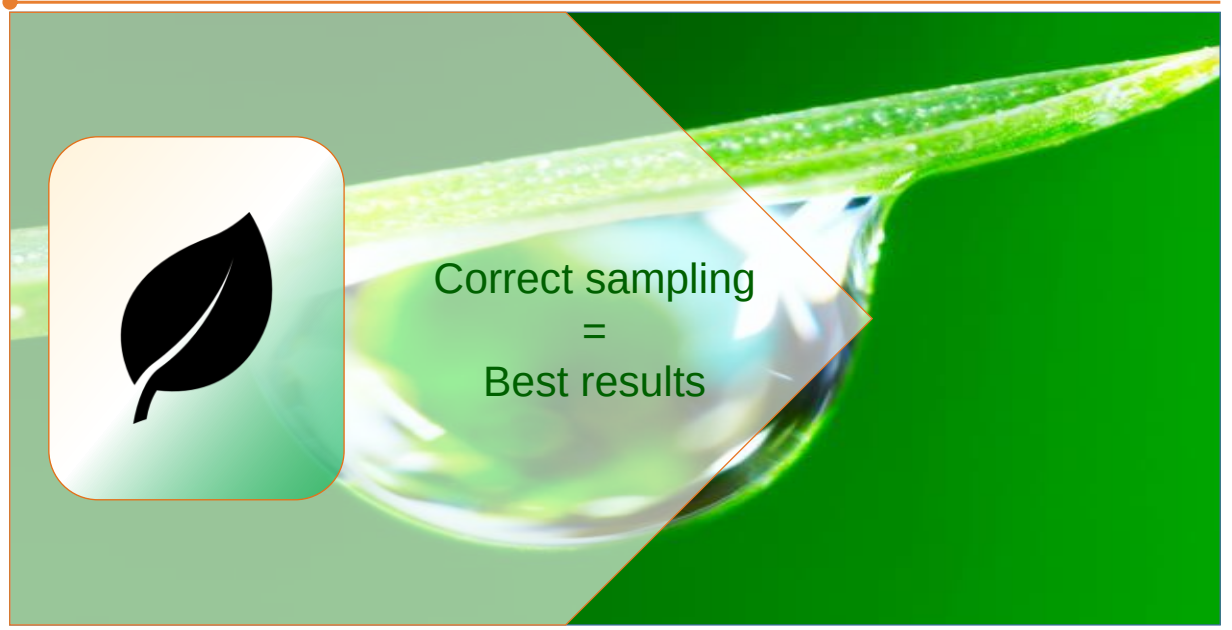

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"Proper sampling is essential"!

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Sample early in the morning (before 9am)

Young and old leaves seperately (mobility)

Manual for every crop on our website

Sample leaves without the petioles

Avoid side paths, head of the growhouse etc.

Sample deficiency leaves seperately from healthy leaves

Free from dew, moisture or dirt

Foliar spray: sample before or at least one week after

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Use the right materials

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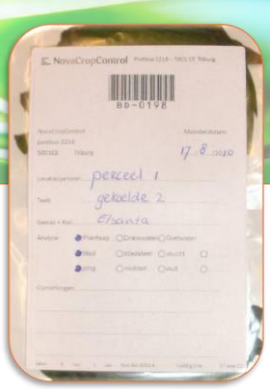
- **Use zip-lock bags**
- **Write down all the information on the stickers:**
  - Location
  - Cultivation
  - Crop-Cultivar
  - Plantpart
  - Remarks



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Don'ts!!!

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Not possible to add a label	Are these bottles clean? (Coca-Cola = pH 2.45 en 6.13 mmol P	Sample too big, is this bag with peat cleaned properly?	Samples in a paper bag, will dry out

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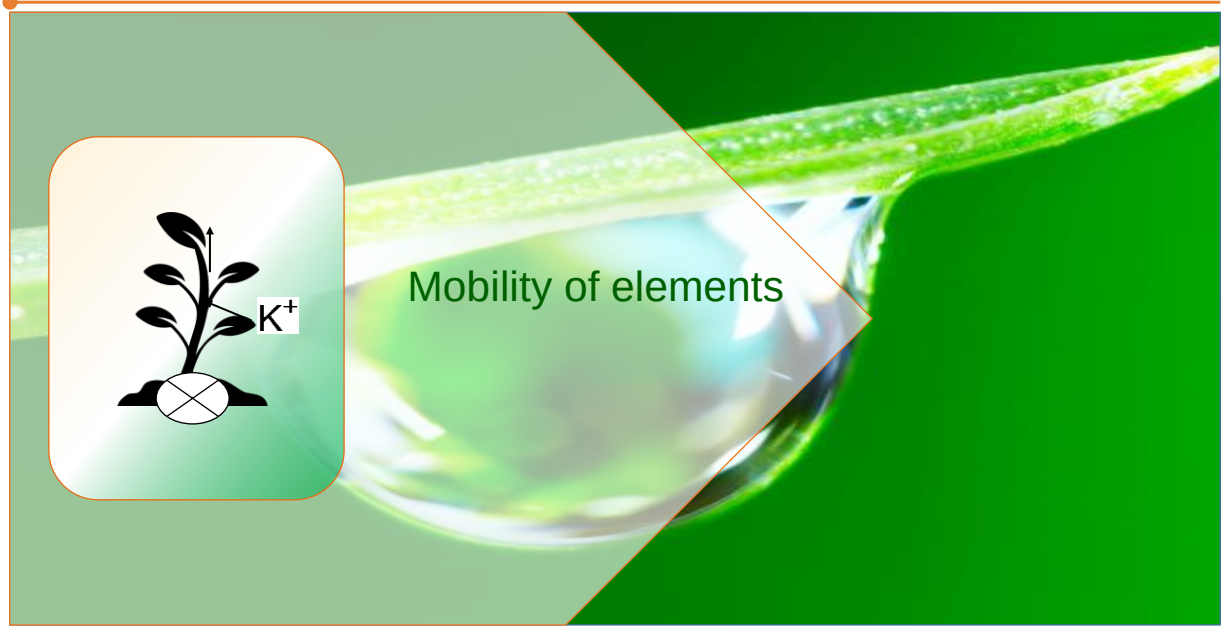

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Mobility of elements

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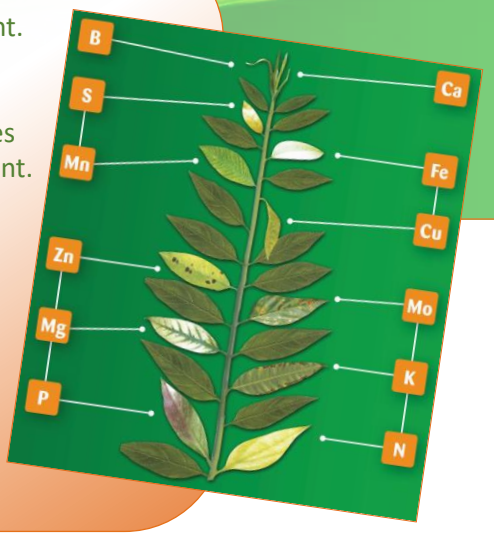
Mobility of elements:

- Recognize a deficiency based on position in the plant.
- Sampling young and old leaves separately for best insight into what is going on in the plant.
- Each deficiency looks different but some deficiencies are similar. (Mg and Mn). Look at position in the plant.



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Mineral mobility in the plant

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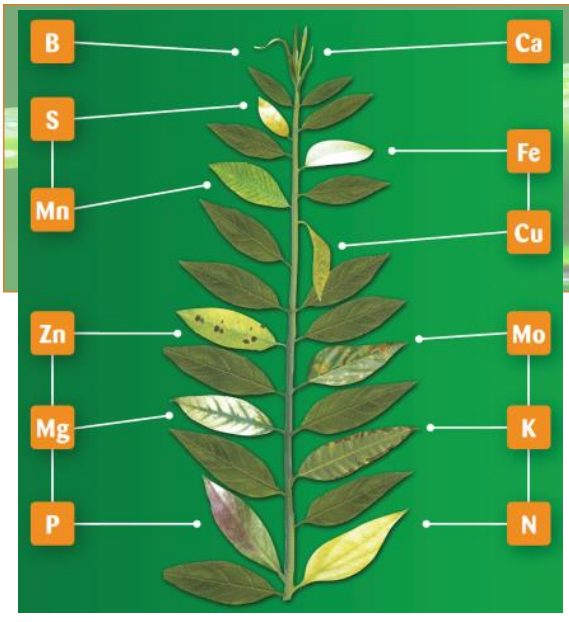

Mobile minerals:
Deficiency appears first in older leaves

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

Medium immobile minerals:
Deficiency appears in the new leaves (S, Fe, Cu, Mn)

- 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 mobility in the plant

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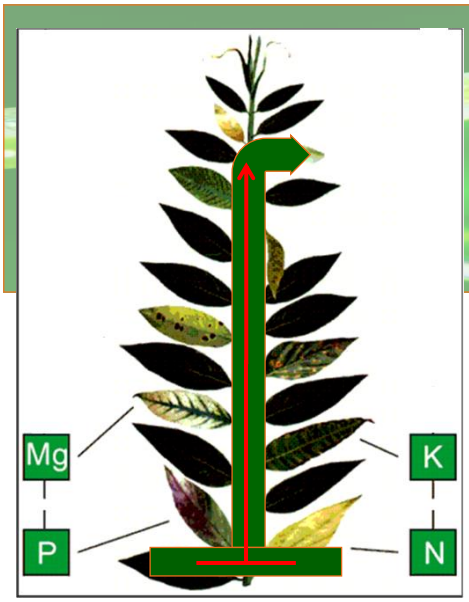

- When roots cannot deliver N,P,K or Mg, the plant will use its reserves.
- Older leaves are storehouse for mobile elements (N, P, K, Mg)
- Plantsap: Values go first down in the old leafs

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Mineral mobility in the plant

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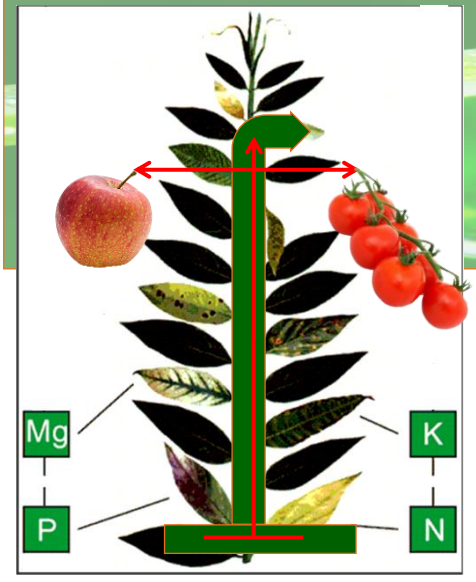

Example:

- When fruit starts to develop, potassium demand increases.
- Potassium in old leaves will be mobilized and transported to younger leaves and fruit.
- Deficiencies of mobile minerals will appear first in older leaves.

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Mineral mobility in the plant

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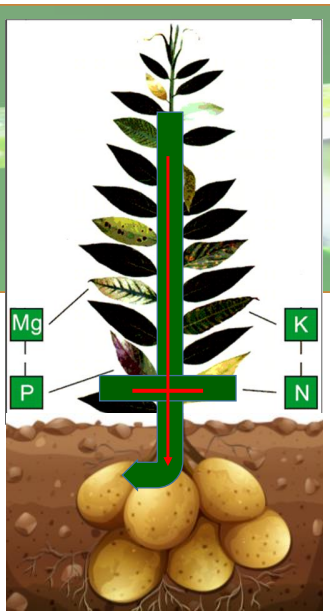

Example:

- When Potato tubers starts to develop, potassium demand increases.
- Potassium in old leaves will be mobilized and transported to younger leaves and the Potato.
- Deficiencies of mobile minerals will appear first in older leaves.
- Potassium important for the quality of the Potato

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Mineral mobility in the plant

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Boron and Calcium not mobile from the old leaves.

- Deficiency first visual in the top leaves
- Transport possible by:
  - Active sap stream
  - Evaporation
  - Root pressure

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Competition in the plant

- Between Cations:
  Calcium - Potassium - Magnesium - Sodium - Ammonium
- Between Anions:
  Nitrate (nitrogen) - Chloride - Sulfur - Phosphate
- Total EC, distribution of this

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Antagonistic interactions Cations

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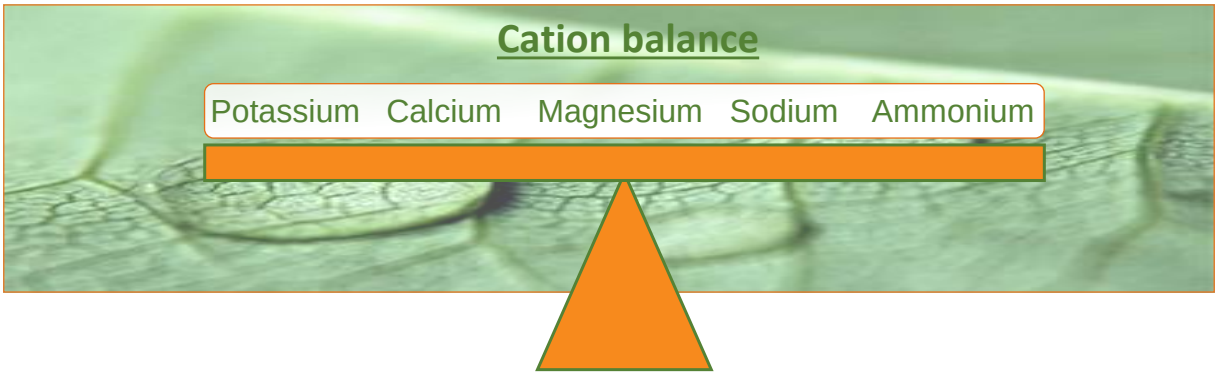

Note:
- Sufficient in the soil/substrate no guarantee for balanced uptake
- Ratio important for the uptake
- One Cation too high presented in plant sap, other Cation(s) deficient

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Antagonistic interactions Cations

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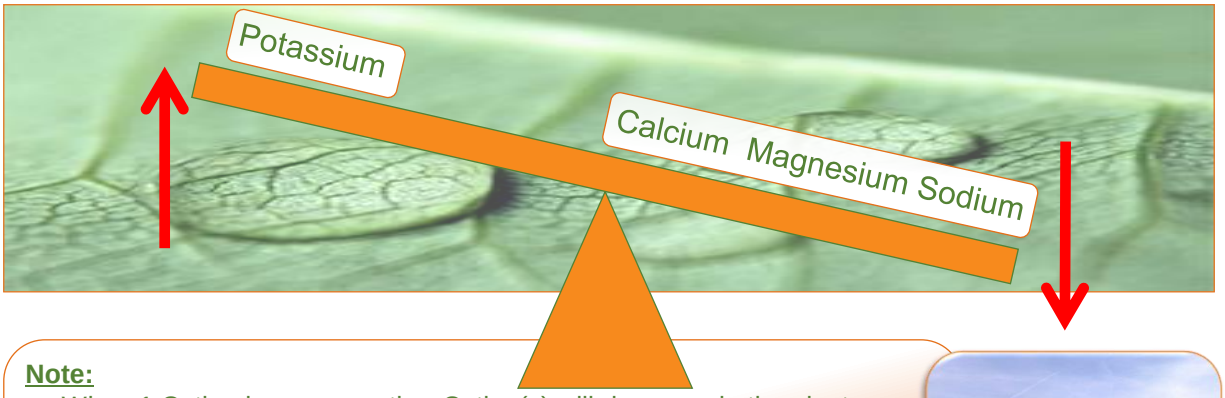

Note:
- When 1 Cation increases, other Cation(s) will decrease in the plant sap.
- When 1 Cation decreases in availability, other Cation(s) will increase in the plant sap
- Due high applications of manure or compost, Potassium availability will raise. Decreased uptake of Calcium and Magnesium.

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Antagonistic interactions Cations

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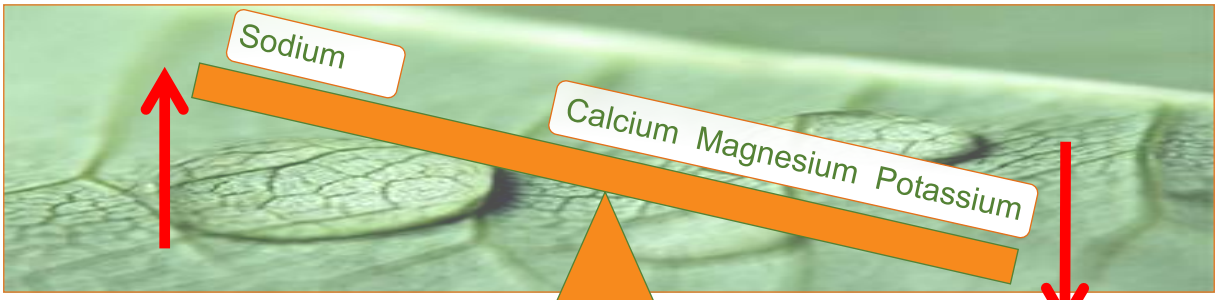
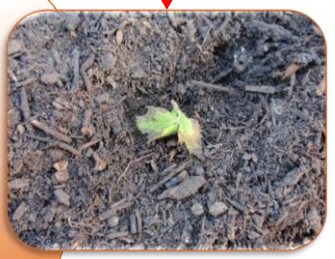


Note:
- Plants need very little sodium.
- Sodium can be taken up easily
- Sodium decreases uptake of , Potassium, Calcium, Magnesium

Causes:
- Water quality
- Ballast with fertilizers (Fe 3% (50 µmol = ± 0.5 mmol Na, replace it for Fe6%
- City water (sometimes 0,6 mmol/l)



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High Sodium

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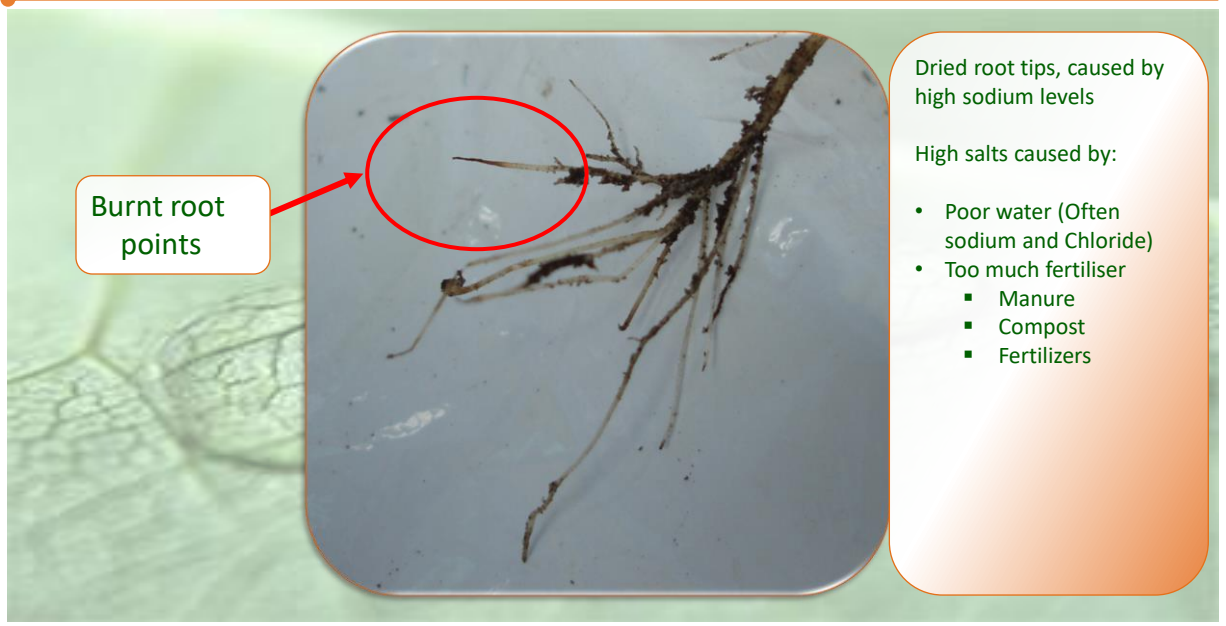

Dried root tips, caused by high sodium levels

High salts caused by:

- Poor water (Often sodium and Chloride)
- Too much fertiliser
  - Manure
  - Compost
  - Fertilizers

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Competetition Cations (Sodium test)

