Leaf and sap testing for managing vegetable crop nutrition

Integrated Crop Protection
PROTECTING CROPS

Soil Wealth
NURTURING CROPS

Horticulture Innovation Australia

ahr applied horticultural research

RMCG
Environment | Water | Agriculture
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Disclaimer

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Presenters

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- Gordon Rogers – Applied Horticultural Research

What we will cover today

- Why test plants?
- Dry tissue analysis
- Sap analysis
- How to interpret results
- What to do if we cannot find desirable ranges?
- Crop removal
- Q & A

Why test plants?

Soil analysis provides information about potential nutrient availability

Plant analysis provides information about actual nutrient uptake

Dry Tissue Analysis

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N-P-K-Ca-Mg-S-Fe-Mn-Cu-Zn-B-(Mo)-Na-Cl

- Aim of testing
- Sampling – who, when
- Lab selection / communication
- Growth stages
- Interpretation / communication

Cabbage dry tissue levels

Cabbage
(Brassica oleracea)

Plant Part Wrapper leaf
Growth Stage Head maturity – early harvest

Nutrient	Deficient	Low	Normal	High	Excess
Nitrogen % (N)	<2.5	2.5–2.8	3.0–5.0	>5.5	
Phosphorus % (P)	<0.2	0.20–0.25	0.3–0.5	>0.5	
Potassium % (K)	<2.0	2.0–2.5	3.0–4.5	>5.0	
Calcium % (Ca)		<1.0	1.5–3.0	>3.5	
Magnesium % (Mg)	<0.15	0.15–0.19	0.2–0.7	>0.7	
Sulphur % (S)	<0.2	0.25–0.29	0.30–0.80	>0.8	
Sodium % (Na)			0–1.0	1.1–1.2	>1.2
Chloride % (Cl)			0–1.8	1.9–2.2	>2.2
Copper[1] ppm (Cu)	<3	3–4	5–20	>20	
Zinc[1] ppm (Zn)	<15	15–19	20–200	>200	
Manganese[1] ppm (Mn)	<20	20–24	25–200	200–400	>400
Iron[2] ppm (Fe)		<50	50–200		
Boron ppm (B)	<20	20–24	25–60	>100	
Molybdenum ppm (Mo)	<0.3	0.3–0.4	0.5–3.0	>3.0	

Leaf analysis report

Date: **9/06/00**

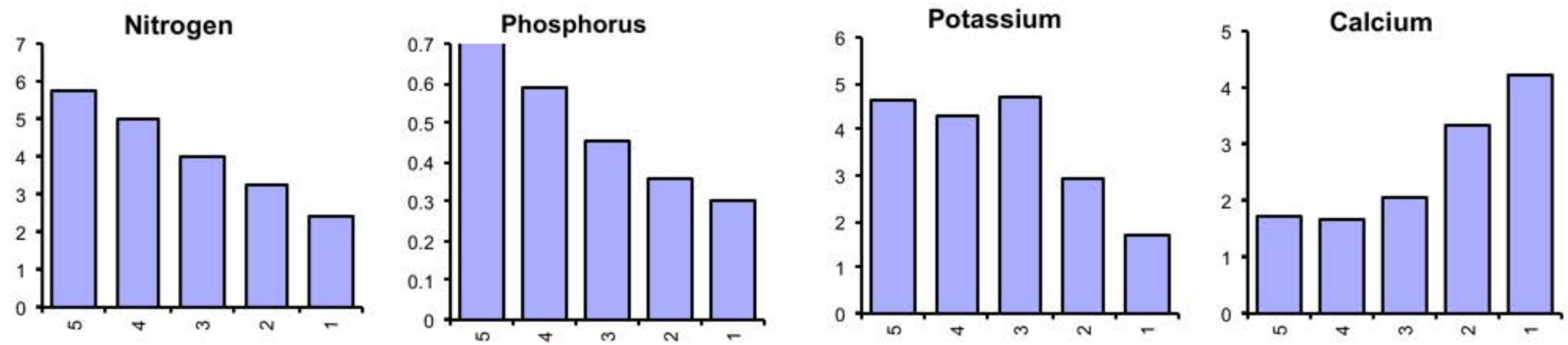
Grower :

Block : **31**

Crop : **Tomato**

Growth stage : **Harvest**

Nutrient		Previous tests 5	4	3	2	1	Current level	Normal Range	Comment
Nitrogen	%		5.8	5	4	3.2	**2.39**	2.0 ... 4.0	low end of range
Phosphorus	%		0.7	0.6	0.5	0.4	**0.3**	0.3 ... 0.7	marginal
Potassium	%		4.7	4.3	4.7	2.9	**1.7**	2.5 ... 5.0	low
Calcium	%		1.7	1.7	2.1	3.3	**4.22**	3.0 ... 5.0	OK
Magnesium	%		0.7	0.7	0.7	0.8	**0.89**	0.4 ... 0.8	OK
Sodium	%		0.1	0.1	0.1	0.3	**0.3**	0.0 ... 0.4	OK
Sulphur	%		0.7	0.8	0.7	1.1	**1.03**	0.4 ... 1.0	OK
Zinc	mg/kg		60	133	230	340	**340**	20 ... 200	OK
Iron	mg/kg		160	137	90	390	**390**	60 ... 300	OK
Copper	mg/kg		30	41	533	820	**540**	5 ... 200	OK
Manganese	mg/kg		65	118	230	390	**280**	25 ... 500	OK
Boron	mg/kg		32	52	48	65	**140**	25 ... 100	OK



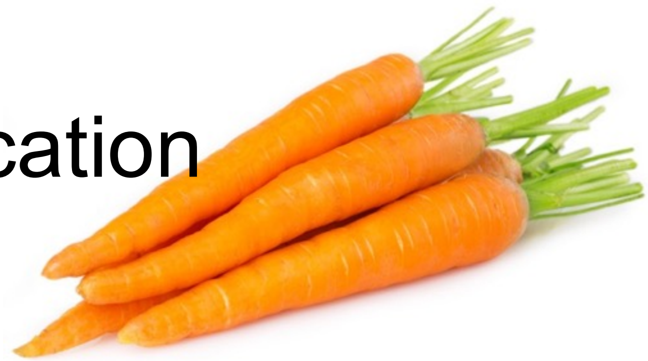
Leaf nutrient levels over previous weeks

Comments:

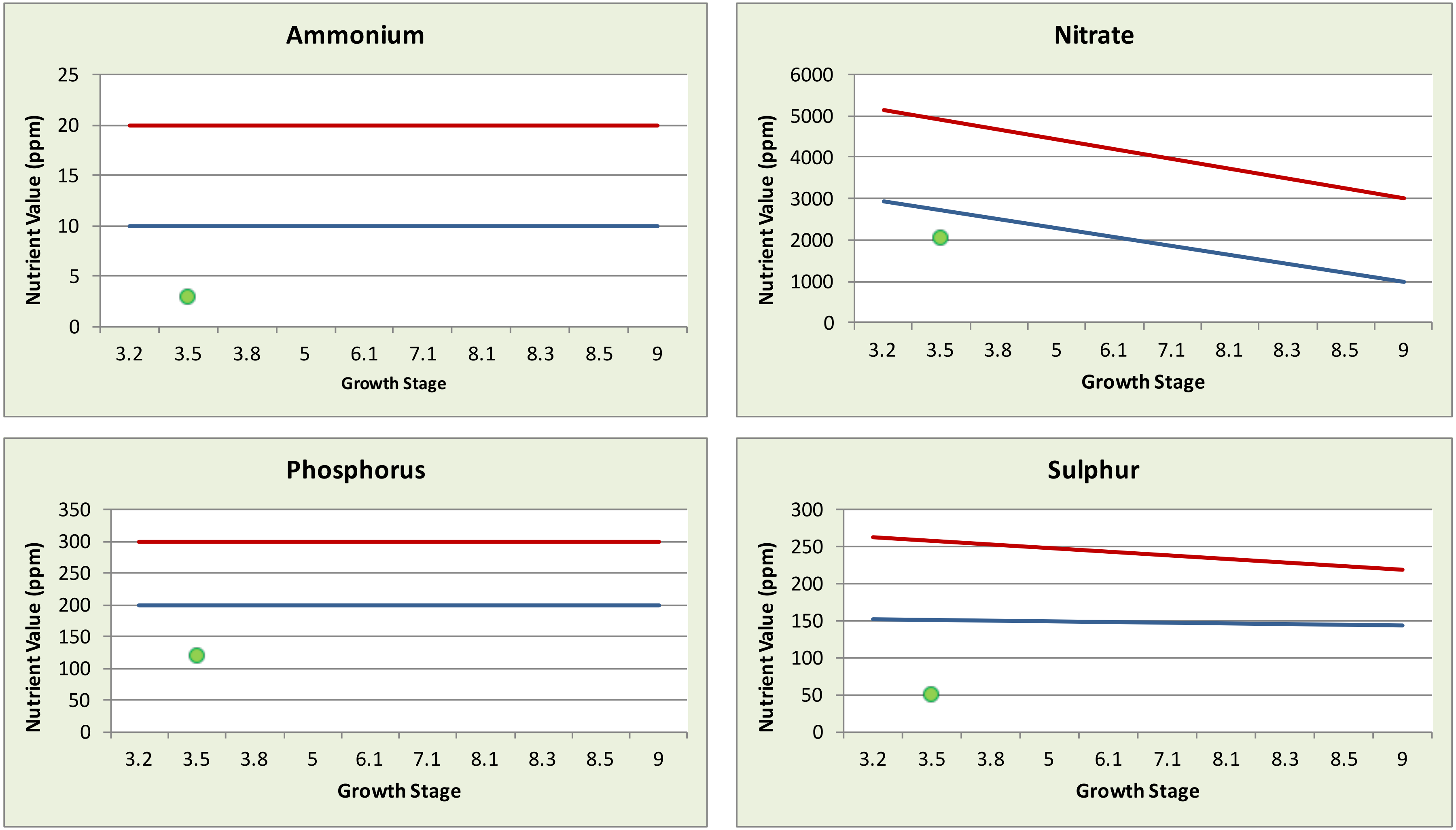
Sap Analysis

NO_3- NH_4 -P-K-Ca-Mg-S-Fe-Mn-Cu-Zn-B-Mo-Na-Cl

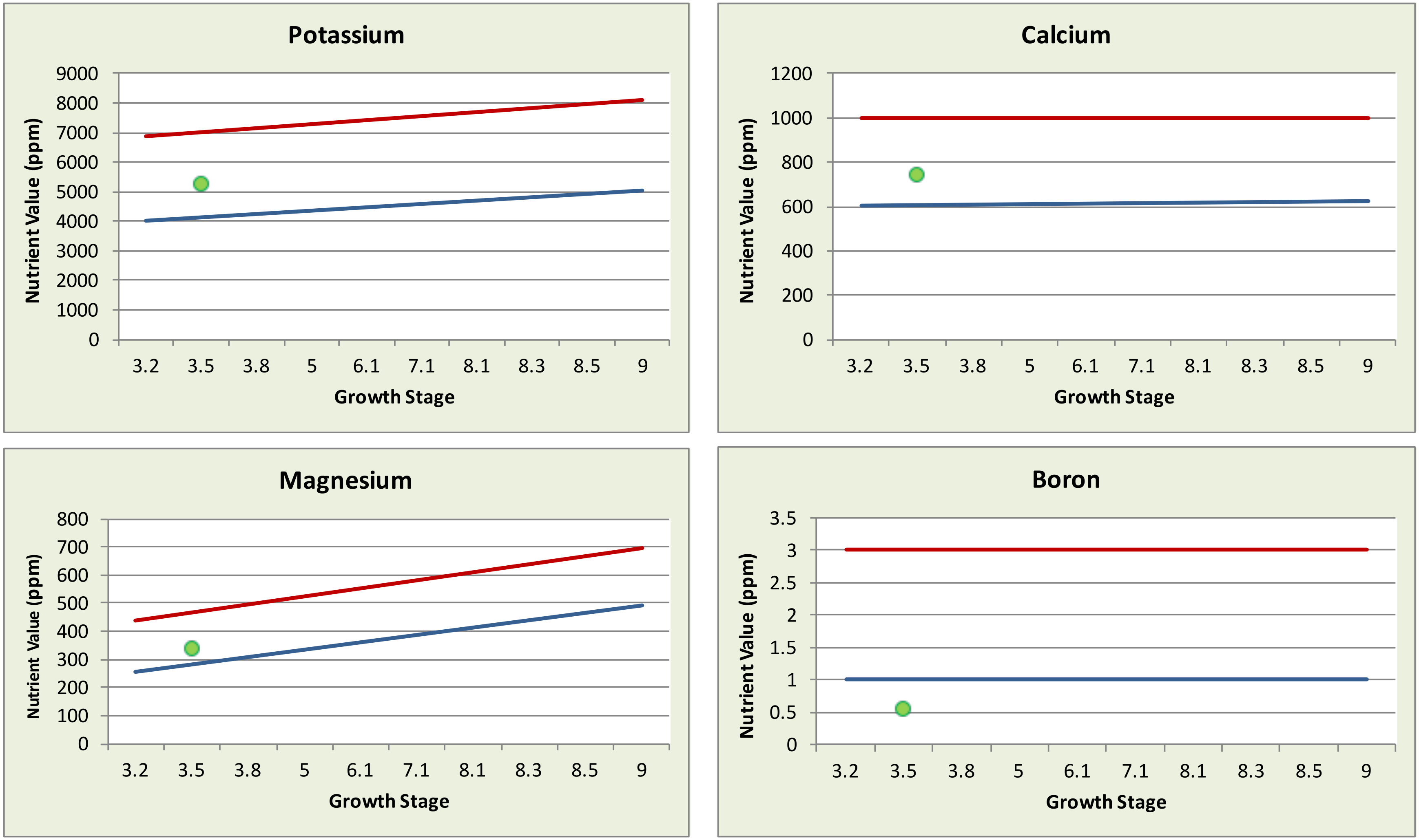
- Aim of testing
- Sampling – who, when
- Lab selection / communication
- Growth stages
- Interpretation / communication



Sap result example



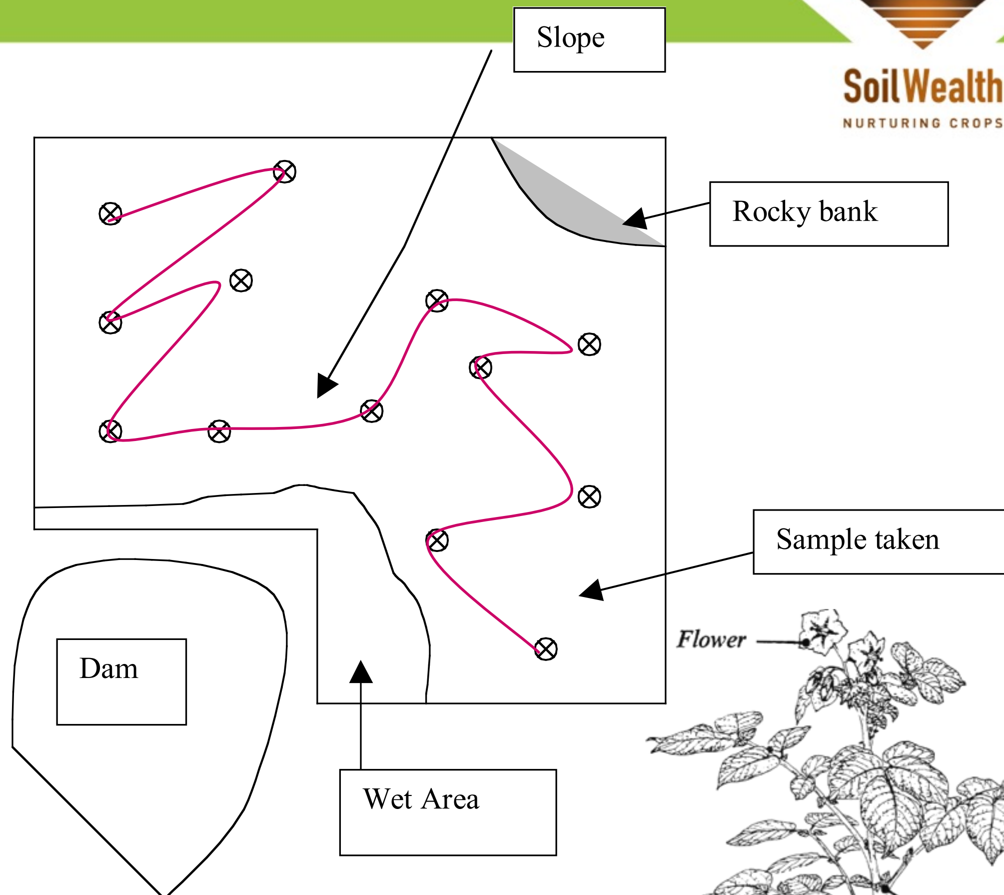
Sap result example

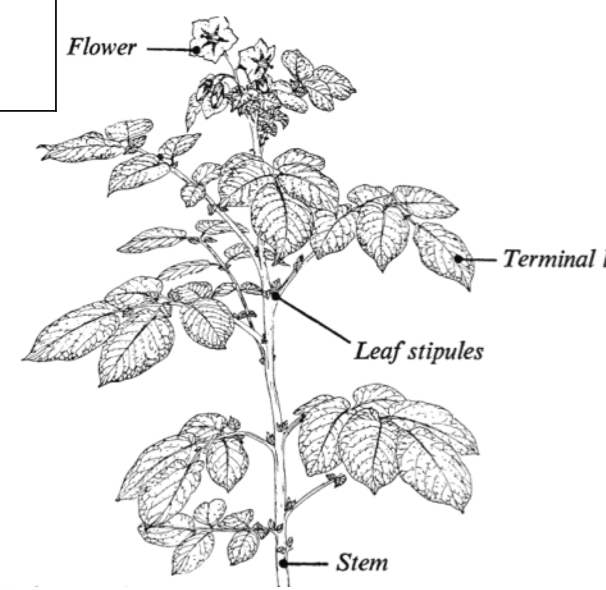


Sampling

Check with your lab!

- Representative
- Record sampling path
- Take photo of crop
- Sufficient material
- Correct plant part
- Time of day
- Labeling
- Record growth stage
- Packaging
- Posting





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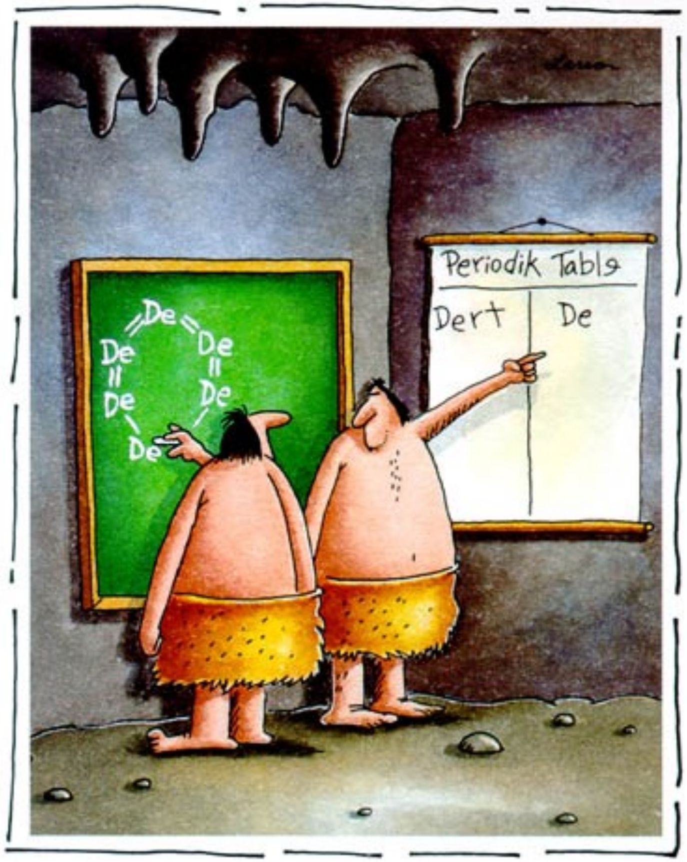
Considerations

- Inspect crop
- Consider growing conditions
- Consider crop management practices
- Consult soil test results

  - Desirable Ranges
  - Comparison between good and poor crops



What to look for in data

- Trends and fluctuations
- Nutrient balances
- Deficiencies
- Inconsistencies between soil and plant test

What can affect all plant analysis results?