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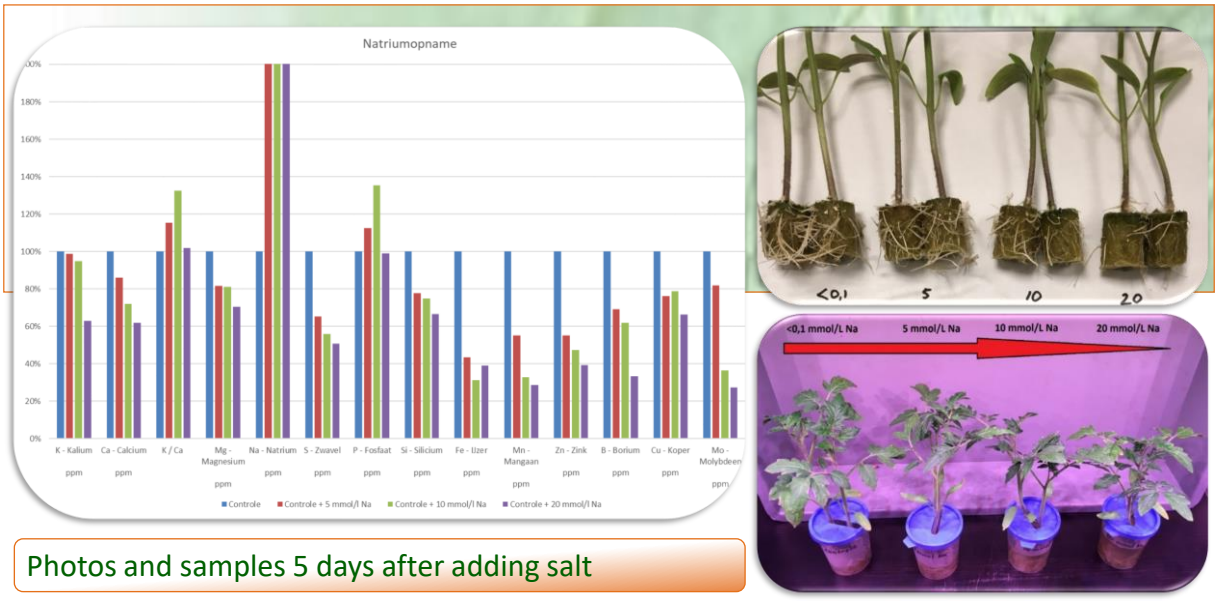

Photos and samples 5 days after adding salt

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Influence Sodium on Calcium uptake

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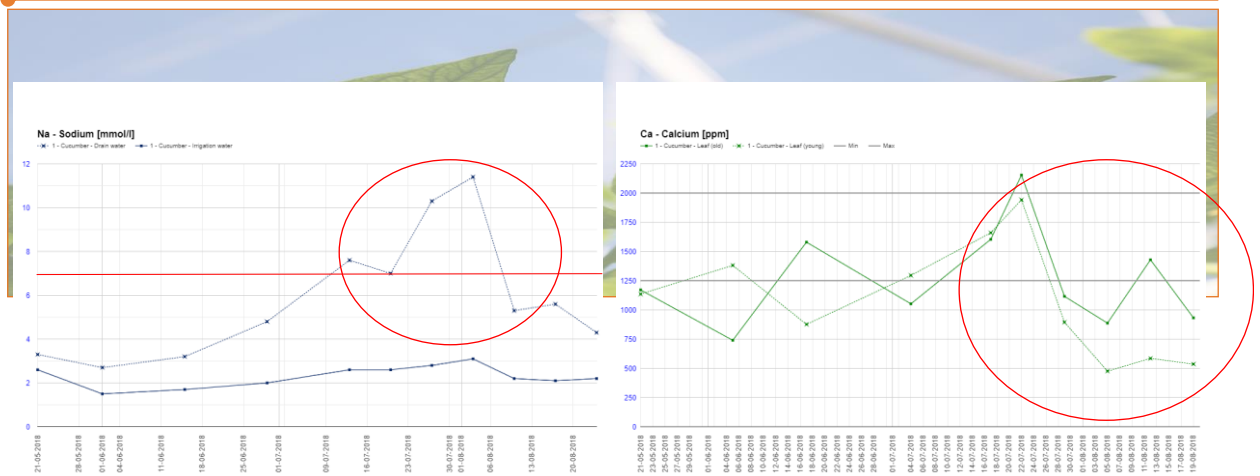

Sodium goes too high and this has big impact on the Calcium uptake!

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Potassium and Calcium ratio

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K/Ca ratio for optimum firmness and size:

Outer tire:
- Calcium for cell strenght

Innertube:
- Potassium for fruit filling

- **Don't forget Mg:**
  High Mg: Too low K or Ca

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Potassium and Calcium ratio

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• Too high Calcium

• Too high Potassium

Gold Specs

Splitting fruits

K/Ca

Blossom end rot

Bad Coloration

• Too low Calcium

• Too low Potassium

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Difference in Potassium and Calcium uptake

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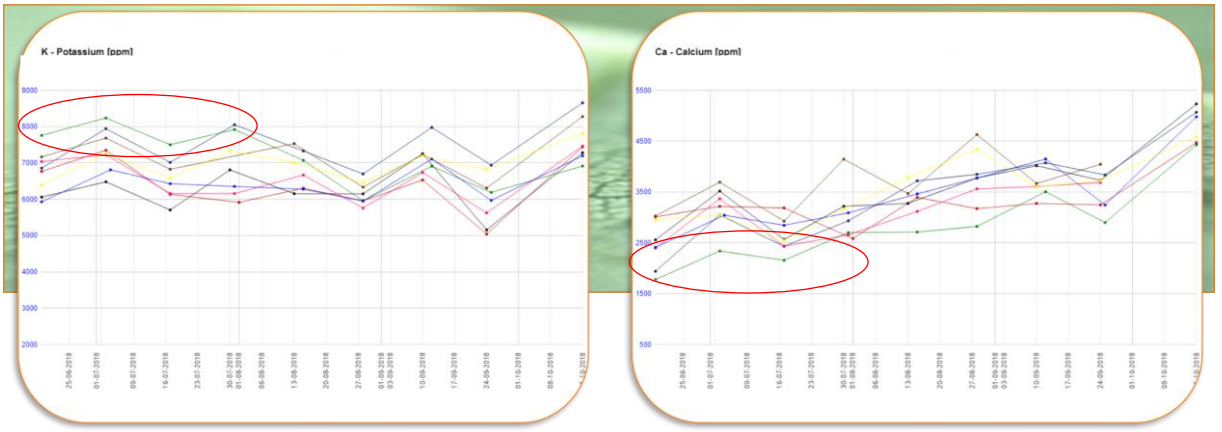

Antagonistic interaction Cations:

- Apple trees: 8 different fields.
- Potassium high (green line), low Calcium uptake.
-

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K/Ca ratio differents between the fields

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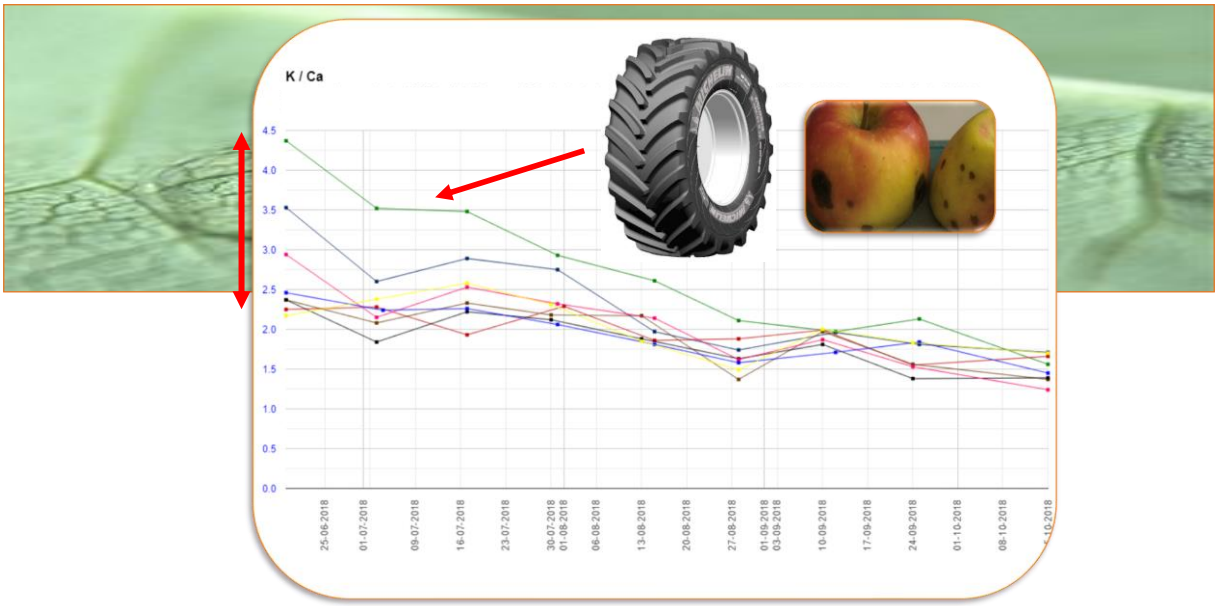

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Target Values give a very good indication

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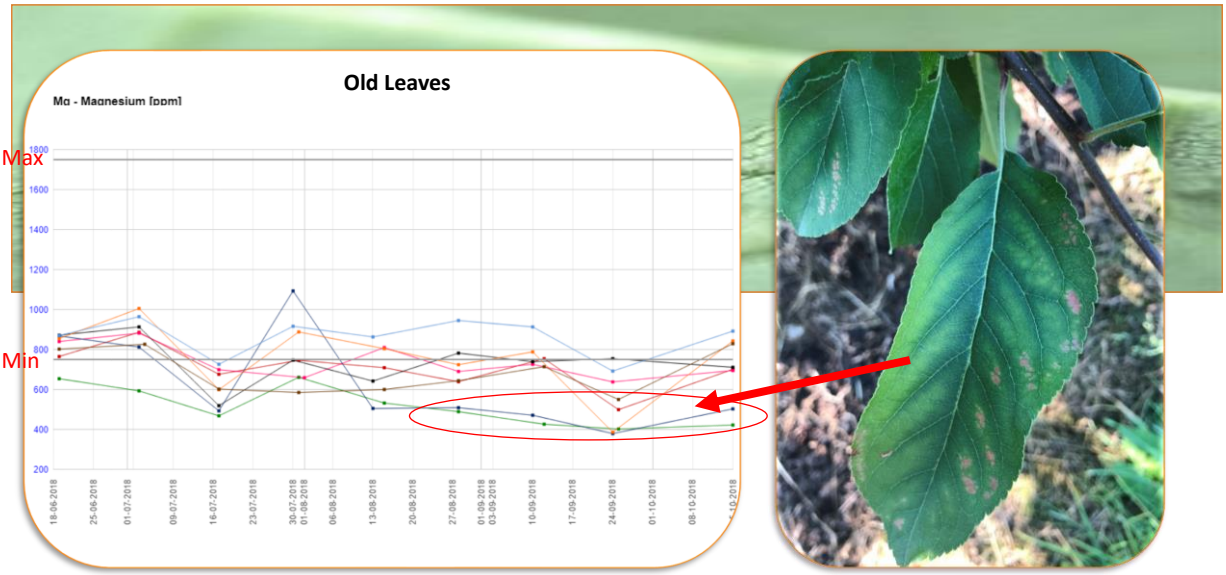

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K/Ca ratio important for Potato

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Storage and quality of the potato tubers are strongly influenced by the K / Ca ratio

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Antagonistic interactions Anions

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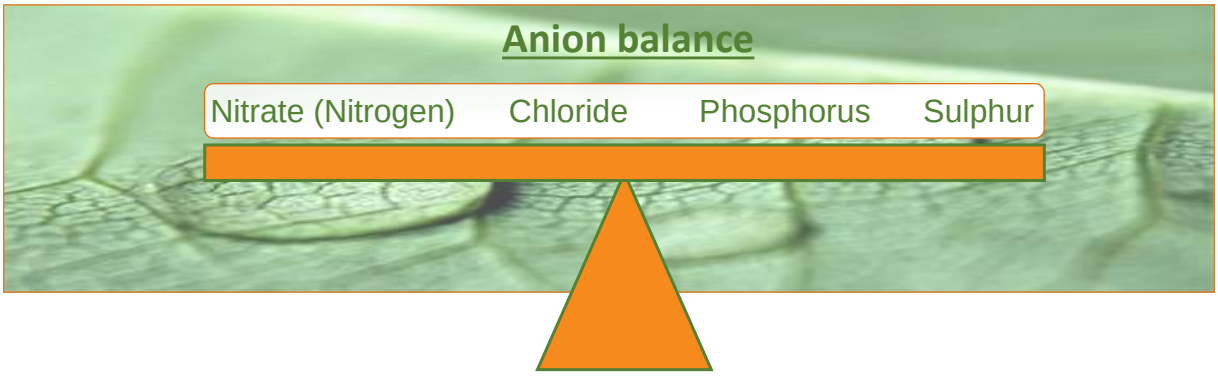

Note:
- Anions have the same interactions as Cations
- When 1 is high, others will decrease

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Lowering Nitrate with Other Anions

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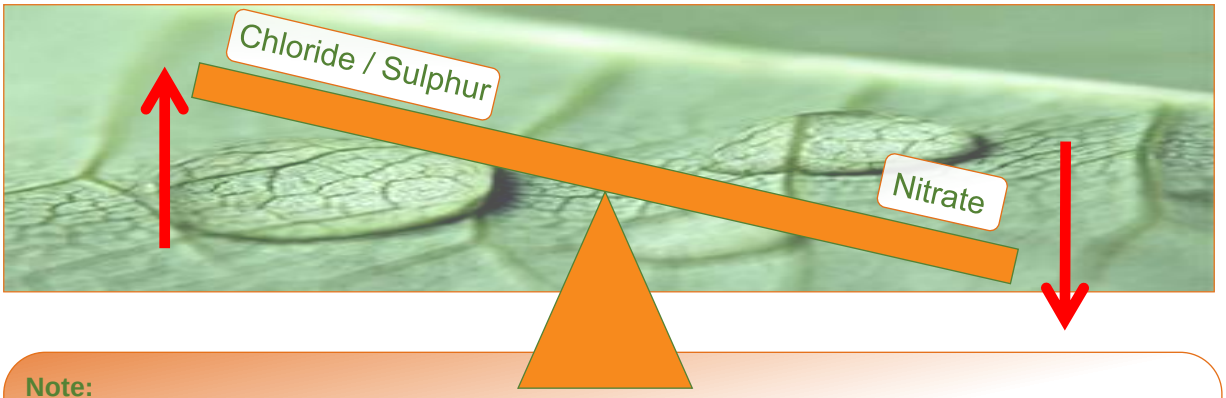

Note:
- Lower Nitrate uptake results in higher Sugar levels (Healthier plant and better fruit taste).
- Lower Nitrate uptake: In fertilizer recipe higher S, Cl (and P) with the same EC result in a decrease of NO3.

- Higher Sulphur helps Nitrate conversion to Proteins
- High Chloride also decreases the uptake of Phosphorus.

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Antagonistic interactions

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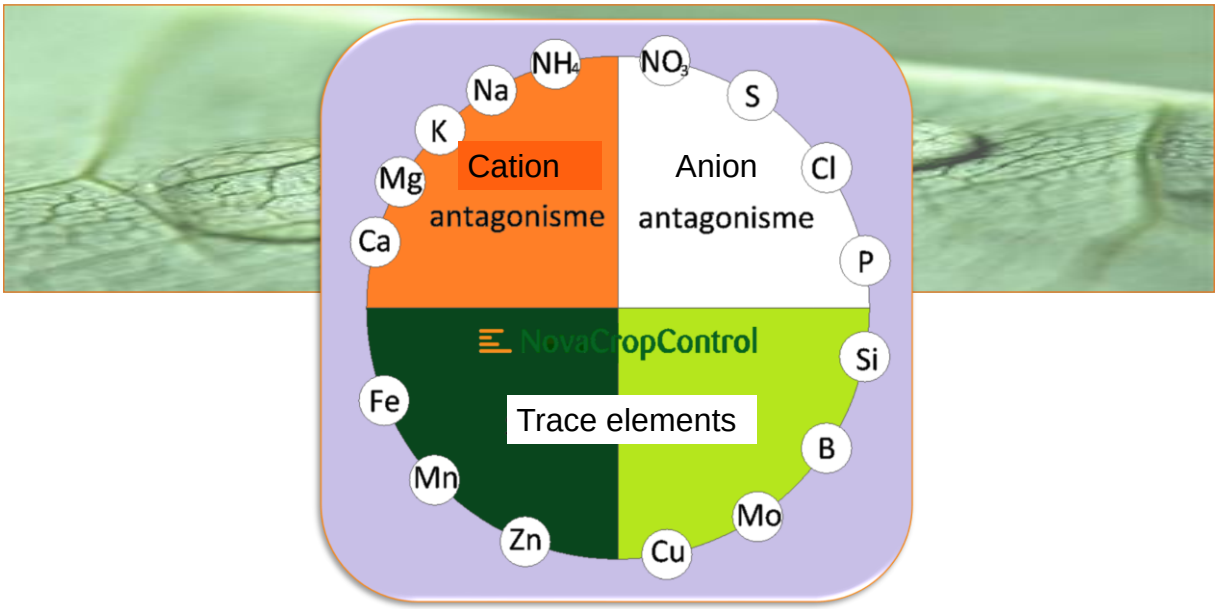

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Antagonistic interactions

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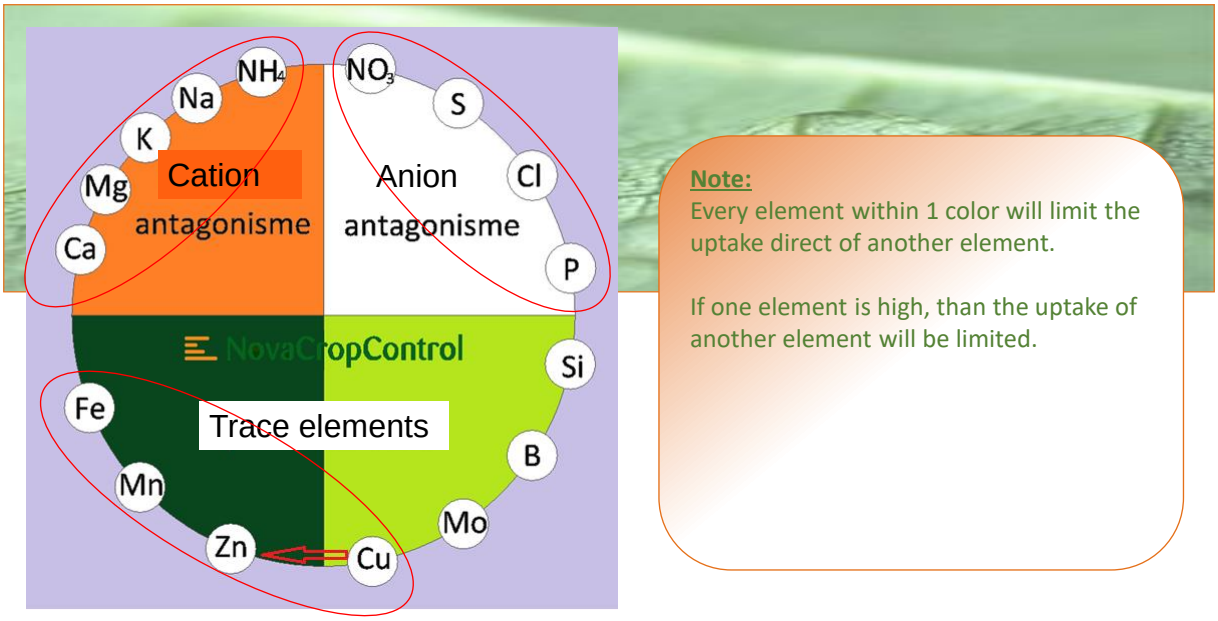

Note:
Every element within 1 color will limit the uptake direct of another element.

If one element is high, than the uptake of another element will be limited.

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Antagonistic interactions

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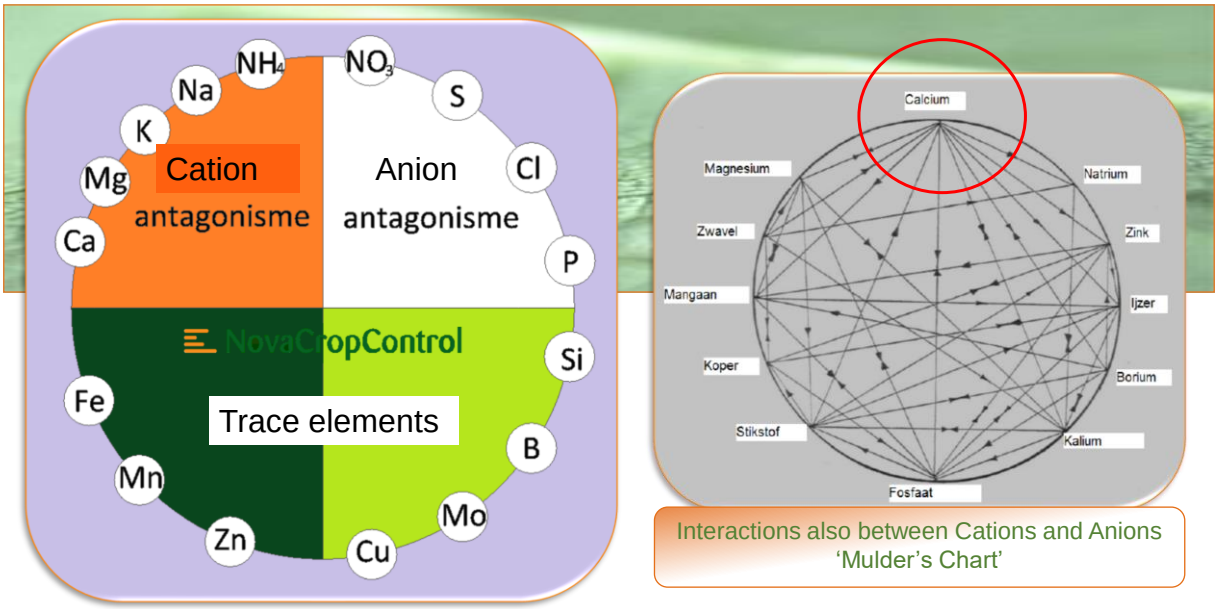

Interactions also between Cations and Anions
'Mulder's Chart'

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The influence of one element on the rest

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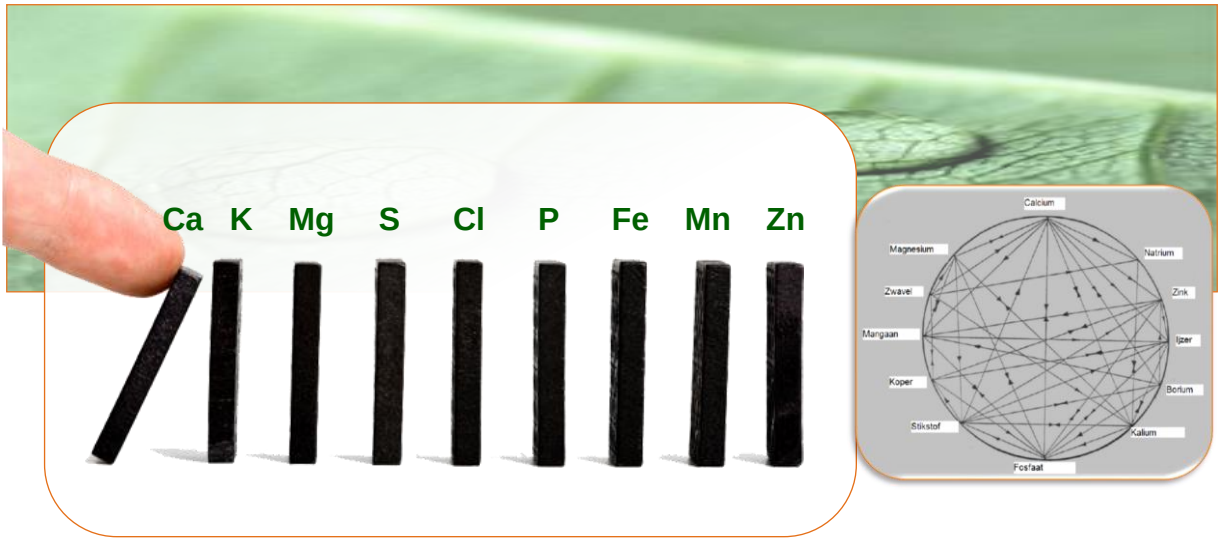

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Antagonistic interactions

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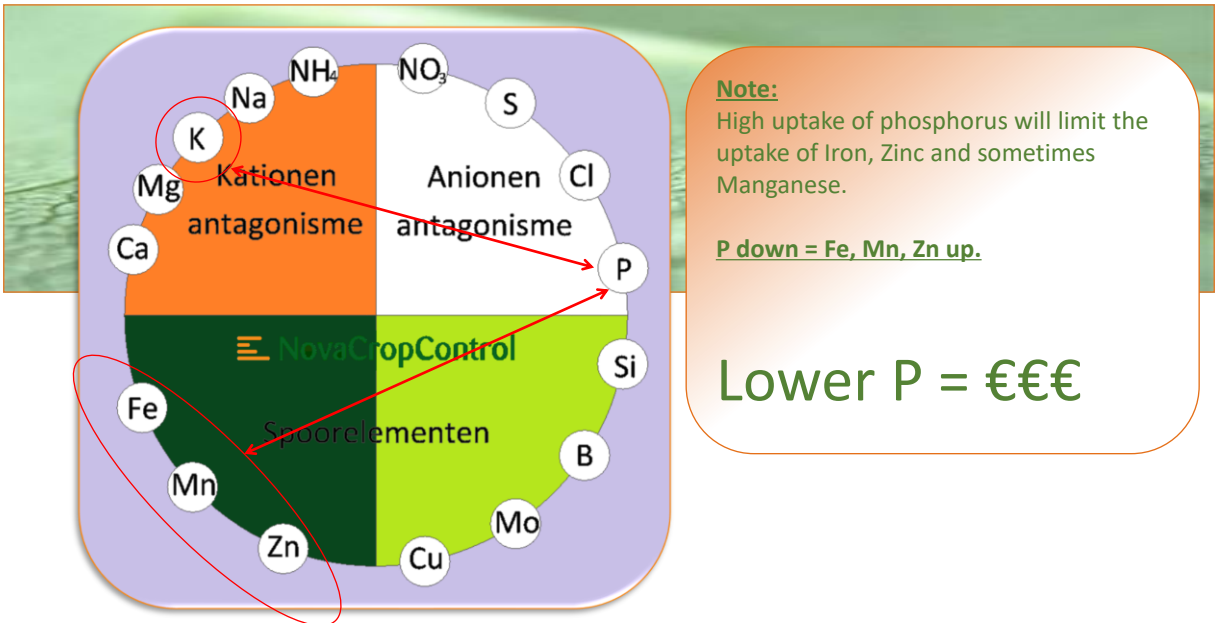

Note:
High uptake of phosphorus will limit the uptake of Iron, Zinc and sometimes Manganese.

P down = Fe, Mn, Zn up.

Lower P = €€€

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Impact of phosphate on potassium uptake

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Note:
- Idea: Better coloration of tomatoes in the winter
- Ascending P fertilization, equal K fertilization
- 2 varieties: Volantis and Romindo

	EC	pH	NH4	K	Na	Ca	Mg	NO3	Cl	SO4	HCO3	P	Si	Fe	Mn	Zn	B	Cu	Mo
Analyse																			
Streefwaarde																			
Basis v.o.	3,0		0,00	6,00	x	8,50	3,50	17,50	4,00	3,50	x	1,50		45	15	10	50	1,50	1,00

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Impact of phosphate on potassium uptake

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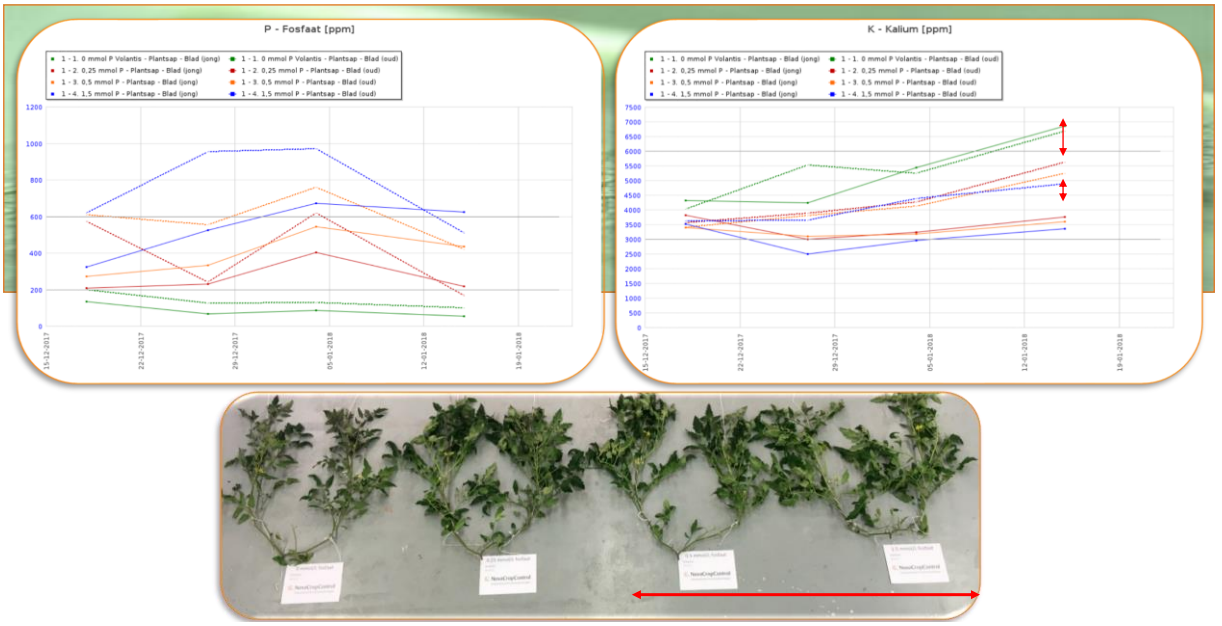

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Phosphorus blocks the uptake of trace elements

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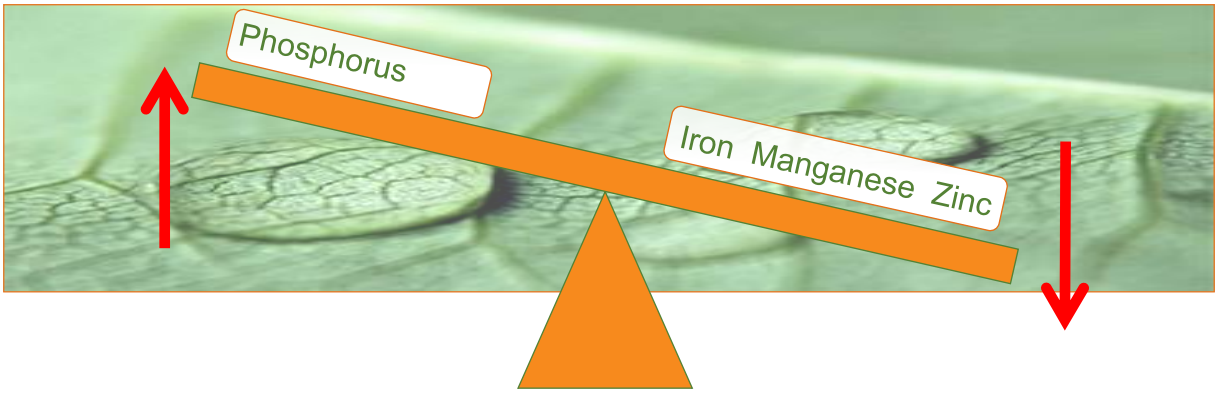

Note:

- Phosphate is important for sugar transport and healthy roots
- But too high phosphate inhibits the uptake of Iron, Manganese and Zinc.

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Influence of P and Mn on the Fe uptake

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Test influence of phosphorus and Manganese on Iron uptake:

- Test October - November 2019
- Irrigation EC: 3.0
- 7 Treatments
- Indoor under artificial lighting
- pH 5.4 - 5.6

Treatments	Phosphorus mmol/l	Iron µmol	Manganese µmol
Treatment 1	1 mmol	35	20
Treatment 2	1 mmol	0	20
Treatment 3	0 mmol	0	20
Treatment 4	0 mmol	35	20
Treatment 5	2 mmol	35	20
Treatment 6	2 mmol	0	20
Treatment 7	1 mmol	0	60

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Influence of P and Mn on the Fe uptake

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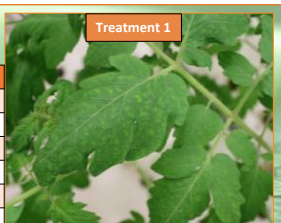
Treatments	P mmol/l	Fe µmol	Mn µmol
Treatment 1	1 mmol	35	20
Treatment 2	1 mmol	0	20
Treatment 3	0 mmol	0	20
Treatment 4	0 mmol	35	20
Treatment 5	2 mmol	35	20
Treatment 6	2 mmol	0	20
Treatment 7	1 mmol	0	60

Treatment 1

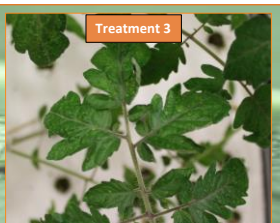


P - Phosphorus ppm	Fe - Iron ppm	Mn - Manganese ppm
787,1	0,97	8,6

Treatment 2

P - Phosphorus ppm	Fe - Iron ppm	Mn - Manganese ppm
700,3	0,85	16,4

Treatment 3



P - Phosphorus ppm	Fe - Iron ppm	Mn - Manganese ppm
98,8	3,48	35,6

Treatment 4

P - Phosphorus ppm	Fe - Iron ppm	Mn - Manganese ppm
99,4	6,40	33,2

Treatment 5

P - Phosphorus ppm	Fe - Iron ppm	Mn - Manganese ppm
828,8	1,12	7,6

Treatment 6

P - Phosphorus ppm	Fe - Iron ppm	Mn - Manganese ppm
901,0	0,80	17,4

Treatment 7

P - Phosphorus ppm	Fe - Iron ppm	Mn - Manganese ppm
721,1	0,70	35,6

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Influence of P and Mn on the Fe uptake

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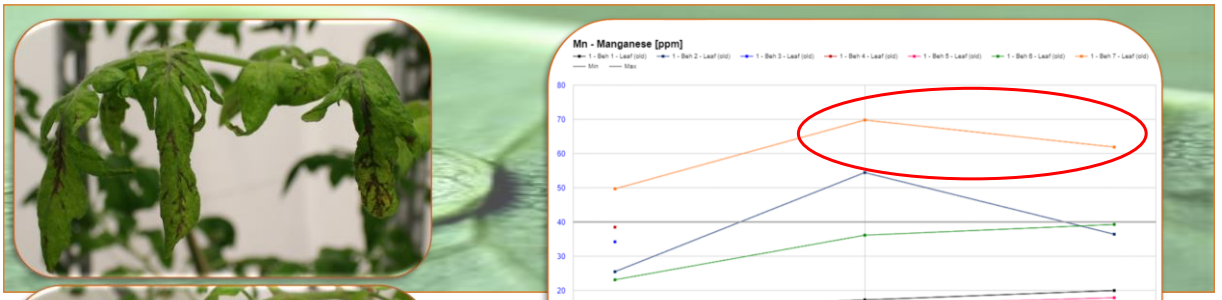

Treatments	P mmol/l	Fe µmol	Mn µmol
Treatment 1	1 mmol	35	20
Treatment 2	1 mmol	0	20
Treatment 3	0 mmol	0	20
Treatment 4	0 mmol	35	20
Treatment 5	2 mmol	35	20
Treatment 6	2 mmol	0	20
Treatment 7	1 mmol	0	60

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Antagonistic interactions

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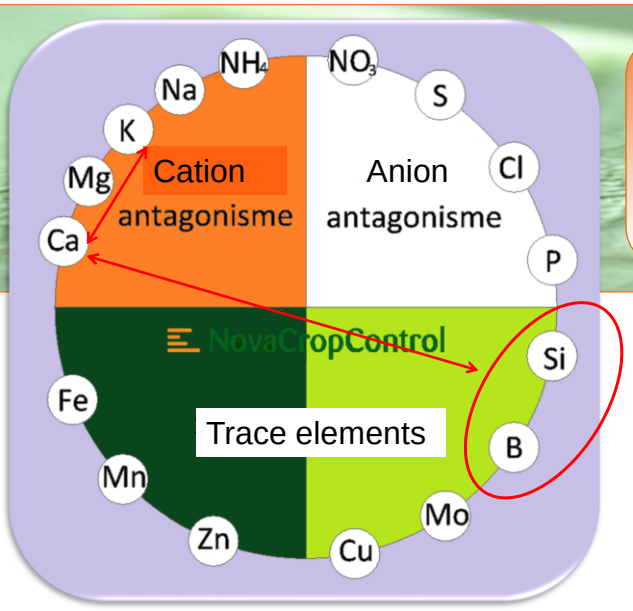

Note:

- Higher uptake of Silica will lead to a higher Calcium uptake.
- A lower uptake of Calcium could lead to an excess of Boron

Albino fruit: result of to high Si

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Antagonistic interactions

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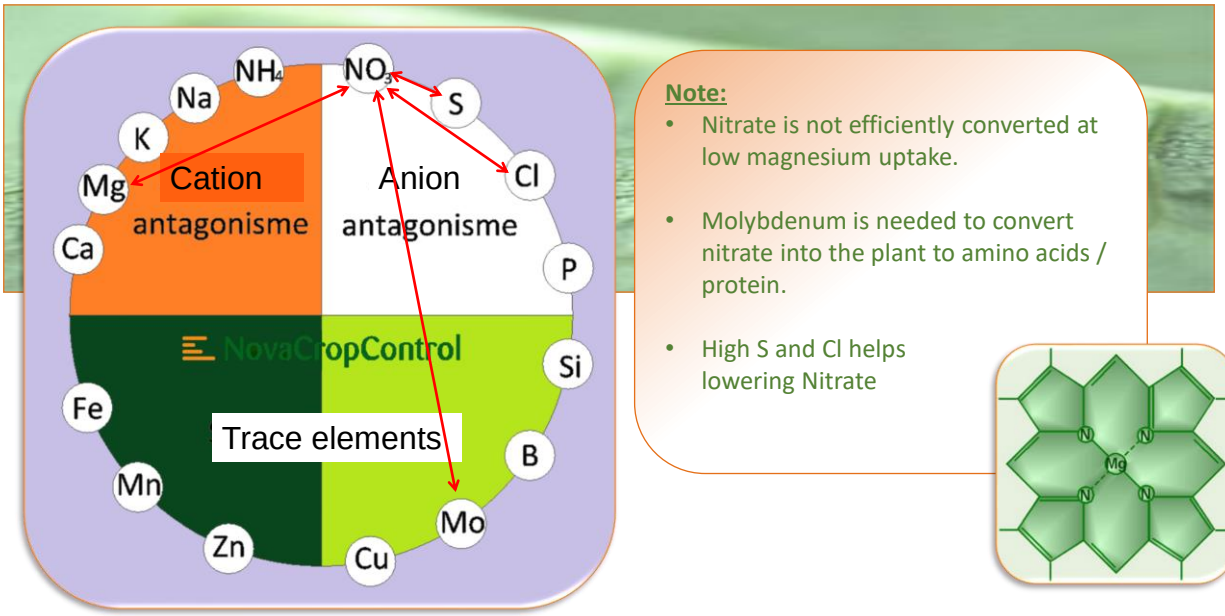

Note:

- Nitrate is not efficiently converted at low magnesium uptake.
- Molybdenum is needed to convert nitrate into the plant to amino acids / protein.
- High S and Cl helps lowering Nitrate

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Functions of minerals

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Element	Advantage	Disadvantage
Sugars	Vital crop, efficient photosynthesis, increased natural resistance and shelf life.	Too high concentrations indicate that the plant is not "working". This will cost production.
EC	Sufficient dissolved minerals are needed for plant growth. Keep in mind: Which minerals are building the EC? The "good", or the "bad" ones?	A high EC will result in leaf burning; low EC values will cause slow growth.
pH	In the low pH range, micronutrients and phosphorus are better available.	Low pH will limit the uptake of macronutrients.
N	**Growth**, leaf and stem mass, vegetative crop stage.	Too vegetative crops, or not developing to the reproductive stage. High Nitrate-Nitrogen causes susceptibility for: **Powdery mildew, botrytis, aphids, spider mite, thrips.**
P	A **good root system**, fertile flowers.	Micronutrients are being **limited in uptake**, first Fe, then Zn and then Mn.
K	Effect on fruit **colour**, producing **firm fruits**. Stimulating growth. Sufficient K will **avoid** leaf burning in illuminated cultivations.	Suppresses Ca in uptake = blossom end rot, excess will cause vegetative growth, limits Mg uptake.
Ca	**Avoiding blossom end rot**, firm fruit skin/cells.	Relatively few disadvantages, Mg and K are less available for uptake.
Mg	**Efficient NO3 conversion**, healthy growth. Important for chlorophyll production.	High Mg will result in lower K and Ca uptake.