Atmospheric factors

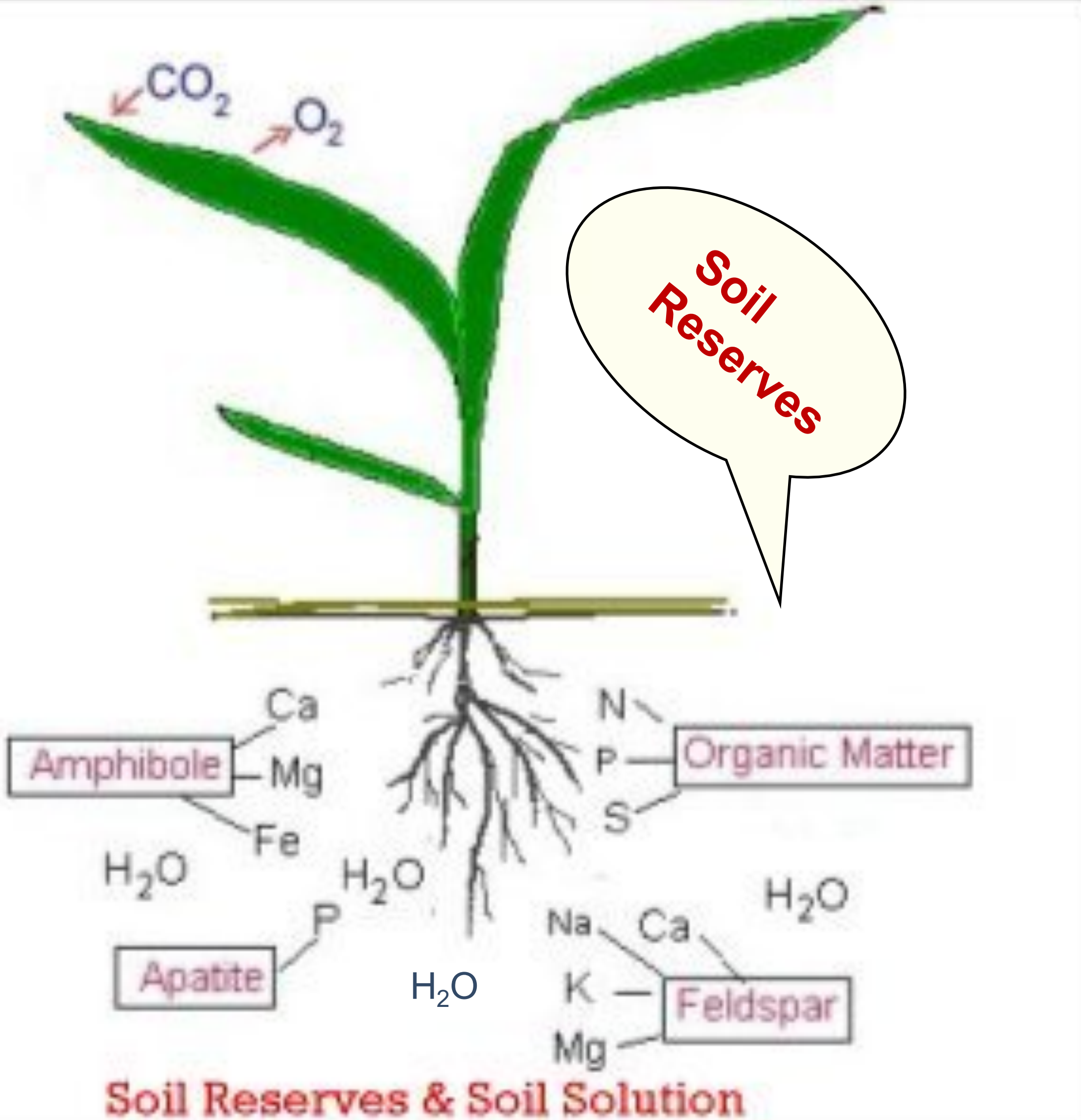
a. temperature
b. relative humidity
c. heat
d. wind
e. radiation

Plant factors

f. root system
g. leaves
h. stomatal features
i. growth stages

Soil factors

j. CEC
k. pH
l. soil conditions
m. buffering capacity
n. soil solution
o. fertility
p. Oxygen



Nutrient budgeting

Dry tissue analysis is the basis for determining nutrient uptake and removal by crops to prepare nutrient budgets

Together with soil test data nutrient budgets can be used to develop fertiliser programs

Nutrient Uptake

All the nutrients taken up by the plant as it grows and matures. This includes above and below-ground parts.

Sometimes the 'term withdrawal' is used instead of 'uptake'.

Determine nutrient uptake

Nutrient Removal

(also called Crop Removal)

The portion of the crop actually taken from the field at harvest i.e. nutrient in grain, potato tubers, bean pods, poppy heads, fruit etc.

Crop residues after crop removal

About 170kg N/ha can stay behind

Thank You

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Additional slides

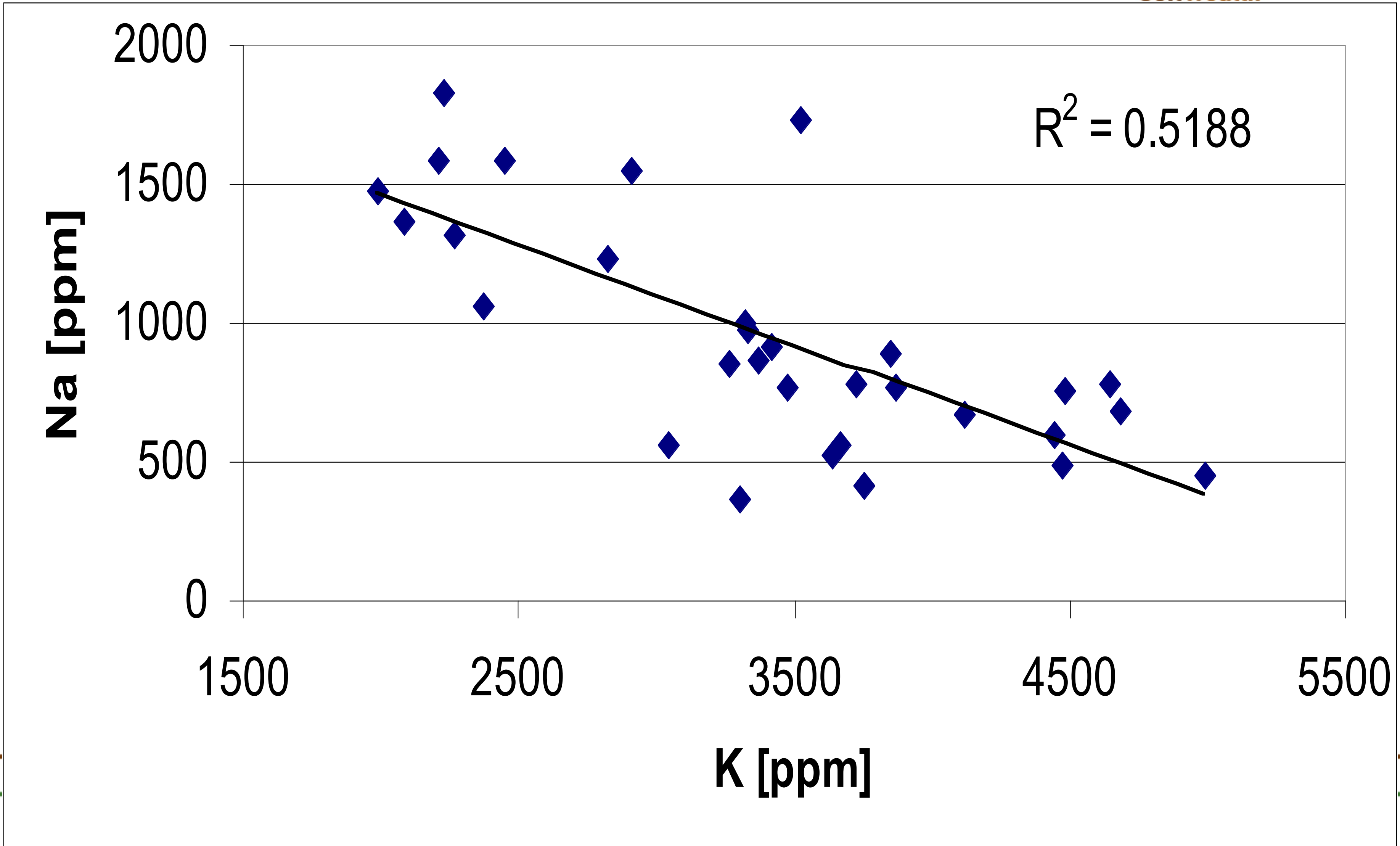
- The following slides were not included in the webinar presentation, but may be useful reference material

- Please use this information as a guide only.

References

- Plant Nutrient Disorders 3. Vegetable Crops. R. Weir and G. Cresswell
- Plant Analysis Interpretation Manual. (1997) Reuter and Robinson.
- Fertiliser company and specialist manuals
- Plant Tissue Analysis and Interpretation for Vegetable Crops in Florida. G. Hochmuth, D. Maynard, C. Vavrina, E. Hanlon, and E. Simonne

Nutrient balances



Some principles for sap levels

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All nutrients high

- Plants may be under stress.
- Moisture (over or under watering) or disease stress - nutrients are highly concentrated in poorly growing plants.
- More obvious in sap results if stress has not been going on for long.

Principles for sap levels [cont.]

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The majority of nutrients are high

- The availability of one nutrient is very low and impedes growth, resulting in high nutrient levels except for the limited nutrient.

- Sampling technique - taking too old plant parts can result in higher than normal levels of some immobile nutrients, such as Calcium and Magnesium.

Principles for sap levels [cont.]

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The majority of nutrients are low

- Low nutrient uptake due to low soil nutrient level or poor uptake conditions

- Good rainfall associated with ideal growing temperatures promoting rapid plant growth resulting in temporary dilution of nutrients (mostly evident in plant sap).

Desirable ranges – dry tissue

Vary by crop and nutrient

Usually a specific growth stage recommended for sampling

Desirable ranges are for specific growth stages

Good to use data derived under Australian condition or similar

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Tissue Analysis — Sap Analysis

Sampling

Tissue Analysis

Annuals: Leaf or petiole of youngest fully expanded leaf (YFL), entire plant, fruit, bulb or tuber

Perennials: center leaf from current years growth, fruit

at any time during the day

Sap Analysis

Annuals: YFL petiole or entire plant, fruit, bulb or tuber

Perennials: fresh growing tip (1-15cm), fruit

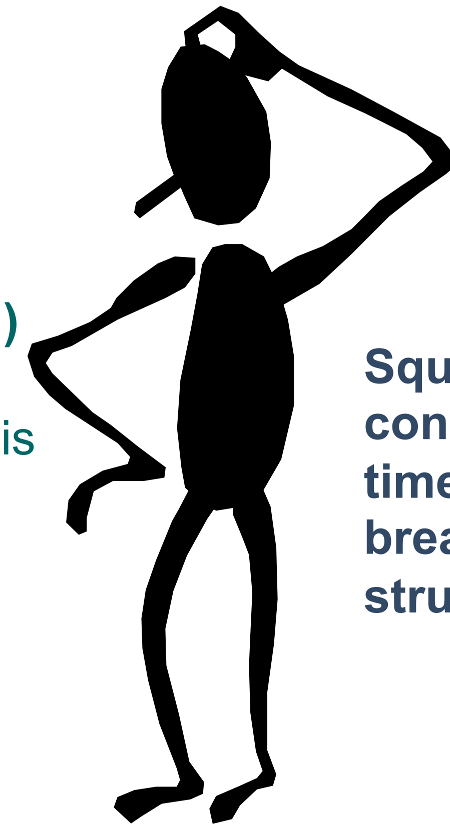
at a certain, consistent time of the day