Element	Advantage	Disadvantage
S	**Efficient NO3 conversion**, healthy growth. Important for protein production.	Acid soil conditions, pH will drop and an extreme uptake of Mn, even till toxic concentrations.
Cl	Healthy growth, **efficient NO3 conversion.**	Competition with NO3 in uptake, can lead to N deficiency.
Fe	Green **leaf colour**, without spots, **avoiding yellow plant heads**.	High Fe results in lower Mn and Zn uptake.
Mn	Green **leaf colour**, without spots, low **fungal susceptibility**	High Mn results in lower Zn and Fe uptake. **High Mn = calyx burning** and fungi growth in the end.
Zn	Green **leaf colour**, without spots, **prevents leaf burning in illuminated cultivations.**	High Zn results in lower Mn and Fe uptake.
B	Stimulates Ca uptake, **ensures firm fruit connection to the vine, limits yellow calyxes. Improved fruiting. Less vine breaking.**	**Toxic** for plants, first leaf tip discolouration, followed by plant die off.
Cu	Limits fungal susceptibility from inside the plant, e.g. **calyx fungi**.	Results in lower Fe and Zn uptake, produces firm crops, slower growth.
Si	Stimulates Ca uptake, firm leaves. Decreases **powdery mildew, botrytis, yellow calyxes and calyx fungi**.	Up to now no disadvantages in tomato, in soft fruits K uptake will be lower, caused by high Ca uptake.
Mo	Necessary for **enzyme processes** for NO3 conversion, healthy growth.	Unknown, can be toxic when concentrations increase too much.

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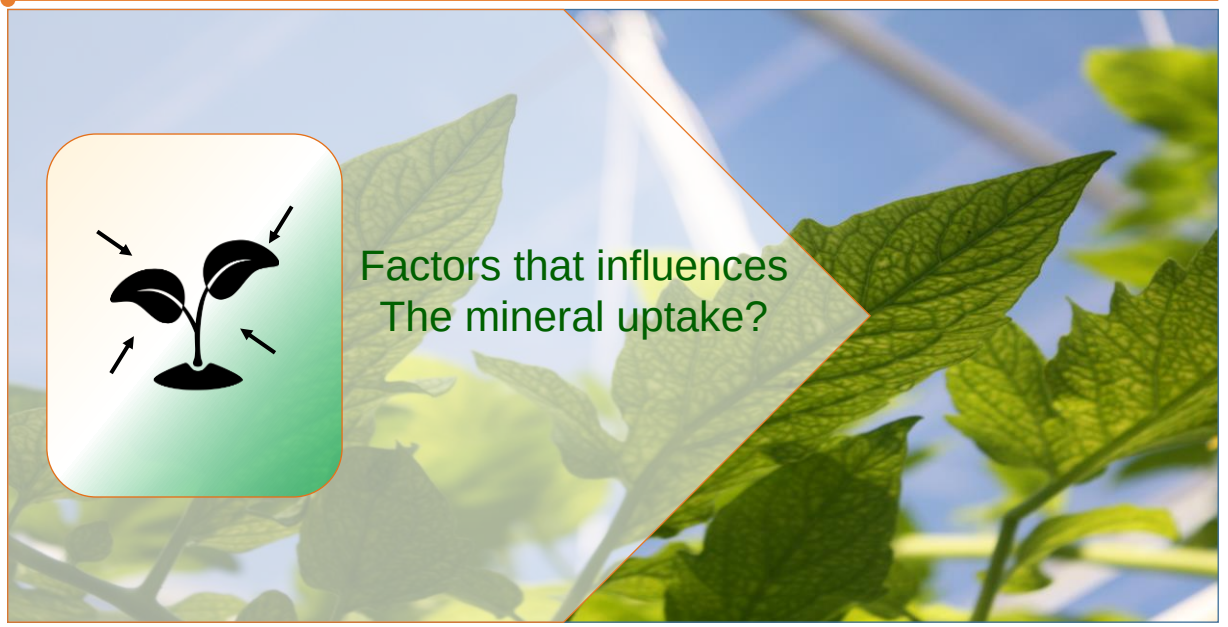

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Factors that influence the mineral uptake

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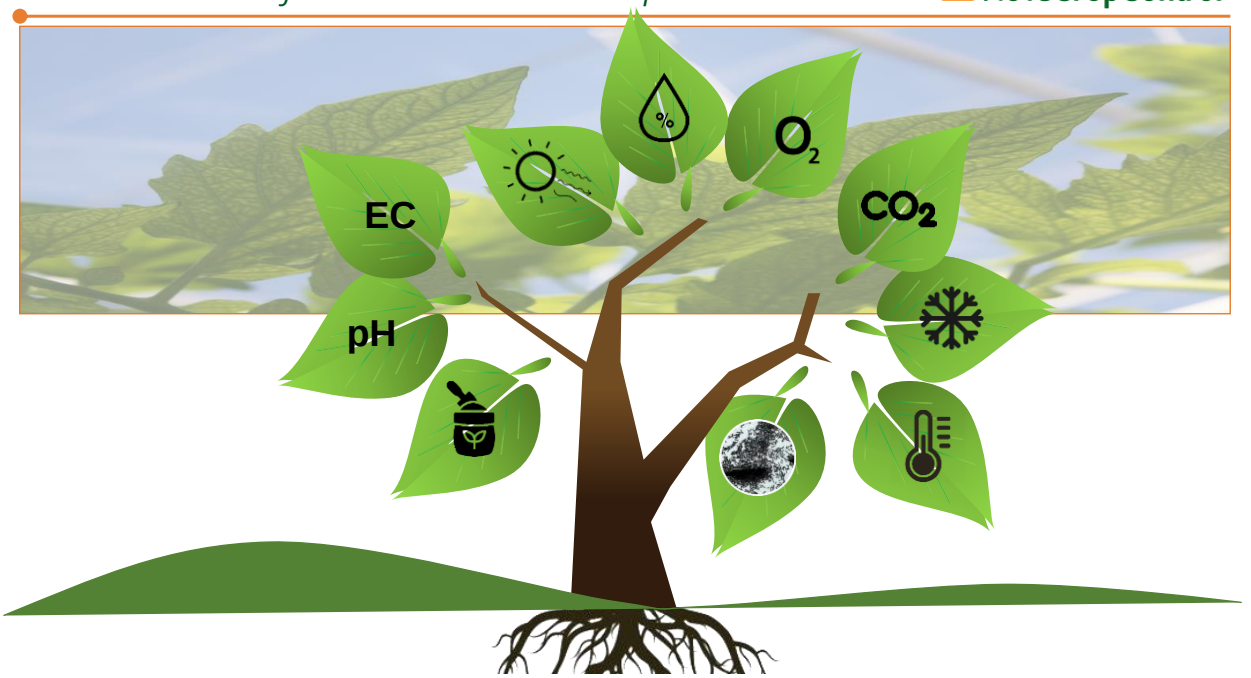

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Factors that influence the mineral uptake

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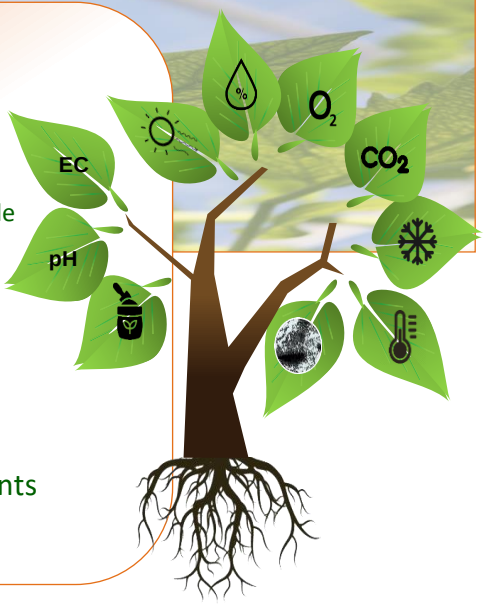
- pH of the soil / substrate / irrigation water
- Imbalance in minerals
- Soil type, quality substrate
- Plant stage (LAI, fruit load etc)
- Release of fertilizers
  - Moment of application with when to becoming available
- Soil structure, rooting, Soil biology
- Climate, temperature, light, moisture, oxygen
- Quality of irrigation water
  - Bicarbonate, pH, Oxygen, micro life
  - Sodium, recirculation, ballast for fertilizers

_____+/-

Current mineral uptake → plant sap measurements



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Acidity influence on nutrition uptake soil

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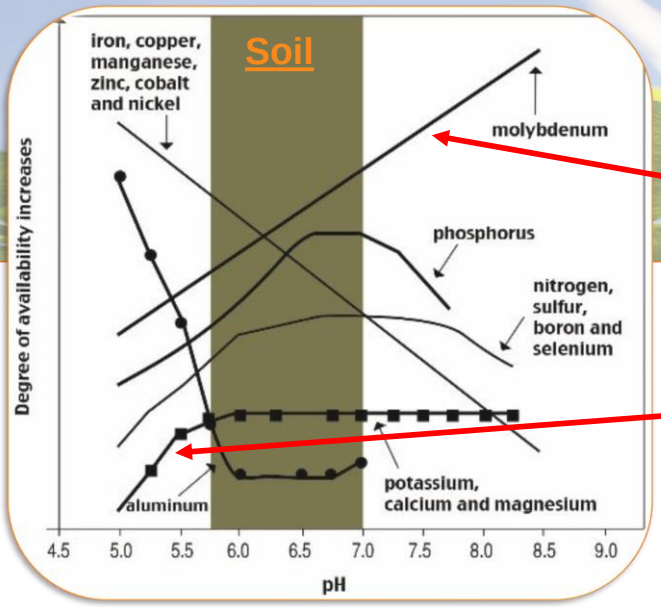

High pH decreases uptake of:

- P (above 7 fixed)
- Trace elements (Fe, Mn, Zn, Cu)
- Mo higher uptake

Low pH: decreases uptake of:

- P
- Mo
- Cations K, Ca, Mg
  N, S, B
- Aluminium higher uptake (indication in plant sap)

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Acidity influence on nutrition uptake soil

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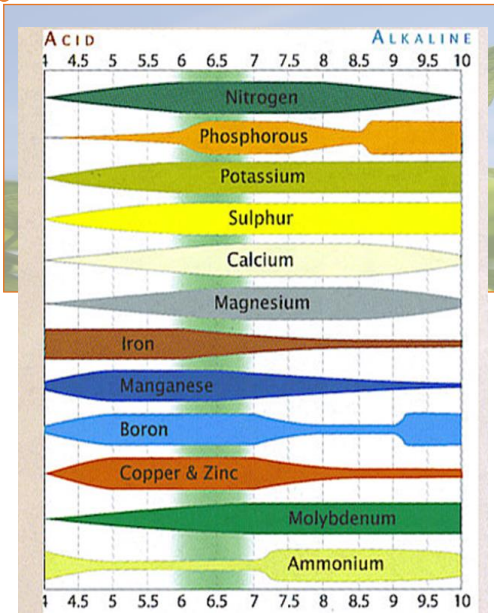

Another picture but now shown separately

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Manganese uptake vs pH

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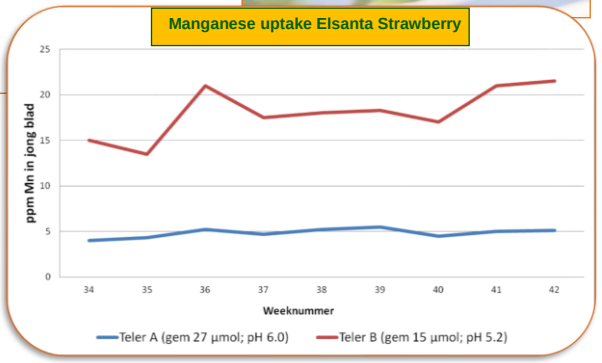
Higher dosage will not always result in a higher uptake

pH of the soil or irrigation water
- Stagnation uptake of trace elements
- Acid conditions, root development problems

Example of the effect of pH on Manganese.
- Strawberry in glasshouse on same substrate
- High supply Mn, lower uptake by the high pH of the irrigation water

	Manganese Drip water	pH Drip water
Grower A	27 µmol	6.0
Grower B	15 µmol	5.2



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Soiltype influence on nutrition uptake

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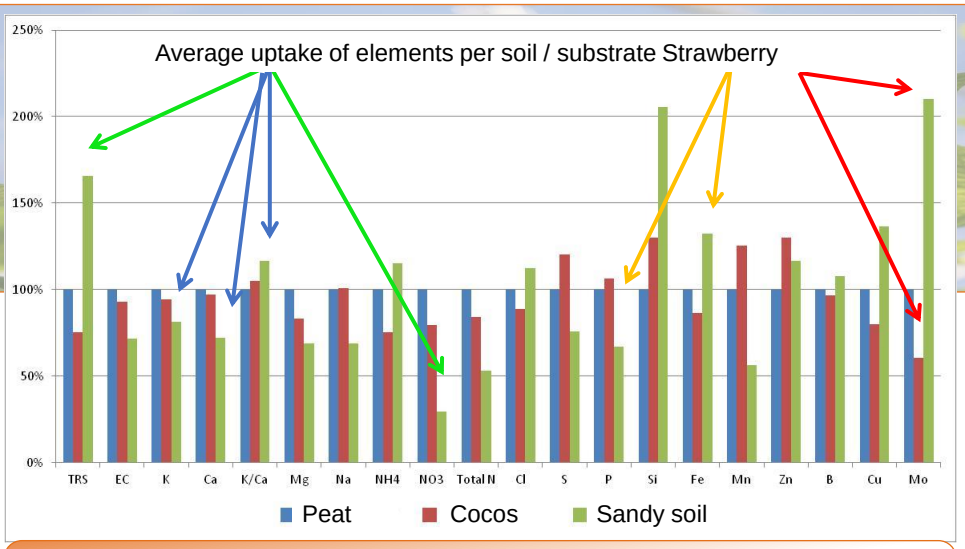

Soil type has a big influence on the nutrition uptake.

- Low Nitrate = high sugars
- Cocos fixes Molybdenum
- Different K/Ca
- Low Phosphorus = higher Iron

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Soillife influence on the Nutrient uptake

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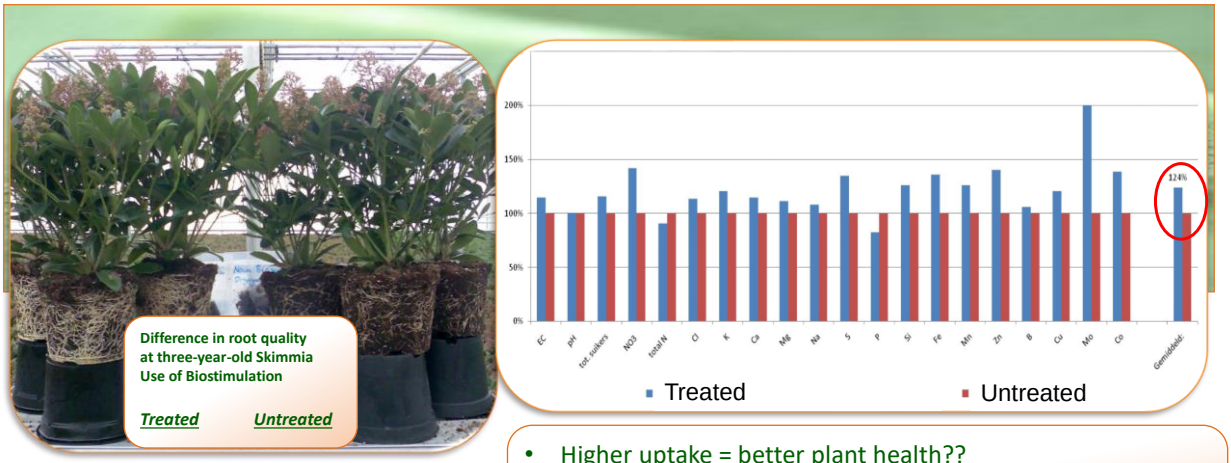

- Higher uptake = better plant health??
- Might lower the feed, to avoid excess of some elements
- More roots = better uptake

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Soil life influence on the Nutrient uptake

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Not treated, 15 cm deep

Treated, 45 cm deep

Treated:
- Ca/Mg/K balanced by Albrecht method
- Compost as inoculant
- Root stimulating (seaweeds, humic acids)

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Quality of root hairs

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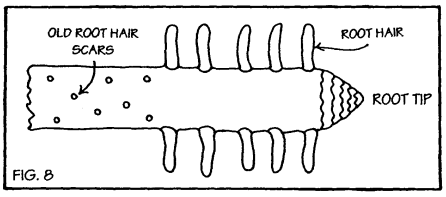
- Root hairs are located at the end of the roots
- Root hairs "just" live 10 up to 12 days
- Nutrients in the soil solution can only be taken up by these hair roots
- Root hairs are important for Calcium uptake
- Healthy root development: Structure, biology, moisture, oxygen

Nutrient uptake as a comparison: Beer from a straw (bad rooting) or from the mug (good rooting).



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Root growth influence on nutrition uptake

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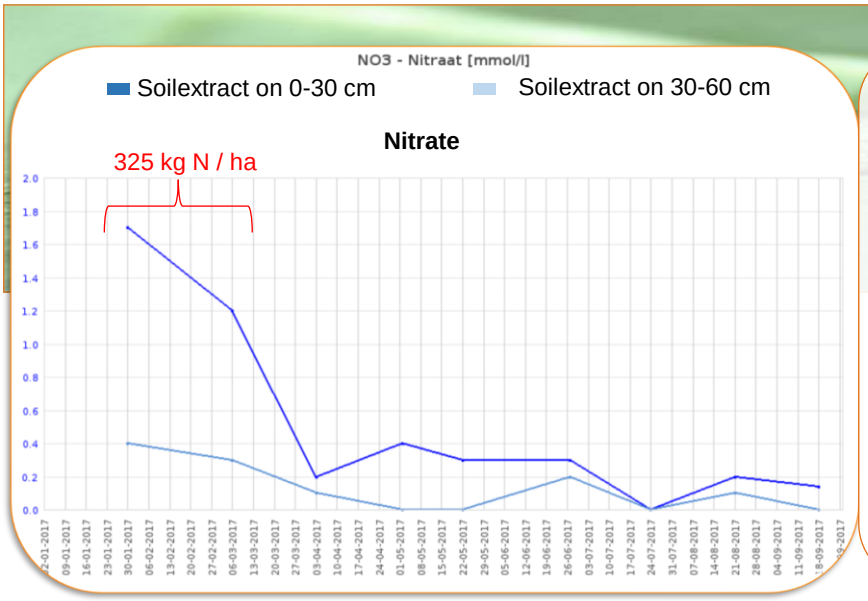

Cultivation organic tomato:
Sandy soil
Organically fertilized with compost

Aim: keep nitrogen low for resilience, generativity and taste

1 mmol N / L = 155 kg / ha / 30 cm

Need Tomato bio = 800 kg N / ha / year

On 30-1-17:
1.7 + 0.4 = 2.1 mmol = 325 kg N available!

Almost the half of what is needed for one year available!

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Root growth influence on nutrition uptake

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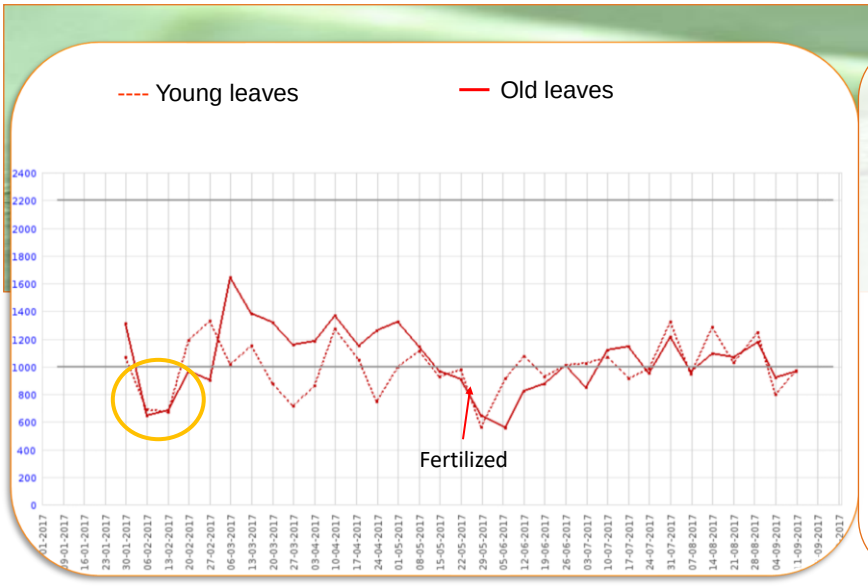

- Dip in nitrogen uptake despite high availability in the ground.
- Rooting, root growth not yet in order.
- Deeper layer not yet reached..

Why?????

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Root growth influence on nutrition uptake

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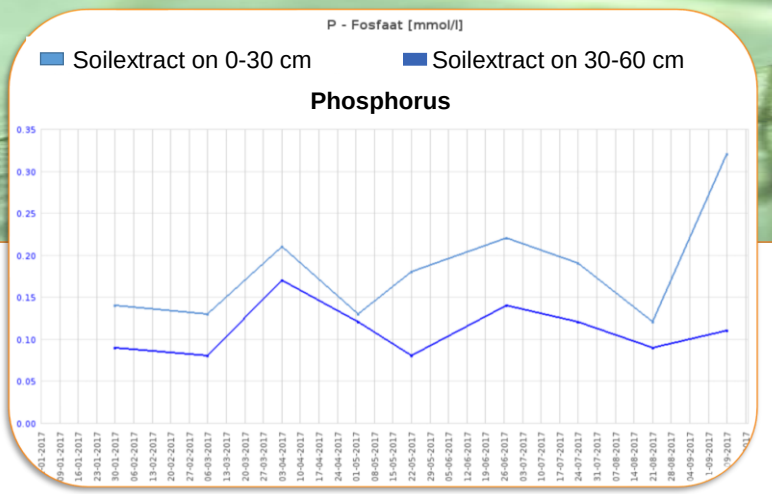
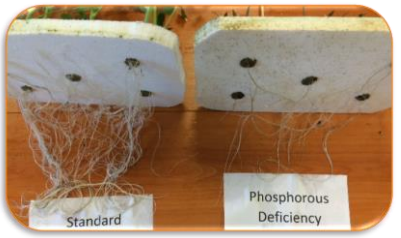


- Possible cause: Low Phosphate = bad root development?
- Available phosphate is low. In the top layer even lower than in the bottom layer.



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Oxygen influence on nutrition uptake

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The importance of sufficient oxygen in the soil is often underestimated:

- Roots need enough oxygen to burn sugars optimally.
- With the released energy, they remain active, so that they are able to absorb fertilizers, so that the plant can grow and produce.
- Soil life also benefits from sufficient oxygen.
- Causes of lack of oxygen:
  - A soil / slab saturated with water.
  - Too high soil / mat temperature
- With a lack of oxygen, the plant not only receives less nutrition, but also becomes more susceptible to root diseases due the less root growth.

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Oxygen influence on nutrition uptake

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Enough Oxygen

Oxygen poor

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Oxygen influence on nutrition uptake

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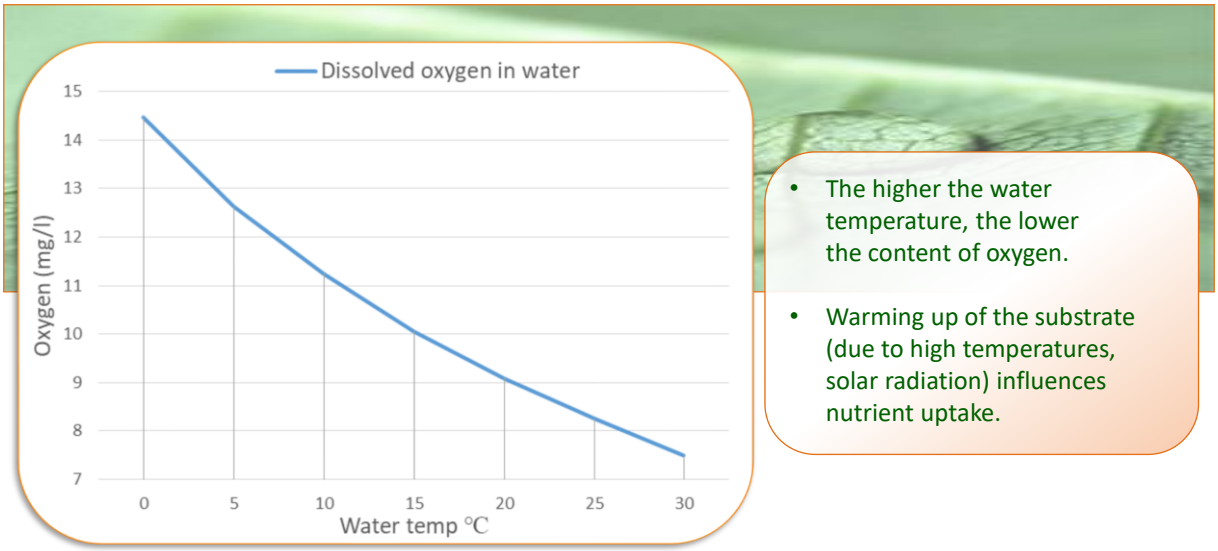

- The higher the water temperature, the lower the content of oxygen.
- Warming up of the substrate (due to high temperatures, solar radiation) influences nutrient uptake.

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Have you eaten enough or still hungry??

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Eyes bigger than the mouth

Plate empty:

- Have had enough or still hungry
- Differents between Irrigation and drain water = uptake???
- Potassium in the drain 0 mmol/l.
- Increase feed or has the plant enough Potassium?

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Why measure in the plant?

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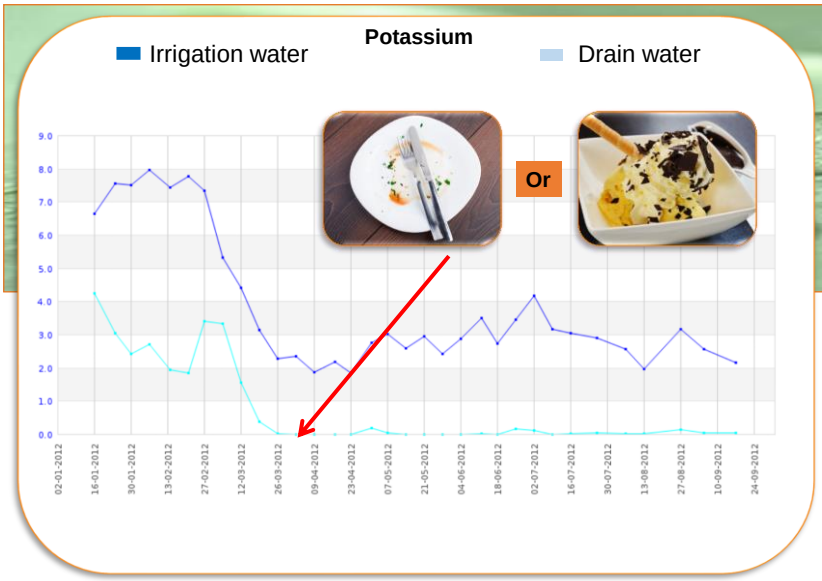

Potassium feed lowered in the irrigation water until the drain dropped to +/- 0 mmol.

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Why measure in the plant?

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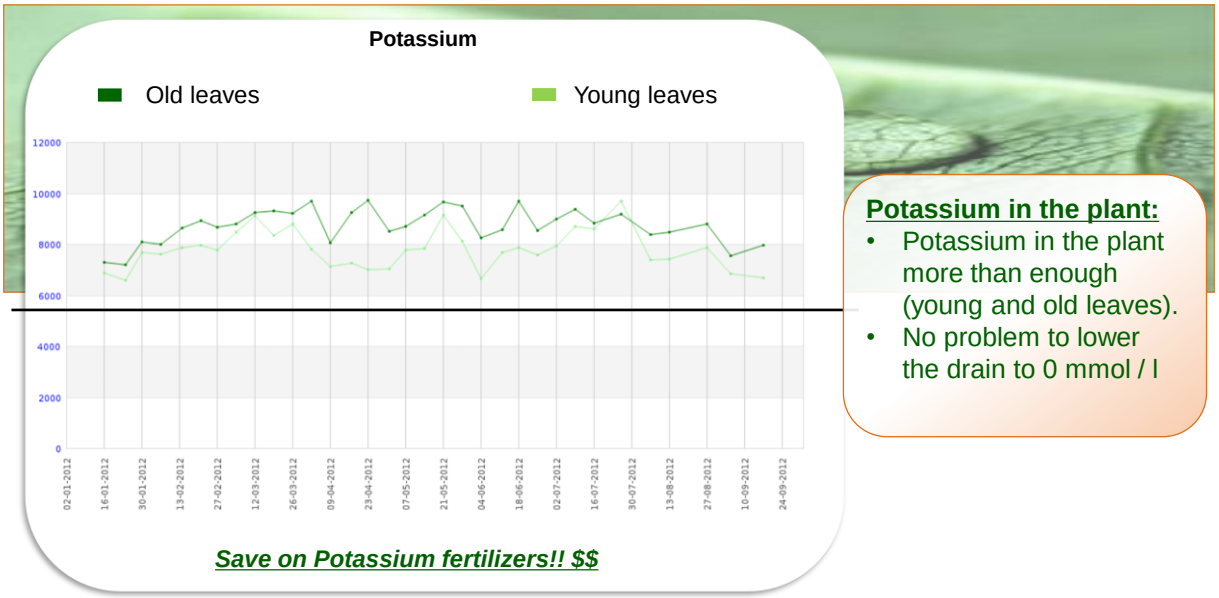

Save on Potassium fertilizers!! $$

Potassium in the plant:

- Potassium in the plant more than enough (young and old leaves).
- No problem to lower the drain to 0 mmol / l

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Soil vs Plant

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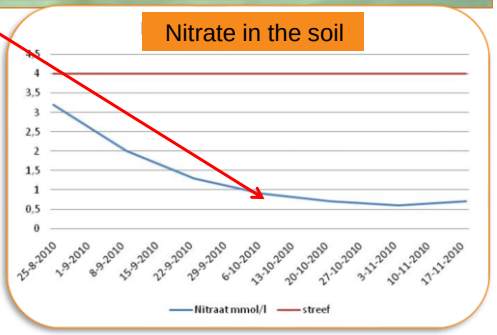
Datum	Omschrijving	Monsternr	EC	EC[c]	pH	NH_4^+	K^+	Na^+	Ca^{2+}	Mg^{2+}	Si	NO_3^-	Cl^-	SO_4^{2-}	HCO_3^-	P_{tot}	Fe	Mn	Zn	B	Cu	Mo
			mS/cm			mmol/l waterextract											µmol/l waterextract					
25-08-2010	Kokos/veen aardbei	1310075	0.4	**0.8**	5.4	0.1	2.3	0.3	1.3	0.6	<0.05	3.2	0.2	1.1	<0.1	0.51	7.4	0.7	1.3	<4	0.27	<0.1
09-09-2010	Kokos/veen	1312072	0.7	**0.8**	5.4	0.2	1.8	0.5	1.9	0.8	<0.05	2.0	0.1	1.9	<0.1	0.76	12.3	1.8	3.6	7	0.27	<0.1
09-09-2010	Water put	1312075	0.7	**0.8**	5.3	<0.1	1.1	0.7	2.0	0.8	0.20	2.4	0.7	1.5	<0.1	<0.05	2.4	10.6	4.3	<4	0.27	<0.1
23-09-2010	Veen/kokos Aardbei	1314355	0.6	**0.8**	5.5	0.1	1.0	0.5	1.6	0.7	<0.05	1.3	0.2	1.6	<0.1	0.43	11.6	0.6	1.9	<4	0.23	<0.1
07-10-2010	Veen/kokos	1316843	0.9	**0.8**	5.5	0.1	0.5	0.7	2.5	1.1	<0.05	0.7	0.2	2.8	<0.1	0.46	9.7	1.3	2.4	<4	0.17	<0.1
21-10-2010	Kokos/ Veen Aardbei	1319900	0.9	**0.8**	4.9	0.2	0.5	0.8	2.8	1.2	<0.05	0.9	0.2	3.1	<0.1	0.43	11.5	1.3	1.9	<4	0.20	<0.1
04-11-2010	Kokos/veen	1322345	0.9	**0.8**	5.1	0.1	0.5	0.9	2.9	1.3	<0.05	0.6	0.2	3.6	<0.1	0.28	10.1	0.7	1.7	<4	0.15	<0.1
18-11-2010	Kokos/ Veen Aardbei	1324519	0.9	**0.8**	5.2	0.1	0.5	0.8	3.0	1.2	<0.05	0.7	0.2	3.5	<0.1	0.32	11.0	1.2	2.0	<4	0.10	<0.1
Streefwaarden	Aardbei, veensubstraat		0.7	**0.8**	5.9	0.4	1.9		1.7	0.7		4.0		1.1		0.34	9.1	5.7	6.9	5	0.80	

Relationship between available nitrogen in soil and plant uptake in strawberry:

- Planted on the 25th of August
- Nitrate in the soil drops from 3.2 to 0.7
- Desired nitrate content in the soil 3.5 to 4
- The soil provides exactly what the plant needs



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Soil vs Plant

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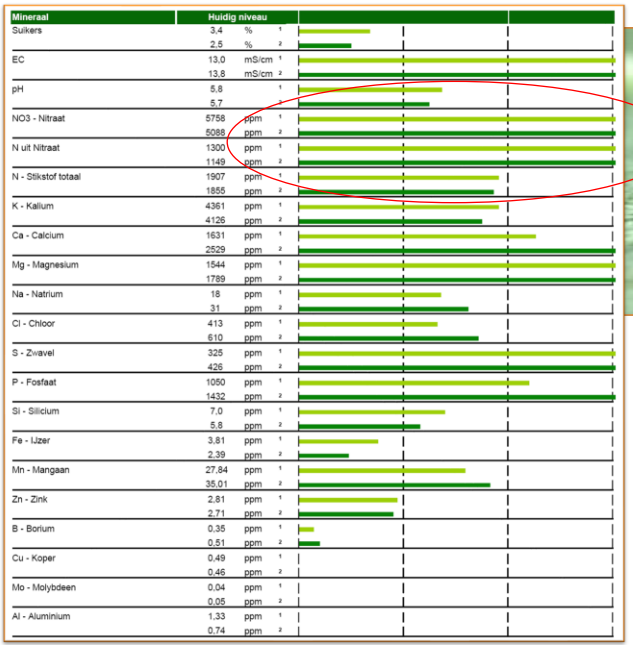
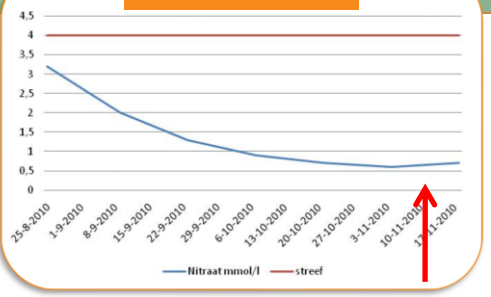


Mineraal	Huidig niveau		
Suikers	3,4	%	1
	2,5	%	2
EC	13,0	mS/cm	1
	13,8	mS/cm	2
pH	5,8		1
	5,7		2
NO3 - Nitraat	5758	ppm	1
	5088	ppm	2
N uit Nitraat	1300	ppm	1
	1149	ppm	2
N - Stikstof totaal	1907	ppm	1
	1855	ppm	2
K - Kalium	4361	ppm	1
	4126	ppm	2
Ca - Calcium	1631	ppm	1
	2529	ppm	2
Mg - Magnesium	1544	ppm	1
	1789	ppm	2
Na - Natrium	18	ppm	1
	31	ppm	2
Cl - Chloor	413	ppm	1
	610	ppm	2
S - Zwavel	325	ppm	1
	426	ppm	2
P - Fosfaat	1050	ppm	1
	1432	ppm	2
Si - Silicium	7,0	ppm	1
	5,8	ppm	2
Fe - IJzer	3,81	ppm	1
	2,39	ppm	2
Mn - Mangaan	27,84	ppm	1
	35,01	ppm	2
Zn - Zink	2,81	ppm	1
	2,71	ppm	2
B - Borium	0,35	ppm	1
	0,51	ppm	2
Cu - Koper	0,49	ppm	1
	0,46	ppm	2
Mo - Molybdeen	0,04	ppm	1
	0,05	ppm	2
Al - Aluminium	1,33	ppm	1
	0,74	ppm	2

Have had enough or are you still hungry?

Nitrate in the soil



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Varieties differ in uptake from each other

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Elsanta, no deficiency

Sonata, deficiency

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Varieties differ in uptake from each other

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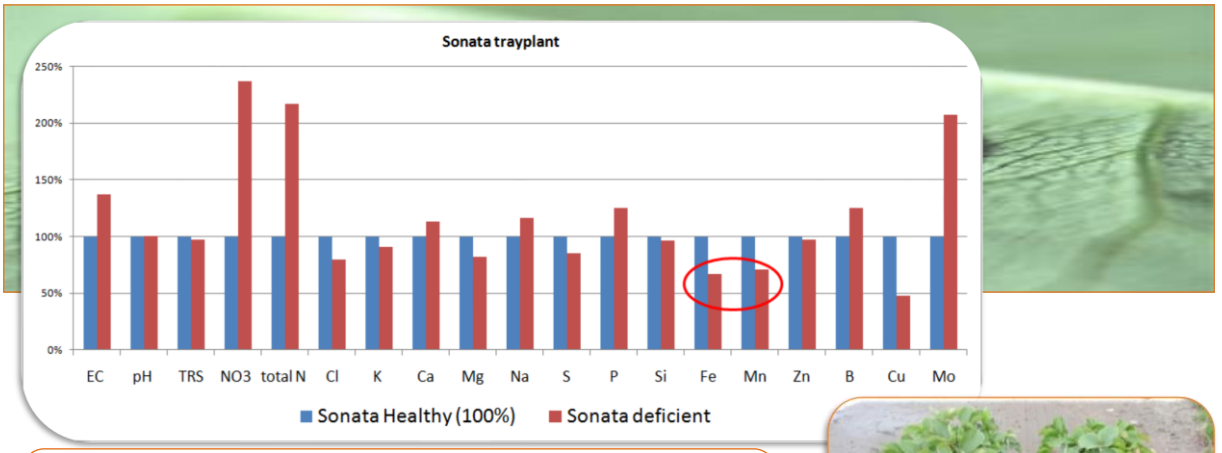

Note:

- High pH of substrate
- Sonata has more difficulty with the uptake of Fe, Mn and Cu

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Rootstock influences nutrient uptake

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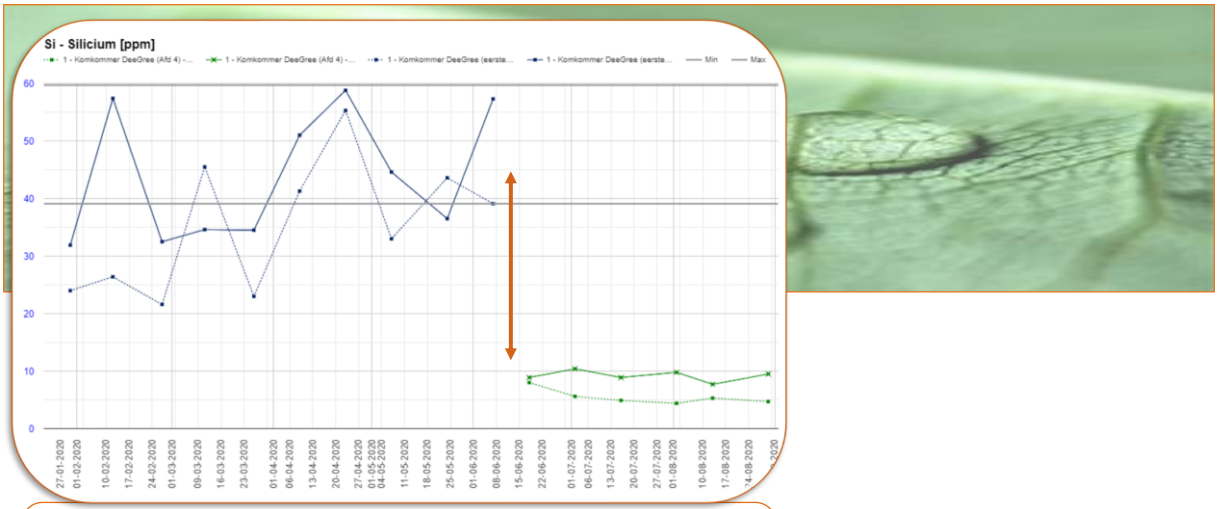

Organic cultivation of cucumbers: Two crops with the same variety (Deegree). Only used a different rootstock for everyone.
Silicon different in absorption.