Tissue Analysis Sap Analysis

Sample Processing

Drying, weighing, grinding, turning to ash, either at high temperature (dry ash) or chemically (wet ash)

Ash is taken up in liquid for analysis



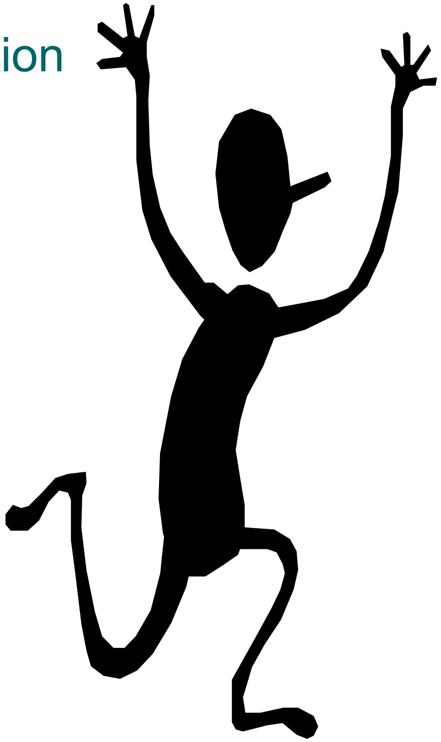
Squeezing using a consistent pressure each time to extract sap without breaking down 'permanent structures'

Tissue Analysis | Sap Analysis

Analysis & Reporting

Nutrients in the sample in relation to its dry weight

reported as %
(g/100g dry matter)
or
[ppm = mg/kg]
(mg/1000g dry matter)



Nutrient concentration in the extracted sap

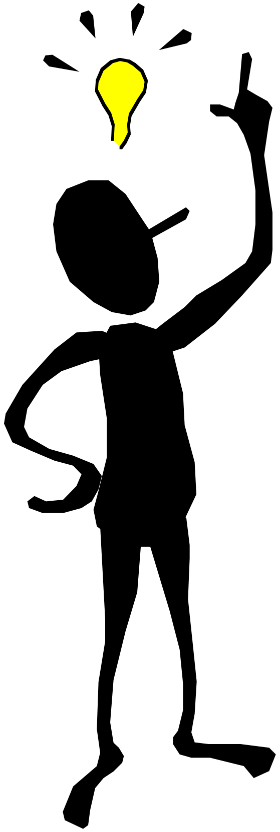
reported as [ppm]
(mg/L sap)

Tissue Analysis | Sap Analysis

Results show

Nutrition summary

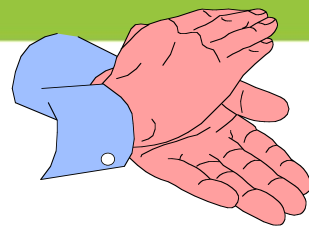
= **nutrient accumulation in the sampled plant part up to the time of sampling**



Nutrient uptake around the time of sampling

= **current nutrient status, current uptake conditions**

Positive Aspects



Tissue Analysis

Little influence of sampling time during the day or growing conditions just prior to sampling on results

Allows review of overall growing conditions and effect of the fertiliser program and calculating removal rates

"ACCOUNT BALANCE"

Sap Analysis

Results reflect growing conditions around the time of sampling; they show current nutrient deficiencies and imbalances

Repeated sampling shows trends and effect of preceding fertiliser applications

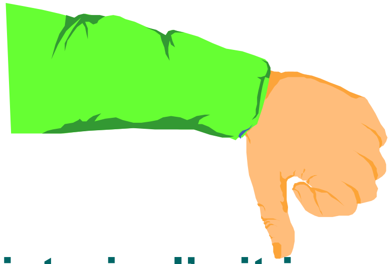
Allows prediction of reaction to nutrient application

"ACCOUNT MOVEMENTS"

Tissue Analysis Sap Analysis

Negative Aspects

The nutrient content of tissue is 'diluted' by starch, sugar and protein which increases throughout the season - nutrient levels decrease depending on the amount of their accumulation.



As tissue analysis is 'historical', it is not a measure of deficiencies or imbalances around sampling or at any times before sampling.

Growing conditions around sampling have to be known and understood in their impact on nutrient uptake.

Quick tests for N and K commonly lead to inconsistent results, due to operator differences in sap extraction procedures, temperature variations during analysis

Tissue Analysis & Sap Analysis

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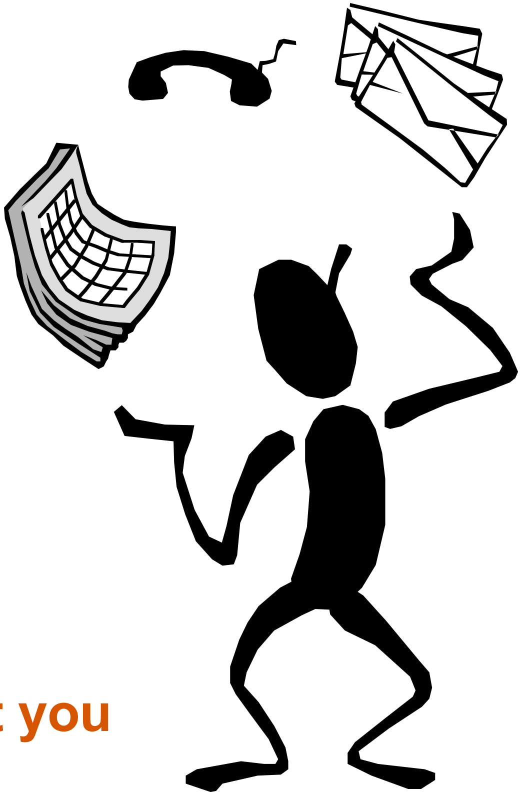
Common Aspects

- Desirable levels are needed per crop, variety and phenological growth stage
- Remote interpretation without crop knowledge is risky
- Excessive soil levels are well not reflected;

an issue for potential nitrogen losses



You need to know why you are testing, what you want to do with the data and the capability of the monitoring tool

Carrot
leaf levels

Carrot
(Daucus carota)

Plant Part Youngest mature leaf (remove extended main petiole)
Growth Stage Mid-grown roots 1–3 cm diameter

Nutrient	Deficient	Low	Normal	High	Excess
Nitrogen % (N)	<1.8	1.8–1.9	2.0–3.5	>3.5	
Phosphorus % (P)	<0.18	0.18–0.19	0.2–0.5	>0.5	
Potassium % (K)	<2.0	2.0–2.4	2.5–4.5	>4.5	
Calcium % (Ca)			1.4–3.0		
Magnesium % (Mg)		0.16–0.19	0.2–0.5	>0.5	
Sulphur % (S)			0.2–0.4		
Sodium % (Na)			0–2.0		
Chloride % (Cl)			0–2.4	2.5–3.0	>3.0
Copper[1] ppm (Cu)		3–4	5–25		
Zinc[1] ppm (Zn)	<18	18–24	25–50		
Manganese[1] ppm (Mn)		<25	30–350		
Iron[2] ppm (Fe)			50–350		
Boron ppm (B)	<20	20–25	30–60	>100	

[1] Values for copper, zinc or manganese in leaves sprayed with fungicides or nutrient sprays containing trace elements cannot give a reliable guide to nutritional status even in washed leaves.
[2] Leaf analysis is not a reliable guide to iron deficiency because of surface contamination with dirt, or immobility of iron within the plant or the presence of physiological inactive iron within tissues.

Lettuce leaf levels

Lettuce
(Latuca sativa)

Plant Part Wrapper leaf
Growth Stage Heads half size

Nutrient	Deficient	Low	Normal	High	Excess
Nitrogen % (N)	<2.8	2.8–3.0	3.1–4.5	>5.0	
Phosphorus % (P)			0.35–0.60	0.7–0.8	>0.8
Potassium % (K)	<3.0	3.0–3.5	4.5–8.0	8.0–9.0	>9.0
Calcium % (Ca)			0.8–2.0		
Magnesium % (Mg)	<0.16	0.16–0.20	0.3–0.7	0.8–0.9	
Sulphur % (S)			0.2–0.3		
Sodium % (Na)			0–0.3	0.4–0.6	>0.7
Chloride % (Cl)			0–1.4	1.6–2.0	>2.0
Copper[1] ppm (Cu)		<5	7–80		
Zinc[1] ppm (Zn)	<20	20–24	25–250		
Manganese[1] ppm (Mn)	<12	12–15	50–300	600–1800	>2000
Iron[2] ppm (Fe)			50–100		
Boron ppm (B)	<11	11–20	25–55		

Broccoli
leaf levels

Broccoli
(Brassica oleracea)

Plant Part Wrapper leaf
Growth Stage Early heading

Nutrient	Deficient	Low	Normal	High	Excess
Nitrogen % (N)	<3.0	3.0–3.2	3.5–5.5	>5.5	
Phosphorus % (P)	<0.2	0.20–0.25	0.3–0.7	>0.7	
Potassium % (K)	<1.6	1.6–1.9	2.0–4.0		
Calcium % (Ca)			1.2–2.5		
Magnesium % (Mg)	<0.15	0.15–0.19	0.2–0.7	>0.7	
Sulphur % (S)	<0.2	0.25–0.29	0.30–0.80	>0.8	
Sodium % (Na)			0–1.0	1.1–1.2	>1.2
Chloride % (Cl)			0–1.8	1.9–2.2	>2.2
Copper[1] ppm (Cu)	<3	3–4	5–20	>20	
Zinc[1] ppm (Zn)	<15	15–19	20–200	>200	
Manganese[1] ppm (Mn)	<20	20–24	25–200	200–400	>400
Iron[2] ppm (Fe)		<50	50–200		
Boron ppm (B)	<20	20–24	25–60	>100	
Molybdenum ppm (Mo)	<0.3	0.3–0.4	0.5–3.0	>3.0	

[1] Values for copper, zinc or manganese in leaves sprayed with fungicides or nutrient sprays containing trace elements cannot give a reliable guide to nutritional status even in washed leaves.
[2] Leaf analysis is not a reliable guide to iron deficiency because of surface contamination with dirt, or immobility of iron within the plant or the presence of physiological inactive iron within tissues.