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Masterclass
Monitoring plant health
Session 2

By:
Eric Hegger

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Subjects

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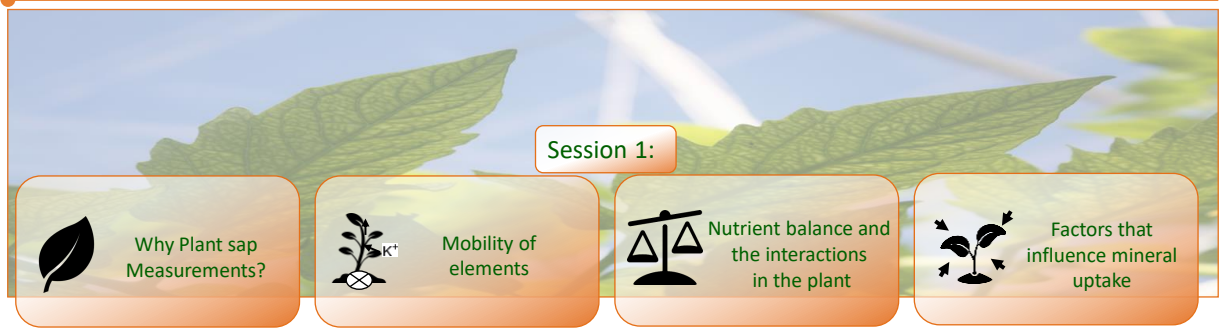

Session 1:

- Why Plant sap Measurements?
- Mobility of elements
- Nutrient balance and the interactions in the plant
- Factors that influence mineral uptake

Session 2:

- Interpreting analyses
- Using bemesting-online
- Nutrition and plant health
- Research on plant health

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Antagonistic interactions

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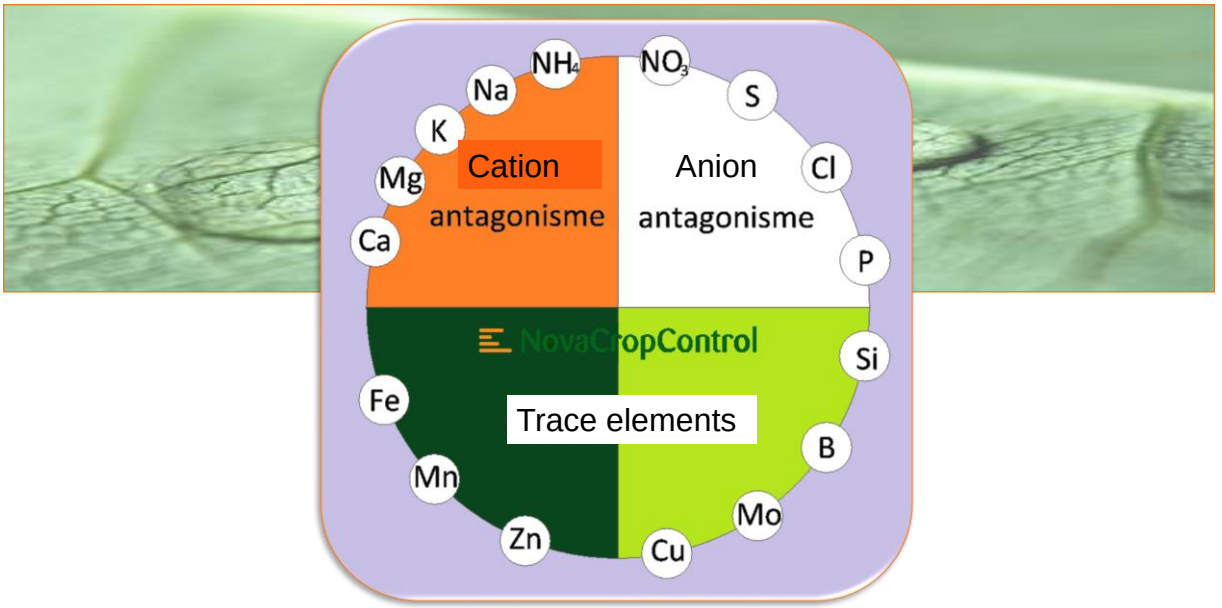

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Factors that influence the mineral uptake

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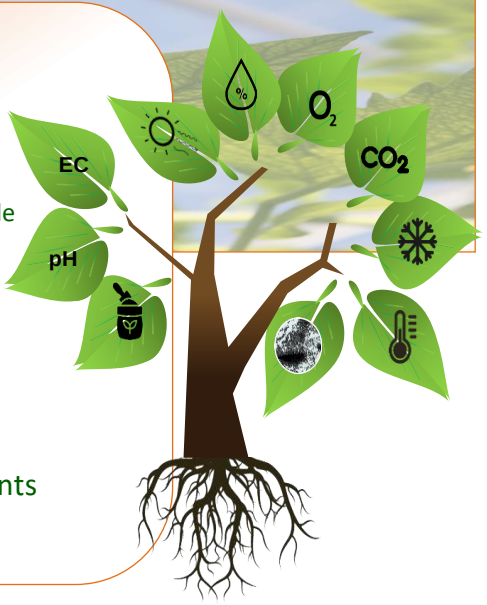
- pH of the soil / substrate / irrigation water
- Imbalance in minerals
- Soil type, quality substrate
- Plant stage (LAI, fruit load etc)
- Release of fertilizers
  - Moment of application with when to becoming available
- Soil structure, rooting, Soil biology
- Climate, temperature, light, moisture, oxygen
- Quality of irrigation water
  - Bicarbonate, pH, Oxygen, micro life
  - Sodium, recirculation, ballast for fertilizers

_____+/-

Current mineral uptake → plant sap measurements



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Interpretation
Analysis

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Interpretation Analysis

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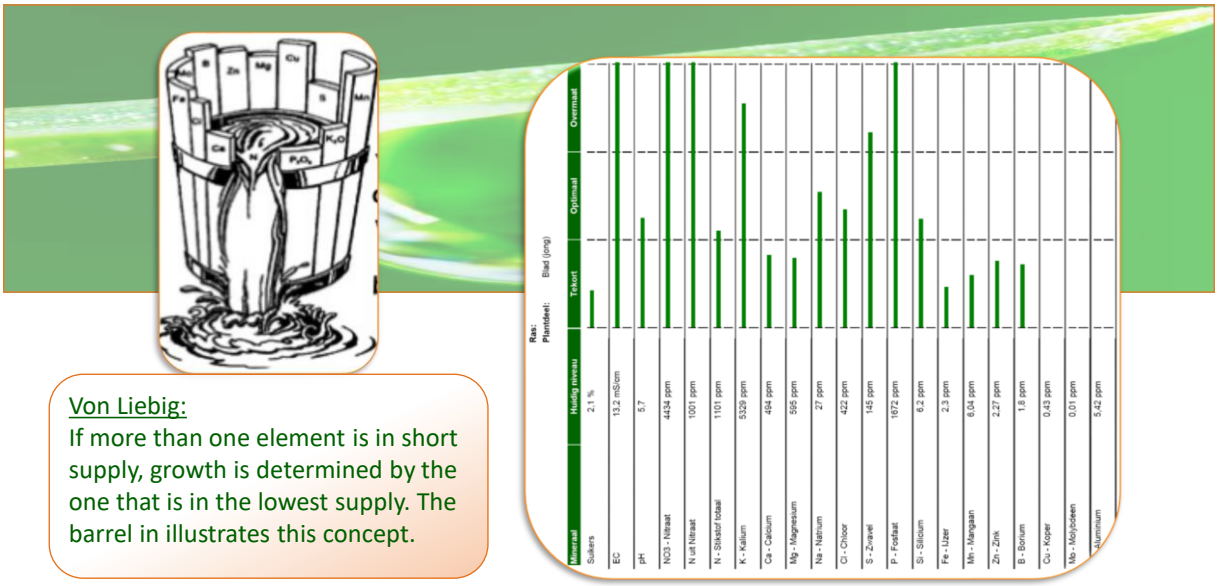

Von Liebig:
If more than one element is in short supply, growth is determined by the one that is in the lowest supply. The barrel in illustrates this concept.

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Interpretation Analysis

NovaCropControl

- Sugars, EC, pH
- Potassium, Calcium, K/Ca, Magnesium, Sodium, Ammonium
- Nitrate, N in Nitrate, Total Nitrogen, Chloride, Sulfur, Phosphorus
- Silica, Iron, Manganese, Zinc, Boron, Copper, Molybdenum, Aluminium

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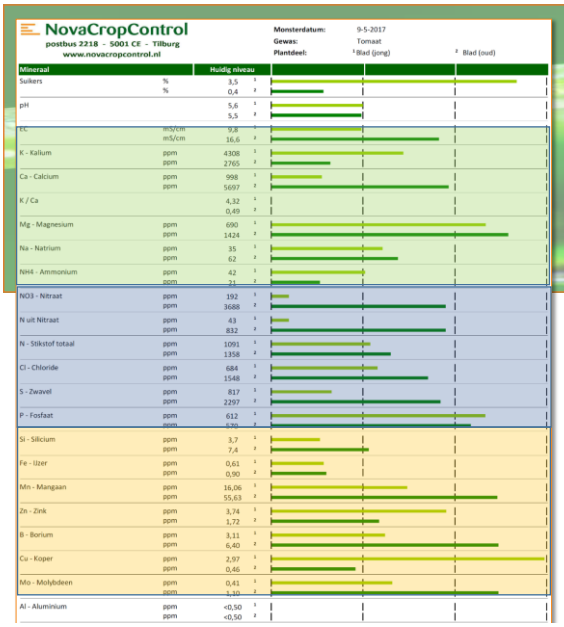
Interpretation Analysis

NovaCropControl



Cations

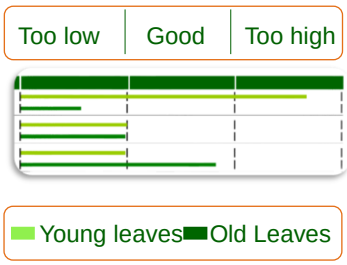
Anions

Trace elements

What do you see?

Think of:

- Deficiency - Excess
- Cause – Effect
- Young – Old
- Interactions



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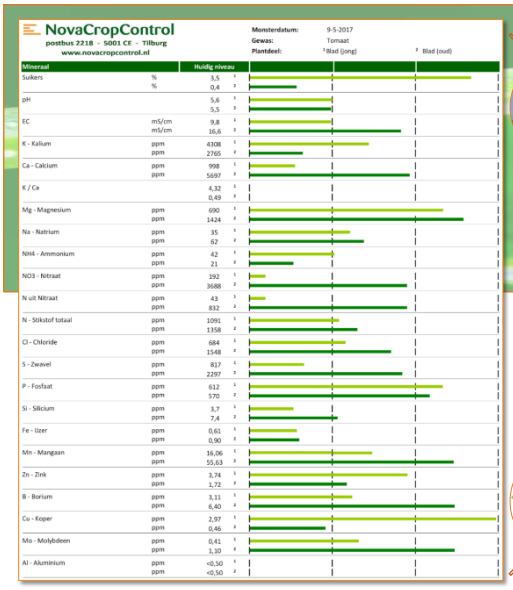
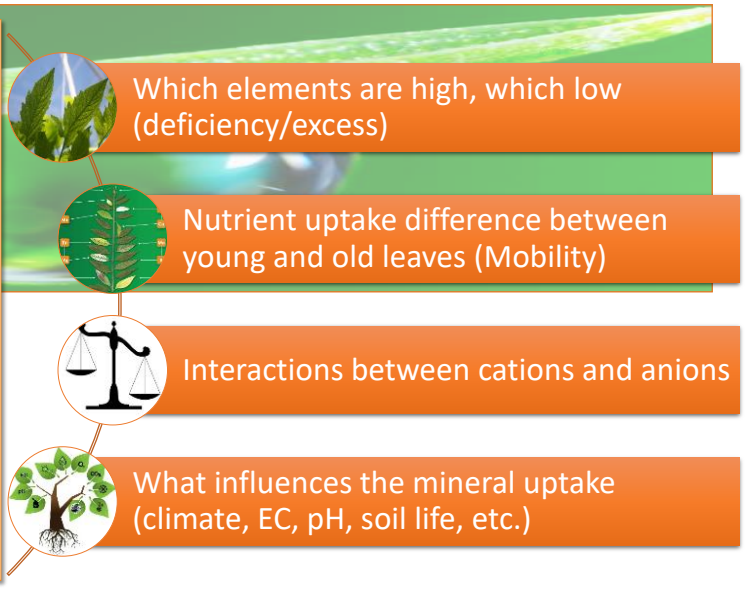
Interpretation Analysis

NovaCropControl





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NovaCropControl
postbus 2218 - 5001 CE - Tilburg
www.novacropcontrol.nl

Monsterdatum: 9-5-2017
Gewas: Tomaat
Plantdeel: [1] Blad (jong) [2] Blad (oud)

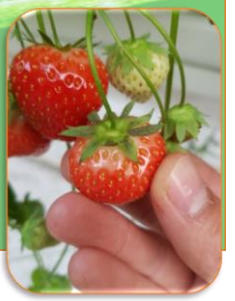
Mineraal		Huidig niveau	
Sugars	%	3,5	[1]
	%	0,4	[2]
pH		5,6	[1]
		5,5	[2]
EC	mS/cm	9,8	[1]
	mS/cm	16,6	[2]
K - Potassium	ppm	4308	[1]
	ppm	2765	[2]
Ca - Calcium	ppm	998	[1]
	ppm	5697	[2]
K/Ca		4,32	[1]
		0,49	[2]
Mg - Magnesium	ppm	690	[1]
	ppm	1424	[2]
Na - Sodium	ppm	35	[1]
	ppm	62	[2]
NH4 - Ammonium	ppm	42	[1]
	ppm	21	[2]
NO3 - Nitrate	ppm	192	[1]
	ppm	3688	[2]
N in Nitrate	ppm	43	[1]
	ppm	832	[2]
N - Total Nitrogen	ppm	1091	[1]
	ppm	1358	[2]
Cl - Chloride	ppm	684	[1]
	ppm	1548	[2]
S - Sulfur	ppm	817	[1]
	ppm	2297	[2]
P - Phosphorus	ppm	612	[1]
	ppm	570	[2]
Si - Silica	ppm	3,7	[1]
	ppm	7,4	[2]
Fe - Iron	ppm	0,61	[1]
	ppm	0,90	[2]
Mn - Manganese	ppm	16,06	[1]
	ppm	55,63	[2]
Zn - Zinc	ppm	3,74	[1]
	ppm	1,72	[2]
B - Boron	ppm	3,11	[1]
	ppm	6,40	[2]
Cu - Copper	ppm	2,97	[1]
	ppm	0,46	[2]
Mo - Molybdenum	ppm	0,41	[1]
	ppm	1,10	[2]
Al - Aluminium	ppm	<0,50	[1]
	ppm	<0,50	[2]

Example 1

NovaCropControl

Excess – Deficiency:

- High values:
  - Sugars (young leaf)
  - Magnesium
  - Phosphate
  - Manganese (old leaf)
  - Boron (old leaf)
  - Copper (young leaf)
- Low Values:
  - Sugars (old leaf)
  - Potassium (old leaf)
  - Calcium (young leaf)
  - Ammonium
  - Nitrate (young leaf)
  - Sulfur (young leaf)
  - Silicon
  - Iron



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Water analyses: Example 1

NovaCropControl

Historie Gietwater		(EC gecorrigeerd)		Hoofdelementen (mmol/l)											Spoorelementen (µmol/l)						
Monsterdatum	Monsternummer	EC mS/cm	pH	NH4	K	Na	Ca	K/Ca	Mg	Si	NO3	Cl	S	HCO3	P	Fe	Mn	Zn	B	Cu	Mo	Al
1-5-2017		3,2	6,1	0,41	8,4	1,3	6,3	1,34	3,2	<0,1	15,3	4,6	4,8	0,1	1,06	55,6	12,6	47,2	136,0	2,8	2,9	<1,0
24-4-2017		3,1	5,9	0,11	6,3	1,5	8,6	0,73	4,7	0,1	12,1	6,0	7,5	0,2	0,99	54,4	14,1	67,9	185,5	4,6	4,7	<1,0
17-4-2017		3,2	6,0	<0,10	6,6	1,6	8,3	0,80	5,2	<0,1	11,0	6,4	7,8	0,2	1,08	62,4	13,5	76,9	210,2	5,0	3,7	1,4
10-4-2017		3,4	5,1	<0,10	6,2	1,2	7,5	0,83	4,0	<0,1	11,2	5,9	6,5	0,2	1,47	50,2	14,5	49,8	150,1	4,0	3,7	1,5
3-4-2017		3,4	6,0	<0,10	6,0	1,2	7,7	0,79	4,6	<0,1	10,2	6,4	7,7	0,2	1,74	39,5	10,6	57,6	141,5	4,4	3,6	1,0
27-3-2017		3,4	5,8	<0,10	7,9	1,0	7,1	1,12	4,2	<0,1	11,3	6,0	6,5	0,2	1,47	47,0	15,1	36,7	117,9	3,7	2,9	<1,0
20-3-2017		3,4	5,6	<0,10	6,9	0,8	7,1	0,96	3,9	<0,1	12,3	6,2	6,0	0,1	1,89	43,7	12,9	34,3	108,3	3,6	2,6	<1,0

Historie Drainwater		(EC gecorrigeerd)		Hoofdelementen (mmol/l)											Spoorelementen (µmol/l)						
Monsterdatum	Monsternummer	EC mS/cm	pH	NH4	K	Na	Ca	K/Ca	Mg	Si	NO3	Cl	S	HCO3	P	Fe	Mn	Zn	B	Cu	Mo	Al
	streefcijfers	3,7																				
1-5-2017		3,9	7,2	<0,10	2,9	3,1	12,1	0,24	8,3	0,2	11,3	10,2	12,3	1,1	0,35	56,7	1,1	134,9	341,6	7,2	7,9	<1,0
24-4-2017		3,8	7,5	<0,10	1,5	3,0	14,6	0,10	9,7	0,2	7,4	10,9	16,0	1,8	0,25	66,8	1,0	166,6	393,9	9,1	10,4	<1,0
17-4-2017		3,9	7,4	<0,10	2,0	3,1	13,5	0,15	10,3	0,2	6,9	11,1	15,4	1,6	0,29	60,4	0,6	165,5	405,2	9,3	8,2	<1,0
10-4-2017		4,4	7,3	<0,10	2,3	2,4	11,1	0,21	7,6	0,2	5,0	10,2	12,9	2,2	0,17	35,2	0,4	111,6	275,9	6,5	6,9	<1,0
3-4-2017		4,0	7,4	<0,10	4,4	2,2	11,9	0,37	8,6	<0,1	6,1	10,9	14,8	2,0	0,27	35,5	0,5	125,3	264,1	7,7	6,7	<1,0
27-3-2017		4,5	7,9	<0,10	3,5	2,5	12,6	0,28	8,7	0,2	3,5	10,7	15,1	4,1	0,10	59,5	9,4	99,5	279,3	7,2	6,8	<1,0
20-3-2017		3,9	7,1	<0,10	5,1	1,3	10,4	0,49	6,4	<0,1	9,6	9,2	10,2	0,9	0,36	26,2	1,6	70,2	172,2	4,6	4,0	<1,0

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Interpretation Analysis: Example 2

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Interpretation Analysis: Example 2

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Mineraal		Huidig niveau	
Sugars	%	1,6	1
	%	1,3	2
pH		6,2	1
		6,1	2
EC	mS/cm	15,4	1
	mS/cm	13,3	2
K - Potassium	ppm	9357	1
	ppm	6846	2
Ca - Calcium	ppm	4508	1
	ppm	2617	2
K/Ca		2,08	1
		2,62	2
Mg - Magnesium	ppm	487	1
	ppm	51	2
Na - Sodium	ppm	10	1
	ppm	12	2
NH4 - Ammonium	ppm	84	1
	ppm	79	2
NO3 - Nitrate	ppm	607	1
	ppm	1183	2
N in Nitrate	ppm	137	1
	ppm	267	2
N - Total Nitrogen	ppm	925	1
	ppm	901	2
Cl - Chloride	ppm	1286	1
	ppm	1040	2
S - Sulfur	ppm	152	1
	ppm	85	2
P - Phosphorus	ppm	135	1
	ppm	81	2
Si - Silica	ppm	44,2	1
	ppm	21,7	2
Fe - Iron	ppm	5,18	1
	ppm	5,75	2
Mn - Manganese	ppm	9,79	1
	ppm	7,17	2
Zn - Zinc	ppm	0,48	1
	ppm	0,41	2
B - Boron	ppm	2,05	1
	ppm	2,16	2
Cu - Copper	ppm	0,42	1
	ppm	0,24	2
Mo - Molybdenum	ppm	0,45	1
	ppm	0,31	2
Al - Aluminium	ppm	0,16	1
	ppm	0,87	2

Excess – Deficiency:

- Older leaves
- Cations not in balance
- Potassium and Calcium very high.
- Magnesium uptake too low causing the deficiency.

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Follow data online on www.bemesting-online.nl

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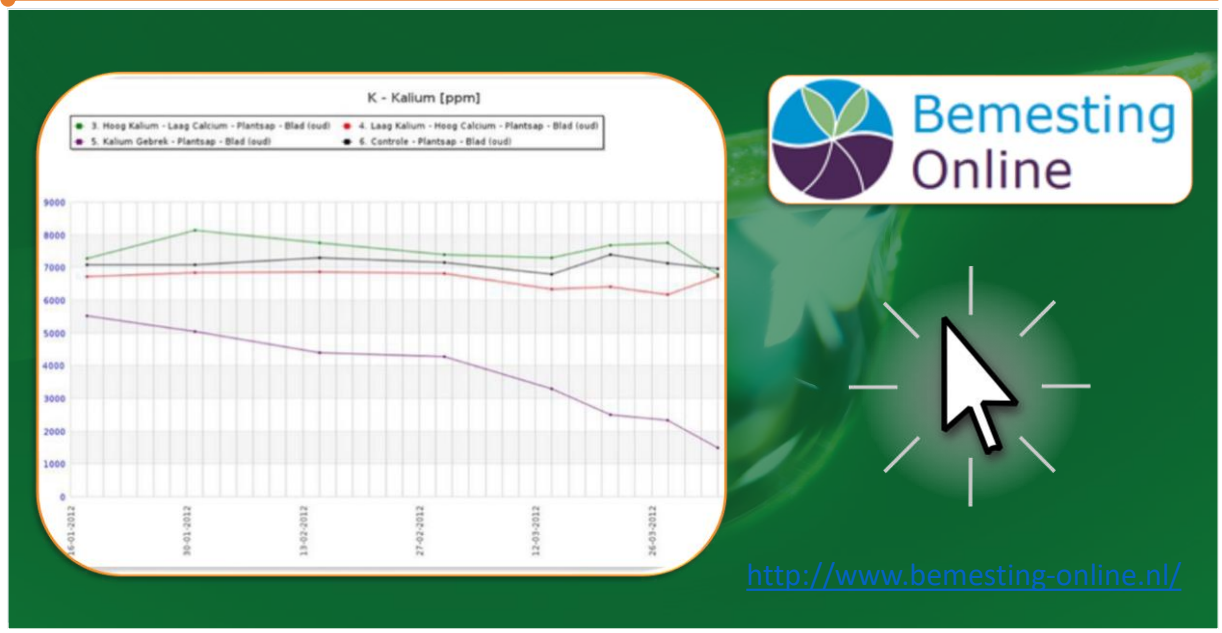

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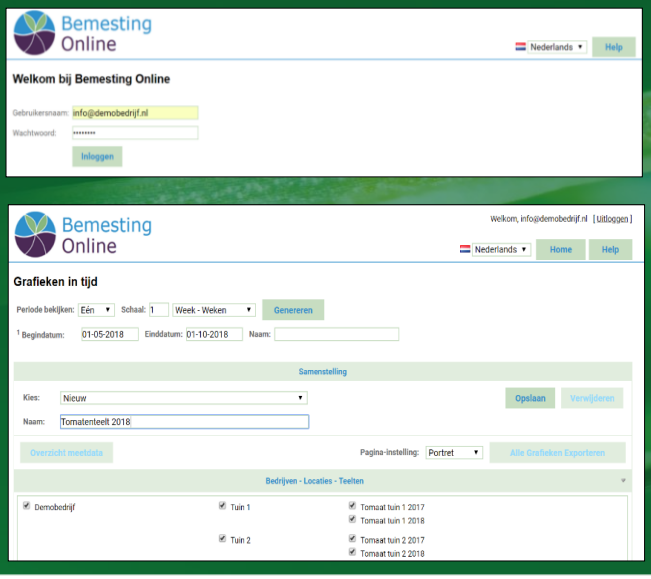
The use of www.bemesting-online.nl

NovaCropControl



- By measuring frequently, the plantsap/water measurements can be viewed over time
- Becomes a steering wheel.
- Clear overview of Irrigation, drain, slab water and absorption via plant sap young and old leaves
- Log on to www.bemesting-online.nl
- Opportunities:
  - Running crops on a farm
  - Different companies
  - Multi-year course
  - Export to PDF or Excel

Voorbeeld

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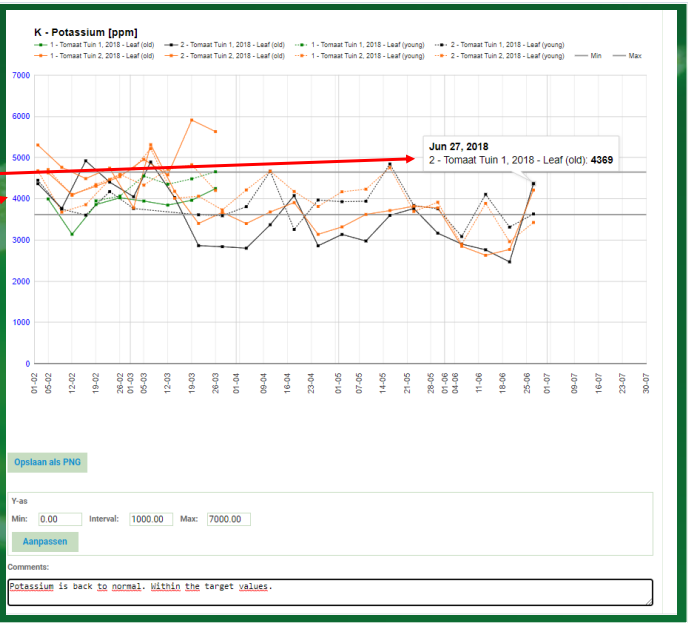
Additional help tools in graph series:

- Reading data in the graph
- Target values shown in the graph
- Save graph separately
- Adjust Y-axis
- Add comments



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Do you feed your plants as athletes?

NovaCropControl

Balanced fertilization = good plant health

Plants under the right growing conditions and with a balanced nutrient intake are resistant to diseases and pests.

Diseases and insects come when they have the right conditions and the right food sources that they need. They choose the susceptible / unhealthy plants for this.

When we provide the plants with the right nutrition, it is possible for the plants to become resistant to the diseases and insects.

An additional advantage is that a balanced mineral intake also has a positive effect on growth, flower and fruit quality (shelf life, firmness, taste).

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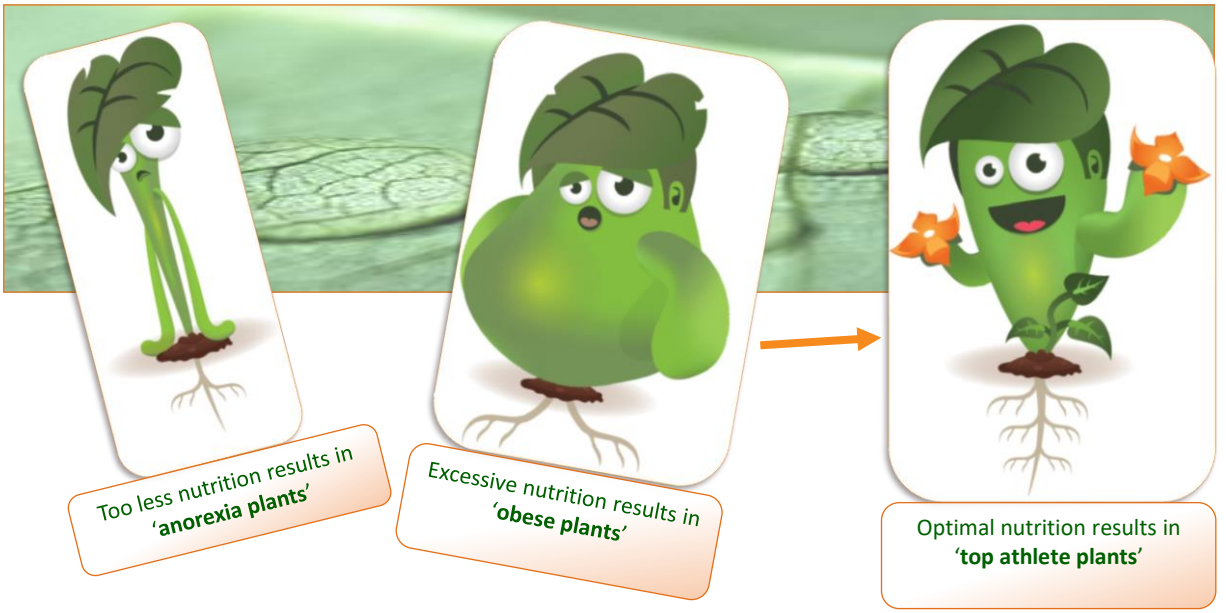
Do you feed your plants as athletes?

NovaCropControl



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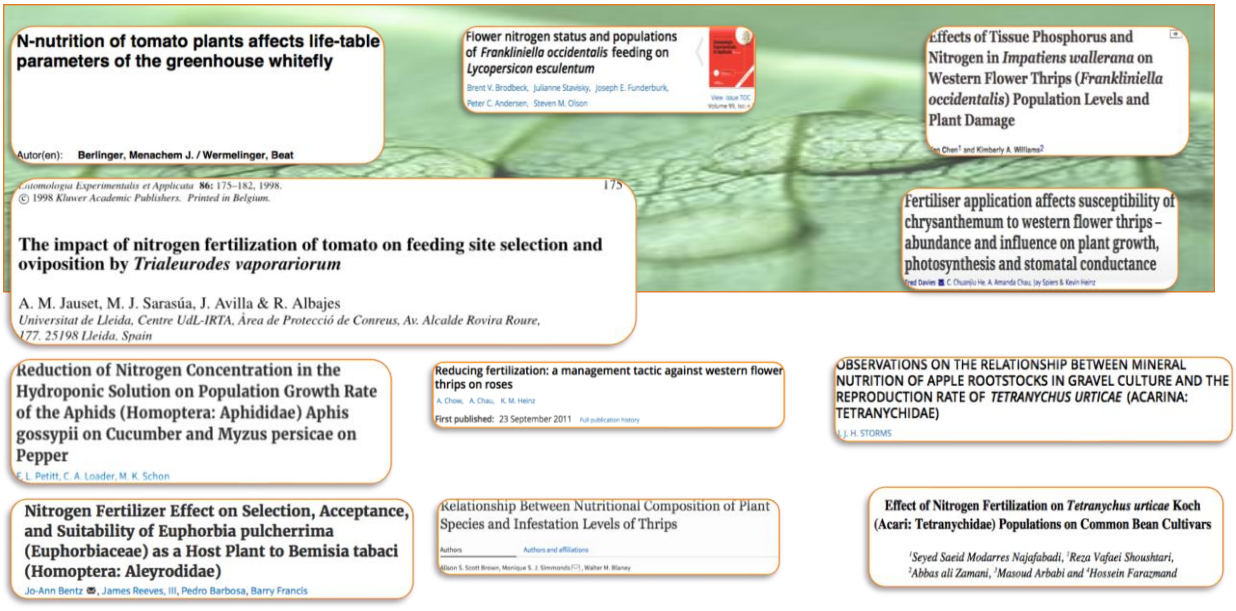
Scientific studies: Good fertilization = good plant health

NovaCropControl



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Plant health vs Nutrient uptake

NovaCropControl

NO3 absorption
- Disease pressure: Mildew, Botrytis, Aphid, spider mite
- Vegetative vs generative growth of the plant

P Management
- Uptake of trace elements, blocked by high P
- Good root growth

K/Ca ratio
- Fruit size and firmness
- Quality and taste

Si Uptake
- Mildew tolerance
- Optimize cell strenght

Trace elements
- Fe, Mn, Zn in balance
- Prefenting yellow heads

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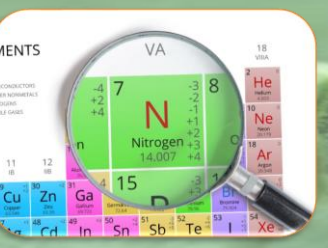
Nitrogen important factor in plant health

NovaCropControl

Measured in the Plant sap analysis as:
- Total nitrogen
- Nitrate nitrogen
- Ammonium nitrogen

Total Nitrogen =
- Ammonium
- Nitrate
- Urea
- Amino Acids and Proteins.



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N in Nitrate to total Nitrogen

NovaCropControl

N in Nitrate to Total Nitrogen explained:

- Depending on the growing conditions, a plant can convert a certain amount of nitrate that the plant absorbs into proteins.
- So when the plant absorbs more nitrate than it can actually convert to proteins, a surplus is created (as fat in humans).
- A certain surplus / stock is not a problem, but when this becomes too much, this influences the health of the plant.
- Plantsap can give a good indication on this.

Excessive nutrition results in **'obese plants'**

Optimal nutrition results in **'top athlete plants'**

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Oversupply Nitrate

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For example (plantsap):

Nitrate: 1500 ppm
N out of Nitrate: 339 (=1500 / 4,43)
Total Nitrogen: 670 ppm

Ratio of Nitrate out of total N:
339 / 670 = **51%**

Susceptibility:

- Tomato → 50% NO3 of total N
- Pepper → 60% NO3 of total N

But every crop has its own %! With low Nitrate levels the amount of total Nitrogen also gives an indication.

- Oversupply (nitrates) could result in increased susceptibility for diseases
- Which amount of nitrate is part of total Nitrogen (degree of conversion)

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Mildew vs Nitrate: Cucumber

NovaCropControl

Mildew Cucumber

Nitrate Accumulation vs Mildew:
Practice comparison: Plantsap measurements in Cucumber leafs

3 objects:
- Affected (Erysiphe sp.)
- Not affected
- Tolerant variety

Object	% Sugars	N out of Nitrate (ppm)	Total N (ppm)	Part of Nitrate in Total N	Manganese (ppm)
Affected	0,4	696	1271	55%	1,8
Not Affected	0,5	552	1168	47%	2,2
Tolerant variety	1,0	380	1266	30%	4,3

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Mildew vs Nitrate: Roses

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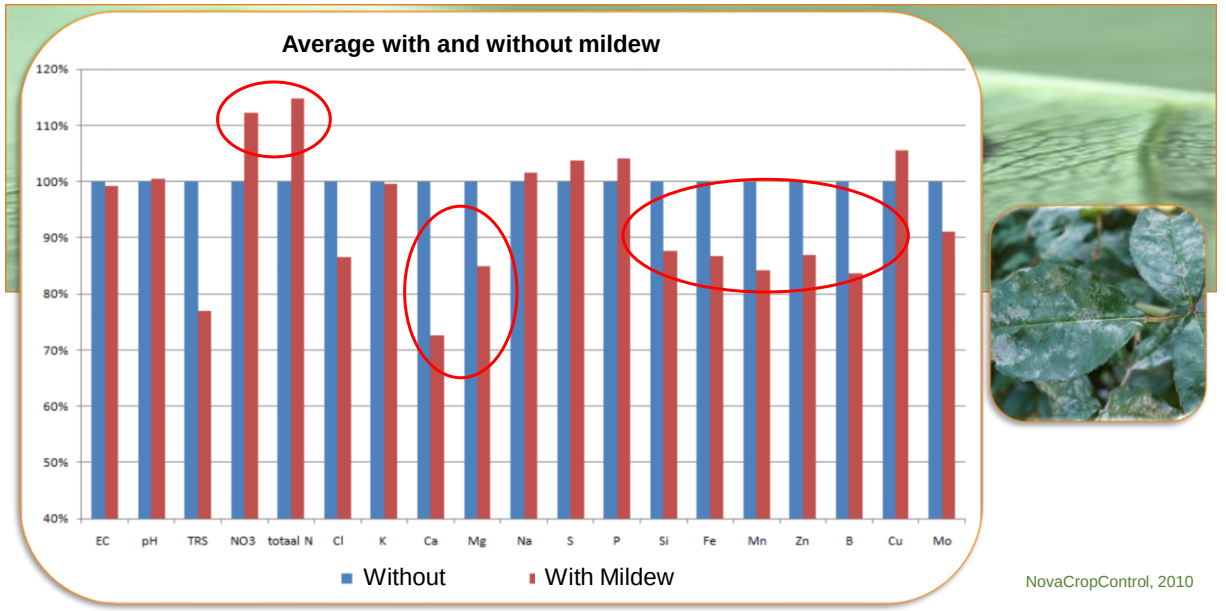

NovaCropControl, 2010

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Plant research in Kohlrabi

NovaCropControl

Mineral deficiency test 2017:

Tested on Kohlrabi (Lech):
- Cocos and yellow sand
- Low nitrate
- Low phosphate
- Low potassium

	EC mS/cm	Potassium mmol/l	Nitrate mmol/l	Phosphorus mmol/l
Standard	2,8	7,5	4	2,28
Nitrate -			2	
Nitrate - -			1	
Potassium -		5		
Potassium - -		3,5		
Phosphorus -				1
Phosphorus - -				0,5

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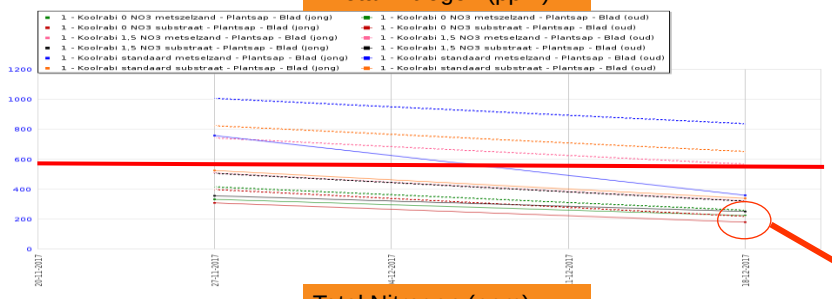
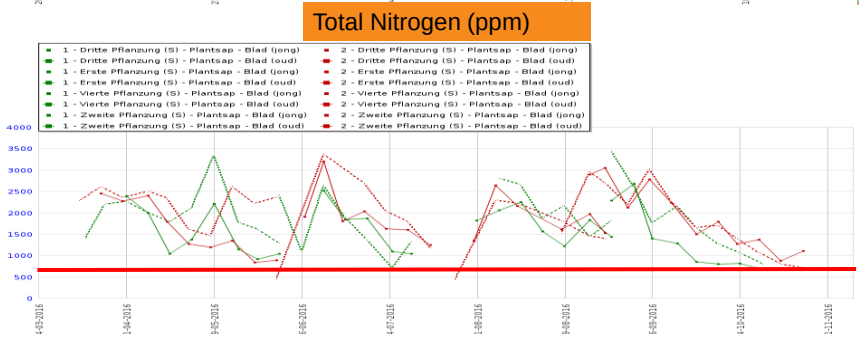
Plant research in Kohlrabi

NovaCropControl

Total Nitrogen (ppm)



Total Nitrogen (ppm)



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Plant research in Kohlrabi

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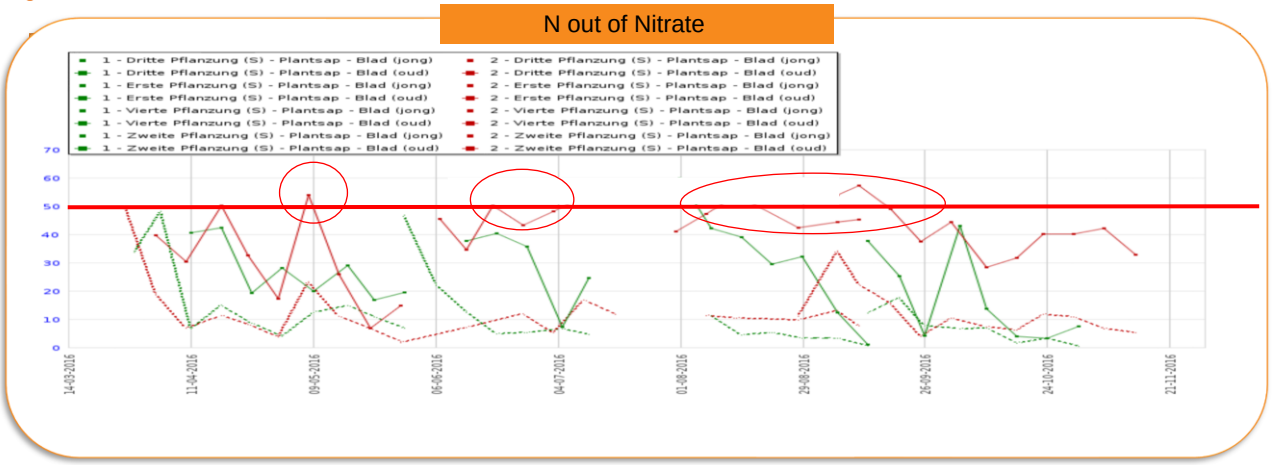
N out of Nitrate



Kohlrabi field:

- In the case of Kohlrabi over 50% makes the plant more susceptible to pests and diseases.