French beans

leaf levels

Beans (French)

(Phaseolus vulgaris)

Plant Part Youngest fully expanded leaf (minus petiole)
Growth Stage Early flowering

Nutrient	Deficient	Low	Normal	High	Excess
Nitrogen % (N)	<3.5	3.5–3.9	4.0–6.0	>6.0	
Phosphorus % (P)	<0.25	0.25–0.32	0.35–0.50	>0.5	
Potassium % (K)	<1.2	1.2–1.7	1.8–4.0	>4.0	
Calcium % (Ca)		1.0–1.2	1.5–3.0	3.5–4.0	
Magnesium % (Mg)	<0.15	0.20–0.24	0.25–0.70	0.8–1.0	1.3–1.7
Sodium % (Na)			0–0.06	0.08–0.2	>0.2
Chloride % (Cl)			0–1.4	1.6–2.0	2.1–6.5
Copper[1] ppm (Cu)	<3	3–5	6–50		
Zinc[1] ppm (Zn)	<18	18–20	30–100		
Manganese[1] ppm (Mn)	<20	20–25	50–300	300–400	>400
Iron[2] ppm (Fe)			50–300		
Boron ppm (B)	<10	15–19	40–60	100–150	
Molybdenum ppm (Mo)	<0.2	0.2–0.4	0.5–1.0	1.5–5.0	

[1] Values for copper, zinc or manganese in leaves sprayed with fungicides or nutrient sprays containing trace elements cannot give a reliable guide to nutritional status even in washed leaves.
[2] Leaf analysis is not a reliable guide to iron deficiency because of surface contamination with dirt, or immobility of iron within the plant or the presence of physiological inactive iron within tissues.

Cabbage leaf levels

Cabbage
(Brassica oleracea)

Plant Part Wrapper leaf
Growth Stage Head maturity – early harvest

Nutrient	Deficient	Low	Normal	High	Excess
Nitrogen % (N)	<2.5	2.5–2.8	3.0–5.0	>5.5	
Phosphorus % (P)	<0.2	0.20–0.25	0.3–0.5	>0.5	
Potassium % (K)	<2.0	2.0–2.5	3.0–4.5	>5.0	
Calcium % (Ca)		<1.0	1.5–3.0	>3.5	
Magnesium % (Mg)	<0.15	0.15–0.19	0.2–0.7	>0.7	
Sulphur % (S)	<0.2	0.25–0.29	0.30–0.80	>0.8	
Sodium % (Na)			0–1.0	1.1–1.2	>1.2
Chloride % (Cl)			0–1.8	1.9–2.2	>2.2
Copper[1] ppm (Cu)	<3	3–4	5–20	>20	
Zinc[1] ppm (Zn)	<15	15–19	20–200	>200	
Manganese[1] ppm (Mn)	<20	20–24	25–200	200–400	>400
Iron[2] ppm (Fe)		<50	50–200		
Boron ppm (B)	<20	20–24	25–60	>100	
Molybdenum ppm (Mo)	<0.3	0.3–0.4	0.5–3.0	>3.0	

Cucurbit leaf levels

Cucurbits
(Cucumber, rockmelon, pumpkin, zucchini)

Plant Part Youngest fully mature leaf with petiole
Growth Stage Early flowering

Nutrient	Deficient	Low	Normal	High	Excess
Nitrogen % (N)	<1.8	1.8–2.4	2.5–4.5	5–6	>6
Phosphorus % (P)	<0.2	0.20–0.25	0.3–0.7	0.8–1.0	>1.0
Potassium % (K)	<2.0	2.0–2.4	2.5–4.0	4.1–5.0	>5.0
Calcium % (Ca)			2.5–5.0		
Magnesium % (Mg)	<0.15	0.15–0.20	0.3–1.5	1.6–2.4	>2.5
Sulphur % (S)		<0.25	0.3–1.0		
Sodium % (Na)			0–0.35	>0.4	
Chloride % (Cl)			0–1.5	1.6–1.8	>2.0
Copper[1] ppm (Cu)	<3	3–7	8–20	30–50	
Zinc[1] ppm (Zn)	<15	15–18	20–60		
Manganese[1] ppm (Mn)	<15	15–20	60–400	400–600	>600
Iron[2] ppm (Fe)		<40	50–300		
Boron ppm (B)	<20	20–25	30–200	200–300	
Molybdenum ppm (Mo)	<0.2	0.2–0.4	0.5–2.0		

[1] Values for copper, zinc or manganese in leaves sprayed with fungicides or nutrient sprays containing trace elements cannot give a reliable guide to nutritional status even in washed leaves.
[2] Leaf analysis is not a reliable guide to iron deficiency because of surface contamination with dirt, or immobility of iron within the plant or the presence of physiological inactive iron within tissues.

Capsicum leaf levels

Capsicum

(Capsicum annum)

Plant Part Upper young mature leaf (with petiole)
Growth Stage Early fruiting

Nutrient	Deficient	Low	Normal	High	Excess
Nitrogen % (N)	<2.5	2.5–2.8	3.0–5.0	>5.0	
Phosphorus % (P)	<0.20	0.23–0.28	0.3–0.6	>0.6	
Potassium % (K)	<2.2	2.2–2.5	3.0–5.5	>5.5	
Calcium % (Ca)			1.0–3.5		
Magnesium % (Mg)	<0.2	0.2–0.24	0.25–1.2	>1.2	
Sodium % (Na)			0–0.3	>0.4	
Chloride % (Cl)			0–1.6	1.7–1.8	>2.0
Copper[1] ppm (Cu)		4–5	10–200		
Zinc[1] ppm (Zn)	<15	18–19	20–100		
Manganese[1] ppm (Mn)	<18	18–20	26–300	>400	
Iron[2] ppm (Fe)			60–300		
Boron ppm (B)	<20	20–25	30–100		
Molybdenum ppm (Mo)	<0.2	0.2–0.4	0.5–2.0		

Egg plant leaf levels

Egg plant
(Solanum melongena)

Plant Part Recently matured leaf (minus petioles)
Growth Stage Full bloom at mid growth stage

Nutrient	Deficient	Below normal	Normal	Above normal	Excess or toxic
Nitrogen % (N)			3.5–4.5		
Phosphorus % (P)	0.22	0.26	0.3–0.6		
Potassium % (K)		2.7	3.0–5.5	6.0	
Calcium % (Ca)			3.0–6.0	7.0	
Magnesium % (Mg)			0.3–0.9		
Sodium % (Na)			<0.2	0.3	>0.4
Chloride % (Cl)			0.5–1.4	1.8	1.9–6.0
Copper[1] mg/kg (Cu)			6–30		
Zinc[1] mg/kg (Zn)			24–60		
Manganese[1] mg/kg (Mn)			40–300		
Boron mg/kg (B)			30–60		

[1] High values may occur without injury, where copper, zinc or manganese containing fungicides were used.

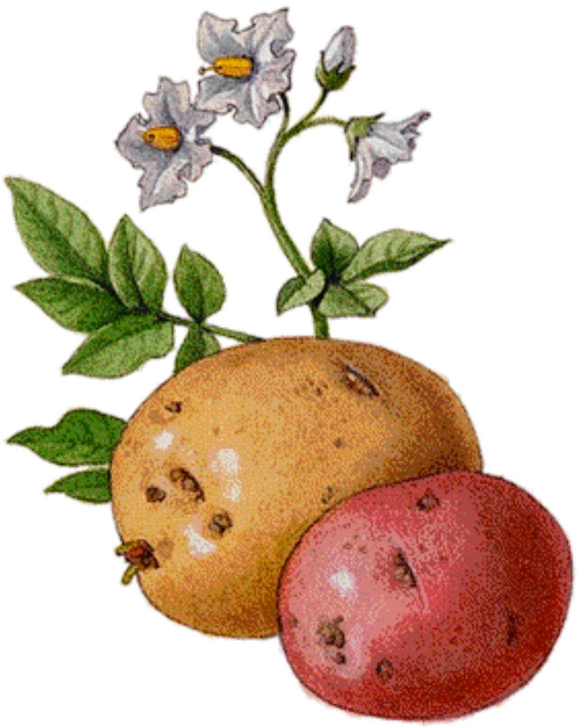
Tomato leaf levels

Tomato
(Lycopersicon esculentum)

Plant Part Youngest mature leaf
Growth Stage First mature fruits

Nutrient	Deficient	Low	Normal	High	Excess
Nitrogen % (N)	<3.0	3.0–3.5	4.0–5.5	>6.0	
Phosphorus % (P)	<0.25	0.25–0.30	0.4–0.7	>0.8	
Potassium % (K)	<2.0	2.0–2.9	3.0–5.0	>6.0	
Calcium % (Ca)			1.5–3.0		
Magnesium % (Mg)	<0.25	0.25–0.30	0.4–0.8	>0.8	
Sulphur % (S)			0.4–1.0		
Sodium % (Na)			0–0.4	0.5–0.6	>0.6
Chloride % (Cl)			0–1.6	1.7–1.8	>2.0
Copper[1] ppm (Cu)		<5	5–200		
Zinc[1] ppm (Zn)	<18	18–19	20–200		
Manganese[1] ppm (Mn)		20–25	25–500	>700	
Iron[2] ppm (Fe)			100–300		
Boron ppm (B)	<12	15–20	25–100	>200	

Potato
leaf levels



Potato
(Solanum tuberosum)

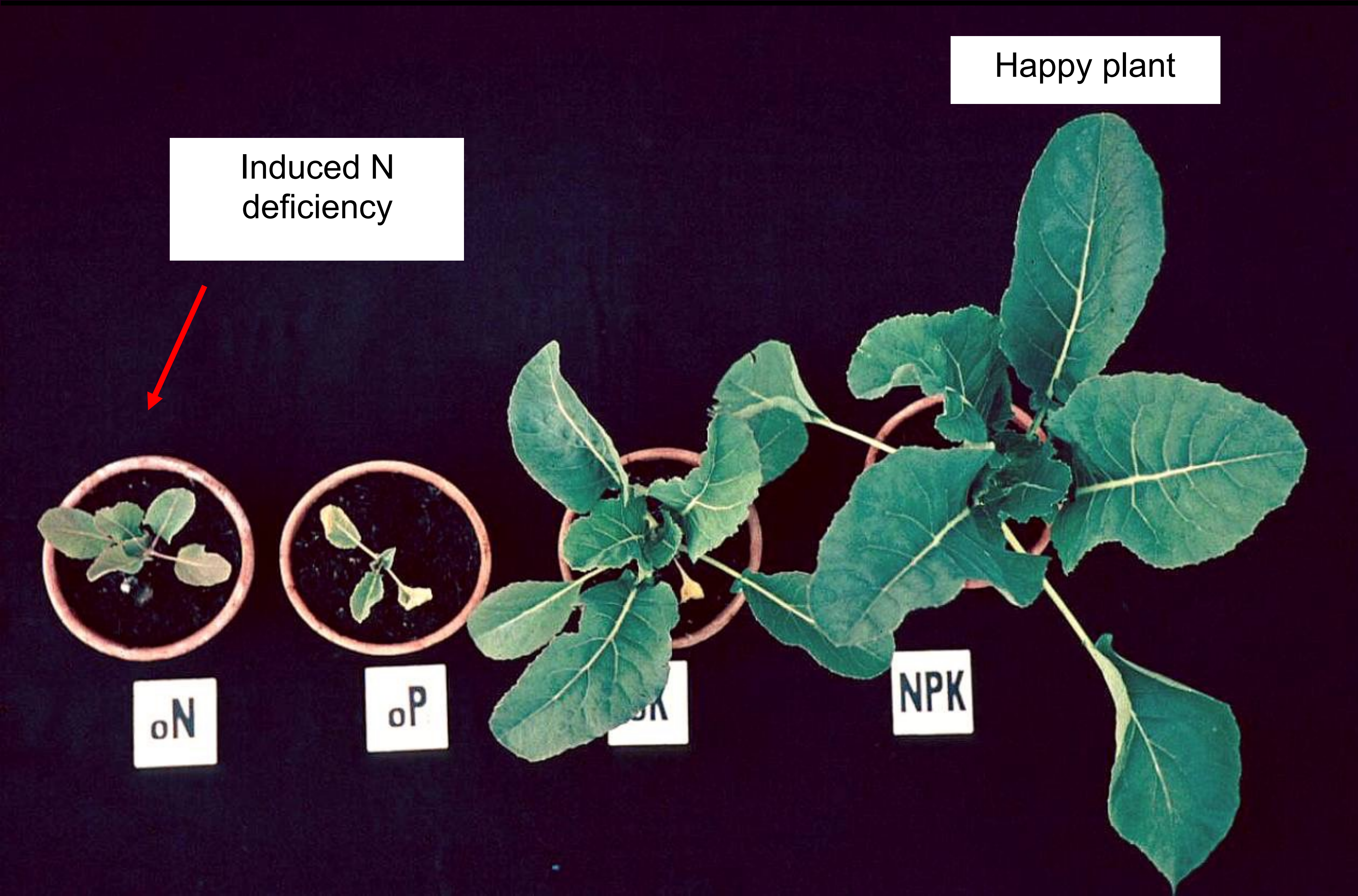
Plant Part Young fully mature compound leaf (usually 4th from tip)
Growth Stage Commencement of flowering or late flowering[1]

Nutrient	Sample date[1]	Deficient	Low	Normal	High	Excess
Nitrogen % (N)	1	<4.2	4.2–4.9	5.0–6.5	>6.5	
	2	<3.5	3.5–4.4	4.5–5.5	5.6–6.0	>6.0
Phosphorus % (P)	1	<0.23	0.23–0.29	0.30–0.55	>0.60	
	2	<0.20	0.20–0.24	0.25–0.45	>0.50	
Potassium % (K)	1	<3.3	3.3–3.9	4.0–6.5	6.5–7.0	>7.0
	2	<3.0	3.0–3.4	3.5–5.5	5.6–6.5	>6.5
Calcium % (Ca)	1	<0.6	0.6–0.8	0.8–2.0	>2.0	
	2	<0.7	0.7–0.9	1.0–2.5	>2.5	
Magnesium % (Mg)	1	<0.22	0.22–0.24	0.25–0.50	>0.50	
	2	<0.20	0.20–0.24	0.25–0.50	>0.50	
Sulphur % (S)	1			0.30–0.50		
	2			0.30–0.50		
Sodium % (Na)	1			0–0.4	>0.4	
	2			0–0.5	>0.5	
Chloride % (Cl)	1			0–3.0	3.0–3.5	>3.5
	2			0–3.5	3.6–4.0	>4.0
Copper[2] ppm (Cu)	1	<3	3–5	5–20	30–100	
	2			5–20		
Zinc[2] ppm (Zn)	1	<15	15–19	20–50		
	2			20–50		
Manganese[2] ppm (Mn)	1	<20	20–30	50–300	700–800	>800
	2			50–500	800–1000	>1000[1]
Iron[3] ppm (Fe)	1			50–150		
	2			50–150		
Boron ppm (B)	1	<15	18–24	30–60		
	2			30–60		

Deficiency Symptoms

- Very bad symptoms are not seen often, due to the use of complete fertilisers – **do not wait to see them!**
- Certain growing conditions, e.g. high humidity, dry or wet soil, high or low pH, can lead to deficiencies or toxicity
- Nutrient imbalances in the soil or ‘ion competition’ may lead to deficiency
- Pest, disease and herbicide damage may look like nutrient deficiency