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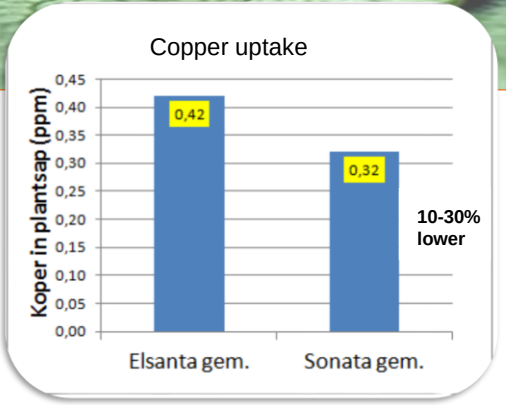
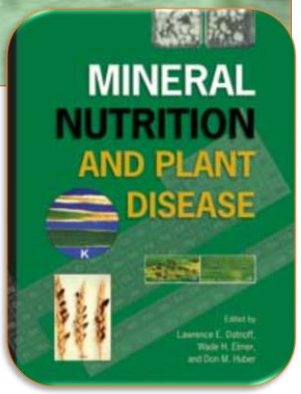
Phytopthora vs. Copper

NovaCropControl

- 2 strawberry varieties
- Elsanta vs Sonata





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Fertilization test Nitrate / Chloride 2018

NovaCropControl

Fertilization test:

- Research into new parameters with regard to plant resistance
- Steering on low nitrogen to improve plant health
- Side effects on taste

- Test in tunnel with different Nitrate / Chloride ratios

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Fertilization test Nitrate / Chloride 2018

NovaCropControl

Nitrogen test

- Correction anions with Chloride
- Aphid test (Nitrate influence on reproduction)
- Placed cage around plants

Treatment	Nitrate	Chloride
Nitrate +	11,2 mmol/l	0 mmol/l
Standard	9 mmol/l	2,2 mmol/l
Nitrate -	6,8 mmol/l	4,4 mmol/l
Nitrate --	4,6 mmol/l	6,6 mmol/l

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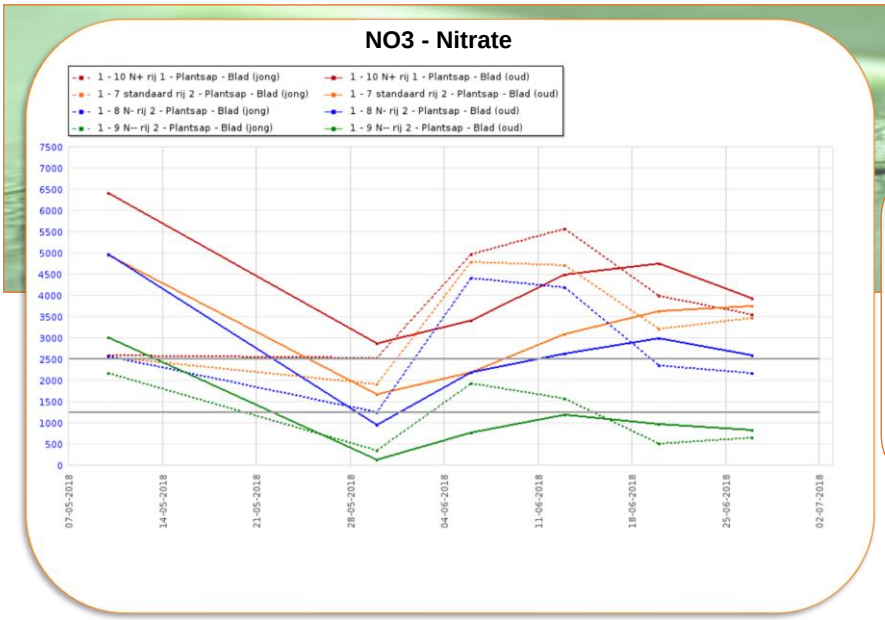
Fertilization test Nitrate / Chloride 2018

NovaCropControl



Nitrate:

- Standard and Nitrate+ almost the same amount.
- Attractiveness for Aphids the same

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Fertilization test Nitrate / Chloride 2018

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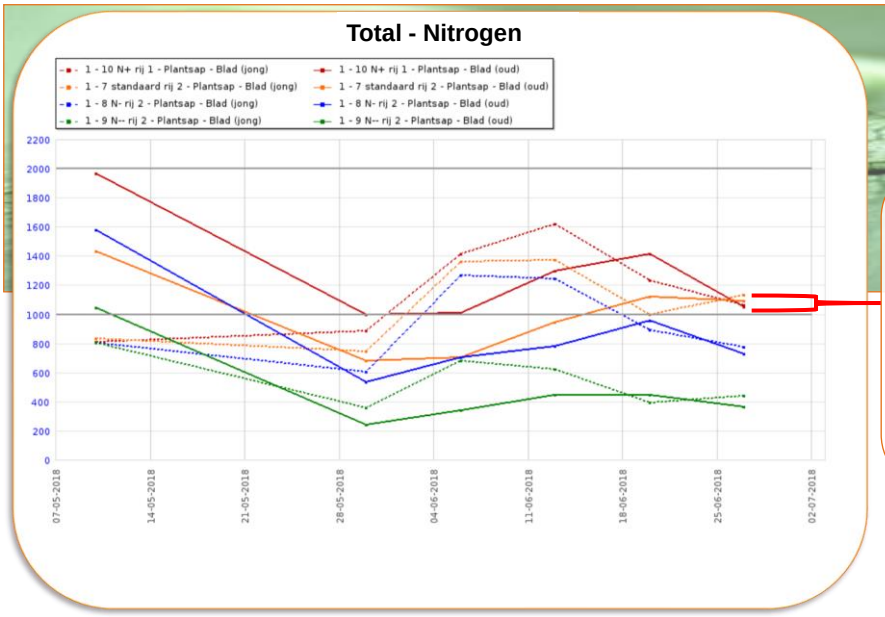

Total Nitrogen:

- Also standard and Nitrate+ almost the same amount.
- Influence on attractiveness for Aphids

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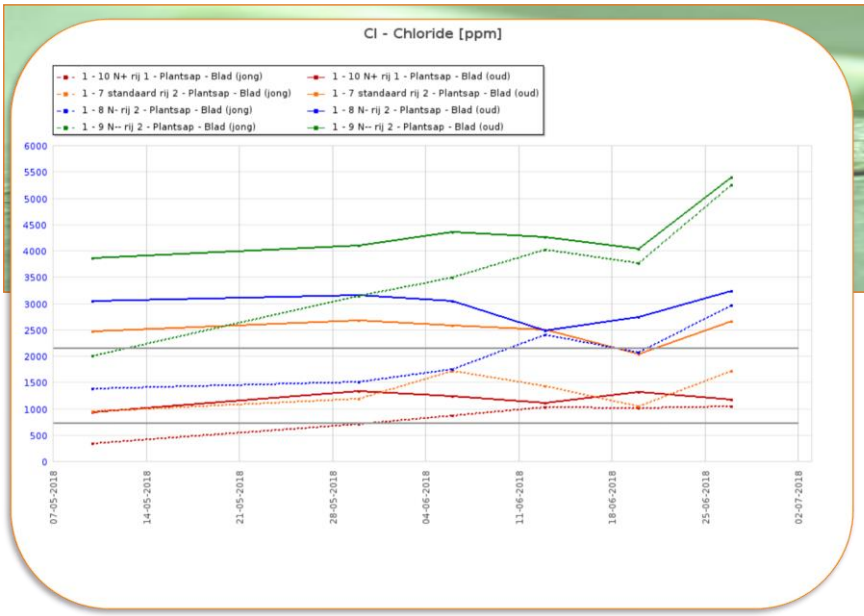
Fertilization test Nitrate / Chloride 2018

NovaCropControl



Chloride:

- Different treatments visible.

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Fertilization test Nitrate / Chloride 2018

NovaCropControl

Results:

- Hardly any difference in colour.
- Same production (but short trial period)

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Fertilization test Nitrate / Chloride 2018

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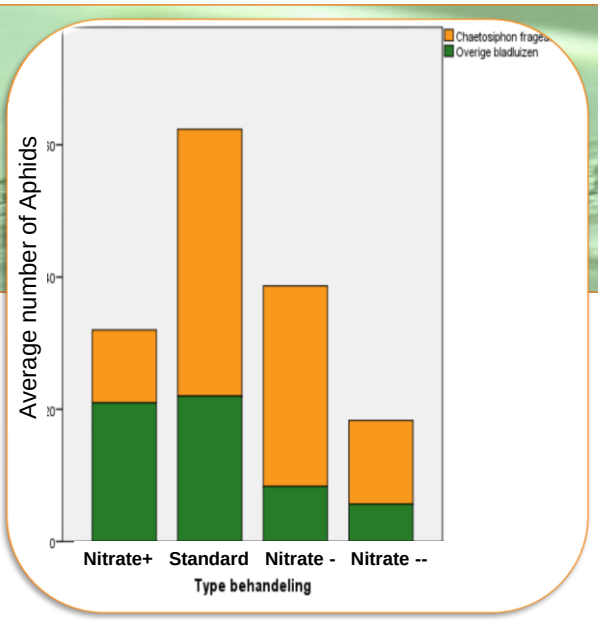

Results:

- Green colour is other race of Aphids
- Nitrate-- lowest Aphids
- Nitrate+ parasitic wasp found
- New trials 2019

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Literature research

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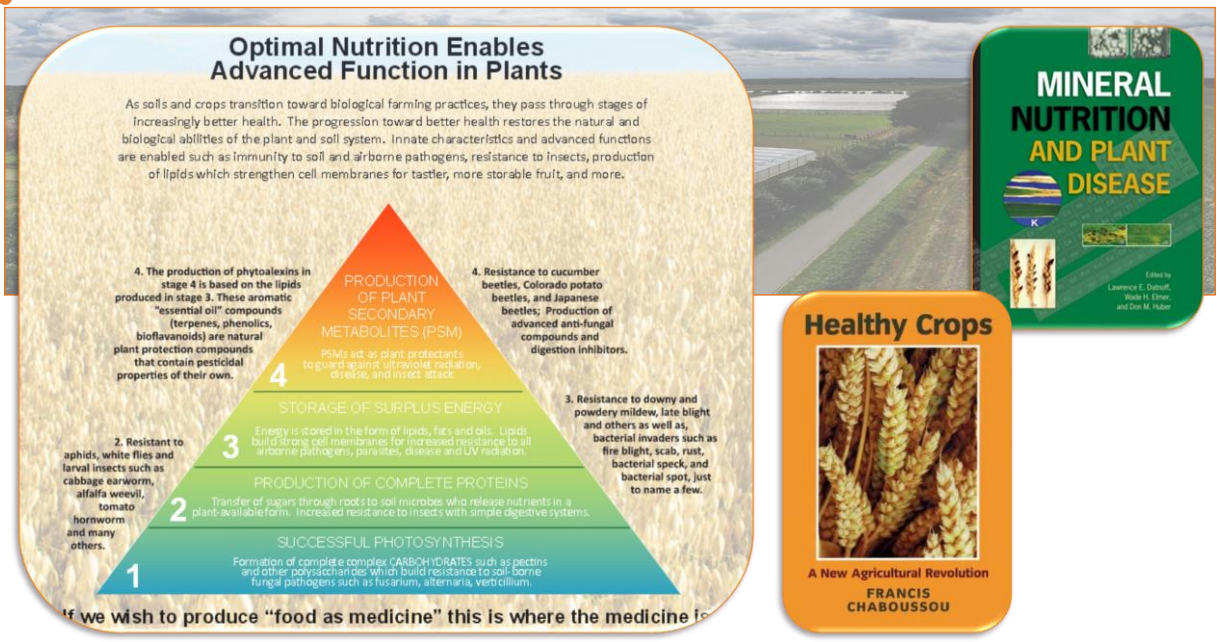

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Goal: Measuring plant resilience

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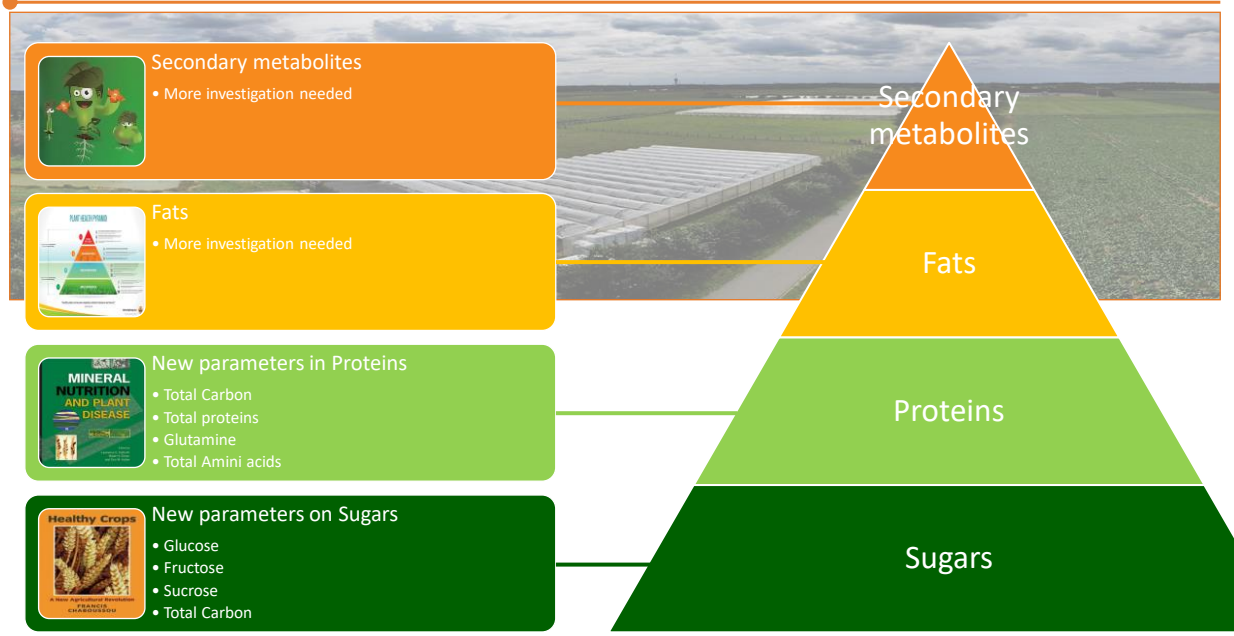

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Carbohydrates

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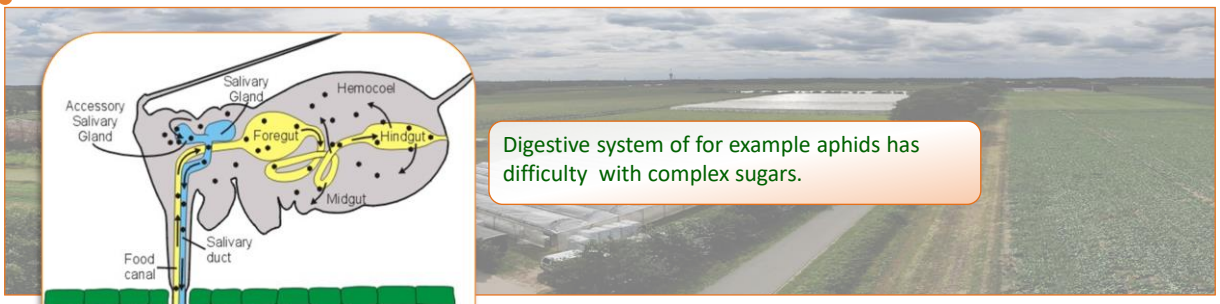

Digestive system of for example aphids has difficulty with complex sugars.

- Glucose, fructose, sucrose are simple carbohydrates
- A lot of simple carbohydrates will make the plant susceptible for diseases
- Lignin, pectin, cellulose and starch are complex carbohydrates
- A lot of complex carbohydrates will make the plant resilience to diseases

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R&D developments Plant health 2020

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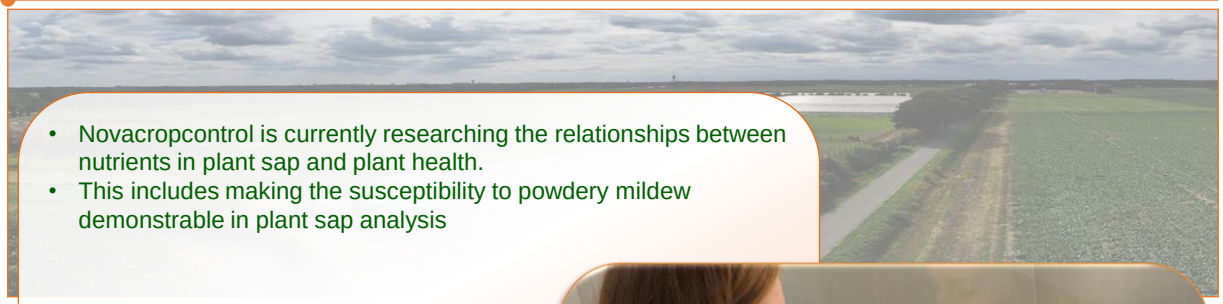
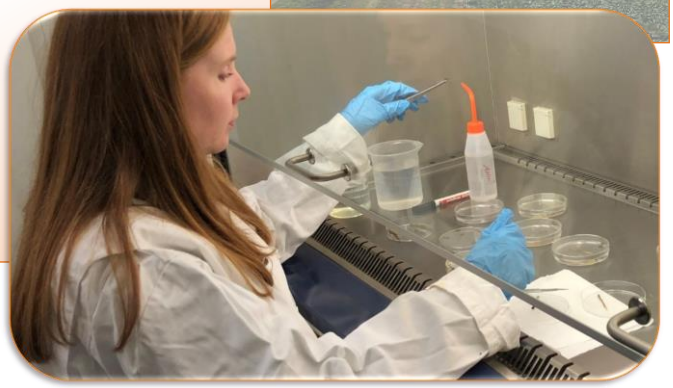


- Novacropcontrol is currently researching the relationships between nutrients in plant sap and plant health.
- This includes making the susceptibility to powdery mildew demonstrable in plant sap analysis



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Test with powdery mildew in tomatoes (2020)

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1. Trial with 7 tomato cultivars to collect plant sap (standard feeding schedule)

2. Infection with mildew in petri dish test (equal temperature and humidity)

After 10-14 days: white spots with spores (> 10,000 / leaf!)

Insensitive variety:

Sensitive variety:

- First relationships found between nutrients in plant sap and powdery mildew (validation ongoing).
- Follow-up trial in tunnel greenhouse with specific Nutrition schedules (NO3 & Mn).

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Test with powdery mildew in tomatoes (2020)

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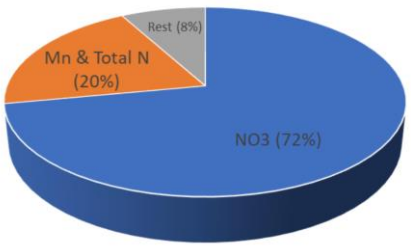
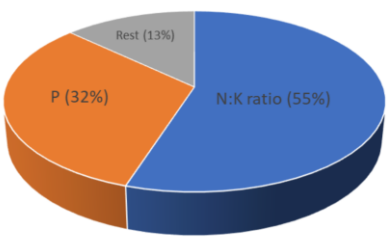
Young leaves



Old leaves



Relationship between plant sap uptake and susceptibility to mildew in young and old leaves:

- Reduced susceptibility to powdery mildew at low N and high K in old leaves is consistent with other literature sources (eg Krauss et al 1998, Balanced nutrition and biotic stress)

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