N-, P-, K-Deficiency Trial



Nitrogen deficiency

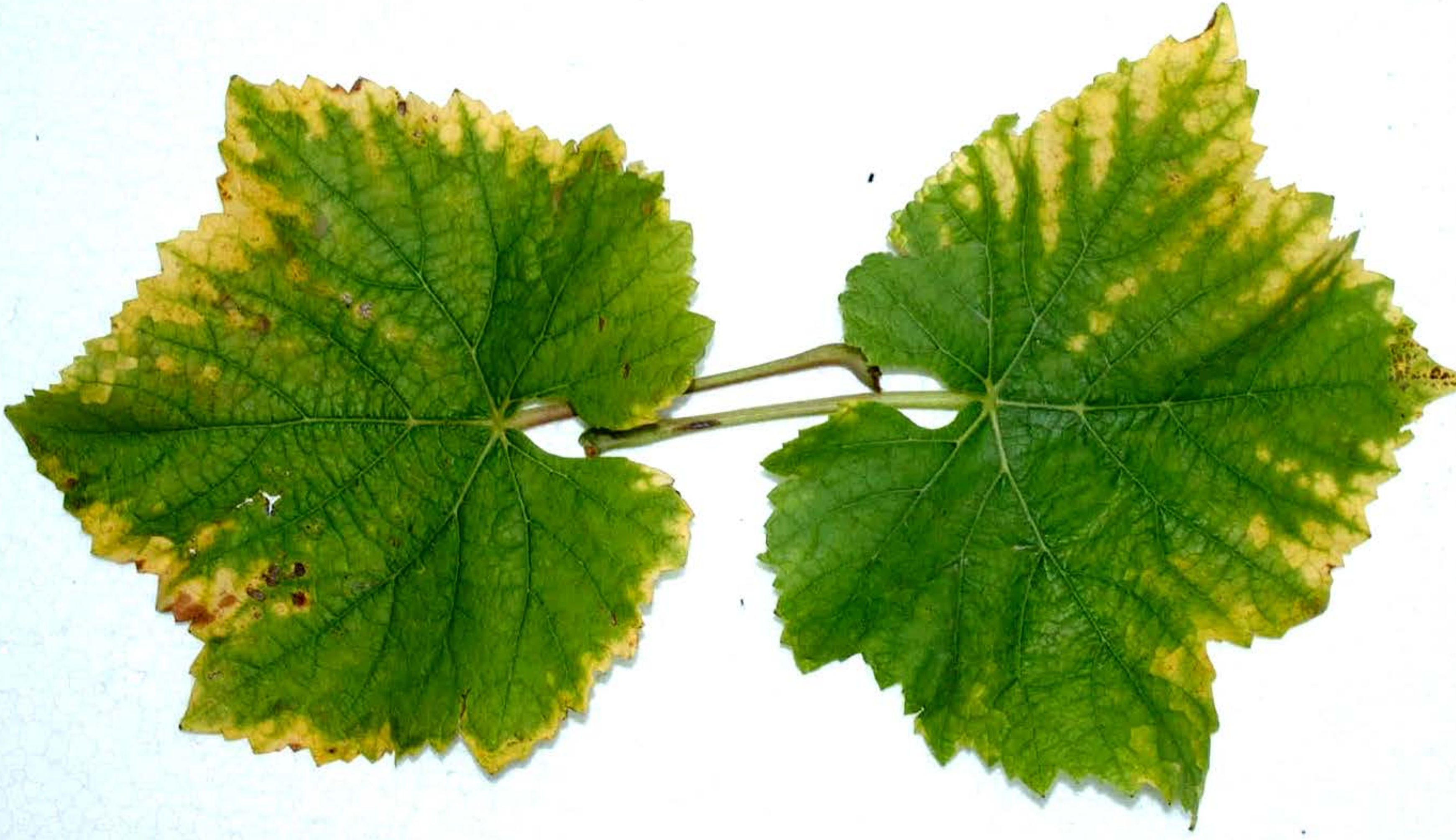
N deficiency

P deficiency

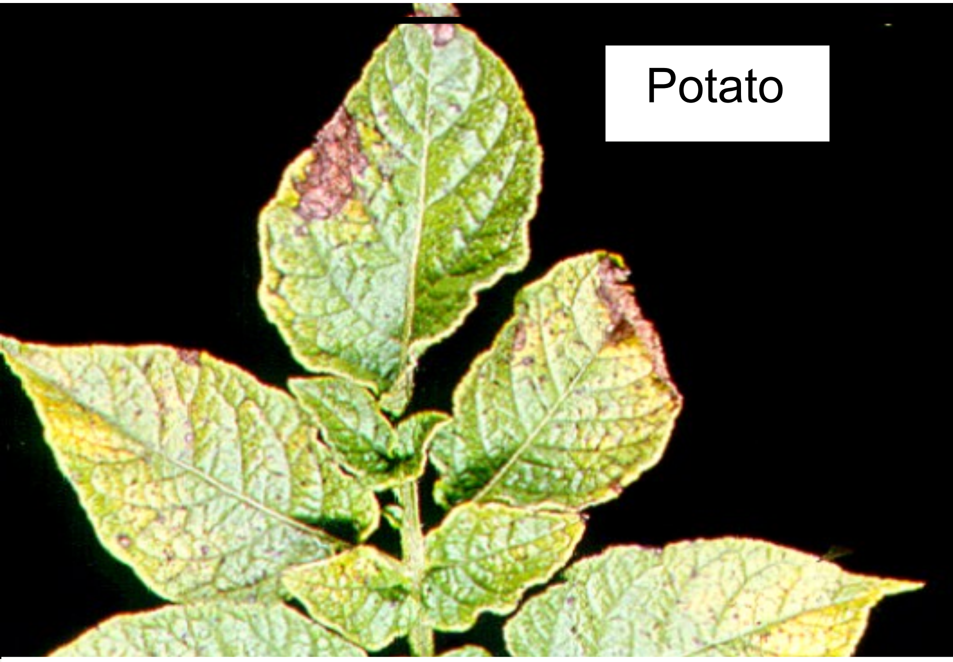
P deficiency

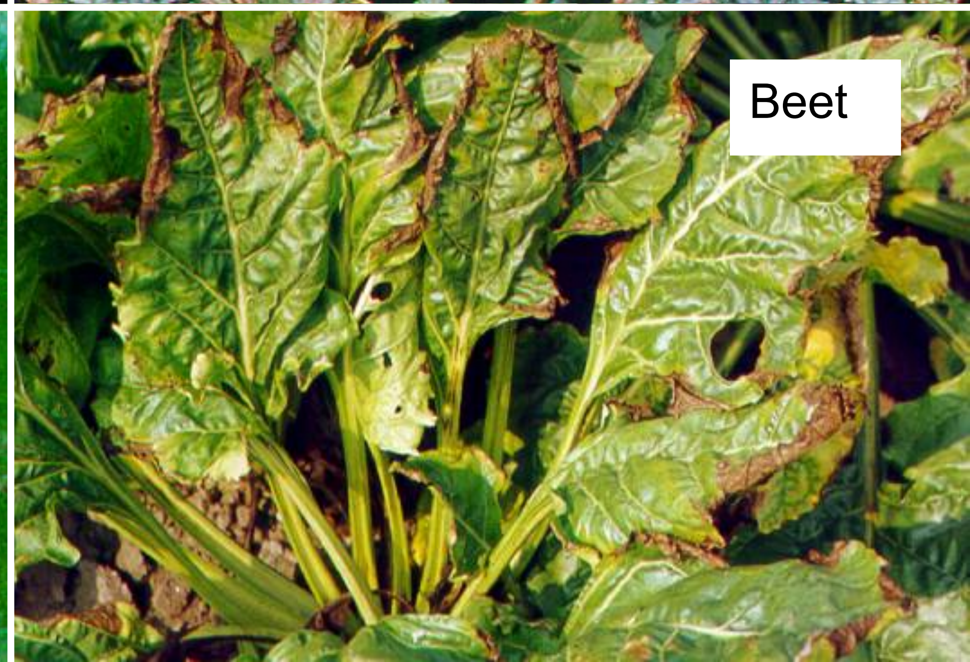
Cold, wet soil can induce P deficiency

K deficiency - grape vine



K deficiency



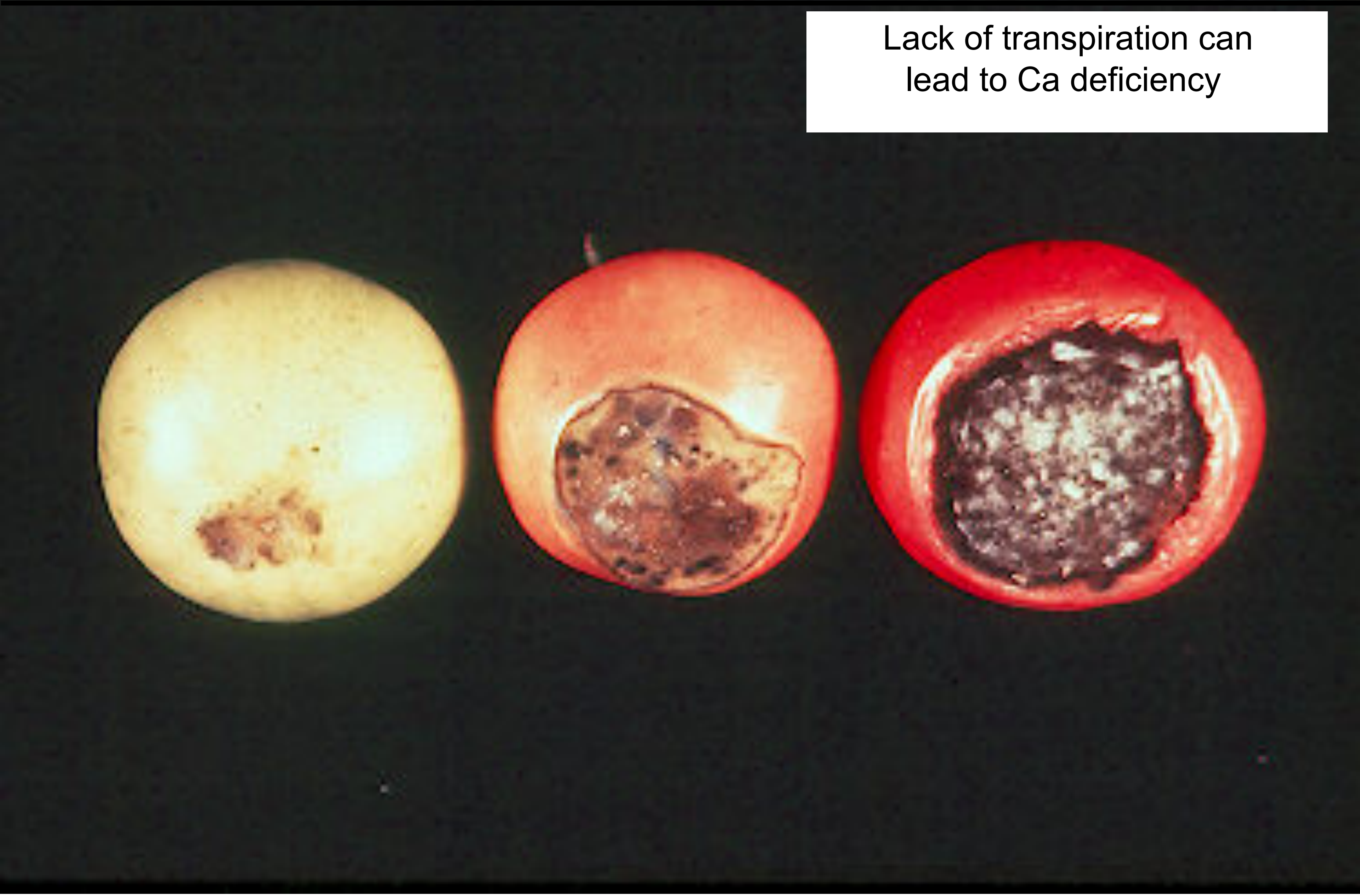


Ca deficiency - necrotic heart

Root zone restriction
can induce Ca deficiency

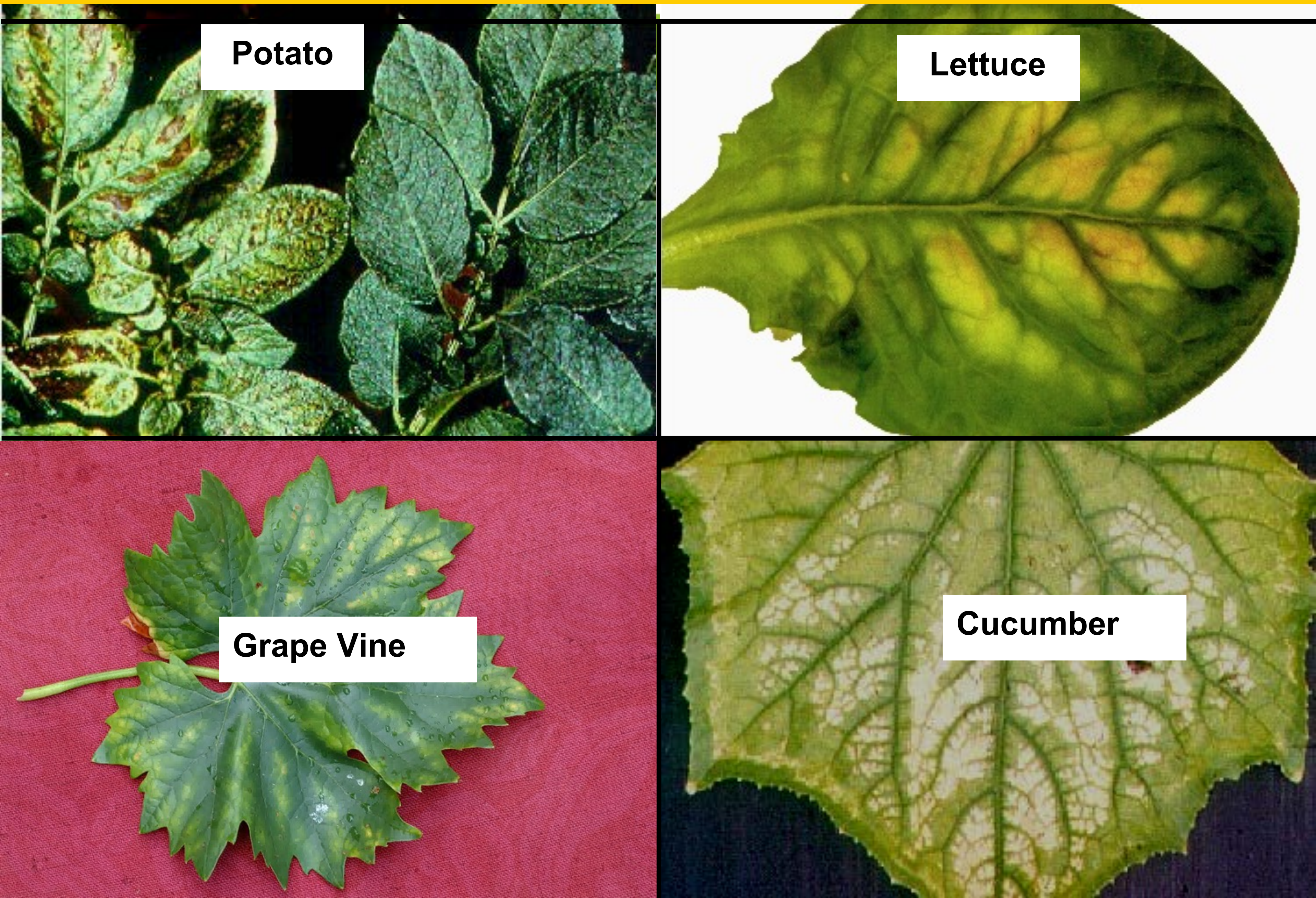
Ca deficiency - blossom end rot

Lack of transpiration can lead to Ca deficiency



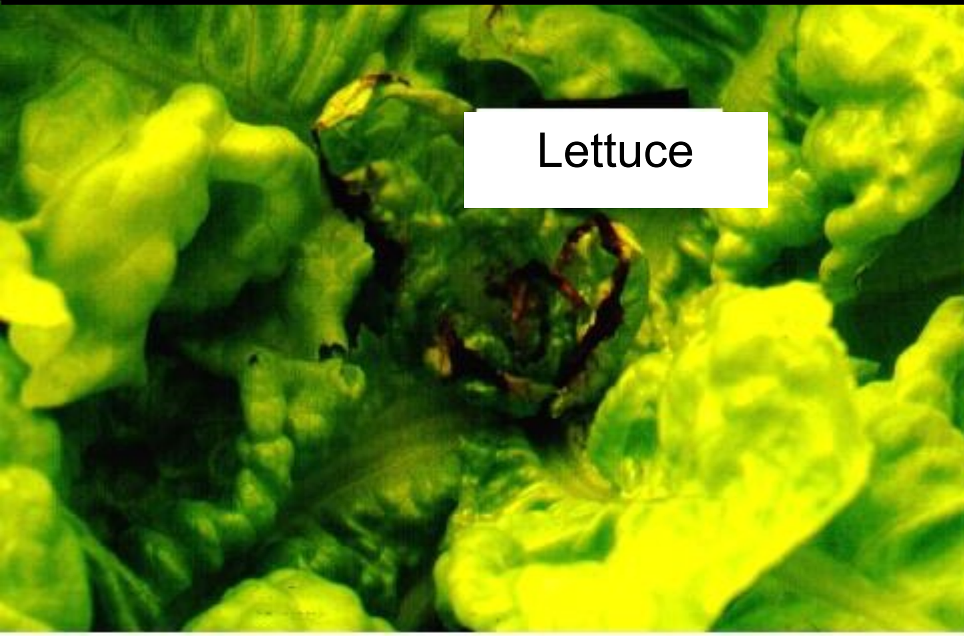
Mg deficiency

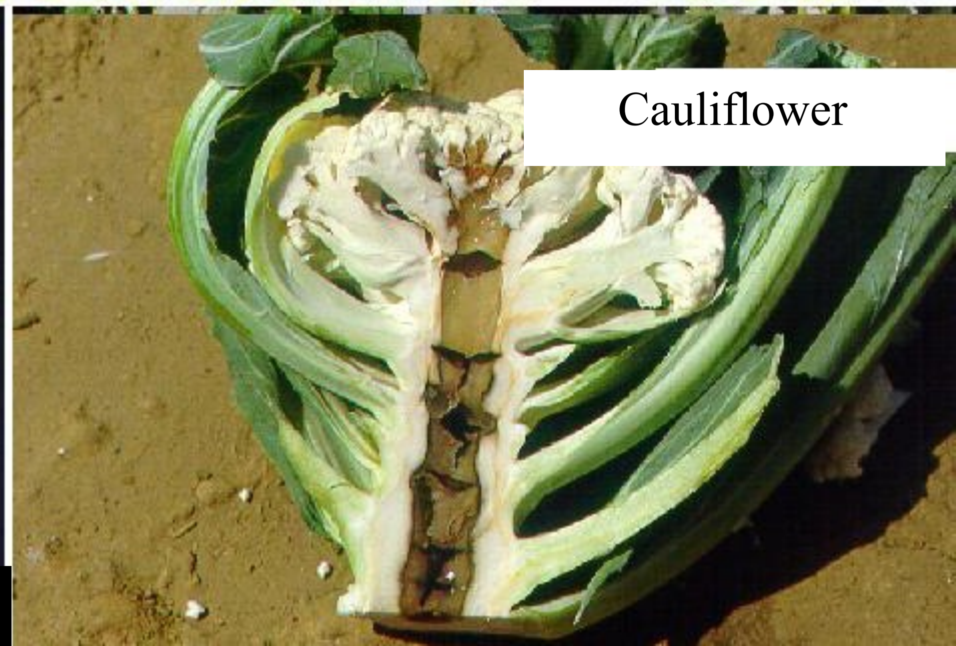
Mg deficiency



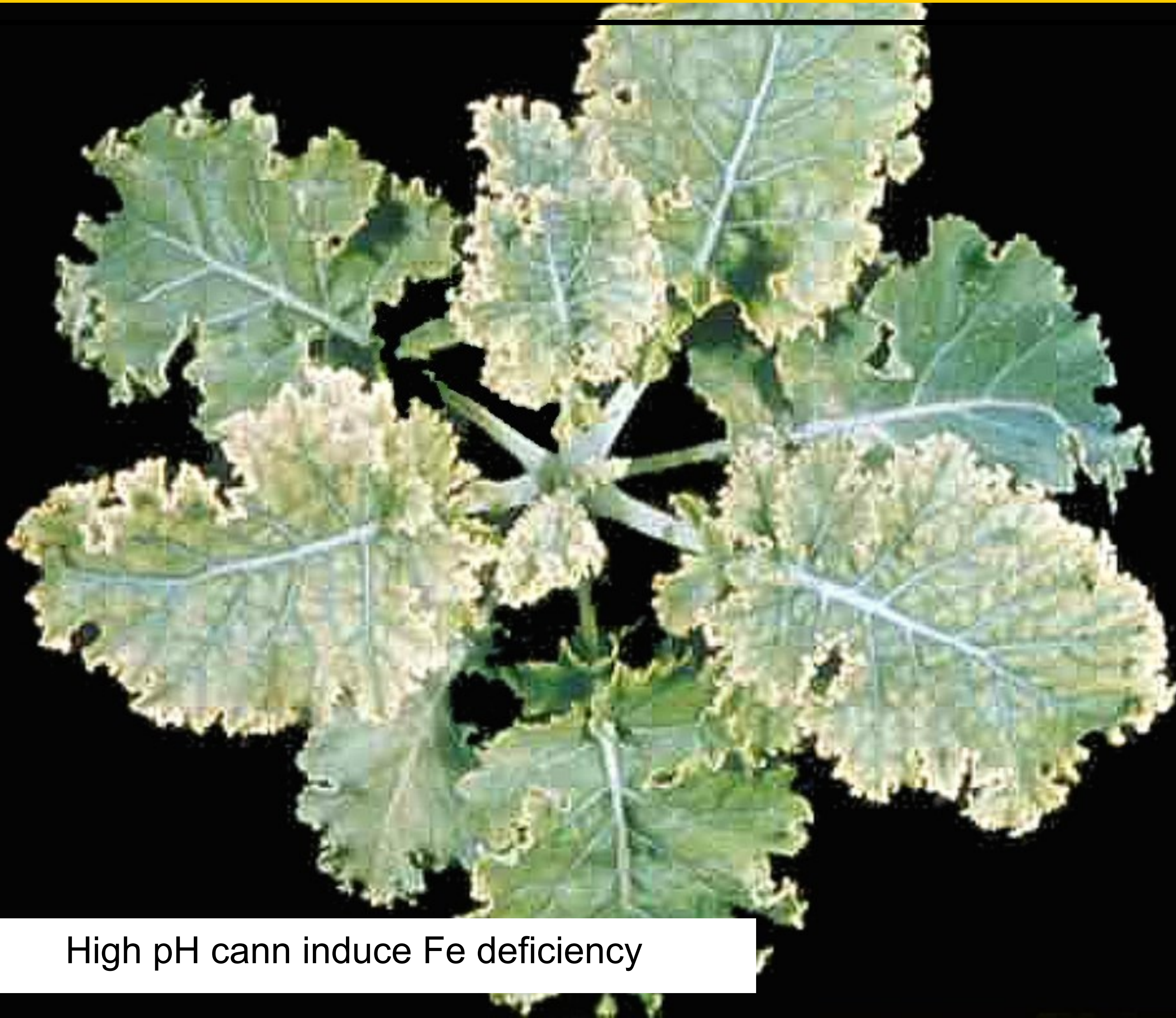
S deficiency

B deficiency





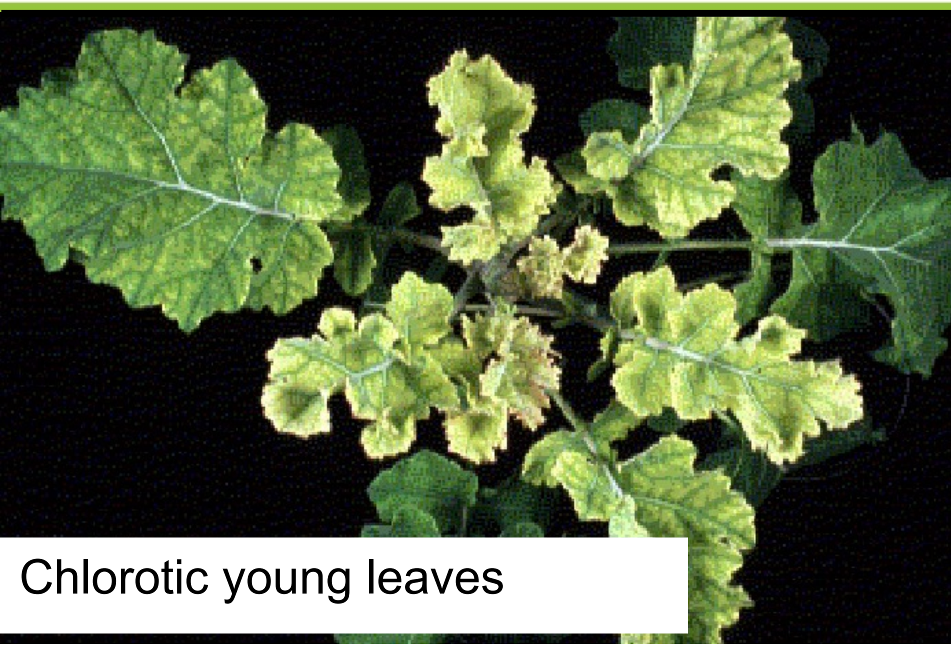
Fe deficiency



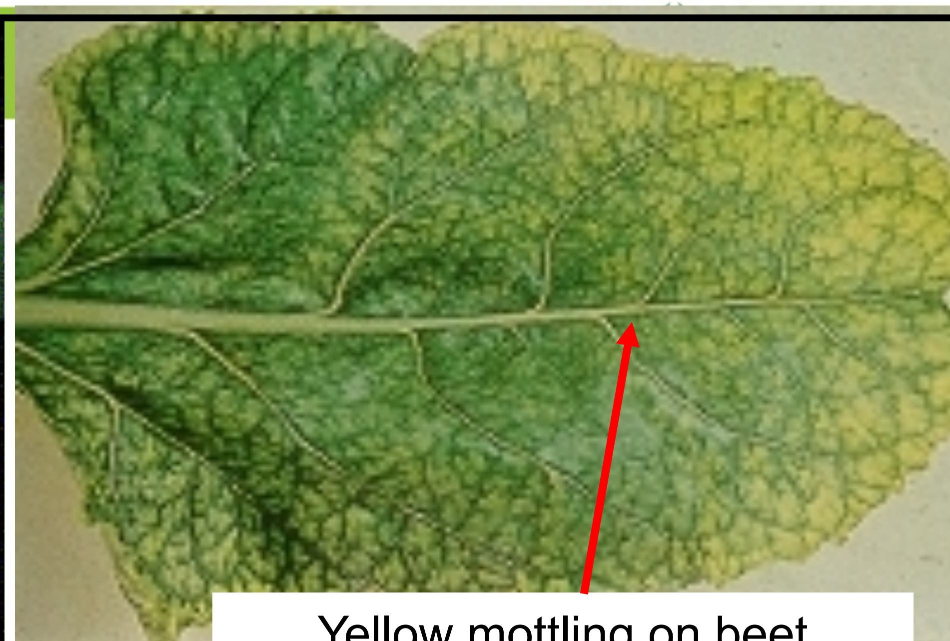
High pH cann induce Fe deficiency

Fe deficiency due to excess Cu

Mn deficiency



Chlorotic young leaves



Yellow mottling on beet

Brassica
- right Fe deficiency
- left Mn deficiency

Mn toxicity - lettuce

Mo deficiency

Mo deficiency